Millstone Power Station Unit 2
Safety Analysis Report

Chapter 9: Auxiliary Systems

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CHAPTER 9 - AUXILIARY SYSTEMS

9.1 GENERAL

The auxiliary systems discussed in this section are those supporting systems which are required to ensure the safe operation, protection or servicing of the major unit systems and, principally, the reactor coolant system. In some cases the dependable operation of several systems is required to fulfill the above requirements and, additionally, certain systems are required to operate under emergency conditions. The extent of the information provided for each system is commensurate with the relative contribute of, or reliance placed upon the system in relation to the overall plant safety. The systems considered are:

a. Chemical and Volume Control System (CVCS);

b. Shutdown Cooling System;

c. Water Treatment System;

d. New Fuel Handling System;

e. Spent Fuel Pool Cooling System;

f. Cooling Water System;

g. Plant Protection System;

h. Fire Protection System;

i. Compressed Air System;

j. Sampling System;

k. Auxiliary Steam System

The majority of the active components within these systems are located outside of the containment. Those systems with connecting piping or ductwork between the containment and the auxiliary building are equipped with containment isolation valves as described in Chapter 5.

Drawing symbols and abbreviations used throughout the FSAR are shown in Figures 9.0–1, 9.0–2, and 9.0–3. Power supplies for these auxiliary systems are discussed in Chapter 8.

FIGURE 9.0–1 P&ID LEGEND

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.0–2 P&ID LEGEND

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.0–3 GENERAL LEGEND NOTES

GENERAL P&ID LEGEND NOTES

1.0 PIPING CLASS CODE DEFINITION

1.1 Piping Classes are designated by a three-letter code. The first letter indicates the Primary Valve and Flange rating; the second letter the type of material; and the third letter the code to which the piping is designed.

1.2 The designations are as follows:

First Letter	**Rating (pounds)**
B	2500
C	1500
D	900
E	600
F	400
G	300
H	150
J	125
K	Class 250 AWWA
L	XH AWWA
M	150 (Gravity)

Second Letter	**Material**
B	Carbon Steel
C	Stainless Steel
D	Copper
E	Ductile Cast Iron, Mechanical Joint
F	Cast Iron, Soil
G	Carbon Steel, Epoxy Lined
R	Carbon Steel Radwaste
S	Stainless Steel Radwaste

FIGURE 9.0–3 GENERAL LEGEND NOTES (CONTINUED)

Third Letter	Design Code	Shop Fabrication	Field Fabrication & Installation
A	Nuclear Power Piping, Class I	ANSI B31.7-69	ASME Section III, 1971
B	Nuclear Power Piping, Class II	ANSI B31.7-69	ASME Section III, 1971
C	Nuclear Power Piping, Class III	ANSI B31.7-69	ASME Section III, 1971
D	Code for Pressure Piping, ANSI B 31.1.0		

1.3 Certain piping systems or portions of piping systems designed and fabricated to ANSI B 31.1.0 shall have additional testing and examination requirements over and above those required by that code. These additional requirements will be identified by a fourth code letter. The code letters and corresponding requirements are described as follows:

Fourth Letter — Additional Specific Requirements

A. ANSI B 31.1.0 Requirements Plus:

1. 100 percent volumetric examination of Butt Welds
2. Seismic Analysis
3. Base Material Traceability (as per Paragraph 1–723.1.3, ANSI B 31.7)

B. ANSI B 31.1.0 Requirements Plus:

1. Random volumetric examination of Butt Welds [(1)]
2. Base Material Identification (as per Paragraph 3-723, ANSI B 31.7)
3. Seismic Analysis

C. ANSI B 31.1.0 Requirements Plus:

1. Base Material Identification (as per ASTM requirements)
2. Seismic Analysis

(1) On Butt Welds over four inch nominal pipe size, a minimum of 10 percent of the Butt Welds in a specified class shall be examined volumetrically. Those welds examined must include welds by each welder or welding operator performing welding in the specified class.

9.2 CHEMICAL AND VOLUME CONTROL SYSTEM

9.2.1 DESIGN BASES

9.2.1.1 Functional Requirements

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

a. Maintain the chemistry and purity of the reactor coolant system;

b. Maintain the required volume of water in the reactor coolant system by compensating for coolant contraction or expansion resulting from changes in reactor coolant temperature and for other coolant losses or additions;

c. Provide a controlled path for transferring fluids to the radioactive waste processing system;

d. Inject concentrated boric acid into the reactor coolant system upon a pressurizer low pressure and/or a containment high pressure signal.

e. Control the boron concentration to obtain optimum control rod positioning, to compensate for reactivity changes associated with major changes in coolant temperature, core burnup, and xenon concentration variations, and to provide shutdown margin for maintenance and refueling operations or emergencies;

f. Provide auxiliary pressurizer spray for operator control of reactor coolant system pressure during shutdown;

g. Provide a means for functionally testing the check valves which isolate the safety injection system for the reactor coolant system;

h. Provide periodic sampling analysis of reactor coolant boron concentration and fission product activity;

i. Collect the controlled bleed off from the reactor coolant pump seals;

j. Pressure test the reactor coolant system.

9.2.1.2 Design Criteria

The CVCS is designed in accordance with the following criteria.

1. The system is designed to accept the discharge when the reactor coolant is heated at the design rate of 100°F/hr and to provide the required makeup when the reactor coolant is cooled at the design rate of 100°F/hr.

2. The system is designed to automatically divert the letdown flow to the radioactive waste processing system (RWS) when the volume control tank is at its highest permissible level and to automatically line up charging pump suction to the RWST on low VCT level.

3. The system is designed to supply makeup or accept discharge due to power decreases or increases.

4. The system is designed with the capability to allow design transients of ±10 percent of full power step changes and ramp changes of ±5 percent of full power per minute between 15 and 100 percent power.

5. The system is designed so that the volume control tank has sufficient capacity to accommodate the reactor coolant system water inventory change for a full to zero power decrease with no makeup system operation, with the volume control tank initially at the normal operating level.

6. The system is designed to assure that the activity in the reactor coolant system does not exceed 411 μCi/cc (at 77°F) for an assumed 1 percent failed fuel condition.

7. The system is designed to maintain the reactor coolant chemistry within the limits specified in Table 9.2-2.

9.2.2 SYSTEM DESCRIPTION

9.2.2.1 System

The CVCS is shown in the simplified block diagram, Figure 9.2–1, and in the detailed piping and instrumentation drawing, Figure 9.2–2. The normal flow path is shown by the heavy lines in Figure 9.2–2. Coolant letdown flow from one reactor coolant loop cold leg first passes through the tube side of the regenerative heat exchanger, where the temperature is reduced to approximately 260°F at normal conditions, and then through the letdown control valves. The letdown control valves are modulated by the pressurizer level control program and control the letdown flow to maintain proper pressurizer level. The letdown coolant temperature is reduced to 120°F in the letdown heat exchanger downstream of the letdown control valves. This final temperature reduction is made to prevent possible damage to the ion exchange resins. Flashing of the hot liquid between the letdown control valves and the letdown heat exchanger is prevented by controlling back pressure with a pressure control valve downstream of the letdown heat exchanger.

The cooled letdown flow is passed through the letdown prefilter to remove suspended solids. The letdown flow is then directed through one of the two purification ion exchangers. The ion exchangers contain resins for removal of corrosion and fission products. The third ion exchanger, the deborating ion exchanger, is used for boron removal near the end of core cycle life when it is no longer practical to use the feed and bleed method for boron dilution. The third ion exchanger is also used for RCS cleanup during plant refueling outages.

The letdown strainer located downstream of the ion exchanger retains particulate matter that may pass through the ion exchanger retention element. It also serves as a backup to the ion exchanger retention element, to prevent resin from entering the volume control tank, in the event of gross failure of this element.

The coolant then flows through the letdown post filter and is sprayed into the volume control tank where gaseous fission products are released and hydrogen gas is dissolved in the coolant. The charging pumps take suction from the volume control tank and pump the fluid through the shell side of the regenerative heat exchanger for recovery of heat from the letdown flow before being returned to the reactor coolant system.

Chemical shim and shutdown control for the reactor is maintained by control of the boron concentration. Boron concentration is monitored by periodic sample analysis. Changing the boron concentration in the reactor coolant system is accomplished by dilution with primary makeup water, addition of concentrated boric acid, or any desired blend of both to the reactor coolant system by the feed and bleed operation.

If the level in the volume control tank reaches the high level setpoint, the letdown flow is automatically diverted to the radioactive waste processing system. If the level in the volume control tank reaches the low-level setpoint, primary makeup water, borated to the existing concentration of the reactor coolant system, can be automatically supplied to the volume control tank by the makeup system. The system is designed to automatically line up charging pump suction to the RWST on low-low VCT level.

With the level in the normal control band, the volume control tank has sufficient capacity to accommodate the reactor coolant system water inventory change for a full to zero power decrease with no makeup system operation.

Concentrated boric acid is prepared in the batching tank and then transferred to the boric acid storage tanks for storage. The boric acid tank contents may be recirculated by the boric acid pumps. These pumps are also used to transfer boric acid to the volume control tank or to the suction of the charging pumps. They also transfer boric acid to the charging pump suction on a safety injection actuation signal (SIAS). On SIAS, both boric acid pumps transfer boric acid directly to the charging pump suction header. Should the boric acid pumps fail to start on SIAS, an additional line is provided for gravity-feeding concentrated boric acid from the storage tanks to the charging pump suction header.

The reactor coolant system may be leak tested when the plant is shut down in accordance with plant procedures. The system is also provided with connections for installing a hydrostatic test pump.

The general CVCS parameters are given in Table 9.2-1. The location numbers on the CVCS Piping and Instrumentation Diagram serve to indicate process flow reference points in the system.

Table 9.2-1 also includes a tabulation of the CVCS process flow data for the three modes of purification loop operation and six modes of makeup system operation using these numbers as reference points. Basically, a letdown flow of 40 gpm is normal purification operation, a letdown flow of 84 gpm is intermediate purification operation and a letdown flow of 128 gpm is maximum purification operation. Typical operating conditions are given for the various makeup system operating modes.

Volume Control

The CVCS automatically controls 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 coolant system and the CVCS during power changes by employing a programmed pressurizer level setpoint which varies with reactor power level. The programmed level setpoint varies linearly with the average reactor coolant temperature. This linear relationship is shown in Figure 4.3–9. The control system compares the programmed level setpoint with the measured pressurizer water level. The resulting error signal is used to control the operation of the charging pumps and the letdown valves, as described below.

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 will start the available standby charging pumps to restore level, and an increase in level will increase the letdown flow rate and initiate a backup signal to stop the operating standby charging pumps. This relationship is shown in Figure 4.3–10.

The volume control tank coolant level is controlled manually or automatically. When the level in the tank reaches the high level setpoint, the letdown flow is automatically diverted to the radioactive waste processing system. When the level in the tank reaches the low level setpoint, makeup water borated to the existing concentration of the reactor coolant system can be automatically supplied. When the level in the tank reaches the low-low level setpoint the charging pump suction is transferred to the refueling water storage tank.

The volume control tank can be vented to the radioactive waste processing system. The volume control tank is designed to handle all gases that come out of solution when the letdown flow is sprayed into the volume control tank.

Chemical Control

Chemistry control of the reactor coolant consists of operational control of oxygen concentration by maintaining excess hydrogen concentration in the reactor coolant. A chemical addition tank and pump are used to inject hydrazine into the suction side of the charging pumps for subsequent injection into the reactor coolant system. The hydrogen concentration in the reactor coolant system is controlled by the hydrogen overpressure in the volume control tank. The lithium that is produced in the reactor coolant by the reaction B^{10} (n, α) Li^7 is used as the pH control agent. The production rate of lithium from this reaction is approximately 100 ppb per day at the beginning of core life, and decreases with core lifetime in proportion to boric acid concentration. One purification ion exchanger is used intermittently to control the lithium concentration. Lithium is also added to the RCS late in core life to maintain pH.

Purification is accomplished by a combination of ion exchange and filtration. Using one purification ion exchanger intermittently, the reactor coolant lithium concentration is controlled within specification limits. The control of other impurities such as chlorides and fission products is accomplished by the continuous operation of the second CVCS purification ion exchanger. This second ion exchanger has been converted to the lithium form and does not remove lithium. These ion exchangers remove soluble nuclides by the ion exchange mechanism and insoluble particles by impingement of these particles on the surface of the resin beds.

Cartridge type filters are located upstream and downstream of the ion exchangers to remove insoluble particles. These filters are removed from service when the pressure drop across the filters, becomes excessive, or when the radiation dose exceeds a predetermined level. A strainer is located downstream of the ion exchangers to insure against the gross release of resin in the unlikely event of an ion exchanger retention element failure.

The volume control tank is provided with a vent to the waste processing system to allow the venting of hydrogen, nitrogen and fission gases.

Instead of controlling the buildup of hydrogen in the waste gases, oxygen is minimized in the gases vented to the waste processing system. All systems and components containing hydrogen are maintained under slightly positive pressure, with nitrogen if required, to prevent the leakage of air into these systems and to preclude the formation of a potentially dangerous mixture of H_2-O_2.

In the event that oxygen concentration exceeds safe limits, nitrogen will be introduced into the waste gas system to lower the concentration of oxygen.

The chemical and volume control system is designed to prevent the reactor coolant fission and corrosion product activities from exceeding the design basis values given in Table 11.A-1 when operating with 1 percent failed fuel.

Reactivity Control

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

a. Optimize the position of the control rods;

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

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

The major components of the makeup system include a batching tank for preparing boric acid solution, two tanks for storing the solution, and two pumps for transferring boric acid solution.

Normally, the CVCS adjusts the boron concentration of the coolant by the feed and bleed operation. To change concentration, the makeup system supplies either demineralized water, concentrated boric acid or any intermediate blend to the volume control tank or charging pump suction. During this time, the letdown stream is diverted to the radioactive waste processing system. Toward the end of a core cycle, the deborating ion exchanger is used to reduce the boron concentration. This avoids the generation of an excessive quantity of waste from feed and bleed operation.

The CVCS can add boron to the reactor coolant at a sufficient rate to override the maximum increase in reactivity due to a cooldown and the decay of xenon in the reactor.

9.2.2.2 Components

Components are designed, manufactured, tested and inspected according to the applicable codes. The following code classifications apply to the CVCS. Components not listed are classified as noncode items.

Component	Design Code	Code Effective Date
Regenerative Heat Exchanger Tube Side (Primary)	ASME III, Class C	1968 Edition through Summer of 1969 Addenda
Regenerative Heat Exchanger Shell Side (Secondary)	ASME III, Class C	1968 Edition through Summer of 1969 Addenda
Letdown Heat Exchanger Tube Side (Primary)	ASME III, Class C	1968 Edition through Summer of 1969 Addenda
Letdown Heat Exchanger Shell Side (Secondary)	ASME III, Class C	1968 Edition through Summer of 1969 Addenda
Ion Exchangers	ASME III, Class C	1968 Edition through Winter of 1969 Addenda
Charging Pumps	ASME III, Class 2	1974 Edition, Summer 1975 Addenda
Boric Acid Makeup Pumps	P&V, Class II	November 1968 Draft
Volume Control Tank	ASME III, Class C	1968 Edition through Summer of 1969 Addenda
Boric Acid Storage Tanks	ASME III, Class C	1968 Edition through Summer of 1969 Addenda
Strainers	B31.7, Class II & III	1969 Edition
Pulsation Dampeners (Discharge)	ASME III, Class 2	1971 Edition with Addendum through Winter 1973

The regenerative heat exchanger has been classified as an ASME Section III, Class C vessel for the following reasons:

1. It is possible to isolate the regenerative heat exchanger on both the shell and tube sides with isolation valves which are remotely operable from the control room;

2. Should it ever become necessary to completely isolate the regenerative heat exchanger an alternate charging path exists through the high-pressure safety injection header;

3. Additional Quality Control and Fatigue Analysis requirements have been placed on the regenerative heat exchanger beyond those normally required of an ASME Section III, Class C vessel.

Regenerative Heat Exchanger

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

Letdown Control Valves

Normally, one of the letdown control valves (CH110P, CH110Q) regulates letdown flow, as required by the pressurizer level control system. The valves reduce the pressure of the letdown fluid to about 500 psig. The letdown flow is nominally 40 gpm, for coolant purification, but will vary as the pressurizer water level changes. The valves are pneumatically 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.

Letdown Heat Exchanger

The letdown heat exchanger cools the letdown flow to a temperature compatible with the purification ion exchanger resins. Reactor building closed cooling water (RBCCW) is the cooling medium on the shell side of the letdown heat exchanger. Tube side materials of construction are austenitic stainless steel; shell side materials of construction are carbon steel. The characteristics of the letdown heat exchanger are given in Table 9.2-5.

Ion Exchangers

Two purification ion exchangers purify the reactor coolant by removing corrosion and fission products. Each unit is designed to handle the maximum letdown flow of 128 gpm. Maximum flow during shutdown purification operation is 300 gpm. The vessels and resin retention element are of austenitic stainless steel construction.

The normal method of adjusting boron concentration is by feed and bleed. Toward the end of a core cycle, the quantities of waste produced due to feed and bleed operations become excessive, and the deborating ion exchanger is used to reduce the boron concentration. The anion resin that is initially in the hydroxyl form, is converted to a borate form as boron is removed.

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

Letdown Filters

The letdown filters remove insoluble materials from the reactor coolant. One filter, the letdown pre-filter, is located in the letdown line upstream of the ion exchangers. The other filter, the letdown post-filter, is located downstream of the ion exchangers. Each filter can accommodate maximum letdown flow of 128 gpm. Maximum flow during shutdown purification operation is 300 gpm. The filter housings are austenitic stainless steel. The characteristics of filters are given in Table 9.2-7.

Volume Control Tank

The volume control tank is used to accumulate letdown flow from the reactor coolant system, to maintain the desired hydrogen concentration in the reactor coolant, and to provide a reservoir of reactor coolant for the charging pumps. A vent to the radioactive waste processing system 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 is provided with overpressure protection. Level controls divert coolant to the radioactive waste processing system on high level or operate the makeup system on low level. The characteristics of the tank are given in Table 9.2-8.

Charging Pumps

The charging pumps return the purification flow to the reactor coolant system during plant steady state operations. The pumps are horizontal, positive displacement type with a leakage collection system. Each charging pump has a capacity of 44 gpm. On a safety injection actuation signal (SIAS), the available pumps are started (normally, one of the pumps will already be running) and pump concentrated boric acid into the reactor coolant system. The pressure containing portions of the pump are austenitic stainless steel with internal materials selected for compatibility with boric acid. The characteristics of the pumps are given in Table 9.2-9. Pulsation dampeners are located on the suction and discharge sides of each pump to minimize vibration induced failures.

Boric Acid Storage Tanks

The operable boric acid storage tank(s), in conjunction with the RWST, store enough concentrated boric acid solution 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 batching strainer before entering the storage tanks. With boric acid concentrations in the BASTs less than or equal to 3.5 weight percent, tank heaters are not required to prevent boron precipitation at Auxiliary Building ambient temperatures. Sampling connections are used to verify that the proper concentration is maintained. The tanks are constructed of stainless steel. The characteristics of the batching tank, boric acid batching strainer and the boric acid tanks are given in Table 9.2-10.

Boric Acid Pumps

The boric acid pumps take suction from the concentrated boric acid tanks and provide boric acid for blended flow to the volume control tank or direct transfer to the charging pump suction header. On initiation of SIAS, these pumps line up with the charging pumps to permit direct transfer of concentrated boric acid into the reactor coolant system. Each boric acid pump is capable of supplying boric acid to three operating charging pumps. All wetted parts, except seals, are stainless steel. The pump and strainer characteristics are given in Table 9.2-11.

9.2.3 SYSTEM OPERATION

9.2.3.1 Startup

During RCS fill, the CVCS back pressure control valve is normally used to control RCS pressure. RCS heatup commences after a steam bubble is established in the pressurizer. During RCS heatup, CVCS (charging pumps and letdown) are used to maintain pressurizer level and RCS inventory; pressurizer heaters and spray are used to maintain RCS pressure. The level controls in the volume control tank automatically divert the letdown flow to the radioactive waste processing system (RWS).

When the reactor is shut down, the volume control tank is vented to the radioactive waste processing system and then pressurized with nitrogen. Prior to reactor startup, a hydrogen blanket is established in the tank. Any oxygen in the reactor coolant is normally removed by radiolytic recombination with excess hydrogen in the coolant.

Throughout startup, the letdown filters are in service to reduce the activity of wastes entering the RWS. The purification ion exchanger is also normally in service. Within limitations placed on the shutdown margin, the boron concentration in the reactor coolant system may be reduced during heatup. The operator may inject a predetermined amount of demineralized makeup water by operating the makeup system in the “Dilute” mode. The concentration of boron in the reactor coolant is verified by chemical analysis.

9.2.3.2 Normal Operation

Normal operation includes both the hot standby condition as well as normal plant operation.

During normal operation:

a. Level instrumentation in the pressurizer automatically controls the volume of water in the reactor system by adjusting the letdown flow.

b. The water level in the volume control tank is maintained manually or automatically, in accordance with plant procedures.

c. The hydrogen concentration and pH of the coolant are controlled in accordance with plant procedures.

d. Changes in reactivity may be compensated for by adjusting the concentration of boron in the reactor coolant system by the feed and bleed operation. Late in core life, the boron in the reactor coolant is maintained at a very low concentration. At this time the feed and bleed operation would generate excessive quantities of wastes so further reduction is accomplished by use of the deborating ion exchanger. During steady state operation, precise reactivity control is accomplished by utilizing the feed and bleed method. Over core life, an increasing quantity of demineralized water is metered to the suction of the charging pumps in order to minimize power level fluctuations.

e. 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 or the volume control tank. When the integrating flowmeter indicates that the selected quantity of makeup water has been added, the makeup flow is automatically stopped.

    2. In the “Borate” mode, a quantity of concentrated boric acid is selected and introduced into the charging pump suction or the volume control tank, as described above.

    3. In the “Manual Blend” mode, the flows of the demineralized water and concentrated boric acid can be set for any blend concentration between demineralized makeup water and concentrated boric acid. This mode is primarily used to supply makeup to the volume control tank and refueling water storage tank.

    4. In the “Automatic” mode, the flow rates of the demineralized water and concentrated boric acid are set to match the concentration present in the reactor coolant system at that time in core life. The solution is automatically blended and introduced into the volume control tank according to signals received from the volume control tank level program.

    The makeup system is normally set for the dilute mode of operation. This allows the operator to closely monitor all additions to the RCS.

f. The letdown flow is normally routed through one of the purification ion exchangers to reduce coolant activity.

9.2.3.3 Shutdown

Plant shutdown 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 condition.

Before the plant is cooled down, the RCS is degassed to reduce the concentration of fission gases and hydrogen in the reactor coolant system. The operator may also increase the letdown flow rate to accelerate the degasification, ion exchange, and filtration processes. All CEAs are inserted and CEDMs deenergized to begin the mode change to the shutdown condition to prevent inadvertent CEA withdrawal from subcritical conditions. During cooldown, boron is added, as needed, to the reactor coolant system in accordance with plant procedures to maintain adequate shutdown margin.

During the cooldown, the charging pumps, letdown control valves and letdown backpressure control valves are used to adjust and maintain the pressurizer water level. The charging system is aligned to the Boric Acid Storage Tank(s) or RWST for RCS makeup during cooldown until the required shutdown margin is verified. The charging suction is then switched to the Refueling Water Storage Tank. These steps ensure the proper shutdown margin is maintained. A portion of the charging flow is used as an auxiliary spray to cool the pressurizer when the pressure of the reactor coolant system is below that required to operate the reactor coolant pumps.

9.2.3.4 Safety Injection Operation (Emergency Operation)

Under emergency conditions, the charging pumps function to inject concentrated boric acid into the reactor coolant system. Either the pressurizer level control or the SIAS will automatically start the available charging pumps. Normally one of the pumps will already be running. The SIAS signal will also function to transfer the charging pump suction from the volume control tank to the discharge of the boric acid pumps. If the boric acid pumps are not operable, boric acid flows by gravity from the concentrated boric acid tanks to the charging pump suction header. If the charging line inside the reactor containment building is inoperative, this line may be isolated outside the reactor containment building, and the concentrated boric acid solution may be injected by the charging pumps through the high pressure safety injection header.

Portions of the charging system may be employed to provide long term cooling and boron precipitation control in the event of a LOCA by simultaneous hot and cold leg injection. In the event that the preferred LPSI hot leg injection method is unavailable, HPSI pump P-41A is aligned to inject to the pressurizer auxiliary spray line, and thus the hot leg, through piping in the charging system.

9.2.4 AVAILABILITY AND RELIABILITY

9.2.4.1 Special Features

To assure reliability, the design of the CVCS incorporates component redundancy as well as operational redundancy. This is provided as follows:

Component	Redundancy
Purification Ion Exchangers	Parallel Standby Unit
Charging Pumps	Two Parallel Standby Units
Letdown Flow Control Valves	Parallel Standby Valve
Boric Acid Pumps and Tanks	Parallel Standby Unit
Backpressure Control Valves	Parallel Standby Valve

In addition to the component redundancy it is possible to operate the CVCS in a manner such that some components are bypassed. While the normal charging path is through the regenerative heat exchanger, it is also possible to charge through the high pressure safety injection header. It is possible to transfer boric acid to the charging pump suction header by bypassing the volume control tank, or by bypassing the makeup flow controls and the volume control tank. On SIAS two separate paths to the charging pump suction header are lined up for boric acid transfer (through boric acid pumps and through the gravity feed line). If the letdown temperature exceeds 140°F, the flow will automatically bypass the ion exchangers and flow to the process radiation monitor and boronometer is stopped.

The charging pumps and boric acid pumps are powered by an emergency bus if normal power is lost. The boric acid pumps and the motor-operated gravity feed boric acid valves are powered from different buses. Separation is provided between the power and control circuits for the redundant boration paths.

Standby features are provided so that at least one charging pump is running after SIAS. Separate power supplies and control circuits are provided among the charging pumps, boric acid pumps and the gravity feed boric acid motor-operated valves. Since both boric acid pumps are powered from the same power supply, the redundancy for boration is achieved by the design of the boric acid gravity feed piping arrangement and gravity feed motor operated valve as the redundant path for boration.

Heating of the boric acid solution in the Boric Acid Storage Tanks and the piping between the BASTs and the charging pumps is not required since the boric acid concentration is limited to 3.5 wt. percent and will remain in solution under normal ambient area temperatures. Heat tracing will be maintained on the Boric Acid Batching Tank, the batching strainers, and the piping upstream of the BASTs because of the possibility of filling these sections with cold water.

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 failure position of the backpressure control valves is the closed position. If the valve fails to open, relief valve CH-354 will protect the low pressure portion of the letdown line under all circumstances. However, if the CVCS is in the maximum purification mode there is a possibility that flashing downstream of the drag valves could occur. However, the maximum purification mode of operation requires maximum component cooling water flow to the letdown heat exchanger; thus, the letdown heat exchanger would prevent any two-phase flow condition downstream of the heat exchanger. In addition, if the temperature out of the letdown heat exchanger exceeds 140°F, the letdown flow would bypass the ion exchangers. Also, should the valves remain open, the low pressure alarm on the backpressure controller would alert the operator that the valve is no longer functional. Note that in none of these cases would the VCT be subject to over-pressure. In any case, the VCT has a relief valve with a relieving capacity of 250 gpm which is set to protect the VCT from exceeding its design pressure. Also, a VCT high pressure alarm provides notification that the VCT is above its normal operating pressure but below the VCT relief valve setting. The volume control tank also has a high temperature alarm above 130°F. Therefore, there is adequate warning and protection to prevent any pressure buildup in the low-pressure portion of the system.

Should the backpressure control valves fail closed, the intermediate pressure relief valve (CH-345) would preclude any overpressure condition from existing. The operator would be alerted to this condition by a high pressure alarm on the pressure controller (PIC-201). There would not be any flashing flow because of the higher set pressure of this relief valve. Since this backpressure control valve fails closed, there is no overpressurization problem downstream of this valve and the relief valve relieves the pressure upstream of this valve.

TABLE 9.2-1 CHEMICAL AND VOLUME CONTROL SYSTEM PARAMETERS

Normal Letdown and Purification Flow, gpm	40
Normal Charging Flow, gpm	44
Reactor Coolant Pump Controlled Bleedoff (4 pumps), gpm	4
Normal Letdown Temperature at Loop, °F	550
Normal Charging Temperature at Loop, °F	395
Ion Exchanger Operating Temperature, °F	120

Chemical and Volume Control System Process Flow Data

CVCS Makeup System Operation - Manual Mode

CVCS Location:	15	16	17	18	19	20	21	22	23	24
Flow, gpm	175	175	10	10	0	10	50	50	60	0
Press., psig	10	90	90	85	15	22	155	20	20	10
Temp., °F	140	140	140	140	140	140	60	60	140	70
CVCS Location:	25	26	27	28	29	30	31	32	33	
Flow, gpm	0	0	165	155	10	10	0	0	0	
Press., psig	90	15	90	90	90	20	10	10	10	
Temp., °F	140	140	140	140	140	140	140	140	140	

CVCS Makeup System Operation - Emergency Boration (SIAS)

CVCS Location:	15	16	17	18	19	20	21	22	23	24
Flow, gpm	142	142	132	0	0	0	0	0	0	0
Press., psig	10	105	105	105	105	15	165	15	15	10
Temp., °F	140	140	140	140	140	140	60	60	140	140

TABLE 9.2-1 CHEMICAL AND VOLUME CONTROL SYSTEM PARAMETERS (CONTINUED)

CVCS Location:	25	26	27	28	29	30	31	32	33	
Flow, gpm	132	132	10	0	10	10	0	0	0	
Press., psig	103	100	105	105	105	20	10	10	10	
Temp., °F	140	140	140	140	140	140	140	140	140	
CVCS Makeup System Operation - Shutdown Boration										
CVCS Location:	15	16	17	18	19	20	21	22	23	24
Flow, gpm	180	180	15	0	0	0	0	0	0	0
Press., psig	10	90	90	90	90	15	165	15	15	10
Temp., °F	140	140	140	140	140	140	60	60	140	70
CVCS Location:	25	26	27	28	29	30	31	32	33	
Flow, gpm	15	15	165	155	10	10	0	0	0	
Press., psig	90	90	90	90	90	20	10	10	10	
Temp., °F	140	140	140	140	140	140	140	140	140	
CVCS Makeup System Operation - Emergency Boration (SIAS) Via Gravity Feed										
CVCS Location:	15	16	17	18	19	20	21	22	23	24
Flow, gpm	0	0	0	0	0	0	0	0	0	0
Press., psig	10	10	10	10	5	15	165	15	15	10
Temp., °F	140	140	140	140	140	140	60	60	140	70
CVCS Location:	25	26	27	28	29	30	31	32	33	
Flow, gpm	0	0	0	0	0	0	66	66	132	
Press., psig	10	5	10	10	10	10	10	10	5	
Temp., °F	140	140	140	140	140	140	140	140	140	

TABLE 9.2-1 CHEMICAL AND VOLUME CONTROL SYSTEM PARAMETERS (CONTINUED)

NOTE:

(1) See Figure 9.2–2, Bechtel CVCS P&ID No. 25203-26017, for location numbers.

(2) The data shown for the various modes of operation is typical.

(3) The pressure in the isolated piping of the CVCS makeup system will normally be 0 psig, but may range as high as 140 psig before the thermal relief valves lift.

Chemical and Volume Control System Process Flow Data

CVCS Normal Purification Operation (One Charging Pump in Operation)

CVCS Location:	1	2	3	4	5	6	7	8	9	10
Flow, gpm	40	40	40	40	40	39	1	39	39	40
Press., psig	2205	2195	465	460	27	26	27	25	24	23
Temp., °F	550	262	262	120	120	120	120	120	120	120

CVCS Location:	10a	10b	10c	11	12	13	14 (a,b,c,d)	14e	14f	14g
Flow, gpm	40	40	44	44	44	44	1	0	4	4
Press., psig	22	20	20	20	2310	2302	100	100	100	21
Temp., °F	120	120	120	120	120	395	120	120	120	120

CVCS Maximum Purification Operation (Two Charging Pumps in Operation)

CVCS Location:	1	2	3	4	5	6	7	8	9	10
Flow, gpm	84	84	84	84	84	83	1	83	83	84
Press., psig	2205	2162	481	460	50	46	50	45	41	37
Temp., °F	550	320	320	120	120	120	120	120	120	120
CVCS Location:	10a	10b	10c	11	12	13	14 (a,b,c,d)	14e	14f	14g

TABLE 9.2-1 CHEMICAL AND VOLUME CONTROL SYSTEM PARAMETERS (CONTINUED)

Flow, gpm	84	84	88	88	88	88	1	0	4	4
Press., psig	33	20	20	20	2310	2278	100	100	100	21
Temp., °F	120	120	120	120	120	350	120	120	120	120

CVCS Maximum Purification Operation (Three Charging Pumps in Operation)

CVCS Location:	1	2	3	4	5	6	7	8	9	10
Flow, gpm	128	128	128	128	128	127	1	127	127	128
Press., psig	2205	2105	510	460	92	82	92	81	71	61
Temp., °F	550	675	375	120	120	120	120	120	120	120
CVCS Location:	10a	10b	10c	11	12	13	14 (a,b,c,d)	14e	14f	14g
Flow, gpm	128	128	132	132	132	132	1	0	4	4
Press., psig	51	20	20	20	2310	2240	100	100	100	21
Temp., °F	120	120	120	120	120	120	120	120	120	120

NOTE:

(1) See Figure 9.2–2 Bechtel CVCS P&ID No. 25203-26017, for location numbers.

(2) The pressure drop across the purification filter and ion exchanger will vary with loading. The pressure drops shown are typical.

(3) The pressure in the volume control tank will vary and this will affect the pressures at locations 5 through 11 proportionally.

CVCS Makeup System Operation - Automatic Mode

CVCS Location:	15	16	17	18	19	20	21	22	23	24
Flow, gpm	175	175	10	10	0	10	140	140	150	0
Press., psig	10	90	90	85	15	22	140	20	22	10
Temp., °F	140	140	140	140	140	140	60	60	70	70

TABLE 9.2-1 CHEMICAL AND VOLUME CONTROL SYSTEM PARAMETERS (CONTINUED)

CVCS Location:	25	26	27	28	29	30	31	32	33	
Flow, gpm	0	0	165	155	10	10	0	0	0	
Press., psig	90	20	90	90	90	20	10	10	10	
Temp., °F	140	140	140	140	140	140	140	140	140	
CVCS Makeup System Operation - Borate Mode										
CVCS Location:	15	16	17	18	19	20	21	22	23	24
Flow, gpm	180	180	15	15	0	15	0	0	15	0
Press., psig	10	90	90	75	15	22	165	20	22	10
Temp., °F	140	140	140	140	140	140	60	60	140	70
CVCS Location:	25	26	27	28	29	30	31	32	33	
Flow, gpm	0	0	165	155	10	10	0	0	0	
Press., psig	90	20	90	90	90	20	10	10	10	
Temp., °F	140	140	140	140	140	140	140	140	140	
CVCS Makeup System Operation - Dilute Mode										
CVCS Location:	15	16	17	18	19	20	21	22	23	24
Flow, gpm	160	160	0	0	0	0	130	130	130	0
Press., psig	10	90	90	15	15	22	140	22	22	10
Temp., °F	140	140	140	140	140	140	60	60	140	70
CVCS Location:	25	26	27	28	29	30	31	32	33	
Flow, gpm	0	0	160	150	10	10	0	0	0	
Press., psig	15	20	90	90	90	20	10	10	10	
Temp., °F	140	140	140	140	140	140	140	140	140	

NOTE:

(1) See Figure 9.2–2, Bechtel CVCS P&ID No. 25203-26017, for location numbers.

(2) The data shown for the various modes of operation is typical

(3) The pressure in the isolated piping of the CVCS makeup system will normally be 0 psig but may range as high as 140 psig before the thermal relief valves lift.

TABLE 9.2-2 REACTOR COOLANT AND DEMINERALIZED WATER CHEMISTRY

PARAMETER	REACTOR COOLANT	DEMINERALIZED WATER
Suspended Solids, ppm maximum	0.35 prior to reactor startup	-
pH at 25°C	Determined by the concentration of boric acid and lithium present. Consistent with the Primary Chemistry Control Program.(4)	-
Chloride, ppm Cl^-, maximum	0.15	0.05
Fluoride, ppm F^-, maximum	0.10	-
Sodium, ppm Na^+, maximum	-	0.01
Hydrogen as H_2, cc(STP)/Kg H_20	25-50	-
Dissolved O_2, ppm maximum	0.1 (1) (2) (3)	0.1
Lithium as Li^7, ppm	Consistent with the Primary Chemistry Control Program. (4)	-
Boron, ppm	0-2620 (5)	-
Conductivity, µS/Cm at 25°C	Relative to lithium and boron concentration	2.0

TABLE 9.2-2 REACTOR COOLANT AND DEMINERALIZED WATER CHEMISTRY (CONTINUED)

PARAMETER	REACTOR COOLANT	DEMINERALIZED WATER

NOTES:

(1) The temperature at which the Oxygen limit applies is > 250°F.

(2) The at power operation residual Oxygen concentration control value is ≤ 0.005 ppm.

(3) During plant startup, Hydrazine may be used to control dissolved Oxygen concentration at ≤0.1 ppm.

(4) During power operation lithium is coordinated with boron to maintain a $pH_{(t)}$ of ≥ 7.0, but ≤ 7.4, consistent with the Primary Chemistry Control Program. Lithium is added to the RCS during plant startup, but prior to reactor criticality, and is in specification per the Primary Chemistry Control Program within 72 hours after criticality. Lithium may be removed from the reactor coolant immediately before, or during, shutdown periods to aid in the cleanup of corrosion products. By evaluation, a maximum lithium concentration of 4.5 ppm is permissible with a target lithium concentration of 4.3 ppm for 100% power operations.

(5) RCS boron concentration is maintained as necessary to ensure core reactivity or shutdown margin requirements are met. Although the RCS and related auxiliary systems containing reactor coolant are designed for a maximum concentration of 2620 ppm boron, it should be noted the design basis for the TSP baskets in the containment sump assumes the RCS, SITs, and RWST are at a maximum boron concentration of 2400 ppm.

TABLE 9.2-3 REGENERATIVE HEAT EXCHANGER

Design Parameters

Quantity	1
Type	Shell and Tube, Vertical
Code	ASME III, Class C (1968 Edition through Summer of 1969 Addenda)
Tube Side (Letdown)	
Fluid	Reactor Coolant, 1 wt % Boric Acid, Maximum
Design Pressure, psig	2485
Design Temperature °F	650
Materials	Stainless Steel, Type 304
Pressure Loss, psi	99 (at 128 gpm)
Normal Flow, gpm	40
Design Flow, gpm	128
Shell Side (Charging)	
Fluid	Reactor Coolant, 12 wt % Boric Acid, Maximum
Design Pressure, psig	3025
Design Temperature °F	650
Materials	Stainless Steel, Type 304
Pressure Loss at 44 gpm, psi	5
Normal Flow, gpm	44
Design Flow, gpm	132

TABLE 9.2-3 REGENERATIVE HEAT EXCHANGER (CONTINUED)

Operating Parameters

Tube Side (Letdown)	Normal	Maximum Letdown / Maximum Charging	Maximum Letdown / Maximum Charging	Maximum Letdown / Minimum Charging
Flow - gpm at 120°F	40	30	128	128
Inlet Temperature °F	550	550	550	550
Outlet Temperature °F	262	165	375	450

Shell Side (Charging)	Normal	Maximum Letdown / Maximum Charging	Maximum Letdown / Maximum Charging	Maximum Letdown / Minimum Charging
Flow - gpm at 120°F	44	132	132	44
Inlet Temperature °F	120	120	120	120
Outlet Temperature °F	395	212	310	452

TABLE 9.2-4 LETDOWN CONTROL VALVES

Quantity	2
Manufacturer	Control Component Incorp.
Design Pressure, psig	2485
Design Temperature, °F	550
Maximum Flow (each), gpm	128
Minimum Flow (each), gpm	30

TABLE 9.2-5 LETDOWN HEAT EXCHANGER

Design Parameters

Quantity	1
Type	Shell and Tube, Horizontal
Code	ASME III, Class C (1968 Edition through Summer of 1969 Addenda)
Manufacturer	Whitlock Manufacturing Co.
Tube Side (Letdown)	
Fluid	Reactor Coolant, 1 weight percent Boric Acid, Maximum
Design Pressure, psig	650
Design Temperature °F	550
Pressure Loss at 128 gpm	21
Materials, psi	Stainless Steel, Type 304
Normal Flow, gpm	40
Maximum Flow, gpm	128 [1]
	300 [2]
Shell Side (Cooling Water)	
Fluid	RBCCW
Design Pressure, psig	150
Design Temperature °F	250
Materials	Carbon Steel
Normal Flow, gpm	190
Design Flow, gpm	1200

1. During letdown system operation.
2. During shutdown purification operation.

TABLE 9.2-5 LETDOWN HEAT EXCHANGER (CONTINUED)

Operating Parameters

Tube Side (Letdown)	Normal	Maximum Letdown / Maximum Charging	Maximum Letdown / Maximum Charging	Maximum Letdown Minimum Charging
Flow - gpm at 120°F	40	30	128	128
Inlet Temperature °F	263	165	375	450
Outlet Temperature °F	120	120	120	127

Shell Side (Cooling Water)	Normal	Maximum Letdown / Maximum Charging	Maximum Letdown / Maximum Charging	Maximum Letdown Minimum Charging
Flow - gpm at 120°F	190	21	1200	1200
Inlet Temperature °F	100	65	100	100
Outlet Temperature °F	130	130	127	135

TABLE 9.2-6 ION EXCHANGERS

Quantity	3
Type	Flushable
Manufacturer	Air Preheater Co.
Design Pressure, psig	200
Design Temperature,°F	250
Normal Operating Pressure, psig	60
Normal Operating Temperature, °F	120
Resin Volume, each (total), ft^3	36.2
Resin Volume, each (useful), ft^3	32.0
Normal Flow, gpm	40
Maximum Flow, gpm	128 [1]
	300 [2]
Code for Vessel	ASME III, Class C (1968 Edition thru Winter of 1969 Addendum)
Retention Screen, U. S. Mesh	80
Material	Stainless Steel, Type 304
Fluid, Boric Acid, wt %	1 Maximum

1. During letdown system operation.
2. During shutdown purification operation.

TABLE 9.2-7 LETDOWN FILTERS

Quantity	2
Type Elements	Disposable Cartridge

Data

Manufacturer	Weight % Efficiency	Normal Operating Temperature, °F	Design Pressure, psig	Maximum Allowable Pressure Loss, Clean, psi	Maximum Allowable Pressure Loss, Loaded, psi	Filter Cartridge Rating (Micron)	Design Temperature, °F	Maximum Flow, gpm	Normal Flow, gpm
Filterite	80 (minimum)	120	200	5 at 132 gpm	40 at 132 gpm	3 Nominal	250	132	40
Pall Cartridge	99 (minimum)			3.44 at 132 gpm	75 at 132 gpm	6, 2, 0.45 Absolute	250	132 [a] 300 [b]	40

a. During letdown system operation.
b. During shutdown purification operation.

Code for Vessel	ASME III, Class C (1968 Edition through Summer of 1969 Addendum).
Material	Austenitic Stainless Steel.
Fluid, Boric Acid, wt %	1 Maximum.

TABLE 9.2-8 VOLUME CONTROL TANK

Quantity	1
Type	Vertical, Cylindrical
Manufacturer	Air Preheater Co.
Design Pressure, Internal, psig	75
Design Pressure, External, psig	15
Design Temperature, °F	250
Normal Operating Pressure, psig	15 - 30
Normal Operating Temperature, °F	120
Normal Spray Flow, gpm	40
Blanket Gas (during plant operation)	Hydrogen
Code	ASME III, Class C (1968 Edition through Summer of 1969 Addenda)
Fluid, Boric Acid, wt %	6.25 Maximum
Material	Austenitic Stainless Steel

TABLE 9.2-9 CHARGING PUMPS

Quantity	3
Type	Positive Displacement
Manufacturer	Gaulin Corp. n
Design Pressure, psig	3010
Design Temperature, °F	250
Capacity, gpm	44
Normal Discharge Pressure, psig	2735
Normal Suction Pressure, psig	20
Normal Temperature, °F	120
Maximum Discharge Pressure (Short Term), psig	3010
Minimum Available Net Positive Inlet Pressure, psia	9.0
Net Positive Inlet Pressure Required, psia	8.25 at 44 gpm
Driver Rating, hp	100
Materials in Contact with Pumped Fluid	Austenitic Stainless Steel
Fluid	12 wt % Boric Acid, Maximum

TABLE 9.2-10 CONCENTRATED BORIC ACID PREPARATION AND STORAGE

Boric Acid Storage Tanks

Quantity	2
Manufacturer	Air Preheater Co.
Internal Volume, each, ft^3	870
Design Pressure, psig	15
Design Temperature, °F	250
Normal Operating Temperature, °F	60-100
Fluid, wt % Boric Acid	
Minimum	2.5
Maximum	3.5
Material	Austenitic Stainless Steel
Code	ASME III, Class C (1968 Edition through Summer of 1969 Addenda)

Boric Acid Batching Strainer

Quantity	1
Type	“Y” type, in line
Manufacturer	Mueller Steam Specialty Co.
Design Pressure, psig	150
Normal Operating Pressure, psig	5
Design Temperature, °F	200
Screen Size, U.S. Mesh	10
Design Flow, gpm	130
Materials	Austenitic Stainless Steel
Fluid, Boric Acid, wt %	3.5
Maximum Pressure Loss, psi	USAS B31.7, Class II & III
Code (1969 Edition)	10

TABLE 9.2-10 CONCENTRATED BORIC ACID PREPARATION AND STORAGE (CONTINUED)

Boric Acid Batching Tank

Quantity	1
Manufacturer	Air Preheater Company
Useful Volume, gallons	635
Design Pressure	Atmospheric
Design Temperature, °F	250
Normal Operating Temperature, °F	85-100
Type Heater	Electrical Immersion
Heater Capacity, Min., kW	45
Fluid, Boric Acid, wt %	12
Material	Austenitic Stainless Steel
Code	Non code

TABLE 9.2-11 BORIC ACID PUMPS AND STRAINERS

PUMPS

Quantity	2
Manufacturer	Goulds Pump Co.
Type	Centrifugal
Design Pressure, psig	150
Design Temperature, °F	250
Design Head, feet	231
Design Flow, gpm	143
Normal Operating Temperature, °F	60-100
NPSH Available (Minimum), feet	20
NPSH Required, feet	8
Horsepower, hp	2.5
Fluid, Boric Acid, wt % maximum	3.5
Material in Contact with Liquid Code (November 1968 Draft)	Austenitic Stainless Steel Pump and Valve Code, Class II

STRAINER

Quantity	1
Manufacturer	Mueller Steam Specialty Co.
Type	"Y" type, in line
Screen Size U.S. Mesh	200
Normal Operating Pressure, psig	80
Design Pressure, psig	150
Pressure Loss, Clean, psi	1 at 30 gpm
Design Temperature, °F	200
Normal Operating Temperature, °F	85-100
Design Flow, gpm	150
Materials	Austenitic Stainless Steel
Fluid, Boric, Acid, wt % Code (1969 Edition)	3.5 USAS B31.7, Class II & III

FIGURE 9.2–1 CHEMICAL AND VOLUME CONTROL SYSTEM FLOW SCHEMATIC (NORMAL OPERATION)

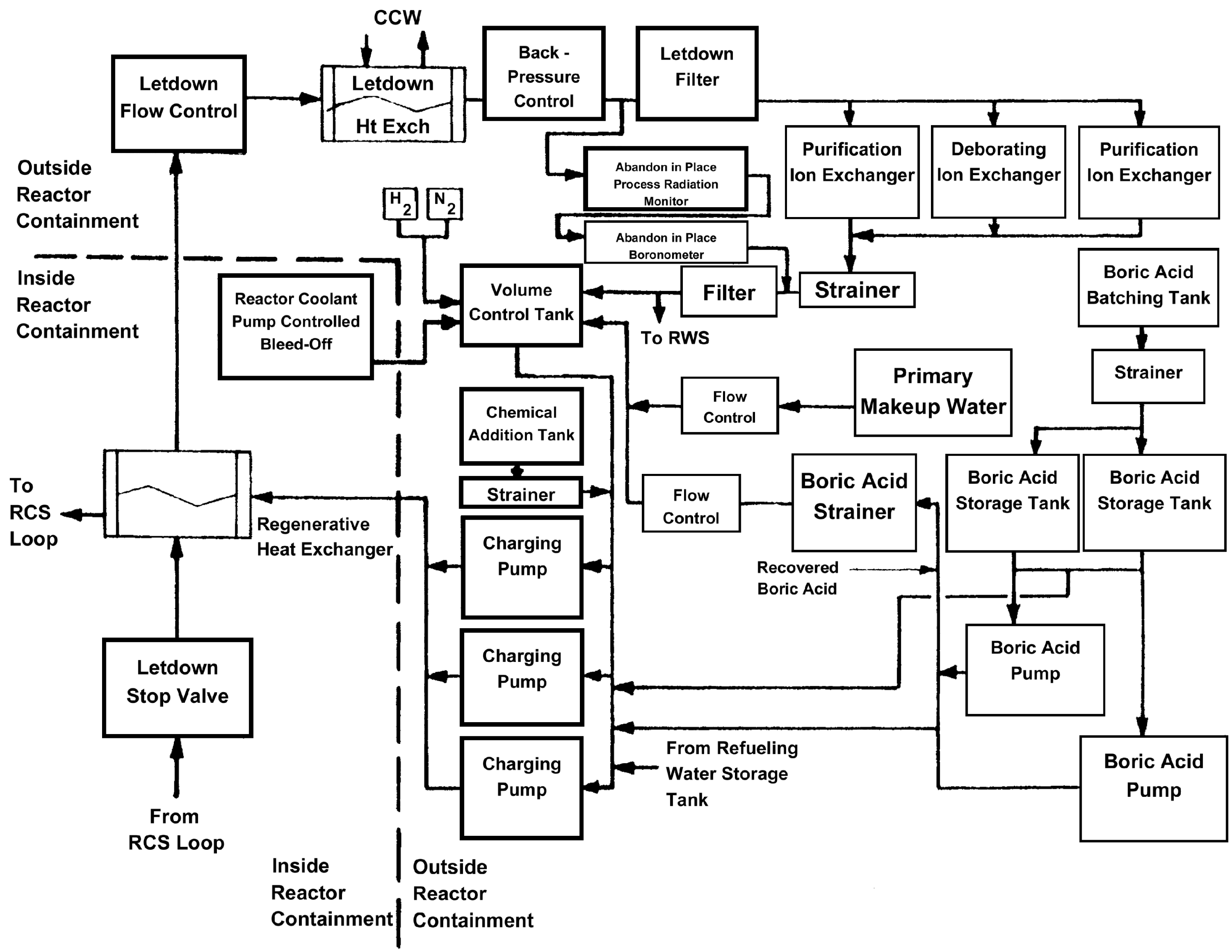


FIGURE 9.2–2 P&IDS: CHARGING; DEBORATING; PURIFICATION; BORIC ACID SYSTEMS (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–2 P&IDS: CHARGING; DEBORATING; PURIFICATION; BORIC ACID SYSTEMS (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–2 P&IDS: CHARGING; DEBORATING; PURIFICATION; BORIC ACID SYSTEMS (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

9.3 SHUTDOWN COOLING SYSTEM

9.3.1 DESIGN BASES

9.3.1.1 Functional Requirements

The shutdown cooling system, in conjunction with the main steam and feedwater systems, is designed to reduce the temperature of the reactor coolant in post shutdown periods from normal operating temperature to the refueling temperature. The main steam and feedwater system is utilized in the initial phase of the cooldown. The shutdown cooling system functions to reduce the coolant temperature to the refueling temperature and also maintains this temperature during refueling.

Refueling water transfer from the refueling water storage tank (RWST) to the refueling cavity in the containment building is normally accomplished after the reactor vessel head has been removed by using the high pressure safety injection pumps, low pressure safety injection pumps or the refueling water purification pumps. The high pressure safety injection pumps take suction from the RWST and discharge into the reactor coolant system and then to the refueling cavity via the open reactor vessel. Pumping continues until the refueling cavity is filled. The low pressure pumps can be used to return the refueling water from the refueling cavity to the RWST.

During shutdown or refueling, the shutdown cooling system can be aligned to cool the spent fuel pool system using the low pressure safety injection pumps (see Section 9.5)

The shutdown cooling system heat exchangers are normally used during the recirculation phase by either the containment spray system or the shutdown cooling system, when RCS conditions permit following a LOCA. If permissible RCS conditions exist post-LOCA, the shutdown cooling heat exchangers may be aligned to the shutdown cooling system and shutdown cooling may be initiated for longterm cooling. Otherwise, the shutdown cooling heat exchangers remain aligned to the containment spray system which is used to cool the recirculated water.

The functional performance requirements for the shutdown cooling heat exchangers during normal alignment or during LOCA recirculation mode are provided in Table 9.3-1.

Following a LOCA, when the containment spray system is no longer required, the RCS is filled, and the shutdown cooling system entry conditions have been met, the preferred method by which to provide long term cooling and boron precipitation control is with the shutdown cooling system in its normal plant operation alignment. In the event that the RCS is not filled 8 to 10 hours after the start of the LOCA, then portions of the shutdown cooling system may be aligned for simultaneous hot and cold leg injection to provide long-term cooling and boron precipitation control.

9.3.1.2 Design Criteria

Code selection and materials requirements are primarily related to the emergency operation capability of the system and are presented in Chapter 6. The shutdown cooling system components are designed to meet the design parameters listed in Table 9.3-2.

System components whose design pressure and temperature are less than the reactor coolant system design limits are provided with overpressure protection devices and redundant isolation means. System discharge from over-pressure protection devices is collected in closed systems.

Materials are selected to meet the applicable code material requirements of the codes given in Table 6.3-3. All parts of components in contact with borated water are fabricated or clad with austenitic stainless steel.

9.3.2 SYSTEM DESCRIPTION

9.3.2.1 System

The shutdown cooling system is shown schematically in Figure 9.3–1. The system uses portions of other systems, i.e., the reactor coolant system (Chapter 4), safety injection system (Section 6.3) and containment spray system (Section 6.4).

In the shutdown cooling system, reactor coolant is circulated using the low pressure safety injection pumps. The flow path from the pump discharge runs through normally locked closed valves SI-452 and SI-453, through the shutdown cooling heat exchangers, through normally closed valves SI-456 and SI-457, through normally locked closed valve SI-657 to the low pressure safety injection header, and enters the reactor coolant system through the four safety injection header legs. (As required for temperature control, a portion of the pump flow may bypass the heat exchangers, going directly to the low pressure safety injection header by flowing through the shutdown cooling heat exchanger bypass valve SI-306.) The circulating fluid flows through the core and is returned from the reactor coolant system through the shutdown cooling nozzle in the loop number 2 reactor vessel outlet (hot leg) pipe. The coolant is returned to the suction of the low pressure safety injection pumps through normally closed valves SI-651 and SI-652. These valves are interlocked to prevent opening when the reactor coolant system pressure exceeds the design pressure of the shutdown cooling system. Further, if either of these valves is open when reactor coolant system pressure exceeds a set point of 280 psia, an annunciator will alarm. Each valve is independently controlled by separate instrumentation channels. The interlock on these valves is also described in Sections 4.3.8.2.3 and 9.3.4.1.

A pressure equalizing line is installed between the valve body of SI-651 and upstream piping 12"-CCA-10. The line will ensure that over-pressurization of the valve bonnet for SI-651 and pressure locking of the valve does not occur.

Shutdown cooling and total low pressure injection flow are measured by an orifice meter installed in the low pressure safety injection header. Flow is indicated in the control room. The flow element also transmits a signal to a controller.

The cooldown rate is controlled by adjusting flow through the heat exchangers with the throttle valve SI-657 on the discharge of the heat exchangers. Relatively constant total shutdown cooling flow to the core is maintained by adjusting the heat exchanger bypass valve controller FIC-306 and/or the injection valves to compensate for changes in flow through the heat exchangers.

9.3.2.2 Interface With Other Systems

Safety Injection System

The low pressure safety injection pumps recirculate the reactor coolant during the shutdown cooling mode of heat removal. The flow path is described in Section 9.3.2.1.

Reactor Coolant System

Temperature control during refueling and the initial cooldown to refueling temperature of the reactor coolant system is accomplished by recirculating reactor coolant through the shutdown cooling heat exchangers. Reactor coolant is circulated from the hot legs to the cold leg side of the reactor vessel, thus maintaining the normal flow direction in the reactor coolant system during the refueling cycle. During normal operation two closed valves provide isolation from the reactor coolant system. The two isolation valves are also provided with pressure interlocks which preclude them from being opened at a reactor coolant system pressure above the design pressure of the shutdown cooling loop.

Reactor Building Closed Cooling Water System

The RBCCW system provides the heat sink to which the reactor coolant system residual heat is rejected. RBCCW water flows through the shell side of the shutdown cooling heat exchangers and also functions to cool the shaft seals on the low pressure safety injection pumps as they circulate the heated reactor coolant.

Containment Spray System

During normal plant operation the containment spray pumps are aligned to flow through the shutdown cooling heat exchangers. In the shutdown cooling mode of operation isolation valves act to separate the heat exchangers from the containment spray system.

Chemical and Volume Control System

Piping and valves are provided in the CVCS such that during shutdown cooling a portion of the flow can be bypassed from the outlet of the shutdown heat exchangers through the letdown portion of the CVCS and returned to the suction line of the low pressure safety injection pumps. Flow through this bypass stream provides filtration and ion exchange of the reactor coolant via the purification filter and ion exchanger.

Spent Fuel Pool Cooling System

During shutdown or refueling, the shutdown cooling system can be aligned to cool the spent fuel pool system using the low pressure safety injection pumps (see Section 9.5).

9.3.2.3 Components

Shutdown Cooling Heat Exchanger and Pumps

The Shutdown Cooling System is made up of components of the Safety Injection System and the Reactor Coolant System. The principal characteristics of the major components in those systems are given in Sections 6.3 and 4.0, respectively.

The shutdown Cooling Heat Exchangers and low pressure safety injection pumps are described in Section 6.3. Additional information covering the characteristics of heat exchangers in the shutdown cooling mode is given in Table 9.3-1.

Shutdown Cooling Pumps

The low pressure safety injection pumps are part of the Shutdown Cooling System but are shared with the safety injection system. During all periods of plant operation when safety injection system operability is required, they are aligned for the emergency core cooling operation.

The low pressure safety injection pumps are vertical centrifugal pumps with mechanical seals to minimize reactor coolant leakage to the atmosphere. The low pressure safety injection pumps are described in Chapter 6.

Shutdown Cooling Valves

Manual isolation valves are provided to isolate equipment for maintenance. Manual valves have backseats to facilitate repacking. Control valves are provided for remote and manual control of heat exchanger tube side flow. Control valve 2-SI-306 has a lantern ring at the bottom of each of two packing boxes followed by a set of packing. It is not equipped with and does not require packing leak-off lines. 2-SI-657 has two sets of packing and intermediate leak-off connections that discharge to the waste processing system. Check valves prevent shutdown cooling reverse flow through the low pressure safety injection pumps.

Shutdown Cooling System Piping

All shutdown cooling system piping is austenitic stainless steel. All piping joints and connections are welded except for a minimum number of injection pumps, for example high pressure safety, and orifice plates.

9.3.3 SYSTEM OPERATION

9.3.3.1 Plant Heatup

Prior to plant heatup, RCS temperature is held stable with the shutdown cooling system removing decay heat. When heatup is started, the flow through the shutdown cooling heat exchangers is reduced to allow decay heat to start warming up the RCS. Since shutdown cooling return temperature is monitored as the indicator of reactor vessel temperature until RCPs are started, this flow reduction must be gradual. After taking into account the possible temperature rise if the steam generators are hotter than the reactor vessel, two RCPs are started. Shutdown cooling flow and temperature may then be adjusted as required to maintain the desired heatup rate within the limits of the Technical Specifications. When heat removal via the steam generators is available, the shutdown cooling system is secured and lined up for emergency operation.

9.3.3.2 Normal Plant Operation

During normal plant operation there are no components of the system in operation. The system is normally aligned for possible emergency operation.

9.3.3.3 Plant Cooldown

Plant cooldown is the series of operations which bring the reactor from a hot standby condition to cold shutdown.

Cooldown to less than 300°F is accomplished by dumping steam to the condenser or to atmosphere. During this time, after safety injection is no longer required, the shutdown cooling system is prepared for operation. This includes aligning the shutdown cooling heat exchangers to the LPSI pumps and the LPSI injection valves. This may also include boron equalization with the RWST (through the SIT test line) or warm-up (through valve 2-SI-400). When dumping steam is no longer effective in cooling down the reactor, and pressure has been reduced to within the design pressure of the shutdown cooling system, shutdown cooling is initiated. This is done preferably with two reactor coolant pumps still operating, but may be done while cooling down on natural circulation. Use of the reactor coolant pumps is preferred due to better control of the cooldown rate and the ability to cool the entire RCS simultaneously.

Initiation of shutdown cooling is done by opening the suction isolation valves and gradually opening the injection valves with the heat exchanger flow control valve shut. When flow through the system is established, the heat exchanger flow control valve is opened gradually to begin removing heat. If reactor coolant pumps are running, vessel temperature is taken as the cold leg temperature. If initiating shutdown cooling from natural circulation, vessel temperature is taken as cold leg temperature until shutdown cooling return temperature becomes lower than cold leg temperature. Then vessel temperature is taken as shutdown cooling return temperature. The RCS is then cooled down at a rate governed by Technical Specifications. Heat removal is controlled by controlling flow through the heat exchangers with the flow control valve. As cooldown progresses, this flow is increased to compensate for reduced temperature difference. Relatively constant total flow is maintained through the use of the heat exchanger bypass valve and/or the injection valves. Component cooling water flow through the heat exchangers may need to be adjusted at some point in the cooldown dependent on whether the reactor coolant pumps are being used and the level of decay heat.

During cold shutdown and refueling, as long as there is fuel in the reactor, shutdown cooling operation is continuous (with brief exception to support refueling).

9.3.3.4 Refueling

The transfer of refueling water from the refueling storage tank to the reactor cavity may be accomplished using the safety injection system at the start of refueling. The reactor vessel head is removed and the high pressure safety injection pumps are started. These pumps take water from the RWST and inject it into the reactor coolant loops through the normal flow paths. The low pressure safety injection pumps or the containment spray pumps may also be used for this operation.

During shutdown or refueling, the shutdown cooling system can be aligned to cool the spent fuel pool system using the low pressure safety injection pumps (see Section 9.5).

At the end of refueling operations, refueling water is returned from the reactor cavity through the reactor coolant system and safety injection system to the RWST. A connection is provided from the shutdown cooling heat exchanger discharge to the refueling water storage tank for this purpose. The low pressure safety injection pumps are used for the transfer operation.

9.3.3.5 Emergency Conditions

Components of the shutdown cooling system are also used for emergency core cooling and their operation in this mode of operation is discussed in Chapter 6.

9.3.4 RELIABILITY AND AVAILABILITY

9.3.4.1 Special Features

The unit can be cooled to refueling temperature within the 27.5 hour time period using one LPSI pump and two heat exchangers. The unit can still be cooled to refueling temperature if only one heat exchanger is available, but it would take considerably longer. The unit can be maintained at refueling temperature with one pump and one heat exchanger after decay heat has decreased sufficiently.

In the event of a tube to shell leak in the heat exchanger, a high level alarm on the component cooling water surge tank will be generated. The tank overflows to the waste disposal system.

Two motor-operated valves in series isolate the shutdown cooling system suction piping from the reactor coolant system. An interlock with pressurizer pressure prevents them from opening when reactor coolant system pressure exceeds the design pressure of the shutdown cooling system. Refer to Section 4.3.8.2.3 for further details. Additionally, one of the valves (2-SI-651) has a disconnect switch in its power circuit locked open while it is closed and the Unit is in Modes 1, 2 or 3, due to Appendix R fire concerns. 2-SI-651 has the disconnect switch in its power circuit locked open while it is open and in Modes 5 or 6, to preclude inadvertent operation during shutdown cooling.

Pressure relief valves are provided to protect isolated sections of piping from overpressure. The source of overpressure for which they are sized is thermal expansion for all but 2-SI-468, which is sized to protect the system from the simultaneous injection of all three charging pumps into a solid system. Insulation is another means for protecting isolated sections of piping from thermal over pressurization due to an ambient temperature rise.

Relief valve 2-SI-469, which is located between two suction isolation valves, has a setpoint of 300 psig and relieves to the primary drain tank. If reactor coolant system pressure is increased with 2-SI-652 inadvertently left not fully closed, or if it is opened prior to sufficiently reducing reactor coolant system pressure, 2-SI-469 will open and relieve to the drain tank which is equipped with pressure, temperature, and level alarms. This arrangement results in an extremely low interfacing systems LOCA frequency associated with the SDC suction path.

The SDC System is susceptible to an overpressure transient due to an inadvertent start of a HPSI pump since the injection capability of a HPSI pump exceeds the installed SDC System relief capacity. To eliminate an over pressurization of the SDC System caused by an inadvertent start of a HPSI pump, the HPSI pumps will be prevented from automatically injecting into the RCS when the SDC System is connected to the RCS, unless the RCS is sufficiently vented. This can be accomplished by the use of administrative controls.

The pressure interlock associated with valve 2-SI-651 in the shutdown cooling system has an installed local control switch which can override the pressure interlock to align the shutdown cooling system for boron precipitation control post-LOCA. Use of the override would only be required if vital bus power to motor control center B51 were lost in conjunction with the LOCA. The operators would verify RCS pressure below the shutdown cooling relief valve setting prior to overriding the pressure interlock. The pressure interlock for 2-SI-652 does not have override capability and cannot be opened if reactor coolant system pressure is greater than 280 psia.

9.3.4.2 Test and Inspections

Each component is inspected and cleaned prior to installation. Demineralized water is used to flush each system. Initially, the system is operated and tested to verify that the flow path, flow, thermal capacity, and mechanical operability meet the design requirements. Instruments are calibrated during testing. The automatic flow control is tested.

Periodic testing of the low pressure safety injection pumps as described in Chapter 6, assures the availability of this equipment for shutdown cooling. Data can be taken during refueling operations to confirm heat transfer capacity.

TABLE 9.3-1 SHUTDOWN COOLING HEAT EXCHANGERS DESIGN BASIS PARAMETERS

Tube Side	Shutdown Cooling Mode (27.5 hours after shutdown)	Recirculation Mode (after LOCA)
Flow, gpm	3000	1350
Heat Load, Million Btu/hr	31	32

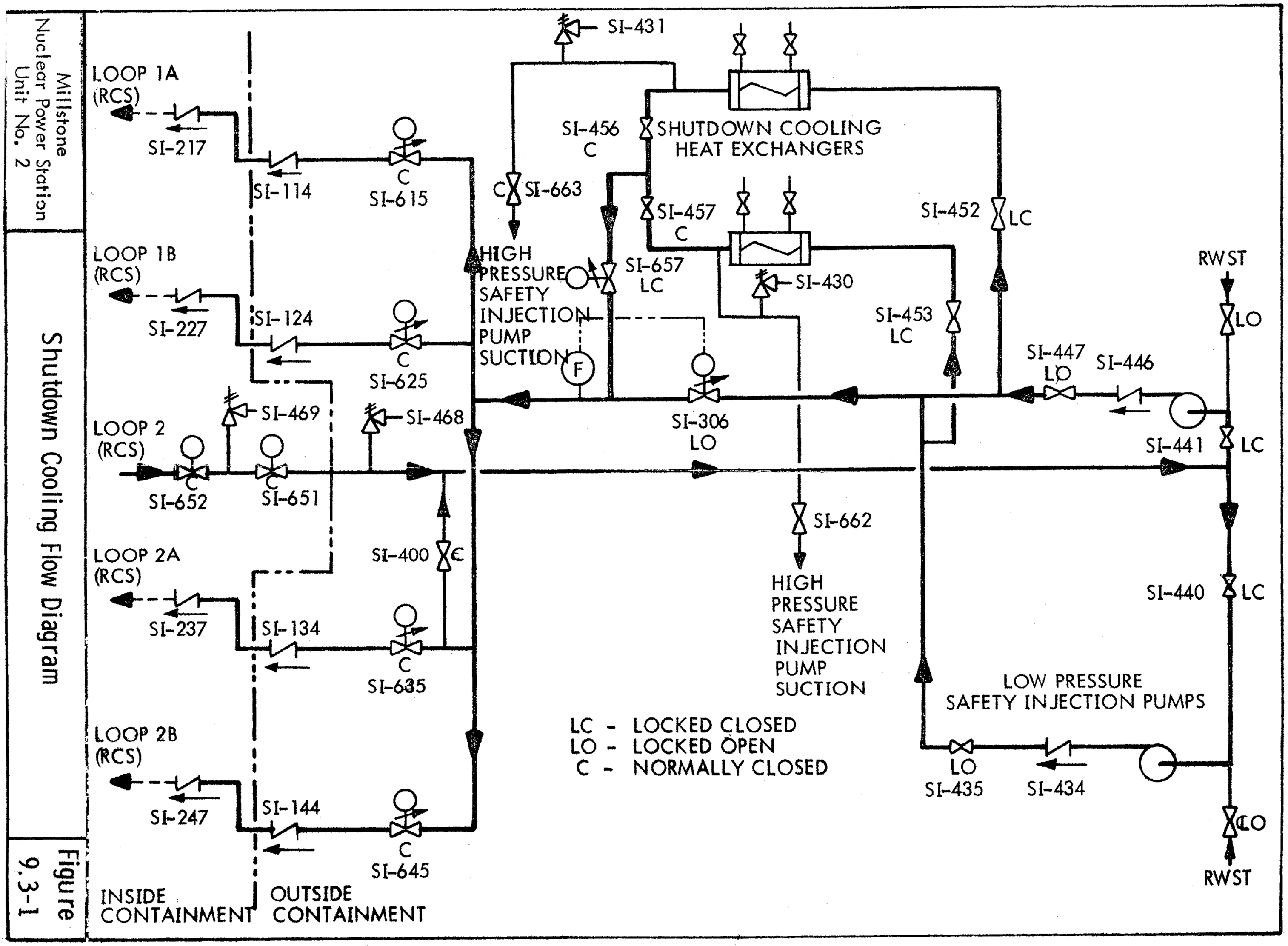
Shell Side	Shutdown Cooling Mode (27.5 hours after shutdown)	Recirculation Mode (after LOCA)
Flow, gpm	3500	2000
Heat Load, Million Btu/hr	31	32

Note: The above flow and heat loads are the minimum required to ensure adequate heat removal during shutdown cooling and post-LOCA recirculation modes.

TABLE 9.3-2 SHUTDOWN COOLING SYSTEM DESIGN PARAMETERS

Shutdown Cooling System Startup	Approximately 3.5 hours after reactor shutdown or trip
Suction Piping Design Pressure, psig	300
Discharge Piping Design Pressure, psig	500
Design Temperature, °F	350
Reactor Coolant System Cooldown Rate, °F/hr	75
Refueling Temperature, °F	130
Material - Piping and Valves	Austenitic Stainless Steel

FIGURE 9.3–1 SHUTDOWN COOLING FLOW DIAGRAM



9.4 REACTOR BUILDING CLOSED COOLING WATER SYSTEM

9.4.1 DESIGN BASES

9.4.1.1 Functional Requirements

The function of the reactor building closed cooling water (RBCCW) system is to transfer heat from safety related structures, systems, and components to an ultimate heat sink. The RBCCW system safety function is to transfer the combined heat load of these structures, system and components under normal operating and loss-of-coolant accident (LOCA) conditions.

9.4.1.2 Design Criteria

The following criteria have been used in the design of the RBCCW system:

a. The system shall have two independent redundant subsystems having 100 percent heat removal capacity following a LOCA.

b. The system shall have suitable subsystem and component alignments to assure operation of the complete subsystem with associated components.

c. Capabilities shall be provided to assure the system operation with either on site power (assuming off site power is not available) or with off site power.

d. A single failure in either subsystem shall not affect the functional capability of the other subsystem.

e. The RBCCW system shall be designed to permit periodic inspection of important components, such as RBCCW pumps, heat exchangers, valves and piping to assure the integrity and capability of the system.

f. The RBCCW system shall be designed to permit appropriate periodic pressure and functional testing to assure: (1) the structural and leaktight integrity of its components; (2) the operability and performance of the active components of the system; and, (3) the operability of the system as a whole. Under conditions as close to the design as practical, performance of the full operational sequence that brings the system into operation, including operation of applicable portions of the protection system, and the transfer between normal and emergency power sources, shall be demonstrated.

g. The system shall be designed to the general criteria as described in Section 6.1.

h. The RBCCW system shall be an intermediate barrier between the service water (seawater) system and the radioactive or potentially radioactive fluids contained in the systems and components being cooled by the RBCCW system.

i. The RBCCW system components shall be designed to operate within the environment to which they are exposed.

j. The RBCCW system shall be evaluated to assure that it maintains structural integrity and pressure boundary for the postulated water hammer loading transient resulting from concurrent occurrences of a Design Basis LOCA event (i.e., LOCA or MSLB) with Loss of Normal Power event (i.e., LNP) as described in NRC Generic Letter GL 96-06. The structural design of piping and supporting components shall accommodate the aforementioned water hammer loading transient, with other applicable concurrent loads, so that continued function of the system is assured to mitigate the consequences of the aforementioned accident.

k. The CAR and CEDM Cooler units shall be evaluated to assure the integrity of the pressure boundary and structural adequacy for the GL 96-06 based water hammer loading condition.

l. The RBCCW supply temperature shall not exceed 85°F in Modes 1, 2 and 3.

9.4.2 SYSTEM DESCRIPTION

9.4.2.1 System

The RBCCW system is shown schematically in Figures 9.4–1 through 9.4–6. The logic diagram is shown in Figure 7.3–1.

The RBCCW system consists of two independent headers, each including one motor-driven RBCCW pump, one RBCCW heat exchanger, and associated piping, valves, instrumentation, controls and a downcomer from the RBCCW surge tank. A third RBCCW pump and heat exchanger is provided as a spare for the system.

Redundant safety feature components, cooled by the RBCCW system, are split between the two independent RBCCW headers. The other systems and components cooled by the RBCCW system are divided between the RBCCW headers to equalize header heat loads.

The items cooled by the RBCCW system are listed in the following. Further information about each may be found in the section referenced in the parentheses.

Containment air recirculation and cooling units (Section 6.5)

Reactor vessel support cooling coils (Section 6.5.4.1)

Containment spray pump seal coolers (Section 6.4)

High and low pressure safety injection pump seal coolers (Section 6.3)

Shutdown cooling heat exchangers (Section 6.4, 6.3)

Engineered safety features room air recirculation and cooling units (Section 9.9.7)

Reactor coolant pump thermal barrier and oil coolers (Section 4.3.3)

Primary drain and quench tank heat exchanger (Section 11.1)

CEDM coolers (Section 9.9.1)

Letdown heat exchanger (Section 9.2)

Degasifier effluent cooler (Section 11.1)

Degasifier vent condenser

Sample coolers (Section 9.6.2.1)

Spent fuel pool heat exchangers (Section 9.5)

Waste gas compressor aftercoolers

Quench tank heat exchanger (Section 10.4.6)

Each RBCCW pump is designed to circulate 7000 gpm of water through the RBCCW system for removing heat from systems and components that handle the reactor coolant, containment atmosphere and engineered safety features. The RBCCW is cooled in the RBCCW heat exchangers by the service water (seawater) (Section 9.7.2.2.1).

The RBCCW System is designed to provide cooling for the following system operating conditions:

I. Normal Operation

II. 3.5 Hours after Shutdown

III. 27.5 Hours after Shutdown

IV. Loss of Coolant Accident (LOCA) Injection Operation

V. LOCA Recirculation Operation

System hydraulic analysis and flow balancing were performed to ensure that the minimum required flows can be provided to essential safety related loads for the above operating conditions. The flow balance was field tested to demonstrate that when the safety injection actuation signal (SIAS) and the sump recirculation actuation signal (SRAS) automatically realigns the system, the minimum required flows will be provided to the essential safety related loads during LOCA injection operation (condition IV) and LOCA recirculation operation (condition V). Table 9.4-3 identifies the minimum required flows for these two post-accident operating conditions.

The RBCCW pump and heat exchanger design is based on requirements during normal operation, normal shutdown cooling and a LOCA. This results in a design which provides an adequate cooling capacity for normal and emergency conditions, including reactor shutdown.

A RBCCW surge tank provides sufficient NPSH for the RBCCW pumps and absorbs the volumetric change due to temperature changes imposed on the water within the RBCCW system. The lower half of the RBCCW surge tank is divided into two equal sections by a vertical weir. If one of the two independent RBCCW headers ruptures, the vertical weir in the RBCCW surge tank assures that 1000 gallons of makeup water will be available to the functional header. Demineralized water is used for makeup and comes from the primary water storage tank (Section 9.12). A flow orifice is located in each surge tank discharge header downstream of the outlet isolation valves to dampen pressure surges that result from cold starts of the RBCCW Pumps that could occur following an LNP scenario.

Makeup water supplied to the RBCCW surge tank enters from the top of the surge tank at two locations on either side of the weir, therefore, makeup water can be supplied to both sections of the tank. To stop the flow of water to the failed header, manual valves can be closed.

The following instrumentation and alarms located on the main control board give sufficient information to assure the operator that makeup water is being supplied to the RBCCW surge tank section supplying the functional header:

1. Position lights ZS-6000 on makeup valve LV-6000 indicate whether the valve is open or closed. A timed alarm ZAH-6000 indicates that the valve has been open longer than required for normal makeup.

2. Level controller LC-6000 controls 6 inches above the weir, so regardless of which side fails, the controller will keep the makeup water valve LV-6000 open until the failed header is repaired or until the valve is closed by the hand switch HS-6000 or by using manual valves.

3. Level indicators LI-6001 and LI-6730 indicate the water level in each of the two sections of the surge tank. Alarm LAHL-6892 indicates high and low water level in the surge tank.

The valves, piping, instrumentation and alarms described above are shown on Figure 9.4–1.

Corrosion inhibitor can be injected into the RBCCW system to increase the optimal concentration during normal operation, as required.

External leaks, relief valve discharges and drains are collected by the drains system and processed through the radioactive waste processing system. Leakage into the RBCCW system can be determined by a radiation monitor installed on the discharge of the RBCCW pumps.

The RBCCW system components located in the containment building are subject to a maximum temperature of 289°F and a maximum relative humidity of 100 percent during post-incident operation. The RBCCW system components located in the auxiliary building are subject to a temperature of 110°F and a maximum relative humidity of 100 percent. The RBCCW pumps and motors are subjected to a maximum temperature of 155°F after a LOCA.

The RBCCW system is designed to permit venting of components, obtaining system water samples, and draining of components to the radioactive waste system.

Components and heat exchangers served by the RBCCW system, which can be isolated are equipped with self-actuated, spring-loaded relief valves for overpressure protection.

9.4.2.2 Components

A description of the major RBCCW system components is given in Table 9.4-1.

9.4.3 SYSTEM OPERATION

9.4.3.1 Normal Operation

During normal operation, RBCCW is supplied to the components described in Section 9.4.2.1 with the exception of the shutdown heat exchangers and the engineered safety features room air recirculation and cooling units.

Two RBCCW pumps and two RBCCW heat exchangers are required for cooling service during normal operation. The heat load per RBCCW heat exchanger during normal operation is 16.8 x 10^6 Btu/hr (header ‘A’) and 23.4 x 10^6 Btu/hr (header ‘B’) and the RBCCW discharge temperature is 85°F when the RBCCW heat exchangers are cooled by service water up to maximum temperature of 80°F.

The operation of the RBCCW system is monitored with the following instrumentation:

a. A temperature detector in the inlet and outlet line of the RBCCWS heat exchangers and temperature alarms in the outlet lines.

b. Pressure indicators in the lines between the pumps and the RBCCWS heat exchangers.

c. Level alarms and a controller on the surge tank.

d. Temperature detectors located on the outlet lines of the components being cooled.

e. Flow indicators and high flow alarms in both headers on the discharge side of the RBCCW heat exchangers.

f. Low pressure alarm in both headers on the discharge side of the RBCCW heat exchanger.

g. Hand switches and indicating lights for the pumps and remotely operated control valves.

9.4.3.2 Emergency Conditions

Following a LOCA, the RBCCW system is automatically aligned for post-incident cooling by the safety injection actuation signal (Section 7.3), the containment isolation actuation signal (Section 7.3) and the sump recirculation actuation signal (Section 7.3). The SIAS and CIAS actuates valves to stop the RBCCW flow to components not required during a LOCA and to initiate RBCCW flow to the engineered safety features room air recirculation and cooling units. The SRAS signal will open the RBCCW shutdown heat exchanger outlet valves. Prior to the SRAS signal, the RBCCW shutdown heat exchanger outlet valves have a safety function to remain closed (during the injection phase of a LOCA) to ensure adequate RBCCW flow is directed to the CAR coolers. The RBCCW is also supplied to the HPSI, LPSI and containment spray pump seal coolers.

The RBCCW system operation during a LOCA uses two RBCCW pumps, two RBCCW heat exchangers and two headers for LOCA cooling. If one RBCCW header is lost, one RBCCW pump, heat exchanger and one header can provide adequate cooling.

Calculations provide the basis for the FSAR Section 14.8.2 Containment Pressurization Analysis. To maximize the containment pressurization consequences following a MSLB or LOCA accident, these analyses minimize the energy removed from containment by the CAR cooling units and the SDC heat exchangers. This is accomplished by assuming design fouling of the CAR cooling units, the SDC heat exchanger, and the RBCCW to Service Water heat exchangers, and minimum RBCCW flow distributions assuming degraded RBCCW pumps. Prior to the sump recirculation (SRAS), two CAR cooling units transfer a maximum of 160 million BTU/hour of energy to the RBCCW system. Following SRAS, two CAR cooling units transfer a maximum of 70 million BTU/hr and the SDC heat exchanger transfers a maximum of 47 million BTU/hour of energy to the RBCCW System.

The RBCCW peak temperature analysis, which maximizes the RBCCW temperatures by assuming clean CAR cooling units and SDC heat exchangers, with maximum RBCCW flow distributions was performed to evaluate the system design capability.

Based on the RBCCW peak temperature analysis, the maximum RBCCW heat load from the two containment air recirculation and cooling units plus the balance of plant components is 204.4 x 10^6 Btu/hr during the injection mode following a LOCA. During the recirculation mode following a LOCA the maximum calculated heat load of 130.7 x 10^6 Btu/hr is transferred to the RBCCW system through the containment air recirculation and cooling units, the shutdown heat exchanger plus the balance of plant components. The design heat removal capacity of the RBCCW heat exchanger is 160 x 10^6 Btu/hr during the injection mode, but calculations demonstrate that the heat exchangers can adequately handle the 204.4 x 10^6 Btu/hr heat load.

The RBCCW peak temperature analysis calculated the maximum system supply temperatures based on maximum RBCCW flow distribution values, clean CAR coolers and SDC heat exchangers, and fouled (design) RBCCW heat exchangers. The component maximum outlet temperatures were then determined based on design heat loads. The system components and piping, as well as the affect on the equipment and rooms being cooled post-accident were evaluated at the maximum RBCCW temperatures. The calculated peak RBCCW temperature supplied to the components during a LOCA/MSLB with LNP (GL 96-06 scenario), and considering no fouling in the CAR Cooler units is less than 149°F.

The following is a list of essential components cooled by the RBCCW System during a LOCA:

Containment Air Recirculation And Cooling Units

Shutdown Cooling Heat Exchangers

Engineered Safety Features Room Air Cooling Coils

High Pressure Safety Injection Pump Seal Coolers

Low Pressure Safety Injection Pump Seal Coolers

Containment Spray Pump Seal Coolers

The nonessential components which are on line after a LOCA are the waste gas compressors, Primary drain and quench tank cooler, CEDM coolers, Reactor vessel support concrete cooling coils, reactor coolant pump thermal barriers and lube oil coolers, and degasifier vent condenser. After SRAS all the nonessential components except for the waste gas compressors and degasifier vent condenser shall be off the line. However, the spent fuel pool heat exchanger will be returned to service within 4 to 5 hours after the start of the LOCA. The Primary Sample Coolers may also be returned to service as necessary to support PASS cooling.

A failure mode analysis is given in FSAR Table 9.4-2 which describes how leaks and malfunctions are detected and what corrective actions must be taken to insure that the safety functions performed by the RBCCW System are not impaired. Once the operator has detected a leak or malfunction, the operator will isolate the equipment for repair maintenance if environmental conditions permit operation of manual valves. If environmental conditions do not permit isolation of the equipment, the entire header may be isolated remotely from the main control room. The safety functions of the RBCCW system can be performed with only one header in operation. If the leak or malfunction involves the RBCCW pump and heat exchanger, the pump and heat exchanger can be isolated remotely from the main control room. Also, equipment in the containment can be isolated remotely in the main control room by closing the containment isolation valves.

Relief valves, on the RBCCW supply and return headers serving the reactor Coolant Pumps integral heat exchangers, ensure that the RBCCW containment isolation valves, on these headers, can be closed during an intersystem LOCA, by ensuring that the valves will not be overpressurized to the point that the valve motors cannot close the valves. The relief valves, which have a set pressure of 165 psig may open upon a rupture of an integral heat exchanger tube (a beyond design basis event). This is required in response to NRC IN 89-54 to preclude an unisolable release of radioactive fluid outside of the containment that may exceed 10 CFR 100 limits.

The operation of the RBCCW system during a LOCA is monitored as described in Section 9.4.3.1.

The RBCCW system, consisting of two independent headers, is at a higher pressure than the service water system during normal operations to prevent service water leaking into the RBCCW system. The only time that the RBCCW system pressure will be lower than the service water system is (1) during shutdown for routine maintenance, (2) if the RBCCW pumps malfunction or (3) if there is a major RBCCW leak greater than 400 gpm. Loss of RBCCW system pressure is indicated by low pressure alarms (PAL-6036 & PAL-6037) located in the RBCCW heat exchanger discharge headers. Once the operator has observed the low pressure alarm, it will be decided whether this branch can be easily isolated; if this is not possible, the RBCCW header will be taken out of service and at the same time the shell side of the RBCCW heat exchanger will be isolated. Therefore, the possibility of service water leaking into the RBCCW heat exchanger is remote. If service water does leak into the RBCCW system during periods of low pressure, it will be detected by manual sampling on a routine basis.

Since the RBCCW system is potentially capable of contaminating the service water system with radioactivity due to leakage, a detection system is located within the RBCCW system.

The RBCCW System is continuously monitored for radioactivity by using a self-contained closed-loop radiation monitoring system consisting of (1) a gamma NaI(T1) scintillation detector assembly, (2) a 4 inch schedule 40 stainless steel sample chamber shielded with lead to reduce the ambient background radiation level, (3) solid-state, control room readout module, (4) local meter indication with visual and audible alarms, and (5) auxiliary support equipment such as piping, valves and recorder.

The RBCCW sample is continuously taken from the RBCCW pump discharge and is circulated through the sample chamber and detector assembly. The sample returns to the RBCCW pump suction.

The radioactivity present in the system is monitored by the gamma detector assembly, displayed and recorded in the control room.

Alarm set points based on the limits established by 10 CFR Part 20, will result in alarm annunciations in the control room and at the monitoring site.

9.4.3.3 Shutdown

The RBCCW system is required for continuous operation during normal unit shutdown cooling (Section 6.3) beginning 3.5 hours after the start of unit shutdown. The RBCCW system supplies cooling water to the shutdown heat exchangers to cool the reactor coolant from 300 to 130°F in 24 hours.

During normal shutdown, such as for refueling, two RBCCW pumps and two RBCCW heat exchangers are used for cooling. The heat load per RBCCW heat exchanger is 84.1 x 10^6 Btu/hr (header ‘A’) and 84.5 x 10^6 Btu/hr (header ‘B’) at 3.5 hours after start of Unit shutdown. The RBCCW heat exchanger discharge is less than 130°F when the RBCCW heat exchangers are cooled by service water at a maximum temperature of 80°F. At 27.5 hours after the start of Unit shutdown, the heat load per RBCCW heat exchanger is reduced to 40.8 x 10^6 Btu/hr.

If one RBCCW heat exchanger or pump should malfunction, the spare can be immediately placed in service, or the unit can be cooled down at a slower rate with one heat exchanger and one pump. During shutdown the operation of the RBCCW system is monitored as described in Section 9.4.3.1.

9.4.4 AVAILABILITY AND RELIABILITY

9.4.4.1 Special Features

The components of the RBCCW system are designed to general design requirements including seismic response as described in Section 6.1. All components are protected from missile damage and pipe whip from high pressure piping as described in Section 6.1.

To ensure pump availability, each RBCCW pump motor is supplied from a specific 4160 volt bus. The buses may be powered from alternate sources (i.e., NSST, RSST, D/G, or via Unit 3 bus 34A or 34B). In the event that reserve station service power is lost, the RBCCW pumps, required for engineered safety features systems cooling or normal shutdown cooling, are automatically supplied by the emergency buses.

The RBCCW pump motor is designed to withstand a maximum temperature of 155°F during a LOCA and maximum relative humidity of 100 percent.

The RBCCW system is provided with a radiation monitor to alarm if radioactive fluids leak into the RBCCW.

A failure mode analysis is given in Table 9.4-2. A rupture in the system is considered an initiating event only; it is not postulated concurrent with a LOCA (or any other Chapter 14 event). System redundancy and header separation have been provided to maintain continuous cooling in the event of a single passive failure during post-accident long term cooling.

9.4.4.2 Tests and Inspection

One RBCCW pump was shop-tested for hydraulic performance. Seven test points were used to generate the performance curve which is shown in Figure 9.4–7.

Each pump was hydrostatically tested at 375 psi, 1.5 times the design pressure of the pump.

Nondestructive testing for the RBCCW heat exchangers were performed in accordance with the ASME Code Section VIII.

The RBCCW heat exchangers were leak tested as follows:

a. Shell side gas test (inert gas) at 188 psig which is 1.25 times the design pressure.

b. Shell side hydrostatic test at 225 psig which is 1.5 times the design pressure.

c. Channels hydrostatic test at 250 psig which is twice the tube side design pressure.

d. Tubes, hydrostatic test at 150 psig, which is 1.2 times the tube side design pressure.

Each component is inspected and cleaned prior to installing it in the system. Following installation, the RBCCW system undergoes a preoperational test before startup. The detail test procedure is described in Section 13.

Instruments are calibrated during testing and the automatic controls are tested for actuation at the proper set points. Alarm functions are checked for operability and limits during preoperational testing.

Initially the system was operated and tested with regard to flow paths, flow capacity and mechanical operability. At least one pump was tested online to demonstrate head and capacity (Section 13).

Data are taken periodically during normal operation to confirm the heat transfer capabilities.

Major components of the system such as pumps, tanks, and heat exchangers are accessible for periodic inspection during operation.

The RBCCW system and components are periodically tested to demonstrate the operability, performance, structural and leaktight integrity of the system and components. The testing is accomplished as follows:

a. During normal operation the RBCCW system components and piping are constantly pressurized by the RBCCW pump, therefore, they are constantly being tested for structural and leaktight integrity.

   The operability and performance of all components except the engineered safety features room air recirculation and cooling units, the shutdown cooling heat exchanger, the spare RBCCW pump and the spare RBCCW heat exchanger is determined by observing the temperature, pressure and flow instrumentation associated with each component.

   Online testing of the spare RBCCW component(s) (pump and/or heat exchanger) is performed by bringing the spare component(s) to be tested into operation while removing the operating component(s) from service. The operation and performance of the spare RBCCW pump and heat exchanger can be determined by observing the pressure and flow instrumentation.

Online testing of the remotely operated valves actuated by SIAS signals and located on the discharge side of the containment air recirculation and cooling units, the spent fuel pool heat exchangers, the safeguards room air cooler units and the degasifier effluent cooler is performed by operating each valve's manual control switch. The position of the valves is verified by position indication lights in the control room. Testing these valves during power operation by initiating SIAS signals is not performed as it results in unnecessary starting of the emergency diesel generators and causes RBCCW system flow transients which operators must respond to.

Online testing of the other remotely operated valves actuated by SRAS is performed by closing the appropriate manual valves and by manually initiating the SRAS signals for the valves on the discharge side of the shutdown heat exchangers. The position of the valves is verified by position indicated lights in the control room.

b. During shutdown the operability and performance of the RBCCW components and the RBCCW system as a whole is determined by observing the flow, pressure and temperature instrumentation.

c. After normal unit shutdown for refueling, the applicable portion of the RBCCW system used for engineered safety feature systems cooling is tested by actuating SIAS and SRAS signals to demonstrate operability and position of valves on a per facility basis. Structural and leaktight integrity of the system is tested separately as part of the Unit 2 Inservice Inspection Program.

The RBCCW containment isolation valves for the supply and return lines for the Containment Air Recirculation and Cooling heat exchangers have "T-Ring" seats. In lieu of test results under 10 CFR 50, Appendix J, Type C testing, the "T-Ring" seats will be replaced based on observed degradation. These valves are not included in the Type C testing program because the valves are open during accident conditions. This eliminates a commitment made under letter A06107, dated 1/16/87 under Docket Number 50-336.

9.4.5 CODE STRUCTURAL QUALIFICATION

The code of record for the RBCCW piping system is USAS B31.1-1967. The portion of piping in the containment penetration area is designated as ANSI B31.7, Class 2.

The piping and support components are designed for the design basis loads for the appropriate load combinations and criteria. The original code qualification was performed for the following load conditions and effects: (a) internal pressure, (b) dead weight, (c) thermal expansion at maximum temperatures, (d) OBE inertia loads, (e) DBE inertia loads, and (f) seismic anchor movements for OBE and DBE, as applicable. The system and components are evaluated for the newly identified LOCA/water hammer loads, including the original design basis loads, considering temperature changes based on zero fouling in the CAR Cooler units.

The postulated LOCA induced dynamic water hammer loads based on the scenario described in GL 96-06 is classified as “Faulted Plant Occasional Mechanical Load” because LOCA is a “Faulted Plant Condition.” Although not part of the original design basis, this load is recognized as a design basis load.

The acceptance criteria for piping is based on maintaining the combined primary stress due to concurrent dead weight, internal pressure and dynamic LOCA/water hammer transient within the material yield stress of piping at operating temperature. The acceptance criteria for design verification of support components corresponds to conservative Emergency stress limits (i.e., ASME Level C Limits) as follows, with a minor exception as noted in item b: (a) structural steel elements-within 90% of yield per AISC Code (b) vendor supplied components Load Capacity per Load Capacity Data Sheets (LCD) Level C, except those supports which are not protecting the safety related function of the RBCCW system in the post-accident scenario may be evaluated using LCD Level D (c) anchor bolts safety factors shall be 4 for Wedge type (e.g., HILTI KWIK BOLT) and 5 for shell type (e.g., Phillips Red Head) consistent with NRC I.E. Bulletin 79-02.

The LOCA/water hammer is analyzed using dynamic time history analysis method. The time history forcing functions applicable to various segments of RBCCW piping are determined by detailed thermal hydraulic analysis of the system using RELAP 5/Mod 3.2 computer code.

TABLE 9.4-1 REACTOR BUILDING CLOSED COOLING WATER SYSTEM COMPONENTS

RBCCW PUMP

Manufacturer	Ingersoll-Rand
Model	12 x 14 SD
Type	Centrifugal, horizontal split case, dual volute with mechanical seals
Quantity	3
Capacity each (gpm)	7000
Head (feet)	150
Pump (rpm)	1750
BHP	312
NPSH required/available (feet)	23/80
Material	
Case	ASTM A48 Gr 30
Impeller	ASTM B143 Alloy 2A
Shaft	AISI-C1045
Motor	350 hp, 400 volt, 60 Hz, 3 phase, 1750 rpm
Codes	
Motor: NEMA	
Pump: Standards of the Hydraulic, Institute ANSI B 16.1, ANSI B 31.1	
Seismic	Class I

RBCCW HEAT EXCHANGER

Manufacturer	Struthers Nuclear
Model	
Horizontal, single-pass, counter-flow straight tubes rolled into tube sheets	
Type	TEMA Type AEL
Quantity	3

TABLE 9.4-1 REACTOR BUILDING CLOSED COOLING WATER SYSTEM COMPONENTS (CONTINUED)

Design duty each (Btu/hr)

26.33 x 10^6 - normal	36.0 x 10^6 - 27.5 hours after shutdown
90.25 x 10^6 - 3.5 hours after	160.0 x 10^6 - loss-of-coolant shutdown
Design Overall fouling factor	0.0008
Design pressure (psig)	Shell side 150; tube side 125
Design temperature (°F)	Shell side 250; tube side 120
Material	
Shell ASTM-A-285-Gr C	
Tubes Aluminum brass ASME SB-111 Alloy 687	
Tube sheets	Aluminum bronze ASME SB-171- CDA614
Channel	Nickel Copper, UNS N04400, unlined
Seismic	Class 1
Code	TEMA Class R, ASME Section VIII

RBCCW SURGE TANK

Manufacturer	PX Engineering
Type	Vertical with vertical weir divider in lower half of the tank
Quantity	1
Design pressure (psig)	15
Design temperature (°F)	250
Volume (gal)	4480
Material	
Shell	ASTM A 285-Gr C
Dished head	ASTM A 285-Gr C
Seismic	Class I
Code	ASME Section VIII

TABLE 9.4-1 REACTOR BUILDING CLOSED COOLING WATER SYSTEM COMPONENTS (CONTINUED)

Pipe:

Size – 12 inch and larger	Wall Thickness – 0.375
Size – 2.5 inch through 10 inch	Wall Thickness – Schedule 40
Size – 2.5 and smaller	Wall Thickness – Schedule 80
Material	Seamless ASTM-A53-B

Code ANSI B31.1.0 plus Random Radiography of Butt Weld Base Material Identification Seismic Analysis ANSI B31.7, Class II Containment Penetration.

Joints Welded except at flanged equipment connections and butterfly valves.

Fittings

2.5 inches and larger

Butt welding, ASTM A-234 WPB or WPB-W, wall thickness to match pipe.

2.5 inches and smaller

3000 lb. socket welding, ASTM A-181, Gr. I Mod

Flanges

150 lb ANSI Std. F&D ASTM A-181 Gr. II (original construction) or ASTM A-105.

ASTM A-181

12 inches and larger	Slip-on, RF
2.5 inches through 10 inches	Weld neck, RF
2 inches and smaller	Socket Weld, RF

Bolting: Bolt-studs, ASTM A-193 B-7 Hex nuts, heavy steel, ASTM A-194 2H.

Valves

2 inches and smaller	600 lb. ANSI, socket weld, carbon steel
2.5 inches and larger	150 lb. ANSI, butt weld, carbon steel (except butterfly valves)
Non-nuclear Butterfly valves	150 lb., wafer, cast iron
Nuclear Butterfly	150 lb, wafer, carbon steel
Valves Code	ASME Section III, Nuclear Power Plant Components, Class II
Seismic Class	I

Intersystem LOCA relief valves

6 inch x 10 inch, ANSI Class 300, RF, carbon steel, ASME Section VIII

TABLE 9.4-2 REACTOR BUILDING CLOSED COOLING WATER SYSTEM FAILURE MODE ANALYSIS

COMPONENT IDENTIFICATION AND QUANTITY	FAILURE MODE	METHOD OF DETECTION AND MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
RBCCW Return Header (2)	a. Break equivalent to 0.5 inch 0.5 inch diameter line	Makeup valve opens alarm for a and b. Surge tank low level alarm for a and b.	a. Loss of water equivalent to makeup capacity	Isolate failed header	One header and its components out of service; Alternate header in operation	Header out of service for repairs; one header sufficient for safe shutdowns
	b. Large break	Low pressure alarm for b. All CRI	b. Loss of one header			
Piston-Operated Valve (6) HV6002 through HV6007	Fails, as is	Position indication CRI	None	Valve operator repaired	Normal operation	Valve can be manually operated
RBCCW pump Suction Header (2)	a. Break equivalent to 1.5 inch diameter line	Makeup valve opens alarm and sump high level alarm for a and b. Surge tank low level alarm for a and b.	a. Loss of water equivalent to makeup capacity	Failed header isolated; standby pump and header put	Normal operation	Suction and discharge header and associated pump out of service for repairs
RBCCW pump Discharge Header (2)	b. Large break	Low pressure alarm for b. All CRI	b. Loss of one header			
RBCCW Pump (3)	Pump stops	Header low pressure alarm; standby pump starts alarm; both CRI	Loss of flow in one header	Isolate pump; put standby pump in service; valve lined up	Normal operation	Pump out of service for repairs
RBCCW Heat Exchanger Supply Header (3)	a. Break equivalent to 1.5 inch diameter line	Makeup valve opens alarm and sump high level alarm for a and b. Surge tank low level alarm for a and b	Loss of water equivalent to makeup capacity	Failed header isolated; standby pump and headers put in service	Normal operation	Header out of service for repair
RBCCW Heat Exchanger Discharge Header (3)	b. Large break	Low pressure alarm for b. All CRI	Loss of one header			
RBCCW Heat Exchanger (3)	a. Shellside rupture; b. Tube rupture	Sump level alarm for a. Header low pressure alarm; Surge tank low level alarm; Makeup valve opens alarm for a and b. All CRI	Loss of water in one header	Failed heat exchanger isolated; standby put into service	Normal operation	Heat exchanger out of service for repairs
Piston-Operated Valve (8) HV6011 through NV6018	Fails, as-is	Position indication	None	Valve operator repaired	Normal operation	Valve can be operated manually
RBCCWS Supply Header (2)	a. Break equivalent to 1.5 inch diameter line	Makeup valve opens alarm for a and b Surge tank low level for a and b	a. Loss of water equivalent to makeup capacity	Isolate failed header	One header and equipment out of service; alternate header in normal operation	Header our of service for repairs; one sufficient for safe shutdown
	b. Large break	High pressure alarm for b.	b. Loss of one header			
	All CRI					
Spent Fuel Pool Heat Exchanger (2)	a. Shell side rupture	a. Surge tank low level alarm and makeup valve opens alarm	a. Loss of water from half of system	a. Isolate failed heat exchanger	a. Redundant heat exchanger available	a, b. Heat exchanger out of service for repairs
	b. Tube rupture	b. High radiation alarm, CRI	b. Radioactivity in header	b. Isolate heat exchanger and	b. Header out of service	b. Drain header
Piston-Operated Valve (2) HV6315, HV6316	Fail closed	Position indication	None	Valve operator repaired	Normal operation	Valve can be operated manually

TABLE 9.4-2 REACTOR BUILDING CLOSED COOLING WATER SYSTEM FAILURE MODE ANALYSIS (CONTINUED)

COMPONENT IDENTIFICATION AND QUANTITY	FAILURE MODE	METHOD OF DETECTION AND MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
Shutdown Heat Exchanger (2)	During shutdown:					
	a. Shell side rupture	a. Surge tank low level alarm and makeup valve opens alarm	a. Loss of water from half of system	a. Isolated failed heat exchanger	Normal shutdown operation at reduced rate	a, b. Redundant heat exchanger out of service for repairs; shut-down heat exchangers not in use during normal operation
	b. Tube rupture	b. Radiation monitor. Both CRI	b. Radioactivity in header	b. Isolate heat exchanger and header		
Piston-Operated Valve (2) HV6050, HV6055	Fails open	Position indication	None	Valve operator repaired	Normal operation	Valve can be operated manually
HPSI Pump Seal (3)			Loss of water less than makeup sys-tem water	HPSI pump isolated	Normal operation	Pump out of service for repairs. Pumps not in use during normal operation
	a. Out leakage	Seal rupture:	a. Makeup valve open alarm; sump pump alarm in engineered safety fea-tures room			
	b. In leakage	b. High RBCCW outlet tempera-ture alarm and surge tank high level alarm. All CRI				
LPSI Pump Seal (2)	Seal rupture:		Loss of water less than makeup sys-tem water	LPSI pump isolated	Normal operation	Pump out of service for repairs; pumps not in operation during normal operation
	a. Out leakage	a. Makeup valve opens alarm and sump pump alarm in engineered safety features room				
	b. In leakage	b. High RBCCW outlet tempera-ture alarm and surge tank high level alarm. All CRI				
Containment Spray Pump Seal (2)	Seal rupture:		Loss of water less than makeup sys-tem water	Pump isolated	Normal operation	Pump out of service for repair; pump not in service during nor-mal operation
	a. Out leakage	a. Makeup valve opens alarm and sump pump alarm in engineered safety features room				
	b. In leakage	b. High RBCCW outlet tempera-ture alarm and surge tank high level alarm. All CRI				
Sample Cooler (7)	Shell side rupture	Surge tank low level alarm and makeup valve opens alarm. Both CRI	Loss of water from header B.	Cooler isolated	No sample	Cooler not available until repaired.

TABLE 9.4-2 REACTOR BUILDING CLOSED COOLING WATER SYSTEM FAILURE MODE ANALYSIS (CONTINUED)

COMPONENT IDENTIFICATION AND QUANTITY	FAILURE MODE	METHOD OF DETECTION AND MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
Letdown Heat Exchanger (1)	a. Shell side	a. Surge tank low level alarm makeup valve opens alarm; possible high temperature in letdown line	a. Loss of water from header B	a. Heat exchanger isolated	a, b. No letdown	a, b. Letdown heat exchanger out of service until repaired
	b. Tube side	b. Surge tank high level alarm and high radiation monitor alarm. All CRI	b. Radioactivity in header B	b. Isolate heat exchanger and header		b. Drain header
Control Valve (1) 2-RB-402	Fails close	Position indication; CRI; Abnormally low letdown temperature	None	Valve operator repaired	Normal operation	
Piston-Operated Valve (4) HV6072, HV6073, HV6075, HV6077	Fails open	Position and flow indications, both CRI	None	Valve operator repaired	Normal operation	Valves can be operated manually
Containment Air Cooler (4)	Tube side	Surge tank low level alarm; makeup valve opens alarm; low flow indication, all CRI	Loss of water from one half of system	Failed cooler isolated	Normal operation	Failed cooler out of service for repairs; only 3 units needed for normal operation
Piston-Operated Valve (8) HV6079, HV6080, HV6083, HV6084, HV6087, HV6088, HV6091, HV6092	Fails open	Position and flow indications, both CRI	None	Valve operator repaired	Normal operation	Valves may be operated manually
Motor-Operated Valve (2) HV6095, HV6096	Fails as is	Position indication, CRI	None	Valve operator repaired	Normal operation	Valves may be operated manually
Reactor Coolant Pump Thermal Barrier and Oil Cooler (4)	a. Rupture of thermal barrier	a. High radiation alarm and high temperature cooling water alarm	a. Partial loss of reactor coolant	a. Isolated failed cooler and header	a. One header out of service	Reactor coolant pump out of service until cooler repaired
	b. Rupture of oil cooler tube side	b. Low oil level alarm and low oil pressure indication	b. Oil in system	b, c. Failed cooler isolated	b, c. Reactor coolant pump out of service	
	c. Rupture of oil cooler shell side	c. Makeup valve opens alarm; low flow alarm; all CRI	c. Loss of water equivalent to makeup capacity			
Reactor Vessel Support Cooling Coils (3)	a. Coil plugs up	a. Low flow alarm	a. Partial loss of cooling capacity redundant independent coil on other header	Failed cooler isolated open valves to	Normal operation	Coil out of service for repair
	b. Coil connection ruptures	b. Low flow alarm and makeup valve open alarms; all CRI	b. Loss of water from header			
CEA Drive Air Cooler (2)	Tube side	Air temperature indicators; makeup valve opens alarm; both CRI	Loss of water in header	Failed cooler isolated	Normal operation	One redundant cooler out of service for repair
Primary Drain Tank and Quench Tank Heat Exchanger (1)	a. Shell side rupture	Surge tank level alarm and makeup valve open alarm for a and b	Loss of water from header A	Isolate heat exchanger	Heat exchanger out of service until repaired	
	b. Tube rupture					
Diaphragm operated Valve (1) HV6118	Fails open	Position indication; CRI	None	Repair operator	Normal operation	Valve can be manually operated

TABLE 9.4-2 REACTOR BUILDING CLOSED COOLING WATER SYSTEM FAILURE MODE ANALYSIS (CONTINUED)

COMPONENT IDENTIFICATION AND QUANTITY	FAILURE MODE	METHOD OF DETECTION AND MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
Motor Operated Valve (2) HV6108, HV6106	Fails as is	Position indication; CRI	None	None; operator repaired during shutdown	Normal operation	Valve can be manually operated
RBCCW Surge Tank (1)	Rupture	Surge tank low level alarm and makeup valve open alarm	Loss of water	Isolate tank	Normal operation	Surge tank out of service until repaired
Diaphragm-Operated Valve (1), LV6000	Fails open	Position indication; CRI	Loss of water	Isolate valve	Normal operation	Manual makeup until repaired
Degasifier Efficient Cooler (1)	a. Shell side rupture	Surge tank low level alarm; makeup valve open alarms for a and b. All CRI	Loss of water from header B	Isolate cooler	Cooler out of service until repaired	
	b. Tube side rupture					
Piston-Operated Valve (1) HV6739	Fail closed	Position indication; CRI	Loss of degasifier efficient cooler and letdown heat exchanger	Valve operator repaired	Normal operation	Valve can be manually operated
Degasifier Vent (1) Condenser	a. Tube side rupture	Surge tank low level alarm and makeup valve open alarm for a and b. All CRI	Loss of water from header B	Isolate vent condenser	Vent condenser out of service until repaired	
	b. Shell side rupture					
Diaphragm Operated Valve (1) HV9309	Fail open	Visual	None	Valve operator repaired	Normal operation	
Waste Gas Compressors (2) (after cooler)	a. Shell side	Surge tank low level alarm and makeup valve open alarm; all CRI	Loss of water from header A	Isolate waste gas compressors	One redundant compressor available	Compressor out of service for repairs
	b. Tube side rupture					
Engineered Safety Features Room Air Recirculation and Cooling Units (2)	Tube side rupture	Surge tank low level alarm, makeup valve open alarm and low flow indication; all CRI	Loss of water from header	Isolate coils	Coil out of service for repairs	Coil not required during normal operation
Quench Tank Heat Exchanger	Tube side rupture	Surge tank low level alarm, makeup valve opens alarm; all CRI	Loss of water from header A	Isolate heat exchanger	Heat exchanger out of service for repairs	
Inter system LOCA Relief Valves	Inadvertent opening	Reduction in RBCCW inventory; surge tank low level alarm	Reduction in RBCCW inventory	Isolate non-essential loop in containment; repair valve	One header out of service	Relief valves are installed to mitigate a beyond design basis event and address NRC IN 89-54

TABLE 9.4-3 MINIMUM REQUIRED RBCCW FLOW TO ESSENTIAL SAFETY-RELATED LOADS LOCA INJECTION AND RECIRCULATION OPERATIONS

Essential Load (Train A Shown)	Condition IV LOCA Injection Flow (gpm)	Condition V	
		LOCA Recirculation (Spent Fuel Pool Cooling Isolated) (Flow gpm)	LOCA Recirculation (Spent Fuel Pool Cooling Restored) Flow (gpm)
CAR Cooler A	2000	1600	1400
CAR Cooler C	2000	1600	1400
SDC Hx A	Isolated	2000	1800
HPSI Pump Seal Cooler A	15	15	15
HPSI Pump Seal Cooler B	15	15	15
LPSI Pump Seal Cooler A	3	3	3
CS Pump Seal Cooler A	11	11	11
ESF Room Cooler A	59	59	59
SFP Cooler A	Isolated	Isolated	1100

FIGURE 9.4–1 P&ID RBCCW SYSTEM RBCCW PUMPS AND HEAT EXCHANGERS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–2 RBCCW SYSTEM SPENT FUEL POOL AND SHUTDOWN HEAT EXCHANGERS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–3 P&ID RBCCW. SYSTEM CONTAINMENT SPRAY PUMP AND SAFETY INJECTION PUMP SEAL COOLERS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–4 P&ID RBCCW. SYSTEM REACTOR COOLANT PUMP, THERMAL BARRIERS AND LUBE OIL COOLERS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

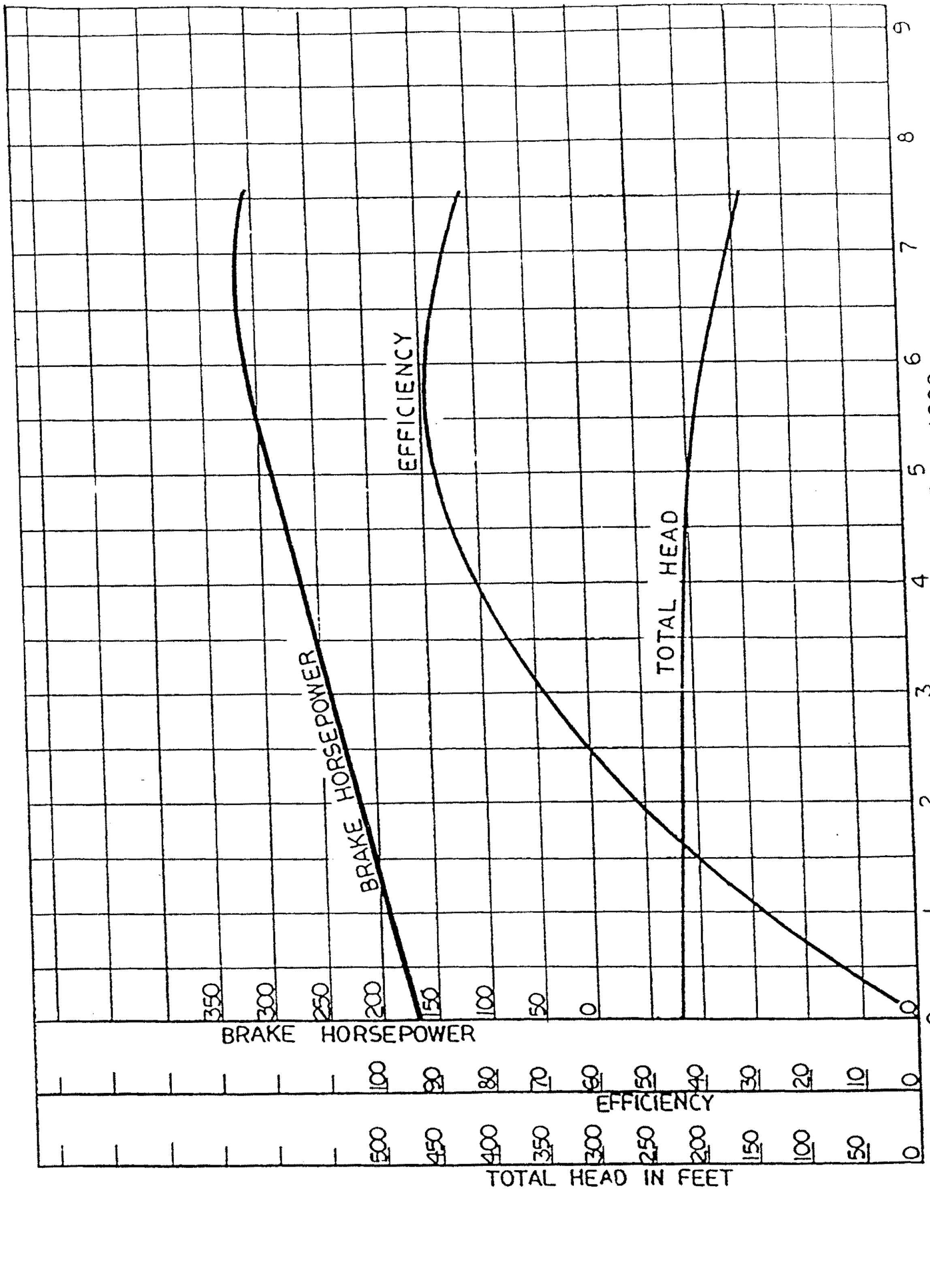
FIGURE 9.4–5 P&ID RBCCW. SYSTEM CONTAINMENT AIR RECIRCULATION AND COOLANT UNIT

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–6 P&ID DIAGRAM RBCCW. SYSTEM REACTOR VESSEL SUPPORT CONCRETE COOLING COILS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–7 REACTOR BUILDING CLOSED COOLING WATER PUMP PERFORMANCE CURVE



9.5 SPENT FUEL POOL COOLING SYSTEM

9.5.1 DESIGN BASES

9.5.1.1 Functional Requirements

The function of the spent fuel pool cooling system is to remove decay heat generated by spent fuel assemblies stored in the pool by limiting the temperature of the borated pool water to an acceptable level, thereby ensuring the cladding integrity of stored spent fuel assemblies. In order to ensure that spent fuel pool water temperature limits and fuel integrity are maintained two different refueling operations are analyzed: (1) Normal refueling involves movement of a maximum of 80 fuel assemblies or the equivalent heat load from the reactor vessel to the spent fuel pool, and (2) A full core offload of all 217 fuel assemblies from the reactor vessel to the spent fuel pool. A full core offload comprises of an end-of-cycle full core offload or a mid-cycle emergency full core offload. In the event of a full core offload, the spent fuel pool water temperature will be limited to the Technical Requirements Manual (TRM) limit of 150°F. This would utilize one train of the shutdown cooling system for the limiting emergency full core offload. Under less limiting full core offload conditions, the Spent Fuel Pool Cooling system or Spent Fuel Pool Cooling supplemented by the Shutdown Cooling system may be used, provided that a Spent Fuel Pool temperature of less than 150°F is maintained

The spent fuel pool cooling system is provided with a cleanup system for maintaining the purity and clarity of water in the spent fuel pool, refueling pool and the refueling water storage tank after completion of refueling operations. The cleanup systems limit operating personnel radiation exposures from these sources by reducing the concentrations of radioactive constituents introduced into these waters.

9.5.1.2 Design Criteria

The spent fuel pool cooling system is designed in accordance with the following criteria:

a. The system shall be designed to ensure adequate decay heat removal capability under normal and postulated accident conditions.

b. The system shall be designed with the ability to permit appropriate periodic inspection and testing of components important to decay heat removal.

c. The system shall be provided with suitable shielding for radiation protection.

d. Reliable and frequently tested monitoring equipment to detect conditions that may result in loss of decay heat removal shall be provided.

e. The system shall be designed with an adequate spent fuel pool makeup system with appropriate provisions for a backup system for filling the pool.

f. Design shall prevent significant reduction in fuel storage cooling water inventory due to equipment failure, maloperation or accident conditions.

g. Appropriate containment and cleanup system for spent fuel pool cooling water shall be provided.

9.5.2 SYSTEM DESCRIPTION

9.5.2.1 System

The spent fuel pool cooling system, shown in Figure 9.5–1 is designed to remove decay heat generated by stored spent fuel assemblies by circulating the borated pool water through a heat exchanger unit consisting of two heat exchangers in parallel. Cooling water for the heat exchangers is supplied by the RBCCWS as described in Section 9.4. The two motor-driven pumps take suction from the spent fuel pool at elevation 35 feet 6 inches, one foot below the normal operating level of elevation 36 feet 6 inches and at elevation 13 feet 0 inches through the lower suction line. The normal depth of the spent fuel pool is approximately 38.5 feet of water. The spent fuel pool cooling water is returned to the bottom of the pool through three headers which penetrate the pool walls approximately one foot below the normal operating water level, on the opposite side of the pool from the supply headers to provide convective circulation of the pool water through the stored fuel assemblies.

There is a make-up connection attached to the emergency make-up water line for a portable diesel driven pump to deliver make-up water to the Spent Fuel Pool. This connection is a defense-in-depth design feature that is available for coping with an extended loss of AC power (ELAP) event. The location of the BDB SFP FLEX make-up connection is shown on Figure 9.5–1, Sheet 2.

Normal Refueling (fuel shuffle)

The first design basis for the spent fuel pool cooling (SFPC) system is for normal refueling (fuel shuffle). Fuel movement to the SFP is assumed to start between 110 and 160 hours of decay, and proceeds at an average rate of 6 fuel assemblies per hour. The case analyzed is refueling at the end of plant life to maximize fuel inventory and therefore decay heat of spent fuel in the SFP. Decay heat calculations are performed with ORIGEN-ARP. This normal refueling, started at 160 hours, produces a maximum conservative heat loading of 14.52×10^6 BTU/hr. With both trains of SFPC in service and 85°F RBCCW spent fuel pool water temperature will be maintained to less than 131°F.

A normal refueling with fuel movement starting after 110 hours of decay, and proceeding at an average rate of 6 assemblies per hour over the refueling is acceptable as long as RBBCW temperature is maintained at or below 75°F. The resulting maximum conservative heat loading in the spent fuel pool is 16.18×10^6 BTU/hr. In the event that more than 81 fuel assemblies need to be moved to the spent fuel pool the evolution may still be defined as a Fuel Shuffle as long as the entire core is not offloaded and the maximum heat load in the spent fuel pool remains less than or equal to this value.

With RBCCW temperature maintained at or below 75°F the spent fuel pool cooling system can maintain the spent fuel pool temperature at approximately 125°F with both pumps and heat exchangers in service.

A single active associated failure analysis of the spent fuel pool cooling system shows the limiting failure to be failure of RBCCW valve 2-RB-8.1A or 8.1B. Failure of either valve closed results in loss of cooling flow to the associated SFPC heat exchanger. This failure is more limiting than the loss of a SFPC pump. Failure of RBCCW valve 2-RB-8.1A or 8.1B in the closed position would result in a SFP bulk water temperature greater than 150°F but less than 200°F, if the failure occurred at maximum heat load. Should this limiting single failure occur, 1 train of the shutdown cooling (SDC) system may be used to cool the SFP, or the SDC system may be used to supplement the SFPC system. Used in this fashion, depending on heat load, between 0 to 1000 gpm of SDC flow would be able to maintain SFP water temperature ≤ 150°F. See Section 9.3 for a description of the SDC. Since the SDC system will eventually be re-aligned for its ECCS requirements for Mode 4, the SFPC system must be capable of sustaining a single failure without assistance from SDC upon entry into Mode 4. Analysis shows that once the SFP heat load drops to 10.16×10^6BTU/HR, even if the limiting SFPC single failure occurs, the SFPC system will be able to maintain SFP bulk water temperature ≤ 150°F. At least 616 hours of being subcritical or a heat load of 10.16×10^6 BTU/HR is required prior to re-entry into Mode 4 from a refueling outage.

Key SFP Cooling and SDC parameters used in this analysis are:

- Credited SFP cooling flow is 850 gpm per SFP cooling pump.
- Credited RBCCW flow to each SFP cooling heat exchanger is 1100 gpm.
- Credited RBCCW flow to SDC heat exchangers is 3500 gpm.
- Credited RBCCW temperature to SFP and SDC heat exchangers is 75°F for fuel movement starting after 110 hours of decay and 85°F for fuel movement starting after 160 hours of decay.
- SFP and SDC heat exchangers have a 1% tube plugging penalty.

Periodic maintenance of the Spent Fuel Pool Cooling system and associated supporting systems is required. During the performance of maintenance activities it may be necessary to remove system components and portions of various support systems from service. While these components and systems are out of service, the ability of the Spent Fuel Pool Cooling system to meet single failure criteria will be limited. These maintenance activities do not conflict with system design or licensing basis. Suitable redundancy is ensured by the shutdown risk program.

Therefore the requirement to maintain the SFP ≤ 150°F can be met during modes 1through 4 with a single train of SFP Cooling. During refueling, for a fuel shuffle, under limiting postulated conditions, 2 trains of SFP cooling are sufficient to maintain SFP bulk water temperature ≤150°F. During refueling, for a fuel shuffle, under limiting postulated conditions, 1 train of SFP cooling will need to be supplemented by Shutdown Cooling to maintain SFP bulk water temperature ≤ 150°F. A single train of Shutdown Cooling is sufficient to remove all decay heat from both the reactor vessel and the SFP. Eventually during refueling, 1 train of SFP cooling is sufficient to maintain SFP bulk water temperature ≤ 150°F. For the final refuel outage, this point is reached 616 hours after shutdown or when the SFP heat load is at or below 10.16 x 10^6 BTU/HR, when 1 train of SFP cooling is sufficient to maintain SFP bulk water temperature ≤ 150°F.

Full Core Offload as Normal Refueling

The second design basis for the SFP cooling system is for a full core offload as normal refueling. Fuel movement to the SFP is assumed to start after 110 hours with a RBCCW temperature of less than or equal to 75°F or after 160 hours with RBCCW temperature of less than or equal to 85°F. The fuel movement is assumed to proceed at an average rate of 6 assemblies per hour until all 217 fuel assemblies are in the SFP and the reactor vessel is empty of fuel. The case analyzed is the final core offload at the end of plant life to maximize the fuel inventory, and therefore decay heat, of spent fuel in the pool. At end of plant life, decay heat removal is needed for a total of 1343 fuel assemblies and 3 consolidated fuel storage boxes. The number of fuel assemblies analyzed in the heat load analysis bounds the number of fuel assemblies which can be physically stored in the SFP. Decay heat calculations are performed with ORIGEN-ARP.

The last full core offload at end of plant life, calculated in the above manner, produces a maximum conservative heat loading of 34.59 MBTU/hr with a 110 hour core hold time and produces 30.90 MBTU/hr with a 160 hour core hold time. With 1 train of SDC available during the core offload to cool both the reactor vessel and the core, spent fuel pool water temperature will be maintained to less than 150°F.

During the refueling evolution, cooling is transitioned from the spent fuel pool cooling system to the shutdown cooling system when the temperature in the spent fuel pool is observed to rise. This transition begins before challenging the conservatively established normal operating pool temperature limit of 120°F.

One train of SDC is assumed to be capable of delivering 3000 gpm, however the split of SDC flow going to the reactor vessel, or cooling the SFP will change during the core offload as the heat load shifts from the core to the SFP. With this limiting heat load, at the start of the offload most of the SDC flow will go to the reactor vessel (approximately 2000 gpm), with lesser SDC flow going to the SFP (approximately 1000 gpm). By the end of the offload most of the SDC flow will go to the SFP (up to 1900 gpm), with lesser SDC flow going to the reactor vessel (>1000 gpm). See Section 9.3 for a description of the SDC system.

Key SDC parameters used in this analysis are:

- Credited SDC flow is 3000 gpm per LPSI pump, with a maximum of 1900 gpm diverted to cooling the SFP.
- Credited RBCCW flow to SDC heat exchangers is 3500 gpm.
- Credited RBCCW temperature to SDC heat exchangers is 75°F for fuel movement starting after 110 hours of decay and 85°F for fuel movement after 160 hours of decay.
- SFP and SDC heat exchangers have a 1% tube plugging penalty.

While the above analysis is for the limiting heat load case at end of plant life, it is acceptable to use SFP cooling, or SFP cooling supplemented by lesser amounts of SDC, during any portion of the core offload, provided that spent fuel pool bulk water temperature can be maintained below 150°F.

Full core offload as a normal activity is acceptable because there are 2 redundant trains of Shutdown Cooling (SDC). One train of SDC is sufficient to ensure that the Spent Fuel Pool (SFP) can be maintained at a bulk water temperature ≤ 150°F even with the entire core offloaded to the SFP. The other train of SDC is available as backup, should there be a failure in the operating SDC train. In the event that maintenance activities during an outage cause the redundant train of SDC to be unavailable, the Containment Spray (CS) pump has sufficient capacity (Design Temperature of 300°F and Design Head of 390 feet at 1600 GPM) in this circumstance to cool the SFP and to ensure that SFP temperature is maintained ≤150°F. The CS pump has no required function with the core defueled. The CS pump supplemented by a SFP cooling train (if required) will be the means of backup to SDC during SDC maintenance activities. Suitable redundancy is ensured per the Shutdown Risk program.

Therefore, for a full core offload as normal refueling, the system is conservatively designed to maintain the water in the spent fuel pool water below 150°F during all normal conditions or single active failure conditions.

Emergency Full Core Offload

The third design basis for the spent fuel pool cooling system is for an emergency full core offload. Fuel movement to the SFP is assumed to start after 110 hours with a RBCCW temperature of less than or equal to 75°F or after 160 hours with RBCCW temperature of less than or equal to 85°F. The fuel movement is assumed to proceed at an average rate of 6 assemblies per hour until all 217 fuel assemblies are in the SFP and the reactor vessel is empty of fuel. The case analyzed is during the final fuel cycle at end of plant life to maximize the fuel inventory, therefore decay heat, of spent fuel in the pool. At end of plant life, decay heat removal is needed for a total of 1343 fuel assemblies and 3 consolidated fuel storage boxes. The number of fuel assemblies analyzed in the heat load analysis bounds the number of fuel assemblies which can be physically stored in the spent fuel pool. Decay heat calculations are performed with ORIGEN-ARP. Significant conservatism is used in the calculation of the decay heat values. A conservatively short decay time of 36 days is chosen for the previous batch of discharge fuel, and 400 days decay for the previous discharge batch, to maximize decay heat of fuel stored in the pool.

The emergency full core offload during the last fuel cycle of operation, calculated in the above manner, produces a maximum conservative heat loading of 39.40 MBTU/hr with a 110 hour core hold time and produces 35.72 MBTU/hr with a 160 hour core hold time. There is no single failure requirement for emergency core offload calculations, per our current licensing basis. With two trains of SDC available during the emergency core offload, approximately 1900 gpm of SDC flow is available to cool the SFP during the entire core offload. With 1900 gpm of SDC flow available to cool the SFP, the SFP water temperature will be maintained to less than 150°F. See Section 9.3 for a description of the SDC system.

Key SDC parameters used in this analysis are:

- Credited SDC flow is 3000 gpm per LPSI pump, with a maximum of 1900 gpm diverted to cooling the SFP.
- Two trains of SDC are assumed to be available.
- Credited RBCCW flow to SDC heat exchangers is 3500 gpm.
- Credited RBCCW temperature to SDC heat exchangers is 75°F for fuel movement starting after 110 hours of decay and 85°F for fuel movement after 160 hours of decay.
- SFP and SDC heat exchangers have a 1% tube plugging penalty.

While the above analysis is for the limiting heat load case at end of plant life, it is acceptable to use SFP cooling, or SFP cooling supplemented by lesser amounts of SDC, during any portion of the emergency core offload, provided that SFP water can be maintained below 150°F.

Therefore, for an emergency full core offload, the system is conservatively designed to maintain the water in the SFP below 150°F.

Also since the emergency core offload represents the limiting heat load in the SFP, an additional analysis is performed to verify that the local water temperatures and local fuel cladding temperatures were less than boiling. Results of that analysis show that at the maximum emergency core offload heat load, the maximum local SFP water temperature along the fuel assembly is less than 178°F, and the maximum local fuel clad temperature is less than 234°F. These temperatures are below the local boiling temperature, at the top of the fuel assemblies, of 240°F.

Normal makeup to the spent fuel pool water inventory is supplied from the primary water storage tank at a rate of 50 gpm. The 50 gpm makeup capability is adequate to provide water at a rate greater than normal water loss due to evaporation and any system leakage. The maximum makeup capability of this permanently installed system is approximately 200 gpm. Backup makeup for the pool is from the RWST by using one Refueling Pool Purification Pump to transfer the water at a rate of approximately 125 gpm. The RWST contents can also be transferred by the use of one LPSI pump and the interconnecting piping between the spent fuel pool cooling system and shutdown cooling system. A makeup capability of 3000 gpm for 15 minutes is possible from this source. Makeup at approximately 100 gpm can be supplied by an Auxiliary Feedwater Pump taking suction from the Condensate Storage Tank. An alternate backup source for makeup is obtained from the fire protection system by using temporary hose connections. Flow is at a rate of 200 gpm.

All leakage and drains from the spent fuel pool cooling system components are collected in the open drains system and processed as aerated liquid waste as described in Section 11.1.3. The maximum system leakage for an extended period of time for which adequate processing by the RWS is possible is 50 gpm.

Sufficient monitoring equipment is provided to detect and alert operating personnel to conditions that may result in loss of decay heat removal capability. Table 9.5-1 lists the monitoring equipment provided.

A low-flow alarm will alert operating personnel that there is either a low pool water level or one or both cooling water pumps has failed to operate. Excessive radiation levels are detected by local area radiation monitors as described in Section 7.5.6.

To prevent significant reduction in the fuel storage cooling water inventory, all connections to the pool penetrate the pool walls near the normal operating water level so that the pool cannot be gravity drained by leaking pumps, valves, etc. The cooling water return piping which extends to the pool bottom is provided with anti-siphon devices.

Section 5.4.3 describes the way the spent fuel pool has been designed to prevent cooling water inventory loss. The spent fuel pool liner leak monitoring and detection system consists of a series of channels welded behind each seam of the pool liner. Any leakage through the pool liner seams is collected in the channels which are piped to the open drain system. The drain header contains a level switch which annunciates in the main control room to alert operating personnel to any leakage. The drain header is provided with valves to isolate the leak and is of a small pipe size (0.5 inch) to prevent significant water loss prior to isolation. The location of the leaks in the pool liner seams is accomplished by pressurizing the channels with air and observing air bubbles rising to the pool water surface. Sections 5.4.3.1.9 and 9.8.4 describe the provisions incorporated in the station design to preclude and/or limit the consequences of a dropped fuel shipping cask.

Boron concentration in the spent fuel pool water is maintained consistent with Technical Specification requirements. The design of the spent fuel storage racks to preclude criticality and the bases for the safe geometry are described in Section 9.8.2.

A cleanup system consisting of pumps, filters, and a demineralizer is provided to maintain the purity and clarity of the water in the spent fuel pool, refueling pool, and the RWST after completion of reactor refueling operations. The cleanup system is designed to remove corrosion and fission products introduced into these waters by leaking fuel assemblies and mixing with reactor coolant during refueling operations. The purity and clarity of these waters are maintained to limit operating personnel doses. The radiation levels are closely monitored during refueling operations to establish the allowable exposures times for personnel in accordance with 10 CFR Part 20.

To facilitate the removal of accumulated dust from the surfaces of both the spent fuel pool and refueling pool, skimmer assemblies with a pump and filters are provided for each pool.

9.5.2.2 Components

A description of the components of the spent fuel pool cooling system is given in Table 9.5-2.

9.5.3 SYSTEM OPERATION

9.5.3.1 Normal Operation

During normal operation of the pool, both pumps and heat exchangers are in continuous service. As the decay heat generated by the spent fuel decreases, one pump is stopped. As the decay heat further decreases, operation of the system is intermittent as required to limit the pool water temperature to less than or equal to 150°F.

As described in Section 9.5.2.1, during refuel operations, the spent fuel cooling system, with assistance from the shutdown cooling system when needed, is capable of maintaining spent fuel pool water temperature below the Technical Requirements Manual (TRM) limit of 150°F for a normal refueling through (and including) the end of plant life refueling. This includes allowance for a single active failure of the spent fuel pool cooling system, or shutdown cooling system, as appropriate.

As described in Section 9.5.2.1, the spent fuel pool heat load must decay to a value of 10.16 x 10^6 BTU/HR, for the SFP cooling system to be capable of withstanding the worst single active failure, and maintain spent fuel pool water temperature ≤ 150°F. For the time period before the SFP heat load drops to 10.16 MBTU/hr, should the limiting single failure occur, 1 train of the shutdown cooling (SDC) system may be used to cool the SFP, or the SDC system may be used to supplement the SFP cooling system, to maintain spent fuel pool water temperature ≤ 150°F.

As a result of this need to depend on the SDC for potential SFP cooling single failure per Technical Requirements Manual (TRM), entry into Mode 4 following a refueling is not allowed until either:

(a) 616 hours has passed since subcriticality for the fuel bundles remaining in the spent fuel pool which were discharged from the previous refueling, of ≤ 81 fuel bundles, or

(b) the heat load to the SFP is less than 10.16 x 10^6 BTU/hr. At a SFP heat load of 10.16 x 10^6 BTU/hr, adequate cooling is available to maintain the SFP bulk water temperatures less than or equal to 150°F should a single failure occur in the SFP cooling system.

These TRM limits assure that the shutdown cooling system would be available for supplemental cooling and not committed to its emergency core cooling system functions.

While water temperatures up to 150°F are allowed in the spent fuel pool, the demineralizers in the spent fuel pool cleanup system should not be exposed to spent fuel pool water temperatures in excess of 140°F, to prevent demineralizer resin degradation. Alarms and procedural controls are used to prevent spent fuel pool water from reaching the demineralizer resin prior to the temperature reaching 140°F.

A portion of the spent fuel pool cooling water flow, approximately 125 gpm, is passed through the cleanup system. Operation of this system as well as the skimmer system is intermittent as required to maintain the clarity and purity of the spent fuel pool water. During refueling operations, the refueling water purification pumps and spent fuel pool filters may be used for purification of the water in the refueling pool. The demineralizer is used as required for purification service on the spent fuel pool or refueling pool. At the completion of the refueling operations, the pumps are used for transferring the remaining refueling water from the pool to the RWST after the water level is lowered to the elevation of the reactor vessel flange.

9.5.3.2 Abnormal Operation

If a mid-cycle emergency full core offload is placed in the spent fuel pool, the cooling capacity for this additional spent fuel is provided by connecting the spent fuel pool cooling system with the shutdown cooling system, if additional cooling is required to limit the pool water temperature. The shutdown cooling system is placed into service by manual initiation.

9.5.3.3 Emergency Conditions

In the event that a serious leak develops in the spent fuel pool liner, makeup water is supplied to the pool from the primary makeup water system by manual initiation from the 14 foot 6 inches level of the auxiliary building. Should the leakage exceed the 50 gpm normal makeup capability, additional makeup is available from the RWST via the refueling water purification system, and the fire protection system by temporary hose connections.

Following a postulated LOCA, RBCCW flow to the spent fuel pool cooling system is stopped by the automatic closing of valves in the cooling water discharge piping from the heat exchangers on SIAS. The availability of cooling water, normally supplied to the spent fuel pool system, allows for greater heat removal capability in the engineered safety features components. As discussed later in Section 9.5.4.1, spent fuel pool cooling loss for a period of 9.76 hours will raise the pool water temperature to 212°F. RBCCW cooling to the spent fuel pool cooling heat exchangers is restored 4 to 5 hours after the start of the postulated LOCA when the heat load on the RBCCW system is substantially reduced.

For the normal case where spent fuel is stored in the spent fuel pool, it is unlikely that a seismic event will cause loss of cooling water flow. The lines from the spent fuel pool to the suction of the spent fuel pool cooling pumps and from the spent fuel pool heat exchangers to the spent fuel pool have been designed and analyzed to Seismic Category I requirements and the remainder of the system, including the spent fuel pool cooling pumps, heat exchangers and their connecting piping, has been analyzed and found to be in accordance with Seismic Category I requirements. This provides assurance that cooling water would be available from the spent fuel pool cooling system.

In the event that the cooling water flow is lost, makeup water is available from one of the two seismic Category I sources. The seismic category 1 makeup sources for the spent fuel pool are:

The auxiliary feedwater system (AFW) interconnection to the spent fuel pool cooling system. This allows the use of any AFW pump and the inventory of the condensate storage tank as makeup to the SFP. This path is nominally designed to deliver 100 gpm by a flow orifice (FO-8954).

The low-pressure safety injection (LPSI) system interconnection to the spent fuel pool cooling system. This allows the use of a LPSI pump and the inventory of the refueling water storage tank (RWST). The LPSI interconnection is also capable of taking water from the refueling cavity during outages when the inventory from the RWST has been utilized to fill the refueling cavity.

The events or malfunctions that may require makeup to the spent fuel include the long-term loss of spent fuel pool cooling heat removal capability, the failure of a steam generator nozzle dam with the fuel transfer tube isolation valve (2-RW-280) open or the refueling pool cavity seal with the fuel transfer tube isolation valve (2-RW-280) open. The catastrophic failure of the cavity seal is not considered to be a credible event, but has been analyzed and is dealt with the unit procedures. Failures of the spent fuel pool structure are not considered to be credible. The aforementioned events or malfunctions could allow the spent fuel to boil thus requiring makeup. The maximum required makeup would be approximately 85 gallons per minute which would be for core offload conditions.

In the case where a full core offload is stored in the spent fuel pool, it is improbable that cooling water flow will be lost entirely due to the redundancy of the cooling equipment. In the event that the cooling water flow is lost while a full core offload is being stored in the spent fuel pool, makeup water may be available from the refueling water storage tank, refueling cavity, or the condensate storage tank.

9.5.4 SYSTEM AVAILABILITY AND RELIABILITY

9.5.4.1 Special Features

The spent fuel pool purification system can be used as a backup to maintain the RWST contents above 50°F. However, this flow path has been administratively prohibited in certain plant operating modes and when the RWST is credited as a borated water source due to seismic/non-seismic piping interconnection concerns.

The spent fuel pool cooling pumps and heat exchanger units can be supplemented by the shutdown cooling system.

The most serious failure of the system would be the complete loss of the spent fuel pool water inventory. To protect against this possibility, all connections to the pool enter near to or above the pool operating water level, so that the pool cannot be gravity drained through leaking valves, piping and equipment maloperation. Piping which extends to the bottom of the pool is provided with antisiphoning devices.

Reliable monitoring equipment, as described in Section 9.5.2.1 is provided to detect and alert plant operating personnel to any conditions which could result in loss of decay heat removal capability.

During refueling, following the loss of all cooling, the minimum times to reach boiling conditions in the SFP occur when the core offload begins at 110 hours after shutdown. During Normal Refueling, Full Core Offload as Normal and Emergency Full Core Offload the minimum times to reach boiling are conservatively determined to be in excess of 6.4 hours, 3.1 hours and 2.8 hours, respectively.

To conservatively estimate the time for the SFP bulk water temperature to reach the SFPC system temperature of 200°F in Modes 1 through 4, the SFP bulk water temperature is assumed to be 150°F at 616 hours after subcriticality and SFP heat load is at or below 10.16 x 10^6 BTU/HR. If loss of SFP cooling is assumed to occur at that time, the SFP bulk water temperature will reach the SFPC system temperature of 200°F in 7.87 hours or 212°F in 9.76 hours. Alternately, for SFP starting bulk water temperatures of 130°F and 117.7°F, it takes 11 hours and 12.96 hours respectively to heat the SFP to 200°F.

Sufficient time is available for operating personnel to locate and correct the malfunction.

That portion of the spent fuel pool cooling system that is used in seismic Category I makeup consists of the section of the spent fuel pool heat exchangers outlet piping downstream of check value 2-RW-8 as shown on Figure 9.5–1. HCC-11 has been designed and analyzed to seismic Category I requirements and additionally all connections have been analyzed up to and including the first seismic restraint beyond the isolation value in each connecting line. Following is a list of the line and valve numbers that constitute the Category I makeup:

Piping

10" - HCC-11, 6" - HCC-11

Valves

2-RW-8, 2-RW-15, 2-RW-65, 2-RW-66, 2-RW-67, 2-RW-71, 2-RW-76, 2-RW-119, 2-RW-213, 2-RW-222

9.5.4.2 Tests and Inspections

Components of the spent fuel pool cooling system are nondestructive tested in accordance with the applicable codes as listed in Table 9.5-2.

All pumps in the spent fuel pool cooling system were manufacturer shop performance tested to demonstrate compliance with design head and capacity requirements. A performance curve for the spent fuel pool cooling pumps is shown in Figure 9.5–2.

Prototype filter cartridge testing was conducted by the filter manufacturer confirming a filter efficiency of 92 weight percent when tested with fine Arizona air dust.

All system components are visually inspected and manually adjusted if required to ensure proper installation and arrangement.

The completely installed spent fuel pool cooling system was pre operation tested prior to startup. The detailed test procedure is described in Section 13.

The components of the spent fuel pool cooling system are located in a low-radiation area which permits access for periodic testing and maintenance.

9.5.5 REFERENCES

9.5-1 Letter from W. G. Counsil to Director of Nuclear Reactor Regulation, "Millstone Nuclear Power Station, Unit Number 2 Control of Heavy Loads Near Spent Fuel," dated July 17, 1978.

TABLE 9.5-1 SPENT FUEL POOL MONITORING EQUIPMENT

Equipment	Function
Spent fuel pool temperature instrumentation	Provides continuous monitoring and recording of pool water temperatures by main control room personnel. Annunciates high temperature alarm in control room.
Spent fuel pool level instrumentation	Annunciates low pool water level alarm in main control room. * Continuous wide range level indication is provided remotely in the Cable Vault and East 480V Switchgear Rooms of the Auxiliary Building.
Spent fuel pool cooling water flow instrumentation	Annunciates low spent fuel pool cooling water flow alarm in main control room.
Spent fuel pool heat exchanger outlet instrumentation	Annunciates high temperature alarm in main control room.

* It is not necessary for this alarm to sound locally since personnel in the area would either visually notice an abnormal pool level or be notified of the abnormal pool level by control room personnel. (Reference 9.5-1).

TABLE 9.5-2 COMPONENTS OF SPENT FUEL POOL COOLING SYSTEM

Cooling Pumps

Type	Horizontal centrifugal
Quantity	2
Design temperature (°F)	200
Design head tdh (feet)	50
Design capacity, each (gpm)	850
NPSH available (feet)	60
Minimum NPSH required (feet)	10
Horsepower	15
Materials	
Case	ASTM A351, Gr CF8M
Impeller	ASTM A351, Gr CF8M
Shaft	ASTM A351, Gr CF8M
Codes and Standards	
Draft ASME Code for Pumps and Valves for Nuclear Service, Class III (1968 Edition)	
Seismic design class	I
Design integrated radiation dosage (rad)	10^6
Supplier	Gould
Heat Exchangers Unit Original Design	
Type	U-tube with single shell pass
Number	2 in parallel
Design heat transfer rate, each (Btu/hr)	5.5×10^6
Heat transfer area, each (ft^2)	589
Design RBCCW temperature, in/out (°F)	85/95
Design spent fuel pool water temperature, in /out (°F)	120/107
Tube design, spent fuel pool water	
Design pressure (psig)	125
Design temperature (°F)	200
Maximum Flow (gpm)	1050
Design Flow (gpm)	850
Pressure drop at 850 gpm flow (psi)	7
Materials	ASTM A249 Type 304
Relief valve setting (psig)	125

TABLE 9.5-2 COMPONENTS OF SPENT FUEL POOL COOLING SYSTEM (CONTINUED)

Shell design (RBCCW)	
Design pressure (psig)	150
Design temperature (°F)	130
Maximum Flow (gpm)	1500
Design Flow (gpm)	1100
Pressure drop at 1100 gpm (psi)	4
Materials	ASTM A106
Relief valve setting (psig)	150
Codes and Standards	ASME Section VIII TEMA “R”
Seismic design class	I
Supplier	Struthers Nuclear

Spent Fuel Pool Demineralizer

Type	Mixed bed, nonregenerable
Number	1
Design pressure (psig)	100
Design temperature (°F)	150
Normal operating pressure (psig)	75
Normal operating temperature (°F)	107-120
Resin volume (ft^3)	42
Design flow (gpm)	132
Normal operating flow (gpm)	125
Material	ASTM A-240 Type 304
Code	ASME Section III for Class 3 Components (1971 Edition)
Seismic design class	II
Supplier	Illinois Water Treatment

Spent Fuel Pool Filters

Type	Disposable cartridge
Number	2
Design pressure (psig)	200
Design temperature (°F)	250
Normal operating pressure (psig)	75
Normal operating temperature (°F)	107-120

TABLE 9.5-2 COMPONENTS OF SPENT FUEL POOL COOLING SYSTEM (CONTINUED)

Filter rating (micron)	3
Design Filter efficiency (%)	80 minutes
Design flow (gpm)	132
Normal operating flow (gpm)	125
Material	
Vessel	ASTM A 312 Type 304
Internals	Type 304 SS, Micarta
Cartridges	Ethylene propylene
Seismic design class	II
Code	ASME Section III Class C (1968 Edition)
Supplier	Filterite Corporation

Refueling Water Purification Pumps

Type	Inline centrifugal
Number	2
Design temperature (°F)	150
Design head, tdh (feet)	165
Design capacity (gpm)	125
NPSH available (feet)	26
Minimum NPSH required (feet)	5
Horsepower	15
Materials	
Case	ASTM A351 Gr CF8M
Impeller	ASTM A351 Gr CF8M
Shaft	ASTM A276 Type 316
Codes and Standards	ASME Section III for Class 3 Components (1971 Edition)
Seismic design class	II
Design integrated radiation dosage over lifetime (rad)	10^6
Supplier	Ingersoll Rand

TABLE 9.5-2 COMPONENTS OF SPENT FUEL POOL COOLING SYSTEM (CONTINUED)

Spent Fuel Pool and Refueling Pool Skimmer Pumps

Type	Inline centrifugal
Number	2
Design temperature (°F)	175
Design head, tdh (feet)	75
Design capacity (gpm)	60
NPSH available (feet)	46
Minimum NPSH required (feet)	6
Horsepower (hp)	3
Materials	
Case	ASTM A351 Gr CF8M
Impeller	ASTM A351 Gr CF8M
Shaft	ASTM A276 Type 316
Code	ASME Section III for Class 3 Components (1971)
Seismic design class	II
Design integrated radiation dosage over lifetime (rad)	10^6
Supplier	Ingersoll Rand

Spent Fuel Pool and Refueling Pool Skimmer Filters

Type	Disposable cartridge
Number	4
Design pressure (psig)	200
Design temperature (°F)	250
Normal operating pressure (psig)	50
Normal operating temperature (°F)	120
Filter rating (micron)	10
Design filter efficiency (%)	80
Design flow (gpm)	132
Normal operating flow (gpm)	60
Material	
Vessel	ASTM A312 Type 304
Internals	Type 304SS, Micarta
Cartridges	Ethylene propylene

TABLE 9.5-2 COMPONENTS OF SPENT FUEL POOL COOLING SYSTEM (CONTINUED)

Code	ASME Section III Class C (1968 Edition)
Seismic design class	II
Supplier	Filterite Corporation

Piping and Valves

Piping

Material	ASTM A-312 Type 304
Design pressure (psig)	100
Design temperature (°F)	150

Joints:

2.5 inches and larger -Butt welded except at flanged equipment

Codes:

Fabrication, ANSI B31.7 Class III

Testing and installation, ASME Section III for Class 3 Components (1971 Edition)

Valves

Materials 2.5 inches and larger - ASTM A351 Grade CF-8

2 inches and smaller - ASTM A182 Type F-304

Ratings 2.5 inches and larger -

2 inches and smaller - 150 lb. butt welded ends. 600 lb. socket welded ends.

Code Draft ASME Code for Pumps and Valves for Nuclear Service (1968 Edition).

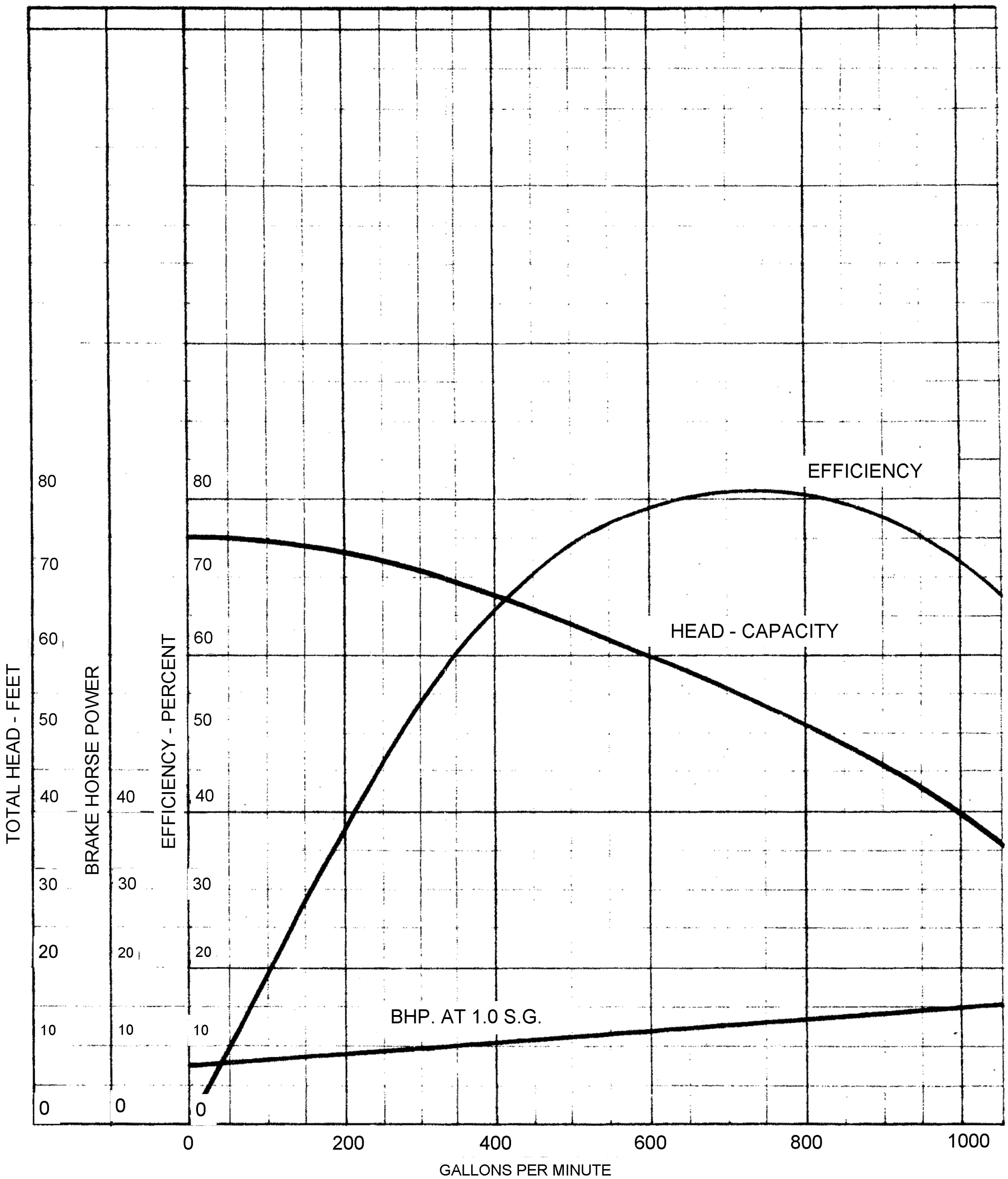
FIGURE 9.5–1 P&ID SPENT FUEL POOL CLEANING AND CLEANUP SYSTEM (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.5–1 P&ID SPENT FUEL POOL CLEANING AND CLEANUP SYSTEM (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.5–2 SPENT FUEL POOL PUMP PERFORMANCE CURVE



9.6 SAMPLING SYSTEM

9.6.1 INTRODUCTION

The sampling system consists of Sampling Stations 1 and 2, the Corrosion Monitoring Sample Station, the Waste Gas Sample Sink, and the Post Accident Sampling System (PASS). These provide the means for determining physical, chemical and radioactive conditions of process fluids, waste gas, and containment air.

Station 1 is in the sampling room located in the auxiliary building. It handles radioactive sampling of the reactor coolant system, the chemical and volume control system (CVCS), and the radioactive waste processing systems. The sample room contains the piping, valves, and cooling equipment necessary to reduce the pressure and temperature of the sample fluid or gas to acceptable levels for grab sampling or collection in sample bottles. The sample streams are radioactive or potentially radioactive and may contain boric acid. Grab samples are taken to the radiochemistry laboratory for analyses. The system also contains online hydrogen and oxygen monitors. (See Figure 9.6–1)

Station 2 is located in the turbine building. Continuous sampling by semi-automatic and manual methods can be performed. This station contains pressure reducing valves, cooling equipment, pressure, temperature and flow control regulators, valves, piping, grab sample sink, continuous O_2 and conductivity monitors, recorders, indicators, ion chromatograph, and on-line sodium monitors. (See Figure 9.6–2)

The Corrosion Monitoring Sample Station provides a means for sampling condenser hotwells for evidence of sea water in-leakage. (See Figure 9.6–3)

The Waste Gas Sample sink provides the means for sampling gasses in the volume control tank, waste gas surge tank, and the waste gas decay tanks. See Section 11.1 for additional discussion of the Gaseous Waste Processing System.

The PASS has the capability to obtain samples of reactor coolant and containment atmosphere under accident conditions. The PASS is comprised of two independent units, designated reactor coolant PASS and containment air PASS. The reactor coolant PASS is designed to obtain representative samples of reactor coolant or liquid from the containment. The containment air PASS is designed to obtain a containment air sample. Once these samples are obtained, radiological and chemical analyses can be performed.

9.6.2 REACTOR COOLANT PASS

9.6.2.1 Equipment Purpose and Description

The reactor coolant PASS is a dual module unit consisting of one sample module and one remote operating panel. Samples are trapped within the sample module. The equipment within the sample module is operated remotely via the remote operating panel. The motive force for obtaining reactor coolant samples is the differential pressure between the primary plant and the volume control tank. Two sampling modes may be chosen, depending upon whether the sample is to be shipped off site for analysis or analyzed onsite. Samples to be analyzed off site are collected in a 2 ml shielded, removable sample chamber within the sample module. Samples to be analyzed on site are collected in shielded containers within the sample module. (See Figure 9.6–4)

9.6.2.1.1 Sample Module

This module contains the valves and components required to physically collect the sample. All components are located within a stainless steel cabinet measuring approximately 22 inches wide, by 24 inches deep, by 36 inches high, which sits on a 2 foot high stand. An exhaust blower is built into the top of the cabinet and discharges into the plant radioactive exhaust ventilation system. Doors are provided on the cabinet for access to remove samples and to perform maintenance. The module is located in the primary sample room. At this location, levels of radiation created at the module during the purge of reactor coolant through the sample lines will not result in significant exposure to the operator at the remote panel or to other individuals.

Sample influent and effluent lines are connected to the sample module. Influent samples are taken from several points at Millstone Unit Number 2 via two flow paths. Reactor coolant samples can be taken from the hot leg of the reactor coolant system. Samples of containment sump liquid can be obtained from the high pressure safety injection pumps, low pressure safety injection pumps, or the containment spray pumps. Both influent samples pass through sample coolers prior to being delivered to the sample module. Effluent lines connected to the module are directed to the volume control tank.

9.6.2.1.2 Remote Operating Panel

This module contains the sample system mimic board, electrical controls, and instrumentation readout necessary to remotely operate the sample module. The remote operating panel is located in the turbine building in an area which will have low radiation levels during an accident. The remote operating panel is connected to the sample module through electrical cables which carry power and instrumentation indication lines. Nitrogen gas supply lines, used to operate valves and purge the radioactive gas sample after sampling is completed, are hard-piped to the sample and remote modules. The face of the module is normally protected by a lockable closure to prevent damage and unauthorized operation.

9.6.2.1.3 Reactor Coolant Auxiliary Valve Operating Panel (RCAVOP)

This panel contains switches and electrical controls to operate the sample system isolation valves and the system flush valves. The RCAVOP is located above the remote operating panel.

9.6.2.1.4 Deionized Water Flushing Module

Deionized water flushing module is a modular unit designed to provide deionized water flushing capability at approximately one gallon per minute and up to 375 psig. The module is located adjacent to the remote operating panel.

The flushing system is a self contained system consisting of a water storage tank, positive displacement pump, and controls to operate the equipment. The equipment is mounted on bedplate to form a modular unit.

9.6.2.2 Design Features

Both operating and equipment failure modes are analyzed to maintain exposure ALARA. Personnel radiation exposure is minimized through the use of remote control operation, flushing techniques, and minimal sample volume and shielding.

Radiation exposure to the operator taking the sample is estimated to be well below the exposure limits defined by 10 CFR 50, Appendix A, GDC-19.

The PASS system piping downstream of the sample coolers is designed for 2500 psig and 165°F. The inherent design of pH probes limits functional usage to pressure of 250 psig. A pressure regulating valve, installed in the influent line, allows fluid to flow through the pH probe. The pH probe outer housing is designed to withstand system design pressure of 2500 psig in the event that the pressure regulating valve fails and the pH probe internals are inadvertently overpressurized.

All fluid boundary materials are of either 300 series stainless steel or Inconel.

The normal fail position of each solenoid valve was selected such that failures will still allow flushing the system to minimize radiation levels.

Solenoid valves are equipped with positive position indication at the remote operating panel.

Radioactive airborne contamination control is provided by a blower which maintains capture velocity into the sample module. This blower exhausts into existing plant ventilation.

Commercially available components are utilized to the maximum extent possible and have been selected based upon a reputation for high quality. Swagelok fittings are utilized wherever possible to be consistent with existing utility sample system components.

PASS piping is sized to maintain turbulent flow thereby minimizing crud buildup and plate-out of radioactive products.

Two sample paths and one effluent return path are available on the reactor coolant PASS providing operational redundancy.

Reactor coolant PASS solenoid containment isolation valves are operated from two control boards, located outside the control room.

The valves required to be operated during the sampling operation are operated by chemistry personnel at the RCAVOP and remote operating panel.

The reactor coolant PASS sample module is powered from vital instrument panel VA20 to allow for operation with a loss of off site power.

Solenoid valves isolating the reactor coolant PASS from the safety class systems are built to the ASME Code, Section III requirements, and are fully qualified for postulated accident conditions.

9.6.3 CONTAINMENT AIR PASS

9.6.3.1 Equipment Purpose and Description

The containment air PASS has the capability of collecting a sample of containment air. The PASS is a dual module unit consisting of one sample module and one remote operating panel. The motive force for obtaining a sample is supplied by the hydrogen analyzer sample pumps which draw the sample from the hydrogen analyzer system through the PASS sample module, returning it back to the hydrogen analyzer system. (See Figure 9.6–5)

9.6.3.1.1 Sample Module

This module contains the valves and components required to physically collect a 10 ml sample of containment air. The equipment is housed within a wall mounted cabinet, located in the spent fuel pool skimmer pump area. An exhaust blower is built into the top of the cabinet and discharges into the plant radioactive ventilation exhaust system. A door is provided on the cabinet for access to remove samples and to perform maintenance. Influent and effluent connections are provided for connection to the sample system piping.

9.6.3.1.2 Remote Operating Panel

This module contains the sample system mimic panel and slave valves required to remotely operate the sample module. The module is located above the Millstone Unit Number 2 railway access area where radiation levels during an accident are low. The remote operating module is connected to the sample module through electrical cables and piping. A control switch is provided to operate a remote valve to purge the sample lines with nitrogen following sample collection and isolation.

9.6.3.2 Containment Air Samples

A 10 ml sample of containment air is isolated in a shielded sample chamber. Samples are withdrawn from the chamber via septum using a syringe, injected into a sealed container, and transported to the laboratory for subsequent analysis.

9.6.3.3 Design Features

Both operating and failure modes have been analyzed to maintain exposure ALARA. Personnel radiation exposure is minimized through the use of remote control operation, flushing techniques, minimal sample volume, and shielding.

Radiation exposure to the operator taking the sample is estimated to be well below the exposure limit defined by 10 CFR 50, Appendix A, GDC-19.

Materials in contact with the containment air sample are of 300 series stainless steel and have been selected to ensure system integrity up to a pressure of 100 psig at 300°F.

Heat generated by flow of hot fluid through the sample module piping is dissipated by a blower which provides capture velocity air flow into the sample module and exhausts to the plant radioactive ventilation system.

Commercially available components have been utilized to the maximum extent possible and are selected based upon a reputation for high quality. Swagelok fittings have been utilized to be consistent with existing plant equipment.

Isolation valves and breakdown connections are provided for solenoid valve and other equipment for maintenance considerations.

The containment air PASS piping and sample pump are sized to maintain turbulent flow, thereby minimizing crud buildup and plate-out of radioactive products.

Two sample paths and two return paths are available on the containment air PASS providing operational redundancy.

All valves are operated from the remote operating panel. Isolation from containment is provided by valves in the hydrogen analyzer system.

The containment air PASS sample module is powered from vital instrument panel VA20 to allow for operation with a loss of off site power.

9.6.4 TEST

The reactor coolant and containment air PASS can be operated during normal plant operations for testing purposes to obtain actual reactor coolant or containment air samples.

FIGURE 9.6–1 P&ID DIAGRAM SAMPLING SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.6–2 P&ID DIAGRAM SAMPLING SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.6–3 P&ID DIAGRAM SAMPLING SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.6–4 P&ID POST ACCIDENT SAMPLING SYSTEM REACTOR COOLANT SAMPLE

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.6–5 P&ID POST ACCIDENT SAMPLING SYSTEM CONTAINMENT AIR SAMPLE

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

9.7 COOLING WATER SYSTEMS

9.7.1 CIRCULATING WATER SYSTEM

9.7.1.1 Design Bases

9.7.1.1.1 Functional Requirements

The function of the circulating water system is to provide a continuous supply of cooling water to the main condenser.

9.7.1.1.2 Design Criteria

a. The circulating water system shall be designed to remove the heat load from the condenser.

b. The circulating water system shall be designed to use sea water for cooling.

9.7.1.2 System Description

9.7.1.2.1 System

The circulating water system is shown in Figure 9.7–1. Four one-fourth capacity (137,000 gpm each) motor driven vertical wet pit pumps circulate the water from the intake structure through the main condenser and discharge into the quarry. The water is taken from Long Island Sound through an intake trash rack and four traveling screens located inside the intake structure. The screens are designed to prevent debris larger than three-eighths inch from passing into circulating water pump, condenser and the service water pumps.

A sodium hypochlorite system capable of chlorinating circulating water on a shock treatment basis is provided. The method of circulating water chlorination is gravity feed injection of sodium hypochlorite solution directly to the running pump suction. The chlorination of the circulating water system, including the condensers, controls biological fouling while maintaining chlorine concentrations within NPDES permit limits.

The total inventory of the circulating water system is as follows:

1. Circulating Water Pump up to Turbine Building Condenser Pit Floor elevation equals 232,000 gallons.

2. Circulating Water above Condenser Pit Floor elevation equals 160,000 gallons.

3. Discharge piping below Condenser Pit Floor elevation to quarry equals 990,000 gallons.

The maximum flow rate through the main condensers is 548,800 gpm.

The minimum time required to stop the circulating water flow would be the coastdown time of the circulating water pumps, 10 seconds. Factors affecting the actual time elapsed would be the operators evaluation of the alarms received in the control room and the severity of the failure. Drop-out time for the control circuitry is in the order of a fraction of a second and is insignificant.

In the event of a gross failure in the circulating water transport system resulting in the flooding of the condenser pit by the discharge from all four circulating water pumps, the total time required to stop all water flow is approximately 16 seconds and occurs automatically.

The circulating water transport system is designed to withstand the maximum operating discharge pressure of the circulating water pumps, 10 psig. Piping is designed for 100 psig, with the expansion joints, butterfly valves, condenser water boxes and tube bundles designed for 25 psig. Normal operating pressure for these components has a range of 0-7 psig, with the outlet waterboxes operating under a vacuum of about 15 to 20 inches Mercury Absolute.

Small leaks around valves and fittings would go undetected except for visual inspection and would drain into the condenser pit sump. The condenser pit sump is provided with 200 gpm capacity sump pumps and provided with high level alarms to indicate water level in the pit 6 inches below the top of the sump. Large leaks due to pipe or expansion joint ruptures would be indicated in the control room by both a gradual loss of vacuum in the condenser shell and high-high condenser pit level switches, set at 10 inches and initiating a trip of the circulating water pumps.

The potential for ruptures is minimized by interlocking the circulating water pumps with the water box butterfly valves, requiring the valves to be open between 20 to 25% prior to starting the pumps. The water box cross connect valves are also interlocked with the water box discharge valves and initiate a pump trip in the event of an incomplete flow circuit. Therefore, the system is adequately protected against over pressuring by the circulating water pumps due to improper valve operation. However, all components in the system are hydrostatically tested at 1.5 times the design pressure of 25 psig to ensure system integrity before normal operation.

Failures in the circulating water transport system would be inconsequential except those occurring above ground in the Turbine Building. The condenser pit is designed to contain these failures and has the capacity to store 284,450 gallons at a maximum depth of 9 feet before spilling over to the Turbine Building ground floor.

The worst case of a major failure would be the complete rupture of all the circulating water piping to both condensers. This would result in the draining into the condenser pit of all circulating water in use in the above ground components, approximately 160,000 gallons, and flooding the pit to a level of 47 inches. When the water level in the pit reaches 10 inches, approximately 4 seconds after the rupture, the high-high level switches in the condenser pit are actuated and cause the circulating water pumps to trip 2 seconds later. During this 6 seconds, the circulating water pumps will have continued to pump approximately 55,500 gallons, which will also drain to the condenser pit raising the water level to 6 feet 2 inches. During the 10 second coastdown time of circulating water pumps, they continue to add about 45,600 gallons to the condenser pit raising the final water level to 7 feet 11 inches, leaving an additional capacity available in the pit of approximately 23,750 gallons before overflowing. During the postulated failure and subsequent flooding of the condenser pit, the water level is rising an average of 5.9 inches per second.

The condenser pit will contain the water from any postulated failures in the circulating water system without affecting any safety related systems.

9.7.1.2.2 Components

The ratings and materials of construction of the circulating water system are given in Table 9.7-1.

9.7.1.3 System Operation

All four circulating water pumps are in operation during normal operation, with the operating speed of the pumps controlled by the variable frequency drives (VFD). In the event of VFD unavailability, the VFD can be bypassed, allowing operation of the pumps at rated speed; however, no speed control is available in this condition. A cross connection is provided between the two water boxes at each end of each condenser shell. Valves are provided so either pump on a condenser shell can provide water to both sides of the condenser if one pump is out of service. The valving also provides capability to back flush each condenser section.

The inlet cross-connect valve between the condenser inlet water boxes will be opened manually (remote) by the operator under the following conditions:

1. With one circulating water pump inoperable.

2. Following the trip of an operating circulating water pump.

3. In anticipation of a circulating water pump trip.

Condition 1:

If a circulating water pump is to be out for maintenance or otherwise inoperable, load will be limited as necessary to maintain vacuum. The inlet cross connect valve will be opened to supply water to both halves of the condenser from the operating pump.

Condition 2:

If during normal operation a circulating water pump(s) should automatically trip, the plant load will be reduced as necessary to maintain vacuum. The discharge valve of the tripped pump(s) will be closed, and the inlet cross connect valve will be opened. The circulating water pumps will trip on the following:

a. Loss of lubricating water.

This trip is preceded by a low lube water pressure alarm.

b. Pump breaker trip.

c. VFD trip.

d. Traveling screens High-High differential pressure.

This trip is preceded by a high differential pressure alarm.

Condition 3:

If during normal operation, it is apparent that a circulating water pump trip is imminent, the plant load will be reduced as necessary to maintain vacuum. The affected pump will be shut down and the pump discharge valve closed. The inlet cross connect valve will be opened. If VFD malfunctions occur, the VFD may be isolated and the affected circulating water pump operated with the VFD bypassed. This operation requires that the affected circulating water pump be shut down during the transfer to the bypass mode of operation.

9.7.2 SERVICE WATER SYSTEM

9.7.2.1 Design Bases

9.7.2.1.1 Functional Requirements

The function of the service water system is to supply a dependable continuous flow of cooling water to the reactor building closed cooling water (RBCCW) heat exchangers, turbine building closed cooling water (TBCCW) heat exchangers, diesel engine heat exchangers, vital AC switchgear room cooling coils, chilled water heat exchangers and the circulating water pump bearings.

9.7.2.1.2 Design Criteria

The service water system is designed to the following design criteria:

a. The service water system shall be designed with suitable redundancy that in the event of a LOCA, concurrent with a loss of off site power and a single active failure, the service water system can perform its safety function. (Note: The postulation of a LOCA concurrent with a seismic event is outside the design basis.)

b. The service water system shall be sized and shall have capacity to provide sufficient water for all modes of operation at a maximum ultimate heat sink temperature of 80°F.

c. The system shall be designed in accordance with the general criteria as described in Section 6.1.

d. The system shall be designed as a moderate energy system.

e. The system shall be designed to withstand a pipe rupture (as an initiating event). Single failures in the redundant train shall not be postulated to occur. Multiple failures of the service water piping will not occur.

The ultimate heat sink consists of the service water cooling system serving the components mentioned in Section 9.7.2.1.1. The water source for the heat sink is the Long Island Sound sea water. It provides sufficient cooling for more than 30 days:

a. to permit safe shutdown and cooldown of the reactor and can maintain a safe shutdown condition for unit 2 and other units at the site;

b. to allow control of an accident in the event one occurs.

The UHS temperature determination method shall use SWS header/branch temperature measurements. Precision instruments installed at the inlet to the reactor building closed cooling water (RBCCW) heat exchangers will normally be used. All in-service precision instruments must be within the limit. If all of the precision instruments are out of service, alternative instruments that measure SW supply side temperature will be used. In this case, an appropriate instrument uncertainty will be subtracted from the acceptance criteria.

SWS supply temperature measurements shall be obtained for each operable SWS loop and the highest valid SWS supply loop temperature shall be used to determine the UHS temperature.

The safety related equipment in the intake structure (pump motors and controls) are protected against the maximum hypothetical tide and storm surges including wave action by being located above elevations 22 feet 0 inches. The pumps are also designed for drought condition for low-low water level of minus 7 feet.

The ultimate heat sink is served only by one source of water, that of the Long Island Sound sea water. The Long Island Sound sea water capacity is sufficient to provide a total maximum quantity of 24,000 gpm cooling water for more than 30 days. A second source of water is not required.

Canals or conduits between the water source and the intake structure are not provided. The intake structure is located on the water source.

9.7.2.2 System Description

9.7.2.2.1 System

The service water system is described by Figure 9.7–1. Three half capacity (12,000 gpm each) vertical wet pit motor driven pumps take suction downstream from the traveling screens in the intake structure. Two independent cross-connected supply headers with isolation valves are provided to all heat exchangers. Two independent discharge headers are provided for the RBCCW heat exchangers that run above ground from the discharge of the heat exchangers to the discharge canal. Two discharge headers are provided, one for each diesel, for the diesel generator cooling water heat exchangers. One discharge header is provided for the TBCCW heat exchangers as the three discharge pipes are combined above ground prior to entering the discharge canal. The discharge header for the chilled water system and for the vital switchgear room cooling heat exchangers combine with the TBCCW heat exchanger discharge header before entering the discharge canal. Normally, one pump and service water header are required to provide cooling of the RBCCW and diesel generator cooling water heat exchangers following a loss-of-coolant accident (LOCA) or for Unit shutdown. In the event of a loss of station power, the pump motors are supplied power from the emergency buses. The TBCCW headers are isolated for either a SIAS or LNP signal.

9.7.2.2.2 Components

A description of the service water system components is given in Table 9.7-2.

9.7.2.3 System Operation

During normal operation two pumps are operating and provide water to the RBCCW and the TBCCW heat exchangers and vital switchgear ventilation system cooling coils. Each pump is capable of supplying the required service water to one train for accident mitigation and safe shutdown. A third standby pump will be started remotely by manual means upon loss of an operating pump. During winter time operation (ultimate heat sink temperature less than 60°F), the standby RBCCW and TBCCW heat exchangers may be placed on-line (service water side only) in order to maintain service water pump minimum flow requirements. This may be necessary since much less service water flow is required to remove RBCCW and TBCCW heat loads as service water temperature decreases.

9.7.2.4 Availability and Reliability

Redundant headers and one spare pump are provided. Sea water is chlorinated to prevent slime, algae, and mussel growth. Thermal backwashing (mussel cooking) is also performed to prevent fouling of the intake structure pump bays. A sodium hypochlorite system capable of chlorinating service water is provided. The service water chlorination system is capable of injecting sodium hypochlorite solution into the service water pump suction bells via an injection pump system. The solution is taken up by the service water pumps and enters the service water system to provide biological fouling control. Pump motors and controls are located at Elevation 22 feet 0 inches for flood protection. The intake structure is designed to withstand any probable tornado missile.

Various types of internal protective coatings and liners are utilized in piping and components throughout the system. Periodic preventive maintenance, surveillances, and inspections ensure that significant coating or lining degradation will be promptly detected. This and proceduralized investigative and corrective actions ensure that coating or lining degradation will not impair service water system safety functionality.

The service water pump has been modified to an open-line shaft design. Thordon bearings are lubricated by sea water flowing through the pump. No external lube water is required.

The service water pumps and motors are not susceptible to a failure from a common cause. Failure of a circulating water line cannot flood the intake structure since the discharge line is low energy and located below grade. There are no sources of potentially damaging internally generated missiles within the intake structure. Rotating components are limited to the relatively slow speed 300 rpm and 900 rpm motors on the circulating water pumps and the service water pumps respectively. The rotating masses therein are essentially encapsulated within heavy motor windings. There is no high-energy fluid system to cause any missile within the intake structure.

The intake structure louvers have been redesigned to resist penetration by any of the design basis tornado driven missiles which were discussed in Section 5.2.5.1.2 of the FSAR.

The exterior concrete walls are of adequate thickness to prevent perforation by any of the design basis missiles. An investigation of generation of a secondary missile due to concrete spalling indicates that only minor spalling may occur due to the impactive energy of the utility pole missile. This spalling is limited to the thickness of the protective cover on the steel reinforcing on the interior of the structure. Secondary missiles thus assumed to form would not reach the closest service water pump. The intake structure is constructed of materials which will not support combustion. Any potential fire, such as a service water pump motor, would be localized in a small area and would normally be mitigated by a dry type of fire protection. The spatial separation (approximately 20 feet.) would prevent damage to the redundant pumps.

The only safety related system in the intake structure is the service water system.

The service water pump motors and controls are protected against the maximum hypothetical tide and storm surges including wave action.The pumps are also designed for low-low water of minus 7 feet. Flooding of the intake structure due to a circulating water pipe rupture is not credible because the circulating water pipes are below the floor on the intake structure. In case of a service water pipe rupture no water accumulation can be sustained in the intake structure due to the floor grating. Catastrophic failure resulting in missile generation have not been experienced with circulating water or screen wash pumps. Therefore, the service water pumps have not been protected against missiles generated by the failure of circulating water or screen wash pumps.

Because of the redundancy of the service water system even if a hypothetical missile is generated and causes the inoperability of one service water pump it will not effect the service water system operation because only two service water pumps are required for normal operation while only one is needed for emergency operation.

The service water system also provides cooling water to the Emergency Diesel Generators when these are started such as in the case of a loss of off site power. If the intake structure becomes flooded and the service water to the diesels must be isolated, cooling to one diesel is provided by a cross-connection to the Fire Water System.

A failure mode analysis is given in Table 9.7-4. A rupture in the system is considered an initiating event only; it is not postulated concurrent with a LOCA (or any other Chapter 14 event). System redundancy and header separation have been provided to maintain continuous cooling in the event of a single passive failure during post-accident long term cooling.

9.7.2.5 Test and Inspections

Each service water pump and strainer was hydrostatically tested at 1.5 times the design pressure.

The service water pump was tested per ASME Power Test Code Section 8.2, 1965 for hydraulic performance. The service water pump design curve is given in Figure 9.7–3.

Each component is inspected and cleaned prior to installation into the system. The service water system undergoes a preoperational test prior to startup; the detailed test procedure is described in Section 13.

Instruments will be calibrated during testing. Automatic controls will be tested for actuation at the proper set points. Alarm functions will be checked for operability and limits during preoperational testing.

The system will be operated and tested initially with regard to flow paths, flow capacity and mechanical operability. At least one pump will be tested on line to demonstrate head and capacity (Section 13).

Major components of the system such as pumps and strainers are accessible for periodic inspection during normal operation.

Heat exchanger fouling and other component degradation is common in open cycle Service Water systems due to both macro and micro fouling. This fouling can lead to an inability to provide the safety related cooling that is the function of the Service Water system. NRC Generic Letter (GL) 89-13 required that actions be taken to confirm and maintain the capability of the Service Water system to perform its design basis functions. Actions performed to ensure the capability of the system to provide the required safety related cooling include:

- Injecting sodium hypochlorite to minimize biofouling. This injection prevents the attachment and subsequent growth of large quantities of mussels.

- Inspecting and cleaning the intake bays to minimize fouling. This cleaning removes fouling that might be drawn into the Service Water system and clog downstream components.

- Flowing Service Water through normally stagnant portions of piping such as supply to the diesel generators and vital chillers to minimize fouling. Stagnant and near stagnant water can be conducive to the biological growth.

- Monitoring of available heat exchanger parameters to detect gross debris loading. This periodic monitoring detects fouling build up in a heat exchanger between visual inspections.

- Inspecting heat exchanger, pipe, and other component internals on the Service Water Side to remove fouling and repair as needed. Periodic inspections identify component degradation or the slow buildup of fouling prior to it affecting component operability.

- Cleaning heat exchangers on the Service Water side to minimize fouling buildup. Cleaning removes deposits of fouling that tend to occur in heat exchanger tubes.

- Tested heat exchangers to confirm design heat transfer capability. This testing and subsequent analysis verified heat exchanger performance was capable of meeting design requirements.

- Filling heat exchangers with fresh water during layup to minimize buildup of fouling and component degradation caused by stagnant seawater.

9.7.3 TURBINE BUILDING CLOSED COOLING WATER SYSTEM

9.7.3.1 Design Bases

9.7.3.1.1 Functional Requirements

The turbine building closed cooling water (TBCCW) system provides cooling water to the auxiliary equipment (associated with the power control system) which is located in the turbine building and for the condensate polishing facility located in warehouse number 5.

9.7.3.1.2 Design Criteria

The turbine building closed cooling water system shall be designed to cool auxiliary equipment over the full range of operation.

9.7.3.2 System Description

9.7.3.2.1 System

The TBCCW system is described by Figure 9.7–2.

The turbine building closed cooling water system uses treated water to remove heat from the turbine components and sample coolers. The system transfers the heat to the service water system in the TBCCW heat exchangers. The system has three half capacity heat exchangers and three half capacity pumps to circulate the cooling water through the system. The system has a head tank and chemical addition provision to take off thermal expansion of water and maintain the water chemistry.

The components cooled by this system include:

1. Stator liquid coolers
2. Electro hydraulic coolers
3. Station air compressor and after cooler
4. Steam generator feed pump lube oil coolers
5. Exciter air cooler
6. Heater drains pumps motors and bearings
7. Condensate pumps motor cooling
8. Sampling Station Number 2 sample cooling
9. Generator isolated phase bus cooler
10. Generator hydrogen coolers
11. Turbine lube oil coolers
12. Local sample coolers
13. Warehouse number 5 air conditioning unit
14. Deleted by MP-PACKAGE-FSC-00-MP2-011
15. Multi-circuit cooler
16. Fuel handling area air conditioning units
17. Auxiliary chilled water system mechanical refrigeration units

9.7.3.2.2 Components

A description of the TBCCW system components is given in Table 9.7-3.

9.7.3.3 System Operation

During normal operation two pumps and two heat exchangers are operating. The third heat exchanger will be operated upon failure of an operating pump or heat exchanger.

TABLE 9.7-1 CIRCULATING WATER SYSTEM COMPONENTS

Traveling Water Screen

Type	Vertical through flow
Quantity	4
Speed (feet per minute)	5 and 20
Material	
Screen	3/8 inch square openings of No. 14 Stainless steel wire
Frame	Stainless steel
Motor Manufacturer	Leeson Electric
Motor	1800/450 rpm, 10/2.5 hp, 3 phase, 60 Hz, 460 V
Codes	NEMA

Screen Wash Pumps

Pump Manufacturer	Fairbanks Morse
Model	14 inch M. C.
Type	Vertical turbine
Quantity	2
Capacity each (gpm)	1760
Head (feet)	210
Material	
Case	ASTM A-48 Class 30, 2-3% Ni
Impeller	ASTM A-296 CF 8M (316 SS)
Shaft	AISI 316 Stainless Steel
Motor Manufacturer	General Electric
Motor	125 hp, 460 V, 3 phase, 60 Hz, 1800 rpm
Codes	NEMA, Standards of the Hydraulic Institute, ASME Boiler and Pressure Vessel Codes, Section VIII ANSI B16.5

TABLE 9.7-1 CIRCULATING WATER SYSTEM COMPONENTS (CONTINUED)

Circulating Water Pumps

Pump Manufacturer	Babcock & Wilcox Canada Ltd.
Model	78BN
Type	Vertical, wet pit
Quantity	4
Capacity each (gpm)	137,200
Head (feet)	24
Material	

Case Materials such as: ASTM A-240, Type 316-L; ASTM A-48 CL-30; ASTM A-436, Type 1B, Ni-Resistant; ASTM A-296, CF 8M (316 SS).

Impeller Shaft - AISI 304 Stainless Steel

Motor Synchronous 1500 hp, 4000 V, 60 Hz, 3 phase, 300 rpm

Codes

NEMA, Standards of the Hydraulic Institute, ASME Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels, ANSI B16.5

Variable Frequency Drive

Manufacturer	Siemens Energy & Automation, Inc.
Model	Harmony Drive
Quantity	4
Type	Air Cooled
Blowers	Transformer Cabinet - 3, Cell Cabinet - 3
Horse Power	1500 hp
Input	4160V, +10%, -15%, 3 phase, 60 Hz, 247A RMS
Output	0-4000V, 3 phase, 0-60 Hz, 260A RMS
Weight	15,580 pounds
Enclosure	NEMA1

TABLE 9.7-2 SERVICE WATER SYSTEM COMPONENTS

Service Water Pumps

Type	Vertical, wet pit
Quantity	3
Capacity each (gpm)	12,000
Head (feet) TDH	100
Material	Stainless Steel
Motor Manufacturer	General Electric
Motor	450 hp, 4000 V, 3 phase, 60 Hz
Codes	NEMA, Standards of the Hydraulic Institute, ASTM, ANSI, G16.5
Seismic	Class 1

Service Water Pipe (Selection based on applicable service)

High Performance Stainless Steel, Unlined
Carbon Steel Pipe, Epoxy or PVC Lined
Stainless Steel Pipe, Epoxy Lined or Unlined
Cast Ductile Iron Pipe, Cement and/or Epoxy Lined
Copper Nickel Pipe, Unlined
Red Brass Pipe, Unlined
Nickel Copper, Unlined

Service Water Valves (Selection based on applicable service)

High Performance Stainless Steel, Unlined
Carbon Steel Valves
Stainless Steel Valves
Cast Ductile Iron Valves
Copper-Nickel Valves
Cast Bronze Valves

Service Water Strainer

Type	Automatic self cleaning
Quantity	3
Design flow rate (gpm)	12,000
Design pressure (psig)	100
Design temperature (°F)	100
Materials	Selected for Salt Water Service
Motor	3/4 hp, 460 V, 1725 rpm, 3 phase, 60 Hz
Codes	NEMA, ASME Section VIII
Seismic	Class 1

TABLE 9.7-3 TURBINE BUILDING CLOSED COOLING WATER SYSTEM COMPONENTS

TBCCW Heat Exchanger

Manufacturer	Southwestern Engineering Co.
Model	TEMA type NEN
Type	One pass shell and tube
Quantity	3
Design duty each (BTU/hr)	28.5×10^6
Design pressure (psig)	
Shell side	125
Tube side	125
Design temperature (°F)	
Shell side	125
Tube side	120
Material	
Shell	ASME SA-516-70 (carbon steel)
Channels	SB-171-715 (70-30 CuNi)
Channel covers	SA-516-70 with SB-171-715 liner
Tube	ASME SB-111-715 D.S.R.
Tube sheet	ASME SB-171-715
Codes	
TEMA - Class C, ASME Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels	
Seismic	None
Specification	SP-ME-542

TBCCW Pump

Manufacturer	Goulds Pump
Model	3405-10 x 12-12
Type	Horizontal centrifugal
Quantity	3
Capacity each (gpm)	3400
Head (feet) TDH	110

TABLE 9.7-3 TURBINE BUILDING CLOSED COOLING WATER SYSTEM COMPONENTS (CONTINUED)

Material	
Case	ASTM A-278-59T, Class 30
Impeller	1106 Bronze
Shaft	AISI Type 316
Motor	125 hp, 460 V, 3 phase, 60 Hz, 1800 rpm
Codes	
NEMA, Standards of Hydraulic Institute, ASME Boiler and Pressure Code Section VIII, Pressure Vessels.	
Seismic	Class 2

TBCCW Head Tank

Manufacturer	PX Engineering
Type	Vertical
Quantity	1
Design pressure (psig)	15
Design temperature (°F)	110
Volume (gal)	1100
Material	ASTM A-285 Gr C
Code	ASME Section VIII
Seismic	Class 2

TABLE 9.7-4 SERVICE WATER COOLING SYSTEM

	COMPONENT IDENTIFICATION & QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
1.	Service Water Cooling Pumps (3)	Pump stops.	Pump trip alarm.	Loss of flow in one header.	Isolate pump. Standby pump is put into service. Valve line-up.	Normal operation.	Pump out of service for repairs.
2.	Piston Operated Valves (2) HV6482, HV6489	a. Fails to open.	a. & b. Position indication C.R.I.	a. None	a. & b. Repair valve operator.	Normal operation.	
		b. Fails to operate (open).		b. Loss of flow from standby pump.	b. Operate valve manually, or direct flow from standby pump to alternate header.		
3.	Service Water Cooling Pump Discharge Header (3)	Pipe break.	Low flow indication on the effected components C.R.I.	Loss of flow in header.	Break isolated. Standby pump is put into service.	Normal operation.	Header out of service for repairs.
4.	RBCCW Heat Exchanger Supply Header and Channels	Pipe break.	Heat exchanger outlet low flow indication. Sump level alarm. Both C.R.I.	Loss of flow in header.	Break isolated. Standby heat exchanger put into service.*	Normal operation.	Header out of service for repairs.

TABLE 9.7-4 SERVICE WATER COOLING SYSTEM (CONTINUED)

	COMPONENT IDENTIFICATION & QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
5.	RBCCW Heat Exchanger (3)	a. Tube side rupture.	a. Makeup valve. None to RBCCW Surge Tank open alarm. b. C.R.I.	None	Failed heat exchanger isolated. Standby heat exchanger put into service. *	Normal operation.	Heat exchanger out of service for repairs.
6.	Piston Operated Valve (2) HV6399, HV6400	Fails as is.	Position indication. C.R.I.	None	Repair valve operator.	Normal operation.	Valve can be manually operated.
7.	RBCCW Heat Exchanger Discharge Header (2)	Pipe break.	High flow indication. Sump level alarm. Both C.R.I.	None	Break isolated. Standby heat exchanger put into service. *	Normal operation.	Header out of service for repairs.
8.	Piston Operated Valve (3) TV6306, TV6306A, TV6307, TV6307A, TV6308, TV6308A	Fails open.	Position indication. Local	Possible rapid cooldown of RBCCW by service water leading to RCP seal problems.	Repair valve operator.	Normal operation.	Place standby heat exchanger into service if modulating control required.

TABLE 9.7-4 SERVICE WATER COOLING SYSTEM (CONTINUED)

	COMPONENT IDENTIFICATION & QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
9.	TBCCW Heat Exchanger	Pipe break.	1. Heat exchanger flow alarm (C.R.I.).	Reduction/Loss	Break Isolated Standby Heat Exchanger put into service.*	Normal operation.	Repair header
	a. Supply Header		2. Possible Surge Tank high level alarm on TBCCW heat up.	Loss of Service Water Flow.			
			3. TBCCW High Temperature Alarm (C.R.I.).				
	b. Discharge Header	Pipe break.	Heat exchanger flow alarm (C.R.I.).	Reduction / Loss of Service Water Flow.	Isolate Service Water to TBCCW Repair Header *	Potential trip / damage to components due to TBCCW heat up.	Repair header.
10.	TBCCW Heat Exchanger (3)	Tube side rupture.	Flow indication; TBCCW Surge Tank low level alarm.	None	Heat exchanger isolated.*	Normal operation.	Heat exchanger out of service for repairs.
11.	Piston Operated Valve (2)HV6438, HV6439	Fail as is.	Position indication. C.R.I.	None	Repair valve operator.	Normal operation.	Valve can be manually operated.
12.	Diaphragm Operated Valves (3) TV6303, TV6304, TV6305	Fail open.	Local visual indication only.	Loss of one heat exchanger.*	Repair valve operator.	Normal operation.	Not required for shutdown.

TABLE 9.7-4 SERVICE WATER COOLING SYSTEM (CONTINUED)

	COMPONENT IDENTIFICATION & QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
13.	Diesel Engine Cooling Water Heat Exchanger (2)	Tube side rupture.	Diesel Generator High Temperature Alarms. C.R.I. Jacket cooling pressure low, jacket cooling level low, jacket cooling temperature high / low. All local.	Loss of one diesel generator.	isolate heat exchanger and repair.	Normal operation (one diesel generator in service).	One diesel generator required during an emergency.
14.	Diesel Engine Cooling Water Heat Exchanger Supply & Discharge Headers	Pipe break.	Heat exchanger outlet low-flow indication, lube oil temperature, local jacket cooling temperature. Local	Loss of flow in system.	Break isolated.	Normal operation (one diesel generator in service).	One diesel generator required during an emergency. SBO allows eight hours to restore power.
15.	Piston Operated Valve (2) FV6389, FV6397	Fail open.	Position indication. C.R.I.	None	Repair valve operator.	Normal operation.	Valve can be manually operated.

TABLE 9.7-4 SERVICE WATER COOLING SYSTEM (CONTINUED)

COMPONENT IDENTIFICATION & QUANTITY		FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
16.	Service Water Header to Circulating Water Pump Bearings & Seals	Pipe break.	Low pressure alarm. C.R.I. Domestic water backup to lube water open. C.R.I.	1. Loss of water.	Isolate break.	Domestic Water System supplying bearings and seals on circulating water pumps.	Normal circulating water pump operation while service water header is repaired.
				2. Loss of service water supply to circulating water pumps.			
17.	Diaphragm Valve (1) PV6522	Fail open.	Visual	None	Repair valve operator.	Normal operation.	

* During wintertime operation (ultimate heat sink temperature less than 60°F), the standby RBCCW and TBCCW heat exchangers may be placed on line (service water side only) in order to maintain service water pump minimum flow requirements. If a standby heat exchanger is required to be placed in-service due to a failure of an RBCCW or TBCCW heat exchanger, then service water pump minimum flow concerns must be met by manually adjusting service water flow in the affected header. This may result in lower temperatures and will require close monitoring of RBCCW or TBCCW component temperatures.

FIGURE 9.7–1 P&IDS - CIRCULATING WATER, SERVICE WATER, SCREEN WASH, SODIUM HYPOCHLORITE (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.7–1 P&IDS - CIRCULATING WATER, SERVICE WATER, SCREEN WASH, SODIUM HYPOCHLORITE (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.7–1 P&IDS - CIRCULATING WATER, SERVICE WATER, SCREEN WASH, SODIUM HYPOCHLORITE (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.7–1 P&IDS - CIRCULATING WATER, SERVICE WATER, SCREEN WASH, SODIUM HYPOCHLORITE (SHEET 4)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.7–2 P&ID TBCCW SYSTEM (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.7–2 P&ID TBCCW SYSTEM (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.7–2 P&ID TBCCW SYSTEM (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.7–3 TYPICAL SERVICE WATER PUMP CERTIFIED TEST CURVE

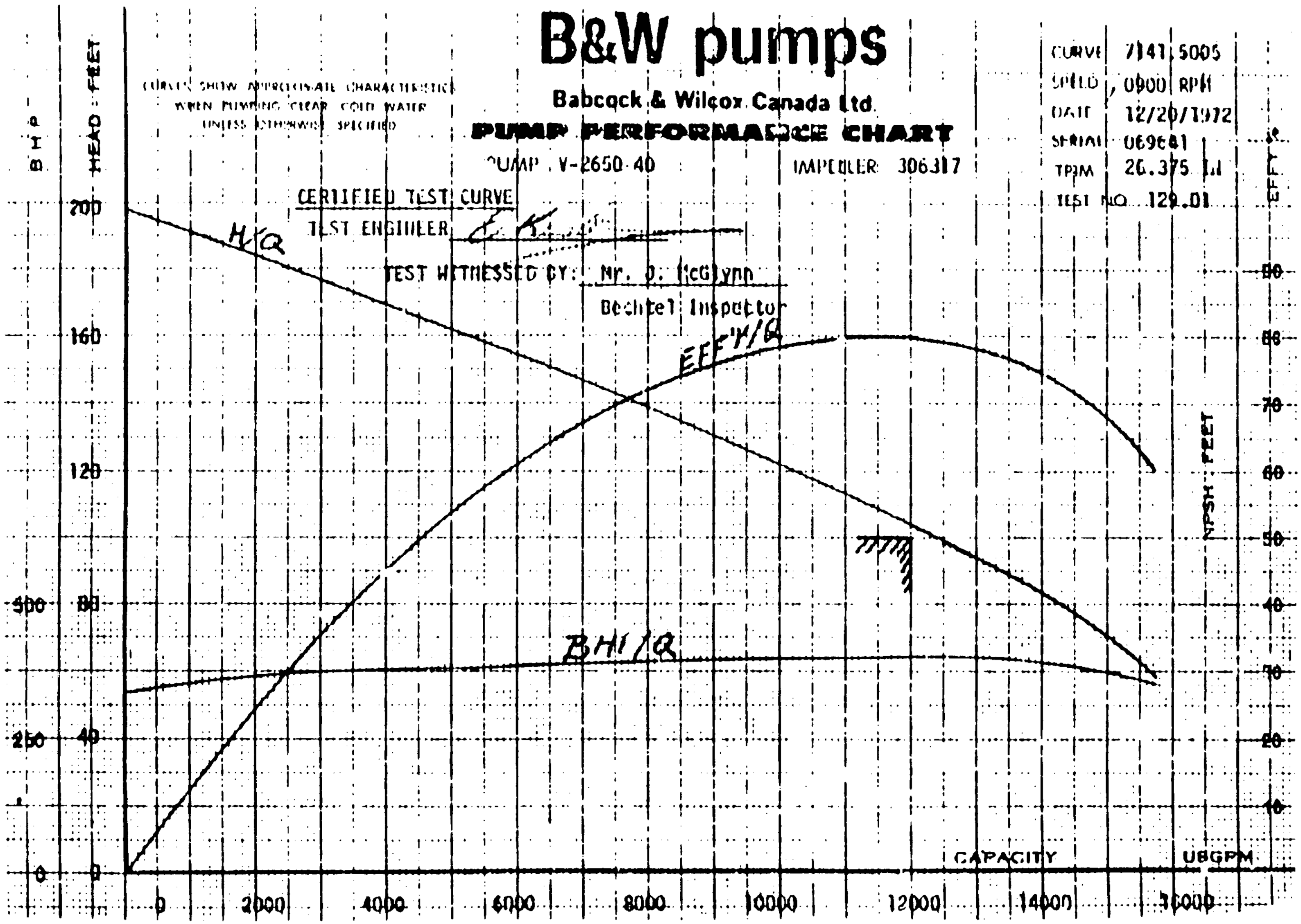


FIGURE 9.7–4 DELETED BY FSARCR 03-MP2-011

9.8 FUEL AND REACTOR COMPONENT HANDLING EQUIPMENT

9.8.1 DESIGN BASES

The fuel and reactor component handling equipment provides for the safe handling, inspection and storage of fuel assemblies, control element assemblies (CEA) and reactor internals under normal conditions. It also provides for the safe disassembly, handling, and reassembly of the reactor vessel closure head, and in-core instrumentation (ICI).

9.8.1.1 Functional Requirements

a. The equipment shall be capable of operation in water with the following design chemistry:

pH (77°F)	4.5 to 10.6
Boric Acid, Maximum, weight percent	1.5
Ammonia, Maximum[(1)], ppm	50
Lithium, Maximum [(1)], ppm	2.5
Dissolved Air, Maximum	Saturated
Chloride, Maximum, ppm	0.15
Fluoride, Maximum, ppm	0.1

b. The equipment will normally be used during refueling for a period of approximately three weeks during which time it must operate continuously without maintenance or service.

c. The equipment is capable of operating dry for the initial reactor core loading.

d. In the event of loss of power, the equipment and its load remains in a safe condition.

e. Equipment located within the reactor containment building is capable of withstanding, without damage, the internal building test pressure.

9.8.1.2 Design Criteria

a. <u>Structural</u>

(1) Concentrations do not occur simultaneously.

1. The stresses under the combined dead weight, live and seismic loads will not exceed the allowable stress derived from the applicable design code based on properties of the material per American Society for Testing and Materials (ASTM) requirements.

2. The equipment will withstand the loading induced by the hypothetical vertical and horizontal seismic loadings which are considered as acting simultaneously on this equipment in conjunction with normal loads without exceeding material yield stresses as specified by ASTM.

3. Where required, keepers are provided to preclude derailment of equipment under seismic loading.

The following refueling equipment has been designed to seismic Category I requirements.

a. reactor polar crane

b. spent fuel cask crane

c. spent fuel pool platform crane (1)

d. new fuel elevator (1)

e. spent fuel storage racks

f. new fuel storage racks

g. permanent reactor cavity seal

h. refueling machine (1)

i. fuel transfer machine (1)

j. fuel tilting mechanisms (1)

k. fuel transfer tube and isolation valve

The refueling machine and the fuel transfer system have been designed to accept the combined dead weight, live-load, and design seismic loads acting simultaneously without exceeding the allowable stress derived from the applicable

(1) Designated Seismic Class II components but designed for Class I earthquake basis.

design code based on properties of the material as specified by ASTM requirements.

The possibility of damage to a fuel assembly as a consequence of mishandling is minimized by extensive training, detailed procedures, and equipment design. Inadvertent disengagement of a fuel assembly from the spent fuel pool platform crane or refueling machine is precluded by positive interlocks. Consequently, the possibility of dropping or damaging a fuel assembly during handling, resulting in the failure of all rods in the fuel assembly with the highest radioactive inventory is minimized. In addition, the exclusion boundary doses resulting from a fuel handling accident have been shown to be within the guideline of 10 CFR Part 50.67 and Regulatory Guide 1.183. The safety aspects of a fuel handling accident are presented in detail in Section 14.7 of the FSAR.

b. Mechanical

1. In general, all hoisting and winching components conform to the requirements of Electric Overhead Crane (EOC)1, Specification number 61 and Crane Manufacturers Association of America (CMAA) Specification number 70.

2. Hoisting units are provided with two means of braking. Electric brakes are capable of holding 100 percent of the motor stall torque and shall permit convenient adjustments. Mechanical load brakes are capable of holding the rated load of the hoist.

3. Drives imparting equipment motions other than hoisting are equipped with automatically operated brakes sized to “soft stop” conditions.

4. Hoist drives are designed to regulate the speed during lowering so as to prevent undue acceleration.

5. Sheaves are supplied with keepers to prevent the wire rope from falling off.

6. If operation of gearing in oil is required, sealed enclosures are provided. Drive mechanisms are installed in pans or similar containment to prevent spillage of lubricants. No oil is used underwater.

7. Grapples and mechanical latches which carry fuel assemblies or CEA's are mechanically interlocked against accidental opening.

8. Equipment is provided with suitable locking devices or restraints to prevent parts, fasteners, or limit switch actuators from becoming loose. In those cases where a loosened part or fastener can drop into, or is not separated by a barrier from, or whose rotary motion could propel it into the

water of the refueling cavity or spent fuel pool, these parts and fasteners are lockwired or otherwise positively captured.

9. The refueling machine is capable of removing and installing a fuel assembly at each operating location at the most adverse combined tolerance condition for the equipment, core internals and fuel assemblies.

10. Electrical limit switches and positive mechanical stops prevent the fuel from being lifted above the minimum safe water cover depth.

c. Electrical

1. Electrical equipment conforms to American National Standards Institute (ANSI) Standards C6.1, C19.1 and C50 and National Electrical Manufacturers Association (NEMA) Standards.

2. Motor housing are grounded with ground straps.

3. Each motor and related conductors is protected against running overload by the use of a separate overload device responsive to motor current, or, in the case of NEMA Design B motors on high reversing duty, by overload devices specifically selected for the applications, such as embedded thermal sensing devices.

4. Where equipment heaters are required, they conform to the following requirements:

    a. All control panels and motors are provided with heaters to maintain the temperature inside the panels above the dew point during periods of system inactivity.

    b. All heaters are supplied by an independent power supply and suitably protected with overload devices specifically designed for the application.

5. Receptacles are suitably protected by overcurrent devices that will open the power supply leads.

6. The refueling machine hoist and the spent fuel pool platform crane hoist are provided with load measuring devices with a visual display of the load and interlocks to interrupt hoisting if the load reaches the overload setpoint and interrupt lowering if the load reaches the underload setpoint.

7. The refueling machine is provided with dual redundant electric brakes.

d. Materials

1. Where wire rope penetrates the borated water, it is unlubricated stainless steel wire rope with stainless steel core. Hoisting rope is stretched to twice the normal working load. Catch pans are provided where the hoisting rope might drip on the equipment or operator.

2. Equipment which will be located or operate submerged in dilute boric acid are of austenitic stainless steel or other corrosion-resistant material.

3. In general, where 17-4 precipitation-hardened stainless steel is used in the design of the equipment, a minimum heat treat temperature of 1100°F (condition H-1100) is required.

4. Wire rope sheave units carrying stainless steel rope are fabricated of austenitic stainless steel or other corrosion resistant material. (Except for the five ton monorail hoist mounted to the spent fuel cask crane, which has a carbon steel bottom block assembly.

e. Radiological Considerations

1. All equipment is designed in an attempt to permit unrestricted access during disassembly, handling and reassembly operations.

2. Crevices in equipment have been minimized to facilitate decontamination.

f. Criticality Accident Requirements

Millstone 2 has chosen to comply with 10 CFR 50.68(b).

9.8.2 SYSTEM DESCRIPTION

9.8.2.1 System

9.8.2.1.1 New Fuel Storage

New fuel assemblies are transported by truck to the plant and into the auxiliary building in regulating agency approved containers. The new fuel assemblies are removed from the shipping containers by the auxiliary hook of the spent fuel cask crane inspected and stored in the new fuel storage racks which are designed for dry storage of 76 fuel assemblies. The arrangement of the racks is shown in Figure 9.8–1.

The new fuel assemblies with or without the CEA’s nested are stored in an environment of air, temperature of 55°F to 110°F ambient and a relative humidity of 30 to 100 percent. The base of the new fuel storage racks is located at Elevation 38 feet 6 inches. The receiving and removal operation of the new fuel assemblies into or out of the storage cells are accomplished by lateral movement of the fuel assemblies above the platform at Elevation 47 feet 6 inches and vertical movement along the vertical guide in the cell while the fuel assemblies are suspended vertically on their longitudinal axis from a special tool attached to the auxiliary hook of the spent fuel cask crane.

The new fuel storage racks are fabricated of stainless steel and consisting of vertical cells in parallel rows with a center-to-center distance of twenty and one-half inches. The new fuel storage racks are designed to the requirements defined below:

a. Structural

The structure consists of vertical elongated cells in rows and is of open construction to permit ventilation. Solid plate partitions are used as shear plates to resist horizontal loads or to transmit shear forces. The storage cells are accessible from the aisles between two rows of storage racks above a platform at Elevation 47 feet 6 inches. Guides, hold downs, and new fuel assembly bracings are provided at suitable horizontal intervals to assist receiving and removal operation as well as securing and maintaining the vertical alignment of the new fuel assembly in place for storage. Vertical guides are continuous for the full length of the fuel assemblies. The bottom plates are raised from the floor level and supported by the base of the new fuel rack. The storage rack and the base are designed to withstand all anticipated loadings, including dropping or side swinging of a fuel assembly on the rack in an accidental event. The structural deformations are limited to preclude any possibility of criticality.

The storage racks are laterally braced one to another and supported in a manner which will not permit a reduction in separation space in the event of a design earthquake. The racks themselves are designed not to collapse or bow under the force of a fuel assembly if dropped or swung against the rack.

b. Stability

The new fuel storage racks are stabilized by floor anchorage only. This system will prevent significant lateral movement of the racks, containing any number of fuel assemblies and subjected to all anticipated loads, including the design basis earthquake (DBE). An insignificant lateral movement is one which will not reduce the center-to-center distance of the cells below the safe geometry margins. The maximum displacement of any member, joint or component of the structure is within the elastic limit of the material.

c. Safe Geometry

K_{eff} for the new fuel storage racks containing adjacent fresh fuel assemblies of 5.0 percent enrichment is less than 0.95 when flooded with clean unborated water, or with low density moderation. The 5 percent enrichment used in the analysis conservatively exceeds the 4.85 percent Technical Specification limit.

All external corners of the new fuel storage racks in the path of the new fuel element when being transported or inserted into the cell for storage are rounded to prevent possible damage to the fuel element if swung against the rack.

The racks consist of eleven modules for a total of 76 cells as shown on Figure 9.8–1.

With the base of the new fuel storage racks 38.5 feet mean sea level the possibility of new fuel being flooded with sea water is precluded. The new fuel vault is situated in an area over which no large piping is routed. Therefore, the only possible source of water into the vault would be minor leakage of rainwater through the roof or wall of the auxiliary building. The walls of the new fuel vault have been provided with block-outs which would allow any water in-leakage to drain out of the vault. Also, the active part of the new fuel assembly is approximately seven inches above the floor of the vault. In addition, the 20.5 inches center-to-center spacing precludes criticality in the highly unlikely event of flooding. Figure 9.8–2 shows a cross section of the new fuel storage vault.

Figures 9.8–3 through 9.8–6 show details of the new fuel storage racks.

As shown in Figure 9.8–2, the racks are a hybrid between side and top loading racks. This design was based on preventing the placing of two new fuel assemblies adjacent to each other and to minimize the amount of overlap between assemblies during handling in the new fuel vault.

The new fuel rack closure bar is an administratively controlled device which is used to laterally support the top of fuel assembly in the rack (see Figure 9.8–6).

The rack has been designed to take an uplift force equal to the dead weight of the empty rack module.

9.8.2.1.2 Spent Fuel Storage

The spent fuel pool is located in the fuel handling area of the auxiliary building. The pool is designed for the underwater storage of spent fuel assemblies after removal from the reactor core. The heat load analysis of the spent fuel pool conservatively accounts for a total of 1349 fuel assemblies. Of these 1349 fuel assemblies, 1343 are intact fuel assemblies, and the other 6 fuel assemblies are assumed to have been consolidated into 3 Consolidated Fuel Storage Boxes. As described later in this section, there are currently 1346 physical storage locations in the spent fuel pool. The spent fuel pool is designed to maintain approximately 24 feet of borated water above the stored fuel assemblies. CEAs removed from the core are stored in the guide tubes of the fuel assemblies.

The spent fuel pool (SFP) also stores Non-standard Fuel Configurations (discussed later in this section). A Non-standard Fuel Configuration is an object containing fuel that does not conform to the standard fuel configuration. The standard fuel configuration is a 14 x 14 array of fuel rods (or fuel rods replaced by un-enriched fuel rods or stainless steel rods) with five (5) guide tubes that occupy four lattice pitch locations each. Fuel in any other array is a "Non-standard Fuel Configuration." Reconstituted fuel in which one or more fuel rods have been replaced by either un-enriched fuel rods or stainless steel rods is considered to be a standard fuel configuration.

The stainless steel storage racks consisting of vertical cells grouped in parallel rows, are designed for a center-to-center distance of 9.8 inches in Regions 1 and 2 and 9.0 inches in Regions 3 and 4. Spent fuel decay heat is removed by the spent fuel pool cooling system described in Section 9.5. The fuel storage racks are designed to the requirements defined below while maintaining a physical arrangement that results in a K_{eff} of 0.95 or less during all normal usage of the racks and under abnormal conditions. The arrangement also provides for adequate convective cooling of stored fuel assemblies.

Figure 9.8–7 provides a schematic of the spent fuel pool arrangement described below.

a. <u>Structural</u>

Region 1 consists of two 8 by 10 modules of spent fuel racks with a nominal center-to-center cell spacing of 9.8 inches. These racks contain Boraflex which is no longer credited in the spent fuel pool criticality analysis. These modules are used to store 80 fuel assemblies (up to a maximum initial planar average enrichment of 4.85 weight percent U-235) in a 2 out of 4 storage pattern as shown in Figure 9.8–7. In a 2 out of 4 storage pattern two locations in a 2 x 2 storage array (4 spent fuel storage locations) can store a fuel assembly, and the other two locations are designated as Restricted Locations as shown in Figure 9.8–7. Fuel storage rack locations designated as Restricted Locations in Figure 9.8–7 shall remain empty. No fuel assembly, no Non-standard Fuel Configuration, no non-fuel component, nor any hardware/material of any kind may be stored in a Restricted Location.(1) There are 80 Restricted Locations in this region.

Region 2 consists of two 8 by 9 modules and one 8 by 10 module of spent fuel racks with a nominal center-to-center cell spacing of 9.8 inches. These racks contain Boraflex which is no longer credited in the spent fuel pool criticality analysis. These modules are used to store spent fuel bundles that have achieved a specified fuel burnup vs. initial planar average enrichment. Region 2 also has two types of storage locations, designated Type 2A and Type 2B. Type 2A locations can store more reactive fuel assemblies than Type 2B. These modules are used to store 164 fuel assemblies in a 3 out of 4 storage pattern in which the fourth location in a 2 x 2 storage array is a Restricted Location as shown in Figure 9.8–7.

(1) Note that Region 1 and 2 SFP rack storage locations contain removable Boraflex panel boxes which house the Boraflex panels. The Boraflex panel boxes were manufactured as an integral part the original SFP racks and as such are NOT stored components in SFP rack storage locations. Criticality analysis has shown that the Restricted Locations are acceptable with or without the Boraflex panel boxes.

There are 60 Restricted Locations in this region.

Region 3 consists of twelve modules of spent fuel racks with nominal center-to-center cell spacing of 9.0 inches, which do not contain Boraflex. These modules are used to store spent fuel assemblies that have achieved a specified fuel burnup vs. initial planar average enrichment. Region 3 requires that fuel assemblies contain either three Borated Stainless Steel Poison Rodlets (installed in the assembly's center guide tube and in two diagonally opposite guide tubes), or a full length, full strength CEA (Note that credit is NOT allowed for the full-length, reduced-strength CEAs used in Cycles 1 through 6 [CEAs with serial numbers 66 through 73, inclusive] and for the part-length CEAs used in Cycle 1 [CEAs with identifier letters A through H, inclusive]). The region consists of 822 storage locations.

Region 4 consists of one 7 by 9 module and one 7 by 11 module of spent fuel racks with a nominal center-to-center cell spacing of 9.0 inches, which do not contain Boraflex. These modules are used to store spent fuel assemblies that have achieved a specified fuel burnup vs. initial planar average enrichment. These modules are used to store 100 fuel assemblies in a 3 out of 4 storage pattern with 40 Restricted Locations.

No structural changes to the storage rack modules were required as they were initially designed to withstand the static and dynamic loads resulting from the storage of both intact fuel assemblies and consolidated fuel in Regions 1, 2, 3, and 4.

The physical arrangement of the storage locations within the racks and the total number of racks provide for a total of 1346 storage locations. Of this number:

- 80 locations are available within Region 1 for the storage of any fuel assembly, with 80 cells designated as Restricted Locations

- 164 locations are available within Region 2 for the storage of fuel assemblies that meet the burnup requirements of this region, with 60 cells designated as Restricted Locations

- all 822 locations are available within Region 3 for the storage of fuel assemblies that meet the burnup requirements of this region (and contain Borated Stainless Steel Poison Rodlets or a CEA)

- 100 locations are available within Region 4 for the storage of fuel assemblies that meet the burnup requirements of this region, with 40 cells designated as Restricted Locations.

With these storage restrictions, the maximum number of rack locations usable for fuel assembly storage become:

80 Region 1 - Storage Locations (including Fuel Assemblies, Non-standard Fuel Configurations, and Non-fuel containing components)

80 Region 1 - Restricted Locations

164 Region 2 - Storage Locations

60 Region 2 - Restricted Locations

822 Region 3 - Storage Locations

100 Region 4 - Storage Locations

40 Region 4 - Restricted Locations

1346 Total Region 1 + 2 + 3 + 4 rack storage locations (including Restricted Locations)

Note that each Non-standard Fuel Configuration must have a separate criticality analysis which may allow storage in one or multiple Regions, and which may or may not require insertion of Borated Stainless Steel Poison Rodlets or a full length, full strength CEA if stored in Region 3. A list of Non-standard Fuel Configurations that have been qualified for storage in any non-restricted pool location is included later in this section.

Fuel assemblies and Non-standard Fuel Configurations shall NOT be stored in Region 1 and 2 storage locations in which the Boraflex panel box has been removed. It is permissible to store non-fuel components in non-restricted locations whether or not the location contains a Boraflex panel box.

It should be noted, however, that both the spent fuel racks and the pool/building structure have been analyzed and qualified for the conditions and maximum loadings associated with consolidated fuel stored in each of the 1346 storage locations.

The spent fuel racks in all four regions are fabricated from 304 stainless steel which is 0.135 inches thick. Each cell is formed by welding along the intersecting seams. This enables each spent fuel rack module to become a free-standing module that meets the seismic design requirements without mechanical dependence on neighboring modules or fuel pool walls for support. The rack modules are classified ANS Safety Class III and Seismic Category I.

The mechanical design of the individual storage modules provides a flow path for convective cooling of the spent fuel assemblies and consolidated fuel storage boxes through natural circulation. Safety analyses of the thermal conditions within the spent fuel pool have been performed to assure that even with the most severe expected heat load, the stored spent fuel can be adequately cooled during normal and abnormal conditions.

b. Stability

The spent fuel racks have been designed for direct bearing onto the spent fuel pool floor. An adjustable pad (Figure 9.8–8D) is provided under each corner of the fuel rack. Fuel rack module leveling is accomplished by adjusting each pad height to conform to the pool floor. Each foot can be raised or lowered one-quarter inch and can rotate two to three degrees to accommodate pool floor variations during installation.

The spent fuel storage racks are designed to withstand forces generated during normal operation, an operating basis earthquake (OBE), or a safe shutdown earthquake (SSE) with the loads associated with consolidated fuel. Lateral and vertical seismic loads along with fluid forces are considered to be acting simultaneously on the fuel racks. The racks are designed to assure rack structural integrity while at the same time keeping the fuel in a subcritical state.

The seismic analysis of the spent fuel rack includes an assessment of the maximum sliding and tipping that can be expected. The racks are installed with a nominal gap of two inches between modules and the pool walls. The analysis has shown that the maximum motion of the racks, including tipping, sliding, and thermal expansion is less than the gap between adjacent modules.

Materials for all components of the rack support system are made of stainless steel with high temperature and corrosion resistance. The design and fabrication of the system is in accordance with the American Institute of Steel Construction (AISC) and American Society of Mechanical Engineers (ASME) Codes where applicable.

c. Safe Geometry

Analyses have been performed to ensure that the multiplication factor, K_{eff} of the storage racks including all uncertainties, is less than 0.95, with a 95% probability at the 95% confidence limit, under all normal conditions with water borated to a minimum of 550 ppm, and all accident conditions with water borated to a minimum of 2100 ppm. Analyses have also been performed to ensure that the K_{eff} of the storage racks, including all biases and uncertainties, is less than 1.00, on a 95% probability at the 95% confidence limit, under all normal conditions with unborated water. These analyses cover all four (4) regions of the spent fuel pool, which are designated Regions 1, 2, 3, and 4. These analyses also address other equipment in the spent fuel pool which may hold fuel assemblies on a temporary basis, such as the new fuel elevator and the fuel transfer machine. Non-standard Fuel Configurations are also addressed by these analyses. A normal spent fuel pool water temperature range from 32°F to 150°F, and an accident condition temperature range from 150°F to boiling are bounded by these analyses.

1. Region 1, Region 2, and Region 4

Region 1 fuel storage racks do not credit fuel burnup and require fuel assembly storage in a 2 out of 4 storage pattern. Region 2 and Region 4 fuel storage racks credit fuel burnup and require storage in a 3 out of 4 storage pattern. Figure 9.8–7 shows the spent fuel rack storage patterns, including the designated Restricted Locations, for each region.

The criticality analysis for Region 1 assumes an infinite array of storage locations exist, and that 2 out of 4 storage locations are filled with fuel assemblies that have an initial planar average enrichment of 4.85 weight percent U-235. The criticality analysis for Regions 2 and 4 assumes that an infinite array of storage locations exist, and 3 out of 4 storage locations are filled with the maximum reactivity fuel assemblies allowed by the Technical Specifications. The moderator for each region is assumed to be water borated to 0 ppm for the $K_{eff} < 1.0$ case, and to a minimum level of 550 ppm for the $K_{eff} \leq 0.95$ case.

The Region 1 and 2 fuel storage racks contain Boraflex which is no longer credited as a neutron absorber.

For Regions 1, 2, and 4 the reactivity effects associated with the following manufacturing material and dimensional tolerances are accounted for: storage rack dimensional tolerances, and fuel dimensional and enrichment tolerances. Also accounted for are eccentric loading of fuel in the storage locations and calculational bias/uncertainties in the methods used to calculate K_{eff}. In addition the Regions 2 and 4 analyses account for the reactivity effects associated with axial fuel burnup variations, uncertainty in fuel isotopics, and uncertainty in the declared burnup, clad creep, fuel rod growth, and migration of volatile fission products.

2. Region 3 - Storage of Fuel Assemblies

Region 3 fuel storage racks do not contain a neutron poison. Fuel may be stored in all locations of Region 3, subject to meeting the fuel burnup restrictions specified by the Technical Specifications, and containing Borated Stainless Steel Poison Rodlets or a full length, full strength CEA (note that the criticality analysis for a given Non-standard Fuel Configuration may qualify it for Region 3 storage without these inserts). Fuel assemblies which have achieved the burnup required by the Technical Specifications and contain Borated Stainless Steel Poison Rodlets or a full length, full strength CEA may be stored in Region 3. The insertion of Borated Stainless Steel Poison Rodlets and full length, full strength CEAs are credited in Region 3. The use of Borated Stainless Steel Poison Rodlets or CEAs reduces the required fuel burnup needed for fuel storage in Region 3. When Borated Stainless Steel Poison Rodlets are installed and credited, three poison rodlets must be placed inside the fuel assembly guide tubes. The three Borated Stainless Steel Poison Rodlets must be located in the center fuel assembly guide tube and any two other guide tubes which are diagonally opposite each other. Qualified fuel assemblies containing Borated Stainless Steel Poison Rodlets or a full length, full strength CEA, as well as qualified Non-standard Fuel Configurations, may be mixed in any manner in the Region 3 storage racks.

The criticality analysis for Region 3 assumes that an infinite array of storage locations exist, all filled with the maximum reactivity fuel assemblies allowed by the Technical Specifications. The moderator is assumed to be 550 ppm borated water at the water temperature which causes the maximum K_{eff}. In Region 3, a positive moderator temperature coefficient exists, therefore, higher water temperatures give larger values of K_{eff}. A water temperature of 150°F is the largest normal spent fuel pool temperature. Spent fuel pool temperatures greater than 150°F are evaluated as accident conditions.

For Region 3 the reactivity effects associated with the following manufacturing material and dimensional tolerances are accounted for: storage rack dimensional tolerances, Borated Stainless Steel Poison Rodlet diameter and boron loading tolerances, and fuel dimensional and enrichment tolerances. Also accounted for are eccentric loading of fuel in the storage locations, calculation bias/uncertainties in the methods used to calculate K_{eff}, the reactivity effects associated with axial fuel burnup variations, uncertainty in fuel isotopics, uncertainty in the declared burnup, clad creep, fuel rod growth, and migration of volatile fission products.

3. All Regions - Non-standard Fuel Configurations

Each region of the SFP may store Non-standard Fuel Configurations, except for the Restricted Locations and locations in which the Boraflex panel box is removed. However, each Non-standard Fuel Configuration must have a separate criticality analysis which may allow storage in one or multiple Regions, and which may or may not require Borated Stainless Steel Poison Rodlets or a full length, full strength CEA if stored in Region 3.

The following list contains Non-standard Fuel Configurations which have been analyzed for SFP storage. They may be stored in all regions (except Restricted Locations and locations in which the Boraflex panel box has been removed). The list also indicates whether or not the Non-standard Fuel Configuration requires insertion of Borated Stainless Steel Poison Rodlets or a CEA if stored in Region 3. The analysis for each Non-standard Fuel Configuration concluded that the multiplication factor, K_{eff} of the storage racks including all uncertainties, is ≤ 0.95 at a 95% probability and 95% confidence level.

Non-standard Fuel Configuration	Description	Borated Stainless Steel Poison Rodlets or full length, full strength CEA Required for Region 3 Storage?
Failed Fuel Storage Grid Cage G-56	Failed fuel storage cage. Normal MP2 fuel lattice spacing	No
B&W Failed Rod Storage Container	NUSCO 40 failed rod storage basket. Contains 16 failed fuel rods and a tube with 5 fuel pellet fragments.	No
Consolidated Fuel Storage Box	Consolidated fuel from two depleted fuel assemblies in each basket.	No
Individual Rod Storage Container	Hollow stainless steel tube stored in a fuel assembly guide thimble with one failed fuel rod inside.	No
Storage Cage 8FR	Donor cage has normal assembly pitch and lattice, 52 depleted fuel pins, 12 natural enrichment pins, 86 non-fuel filler rods, and 26 empty locations.	No
Fuel Assembly P-26 (has missing fuel rod)	Failed assembly in which a fuel rod was removed and not replaced.	Yes

4. Other Equipment Which May Store Fuel on a Temporary Basis

There are two pieces of equipment in the spent fuel pool, other than the storage racks, which could store fuel on a temporary basis. They are: the new fuel elevator and the fuel transfer machine.

The new fuel elevator has been analyzed to be capable of storing a fresh 4.85 weight percent U-235 fuel assembly, and maintaining the K_{eff} of the storage racks including all uncertainties, to less than 0.95, with a 95% probability at the 95% confidence limit.

The fuel transfer machine is capable of storing two fuel assemblies. The fuel transfer machine has been analyzed to be capable of storing two fresh 4.85 weight percent U-235 fuel assemblies, and maintaining K_{eff} of the transfer machine configuration including all uncertainties, to less than 0.95, with a 95% probability at the 95% confidence limit.

5. Accident Conditions

Analyses have been performed to ensure that the multiplication factor, K_{eff} of the storage racks including all uncertainties, is less than 0.95, with a 95% probability at the 95% confidence limit, under all normal conditions with credit for 550 ppm borated water, and all accident conditions with credit for a total of 2100 ppm boron in the water.

The following conditions were considered in these analyses (Note that the following scenarios assume fuel contains zero gadolinia loading):

- Multiple misloads of 4.85 weight percent U-235 fresh fuel assemblies into Region 1 and 2 storage locations.

- Multiple misloads of higher than typical reactivity depleted fuel assemblies (initial enrichment of 4.20 weight percent U-235 and 10 GWD/MTU burnup) into Region 3 and 4 storage locations.

- Mislead or dropping of a single 4.85 weight percent U-235 fresh fuel assembly into a Region 4 storage location.

- Dropping or misplacing a 4.85 weight percent U-235 fresh fuel assembly between Region 3 and the new fuel elevator, with a 4.85 weight percent U-235 fresh fuel assembly in the new fuel elevator.

- Three 4.85 weight percent U-235 fresh fuel assemblies are allowed to touch edge to edge. This bounds a scenario in which two fresh fuel assemblies are in the fuel transfer cart and another fresh fuel assembly, by some undefined means, is allowed to come edge to edge with the fuel assembly in the transfer cart.

- Loss of pool cooling resulting in SFP temperature increase and voiding.

- Dropping of a fuel assembly or Non-standard Fuel Configuration which comes to rest on top of the racks in a horizontal position.

- Lateral rack movement due to a seismic event affecting the spacing between racks of any of the Regions.

The bounding scenario is multiple misloads of higher than typical reactivity depleted fuel assemblies (initial enrichment of 4.20 weight percent U-235 and 10 GWD/MTU burnup) into Region 3 and 4 storage locations. The analysis shows that a 2100 ppm boron concentration ensures that K_{eff} remains $\leq$ 0.95, including all uncertainties and biases.

The spent fuel shipping cask is placed in the spent fuel pool cask laydown area for loading. The spent fuel cask is designed such that spent fuel assemblies can be placed into the cask while maintaining adequate water coverage above the fuel assembly. After loading with fuel assemblies, the cask cover is fastened to the cask and the cask is transferred to the cask wash area by the spent fuel cask crane. Interlocks are provided on the cask crane to prevent handling of the shipping cask above the storage racks and stored fuel. The cask cover is fastened in place before the cask is moved from the pool to prevent the fuel assemblies from falling out in the unlikely event of a dropped cask accident. Also it prevents the cask cover from becoming a missile in the event of a dropped cask accident. While the cask is en route to the decontamination pit at elevation (+) 38 feet six inches, plastic or other means are provided to catch any contaminated water dripping off the cask. The cask is washed down with demineralized water which is drained to the radioactive processing system. Checks are made to ensure that surface contamination meets transportation regulatory requirements.

Temperature monitoring and alarm instrumentation as described in Section 9.5 are provided in the fuel pool to assure that the decay heat from the spent fuel elements is being removed. A local monitor is used to assure that proper radiation levels are maintained. Means are provided to control entry of personnel and to account for the flow of tools in and out of the area.

Figure 9.8–9 shows the physical arrangement of the ten leak collection zones of the spent fuel pool liner. Figure 9.5–1 of the FSAR shows, schematically, the leak detection equipment.

Leakage from any portion of the spent fuel pool liner would collect in one of the ten zone collector channels and would drain out of the channel into a common header. Once in the header the leakage would accumulate upstream of closed valve 2-RW-175. This accumulation would trip level switch LS-7321 which would, in turn, annunciate the appropriate alarm on the main control board.

The liner plate was manufactured under quality assurance requirements and was tested for leak tightness prior to plant operation. Therefore, no leakage is expected under normal conditions.

The spent fuel cask crane, which includes a monorail hoist, and spent fuel pool platform crane are capable of passing over the spent fuel pool. Since both are designed and analyzed for seismic Category l requirements, their failure and subsequent falling into the pool is thought to be an incredible accident and will not be considered in this discussion.

The spent fuel cask crane handles the following items in the area of the spent fuel pool:

a. The spent fuel cask.

b. The spent fuel pool bulkhead gates.

c. The new fuel assemblies.

The spent fuel cask crane (SFCC), which includes the main hoist (125 tons) and auxiliary hoist (15 tons), has been designed to meet the single failure proof requirements in accordance with NUREG-0612 and NUREG-0554. The design features will ensure that a single failure will not result in the loss of the capability of the system to safely retain the load. Load drop events are not credible for loads lifted by the SFCC when handled and rigged in accordance with the single failure criteria.

The spent fuel pool bulkhead gates are essentially 26 foot long by three foot six inches wide by one inch thick flat plates weighing approximately 5100 pounds each. The gates are normally stored on the west wall of the spent fuel storage area just south of the transfer slot and on the east wall just south of the cask laydown area transfer slot. If for some reason either transfer canal or the cask laydown area must be drained, the spent fuel cask crane moves the gate from its storage location to the transfer slot. Movement of the gates will be performed under administrative controls to ensure compliance with the heavy loads guidelines of NUREG-0612 through use of a “single failure proof” lifting system or through the use of controlled safe load paths and therefore fuel damage from a spent fuel pool bulkhead gate drop is not a credible event.

New fuel assemblies are transferred to the spent fuel pool by using a short fuel handling tool attached to the auxiliary hook of the spent fuel cask crane and transferring the new fuel assembly into the new fuel elevator located in the spent fuel pool. The new fuel assembly is handled and rigged in accordance with the single failure proof criteria of NUREG-0612. Therefore, a new fuel assembly load drop is not a credible event.

The spent fuel pool platform crane manipulates the fuel under water by means of long tools attached to the hoist. Since there is some operator handling in attaching or detaching the tools, it is conceivable that a tool could be dropped. The tools are approximately 32 feet long by three inches in diameter, weighing approximately 270 pounds. The pool water would offer practically no resistance to this shape, but the weight and drop height are small enough that no damage would be caused to rack or the fuel stored inside even if the dropped tool hit directly on a fuel assembly. It is also conceivable that a fuel assembly could be dropped while being handled over the spent fuel racks. The racks have been designed to withstand the dropping of the fuel assembly with no appreciable damage.

The rack has been designed and analyzed to take an uplift force equal to 6000 pounds. The normal capacity of the spent fuel pool platform crane is 2000 pounds, which is less than the analyzed weight so that it is unlikely that the hoist would cause any damage if it were caught on the rack and the crane's overload device failed to operate.

6. Spent Fuel Pool Dilution

Criticality analysis has shown that 600 ppm of soluble boron is sufficient under normal conditions in the SFP, to assure not to exceed the 0.95 k_{eff} design basis (including biases and uncertainties). The actual analysis shows that 550 ppm of soluble boron is sufficient to meet this k_{eff} requirement. The criticality analysis has also shown that 0 ppm of soluble boron, under normal conditions in the SFP, assures k_{eff} is maintained less than 1.00 (including biases and uncertainties). An engineering analysis of potential scenarios which could dilute the boron concentration in the SFP demonstrates that sufficient time is available to detect and mitigate a boron dilution prior to reaching 600 ppm, thus not exceeding the 0.95 k_{eff} design basis (including biases and uncertainties). It should be noted that the criticality analysis credits 2100 ppm of soluble boron in the SFP for certain accident conditions. However, a boron dilution event does not need to be considered for these conditions. This is because the simultaneous occurrence of two unlikely and independent events such as a boron dilution event and another independent accident condition is not required to be considered.

The systems which could dilute the spent fuel pool, either by direct connection to the spent fuel pool, or by a potential pipe crack/break have been analyzed. There is no automatic spent fuel pool level control system in the spent fuel pool, so that any dilution to the spent fuel pool will add water to the spent fuel pool. Therefore the addition of unborated water to the SFP will lead to increased SFP water level, and if not controlled, an overflow of the SFP.

The ability to prevent the SFP soluble boron concentration from being diluted from less than the TS minimum value of 2100 ppm (analysis was performed at 1720 ppm) to a value of 600 ppm has been demonstrated by showing that each potential dilution source meets one of the following two criteria:

- The dilution source does not have a sufficient volume of unborated water to be capable of diluting the SFP soluble boron concentration from 1720 ppm (less than the 2100 ppm TS requirement) to 600 ppm.

- The dilution source flowrate of unborated water is ≤ 200 gpm. At a dilution flowrate of 200 gpm of unborated water, at least 19 hours will be needed for the SFP soluble boron concentration to be reduced from 1720 ppm (less than the 2100 ppm TS requirement) to 600 ppm. Should a dilution occur, the water added to the SFP will eventually cause a SFP high water level alarm in the control room alarm, or be detected by the Plant Equipment Operator (PEO) detecting high SFP water levels or SFP overflow. A time of 19 hours is ample time to detect and terminate the dilution event.

7. Spent Fuel Storage in an Independent Spent Fuel Storage Installation (ISFSI)

With the installation of the Millstone ISFSI, “dry” storage of Unit 2 spent fuel on the Millstone ISFSI provides an available fuel storage option. Millstone has selected the NUHOMS ® spent fuel storage system under Transnuclear Corporation’s general license as authorized per 10 CFR 72 and approved by the NRC in Certificate of Compliance Number1004 for an Independent Spent Fuel Storage Installation.

The ISFSI is designed to accommodate on site spent fuel storage through the end of plant life including 20 year license renewal, or until transfer of the spent fuel to a DOE repository. The spent fuel storage canisters are dual purpose, designed for storage in an ISFSI per 10 CFR 72 requirements and transport off site in a spent fuel shipping cask per 10 CFR 71 requirements.

The NUHOMS ® system consists of reinforced concrete horizontal storage modules (HSMs) and steel dry shielded canisters (DSCs) assembled on a concrete pad within the site protected area boundary. System operation is totally passive crediting natural air circulation for cooling.

Spent fuel is selected based on the Unit 2 spent fuel strategy and the NUHOMS ® Technical Specification requirements for fuel qualification. The DSC consists of a shell and basket assembly, which can accommodate 32 fuel assemblies. The DSC is inserted into a transfer cask and placed in the cask laydown area of the Unit 2 spent fuel pool for fuel loading. Once loaded, the transfer cask/DSC is relocated to the cask wash pit for draining, drying, closure operations and decontamination. The transfer cask is utilized to transfer the loaded DSC to the ISFSI pad for loading into an HSM. The HSM array consists of precast concrete components forming a series of concrete storage modules for dry shielded canisters storing spent fuel.

9.8.2.1.3 Fuel Transfer Tube and Isolation Valve

A fuel transfer tube extending through the containment wall connects the refueling pool with the spent fuel pool as shown in Figure 9.8–10. During reactor operation, the transfer tube is closed by means of a manually operated isolation valve located on the spent fuel pool side of the transfer tube and a blind flange located inside the containment. Section 9.8.3.2, "Standard System Operations" describes preparation of the fuel transfer tube for refueling operations.

Section 9.8.3.2 also includes a description of actions to isolate the transfer tube at the completion of refueling operations.

The transfer tube isolation valve is bolted to the spent fuel pool end of transfer tube. The valve is supported in such a manner to allow for horizontal movement along the centerline of the transfer tube. The manual operator for the valve is designed to allow for movement of the valve due to thermal expansions and still permit operation. The valve stem extends above the operating pool water level at elevation (+) 36 feet 6 inches and designed for manipulation from the operating deck at elevation (+) 38 feet 6 inches. The valve is furnished with a spur gear operator and position indicator.

9.8.2.1.4 Spent Fuel Pool Platform Crane

The spent fuel pool platform crane consists of a bridge which spans the width of the spent fuel pool and a trolley mounted hoist that traverses the length of the bridge. The crane is located above the spent fuel pool and rides on rails set in the concrete on the north and south sides of the pool. Electric motors position the bridge and trolley over the specified rack location, new fuel elevator, transfer carriage upender, and spent fuel shipping cask.

The spent fuel pool platform crane transfers:

1. spent fuel assemblies from the upender to the spent fuel storage rack,

2. new fuel assemblies from the new fuel elevator to the upender normally via temporary positions in the spent fuel storage racks,

3. spent fuel assemblies from the spent fuel storage racks to the spent fuel shipping cask,

4. damaged or leaking fuel assemblies into a special container which, in turn, is placed into a special damaged fuel shipping cask,

5. spent fuel assemblies to and from the new fuel elevator for inspection

   In addition, the spent fuel pool platform crane may be used for retrieving dropped items from the spent fuel pool or to place in and retrieve from the pool various items that may be stored in the spent fuel pool for radioactive decay.

6. CEAs in the spent fuel storage racks.

9.8.2.2 Components

9.8.2.2.1 New Fuel Storage Racks

The new fuel storage racks are a welded construction of stainless steel to provide dry, vertical storage for 76 assemblies. The new fuel assemblies are placed into the rack through the top of the new fuel storage rack. All welding of the racks conforms to the applicable requirements of ASME Section VIII.

9.8.2.2.2 Design and Fabrication of Spent Fuel Racks

The modules of Regions 1, 2, 3, and 4 are designed and licensed to store fuel with a maximum initial planar average enrichment of 4.85 weight percent U_{235} depending on the fuel history and the specific requirements of the respective Region of the spent fuel pool where the fuel is to be stored.

The spent fuel storage racks are fabricated with 304 stainless steel having a maximum carbon content of 0.065 percent, with a 304 stainless steel module wall thickness of 0.135 inches. The racks are monolithic honeycomb structures with square fuel storage locations as shown in Figure 9.8–8A. Each storage location is formed by welding stainless steel sections along the intersecting seams, permitting the assembled cavities to become the load bearing structure, as well as framing the storage cell enclosures. Each module is free standing and seismically qualified without mechanical dependence on neighboring modules or pool walls. This feature allows remote installation (or removal if required for pool maintenance). Reinforcing plates at the upper corners provide the required strength for handling. The racks are designed to withstand the dropping of a fuel assembly or a consolidated storage box onto the top of the racks with no loss of design function. Figure 9.8–7 shows the arrangement of Regions 1, 2, 3, and 4 modules in the Millstone Unit Number 2 pool, including the Restricted Locations.

Stainless steel bars, which are inserted horizontally through the rectangular slots in the lower region of the module, support the fuel assemblies. The support bars are welded in place and support an entire row of fuel assemblies. The module is supported by adjustable pads to facilitate leveling at installation.

Loading of the fuel racks is facilitated via movable lead-in funnels. The openings of the funnels are symmetrical. The funnels are placed on top of the rack module.

Regions 1 and 2 have a combined maximum total of 244 locations available for storage. Each storage location, including Restricted Locations, contains or contained a Boraflex poison insert which is no longer credited. Some storage locations may have their Boraflex panel boxes removed. Fuel assemblies and Non-standard Fuel Configurations shall NOT be stored in locations where these boxes have been removed (it is permissible to store non-fuel components in these locations except for the Restricted Locations). These inserts are made up of Boraflex sheets enclosed, but not sealed, between two stainless steel sheets. The neutron absorbing material, Boraflex, is designed to be compatible with the pool environment. Positive venting of the poison is provided by the three-eighth inch diameter hole in the inner walls of the inserts. The stainless steel sheets are configured such that a minimum water gap is maintained between the insert and the cell wall. These inserts lock into the storage cavity using a spring locking mechanism on the upper end which snaps into a hole in the surrounding cell wall. These poison inserts are neutron absorbers. A typical Region 1 and 2 fuel rack module and poison box is shown in Figures 9.8–8A and 9.8–8C.

The neutron absorbing material, Boraflex, existing in Regions 1 and 2 spent fuel racks is manufactured by Brand Industrial Services, Inc., and fabricated in accordance with the quality assurance criteria of 10 CFR 50, Appendix B. Boraflex is a silicone based polymer containing fine particles of boron carbide in a homogeneous, stable matrix.

Region 3 consists of a maximum of 822 storage locations with no Restricted Locations, and spent fuel assemblies and qualified Non-standard Fuel Configurations can be stored in these locations. Region 3 employs a combination of burnup credit and insertion of Borated Stainless Steel Poison Rodlets or a full length, full strength CEA for reactivity control (Non-standard Fuel Configurations may be qualified for Region 3 storage without insertion of Borated Stainless Steel Poison Rodlets or a CEA).

Region 4 has a maximum of 100 storage locations available for storage of fuel assemblies and Non-standard Fuel Configurations, and also employs burnup credit for fuel assemblies.

Regions 3 and 4 are reserved for fuel that has sustained a specified burn-up and for qualified Non-standard Fuel Configurations. The spent fuel rack design is based on the criticality acceptance criteria specified in Revision 2 of Regulatory Guide 1.13 (1981 draft version [(1)]) which allows credit for reactivity depletion in spent fuel. (Previously, the physics criteria for fuel stored in the spent fuel pool were defined by the maximum unirradiated initial enrichment of the fuel.) A typical Region 3 and 4 module is shown in Figure 9.8–8B.

The entire fuel assembly storage rack is constructed of type 304 stainless steel. All welded construction is used in the fabrication of the fuel assembly storage rack. Design of the individual cells provides assurance of smooth, snag free passage in the storage cavities so that it is highly improbable that a fuel assembly could become stuck in the rack.

The storage racks are structurally sized in accordance with ASME Boiler and Pressure Vessel Code, Section III, Subsection NF, design allowable stress limits. Welding is performed in accordance with ASME Boiler and Pressure Vessel Code, Section IX. The spent fuel racks are Seismic Category I, Quality Class 2 structure, ANS Safety Class III.

9.8.2.2.3 Reactor Refueling Machine

The reactor refueling machine is shown in Figure 9.8–11. The refueling machine is located above the refueling pool and rides on rails set in the concrete on each side of the pool. The refueling machine consists of a bridge which travels along the north-south axis, a trolley which travels along the east-west axis on the bridge, and a hoist which raises and lowers fuel assemblies with the grapple. The grapple is a pneumatically-operated, rotating hook which engages the fuel

(1) The 1981 draft of Revision 2 of Regulatory Guide 1.13 was referenced in the Millstone Unit 2 spent fuel pool storage expansion licensing amendment request submitted in 1985. The NRC approved this request in 1986 (Amendment Number 109). Subsequently, the final version of the Revision 2 of Regulatory Guide 1.13, approved in 2007, removed discussion of credit for reactivity depletion in spent fuel.

assembly. The hoist lifts the fuel assembly and the grapple mechanism into the refueling machine's hoist box, which is then lifted into the refueling machine's mast, which acts as a protective shroud around the hoist box and fuel assembly. The hoist, hoist box, mast and grapple mechanism are all supported from the trolley.

Bridge, trolley, and hoist drives are variable speed with a range of 0 to 50 ft/min on the bridge, 0 to 30 ft/min on the trolley and 0 to 40 ft/min on the fuel hoist. All other devices on the RFM operate at a single speed. Operating speeds of the air actuated devices (grapple and spreader) are adjustable at a pneumatic control panel.

The refueling machine has three (3) modes of operation; automatic, semi-automatic and manual. All three axes of motion can be controlled via handwheels in the event that the control system is inoperable.

9.8.2.2.3.1 RFM Control System

The RFM control system monitors all hoist movements using dual-redundant position encoders on all three axes of movement, a load weighing system and the following condition detection limit switches:

- Slack Cable
- Fuel Spreader Retracted
- Fuel Spreader Extended
- Grapple Closed
- Hoist-up Limit
- Hoist Box Latched
- Grapple Open

The RFM control console is installed on the trolley deck during refueling operations only and moved to a storage location at the conclusion of refueling operations. All external electrical connections to the Control Console are made by quick-disconnect connectors. The console has a horizontal shelf and a vertical panel. The horizontal shelf has a control panel which contains the operating controls and indicator lights for the bridge, trolley and hoist mechanism, an operator consolet with an analog joystick for each axis of movement and grapple and fuel spreader control switches. The vertical panel contains additional indicator lights, override and emergency stop push buttons, hoist load meter, computer monitor and position readouts. The control console also includes a Gai-Tronics jack, phone and speaker to support refueling communication needs.

9.8.2.2.3.2 Bridge and Trolley

The bridge is operated by moving the joystick towards the FORWARD or REVERSE positions, the trolley is operated by moving the trolley joystick towards the LEFT or RIGHT position. Speed is determined by how far the joystick is displaced from the neutral position. The refueling machine control system monitors all bridge and trolley movements using dual-redundant, rack and pinion encoders. In the event of a power loss or emergency stop, the bridge brake will set and stop the bridge with a deceleration less than 0.1g and the bridge encoders will not lose track of the bridge position. The trolley will brake to a complete stop and the trolley encoders will not lose track of the trolley position. Both electric brakes can be manually released for handwheel operation. The trolley also features two deck-mounted viewing windows and a pneumatic control panel which operates the fuel grapple, fuel spreader and hoist box latch and a camera system that provides operators with an overall view of the area under the trolley deck.

9.8.2.2.3.3 Hoist

The main fuel hoist lifts and lowers the hoist box assembly and consists of an AC servo motor, motor drive, gearbox, two (2) electric-brakes, hoist drum, hoist cable and a limit switch. The hoist is mounted on the trolley and has a rated capacity of 3590 pounds. The main fuel hoist is operated by moving the hoist joystick in the RAISE and LOWER position. Speed is determined by how far the joystick is displaced from the neutral position. The refueling machine control system monitors all hoist movements using dual-redundant, stainless steel tagline encoders. The load weighing system provides a six (6) position selector switch on the control console to choose the fuel type, and thus adjust the individual setpoints for each type.

The mast is equipped with a retractable stop called the Latch, located near the top of the mast. During operation over the upender, the hoist box automatically engages this stop to hold it in its upper, retracted, position. When the weight of the hoist box is transferred to the Latch, a “Hoist Box Latched” message is displayed on the touch screen, indicating the hoist box is supported by the Latch. The hoist is latched automatically when the refueling machine is over the upender area, and unlatched automatically when it is not over the upender area.

9.8.2.2.3.4 Mast/Hoist Box

The mast is a vertically-oriented, cylindrical structure supported by the trolley. Mounted within the mast is the hoist box. The hoist box descends from the mast when the hoist is lowered. The grapple is rotated to an Open position via a pneumatic mechanism. Lowering the grapple further allows it to pass over the top fitting of the fuel assembly. The grapple is rotated to a closed position, engaging the fuel assembly. The hoist raises the fuel assembly and the grapple mechanism into the hoist box, which is then lifted into the mast, which acts as a protective shroud around the hoist box and fuel assembly. The hoist box is equipped with a fuel spreader to ensure adequate spacing between fuel assemblies. The mast can also be manually rotated via a hand wheel.

9.8.2.2.3.5 Auxiliary Hoist

The RFM Auxiliary Hoist is rated to 1,000 pounds capacity and includes a motorized trolley, load cell and pendant. The pendant is used for manual control of the auxiliary hoist, its trolley and the RFM bridge. The pendant also contains local load and height indicators and can be used to initiate an Emergency Stop. The auxiliary hoist travels along the east-west axis on the monorail frame mounted to the RFM bridge. The auxiliary hoist contains a load setpoint module which will limit upward hoist travel. In the event of a power loss, the auxiliary hoist will brake to a complete stop. The electric brake can be released for manual handwheel operations.

9.8.2.2.3.6 Modes of Operation

In Manual mode, control of all axes of motion (bridge, trolley and hoist) is accomplished using joysticks that provide analog speed commands to the PLC. All RFM travel boundaries, operator displays, and safety interlocks remain functional. Arrows will indicate bridge and trolley positions as the RFM moves in response to joystick commands. The encoder positions associated with the desired location will also be displayed for numerical comparison with the instantaneous position indications on the control console. Once over the core, hoist speed icons will indicate regions where the hoist may operate at high speed or low speed.

In Semi-automatic mode, the Operator manually enters a destination coordinate via the touchscreen. The bridge and the trolley will move simultaneously toward the destination coordinate. Hoist motion will be controlled manually along with the grapple.

Automatic mode includes all features of the Semi-automatic Mode with the added capability to execute a sequence of movements based on fuel management software stored on the computer. The sequence of movements will be displayed on screen. Operators will have the opportunity to verify each move before it is executed.

Interlock override mode allows the operators full control of the RFM in the event of a PLC failure. Interlock override mode bypasses the PLC via a key switch on the control console. With the PLC bypassed, the RFM will operate as commanded by the operators at intermediate speeds (Trolley - 5 ft/min, Bridge and Hoist - 10 ft/min) with no regard to PLC programmed travel limits and interlocks. The Hoist Up Limit and Slack Cable Limit switches will still prevent hoist movements in the up and down direction.

All three axis of motion can also be controlled via handwheels in the event that the control system is inoperable.

9.8.2.2.4 Transfer Carriage

A transfer carriage conveys the fuel assemblies between the refueling pool and the spent fuel storage area. Large wheels 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 mechanisms. The carriage is driven by steel cables connected to the carriage and through sheaves to its driving winch mounted on the operating floor located on the spent fuel pool side. A two-pocket fuel carrier is mounted on the carriage and is pivoted for tilting by the upending machines.

The support for the replaceable rails on which the transfer carriage rides are welded to the 36 inch diameter transfer tube. The rail assemblies are fabricated to a length which will allow them to be lowered for installation in the transfer tube. There are no rails in the valve on the fuel storage side of the transfer tube to allow closing of the valve.

9.8.2.2.5 Upending Machine

Two upending machines are provided, one in the containment refueling pool and the other in the spent fuel pool. 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. Two hydraulic cylinders, attached to both the vertical and horizontal positions required by the fuel transfer procedure. Each hydraulic cylinder can perform the upending operation and can be isolated in the event of its failure. A long tool is also provided to allow manual rotation of the fuel carrier in the event that both cylinders fail or hydraulic power is lost.

9.8.2.2.6 Reactor Vessel Head Lifting Rig

The reactor vessel head lifting rig is shown in Figure 9.8–13.

The lifting rig is composed of a removable three part lifting frame and a three part column assembly which is attached to the reactor vessel closure head. The column assembly supports the three hoists which are provided for handling the hydraulic stud tensioners, the studs, washers and nuts, and links the lifting frame with the reactor vessel head.

The weight of the reactor vessel head, with the lift rig, CEDMs and CEDM cooling shroud attached, is approximately 140 tons and its shape is approximated by a right circular cylinder 17 feet in diameter and 37 feet high. The maximum height above the reactor vessel flange to which the reactor vessel head may be lifted is 30 feet. In operation, the head with lift rig attached will be lifted above the vessel only as high as required to clear the control element drive mechanism (CEDM) extension shafts, approximately 28 feet.

The equipment used in lifting the reactor vessel head, namely the head lift rig and the reactor polar crane, is analyzed for Seismic Class I requirements and has been manufactured under the quality assurance supervision of a “Q-Listed” item.

9.8.2.2.7 Core Support Barrel Lifting Rig

The core support barrel lifting rig, shown in Figure 9.8–14, is provided to withdraw the core barrel from the vessel for inspection purposes. The upper clevis assembly is a tripod shaped structure connecting the lifting rig to the containment crane lifting hook. The lifting rig includes a spreader beam providing three attachment points which are to be threaded to the core support barrel flange. This is accomplished manually from the refueling machine bridge by means of the lifting bolt torque tool. Correct positioning of the lifting rig is assured by attached guide bushing which mate to the reactor vessel guide pins.

9.8.2.2.8 Upper Guide Structure Lifting Rig

The upper guide structure (UGS) lifting rig is shown in Figure 9.8–15.

This lifting rig consists of a delta spreader beam which supports three columns providing attachment points to the UGS. Attachment to the upper guide structure is accomplished manually from the working platform by means of lifting bolt torque tools. The integral ICI hoist connects to an adaptor which is manually attached to the ICI structure by utilizing an adapter torque tool The ICI is then lifted by the crane hook. The upper clevis assembly, which is common to this and the core support barrel lifting rig, is installed prior to lifting of the structure by the crane hook. Correct positioning is assured by attached bushings which mate to the reactor vessel guide pins.

The weight of the UGS and lift rig is approximately 58 tons and its shape can be approximated by a right circular cylinder 14 feet in diameter and 44 feet in height. The maximum height to which the UGS may be lifted is approximately 18 feet. The normal lift height is approximately 13.5 feet.

The equipment used in lifting the UGS, namely the UGS lift rig and the reactor polar crane, is analyzed for seismic Category I requirements and has been manufactured under the quality assurance supervision as outlined in Appendix 1B (located in the original FSAR dated August 1972). In addition the maximum capacity of the reactor polar crane is 160 tons which is approximately 100 tons greater than the lift weight of the UGS.

9.8.2.2.9 Stud Tensioners

Hydraulically operated stud tensioners are used to apply and remove the preload on the reactor vessel head closure studs. These tensioners are suspended from electric hoists which are attached to the head lift rig. The tensioner assemblies, when placed over the studs, rest upon the reactor vessel head flange. An internal socket is attached to the stud by engagement with the stud upper threads and when hydraulic pressure is applied to the stud tensioner pistons, the studs are elongated a predetermined amount. After closure nuts are seated, the hydraulic pressure is released which result in the preload necessary to maintain the seal between the reactor vessel and the reactor vessel head.

A portable pumping unit mounting on a two-wheel truck is the source of hydraulic power. Two air-operated pumps connected in parallel produce the hydraulic pressure which is routed by hose to the tensioner pistons. The control panel contains an air gauge indicating the regulated air pressure and air valve for operating the pump. An hydraulic gauge showing the pump pressure is also provided as is the hydraulic valve.

9.8.2.2.10 Surveillance Sample Handling Tool

The tool is of simple tubular construction and is approximately 40 feet long to allow it to be operated from the refueling machine. It has a female acme thread on the end which mates with a male thread on the sample holder. Rotation of the tool handle threads the tool to the holder and also unlocks the latching mechanism, which allows removal of the holder by use of the overhead crane. (Figure 9.8–16).

9.8.2.2.11 Mechanism Uncoupling Tool

This tool is approximately 17 feet long and consists basically of two concentric tubes with a funnel at the end to facilitate engagement with the extension shafts. When installed, pins attached to the outer tube are engaged with the extension shaft outside diameter and the pins carried by the inner tube are inserted in the inner operating rod of the extension shaft. The inner tube of the tool is then lifted and rotated relative to the outer tube which compresses a spring allowing the gripper to release, thus separating the extension shaft from the CEA. The extension shaft is then handled by the tool.

9.8.2.2.12 Underwater Television

The underwater television camera has been removed from the Fuel Hoist Assembly for the Reactor-Refuel Machine. An updated video camera system is utilized during fuel movement activities.

9.8.2.2.13 In Mast Sipping Equipment

An in mast sipping system is provided to test irradiated fuel assemblies for fuel cladding defects. This system consists of both permanently mounted components and a portable skid that is set onto the refueling machine trolley when a sipping test is to be performed. The in mast sipping system takes a water sample from around each fuel assembly as it is lifted from the core into the mast. The water soluble and/or gaseous fission products escaping from a failed fuel rod during this handling process are drawn from the mast region of the fuel assembly handling machine through tubing, degassed continuously, and the gas is directed to a detector. The detector measures the fission products and determines the isotopes present. A determination of fuel integrity can be made based upon the concentrations and types of isotopes present. The sample system is then directed back to the refuel cavity and released below the water surface.

The tubing and nozzles are permanently installed. The sampling detectors and other equipment are part of the portable skid installed onto the refueling machine for each refueling that sampling is required.

9.8.2.2.14 Hydraulic Power Package

The hydraulic power package provides the motive force for raising and lowering the upender with the fuel carrier. It consists of a stand containing a motor coupled to a hydraulic pump, a sump reservoir, valves and the necessary hoses to connect the power package to the hydraulic cylinders on the upender. The valves can be lined up to actuate either or both upender cylinders. The hydraulic fluid is deionized water.

9.8.2.2.15 Fuel Transfer Tube and Isolation Valve

The 36 inch diameter transfer tube is contained in a 42 inch diameter tube which is sealed to the containment. The two concentric tubes are sealed to each other by a welding ring on the refueling pool side and a bellows-type expansion joint on the spent fuel pool side. The transfer tube is fabricated of ASTM-A-358, Type 304 material. All welding on the tube is in accordance with the requirements of ASME Section VIII, where applicable.

Description of the transfer tube isolation valve is given in Table 9.8-1.

9.8.2.2.16 Spent Fuel Pool Platform Crane

The general arrangement of the spent fuel pool platform crane is shown in Figure 9.8–17. The crane travel limits are shown in Figure 9.8–18. Details of the crane are given in Table 9.8-2.

The crane is provided with two hold-down bars bolted to each truck frame with the flange extending under the head of the rail to preclude derailment under seismic loads.

Bumpers - Four heavy duty spring bumpers are provided at the ends of each bridge truck to prevent crane derailment and smooth stopping. The bridge and trolley are provided with encoders as discussed in Section 9.8.4.1.10.

The factor of safety for the crane is 5.0, except that a factor of 10 is used for cables.

Welded fabrication is in accordance with the latest American Welding Society (AWS) Standard Specification for Welded Highway and Railway Bridges (AWS D2.0). Structural components of the crane which are not to be submerged in the spent fuel pool are fabricated from ASTM A-36 material or equal.

Structural components of this equipment which are designed for submerged service or come in contact with components which have been, are fabricated of austenitic stainless steel.

All three motions of this equipment (bridge, trolley, hoist) may be accomplished manually.

9.8.2.2.17 Spent Fuel Cask Crane

The spent fuel cask crane, located in the auxiliary building as shown in Figure 9.8–19, is described in Table 9.8-3.

9.8.2.2.18 New Fuel Elevator

The new fuel elevator provides a means of lowering new fuel assemblies from the fuel handling area at elevation (+) 38 feet 6 inches down to a level where the spent fuel platform crane can pick up the assembly by means of the long fuel handling tool. The elevator consists of carriage, that is similar in design to a spent fuel storage rack cell, that rides on a track mounted to imbeds in the spent fuel pool wall. Motive force is provided by an electric motor through a winch with redundant hoisting cables. Electric interlocks are provided to give a “soft stop” at both the upper and lower limits of travel. All wetted parts are of stainless steel.

The new fuel elevator is also used as a spent fuel inspection stand. A manually operated turntable on the bottom of the carriage rotates the spent fuel assembly in front of a portable underwriter TV camera to allow inspection. Raising and lowering of the elevator allows full length inspection. An electrical interlock prevents raising of a spent fuel assembly above the minimum shielding depth. A mechanical interlock provides backup should the electrical interlock fail.

9.8.2.2.19 Spent Fuel Inspection Machine
(Deleted - Equipment Permanently Removed)

9.8.2.2.20 Heated Junction Thermocouple Handling Canister Design

The heated junction thermocouple (HJTC) probe handling hardware configuration is shown on Figure 9.8–20. The Grayloc flange is disassembled, and a protective bullet nose assembly is screwed onto the HJTC probe seal plug. The hub adapter is lowered over the bullet nose onto the Grayloc seal ring and secured (hand tight) using the Grayloc clamp assembly. The handling canister is then positioned over the bullet nose assembly and a cable is attached to the bullet nose assembly. The handling canister is then lowered over the bullet nose assembly with the weight of the handling canister supported by the overhead crane. The cable assembly supporting the HJTC Probe is then tied off to a lanyard attached to the canister. The winch at the base of the canister is removed with quick disconnect pins. The handling canister assembly, with the HJTC probe inside, is then removed to the storage area using the overhead crane. The operation is then repeated for the other HJTC probe location with a second handling canister. After the reactor vessel head has been reinstalled, the above procedure is reversed to reinsert the HJTC probes. Some of the specific features for the design of the handling hardware are as follows:

a. The bottom zone of the canister contains sealed attenuating material such that exposure to personnel from the HJTC probe will be kept reasonably low. Estimated radiation levels are provided in Table 9.8-5.

b. The attenuating material is encapsulated in stainless steel.

c. A winch, attached to the base of the canister with quick release pins, is operated by one man. The man would be standing on a work platform above the control rod drive mechanism housings. (Work would be done in parallel with the other normal head area work.)

d. Modifications to the head lift rig or any head area components are not required for probe handling.

e. The reactor head area/control rod drive (CRD) mechanism area is left completely unencumbered and servicing of the drive mechanisms and underside of the head may be performed without increased personnel radiation exposure and without risk of damage to the probes.

f. The weight of a handling canister is maintained at less than 1500 pounds, including the attenuating material.

g. A removable drop catcher is provided on the bottom of the handling canister to prevent water dripping while the canister is being transported from the reactor vessel to the storage area.

h. A hub adapter is provided to protect the Grayloc seal ring surface and to pilot the lower end of the handling canister.

9.8.3 SYSTEM OPERATION

9.8.3.1 New Fuel Transfer

New fuel assemblies are removed from their regulatory agency approved shipping containers inspected and placed in the new fuel storage racks or in the new fuel elevator. This is accomplished by using a short fuel handling tool attached to the auxiliary hook of the spent fuel cask crane. New CEAs are inserted into the guide channels of the fuel assemblies while the new fuel is in the new fuel elevator.

Prior to the start of reactor refueling operations the new fuel is removed from the new fuel storage racks and transferred to the new fuel elevator. This operation is accomplished by the auxiliary hook of the spent fuel cask crane and the short fuel handling tool.

The new fuel elevator lowers the fuel assembly down into the spent fuel pool where the spent fuel pool platform crane transfers the fuel assembly normally to a spent fuel rack, or, directly to the spent fuel pool side upending mechanism. Interlocks are provided to prevent the spent fuel pool platform crane from lowering the fuel assembly unless the upender is in the vertical position. Interlocks are also provided to prevent raising or lowering the upender if the spent fuel platform crane is in the upender zone with the hoist below the hoist-clear elevation. The spent fuel platform crane attaches to the fuel assemblies by means of a long fuel handling tool. After the spent fuel platform crane has placed a new fuel assembly in the upending mechanism, it removes a spent fuel assembly from the other position of the upending mechanism and transfers the spent fuel to a designated position in the spent fuel storage racks.

9.8.3.2 Standard System Operations

Refueling operations are initiated with the removal of the missile shield from over the reactor. The CEDMs are disengaged from their drive shaft extensions by de-energizing the electromagnets, and both CEDM and ICI cabling are disconnected in preparation for head removal. The stud tensioners are employed to remove the vessel head studs which are then removed and stored. Plugs are installed to protect the empty stud holes and two alignment pins are placed to assist in subsequent operations. The CEDM coolant shroud is disconnected from its duct work and the vessel vent line removed. The hatches in the reactor vessel cavity seal are closed to prevent water from entering the lower portion of the vessel cavity. A lifting frame is then installed on the head assembly and, by means of the containment building overhead crane, the head is removed to its storage location.

A fuel transfer tube extending through the containment wall connects the refueling pool with the spent fuel pool as shown in Figure 9.8–10. During reactor operations, this transfer tube is isolated by (1) a manually operated isolation valve that is outside containment and within the fuel transfer canal and (2) a blind flange located inside containment.

During preparations for filling the refueling pool for refueling operations, the blind flange on the fuel transfer tube is removed.

Following verification that the water inventories of the spent fuel pool, fuel transfer canal and refueling pool are at a common elevation, the isolation valve of the fuel transfer tube is opened.

Using the refueling machine walkway as a work platform, the CEDM drive shaft extensions are disconnected from their CEAs by means of tools hung from the polar crane and the refuel machine. The UGS lift rig is installed and the ICI plate is withdrawn into the UGS and locked in place.

Provision is made in the refueling pool for the temporary storage of the UGS of the reactor vessel internals.

9.8.3.3 Refueling Operations

The normal fuel management sequence is initiated by positioning the refueling machine hoist above the desired fuel assembly in the core. The operators lower the hoist until it stops at the UPPER GRAPPLE OPERATING ZONE (UGOZ), the indicator illuminates and the operator energizes the grapple mechanism which rotates to OPEN the grapple. When the SPREADER is fully extended, the hoist is lowered until it stops at the LOWER GRAPPLE OPERATING ZONE (LGOZ), the indicator illuminates and the operator energizes the grapple mechanism to close the grapple onto the fuel assembly. The hoist motor is started and the fuel assembly is withdrawn into the hoist box which protects the fuel assembly during the traverse to the upender. The hoist is raised until the HOIST UP LIMIT is reached, then the hoist will automatically stop. The grapple has been designed to preclude inadvertent disengagement as the fuel assembly is lifted vertically from the core. Grapple operation is interlocked both mechanically and electrically to permit grapple actuation only in two operating zones UGOZ and LGOZ. Due to the mechanical interlocks, the grapple must be closed while it is being raised or lowered within the hoist box.

After removal from the core, the spent fuel assembly is lowered into one of the two fuel carrier pockets located in the refueling pool upender. The refueling machine ungrapples the spent fuel assembly, raises the hoist and returns to the reactor core to move the next fuel assembly in accordance with the fuel management procedure. Under certain fuel management procedures, the refueling operator then repeats the process and removes another spent fuel assembly and traverses to the refueling pool upender and the second spent fuel assembly is lowered into the second of the two fuel carrier pockets.

The upender lowers the fuel carrier to the horizontal position and the cable drive transports the carriage through the fuel transfer tube to the spent fuel pool upender. Once received in the spent fuel pool upender, the upending mechanism raises the fuel carrier to the vertical position. The spent fuel pool platform crane removes the spent fuel assemblies and places them into predetermined spent fuel rack locations. The fuel carrier is lowered to the horizontal position and returned to the refueling pool for one or two more spent fuel assemblies or the spent fuel platform crane operator grapples a new fuel assembly and traverses to the spent fuel pool upender in accordance with the fuel management procedure.

When the fuel carrier returns to the refueling pool upender, the fuel carrier is raised to vertical and the refueling machine operator either removes the new fuel assembly from the fuel carrier and transfers it to the core or places another spent fuel assembly into the fuel carrier. This sequence is repeated until the refueling sequence is completed.

For transferring CEAs among fuel assemblies in the refueling pool, a CEA handling tool attached to the auxiliary hoist of the refueling machine is used. For transferring CEAs among fuel assemblies in the spent fuel storage racks within the spent fuel pool, a CEA handling tool attached to the spent fuel pool platform crane is used (refer to Section 9.8.2.1.4).

Neutron sources are transferred between fuel assemblies in the spent fuel pool via a tool manipulated from the spent fuel platform crane. Capsules containing surveillance samples are removed from the reactor vessel assembly utilizing a tool manipulated from the refueling machine which then transports them to the upender station for insertion into a container similar to a dummy fuel assembly. The transfer carrier transports the container with the surveillance capsules to spent fuel storage area for eventual disassembly and sample evaluation.

In mast sipping of fuel assemblies can be conducted, if required, during normal fuel handling operations. A removable control console is installed on the refueling machine with connections to the tubing within the refuel mast. The in mast sipping takes a water sample from around each fuel assembly as it is lifted from the core into the mast. The water soluble and/or gaseous fission products escaping from a failed fuel rod during this handling process are drawn from the mast region of the fuel assembly handling machine through tubing, degassed continuously, and the gas is directed to a detector. The detector measures the fission products and determines the isotopes present. A determination of fuel integrity can be made based upon the concentrations and types of isotopes present. The sample stream is then directed back to the refuel cavity and released below the water surface.

9.8.3.4 Refueling Restoration

At the completion of the refueling operation, the transfer valve is manually closed. The UGS is reinserted in the vessel and the ICI plate placed in position. The drive shaft extensions are reconnected to the CEAs. The water in the refueling pool is lowered, utilizing one of the low-pressure safety injection (LPSI) pumps or one of the purification pumps. The head is then lowered until the drive shaft extensions are engaged by the CEDMs. Lowering of the head is continued until it is seated. Then the head is bolted down, and the transfer tube blind flange installed. The hatches in the cavity seal between the reactor vessel flange and the pool are opened to permit cooling air flow. The CEDM and ICI cabling is reconnected. The coolant ducting is reconnected to the shroud, the vessel vent piping installed, and the missile shield placed in position.

9.8.3.5 Emergency Conditions

The failure mode analysis is shown in Table 9.8-4.

9.8.4 AVAILABILITY AND RELIABILITY

9.8.4.1 Special Features

9.8.4.1.1

The new fuel storage racks are designed to maintain the minimum center-to-center distance necessary to preclude criticality of the new fuel even with unborated water. In addition the structural design precludes any deformation of the racks during earthquake loads, that would reduce the center-to-center spacing to a point where the new fuel would approach criticality.

9.8.4.1.2

The spent fuel storage racks are designed to maintain the minimum center-to-center distance necessary to preclude criticality of the spent fuel even with unborated water under normal operating conditions. In addition the structural design prevents deformation of the racks that reduces the center-to-center spacing to a point where the spent fuel would become critical due to a DBE or a dropped fuel assembly (horizontal) on top of the storage racks. The structure provides for adequate convective cooling of stored fuel assemblies.

9.8.4.1.3

Reliability of the fuel handling equipment including the bridge and trolley, the lifting mechanisms, the upending machines, the transfer carriage, and the associated instrumentation and controls has been assured through implementation of pre-operational tests and routines. Prior to the first actual fuel loading, the equipment was cycled through its operations using dummy fuel. In addition, the following special features of the equipment assure safe and reliable operation:

9.8.4.1.4

Provision for seismic loading is made by proper sizing and arrangement of the structure and components of the equipment. Where required, mechanical means (clips, guide tools, etc.) are utilized to prevent overturning or derailing of the equipment during an earthquake.

9.8.4.1.5

A bumper ring mounted on the refueling machine mast interrupts the bridge and trolley drives should the mast be driven into an obstruction. This feature prevents damage to either the refueling machine or to members or components into which it may be driven.

9.8.4.1.6

The three major subsystems of the overall fuel handling complex (Refueling Machine, Spent Fuel Pool Platform Crane and Fuel Transfer System) are electrically interlocked within each other and conjointly with each other to prevent incorrect and potentially damaging sequences of operation. These interlocks accomplish the following:

a. Bridge, trolley and hoist speeds are restricted in areas where fuel assemblies are handled near potential interferences.

b. Hoist drives cannot be operated if either the bridge or trolley drives are operating.

c. Up motion of the hoist is stopped if the hoist is at the up limit or if the hoist is overloaded.

d. Hoist down motion is stopped if the hoist load is below a preset limit or if the cable is slack.

e. The refueling machine bridge and trolley drives may not be actuated when the spreader device is extended.

f. The refueling machine bridge and trolley are inoperative if the fuel hoist is in or below the Upper Grapple Operate Zone (UGOZ), or during interlock override at creep speed only.

g. The refueling machine hoist cannot be raised if the grapple is above the Upper Grapple Operating Zone (UGOZ) and is not closed.

h. The refueling machine hoist is latched automatically when the machine is in the upender zone and unlatched automatically when it is outside the upender zone.

i. The refueling machine fuel spreader cannot be extended when the machine is in the upender zone.

j. The refueling machine hoist cannot lower if in the upender zone and the upender is not vertical.

k. The upender cannot raise or lower if the refueling machine is in the upender zone and the hoist is not in the full up position.

l. The spent fuel pool platform bridge cannot traverse into the upender zone if the upender is not vertical, unless the hoist is full up (loaded) or above the hoist clear elevation (unloaded).

m. The spent fuel pool platform hoist cannot lower if in the upender zone and the upender is not vertical.

n. The upender cannot raise or lower if the spent fuel pool platform hoist is in the upender zone, unless the hoist is full up (loaded) or above the hoist clear elevation (unloaded).

o. The fuel transfer carrier cannot begin a transfer unless both upenders are horizontal. Once started, the carrier travel will be stopped if the cable tension exceeds a preset limit.

9.8.4.1.7

The refueling machine is equipped with various mechanical interlocks to provide for safe and proper operation. They include, positive mechanical locking of the refueling machine grapple to the fuel bundle, and a positive mechanical stop to prevent raising a fuel bundle above the minimum depth of water.

9.8.4.1.8

Miscellaneous special design features include — backup hand operation of hoist and traverse drives in the event of power failure; an available 4 to 1 gear reduction at the winch motor to permit applying an increased pull on the transfer carrier in the event it becomes stuck; a viewing port in the refueling machine trolley deck to provide visual access to the reactor for the operator; electronic and visual indication of the refueling machine position over the core; a protective shroud into which the fuel bundle is drawn by the refueling machine; transfer system upenders manual operation by a special tool in the event that the hydraulic system becomes inoperative; removal of the transfer system components from the refueling pool for servicing without draining the water from the pool.

9.8.4.1.9

The manual operator for the fuel transfer tube isolation valve extends from the valve to the deck at elevation +38 feet 6 inches. Also, the operator has enough flexibility to allow for operation of the valve due to thermal expansion of the fuel transfer tube.

9.8.4.1.10

The spent fuel pool platform crane is provided with encoders that monitor the bridge, trolley and hoist positions and a programmable logic controller that establishes appropriate boundaries to assure that fuel assemblies do not contact any of the walls or other equipment in the spent fuel pool area. The hoist is also provided with a geared limit switch that assures the minimum water necessary for shielding and an anti-two block switch that protects the hoist from damage if the geared limit switch fails. The fuel is also protected from damage by a load cell that interrupts hoist movement in the event of overload or underload conditions while raising or lowering. Interlocks between the platform crane and fuel transfer system prevent lowering a fuel assembly into the fuel carrier unless the upender is vertical and prevent the platform crane from entering the upender zone unless the hoist is at an elevation that avoids interference with the upender.

The spent fuel pool platform crane bridge and trolley will not derail under design seismic conditions.

9.8.4.1.11

The single failure proof design of the spent fuel cask crane utilizes limit switches to actuate special features that sense over travel (control and power), overweight (loads), overspeed (trolley and hoists), mis-spooling (wire rope on drum) and unbalanced reeving (wire rope). The electrical design addresses the effects of phase reversal or phase loss in the hoist power supply as well as undervoltage, overvoltage and overcurrent protection. Detection of any of the above faults removes power from the hoists, placing them in a safe condition. Bridge and trolley motions are limited by travel limit switches, which de-energize the motor at end travels.

The spent fuel cask crane travels within the Auxiliary/Warehouse buildings but has features that can restrict its path in certain areas. The cask crane has a position switch for NORMAL / CASK HANDLING / NEW FUEL modes. When in the NORMAL mode, the crane cannot travel over the fuel pool. When the switch is positioned in the CASK HANDLING position, the crane can only travel into the cask pit area of the fuel pool. When the switch is positioned in the NEW FUEL mode, the crane can only travel into the new fuel area of the fuel pool. This switch is a key lock switch and will be controlled administratively.

Both the main and auxiliary hoists have redundant brakes to allow portions of the hoist drive train to be repaired while retaining the load. The hydraulic brakes on the main hoist can be manually modulated to lower a load in the event of a hoisting equipment failure. The auxiliary hoist holding brakes are provided with manual override levers to permit manual load lowering.

The main and auxiliary hoisting systems also have various modes of operation. The main hoist lift mode selector switch is a two position switch that can be selected to critical or non-critical main hoist operation. In the critical (CRIT) position, the main hoist ultra lift feature is disabled and the overspeed system is set to trip at 110% of critical speed. The lifting speed is limited to 5 feet per minute (fpm). In the non-critical (NON) position, the main hoist ultra lift feature is enabled and the overspeed system is set to trip at 110% of non-critical speed. The lifting speed is limited to 7.5 fpm. The auxiliary hoist lift mode selector switch is a two position switch that can be selected to critical or non-critical auxiliary hoist operation. In the critical (CRIT) position, the auxiliary hoist ultra lift feature is disabled and the overspeed system is set to trip at 110% of critical speed. The lifting speed is limited to 20 feet per minute. In the non-critical (NON) position, the auxiliary hoist ultra lift feature is enabled and the overspeed system is set to trip at 110% of noncritical speed. The lifting speed is limited to 31 feet per minute.

The cask crane is equipped with laser distance measuring devices for the bridge and trolley. These devices are retro-reflective and utilize a target for accuracy. The target for the trolley system is attached to the trolley structure, while the bridge target is attached to the building wall. Each system measures the time for the laser light to return to the unit and communicates the calculated distance from the southeast corner of the building to the throat of the main hoist hook, then sends this number to the attached scoreboard display mounted on the bridge. The display reads in feet and inches continuously while power is applied to the crane. This feature enhances the manual positioning capabilities of the cask crane when handling heavy loads particularly around sensitive areas of the spent fuel pool.

The cask crane is designed to retain control of the main hoist 125 ton maximum critical load (MCL) and auxiliary hoist 15 ton MCL for all load combinations including a single broken rope, two blocking, load hang up and OBE & SSE seismic events.

The seismic and structural analysis of the cask crane determined that there is no trolley or bridge uplift for any of the applied loading combinations. The bridge and trolley are provided with seismic restraints to trap it between the bridge girders and runway beams in the event of a wheel flange or rail failure.

Analysis determined that the bridge will remain on the runway and the trolley will remain on the bridge with the brakes applied during an OBE and SSE event. The cask crane is designed to remain in place and hold the load during an OBE and SSE event.

9.8.4.2 Test and Inspections

Equipment listed under this section has had nondestructive testing in accordance with the procedures of Section VIII of the ASME Code where applicable.

In addition the entire fuel handling system was tested using a dummy fuel element before the plant was put into operation.

The following specific tests are performed on the individual equipment in addition to the above test.

The new and spent fuel storage racks are tested with a dummy fuel assembly for ease of insertion and alignment each time a cavity is fabricated, and after the rack is assembled.

The fuel transfer tube is given a vacuum base test to check for leaks.

The spent fuel pool platform crane and spent fuel cask crane cables are given rope tests.

The spent fuel pool platform crane and spent fuel cask crane, after fabrication and assembly at the vendor’s shop, are given no-load running tests.

Hooks which are designed to support fuel assemblies are volumetrically tested to detect internal defects prior to testing. The hooks are tested at 150 percent of rated load. After the 150 percent load test, they are subjected to liquid penetrant inspection in accordance with ASME Section VIII Pressure Vessels Code.

After installation, the fuel handling devices are thoroughly field tested using a dummy fuel assembly.

During manufacture at the vendor’s plant, various in-process inspections and checks are required including certification of materials and heat treating, and liquid-penetrant or magnetic-particle inspection of critical welds. Following completion of manufacture, compliance with design and specification requirements is determined by assembling and testing the equipment in the vendor's shop. Utilizing a dummy fuel assembly and a dummy CEA, each having the same weight, center of gravity, exterior size and end geometry as an actual assembly, all equipment is run through several complete operational cycles. In addition, the equipment is checked for its ability to perform under the maximum limits of load, fuel mislocation and misalignment. All traversing mechanisms are tested for speed and positioning accuracy. All hoisting equipment is tested for vertical functions and controls, rotation, and load misalignment. Hoisting equipment is also tested to 125 percent of maximum working load. Setpoints are determined and adjusted and the adjustment limits are verified. Interlock function, and backup systems operations are checked. Those functions having manual operation capability are exercised manually. During these tests the various operating parameters such as motor speed, voltage, and current, hydraulic system pressures, and load measuring accuracy and setpoints are recorded. At the completion of these tests the equipment is checked for cleanliness and the locking of fasteners by lockwire or other means is verified.

When finally installed in the field, the equipment is again tested in a manner which, in effect, is a repeat of the tests performed at the vendor’s plant. This allows determination of any changes in adjustment and condition which may have ensued from transit to the site. In addition, the tests in the field permit determination of characteristics which are unique to the actual site installation and, therefore, cannot be duplicated in the vendor’s shop test.

TABLE 9.8-1 TRANSFER TUBE ISOLATION VALVE

Type	Wedge gate
Size, inches	36
Design pressure, psia	83
Normal operating differential pressure, psi	14.3 psi
Design temperature, °F	150
Normal operating temperature, °F	120
Materials	Stainless Steel
Design Code	Draft ASME Code for Pumps and Valves for Nuclear Power, Class II
Seismic Design Classification	1
Design Integrate Dosage	$3.2x10^8$ R
Supplier	W. G. Rovang & Associates

TABLE 9.8-2 SPENT FUEL POOL PLATFORM CRANE

Bridge	
Capacity, tons	26
Drive	2 hp motor
Speed, fpm (variable)	0-40
Manufacturer	Dwight-Foote/PaR Nuclear
Trolley	
Capacity, tons	2
Drive	0.5 hp motor
Speed, feet per minute (variable)	0-45
Manufacturer	Shepard Niles/PaR Nuclear
Hoist	
Capacity	2000 lb
Drive	3 hp motor
Speed, fpm (variable)	0-33 feet per minute (variable)
Maximum lift, feet	23
Manufacturer	Shepard Niles/PaR Nuclear

TABLE 9.8-3 SPENT FUEL CASK CRANE

Bridge	
Speed, fpm	1.25 - 50 (infinitely variable)
Drive	Variable Frequency
Trolley	
Speed, fpm	1 - 40 (infinitely variable)
Drive	Variable Frequency
Hoists	
Main hoist capacity	125 tons
Auxiliary hoist capacity, tons	15
Drive for main hoist	Variable Frequency n
Drive for auxiliary hoist	Variable Frequency
Speed of main hoist, fpm	0.25 - 5 critical load speed (infinitely variable) 0.25 - 7.5 non-critical load speed (infinitely variable)
Speed of auxiliary hoist, fpm	0.25 - 20 critical load speed (infinitely variable) 0.25 - 31 non-critical load speed (infinitely variable)
Seismic Design Classification	1
Supplier	Harnischfeger Corp. (Bridge & Monorail) American Crane and Equipment Corp. (ACECO) (MH, AH & Trolley)

TABLE 9.8-4 FAILURE MODE ANALYSIS

COMPONENT IDENTIFICATION	FAILURE MODE	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	REMARKS
Refueling Machine. Fuel Hoist weight system	Electrical Overload Trip fails	None	Continue refueling, repair on non-interfering basis	Use visual presentation of load on meter.
	Complete system fails	None	As above	Control System will automatically disable the hoist.
Fuel Carrier	Wheels lock in transfer tube	Transfer change completed	Switch to 4:1 gear reduction	Torque sufficient to move fuel carrier with all wheels locked
Hydraulic Power supply for upender	Line to cylinder on upender ruptures	None	Valve off defective line	Upender has two cylinders, each of which is capable of raising upender
	Loss of hydraulic power	Process can continue on slower basis	Upend manually	Use tool provided
Brake on R. M. fuel hoist	Does not provide required brake load	None	Continue, repair on non-interfering	Redundant brake system provided
Fuel Carrier Cable	Cable parts	Delays refueling	Move fuel carrier to safe position with manual tool	Remove fuel prior to repair
Refueling Machine Hoist Motor	Power Failure	Operation can be completed	Repair	Hoist using manual hand-wheel
Bridge Drive Motor	Power Failure	Operation can be completed	Repair	Drive using manual hand-wheel
Electronic Position Indication	Power Failure	None	Repair non-interfering basis	Redundant position indicator is available on the console’s touchscreen display

TABLE 9.8-4 FAILURE MODE ANALYSIS (CONTINUED)

COMPONENT IDENTIFICATION	FAILURE MODE	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	REMARKS
Fuel Carrier Position Sensing System	Electrical Failure	None	Repair non-interfering basis	Winch motor stalls on overload
Refueling Machine	Loss of air pressure	None	Repair	Continue, using manual mode
Dual under deck camera system	Power or Video failure	None	Continue, repair on non-interfering	Refueling can continue using direct visual observation of machine operation

TABLE 9.8-5 RADIATION LEVELS FROM HEATED JUNCTION THERMOCOUPLE (R/HR)

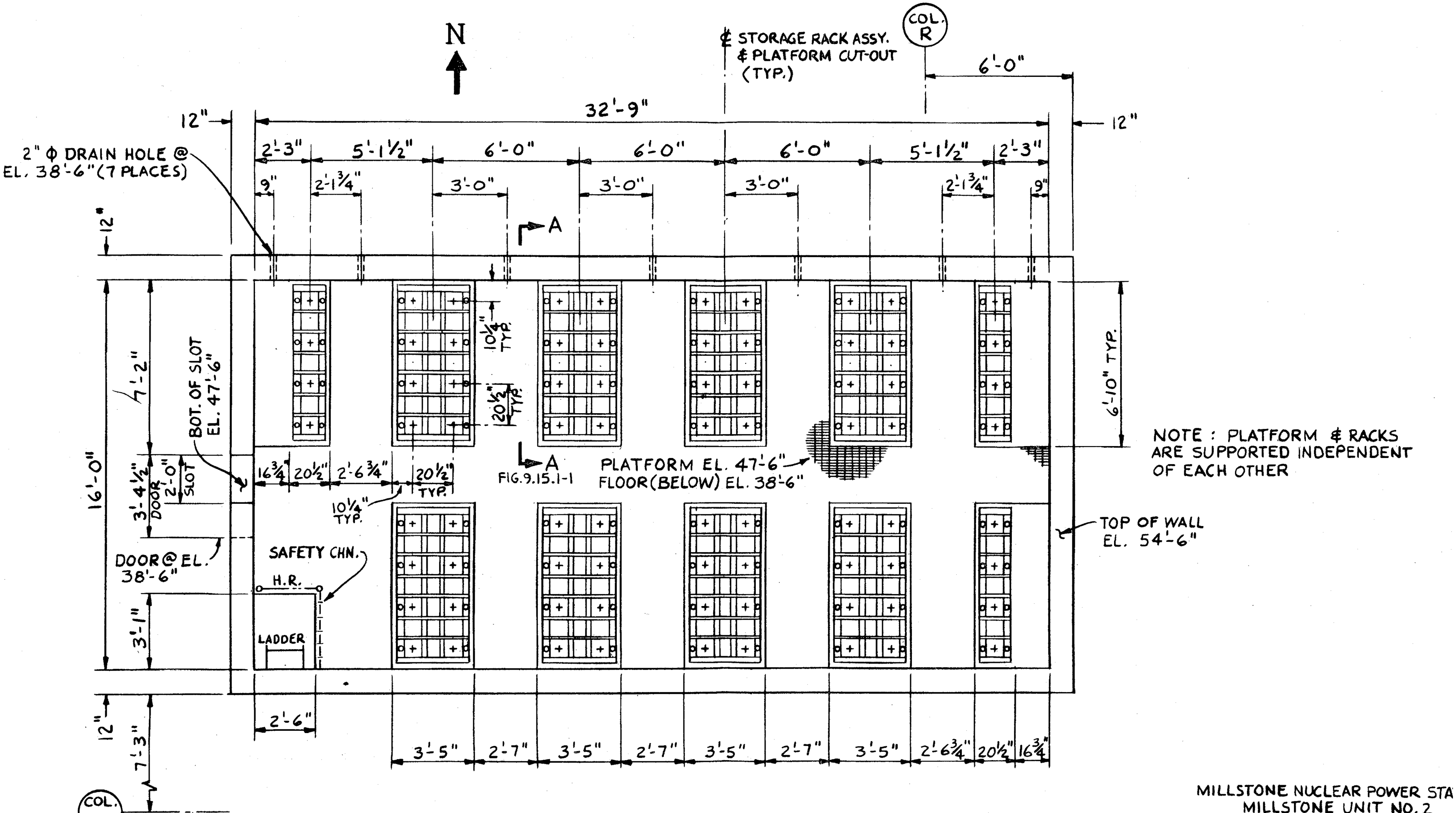
	Dose Rates				
	Crud Contribution		Activation Contribution		Total
Surface of Canister Zone A	0.007-.02	+	0.20	=	0.22
Surface of Canister Zone B	0.007-.25	+	0	=	0.25
Surface of Canister Zone C	0.07-2.5	+	0	=	2.5
1 foot from Surface Zone A	Insignificant	+	0.05	=	0.05
1 foot from Surface Zone B	0.125	+	0	=	0.125
1 foot from Surface Zone C	0.5-1.25	+	0	=	0.5-1.25

Notes: See Figure 9.8–20 for definition of zones.

Worker dose in Shielded Zone for ten minutes = (10/60) x (.125 R/hr) = 0.021 R

21mR

FIGURE 9.8–1 PLAN OF NEW FUEL STORAGE RACKS



PLAN OF NEW FUEL STORAGE RACKS

FIGURE 9.8–2 NEW FUEL STORAGE RACKS - SECTION “A-A”

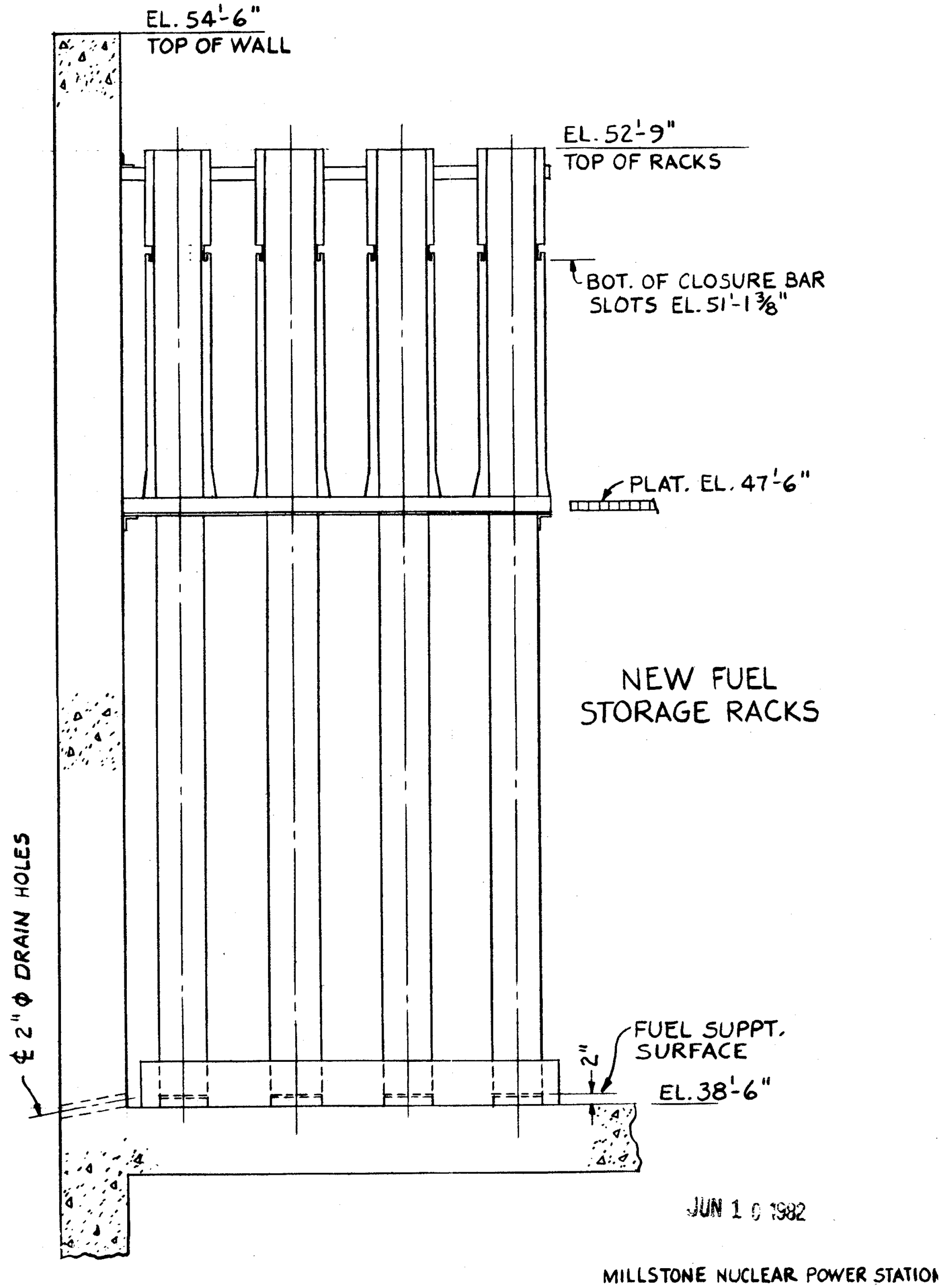


FIGURE 9.8–3 NEW FUEL STORAGE RACK ASSEMBLY (8 RACK MODULE)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.8–4 NEW FUEL STORAGE RACK ASSEMBLY (4 RACK MODULE)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.8–5 STORAGE RACK

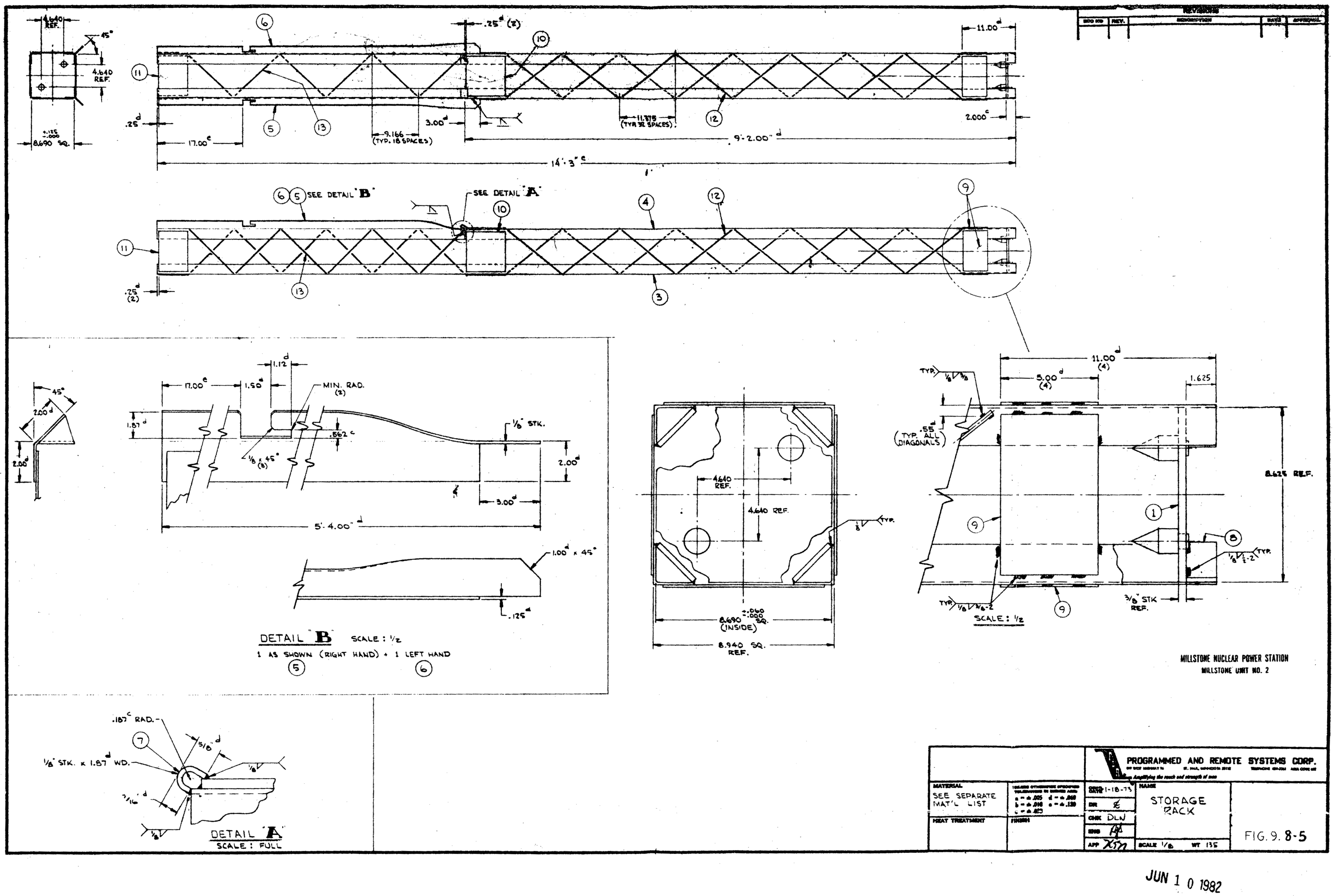
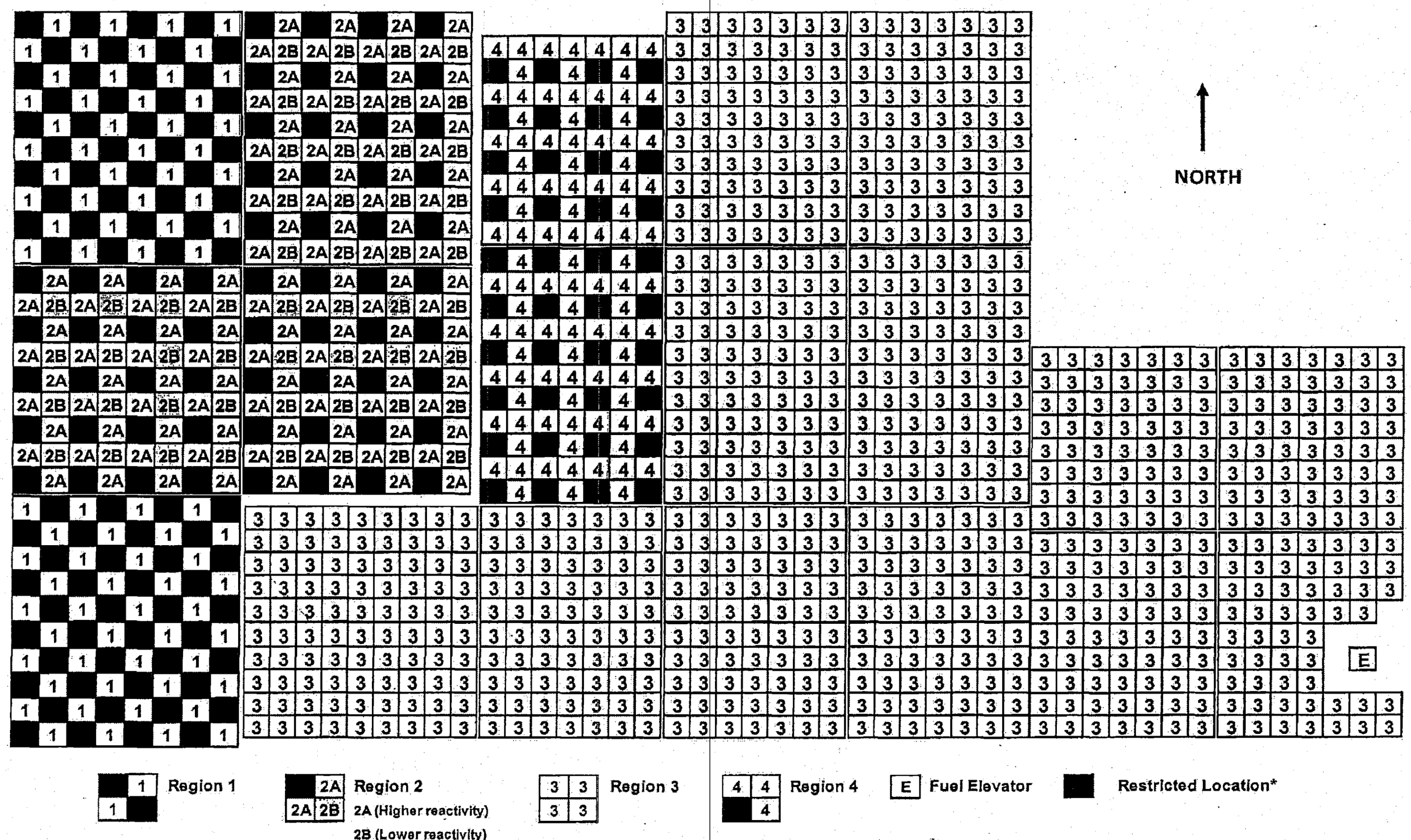


FIGURE 9.8–6 CLOSURE BAR NEW FUEL STORAGE RACKS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.8–7 FUEL POOL ARRANGEMENT - FOUR REGION



* A Restricted Location shall remain empty. No fuel assembly, no Non-standard Fuel Configuration, no non-fuel component, nor any hardware/material of any kind may be stored in a Restricted Location.

FIGURE 9.8–8A TYPICAL SPENT FUEL RACK MODULE/POISON BOX - REGIONS 1 AND 2

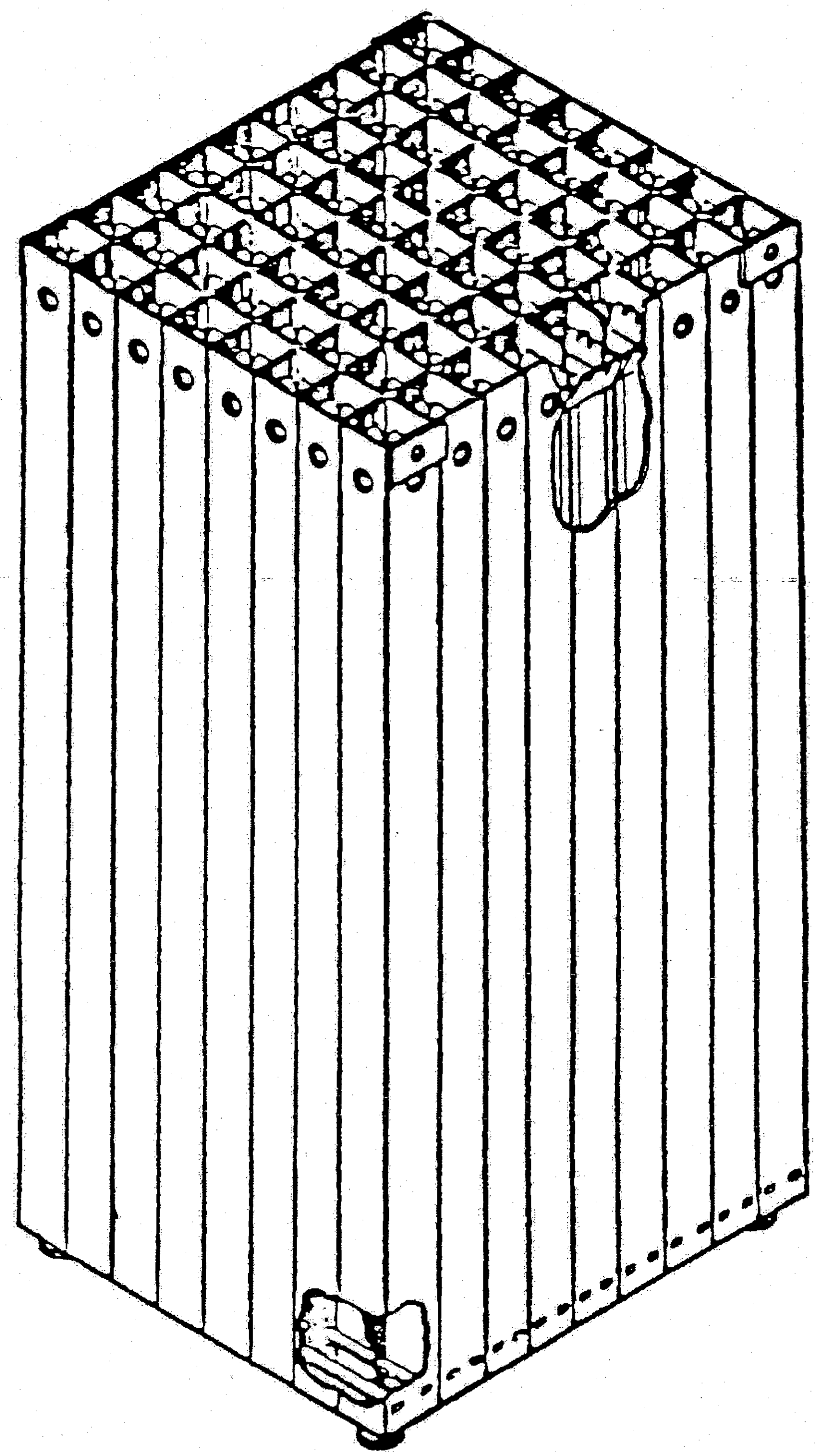


FIGURE 9.8–8B TYPICAL SPENT FUEL RACK MODULE/REGIONS 3 AND 4

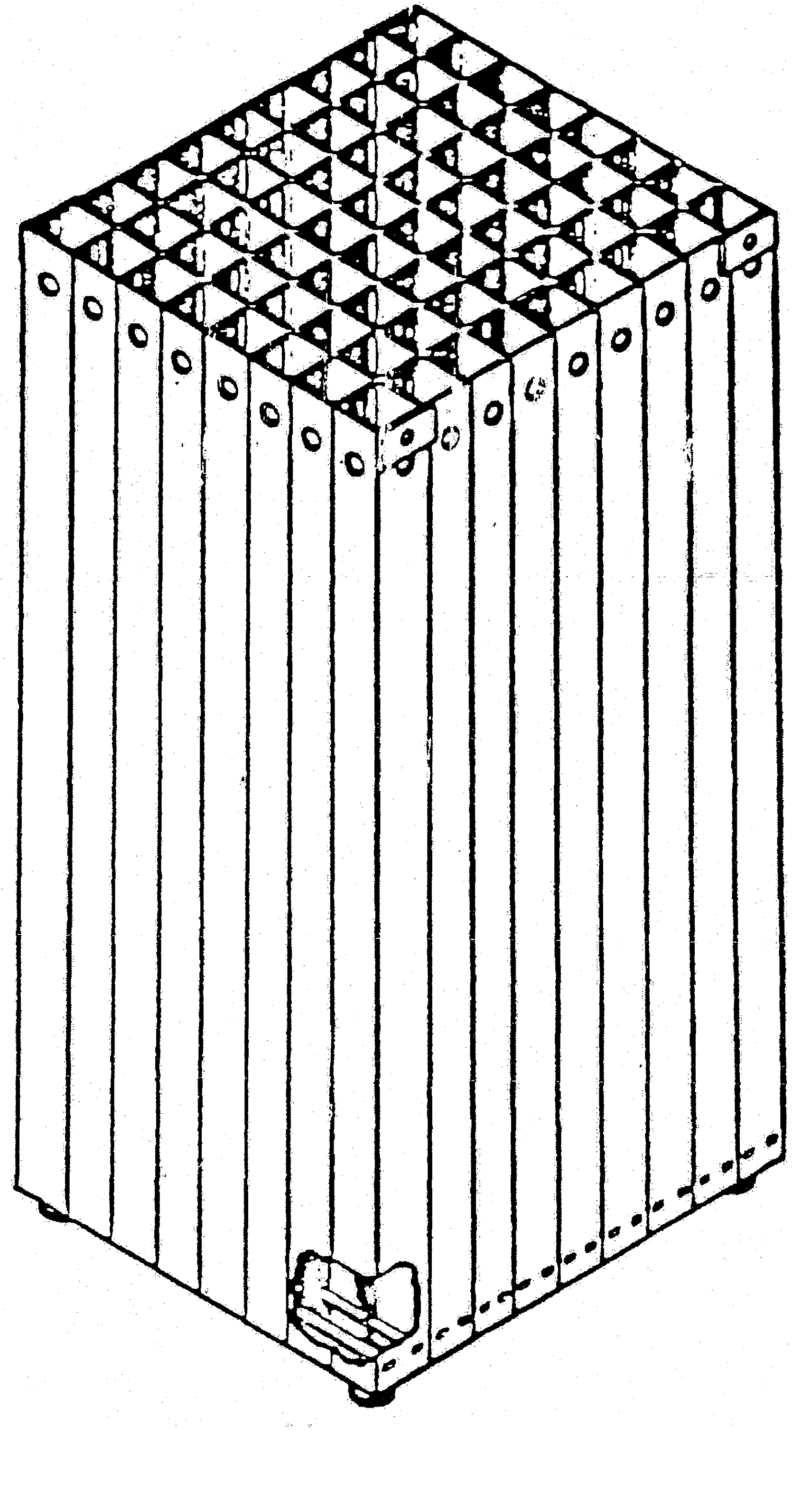


FIGURE 9.8–8C POISON BOX (BORAFLEX POISON NO LONGER CREDITED)

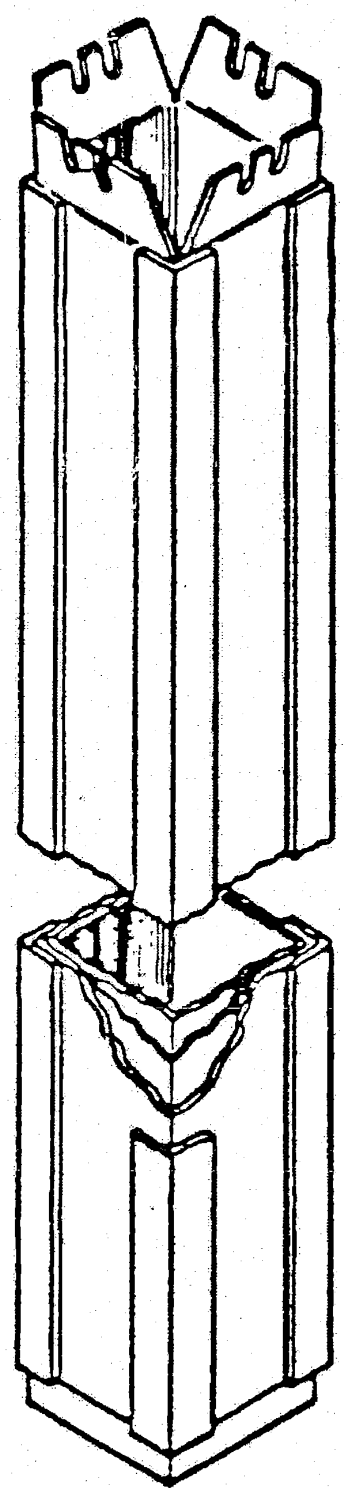


FIGURE 9.8–8D ADJUSTABLE FOOT

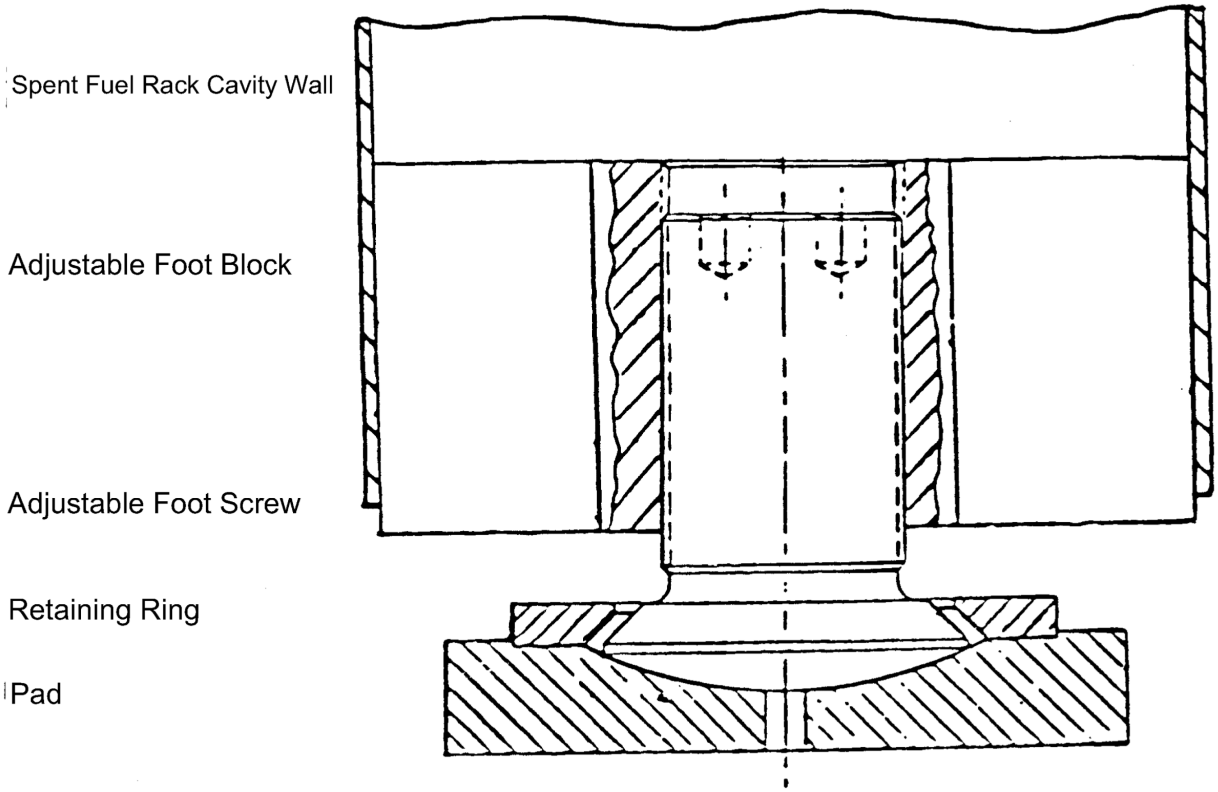
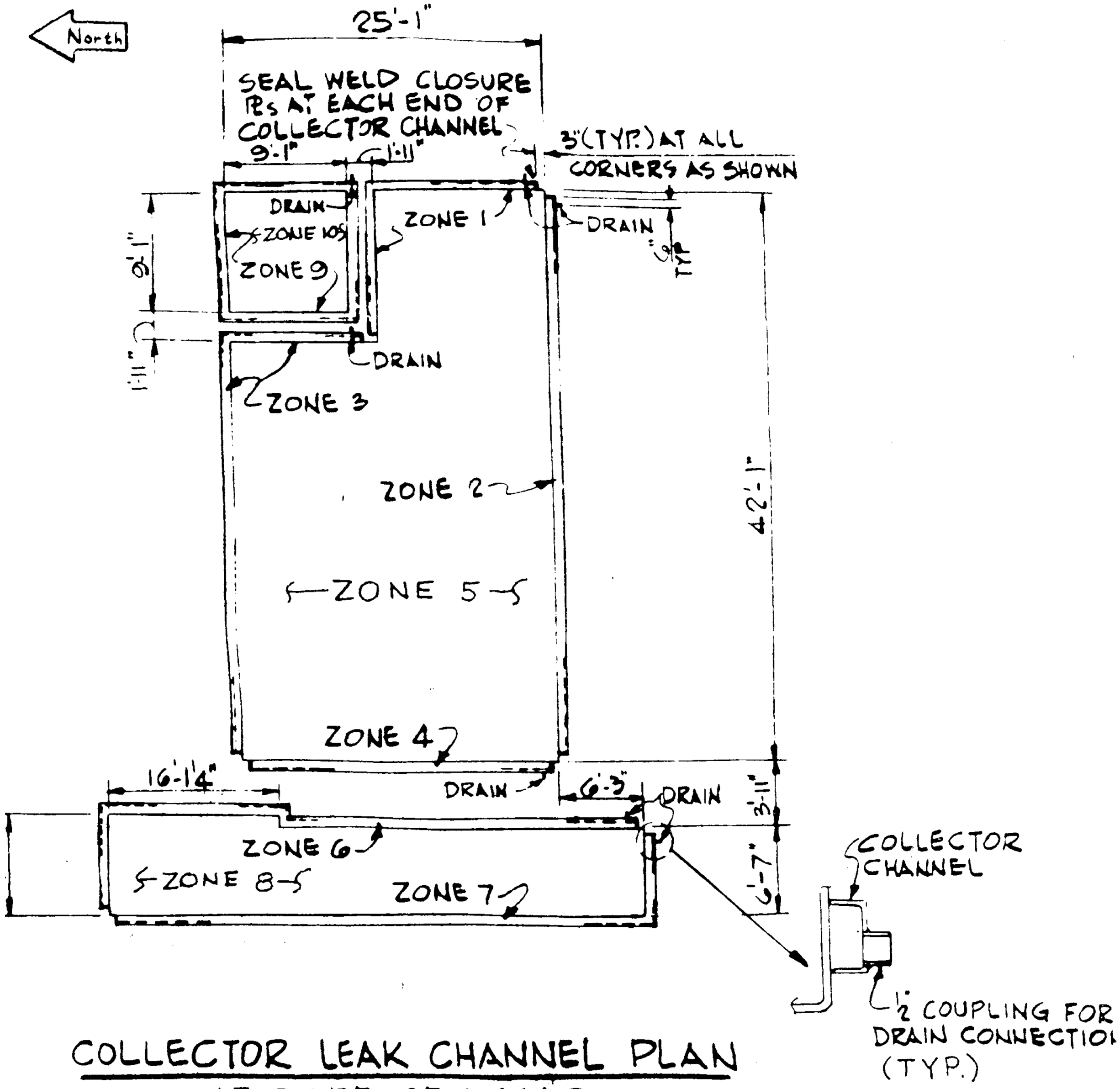


FIGURE 9.8–9 COLLECTOR LEAK CHANNEL PLAN AT BASE OF WALLS



COLLECTOR LEAK CHANNEL PLAN AT BASE OF WALLS

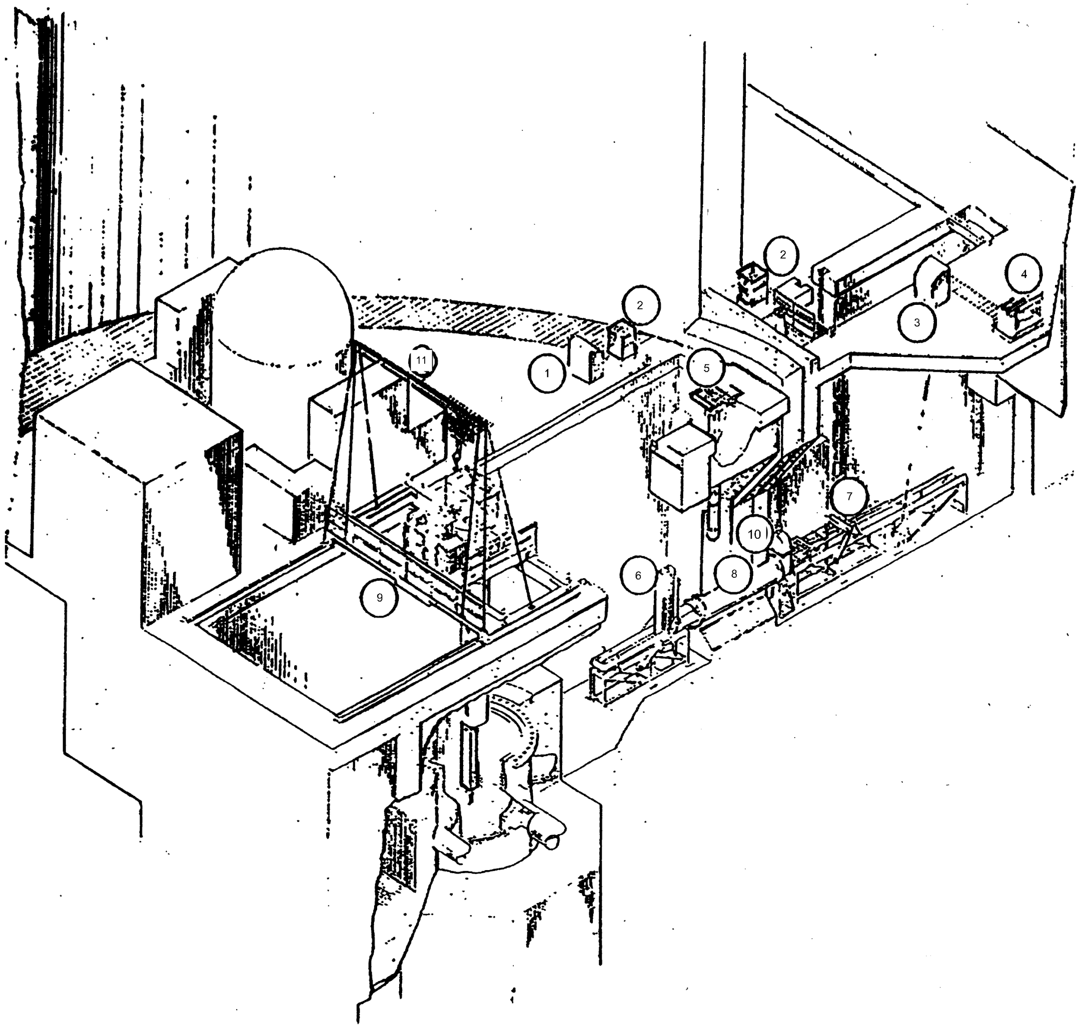
3/32" = 1'-0"

NOTE:

ZONES 5, 8 + 10 ARE USED TO DETECT LEAKAGE THROUGH THE FLOOR OF THE LINER IN THE SPENT FUEL POOL, TRANSFER CANAL & CASK LAYDOWN AREA, RESPECTIVELY.

FIGURE 9.8-9

FIGURE 9.8–10 REFUELING EQUIPMENT ARRANGEMENT



1. TRANSFER MACHINE AND CEA CONSOLE
2. HYDRAULIC POWER PACKAGE
3. TRANSFER MACHINE CONSOLE
4. TRANSFER MACHINE WINCH ASSEMBLY
5. CEA CHANGE MECHANISM REMOVED. REFER TO SAR CHANGE PACKAGE PKG FSC MP2-UCR-2009-006
6. FUEL CARRIAGE
7. UPENDER
8. TRANSFER TUBE
9. REFUELING MACHINE
10. ISOLATION VALVE
11. AUXILIARY HOIST

FIGURE 9.8–11 REFUELING MACHINE

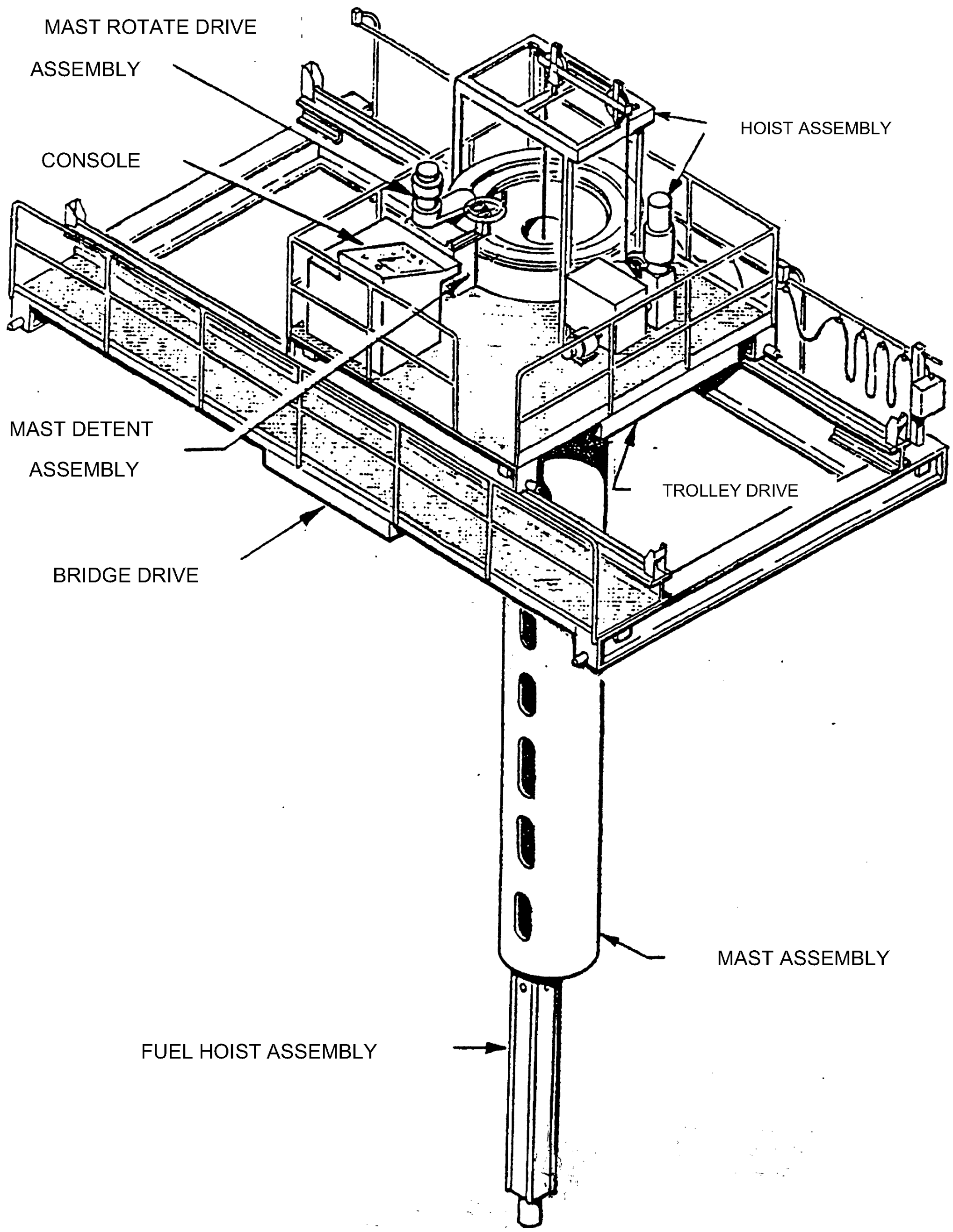


FIGURE 9.8–12 DELETED BY PKG FSC MP2-UCR-2009-006

FIGURE 9.8–13 REACTOR VESSEL HEAD LIFTING RIG

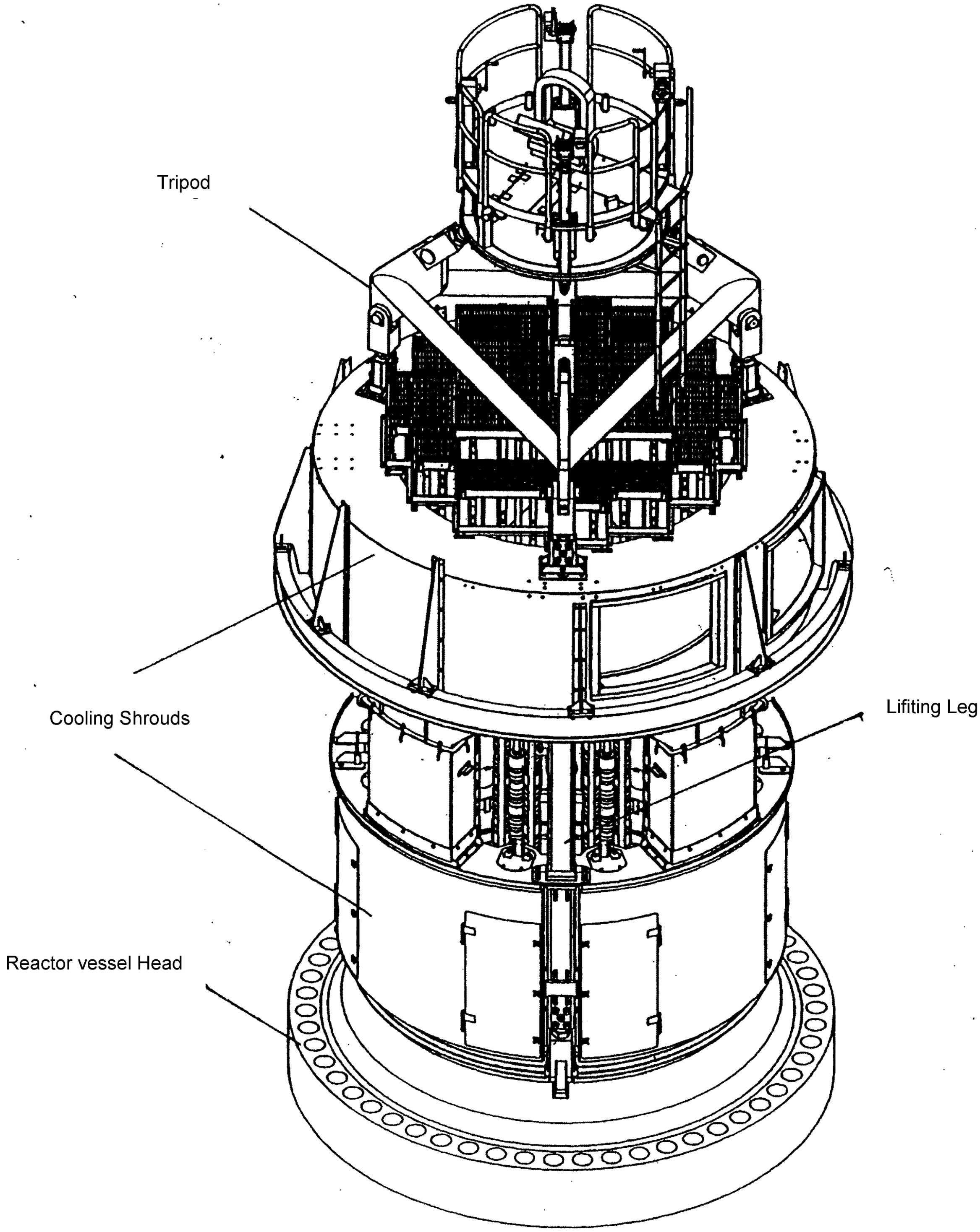


FIGURE 9.8–14 CORE SUPPORT BARREL LIFTING RIG

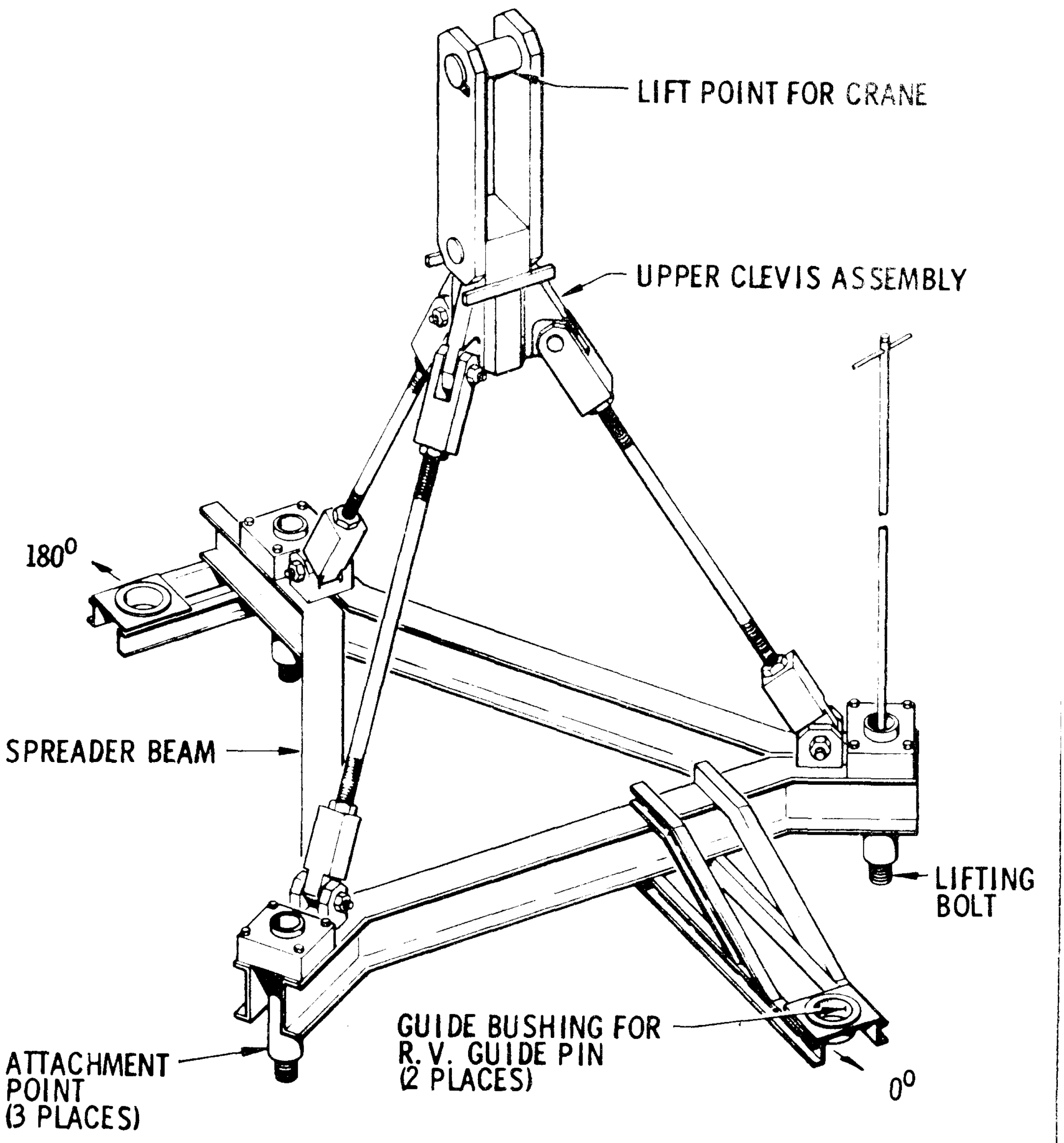


FIGURE 9.8–15 UPPER GUIDE STRUCTURE LIFTING RIG

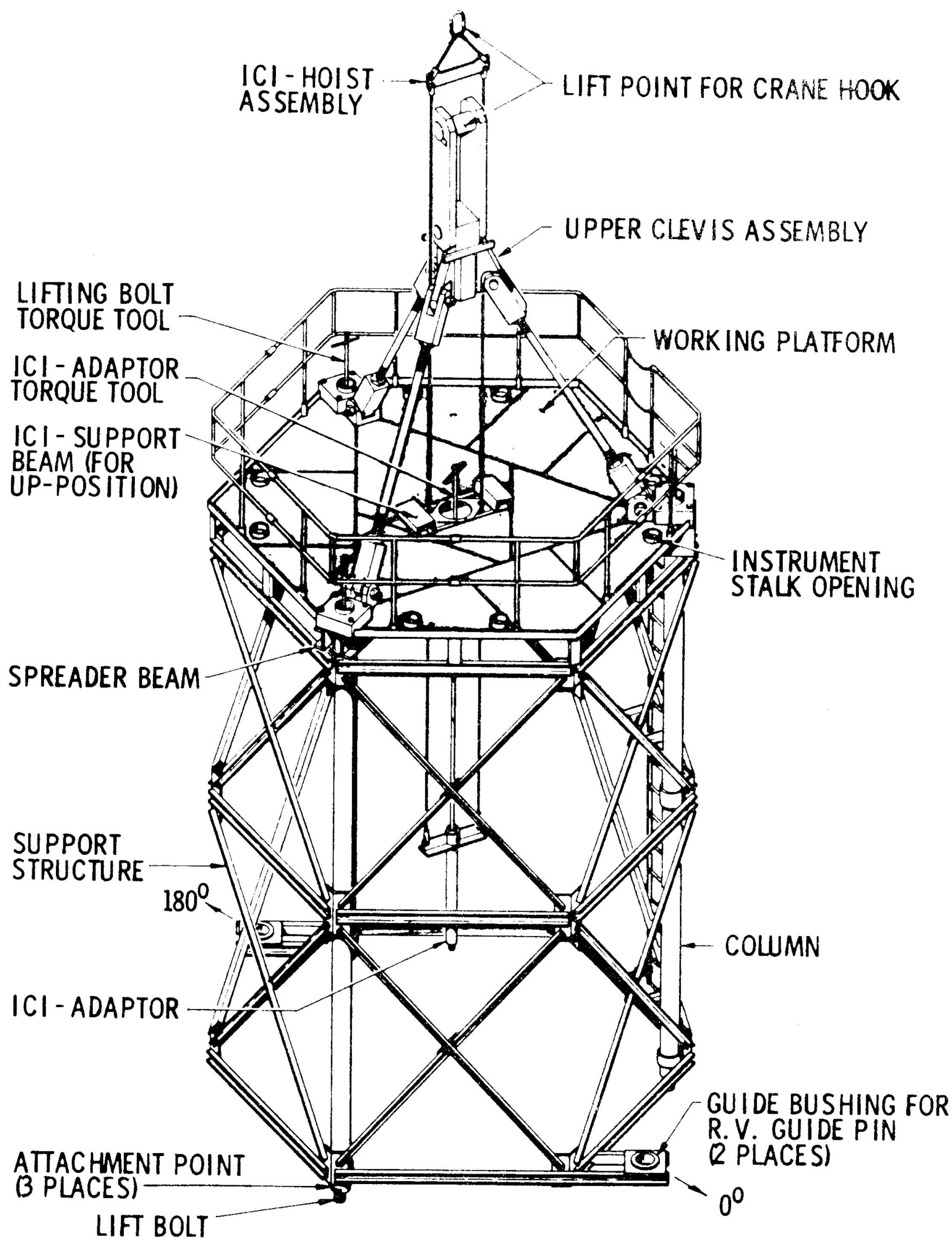


FIGURE 9.8–16 SURVEILLANCE CAPSULE RETRIEVAL TOOL

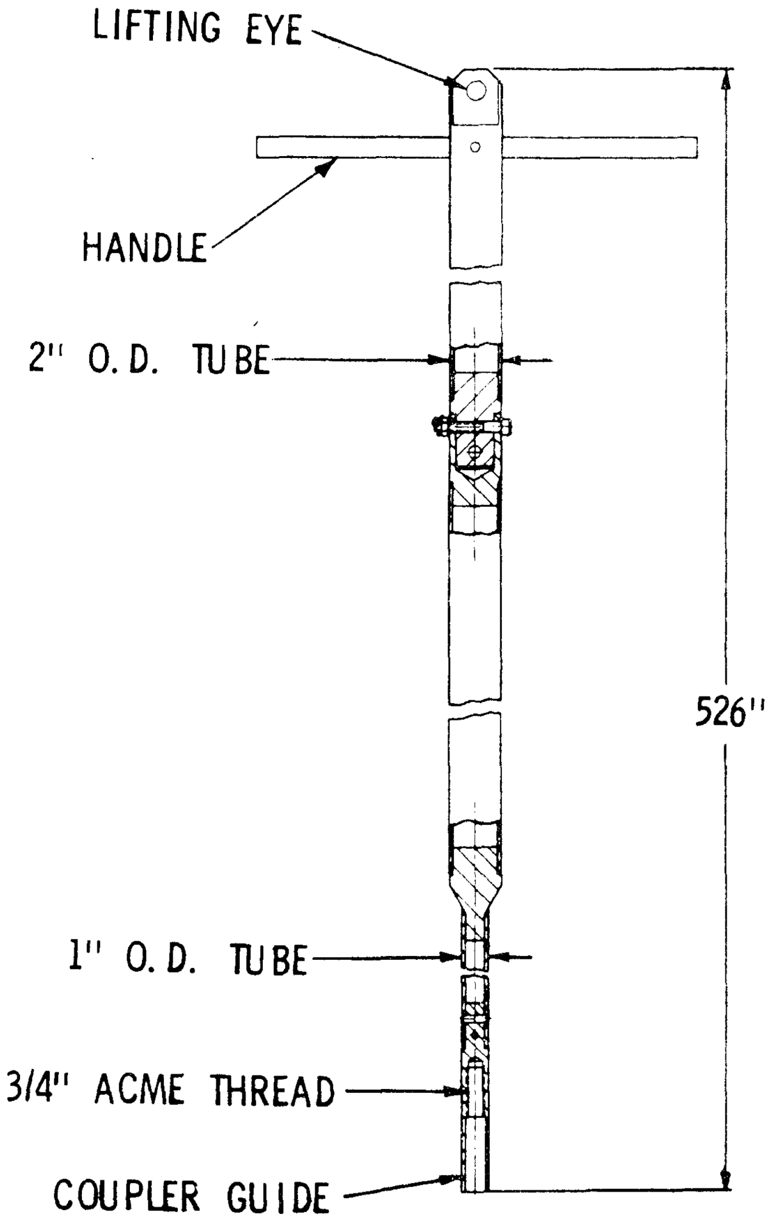


FIGURE 9.8–17 SPENT FUEL POOL PLATFORM CRANE

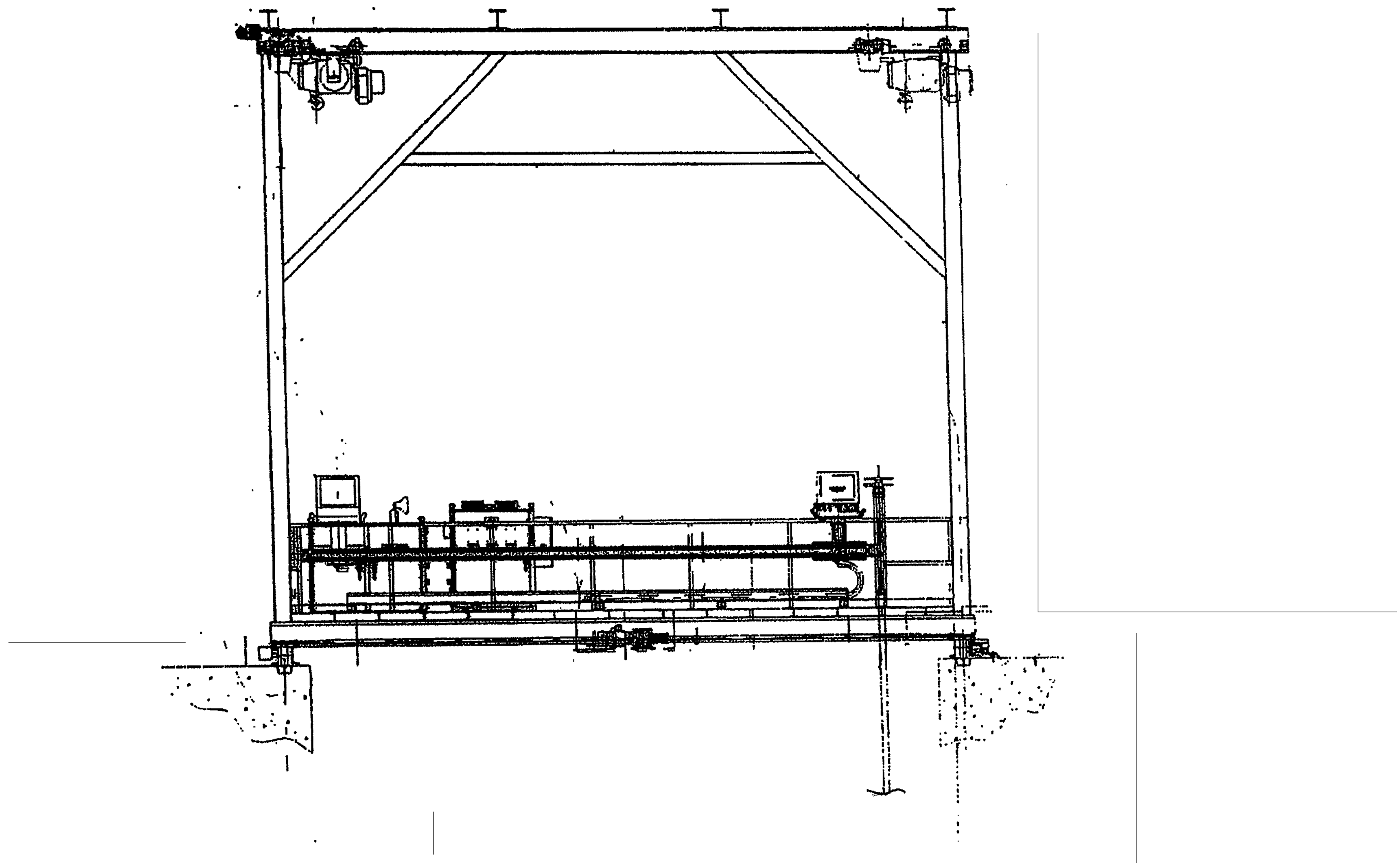


FIGURE 9.8–18 SPENT FUEL POOL PLATFORM CRANE TRAVEL LIMITS

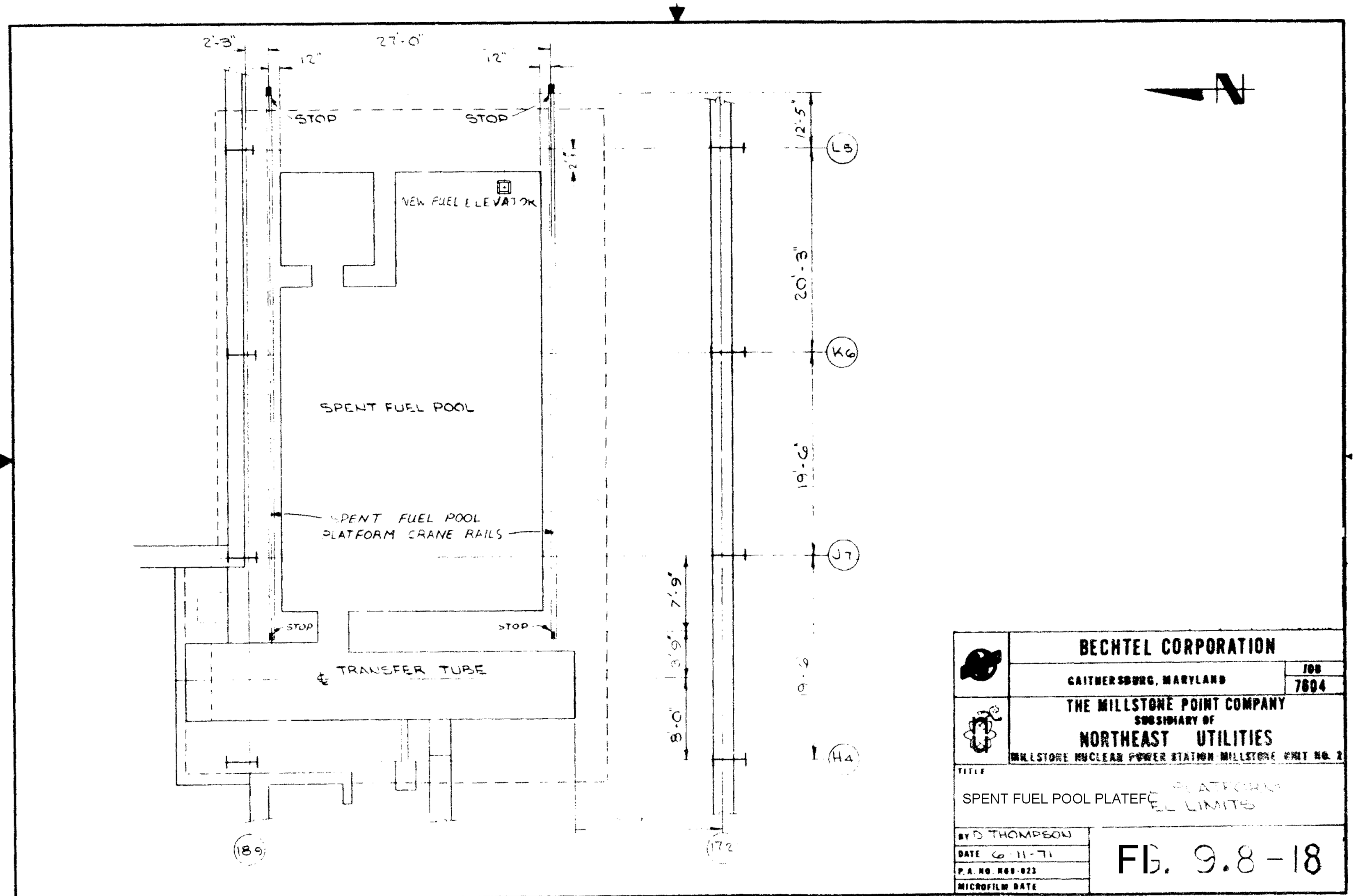
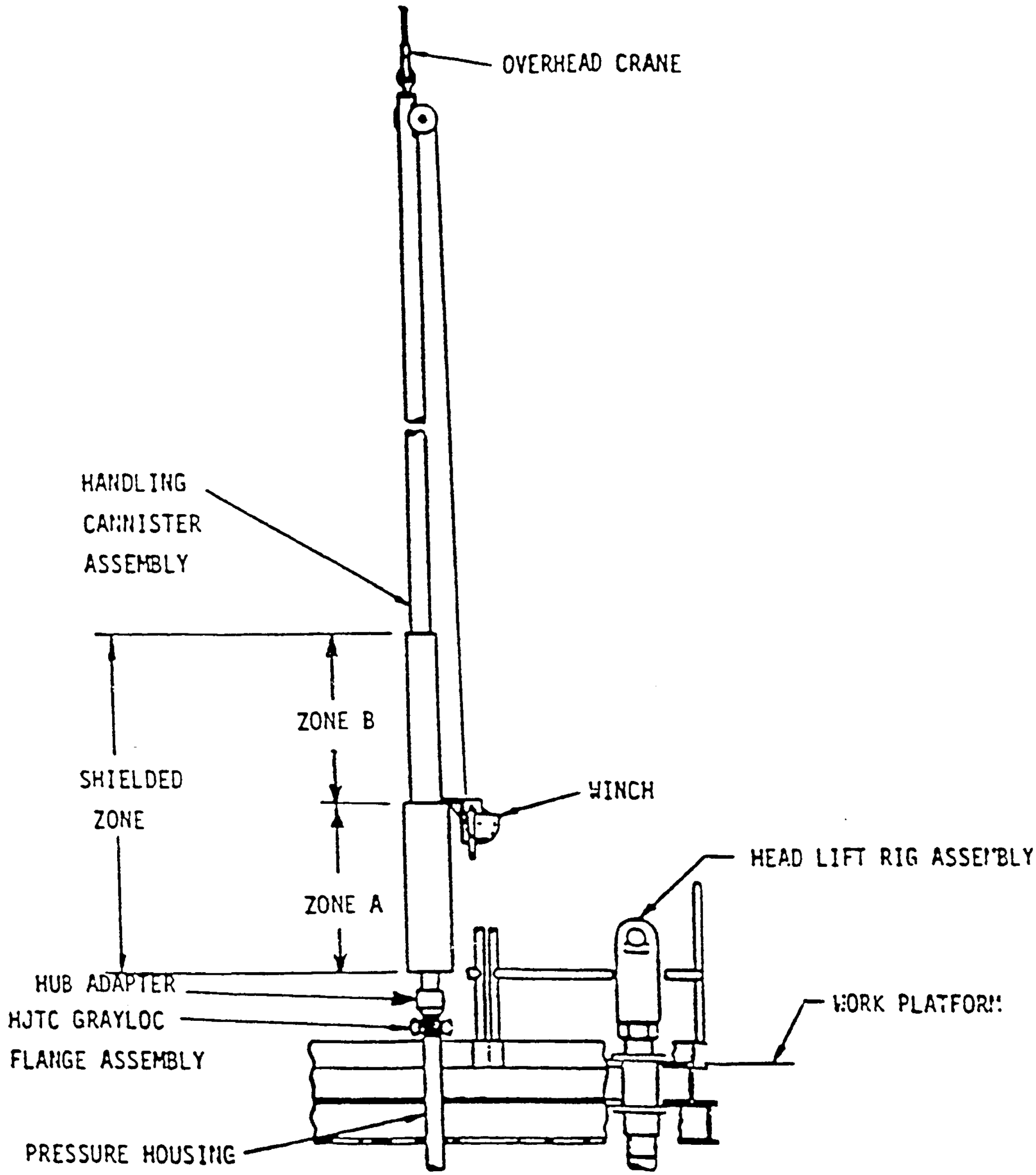


FIGURE 9.8–19 SPENT FUEL CASK CRANE

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.8–20 HEATED JUNCTION THERMOCOUPLE HANDLING CANISTER



9.9 PLANT VENTILATION SYSTEMS

9.9.1 DESIGN TEMPERATURE BASES

Outdoor Design Temperatures

Most original Millstone Unit 2 HVAC calculations are based on design conditions for New Haven, Connecticut, specified in the Heating Ventilating Air Conditioning Guide, 1956 published by the American Society of Heating and Ventilating Engineers (ASHVE - now titled ASHRAE, American Society of Heating, Refrigerating, and Air Conditioning Engineers). The summer and winter outdoor design temperatures selected for Millstone Unit 2 calculations to December 3, 1996 were based on values "in common use" per the ASHVE Guide as follows:

Season	Temperature	Source
Winter	0°F dry bulb	ASHVE Guide, Chapter 14 Table 1, Column 9
Summer	95°F dry bulb, 75°F wet bulb	ASHVE Guide, Chapter 15 Table 3, Columns 7 & 8

However, some original HVAC calculations were also based on the ASHRAE Fundamentals Handbook 1972, using an outdoor design DB temperature of 86°F (2.5% design).

The current design basis temperatures for Millstone Unit 2 heating, ventilating, and air conditioning (HVAC) are based on general, long-term, climatic data of averages and extremes obtained from the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) 1972 Fundamentals Handbook, Design Weather Data for New London, Connecticut. The selected outdoor temperature values have been substantiated by data collected from the Millstone Site meteorology tower during a nineteen year span (1974-1992). Millstone Site Climatological summary of occurrences of outdoor ambient temperatures below 0°F and above 86°F and their durations are shown in Reference 2.3-1, Table 2.3-19, of Section 2.3. The summer and winter outdoor design temperatures are as follows:

Season	Temperature	References
Winter	0°F dry bulb	a) ASHRAE 1972, Weather Data and Design Conditions, page 671
Summer	86°F dry bulb, 75°F wet bulb	a) ASHRAE 1972, Weather Data and Design Conditions, page 671

Typically nuclear power plants use a 99% winter design temperature. This represents the temperature that has been equaled or exceeded by 99% of the total hours in the average winter months of December, January, February (a total 2160 hours). In New London, Connecticut, this is a 4°F (ASHRAE 1972, page 671, column 4, winter 99%). A conservative design winter temperature of 0°F is selected for Unit 2 and is consistent with the median of the annual extreme minimum in New London (ASHRAE Fundamentals 1972, page 671, column 4). Summer outdoor design temperatures are typically based on 2.5% exceedence. In New London, these temperatures are 86°F DB and 75°F WB (ASHRAE Fundamentals 1972, page 671, summer, columns 6 and 8). These represent values that are exceeded 2.5% of the total summer hours of 2928; i.e., 73 hours, and are used for the summer outdoor design temperatures for Unit 2.

Monthly, seasonal and annual averages and extremes of temperature from 1901 through 1981 at Bridgeport, Connecticut, are shown in Reference 2.3-1, Table 2.3-1, of Section 2.3, and for the Millstone Site from 1974 through 1992 on Table 2.3-19 of the same reference. These extreme low and high temperatures are not used in design but do establish and acknowledge that when the maximum temperature exceedences occur above or below the design temperatures, it is for a short duration of time. The episodes from 1974 through 1992 that occurred below 0°F and above 86°F with the duration for each occurrence are shown in Reference 2.3-1, Table 2.3-19 of Section 2.3.

Indoor Design Temperatures

Indoor design temperatures for the various areas of the plant are based on design outdoor temperatures specified above. Indoor design temperatures excursions may occur coincident with outdoor air temperature excursions for short periods of time. However, temperature excursions are mitigated by thermal inertia effects of heavy concrete structures, below grade walls and other factors. In general, critical areas containing equipment required for safety related functions are monitored by installed instrumentation and alarms and/or inspected on a periodic basis (i.e., Control Room, Diesel Generator rooms, Intake Structure, etceteras.). Abnormal temperature conditions will be monitored, evaluated and corrected by operator actions. Equipment evaluations consider loss of ventilation for up to 24 hours without operator action. After 24 hours, the evaluations consider operator actions to occur to reduce ambient temperatures.

A summary of the indoor design temperatures for the significant areas of the plant are provided in Table 9.9-21.

9.9.2 CONTROL ELEMENT DRIVE MECHANISM COOLING SYSTEM

9.9.2.1 Design Bases

9.9.2.1.1 Functional Requirements

The Control Element Drive Mechanism (CEDM) cooling system functions to maintain a suitable environment within the CEDM shroud to provide an acceptable coil life and maintain an acceptable coil replacement cycle.

9.9.2.1.2 Design Criteria

The following criteria have been used in the design of the CEDM cooling system:

a. The system shall have three redundant, independent subsystems, each having 50 percent of the total required heat removal capability.

b. The system shall have suitable subsystem and component alignments to assure operation of complete subsystem with associated components.

c. Capabilities shall be provided to assure the system operation with on site power (assuming off site power is not available) or with off site electrical power.

d. A single failure in either subsystem shall not affect the functional capability of the other subsystem.

e. The system shall be designed to permit periodic inspection of important components, such as fans, cooling coils, ductwork, piping, valves and instrumentation to assure the integrity and capability of the system.

f. The components of the CEDM cooling system shall be designed to operate in the environment to which exposed.

9.9.2.2 System Description

9.9.2.2.1 System

The CEDM cooling system is shown schematically in Figure 9.9–1.

The CEDM cooling system consists of three identical, redundant, independent fan-coil units, each capable of removing 0.81 x 10^6 Btu/hr. The containment air is circulated through the finned-tube-water cooling coils and is supplied by fans to the CEDM shroud. The CEDM shroud is provided with internal baffles to assure proper air distribution over the CEDM coils. The Reactor Building Closed Cooling Water (RBCCW) system (Section 9.4) serves as the cooling medium. Air is supplied via two ducts to the upper cooling plenum from two of the three cooling units located on the missile shield above. The air is distributed through four vertical ducts of the shroud to the lower plenum. The air is discharged through holes in the inner shell of the lower plenum.

9.9.2.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-1. Fan performance curve is shown in Figure 9.9–5.

9.9.2.3 System Operation

Cooling is required for the CEDM whenever the coils are energized (Section 3.3.3). Cooling is not required for safe shutdown of the unit but can be provided to prolong coil life.

9.9.2.3.1 Normal Operation

Air at 95°F is supplied into the shroud to remove the sensible heat from the CEDM coils. The cooling air maintains these CEDM coils below a maximum operating temperature of 350°F. The air is heated sensibly to 120°F and discharged from the shroud.

Total heat removal capabilities are provided by operating any two of the three CEDM coils. The switchover from one fan-coil unit to the other is accomplished by remote manual control from the control room. A damper on each fan discharge prevents short circuiting of air through the idle unit. The air temperature entering the CEDM is monitored by the computer (Section 7.5.5). Motor trip alarms are provided for all fans.

9.9.2.3.2 Abnormal Operation

During abnormal operation, the CEDM cooling system functions as required to maintain the environment within the shroud. Cooling is required for a short time only following a scram of the control rods. Whenever the rods are scrammed, the CEDM coils are de-energized. The CEDM cooling system functions to remove residual heat until the CEDM coils are cooled to ambient temperatures. The CEDM coil temperatures are monitored on the computer.

The cooling of the CEDM coils during abnormal conditions is not critical to shutdown. However, this operation is provided to maintain an acceptable CEDM coil life.

9.9.2.4 Availability and Reliability

9.9.2.4.1 Special Features

Any two of the three CEDM cooling units is capable of maintaining the design environment within the CEDM shroud. Any one of the three units is capable of maintaining the shroud ambient temperature below 145°F which is the recommended maximum design temperature. Therefore, shutdown is required only upon failure of all three of the CEDM cooling units.

The components of the CEDM cooling system are designed to operate in an environment of 120°F, atmospheric pressure, 100 percent relative humidity and 5 x 10^6 rad of accumulated (40 years) radiation dose.

The CEDM cooling units are located on the reactor vessel missile shield and, therefore, are not exposed to flooding or credible missiles.

9.9.2.4.2 Tests and Inspection

The vaneaxial fans are similar to fans which are rated in accordance with Air Moving and Conditioning Association (AMCA) Standard 211A. The water cooling coils are tested in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and Tubular Exchanger Manufacturers Association (TEMA), Class C. The ductwork is designed and fabricated in accordance with Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Standard, "High Velocity Duct Construction Standards."

The CEDM cooling system undergoes an acceptance test prior to startup. The test procedure is described in Chapter 13.

The CEDM cooling system is not accessible for inspection or maintenance except during shutdown.

9.9.3 CONTAINMENT AND ENCLOSURE BUILDING PURGE SYSTEM

9.9.3.1 Design Bases

9.9.3.1.1 Functional Requirements

The purge system functions to maintain a suitable environment for personnel access into the containment or enclosure building. The purge system provides fresh air ventilation or heating whenever required.

9.9.3.1.2 Design Criteria

The following criteria have been used in the design of the purge system:

a. The containment and enclosure building purge system shall be designed to permit periodic inspection of important components such as fan, motor, belt, coil, ductwork, piping and valves to assure the integrity and capability of the system.

b. The purge containment isolation valves shall be designed with leak detection capabilities.

c. The components of the system shall be designed to operate in the environment to which exposed.

9.9.3.2 System Description

9.9.3.2.1 System

The purge system is shown schematically in Figure 9.9–1.

The purge system can be lined up to either containment or the enclosure building.

The purge system is designed to provide adequate fresh air for the containment or the enclosure building by using supply fan F-23. However, the purge rate is balanced to maintain a negative pressure in the area being purged. Its associated steam heating coil, X-43, is sized to temper 0°F outside air to 70°F for personnel comfort, maintaining a desired environment atmosphere temperature of approximately 60°F, which is consistent throughout the plant for unmanned areas.

The purge system consists of an air handling unit, located in the auxiliary building, which supplies filtered and tempered air to either the containment or the enclosure building. All the purge system, except interior ducts and two isolation valves, will be located outside the containment. Branch ducts and isolation dampers are provided for ventilating the enclosure building. Auxiliary steam is provided as the heating medium when required.

9.9.3.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-2. Fan performance curve is shown in Figure 9.9–6.

9.9.3.3 System Operation

The purge system is not operating and the containment isolation valves are locked closed in Modes 1 through 4 by shutting them, pulling their control power fuse and locking their associated fuse block. By locking them closed in this manner, these valves are considered sealed closed isolation valves. When access to the containment is desired and the Plant is in the cold shutdown or the refueling mode, the purge fan, if required, is started and the isolation valve opened. If a high containment radiation level is detected, the containment air purge supply and exhaust valves, 2-AC-4, 2-AC-5, 2-AC-6 and 2-AC-7, receive a signal to close (FSAR Section 7.3.2.2.c). However, automatic isolation of the purge valves is not credited in the fuel handling accident analyses.

9.9.3.3.1 Normal Operation

The purge system is initiated manually in the control room by operator action. Hand switches are provided to start the fan and open isolation valves and dampers. The third main exhaust fan (Section 9.9.9 is started to exhaust the containment through particulate and high efficiency particulate air (HEPA) filters (Section 9.9.9.2.2). The system performance is monitored by containment temperature indication (Section 7.5). Air is supplied in the containment above the operating floor. Mixing is provided by the containment air recirculation and cooling system (Section 6.5) throughout the lower elevations of the containment. Mixing is provided throughout the upper regions of the containment by the containment auxiliary circulation system (Section 9.9.3). The containment ambient conditions during shutdown are described in Section 6.5.3.4.

Outside air is filtered prior to distribution within the containment. A steam heating coil is provided for tempering the outside air when required. During summer conditions, the outside air is supplied at approximately 86°F. During winter conditions, the outside air is tempered and supplied at 70°F.

Radioactive effluents released to the site boundary resulting from the containment purge operations are described in the Environmental Report.

The containment isolation valves (2-AC-4, 2-AC-5, 2-AC-6, 2-AC-7) on the purge system are locked closed, pneumatically isolated and electrically isolated during all modes of operation except cold shutdown and refueling. This is accomplished by closing the instrument air isolation valves and pulling the control power fuses for each of the valves. The associated instrument air isolation valves and fuse blocks are then locked. Once electrically isolated, the valves do not have control room indication.

Following a Containment Isolation Actuation Signal (CIAS) the supply fan, if operating, and associated isolation damper, if open, are isolated. Damper closing is monitored by position indication in the control room.

The enclosure building is heated or ventilated when required by the purge system. Branch ducting is provided from the main purge line for the enclosure building. Ventilation may be required for this area periodically throughout the summer to maintain the enclosure building temperature below 120°F. Auxiliary heating, in addition to unit heater, may be required periodically through the summer to the winter to maintain the enclosure building temperature above 70°F. Unit heaters are located near Elevation 48-6 to maintain the lower regions of the enclosure building at 70°F. The upper regions in the enclosure building are maintained at 55°F minimum. Ventilation and auxiliary heating in the enclosure building is an operator option for personnel comfort and not essential for unit operation.

9.9.3.4 Availability and Reliability

9.9.3.4.1 Special Features

All components of the purge system are designed to operate in their respective environments. Components inside containment are designed to operate in an environment of 120°F, atmospheric pressure, 100 percent relative humidity and 5×10^6 rads of accumulated radiation dose (40 years). All components located outside the containment are designed for operation in an environment of 110°F, 100 percent relative humidity and atmospheric pressure.

9.9.3.4.2 Tests and Inspections

The purge air handling unit fan is similar to fans which are rated in accordance with AMCA Standard 211A. The heating coil is of the steam distributing type and provided with adequate condensate drainage capacity to prevent freezing. The steam coil is tested in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and TEMA, Class C. The ductwork is designed and fabricated in accordance with SMACNA Standard, “High Velocity Duct Construction Standards.” The purge butterfly valves are in accordance with ASME Code, Section III, Class 2. The purge system undergoes an acceptance test prior to startup. The test procedure is described in Chapter 13. The purge ventilation equipment and exterior containment isolation valves are accessible for periodic tests, inspection and maintenance. The ductwork and valves inside the containment are accessible during unit shutdown. Purge valve elastomers and shaft packing are adjusted and/or replaced based on 10 CFR 50, Appendix J, Type C test results.

The containment purge isolation valve seats are designed to withstand the pressure and temperature transients associated with the Loss of Coolant Accident (LOCA).

9.9.4 CONTAINMENT AUXILIARY CIRCULATION SYSTEM

9.9.4.1 Design Bases

9.9.4.1.1 Functional Requirements

The containment auxiliary circulation system functions to maintain a uniform temperature by mixing the containment atmosphere.

9.9.4.1.2 Design Criteria

The components of the containment auxiliary circulation system shall be designed to operate in the environment to which exposed.

9.9.4.2 System Description

9.9.4.2.1 System

The containment auxiliary circulation system is shown schematically in Figure 9.9–1. The containment auxiliary circulation system consists of ductwork from the containment dome region and two, two speed vaneaxial fans. The fans are provided with two-speed motors to reduce horsepower requirements during leak rate testing conditions (Section 5.2.8). The system exhausts air from the upper regions of the containment through the ductwork and discharges near the inlets of the containment air recirculation units (Section 6.5). This operation provides a thoroughly mixed containment atmosphere and uniform air temperatures.

9.9.4.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-3. Fan performance curve is shown in Figure 9.9–7.

9.9.4.3 System Operation

The containment auxiliary circulation system operates during normal operation and is capable of operation during leak rate testing conditions.

9.9.4.3.1 Normal Operation

The containment auxiliary circulation fans are started manually from the control room. During normal operation, these fans operate at the high speed condition to provide a uniform containment temperature by mixing.

The containment auxiliary circulation system is capable of approximately 75 percent of the total flow of the containment air recirculation and cooling system (Section 6.5). Air from the upper regions of the containment is discharged near the operating floor level where it is mixed. This mixture is distributed throughout the lower regions of the containment by the containment air recirculation and cooling system (Section 6.5).

The containment auxiliary circulation system operates during containment purge operations (Section 9.9.2) to provide mixing.

The fans can operate at the low speed during the elevated pressure conditions of the leak rate testing (Section 5.2.8) conditions. This low speed operation is provided to reduce motor horsepower requirements. Fan operation is monitored by motor trip alarms.

9.9.4.4 Availability and Reliability

9.9.4.4.1 Special Features

The components of the containment auxiliary circulation system are designed to operate in the normal containment environment and under leak rate testing conditions. The normal environment conditions are 120°F, atmospheric pressure, 100 percent relative humidity and 40 year accumulated radiation dose of 5 x 10^6 rad. Leak rate testing environmental conditions are 90°F and 62.1 psig.

The containment auxiliary circulation system is not essential for normal operation. Therefore, loss of both subsystems will not require a unit shutdown.

9.9.4.4.2 Tests and Inspection

The vaneaxial fans are similar to fans which are rated in accordance with AMCA Standard 211A. The ductwork is designed and fabricated in accordance with SMACNA Standard, “Low Velocity Duct Construction Standards.”

The containment auxiliary circulation system undergoes an acceptance test prior to startup. The containment auxiliary circulation system is accessible only during shutdown for inspection and maintenance.

9.9.5 CONTAINMENT PENETRATION COOLING SYSTEM

9.9.5.1 Design Bases

9.9.5.1.1 Functional Requirements

The containment penetration cooling system functions to limit the concrete temperature to 150°F around all containment penetration sleeves which contain systems operating at temperatures greater than 150°F.

9.9.5.1.2 Design Criteria

The following criteria have been used in the design of the containment penetration cooling system:

a. The system shall have two redundant fans each having 100 percent of the total required heat removal capability.

b. The components of the containment penetration cooling system shall be designed to operate in the environment to which exposed.

c. The system shall be designed to permit periodic inspection of important components, such as fans and ductwork to assure the integrity and capability of the system.

9.9.5.2 System Description

9.9.5.2.1 System

The containment penetration cooling system is shown schematically in Figure 9.9–2. The containment penetration cooling system consists of two full capacity redundant vaneaxial fans and associated system ductwork. The containment penetration cooling system supplies enclosure building air to any containment penetration which has a normal operating temperature greater than 150°F. Each of these penetration sleeves is provided with a baffle plate in the horizontal plane (see Figure 5.2–8). Cooling air is supplied in the bottom half of the sleeve, forced down the penetration to the flued head where the air is deflected back along the upper portion of the sleeve and discharged back into the enclosure building. The temperature of the concrete around the penetration sleeve will be maintained below 150°F for all penetrations during normal operating conditions.

9.9.5.2.2 Components

The major system components and associated fabrication and performance data are listed in Figure 9.9–4. Fan performance curve is shown in Figure 9.9–8.

9.9.5.3 System Operation

The containment penetration cooling system operates at any time normal penetration cooling is required.

9.9.5.3.1 Normal Operation

The containment penetration cooling system is started manually by hand switches located in the control room.

Cooling air is provided from the enclosure building to cool the penetration sleeves. Adequate cooling can be provided by air below 120°F. Cooling air is available for the enclosure building from the purge system (Section 9.9.2), if required, to maintain the ambient temperature below 120°F. Cooling air at a maximum temperature of 120°F is supplied to the penetrations at the rates indicated in Table 9.9-5.

The performance of the containment penetration cooling system is monitored by temperature indication in each main steam and main feedwater penetration. Fan operation is monitored by motor trip alarms. Interlocks are provided to prevent short circuiting of air through idle equipment.

9.9.5.4 Availability and Reliability

9.9.5.4.1 Special Features

The containment penetration cooling system is provided with two full capacity fans. Each fan has the capability of maintaining the concrete temperature around the sleeve below 150°F. Following the unlikely loss of penetration cooling, a maximum temperature of 390°F may be tolerated for 120 days without appreciable loss of strength of the concrete (Section 5.1.3). The components of the containment penetration cooling system are designed to operate in an environment of 120°F, atmospheric pressure and 100 percent relative humidity.

9.9.5.4.2 Tests and Inspection

The vaneaxial fans are similar to fans which are rated in accordance with the AMCA Standard 211A. The system ductwork is designed and fabricated in accordance with SMACNA Standard, "High Velocity Duct Construction Standards." The containment penetration cooling system undergoes an acceptance test prior to startup. The test procedure is described in Chapter 13. Equipment is located in controlled access areas but can be inspected periodically.

9.9.6 RADWASTE AREA VENTILATION SYSTEM

9.9.6.1 Design Bases

9.9.6.1.1 Functional Requirements

The radwaste ventilation system is a Non-QA system, consisting of supply fan F-16 in combination with the main exhaust fans F-34A/B/C. It functions to provide a suitable environment for the equipment and fresh air ventilation for personnel within the potentially radioactive areas of the auxiliary building. The areas serviced by this system consist of the auxiliary building elevations (-)45 foot 6 inches, (-)25 foot 6 inches, and (-)5 foot 6 inches in its entirety, the general open area at elevation 14 foot 6 inches (i.e., area by: elevator, MCC's B51 and B61), and the closed rooms (142A, 150) located adjacent to the truck bay area of the auxiliary building at elevation 14 foot 6 inches.

9.9.6.1.2 Design Criteria

The following criteria have been used in the design of the radwaste ventilation system:

a. The system shall be designed to permit periodic inspection of important components, such as fan, motor, belt, coil, filters, ductwork, piping and valves to assure the integrity and capability of the system.

b. The components of the radwaste ventilation system are designed to operate in the environment to which exposed.

c. The potentially radioactive areas of the auxiliary building shall be served by a separate ventilation system from the clean areas.

d. The potentially radioactive areas of the auxiliary building shall be maintained at a negative pressure.

9.9.6.2 System Description

9.9.6.2.1 System

The radwaste ventilation system is shown schematically in Figure 9.9–3.

The radwaste area ventilation system consists of a supply fan F-16 providing 100%, once through, tempered outside air through a steam heating coil to all levels of the auxiliary building containing potentially radioactive areas, with the exception of the spent fuel area which has its own ventilation system (Section 9.9.8). Air flow rates are established to maintain the areas at or below its maximum design temperature of 110°F and steam coils are provided to maintain a minimum temperature of 55°F.

The air is drawn from the potentially radioactive areas of the auxiliary building via the main exhaust system, fans F-34A/B/C, (Section 9.9.9) through the radwaste system HEPA filter unit L-26 and is discharged into the Unit 2 stack.

The auxiliary building's potentially radioactive areas are maintained at slightly negative pressure within their defined pressure boundaries. This negative pressure is induced and maintained within these boundaries by exhausting more air, via the main exhaust fans F-34A/B/C, than the supply air flow rate provided by fan F-16. The directional air flow between these radioactive areas is maintained in the direction of potentially higher radioactivity.

9.9.6.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-6. Fan performance curve is shown in Figure 9.9–9.

9.9.6.3 System Operation

The radwaste ventilation system is required for building ventilation during unit operation and during shutdown operation.

9.9.6.3.1 Normal Operation

The radwaste ventilation system is manually started from a local control hand switch in the control room mechanical equipment area. The system logic (Figure 9.9–10) requires two main exhaust fans (Section 9.9.9) to be operating prior to initiation of the supply fan F-16.

The supply fan F-16 distributes fresh outside air to the potentially contaminated areas at all levels of the auxiliary building. A steam heating coil is provided for tempering outside air when required. A flow switch is provided on the supply unit discharge to monitor air flow and alarm low flow conditions. A temperature switch is provided at the heating coil outlet to monitor temperature and alarm low temperature conditions. Two (2) safety related steam leak detection temperature detectors (RTD's) are located in the ductwork downstream of the heating coils to isolate auxiliary steam to the Auxiliary Building (Section 7.10).

Outdoor air is supplied at approximately 86°F during summer operations to limit the auxiliary building ambient temperature to 110°F. During winter operations, the air is tempered to maintain a minimum auxiliary building temperature of 55°F in the areas with storage tanks containing boron solution to prevent boron precipitation. However, booster coils are provided for elevation 14 feet 6 inches floor level to maintain a desired temperature of 70°F within the dressing area for personnel comfort.

The exhaust from the radwaste areas is filtered through particulate and HEPA filters and is discharged by the main exhaust fans through the Unit 2 stack. This is described in Section 9.9.9. Radiation monitoring is described in Section 7.5.6.

9.9.6.4 Availability and Reliability

9.9.6.4.1 Special Features

To assure an overall slight negative pressure within the potentially radioactive areas of the auxiliary building, the supply fan, F-16, can be started only if two main exhaust fans F-34A/B/C (Section 9.9.9) are in operation. Upon the loss of the supply fan, F-16, the main exhaust fans keep operating, thus maintaining a negative pressure within these areas. However, the supply fan, F-16, is returned to service as soon as practicable. Upon the loss of two main exhaust fans, a main exhaust duct pressure switch trips off supply fan F-16.

Two automatically closed dampers, in a series arrangement, are provided at all penetrations into the Enclosure Building Filtration Region (EBFR) (Section 6.7). These dampers are pneumatically actuated and designed to fail in a closed position. All components of the radwaste ventilation system are designed to operate in an environment of 110°F, atmospheric pressure and 100 percent relative humidity.

Two safety related temperature detectors are installed in ductwork downstream of the steam heating coil to detect potential steam leaks. Actuation of either of these temperature detectors will cause isolation of the auxiliary steam supply to the Auxiliary Building in isolation valves located in the Turbine Building. This condition will also be alarmed in the control room.

9.9.6.4.2 Tests and Inspection

The centrifugal fans are similar to fans which are rated in accordance with AMCA Standard 211-A. The steam heating coils are tested in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and TEMA, Class C. The ductwork is designed and fabricated in accordance with SMACNA Standard, “High Velocity Duct Construction Standards.”

The radwaste ventilation system undergoes an acceptance test prior to start-up. The test procedure is described in Chapter 13.

All components of the radwaste ventilation system are accessible for inspection and maintenance.

9.9.7 NONRADIOACTIVE AREA VENTILATION SYSTEM

9.9.7.1 Design Bases

9.9.7.1.1 Functional Requirements

The nonradioactive area ventilation system is a non-QA system, consisting of supply fan F-17, recirculating fan F-19, and exhaust fan F-26 for the East 480-volt switchgear room, and exhaust fan F-112A & F-112B for the remaining areas. It functions to provide a suitable environment for the equipment and fresh air ventilation for personnel within the clean areas of the auxiliary building, and the East & West turbine building cable vaults. However, there is no heating coil associated with this system as there is sufficient heat rejected by the electrical equipment within these areas. The maximum design temperature in these areas is 104°F and the minimum is 55°F for personnel comfort, which is consistent throughout the plant for unmanned areas, with the exception of the battery rooms, which is 60°F.

The nonradioactive areas of the auxiliary building consist of the East 480 volt switchgear room (elevation 36 foot 6 inches), the main cable vault (elevation 25 foot 6 inches), the East & West DC switchgear rooms as well as the East & West battery rooms (elevation 14 foot 6 inches), and the HVAC equipment room (elevation 36 foot 6 inches), which has no ventilation system. The East & West turbine building cable vaults, elevation 45 foot, are opened to the auxiliary building main cable vault (elevation 25 foot 6 inches). The auxiliary building nonradioactive areas are physically separated from the potentially radioactive areas. Other than the East 480 volt switchgear room, which is maintained at a slightly negative pressure, there is no pressurization requirement for the remaining nonradioactive areas.

9.9.7.1.2 Design Criteria

The following criteria have been used in the design of the nonradioactive ventilation system:

a. The system shall be designed to permit periodic inspection of important components, such as fan, motor, belt, filters, ductwork, piping and valves to assure the integrity and capability of the system.

b. The components of the nonradioactive ventilation system are designed to operate in the environment to which exposed.

9.9.7.2 System Description

9.9.7.2.1 System

The nonradioactive area ventilation system is shown schematically in Figure 9.9–3.

The clean areas of the auxiliary building as well as the East & West turbine building cable vaults are served by the nonradioactive ventilation system which consists of supply fan F-17, recirculating fan F-19, and exhaust fans F-26 for the East 480 volt switchgear room and battery rooms exhaust fans F-112A & F-112B for the remaining areas.

The battery rooms are ventilated by drawing main cable vault air through the battery rooms while also drawing a small amount from the DC switchgear rooms into the battery rooms with roof exhaust fans F-112 A & F-112B which discharge to atmosphere. All rooms are separated by fire dampers.

9.9.7.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-7. Fan performance curves are shown in Figures 9.9–11 through 9.9–14.

9.9.7.3 Systems Operation

The nonradioactive area ventilation system is required during normal and shutdown operations.

9.9.7.3.1 Normal Operation

The nonradioactive area ventilation system supply fan, F-17, is interlocked with the East 480 volt switchgear room exhaust fan F-26 via a room thermostat and time delay relays. These fans start at 75°F and reset at 72°F, with a 20 minute time delay. This interlock scheme ensures that the exhaust fan F-26 starts before supply fan F-17. The control scheme is designed to limit the number of fan starts to three per hour by running the fans F-17/F-26 for a minimum time of 20 minutes per start. This system is designed to maintain the East 480 Volt switchgear room below 104°F, based on a summer outdoor design temperature of 86°F. During winter operation there is sufficient heat generated by the electrical equipment to maintain the room temperature above 55°F for personnel comfort, which is consistent throughout the plant for unmanned areas.

Because the East 480 volt switchgear room is the dominant heat load area, the thermostat controlling supply fan F-17 is located within this room. During warm weather, these areas served by fan F-17 get adequate cooling since the controlled area has a higher demand; during cold weather, these areas temperatures may be lower than the dominant area. Although this is not a concern for the cable vault areas, the minimum desired battery room temperature is 60°F. The battery rooms are provided with HI-LO temperature alarms. Historically, since the steam coil was removed from fan F-17 in 1992, temperature in the battery rooms has not been a problem. The impact on the DC switchgear rooms temperature, caused by the small amount of fresh air drawn through it, is insignificant.

A recirculating fan, F-19, equipped with a chilled water coil X-40, and located in the upper 4160 volt AC switchgear room, elevation 56 foot 6 inches, provides extra cooling for the main cable vault, as well as the East and West turbine building cable vaults.

9.9.7.4 Availability and Reliability

9.9.7.4.1 Special Features

The East & West battery rooms are interconnected by ductwork to assure venting following the failure of either 50 percent air flow capacity exhaust fans F-112A or F-112B, which is adequate to maintain room temperatures.

All components of the nonradioactive ventilation system are designed to operated in an environment of 110°F, atmospheric pressure, and 100 percent relative humidity.

9.9.7.4.2 Tests and Inspection

The centrifugal and vaneaxial fans are similar to fans that are rated in accordance with AMCA Standard 211-A. The ductwork is designed and fabricated in accordance with SMACNA Standard, "Low Velocity Duct Construction Standards."

The nonradioactive ventilation system undergoes an acceptance test prior to startup.

The nonradioactive system is accessible for periodic tests and inspection.

9.9.8 ENGINEERED SAFETY FEATURES ROOM AIR RECIRCULATION SYSTEM

9.9.8.1 Design Bases

9.9.8.1.1 Functional Requirements

The Engineered Safety Features Room Air Recirculation System (ESFRARS) functions to maintain a suitable environment for the electric motor drivers of the safety injection and containment spray pumps during post accident operation.

9.9.8.1.2 Design Criteria

The following criteria have been used in the design of the ESFRARS:

a. The system shall have two redundant, independent subsystems, each having 100 percent of the total required heat removal capability.

b. The system shall have suitable subsystem and component alignments to assure operation of the complete subsystem with its associated components.

c. Capabilities shall be provided to assure the system operation with on site power (assuming off site power is not available) or with off site electrical power.

d. A single failure in either subsystem shall not affect the functional capability of the other subsystem.

e. The system shall be designed to permit periodic inspection of important components, such as fans, coils, ductwork, piping and valves to assure the integrity and capability of the system.

f. The system shall be designed to permit appropriate periodic functional testing to assure the operability and performance of the active components of the system, and the operability of the system as a whole. Under conditions as close to the design as practical, the performance shall be demonstrated of the full operational sequence that brings the system into operation, including operation of applicable portions of the protection system, the transfer between normal and emergency power sources, and the operation of the associated cooling water system.

g. The system shall be designed to the general criteria as described in Section 6.1.

h. The components of the system shall be designed to operate in the most severe post-accident environment as described in Section 6.1.

9.9.8.2 System Description

9.9.8.2.1 System

The ESFRARS is shown schematically in Figure 9.9–2. The automatic initiation logic for ESFRARS is described by the combination of: (a) the initiation logic diagram for the Safety Injection Actuation Signal (SIAS) in Figure 7.3–1, and (b) the tabulation of the equipment that is actuated by SIAS in Figures 7.3–2A through 7.3–2D.

The ESFRARS consists of two redundant, independent subsystems, each capable of maintaining the required temperature in one engineered safety features pump room (Section 6.1.4.1). Each ESFRARS subsystem consists of a fan and finned tubed heat exchanger. Each safeguard pump room contains one full capacity ESFRARS fan and coil unit. The third High Pressure Safety Injection (HPSI) pump room is served by both fan and coil units.

Each ESFRARS fan and coil unit is capable of cooling two HPSI pumps (including the swing pump in “C” cubicle), one Low Pressure Safety Injection (LPSI) pump and one containment spray pump. The ESFRARS is designed to limit the maximum ambient temperature to 177.9°F. All components can withstand the ambient conditions.

9.9.8.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-8. Fan performance curve is shown in Figure 9.9–15.

9.9.8.3 System Operation

The ESFRARS is provided to maintain a suitable environment for the safety injection and containment spray equipment following a LOCA.

During normal plant operations, the Radwaste Ventilation System (F-16), Section 9.9.5 services the ESF pump rooms. However, during operation of the shutdown cooling system, the ESFRARS may be operated to supplement the cooling provided by fan F-16.

9.9.8.3.1 Emergency Conditions

The ESFRARS is automatically initiated by the safety injection actuation signal (SIAS) (Section 7.3). Room air is circulated over the water cooling coils by the vaneaxial fans and discharged back into the room. A minimum air flow of 3,650 CFM is diverted to the third high pressure safety injection pump room from each recirculation unit fan (F-15A and F-15B).

The ESFRARS is aligned with the respective emergency power source (Section 8.3) as the associated safety features equipment served. The RBCCW system (Section 9.4) serves as the heat sink.

System operation is monitored by temperature and flow indication of the water side. Indication is provided in the control room. Fan operation is monitored by motor trip alarms. High room temperature is alarmed in the control room.

9.9.8.4 Availability and Reliability

9.9.8.4.1 Special Features

The components of the ESFRARS are designed to the general criteria including seismic response as described in Section 6.1. All components are protected from missile damage and pipe whip by physical separation of duplicate equipment as described in Section 6.1.

The ESFRARS fan and coil units are completely redundant, physically separated in water tight pump rooms and powered by separate emergency power sources. A failure mode analysis for the ESFRARS is given in Table 9.9-16.

Each ESFRARS subsystem is designed to remove the heat given off by two HPSI pumps (including the swing pump in the “C” cubicle), one LPSI pump, and one containment spray pump. However, since the LPSI pumps are not required following the recirculation mode (Section 6.3), the fan coil units have additional cooling capabilities.

The ESFRARS is provided to maintain an ambient temperature of no greater than 177.9°F for the electric motor drivers of the engineered safety feature pumps. The safety injection and containment spray pump motors can withstand exposure to the ambient conditions.

All components of the ESFRARS are designed to operate in an environment of 177.9°F, atmospheric pressure and radiation level of at least 10^6 rad. Electric motors are designed for 100 percent relative humidity.

9.9.8.4.2 Tests and Inspection

One of the two vaneaxial fans is rated in accordance with AMCA Standard 211-A. The water cooling coils are tested in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and TEMA, Class R. The ductwork is designed and fabricated in accordance with SMACNA Standard, "High Velocity Duct Construction Standards."

Provisions are incorporated into the system design for on-line testing capabilities. Each ESFRARS subsystem is tested separately from the redundant subsystem. The ESFRARS is automatically started by manually initiating the SIAS. Fan operation is indicated by motor trip alarms.

The ESFRARS undergoes a preoperational test prior to startup. The test procedure is discussed in Chapter 13.

The components of the ESFRARS are accessible for periodic inspection and maintenance.

9.9.9 FUEL HANDLING AREA VENTILATION SYSTEM

9.9.9.1 Design Bases

9.9.9.1.1 Functional Requirements

The fuel handling area ventilation system is a non-QA system, consisting of supply fan F-20 in combination with the main exhaust fans F-34A/B/C and a recirculating fan F-140 (coil X-191). It functions to provide a suitable environment for the equipment and fresh air ventilation for personnel within the fuel handling area of the auxiliary building. The fuel handling area consists of the open area at elevation 38 foot 6 inches, the mezzanine on the East side, and the open lower area known as the truck bay area.

9.9.9.1.2 Design Criteria

The following criteria have been used in the design of the fuel handling ventilation system:

a. The system is designed to permit periodic inspection of important components, such as fan, motor, belt, oil, filters, ductwork, piping and valves, to assure the integrity and capability of the system.

b. The components of the fuel handling ventilation system are designed to operate in the environment to which exposed.

c. The fuel handling area which is part of the auxiliary building shall be served by a separate ventilation system.

d. The fuel handling area shall be maintained at a slightly negative pressure.

9.9.9.2 System Description

9.9.9.2.1 System

The fuel handling area ventilation system is shown schematically in Figure 9.9–3.

The fuel handling area ventilation system is designed to provide adequate ventilation in the spent fuel pool area and to prevent cross contamination with surrounding areas. The maximum design temperature in the fuel handling area is 110°F, and the minimum temperature maintained at 55°F, which is consistent throughout the plant for unmanned areas. However, booster coils are provided to maintain a desired temperature of 70°F for personnel comfort (e.g., dressing area).

The fuel handling ventilation system consists of a supply fan, F-20, providing 100 percent outside fresh air, tempered through a steam coil, to the spent fuel area at elevation 38 feet 6 inches.

A self contained air conditioning unit F-140 (coil X-191), located in the spent fuel pool area, provides cooling whenever operations in the spent fuel pool area are required during extreme warm weather. The air conditioner discharges through ductwork along the south wall of the spent fuel pool. The ductwork has been sized to accommodate a second air conditioning unit of similar size.

The air is drawn through return registers located on the north side wall, immediately above the spent fuel pool, to ensure that the negative pressure within the fuel handling area of the auxiliary building is at its strongest across the spent fuel pool surface area where the radioactive gaseous release is most likely to occur. The air is exhausted at a greater rate than it is supplied to ensure an overall negative pressure within the fuel handling area of the auxiliary building.

During normal operation, air is drawn by the main exhaust fans F-34/A/B/C through HEPA filter unit L-27. Prior to the handling of irradiated fuel, the exhaust air control logic may be aligned to the auxiliary exhaust system (AES).

Ventilation of the fuel handling area during handling of irradiated fuel may be provided by main exhaust or the auxiliary exhaust system (AES), but neither system is required. While these systems are used and fuel handling area boundary integrity is set, then any radioactive effluent is discharged via a filtered and monitored pathway. The integrity of the fuel handling area boundary is not a requirement while main exhaust or AES ventilation is in use. In the event that neither ventilation system is available, then suitable radiological monitoring is recommended per the Millstone Effluent Control Program.

As discussed in the Millstone Unit 2 Environmental Report and FSAR Section 14.7, an accident is not credible unless fuel is being handled or a heavy object has been moved over the spent fuel pool.

The radiation monitoring system in the fuel handling area consists of four (4) gamma sensitive plastic scintillation, detector assemblies equally spaced above the spent fuel pool area with local indication plus visual and audible alarms.

Alarm circuitry of the readout module located in the control room will provide contact closure (2-out-of-4 matrix) upon high radiation for automatic operation of the auxiliary exhaust system. The automatic operation of the auxiliary exhaust system is not credited in the fuel handling accident analysis.

Alarm set points are adjustable and are normally set for 50 mr/hr.

9.9.9.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-9. The fan performance curve is shown in Figure 9.9–16. The EBFS is described in Section 6.7.

9.9.9.3 System Operation

The fuel handling area ventilation is available during normal and shutdown operations.

9.9.9.3.1 Normal Operation

The fuel handling area ventilation system is manually started from the control room. The system logic requires one main exhaust fan (Section 9.9.9) to be operating prior to initiation of the supply fan (F-20).

During normal operation, it may be necessary to move heavy equipment over the spent fuel pool (i.e., moving fuel assembly, fuel cask), in which case the AES may be manually initiated. Manual initiation of AES is not credited in the fuel handling accident analyses.

The supply fan F-20 distributes fresh outside air to the operating floor level at elevation 38 feet 6 inches. A steam heating coil is provided for tempering outside air when required. A flow switch is provided on the supply unit discharge to monitor air flow and alarm flow conditions.

Outdoor air is supplied at approximately 86°F during summer operation to limit the fuel handling area maximum temperature to 110°F. During winter operation, the air is tempered to maintain a temperature at 55°F, which is consistent throughout the plant for unmanned areas. However, supplemental building heat is provided by steam unit heaters to maintain a desired temperature of 70°F for personnel comfort (e.g,. dressing area).

During normal operation, air is pulled across the spent fuel pool surface by the main exhaust fans F-34A/B/C (Section 9.9.9) through the HEPA filter unit (L-27) prior to discharge to the Unit 2 stack. The effluent is monitored for radiation (Section 7.5.6).

The air conditioning unit F-140 is manually started and stopped locally as required by the operator to maintain comfortable conditions for the personnel working in the area.

9.9.9.3.2 Emergency Operations

There is no requirement for operation of the fuel handling area ventilation system prior to movement of irradiated fuel or a cask in the spent fuel pool. Nor is there any requirement for operation of any ventilation system to mitigate a fuel handling accident, or a cask drop accident in the fuel handling area. Post-accident doses attributable to a fuel handling or cask drop accident are within the criteria identified by Regulatory Guide 1.183 and 10 CFR 50.67 and do not credit either the main exhaust or AES ventilation systems.

9.9.9.4 Availability and Reliability

9.9.9.4.1 Special Features

During normal plant operation, to assure a negative pressure within the fuel handling area of the auxiliary building, the supply fan F-20 can be started only if one main exhaust fan F-34A/B/C (Section 9.9.9) is operating. Upon a loss of the supply fan F-20, ventilation is still maintained, although at a lower rate by infiltration induced by an increased negative pressure generated by main exhaust fans. However, the supply fan F-20, is returned to service as soon as practicable.

Upon the loss of all three main exhaust fans F-34A/B/C, a main exhaust duct pressure switch trips-off supply fan F-20.

Round ductwork is provided for additional strength for the AES. Generally, if space permits, round ductwork is provided for seismic Class 1 requirements. This facilitates seismic analysis of the system. The components of the EBFS are described in Section 6.7.

All components of the normal fuel handling ventilation system are designed to operate in an environment of 110°F, atmospheric pressure and 100 percent relative humidity.

9.9.9.4.2 Tests and Inspection

The centrifugal fans are similar to fans which are rated in accordance with AMCA Standard 211-A. The steam heating coils are tested in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and TEMA, Class C. The ductwork is designed and fabricated in accordance with SMACNA Standard, “High Velocity Duct Construction Standards.”

The normal ventilation system undergoes an acceptance test prior to startup, while the AES undergoes a preoperational test. The test procedure is described in Chapter 13.

The AES is incorporated with provisions for online testing. The AES is manually initiated in the control room by operator action. The EBFS is automatically isolated from the EBFR and aligned with the fuel handling area. The normal ventilation is isolated from the fuel handling building.

System operation is monitored by flow and filter differential pressure indication. Damper opening and system alignment is monitored by positioned indication in the control room.

The components of the fuel handling ventilation system are accessible for periodic inspection and maintenance.

9.9.10 MAIN EXHAUST VENTILATION SYSTEM

9.9.10.1 Design Bases

9.9.10.1.1 Functional Requirements

The main exhaust ventilation system is a Non-QA system, consisting of exhaust fans F-34A/B/C. It functions to filter the exhaust from all potentially radioactive areas of the unit.

9.9.10.1.2 Design Criteria

The following criteria have been used in the design of the main exhaust system:

a. The system shall be designed to permit periodic inspection of important components, such as fan, motor, belt, coil, filters, ductwork, piping and valves, to assure the integrity and capability of the system.

b. The components of the main exhaust system are designed to operate in the environment to which exposed.

c. The potentially radioactive areas of the auxiliary building shall be served by a separate ventilation system from the clean areas.

d. The potentially radioactive areas of the auxiliary building shall be maintained at a negative pressure in respect to the clean areas.

9.9.10.2 System Description

9.9.10.2.1 System

The main exhaust system is shown schematically in Figures 9.9–1 and 9.9–2.

The main exhaust ventilation system is a Non-QA system and is designed to exhaust air from the areas of the auxiliary building served by the radwaste supply fan F-16, the spent fuel handling area supply fan, F-20 and the containment/enclosure building purge fan, F-23. Exhaust air from these areas is processed through HEPA filter units prior to discharge through the unit 2 stack.

The main exhaust ventilation system consists of three filter units (L-25, L-26, L-27), three centrifugal fans F-34A/B/C, and a pressure relief damper 2-AC-59. Each filter unit is associated with a respective area and is designed for the full system flow. Each main exhaust fan is sized for 32,000 cfm. However, during start-up it was accepted that the exhaust fans could not generate the design flow and consequently, supply fans F-16, F-20, F-23 serving the areas covered by the main exhaust fans are balanced to assure that the exhaust air flow is greater than the supply air flow to maintain a negative pressure in these areas. Normally, two fans are required for the radwaste and fuel handling areas with the third fan on standby. During purging operations or enclosure building ventilation, all three exhaust fans are operating.

9.9.10.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-10. Fan performance curve is shown in Figure 9.9–18.

9.9.10.3 System Operation

The main exhaust ventilation system is required during normal and shutdown operations.

9.9.10.3.1 Normal Operation

The main exhaust ventilation system is manually started from the control room. Normally two of the three fans, F-34A/B/C are initiated for normal operation. Three fans are required to operate during purging or enclosure building ventilation operations. The third fan serves as backup for the two operating and provides redundancy in system design.

Air is exhausted from the respective areas in the auxiliary building at a greater rate than it is supplied to induce a negative pressure in these areas. The exhaust air is processed through the respective HEPA filter unit to remove airborne particulate matter. The exhaust duct from each of the three areas is provided with process radiation monitors (Section 7.5.6) to alarm high radiation levels.

Flow switches are provided at each fan discharge to alarm low flow conditions. A counterweight backdraft damper is provided at each exhaust fan discharge to minimize recirculation through an idle fan. The damper position for the air pressure damper 2-AC-59, and for each HEPA filter unit (L-25, L-26, L-27) isolation damper, is monitored in the control room.

9.9.10.4 Availability and Reliability

9.9.10.4.1 Special Features

Two of the three main exhaust fans F-34A/B/C are required for normal operation. Although purging containment or enclosure building ventilation requires the third fan, this operation is discontinued upon the loss of any exhaust fans. Purging is not essential for unit operation or for shutdown and can be discontinued at any time to assure availability of exhaust fans for the auxiliary building.

Provisions for outside makeup air are provided through damper 2-AC-59 to act as a pressure relief damper whenever the pressure in the main exhaust duct exceeds a preset limit switch (automatic function) and to act as a flow balancing damper whenever an auxiliary building HEPA filter unit L-26/L-27 is taken out of service for maintenance, testing or filter replacement. Outside air is available at a maximum rate of 20,000 cfm (automatic function) to prevent the main exhaust plenum from exceeding its design negative pressure of (-)6 inches wg. By procedure, a manual function, whenever the radwaste ventilation system HEPA filter unit, L-26 is isolated supply fan F-16 is taken out of service, only one exhaust fan is allowed to operate and the makeup air damper 2-AC-59 is manually controlled to open at its minimum flow. This operation is necessary because one exhaust fan's capacity exceeds the spent fuel handling fan, F-20, rated at approximately 20,000 cfm. The minimum flow is preset to match the actual exhaust fan capacity with the actual fuel handling HEPA filter L-27 rated flow to maintain approximately the same negative pressure within the fuel handling area.

All the MES fans will trip on receipt of a Channel 1 CIAS actuation signal. This trip signal can be overridden to restart the fans to restore the ventilation if a CIAS signal is still present. This trip signal is not a credited engineered safety feature (ESF) equipment actuation. The trip will minimize the consequence of the single failure of dampers 2-AC-11 (Section 6.7.4.1.2).

By procedure, with the fuel handling HEPA filter unit L-27 out of service, supply fan F-20 is deenergized, makeup damper 2-AC-59 is opened to its maximum setting providing approximately 20,000 cfm and two main exhaust fans are activated. The maximum makeup flow is preset to match the actual exhaust fans capacity with the actual radwaste HEPA filter L-26 rated flow to maintain approximately the same negative pressure within the radwaste areas of the auxiliary building.

Outside makeup air capabilities are not required for the purge exhaust scenario since the requirements for the HEPA filter unit L-25 are within one exhaust fan capacity.

Each ventilation filter unit is provided with a differential pressure control damper to maintain a constant pressure drop across each unit as the filters get dirty. This provides the means to balance air flow for operations among parallel HEPA filter units L-25, L-26 and L-27.

To assure a negative pressure within the auxiliary building, the main exhaust fans must be started prior to starting any of the supply fans F-16, F-20, or F-23. The exhaust fans can maintain the specific area negative pressure upon the loss of its respective supply fan. However, upon the loss of one or more main exhaust fans F-34A/B/C, supply fans F-16, F-20 and F-23 will trip off based on their respective pressure switches related setting.

The discharge duct from the non-safety related Chemistry Laboratory Exhaust Ventilation Fans, F-165 and F-166 is connected to the inlet plenum of Main Exhaust Fans F-34A/B/C. This duct is equipped with an air operated isolation damper, 2.HV-710, which is controlled by a solenoid valve designed to close the damper when a low or no flow condition exists in the plenum. The damper also closes on loss of instrument air.

All components of the main exhaust ventilation system are designed to operate in an environment of 110°F, atmospheric pressure, and 100 percent relative humidity.

9.9.10.4.2 Tests and Inspections

The centrifugal fans are similar to fans which are rated in accordance with AMCA Standard 211-A. The ductwork is designed and fabricated in accordance with SMACNA Standard, “High Velocity Duct Construction Standards.”

The HEPA filters are periodically tested in accordance with Regulatory Guide 1.140 and ANSI N510-1975, Testing of Nuclear Air-Cleaning Systems.

The main exhaust system undergoes an acceptance test prior to startup. The test procedure is described in Chapter 13.

All components of the main exhaust system located outside the containment are accessible for inspection and maintenance. Components within containment are accessible only during shutdown.

9.9.11 CONTROL ROOM AIR CONDITIONING SYSTEM

9.9.11.1 Design Bases

9.9.11.1.1 Functional Requirements

The control room air conditioning system functions to maintain a suitable environment for personnel and for safety related control and electrical equipment.

9.9.11.1.2 Design Criteria

The following criteria have been used in the design of the control room air conditioning system:

a. The system shall have two redundant, independent subsystems, each having 100 percent of the total required heat removal capability. However, there are some common supply and return ductwork and dampers.

b. The system shall have suitable subsystem and component alignments to assure operation of the complete subsystem with its associated components.

c. Capabilities shall be provided to assure system operation with either on site power (assuming off site power is not available) or with off site electrical power.

d. A single failure in either subsystem shall not affect the functional capability of the other subsystem.

e. The system shall be designed to permit periodic inspection of important components, such as fans, motors, coils, compressor, filters, piping, valves, instrumentation and ductwork, to assure the integrity and capability of the system.

f. The control room air conditioning system shall be designed to permit appropriate periodic pressure and functional testing to assure (1) the structural and leak-tight integrity of its components; (2) the operability and performance of the active components of the system; and (3) the operability of the system as a whole. Under conditions as close to the design as practical, performance shall be demonstrated of the full operational sequence that brings the system into operation, including operation of applicable portions of the protection system, and the transfer between normal and emergency power sources.

g. The system shall be designed to the general criteria as described in Section 6.1.

h. The components of the control room air conditioning system shall be designed to operate in the most severe post-accident environment in which exposed.

i. Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposure in excess of 5 rem whole body, or its equivalent to any part of the body, for the duration of the accident.

9.9.11.2 System Description

9.9.11.2.1 System

The control room air conditioning system is shown schematically in Figure 9.9–4A.

The control room air conditioning system consists of two full capacity, completely independent air handling and mechanical refrigeration subsystems with the exception of some common ductwork and dampers. Each control room air conditioning subsystem is a single zone system. The system has the capability of ventilating with outside air while cooling, using mechanical refrigeration.

Each subsystem is provided with a bypass through the control room filtration system (CRFS) consisting of particulate, HEPA and charcoal filters and fan. The physical properties of the CRFS charcoal filters are listed in Table 9.9-11. Each CRFS unit is capable of filtering 2500 cfm of control room air or for an Emergency Fresh Air Intake Mode, to introduce an adequate supply of outside air into the system after filtering.

Outside air is not provided for pressurizing the control room because of the potential radioactivity during the post-accident condition. Outside makeup air is avoided to minimize possibilities of inducing contamination into the control room. Outside air is introduced over the long term post-accident case only to provide fresh air for personnel safety.

Control room pressure is maintained at a relatively neutral pressure during normal plant operations by air balancing the HVAC system. When the HVAC system is in recirculation mode (accident condition), the control room in-leakage rate is limited by Technical Specification limits.

The control room air conditioning system is designed to maintain a suitable environment in the control room for operating personnel and safety related control equipment. The control room is maintained at 78°F in the summer and 72°F in the winter.

The control room air conditioning system is equipped with full capacity redundant fans, filters, and mechanical refrigeration equipment, plus the necessary dampers and controls for automatically switching to full recirculation for post-accident operation. The control room area system performance is continually monitored with alarms for high radiation, fan failure and excessive pressure drop through filters. The control room operator has remote, manual control for selecting damper position, backup fan and filter operation to ensure satisfactory control room conditions following an accident.

The dose in the Unit 2 control room, resulting from a Design Basis Accident (DBA), has been determined as follows. The fission product release model given in Regulatory Guide 1.183 is assumed. All activity is assumed to be in the containment atmosphere. The dose to operating personnel in the control room as a result of inhalation, submersion and shine following a LOCA is described in Section 14.8.4.

Airborne radiation in the control room is negligible since any leakage out of the containment is into the enclosure building filtration region (Section 6.7) where it is filtered by charcoal filters and released through the Millstone stack. In addition, the control room is provided with an air conditioning system which may be operated in a closed, complete recirculation mode with provisions for filtering through charcoal filters following a high radiation level.

9.9.11.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-11. Fan performance curves are shown in Figures 9.9–19 through 9.9–22.

Figure 9.9–4 indicates that a fan unit has been provided between the supply plenum and the control room (coordinates A-8). This blower is part of the process radiation monitor for the supply air duct. This is not part of the process air conditioning system.

9.9.11.3 System Operation

9.9.11.3.1 Normal Operation

The control room air conditioning system operates during all modes of operation and shutdown. The flow rate associated with normal operation of the control room air conditioning system is given in Table 9.9-11. The normal flow rate is approximately 14,800 cfm.

One hand switch starts the supply air handling unit, opens the outside air dampers and places the temperature control system in control of system operation. A second hand switch starts the exhaust fan and opens the associated isolation damper. The temperature control system satisfies the room cooling requirements by providing mechanical refrigeration. System operation is monitored by control room temperature indication in the control room. System alignment is monitored by valve position indication on the control boards. Flow balance and neutral pressure is maintained by directing some flow to the cable vault, equivalent to the fresh air intake.

Smoke detectors are provided in the return ductwork to automatically isolate the supply unit and initiate purging operations. The control room is purged by operating the exhaust fans and discharging to atmosphere. Discharge dampers to other areas are automatically closed. Both control room air conditioning subsystems are served by the smoke detection system. Fire dampers are provided at all ductwork penetrations through firewalls.

9.9.11.3.2 Emergency Operation

Normally, the method of conditioning the air is controlled by the automatic temperature control system. In the event of a LOCA emergency safeguards system generates an EBFAS, which automatically shifts the control room air conditioning system to a complete recirculation mode of operation in which outside air is not introduced into the system and all outside air dampers are closed. In addition, in the event of a fuel handling accident in the Spent Fuel Pool area, an AEAS is generated which automatically shifts the system to the complete recirculation mode. The analysis does not credit AEAS or EBFS during a fuel handling or cask drop accident. The automatic control system is capable of cooling using the mechanical refrigeration. Portions of the system air or outside air, can be manually bypassed through the CRFS charcoal filters for cleanup prior to supplying air into the conditioned space. The smoke detection system is overridden by the complete recirculation mode of operation to prevent malfunctions during post-accident conditions.

System operation is monitored by temperature indication. Process and area radiation monitors are provided in the room supply air duct and control room to indicate and alarm high radiation levels. Operation of the CRFS is monitored by filter bank differential pressure and temperature indication. Fan operation is monitored by motor trip alarms.

In the event of a LOCA or a fuel handling accident, the control room air conditioning system is automatically switched to the isolation/ recirculation mode. Tests show that the unfiltered in-leakage is less than 200 scfm.

A fresh air make-up system will not be used to maintain a positive pressure differential with respect to the external environment or the adjacent internal spaces at any time during the normal or emergency modes of operation.

The control room air conditioning system mode of operation includes an automatic isolation of the system to the complete recirculation mode and automatic initiation of the bypass filtering operation. This automatic switchover to the complete recirculation mode and filtering mode is initiated by the EBFAS or the AEAS.

The post-accident mode of operation is a closed cycle with air intakes and outlets isolated. The control room atmosphere is exhausted from the space, filtered, and cooled as required and returned to the space. Outside air is not introduced into the system unless required for personnel safety.

9.9.11.4 Availability and Reliability

9.9.11.4.1 Special Features

The components of the control room air conditioning system are designed to engineered safety feature requirements including seismic response as described in Section 6.1. All components are protected from missile damage and pipe whip by physical separation of duplicate equipment, as described in Section 6.1.

Each air conditioning subsystem is capable of maintaining a suitable environment within the control room. Each system is designed for the normal control room cooling load which is greater than the cooling requirements under post-accident operation. Each system is completely independent, including the control and filtration systems with the exception of some common ductwork and dampers. Common components such as dampers are isolated during post-accident operation. Control inputs to these devices are overridden. Each subsystem is powered by a separate emergency source (Section 8.3). A failure mode analysis for the control room air conditioning system is given in Table 9.9-17. Although there are common plenums, all ductwork is considered a passive component not subject to a single failure mode.

The charcoal filter elements within the CRFS are analyzed to ensure adequate residual heat-removal capabilities following any single failure. The analysis concludes that the maximum temperature calculated, based on a radioactive filter inventory which was conservatively assumed to be ten (10) times greater than the maximum inventory calculated resulting from a design basis accident at the site, was less than 212°F (100°C). This is substantially below the charcoal ignition temperature, thus filter bed isolation should not constitute a fire hazard. Temperature indication is provided to alert personnel of excessive charcoal bed temperature.

All control room air conditioning system fans and filters are remote from the control area and are not exposed to fire hazards. The atmosphere within the control room is maintained as constant as possible during the post-accident recirculation mode.

Isolation dampers are provided at each fan discharge to prevent short circuiting of air through idle units.

Snow screens are located on the roof around the Control Room Make-up Inlet Housing, the Control Room Condenser Fan Housings F-36A and F-36B, and the Control Room Exhaust Housing.

The shielding design limits dose rates in the control room to less than 0.5 mrem/hr and does not exceed 5 rem for the duration of the DBA.

All components of the control room air conditioning system located outside the conditioned space are designed to operate in an environment of 110°F atmospheric pressure and 100 percent relative humidity. Typically, safety related components within the conditioned space are designed to operate in an environment of 104°F (40°C) and 10 to 95 percent relative humidity.

9.9.11.4.2 Tests and Inspection

The centrifugal and vaneaxial fans are similar to fans which are rated in accordance with AMCA Standard 211A. The condenser and compressor are rated in accordance with Air Conditioning and Refrigeration Institute (ARI) Standard 410-64 and 520-68, respectively. The evaporator coils are rated in accordance with American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 33-64. Refrigeration equipment is manufactured in accordance with ANSI B9.1, Safety Code for Mechanical Refrigeration. Refrigeration piping is designed, fabricated and tested in accordance with ANSI B31, 5-1966, Refrigeration Piping Systems. Filters are described in Section 6.7.4.2.

The ductwork is designed and fabricated in accordance with SMACNA Standard, “Low Velocity Duct Construction Standards.”

The control room air conditioning system is incorporated with provisions for online testing. Each subsystem is tested independently for operation of associated components. The subsystem in operation is tested by manually switching to the complete recirculation mode. System alignment and valve positions are monitored in the control room by position indication while system performance is monitored by temperature indication. The associated filtration system is manually initiated for alignment with the control room by-passed air and for fresh outside air. System alignment and valve position are monitored in the control room by position indication.

The redundant air conditioning subsystems are operated alternately to provide assurance of operability.

The control room air conditioning system undergoes a preoperational test prior to startup. The procedure is described in Chapter 13.

All components of the control room air conditioning system are accessible for periodic inspection and maintenance.

9.9.12 DIESEL GENERATOR VENTILATION SYSTEMS

9.9.12.1 Design Bases

9.9.12.1.1 Functional Requirements

The normal diesel generator room ventilation system (Fan F-27) functions to maintain a suitable environment for equipment and plant operating personnel during normal operation and shutdown conditions. The emergency diesel generator ventilation (DGV) system (Fan F-38A/F-38B) functions to maintain a suitable environment for equipment during emergency conditions.

9.9.12.1.2 Design Criteria

The following criteria have been used in the design of the diesel generator room ventilation system:

a. The system shall be designed to permit periodic inspection of important components, such as fan, motor, belt, coil, and ductwork, to assure the integrity and capability of the system.

b. The components of the system shall be designed to operate in the environment to which exposed.

The following criteria have been used in the design of the emergency DGV system:

a. The system shall have an independent ventilation subsystem for each Emergency Diesel Generator (EDG) room (2), having 100 percent of the total required heat removal capability.

b. The system shall have suitable subsystem and component alignments to assure operation of the complete subsystem with its associated components.

c. Capabilities shall be provided to assure the system operation with on site power (assuming off site power is not available) or with off site electrical power.

d. A single failure in either subsystem shall not affect the functional capability of the other subsystem.

e. The system shall be designed to permit periodic inspection of important components, such as fans and ductwork to assure the integrity and capability of the system.

f. The DGV system shall be designed to permit appropriate periodic pressure and functional testing to assure the operability and performance of the active components of the system, and the operability of the system as a whole. Under conditions as close to the design as practical, performance shall be demonstrated of the full operational sequence that brings the system into operation, including operation of applicable portions of the protection system and transfer between normal and emergency power sources.

g. The system shall be designed to the general criteria as described in Section 6.1.

h. The components of the DGV system shall be designed to operate in the most severe post-accident environment to which it is exposed.

9.9.12.2 System Description

9.9.12.2.1 System

The normal non-safety diesel generator room ventilation system (F-27), and the QA-safety DGV systems (F-38A/B) are shown schematically in Figure 9.9–4.

The normal non-safety diesel generator room ventilation system (F-27), which serves both diesel generator rooms, consists of a heating and ventilation supply air unit and louvered exhaust.

The diesel generator rooms are served, during normal operation, by the normal non-safety diesel generator room ventilation system (F-27), which supplies tempered air to these areas. During winter conditions approximately 80 percent of the air flow is recirculated to minimize heating requirements. These rooms are vented to atmosphere through exhaust louvers.

During emergency operation, DGV fan (F-38A/B) consisting of a direct drive, in-line, vaneaxial fan is provided for each diesel generator room to provide a suitable operating environment for the diesels during required conditions. The DGV system is provided with a modulating recirculation damper 2-HV-257A/B which is controlled by a room thermostat to maintain a suitable environment for personnel and equipment during winter conditions. Temperature alarms are provided to indicate low and high room temperature conditions.

9.9.12.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-12. Fan performance curves are shown in Figures 9.9–23 and 9.9–24.

9.9.12.3 System Operation

The normal non-safety diesel generator room ventilation system (F-27) operates during all modes of unit operation and during shutdown. The QA Category 1 DGV systems (F-38A/B) operate during emergency operations.

9.9.12.3.1 Normal Operation

The normal non-safety diesel generator room ventilation system (F-27) is manually initiated by operator action from a locally mounted control panel.

The system is designed to maintain a minimum room temperature of 55°F during winter conditions coincident with 0°F outside ambient air temperature, and to maintain room temperature below 120°F during the summer conditions coincident with 86°F outside ambient air temperature. A temperature sensing element is provided in each diesel generator room to alarm high and low room temperature conditions.

9.9.12.3.2 Emergency Operation

When required, the emergency DGV fans (F-38A/B) are automatically started, and the exhaust dampers (2-HV-255A/B) are opened by the same logic that initiates the diesel generators (Section 8.3).

The DGV system is designed to maintain the room temperature below 120°F during emergency operation by providing outside cooling air. Summer conditions require 100 percent outside air. During winter conditions, a modulating recirculation damper (2-HV-257A/B), controlled by a room thermostat, limits the outside air intake to maintain a suitable environment for personnel and equipment.

The DGV fans (F-38A/B) are interlocked with the diesel generator such that the fans operate at any time the diesel generator is operating. The modulating circulation dampers (2-HV-257A/B), are pneumatically controlled and designed to fail in the closed position. The exhaust damper (2-HV-255A/B) is pneumatically controlled and designed to fail in the open position.

The inlet and exhaust ductwork are missile protected.

The diesel generator room ventilation system F-27 (Seismic Class 2) is connected to the inlet of the DGV fan F-38B. This connection to the DGV inlet (F-38B) is Seismic Class 1 up through the first isolation damper 2-HV-253B on the nonvital fan F-27. Some recirculation flow is assumed for F-38B via this path. Fan F-27 and its isolation damper 2-HV-253B have no automatic controls, and are manually controlled by their individual local switches.

The DGV systems F-38A/B have an inherent short circuiting air flow due to leakage through the recirculation damper 2-HV-257A/B and due to the exhaust louvers proximity to the intake louvers.

Since Train “B” DGV system has interaction with the non-QA ventilation system, an analysis conservatively evaluated Train “B” for recirculation air flow. Results show that the amount of recirculation due to damper 2-HV-253B remaining open, the non-vital ductwork being ruptured, and the proximity of the intake louvers to the exhaust louvers may reach 25 percent of design air flow without exceeding the EDG room temperature limits of 120°F. This analysis also conservatively bounds Train “A.”

9.9.12.4 Availability and Reliability

9.9.12.4.1 Special Features

The components of the DGV system are designed to engineered safety feature requirements including seismic response as described in Section 6.1. All components are protected from missile damage and pipe whip by physical separation of duplicate equipment as described in Section 6.1.

The availability of the DGV system is assured by locating duplicate equipment in separate diesel generator rooms. Each DGV fan is powered by the associated diesel generator located in the respective room. The DGV system is designed with a specific component failure mode to assure the availability of air cooling during the worst case. A failure mode analysis for the DGV system is given in Table 9.9-18.

Operation of the normal diesel generator room ventilation system (Fan F-27) is not vital for plant operation since the diesels are not normally operating. However, low/high temperature alarms are provided to alert plant personnel to take remedial action. Room temperature limitations of 55°F minimum and 120°F maximum are imposed to assure a suitable environment for the diesel generators.

The components of the normal diesel generator room ventilation system (Fan F-27) are specified to operate in an environment of 110°F and 100 percent relative humidity. The components of the emergency DGV system (Fan F-38A/F38B) are designed to operate in an environment of 120°F and 60 percent relative humidity. The DGV fan motor is designed to operate in an environment of 120°F and 100 percent relative humidity.

9.9.12.4.2 Tests and Inspection

The centrifugal and vaneaxial fans are similar to fans which are rated in accordance with AMCA Standard 211-A. One of the DGV fans is rated in accordance with the above. The electric heating coils are built in accordance with the National Electric Code and Underwriters Laboratory requirements. The ductwork is designed and fabricated in accordance with SMACNA Standard, “Low Velocity Duct Construction Standards.”

The DGV system is incorporated with provisions for online testing. The subsystem is tested coincident with the respective diesel generator (Section 8.4.1) but separately from the redundant subsystem. The subsystem is automatically initiated by starting the respective diesel generator manually. Subsystem operation and alignment are indicated by visual inspection.

The DGV system undergoes a preoperation test prior to startup and the diesel generator room system is acceptance tested. Test procedures are described in Chapter 13.

The DGV systems are accessible for periodic maintenance and inspections.

9.9.13 TURBINE BUILDING VENTILATION SYSTEM

9.9.13.1 Design Bases

9.9.13.1.1 Functional Requirements

The turbine building ventilation system functions to maintain a suitable environment for equipment and personnel within the turbine building.

9.9.13.1.2 Design Criteria

The following criteria have been used in the design of the turbine building ventilation system:

a. The system shall be designed to permit periodic inspection of important components, such as fans and ductwork to assure the integrity and capability of the system.

b. The components of the turbine building ventilation system shall be designed to operate in the environment to which exposed.

9.9.13.2 System Description

9.9.13.2.1 System

The turbine building ventilation system is shown schematically in Figure 9.9–4. The turbine building ventilation system is designed to maintain the turbine building environment between 55 and 110°F. The turbine building is provided with a forced air ventilation system using outside air for the removal of building heat. Recirculation of building air through the ventilation system is provided for cold weather heating. Unit heaters are provided throughout the building to provide heating for shutdown during cold weather.

The turbine building ventilation system consists of nine supply air fans; F-101A through -101G, supplemental supply fan F-102, and heater drain pumps' motors cooling supply fan F-143, 10 roof exhaust fans F-111A through -111J and lube oil room and access control area exhaust fan F-124. Transfer grilles are provided between the operating floor and lower elevations to enhance air distribution.

9.9.13.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-13. Fan performance curves are shown in Figures 9.9–25 and 9.9–27.

9.9.13.3 System Operation

9.9.13.3.1 Normal Operation

The turbine building ventilation system is manually started by operator action at locally mounted control panels. Turbine building supply fans F-101A through -101G, provide 100 percent outside air during periods of warm weather to limit the turbine building ambient temperature to 110°F. Supplemental supply fan F-102 is operated to supply additional outside air to the steam generator feed pump's and southeast turbine bay area, and fan F-143 is operated to provide additional outside air to the heater drain pumps' motors.

Air is exhausted from the turbine bay by roof exhaust fans F-111A through F-111J and from the lube oil room and access control area by fan F-124.

During cold weather operation, recirculation is provided by turbine building supply fans F-101A through F-101G. Each of the seven fans can supply approximately 20 percent outside air and 80 percent return air to maintain a minimum temperature of 55°F for personnel comfort without supplemental heating. Unit heaters supplied by auxiliary steam can be operated to maintain 55°F when the unit is shutdown during periods of cold weather. Supply and exhaust fans are operated as necessary.

9.9.13.4 Availability and Reliability

9.9.13.4.1 Special Features

There are no requirements to maintain the turbine building at any specific pressure under any modes of operation.

All ductwork penetrations through fire walls are provided with fire dampers. The turbine building is provided with vent area through the ventilation equipment at 1 square foot of vent area per 100 square feet of floor area. This vent area is provided as a means of smoke removal since the ventilation equipment may be out of service.

The components of the turbine building ventilation system are designed to operate in an environment of 110°F and atmospheric pressure.

9.9.13.4.2 Tests and Inspections

The vaneaxial fans are similar to fans which have been rated in accordance with AMCA Standard 211-A. All fans are provided with steel wheels and housings. The ductwork is designed and fabricated in accordance with SMACNA Standards, “Low Velocity Duct Construction Standards.”

The turbine building ventilation system undergoes an acceptance test prior to startup. The test procedure is described in Chapter 13.

The turbine building supply and exhaust fans are accessible for periodic tests and inspections.

9.9.14 ACCESS CONTROL AREA AIR CONDITIONING SYSTEM*

*NOTE: The area is no longer an access control area. It was converted to office space consisting of offices, lunch and locker rooms and hallways.

9.9.14.1 Design Bases

9.9.14.1.1 Functional Requirements

The air conditioning system functions to maintain a suitable environment for personnel comfort within the area.

9.9.14.1.2 Design Criteria

The following criteria have been used in the design of the area air conditioning system:

a. The system shall be designed to permit periodic inspection of important components, such as fans and ductwork to assure the integrity and capability of the system.

b. The components of the air conditioning system shall be designed to operate in the environment to which exposed.

9.9.14.2 System Description

9.9.14.2.1 System

The air conditioning system is shown schematically in Figure 9.9–4.

The access control area air conditioning system is provided for comfort cooling and heating of the access control area, the instrument shop and selected areas in Unit 1 such as the lunch room and office spaces. The HVAC system is designed to maintain an environment of 78°F and 50 percent relative humidity in the conditioned space.

The system consists of self-contained air conditioning unit which houses the supply fan, chilled water coil, and filters. Chilled water is provided by the Auxiliary Chilled Water System. Steam distributing coils are provided for heating during winter operation.

The air handling unit supply fan delivers ventilation air to the various rooms which include office space, locker and lunch rooms, and the hallways. Air is distributed and recirculated through ductwork. Fresh air is mixed with return air. Excess air is exhausted either by the main exhaust fans (F-34A/B/C) and discharged through Unit 2 stack or by exhaust fan F-124 which discharges directly to the outside.

9.9.14.2.2 Components

The major system components and associated fabrication and performance data are listed in Table 9.9-14. Fan performance curve is shown in Figure 9.9–28.

9.9.14.3 System Operation

The access control area air conditioning system operates during unit operation and during shutdown.

9.9.14.3.1 Normal Operation

The air conditioning system is manually initiated by operator action at a locally mounted control panel. The system operation is automatically controlled by the temperature control system.

Minimum outside air is provided through penthouse louvers located on the turbine building. The conditioned air is recirculated through the unit to conserve refrigeration and heating requirements.

Air flow which is equivalent to the outside air makeup is exhausted without recirculation.

During the winter heating cycle, steam heat is available by the steam distributing coil.

9.9.14.4 Availability and Reliability

9.9.14.4.1 Special Features

The air conditioning system is designed to provide personnel comfort. Loss of the system will not require shutdown. Fire dampers are provided at all penetrations through fire walls.

The components of the air conditioning system are designed to operate in an environment of 110ºF, atmospheric pressure and 100 percent relative humidity.

9.9.14.4.2 Tests and Inspection

The centrifugal fan is similar to fans which are rated in accordance with AMCA Standard 211A. The condenser and compressor are rated in accordance with ARI Standard 410-64 and 520-68, respectively. The evaporator coils are rated in accordance with ASHRAE Standard 33.64. Refrigeration equipment is manufactured in accordance with ANSI B9.1, "Safety Code for Mechanical Refrigeration." Refrigeration piping is designed, fabricated and tested in accordance with ANSI B31.5-1966, "Refrigeration Piping Systems."

The ductwork is designed and fabricated in accordance with SMACNA Standard, "Low Velocity Duct Construction Standards."

The air conditioning system undergoes an acceptance test prior to startup. The test procedure is described in Chapter 13.

All components of the access control area air conditioning system are accessible for periodic inspection and maintenance.

9.9.15 BALANCE OF UNIT

9.9.15.1 Design Bases

9.9.15.1.1 Functional Requirements

Ventilation systems for the balance of the unit function to provide a suitable environment for equipment and ventilation for operating personnel.

9.9.15.1.2 Design Criteria

The following criteria have been used in the design of the systems:

a. The system shall be designed to permit periodic inspection of important components, such as fans and ductwork to assure the integrity and capability of the system.

b. The components of the systems shall be designed to operate in the environment to which exposed.

9.9.15.2 System Description

9.9.15.2.1 System

Non safety-related Heating/Ventilation & Air Conditioning (HVAC) systems are provided for the intake structure and other general areas of the plant (i.e., radiation protection facility, telephone rooms, computer rooms, etc.) to maintain a year round environment suitable for personnel and equipment. However, the only areas containing safety related equipment are the main equipment room of the intake structure, which houses the safety related service water system, as well as other non safety related equipment such as the circulating water pumps, traveling screens and the Old Computer Room which houses the safety related Inadequate Core Cooling Monitoring System (ICCMS) as well as other non safety-related equipment including CISCO Network Switches that relay data from the Station Transformers and RCP vibration monitors to the PPC.

During normal operation, the temperature of the intake structure main equipment room is a minimum of 45°F, and a maximum of 104°F, with a design basis minimum temperature of 40°F. Upon loss of ventilation exhaust fans F-114A/B/C, the maximum nominal design temperature of this area of the intake structure is 130°F. In the event of such a loss of forced ventilation, two passive nonmechanical roof ventilators X-219A and X-219C maintain the main equipment room at or below 130°F through natural circulation. The non safety related equipment located within the main equipment room of the intake structure is designed for 104°F while the safety related equipment is qualified for a nominal temperature of 130°F.

During normal operation, the temperature of the Old Computer Room is nominally maintained at 70°F. The majority of room heat gain is from interior walls and the floor separating adjacent plant spaces that are at higher temperatures given normal plant operating conditions. A comparatively small amount of heat gain is due to equipment within the room. As a result, no heating is required in colder weather due to heat loss through exterior walls and the ceiling/roof. Upon loss of the air conditioning system (X199/198), under worst case accident conditions, the room temperature will rise to 117.4°F. This results in internal ICCMS cabinet temperatures less than their maximum allowable temperature of 122°F.

9.9.15.2.2 Components

The major system components and associated fabrication and performance data for the main equipment room of the intake structure and Old Computer Room are listed in Table 9.9-15.

9.9.15.3 System Operation

These non-safety related HVAC systems maintain a year round environment suitable for personnel and equipment during normal and shutdown plant operations. Since the main equipment room of the intake structure and the Old Computer Room of the Auxiliary Building are the only areas containing safety related equipment, the other plant areas will not be discussed in the subsequent subsections.

9.9.15.3.1 Normal Operation

In the summer mode, the ventilation/cooling is provided to the main equipment room by roof exhaust fans F-114A/B/C which draw outside air through the four 8 foot by 10 foot louvered openings in the west wall of the intake structure, past the equipment being cooled, then out through the exhaust fan discharge. In the winter mode, the wall louvers are closed, thermostatically controlled electric heaters operate as needed during times of colder outdoor temperatures, and the exhaust fans are manually cycled on/off as necessary to maintain main equipment room temperatures in the range of 45°F to 104°F.

The exhaust fans F-114A/B/C are manually started by operator action at locally mounted control switches.

The Old Computer Room is cooled by a split air conditioning system that is automatically controlled by a thermostat nominally set to 70°F. Air is circulated within the room by Air Handler X-198 which distributes air to four ceiling outlets. Air conditioning is required all year round primarily due to the heat gain through interior walls and the floor.

9.9.15.4 Availability and Reliability

9.9.15.4.1 Special Features

A loss of the intake structure ventilation/cooling system, which is of concern only in the summer mode of operation, will not require a plant shutdown, since passive roof ventilators X-219A and X-219C, in conjunction with the opened wall louvers, provides natural circulation which maintains the space at or below 130°F. This natural circulation results from a draft being created between the louvers in the west wall of the intake structure, past the service water pumps, and up through the roof ventilators. All safety related components in the main equipment area of the intake structure are qualified for operation in a 130°F environment.

A loss of heating in the intake structure main equipment room, either through reduced heat load (during shutdown conditions) or loss of the space heaters, which is of concern only in the winter mode of operation, could cause freezing conditions that could affect the operability of the service water strainer backwash control system. Therefore, safety related temperature controllers are installed, which automatically initiate the service water strainer backwash cycle if the main equipment room of the intake structure falls to 40°F or below.

A loss of air conditioning in the Old Computer Room will not result in exceeding the qualified operating temperature of 122°F for all safety related components in this area.

9.9.15.4.2 Tests and Inspection

The roof exhaust fans (F-114A/B/C) are similar to fans which have been rated in accordance with AMCA Standards.

The Intake Structure systems underwent acceptance tests prior to startup. Test procedures are described in Chapter 13.

The components of the systems are accessible for maintenance and inspection.

9.9.16 VITAL SWITCHGEAR VENTILATION SYSTEM

9.9.16.1 Design Bases

9.9.16.1.1 Functional Requirements

The vital switchgear ventilation system function to maintain a suitable environment for the safety related electrical equipment during normal operation, loss of off site power and post-accident conditions.

9.9.16.1.2 Design Criteria

The following criteria have been used in the design of the vital switchgear ventilation system:

a. Each redundant switchgear group shall have an independent subsystem having 100 percent of the total required heat removal capability.

b. The system shall have suitable subsystem and component alignments to assure operation of the complete subsystem with its associated components.

c. Capabilities shall be provided to assure the system operation with on site power (assuming off site power is not available) or with off site electrical power.

d. A single failure in either subsystem shall not affect the functional capability of the other subsystem.

e. The system shall be designed to permit periodic inspection of important components such as fans, coils, ductwork, piping and valves to assure the integrity and capability of the system.

f. The system shall be designed to permit appropriate periodic functional testing to assure the operability and performance of the active components of the system, and the operability of the system as a whole. Under conditions as close to the design as practical, the performance shall be demonstrated of the full operational sequence that brings the system into operation, including operation of applicable portions of the protection system, the transfer between normal and emergency power sources, and the operation of the associated cooling water system.

g. The system shall be designed to the general criteria as described in Section 6.1.

h. The components of the system shall be designed to operate in the most severe post-accident environment as described in Section 6.1.

9.9.16.2 System Description

9.9.16.2.1 System

The vital switchgear ventilation system is shown on Figure 9.9–3, 9.9–4 and 9.9–31.

The vital switchgear ventilation system consists of independent subsystems, capable of removing 100% of the heat generated in the associated vital electrical equipment room. The vital AC switchgear rooms containing the 4160 volt and 6900 volt electrical equipment and the west 480 volt unit load center are each cooled by separate closed cycle air subsystems sized for 100% of the room cooling requirements under normal plant operation and emergency conditions such as Loss of Coolant Accident "LOCA" and High Energy Line Break "HELB". Therefore, since each subsystem is normally operating, and the normal cooling requirements exceed the cooling requirements for emergency operation, no system realignment is necessary for emergency conditions.

Each of the above subsystems consist of fan-coil units utilizing service water as the ultimate heat sink. The original room temperature was limited to 40°C (104°F) for the vital AC switchgear rooms. However, engineering analysis responsive to NRC Generic Letter 89-13 "Service Water System Problems Affecting Safety-Related Equipment, July 18, 1992," identified the need to raise the room temperature limitation for the upper and lower 4160/6900 volt switchgear rooms. As a result, the upper and lower 4160/6900 volt rooms have been qualified for a room temperature limitation of 50°C (122°F).

The subsystem for the upper switchgear room is contained within the upper switchgear room. The subsystem for the lower switchgear room is located in an adjacent cable vault. This affords protection for both subsystems in the event of a high energy pipe rupture. Service water supply is provided with isolation valves located outside the rooms. Water detectors within the rooms' coffer dam will cause the corresponding isolation valve to close automatically to prevent flooding.

The east 480 volt unit load center is located in the auxiliary building and is cooled during normal and emergency operations by 100% outside air supply systems. The room temperature for both the east and west 480 volt unit load center rooms is limited to 40°C (104°F).

The east and west vital DC switchgear rooms are provided with closed cycle air subsystems utilizing mechanical refrigeration to maintain the ambient conditions within these areas. Cooling is normally provided by nonvital chilled water. The room temperature is limited to 40°C (104°F).

The MCC B51 and B61 enclosures are provided with self-contained air conditioning units. (Vital MCC Coolers Number A/C-3 (B51) and A/C-4 (B61)) which maintain the ambient temperature inside the enclosures below 122°F during normal plant operation and emergency conditions such as Loss of Coolant Accident “LOCA” and High Energy Line Break “HELB.” No system realignment is necessary during emergency conditions.

9.9.16.2.2 Components

The major system components and associated performance data are listed in Table 9.9-19.

9.9.16.3 System Operation

9.9.16.3.1 Normal Operation

The subsystems serving the two 4160 volt and 6900 volt rooms and the east and west 480 volt unit loadcenters operate during normal operation and are actuated by room thermostats. Normal cooling for the east 480 loadcenter is provided by the nonradioactive ventilation system. (See Section 9.9.6.) Air is supplied and exhausted through the roof louvers provided for the nonradioactive ventilation system and the vital switchgear east 480V room ventilation system.

The vital DC switchgear ventilation system operates during normal unit operation. Chilled water is aligned for normal cooling from the auxiliary chilled water system (see Section 9.9.16). Valving and components are initiated by remote manual operation.

The Vital Coolers A/C-3 (MCC B51) and A/C-4 (MCC B61) operate during normal plant operation and are supplied with electrical power from the same MCC it serves. Each cooler is provided with an integral temperature controller which cycles the unit, as required, to maintain the temperature inside the enclosure below 122°F.

9.9.16.3.2 Emergency Operation

The vital AC switchgear room ventilation system will operate during post accident or loss of off site power conditions, depending on the cooling requirements as determined by the corresponding room thermostats.

The vital DC switchgear ventilation system, if not already running, is automatically initiated by the SIAS or by a loss of AC power. The vital chilled water system automatically assumes the emergency alignment upon SIAS or loss of normal power. To maintain room cooling, the chilled water supply valve to each room’s heat exchanger is secured open and the fans run continuously.

The Vital Coolers A/C-3 (MCC B51) and A/C-4 (MCC B61) operate during emergency conditions such as Loss-of-Coolant Accident “LOCA” and High Energy Line Break “HELB” to limit the temperature inside the enclosures below 122°F. Following a loss of normal power the Vital Coolers, which are powered by the MCC it serves, are automatically supplied with safety related power via the emergency diesel generators.

9.9.16.4 Availability and Reliability

9.9.16.4.1 Special Features

The components of the vital switchgear ventilation system are designed to engineered safety feature requirements including seismic response, as described in Section 6.1.

The availability of the system is assured by providing duplicate, full-capacity equipment, each subsystem physically separated from its counterpart. The system is powered by separate, emergency buses.

The equipment in the 6900 volt and 4160 volt rooms is designed to operate in an environment of 122°F and 100% relative humidity.

9.9.16.4.2 Tests and Inspections

The centrifugal and vaneaxial fans are rated in accordance with AMCA Standard 211A. The ductwork is designed and fabricated in accordance with SMACNA Standard, "High Velocity Duct Construction Standards" or "Low Velocity Duct Construction Standards," as appropriate.

The vital switchgear ventilation system is incorporated with provisions for online testing. Each subsystem is tested independently for operation of associated components. The subsystem in operation is tested by manually switching to the emergency mode. System alignment and valve positions are monitored on the local control panel by position indication while system performance is monitored by temperature indication.

The vital switchgear ventilation system undergoes a preoperational test prior to startup. The procedure is described in Chapter 13.

All components of the vital switchgear ventilation system are accessible for periodic inspection and maintenance.

9.9.17 AUXILIARY CHILLED WATER SYSTEM

9.9.17.1 Design Bases

9.9.17.1.1 Functional Requirements

The auxiliary chilled water system functions to provide a source of chilled water to maintain a suitable environment for portions of the safety related electrical equipment during normal plant operations and to provide a source of chilled water for other non-safety related plant cooling requirements.

9.9.17.1.2 Design Criteria

The auxiliary chilled water system has been designed to the following criteria:

a. Two identical mechanical refrigeration units provide a source of chilled water during normal plant operation.

b. The auxiliary chilled water system isolates automatically from the safety related chilled water system upon receipt of a SIAS.

c. Connections to the safety related chilled water system have been designed to Seismic I requirements.

9.9.17.2 System Description

9.9.17.2.1 System

The auxiliary chilled water system is shown on Figure 9.9–31. The auxiliary chilled water system consists of two identical mechanical refrigeration units which can be operated either singularly or in parallel to provide a source of chilled water during normal plant operation. Cooling of the mechanical refrigeration units is provided by the Turbine Building Closed Cooling Water (TBCCW).

9.9.17.2.2 Components

The major system components and associated performance data are listed in Table 9.9-20.

9.9.17.3 System Operation

9.9.17.3.1 Normal Operation

The auxiliary chilled water system (see Figure 9.9–31) operates during normal operation with the access control area temperature being controlled by a temperature controller.

9.9.17.3.2 Emergency Operation

Auxiliary Chilled Water System is automatically isolated following a SIAS, loss of off site power, or loss of control air.

9.9.17.4 Availability and Reliability

9.9.17.4.1 Special Features

The availability of the system is assured by providing duplicate equipment to provide the necessary operating flexibility. The mechanical refrigeration units are liberally sized so that one unit can handle the expected heat loads. As additional need for chilled water develops due to plant design changes both units may be required to operate.

9.9.17.4.2 Tests and Inspections

The mechanical refrigeration units are rated in accordance with the ARI Standard 590-62.

All components of the auxiliary chilled water system are accessible for periodic inspection and maintenance.

9.9.18 VITAL CHILLED WATER SYSTEM

9.9.18.1 Design Basis

9.9.18.1.1 Functional Requirements

The Vital Chilled Water System functions to provide a source of chilled water to maintain a suitable environment for portions of the safety related electrical equipment during loss of off site power and post-accident conditions.

9.9.18.1.2 Design Criteria

The following criteria have been used in the design of the Vital Chilled Water System:

a. Each redundant vital switchgear group shall have an independent vital chilled water subsystem having 100 percent of the loss of off site power or post-accident heat removal capability.

b. The systems shall have a suitable subsystem and component alignments to assure operation of the complete subsystem with its associated components.

c. Capabilities shall be provided to assure the system operation with on site power (assuming off site power is not available) or with off site electrical power.

d. A single failure in either subsystem shall not affect the functional capability of the other subsystem.

e. The system shall be designed to permit periodic inspection of important components such as cylinder heads, tubing, piping, and valves to assure the integrity and capability of the system.

f. The system shall be designed to permit appropriate periodic functional testing to assure the operability and performance of the active components of the system, and the operability of the system as a whole. Under conditions as close to the design as practical, the performance shall be demonstrated of the full operational sequence that brings the system into operation, including operation of applicable portions of the protection system, the transfer between normal and emergency power sources, and the operation of the associated cooling water system.

g. The system shall be designed to the general criteria as described in Section 6.1.

h. The components of the system are designed to operate in a mild environment. Harsh environmental conditions may result from a turbine building fire or a high-energy line break event. However, operability of chillers X-169A/B is not required to mitigate these events.

9.9.18.2 System Description

9.9.18.2.1 System

The Vital Chilled Water System is shown on Figure 9.9–31. The Vital Chilled Water System consists of two chiller subsystems, both of which are designed to engineered safety features (ESF) requirements to provide a source of chilled water to the Vital Switchgear Ventilation System during loss of off site power and post-accident conditions.

9.9.18.2.2 Components

The major system components and associated performance data are listed in Table 9.9-21.

9.9.18.3 System Operation

9.9.18.3.1 Normal Operation

Two Vital Chilled Water subsystems, X-169A/B are in standby mode during normal operation. Vital Switchgear Ventilation chilled water is supplied by the Auxiliary Chilled Water System, X-196A/B during normal operation.

9.9.18.3.2 Emergency Operation

Two Vital Chilled Water subsystems are automatically initiated by a SIAS or by a loss of normal AC power to provide a source of chilled water to the Vital Switchgear Ventilation System.

9.9.18.4 Availability and Features

9.9.18.4.1 Special Features

The availability of the system is assured by providing duplicate equipment. The two independent mechanical refrigeration units are sized such that each unit can handle its entire loss of off site power or post-accident condition load. The refrigeration units are powered by separate emergency buses.

The Vital Chilled Water System is designed with specific failure modes to assure emergency system alignment.

9.9.18.4.2 Tests and Inspections

The mechanical refrigeration units are rated in accordance with the ARI Standard 590.

All components of the Vital Chilled Water System are accessible for periodic inspection and maintenance.

The condenser and evaporator sections of the vital chillers are stamped in accordance with American Society of Mechanical Engineers (ASME) Code Section VIII. Refrigeration equipment is manufactured in accordance with American National Standards Institute (ANSI) B 9.1, Safety Code for Mechanical Refrigeration. Refrigeration piping is designed, fabricated, and tested in accordance with ANSI B 31.5, Refrigeration Piping Systems.

TABLE 9.9-1 CONTROL ELEMENT DRIVE MECHANISM COOLING SYSTEM

Fan (F-13A/B/C)	
Type	Vaneaxial
Flow (cfm)	31,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction
Horsepower rating (hp)	25
Code	NEMA MG-1
Seismic Class	II
Coil (X-34A/B/C)	
Type	Water (RBCCW)
Heat removal capability, each (Btu/hr)	8.10×10^5 (nominal rating)
Air temperature entering/leaving (°F)	120/95 (nominal rating)
Water temperature entering/leaving (°F)	85/95 (nominal rating)
Water flow rate (gpm)	165 (nominal rating)
Code	ASME Section VIII TEMA, Class C
Seismic Class	II
Ductwork	
Material/Type	IAW Specification 526
Standard	SMACNA
Seismic Class	II

TABLE 9.9-2 CONTAINMENT AND ENCLOSURE BUILDING PURGE SYSTEM

Fan (F-23)

Type	Centrifugal
Flow (cfm)	32,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II

Motor

Type	Induction
Horsepower rating	15
Code	NEMA MG-1
Seismic Class	II

Coil (X-43)

Type	Steam distributing
Heat transfer (Btu/hr)	2.42×10^6 (nominal rating)
Air temperature entering/leaving (°F)	0/70 (nominal rating)
Code	ASME Section VIII TEMA, Class C
Seismic Class	II

Particulate Filters

Quantity	Media (field cut)
Type	Throwaway

Ductwork

Material/Type	IAW Specification M-52
Standard	SMACNA
Seismic Class	II

TABLE 9.9-2 CONTAINMENT AND ENCLOSURE BUILDING PURGE SYSTEM (CONTINUED)

Piping

Material	ASTM A-333 Grade 6
Wall (inches)	0.375
Fittings	Butt-welded except at flanged equipment
Flanges	Carbon steel, ANSI 150 lb rating
Code	ANSI B31.7, Class II
Seismic Class	I

Valves (2AC-4/5/6/7)

Type	Wafer-type butterfly
Class	150 lb
Line size (inches)	48
Code	ASME Section III, Class 2, 1971
Seismic Class	I

TABLE 9.9-3 CONTAINMENT AUXILIARY CIRCULATION SYSTEM

Fan (F-24A/B)	
Type	Vaneaxial
Flow (cfm)	75,000/37,500 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction (2 speed)
Horsepower rating (hp)	60/30
Code	NEMA MG-1
Seismic Class	II
Ductwork	
Material/Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II

TABLE 9.9-4 CONTAINMENT PENETRATION COOLING SYSTEM

Fan (F-37A/B)

Type	Vaneaxial
Capacity (cfm)	4,320 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II

Motor

Type	Induction
Horsepower rating (hp)	5
Code	NEMA MG-1
Seismic Class	II

Ductwork

Material/Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II

TABLE 9.9-5 PENETRATION AIR COOLING REQUIREMENTS

Penetration Number	System	Air Required (cfm)
19	Main steam	1000
20	Main steam	1000
15	Main feedwater	360
16	Main feedwater	360
22	Steam generator blowdown	300
23	Steam generator blowdown	300
10	Shutdown cooling	300
2	Letdown	100
65	Steam generator blowdown sample	200
72	Steam generator blowdown sample	200
21	Reactor containment and pressurizer sample	200 4320

TABLE 9.9-6 RADWASTE VENTILATION SYSTEM

Fan (F-16)

Type	Centrifugal
Flow (cfm)	40,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II

Motor

Type	Induction
Horsepower rating (hp)	40
Code	NEMA MG-1
Seismic Class	II

Coil (X-37)

Type	Steam distributing
Heat transfer (Btu/hr)	2.72×10^6 (nominal rating)
Air temperature entering/leaving (F)	0/60
Code	ASME Section VIII, TEMA Class C
Seismic Class	II

Filters

Quantity per unit	Media (field cut)
Type	Throwaway

Ductwork

Material/Type	IAW Specification M-526
Seismic Class	II

TABLE 9.9-6 RADWASTE VENTILATION SYSTEM (CONTINUED)

Booster Coils (X-56 / 57 / 58)

	X-56	X-57	X-58
Type	Steam distributing		
Air entering temperature (F)	55	55	55
Code	ASME Section VIII, TEMA Class C		
Air leaving temperature (F)	70	80	70 (nominal rating)
Air flow (cfm)	550	3510	645 (nominal rating)
Seismic Class	II		

TABLE 9.9-7 NONRADIOACTIVE VENTILATION SYSTEM

Fan F-17

Type	Centrifugal
Flow (cfm)	25,750 (nominal rating)
Code	AMCA 211-A
Seismic Class	II

Motor

Type	Induction
Horsepower rating (hp)	20
Code	NEMA MG-1
Seismic Class	II

Particulate Filters

Quantity	Media (field cut)
Type	Throwaway

Ductwork

Material/Type	IAW Specification M-526
Standard	SMACNA

East 480 Loadcenter Room Normal Exhaust Fan F-26

Type	Vaneaxial
Flow (cfm)	17,500 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II

Motor

Type	Induction
Horsepower rating (hp)	10
Code	NEMA MG-1
Seismic Class	II

TABLE 9.9-7 NONRADIOACTIVE VENTILATION SYSTEM (CONTINUED)

Ductwork

Material/Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II

Battery Room Roof Exhaust Fans F112A/F112B

Type	Roof exhaust
Flow (cfm)	4125 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II

Motor

Type	Induction
Horsepower rating (hp)	3
Code	NEMA
Seismic Class	II

Cable Vault Transfer Fans F-123

Type	Propeller
Flow (cfm)	1,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II

Motor

Type	Induction
Horsepower rating (hp)	1/8
Code	NEMA MG-1
Seismic Class	II

Ductwork

None	(Fan mounted in wall only)

TABLE 9.9-7 NONRADIOACTIVE VENTILATION SYSTEM (CONTINUED)

Cable Vault Air-Recirculation Fan (F-19)

Type	Centrifugal
Flow (cfm)	16,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II

Motor

Type	Induction
Horsepower rating (hp)	15
Code	NEMA
Seismic Class	II

Coil (X-40)

Type	Chilled water
Heat transfer (Btu/hr)	154,000 (nominal rating)
Code	ASME Section VIII, TEMA Class C
Seismic class	II

Particulate Filter

Quantity	12
Type	Throwaway

Ductwork

Material/Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II

TABLE 9.9-8 ENGINEERED SAFETY FEATURES ROOM AIR RECIRCULATION SYSTEM

Fans (F-15A/B)

Type	Vaneaxial
Capacity (cfm)	18,650 (minimum)
Standard	AMCA 211-A
Seismic class	I

Motor

Type	Induction
Horsepower rating (hp)	15
Code	NEMA MG-1
Seismic Class	I

Coils (X-36A/B

Type	Water (RBCCW)
Heat removal capability, each (Btu/hr)	Note 1
Air temperature entering/leaving (°F)	Note 1
Water temperature entering/leaving (°F)	Note 1
Water flow rate (gpm)	60 (minimum)
Code	ASME Section VIII TEMA, Class R
Seismic Class	I

Ductwork

Material/Type	IAW Specification M-506
Standard	SMACNA
Seismic Class	I

Note 1: Calculation 96-ENG-1529M2 provides a summary of performance data for various RBCCW inlet temperatures including a post-accident temperature transient.

TABLE 9.9-9 FUEL HANDLING VENTILATION SYSTEM

Fan (F-20)

Type	Centrifugal
Flow (cfm)	18,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II

Motor

Type	Induction
Horsepower rating (hp)	15
Code	NEMA
Seismic Class	II

Coil (X-41)

Type	Steam distributing
Heat transfer (Btu/hr)	164×10^6 (nominal rating)

Coils

Air temperature entering/leaving (°F)	0/85
Code	ASME Section VIII, TEMA Class C

Particulate Filters

Quantity	12
Type	Throwaway .

Ductwork

Material/Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II

TABLE 9.9-9 FUEL HANDLING VENTILATION SYSTEM (CONTINUED)

Air Conditioner (F-140)

Type	Self Contained
Capacity	15 Ton
Standard	ARI 520
Seismic Class	II

Sub-components:

Evaporator (X-191)	Direct expansion (Refrigerant R-22)
Condenser	Water cool (TBCCW)
Compressor	Hermetic (Refrigerant R-22)

Motor:

Type	Induction
Horsepower rating (hp)	2
Code	NEMA

Particulate Filters:

Quantity	2
Type	Throwaway

TABLE 9.9-10 MAIN EXHAUST SYSTEM

Fan (F-34 A/B/C)	
Type	Centrifugal
Flow (cfm)	32,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction
Horsepower rating (hp)	40
Code	NEMA
Seismic Class	II
Filter Housing (L-25, L-26, L-27)	
Housing material standard	ASTM A-415
Frame material standard	ASTM A-36
Seismic Class	II

Particulate Filters	Quantity (per unit)
L-25	32
L-26	44
L-27	20

Type (prefilter)	Throwaway

HEPA Filters	Quantity (per unit)
L-25	32
L-26	44
L-27	20

Type	High efficiency, dry
Rate air flow per filter at 1 in WG	1,000 cfm
Standard	MIL-STD-282
Ductwork	
Material/Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II

TABLE 9.9-11 CONTROL ROOM AIR CONDITIONING SYSTEM

Supply Fan (F-21A/F-21B)

Type	Centrifugal
Flow (cfm)	16,460 (nominal rating)
Standard	AMCA 211-A
Seismic Class	I

Motor

Type	Induction
Horsepower rating (hp)	15
Code	NEMA
Seismic Class	I

Coil - Evaporator (X-42A / X-42B)

Type	Direct expansion
Heat transfer (Btu/hr)	432,000 (nominal rating)
Standard	ASHRAE Standard 33-64
Seismic class	I

Particulate Filters

Quantity (per unit)	10
Type (prefilter)	Throwaway
Quantity (per unit)	10
Type (primary)	High efficiency (bag)

Compressor (F22A / B)

Type	Hermetic
Power input (kW)	44
Standard	ARI 520-68
Seismic Class	I

Condenser

Type	Air cooled
Seismic Class	I

TABLE 9.9-11 CONTROL ROOM AIR CONDITIONING SYSTEM (CONTINUED)

Fan (F-36A / F-36B)

Type	Centrifugal
Flow (cfm)	23,900 (nominal rating)
Standard	AMCA 211-A
Seismic Class	I

Motor

Type	Induction
Horsepower rating (hp)	20
Code	NEMA
Seismic Class	I

Coil - Condenser

Type	Refrigerant condenser (R-22)
Heat transfer (Btu/hr)	588,000
Standard	ARI Standard 410-64
Seismic Class	I

Particulate Filters

Quantity (per unit)	16
Type	Throwaway

Exhaust Fan (F-31A/F-31B)

Type	Vaneaxial
Flow (cfm)	16,460 (nominal rating)
Seismic Class	I
Standard	AMCA 211-A

Motor

Type	Induction
Horsepower rating (hp)	7.5
Code	NEMA
Seismic Class	I

TABLE 9.9-11 CONTROL ROOM AIR CONDITIONING SYSTEM (CONTINUED)

Control Room Filtration Fan (F-32A/F-32B)	
Type	Centrifugal
Flow (cfm)	2500 (±10%)
Standard	AMCA 211-A
Seismic Class	I
Motor	
Type	Induction
Horsepower rating (hp)	5
Code	NEMA
Seismic Class	I
Filtration Unit (L-30A/B)	
Housing Seismic Class	I
Particulate Filters	
Quantity per unit	2
Type	Throwaway
HEPA Filters	
Quantity (per unit)	2
Type	High Capacity
Rate air flow per filter at 1.30 in WG	1500 CFM
Rate air flow per filter at 0.87 in WG	1000 CFM
Standard	MIL-STD-282
Charcoal Filters	
Quantity per unit (trays)	6
Charcoal type	CNN-816 activated coconut shell
Rated flow per unit	2500 CFM
Standard	ANSI N-509
Refrigeration Piping	
Standard	ANSI B9.1, ANSI B31.5 (1966)
Seismic Class	I
Ductwork	
Material/Type	IAW Specification M-506
Standard	SMACNA
Seismic Class	I

TABLE 9.9-12 DIESEL GENERATOR VENTILATION SYSTEMS

Fan (F-27)	
Type	Centrifugal Class
Flow (cfm)	1000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II
Motor	
Horsepower rating (hp)	1.0
Code	NEMA
Seismic Class	II
Coil (X-44)	
Type	Electric
Heat transfer (kW Btu/hr)	18kW / 61,4000 Btu/hr (nominal rating)
Filters	
Quantity	1
Type	Throwaway
Ductwork (Non-Vital)	
Material / Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II
DGV Fan (F-38A / F-38B)	
Type	Vaneaxial
Flow (cfm)	31,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	I
Motor	
Horsepower rating (hp)	20
Code	NEMA
Seismic Class	I
Ductwork (Vital)	
Material/Type	IAW Specification M-506
Standard	SMACNA
Seismic Class	I

TABLE 9.9-13 TURBINE BUILDING VENTILATION SYSTEM

Supply Fan (F-101A through G)	
Type	Vaneaxial
Capacity (cfm)	44,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction
Horsepower rating (hp)	20
Code	NEMA
Seismic Class	II
Supply Fan (F-102)	
Type	Vaneaxial
Flow (cfm)	44,400 (nominal rating)
Code	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction
Horsepower rating (hp)	25
Code	NEMA
Seismic Class	II
Roof Exhaust Fans (F-111A through J)	
Type	Roof exhaust
Flow (cfm)	35,400 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction
Horsepower rating (hp)	5
Code	NEMA
Seismic Class	II

TABLE 9.9-13 TURBINE BUILDING VENTILATION SYSTEM (CONTINUED)

Exhaust Fan (F-124)	
Type	Centrifugal (inline)
Flow (CFM)	1,500 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction
Horsepower rating (hp)	1
Code	NEMA
Seismic Class	II
Ductwork	
Material/Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II
Supply Fan (F-143)	
Type	Inline
Flow (cfm)	15,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction
Horsepower rating (hp)	5
Code	NEMA
Seismic Class	II
Ductwork	
Material / Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II
TDAFW Exhaust Fan (F-158)	
Type	Roof exhauster
Flow (CFM)	1,000 (nominal rating)
Standard	AMCA 211-A
Seismic Class	II

TABLE 9.9-13 TURBINE BUILDING VENTILATION SYSTEM (CONTINUED)

Motor

Type	Induction
Horsepower rating (hp)	1/4
Code	NEMA
Seismic Class	II

TABLE 9.9-14 ACCESS CONTROL AREA AIR CONDITIONING SYSTEM

NOTE: The area is no longer used as an access control area. It was converted to office space consisting of offices, lunch and locker rooms, and walkways.

Fan (F-116)	
Type	Centrifugal
Flow (cfm)	15,550 (nominal rating)
Code	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction
Horsepower Rating	20
Code	NEMA-G
Seismic Class	II
Cooling Coil (X-85)	
Type	Chilled Water
Heat Transfer (Btu/hr)	420,000 (nominal rating)
Air Temperature Entering (°F)	80.7 DB, 66.6 WB (nominal rating)
Air Temperature Leaving (°F)	60 DB, 57 WB (nominal rating)
Cooling Coil	
Code	ASME Section VIII, TEMA Class C
Seismic Class	II
Heating Coil (X-167)	
Type	Steam distributing
Heat transfer (Btu/hr)	418,000 (nominal rating)
Code	ASME VIII
Seismic Class	II

TABLE 9.9-14 ACCESS CONTROL AREA AIR CONDITIONING SYSTEM (CONTINUED)

Particulate Filters

Quantity (per unit)	8
Type (prefilter)	Throwaway
Quantity (per unit)	8
Type (primary)	High efficiency (bag)

Ductwork

Material/Type	IAW Specification M-526
Standard	SMACNA 9l
Seismic Class	II

TABLE 9.9-15 BALANCE OF UNIT VENTILATION SYSTEM

Intake Structure Fan (F-114A/B/C)

Type	Roof exhauster
Flow (CFM)	30,000
Standard	AMCA 211-A
Seismic Class	II
Motor	
Type	Induction
Horsepower rating (hp)	7.5
Code	NEMA
Seismic Class	II

Intake Structure Ventilators (X-219A/C)

Type	Passive, Non-Mechanical
Flow Rate	Variable
Code Requirements	ANSI/AWS D1.1 (1997) ANSI/AWS D1.3 (1989)
Seismic Class	II
Ductwork	
Material/Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II

Old Computer Room

Air Conditioner	
Type	Split system
Capacity (Ton)	4 (nominal rating)
Standard	ARI 520
Seismic Class	II
Subcomponents	
Evaporator Unit (X-198)	
Type	Direct expansion (refrigerant R-410A)

TABLE 9.9-15 BALANCE OF UNIT VENTILATION SYSTEM (CONTINUED)

Motor	
Type	Induction
Horsepower rating (hp)	0.75
Code	NEMA
Seismic Class	II
Condenser Unit (X-199)	
Type	Air cooled
Compressor	
Type	Scroll Hermetic
Ductwork	
Material/Type	IAW Specification M-526
Standard	SMACNA
Seismic Class	II
New Computer Room	
Air Conditioner (F-144A/B)	
Type	Split system
Capacity (Btu/hr)	218,000 (nominal rating)
Standard	ARI 520
Seismic Class	II
Subcomponents	
Evaporator Unit (X-200/X-201)	
Type	Direct expansion (refrigerant R-22)
Motor	
Type	Induction
Horsepower rating (hp)	7.5
Code	NEMA
Seismic Class	II
Condenser Unit (X-202/X-203)	
Type	Air cooled
Compressor	
Type	Hermetic

TABLE 9.9-15 BALANCE OF UNIT VENTILATION SYSTEM (CONTINUED)

Particulate Filter	
Quantity (per unit)	8
Type	Throwaway
Ductwork	
None	

SAJE Fans

	F-55A	F-55B
Type	Centrifugal	Centrifugal
Flow (cfm)	3204 (nominal rating)	1240 (nominal rating)
Standard	NAFM	NAFM
Seismic Class	II	II
Motor type	Induction	Induction
Motor horsepower rating (hp)	50	10
Motor Code	NEMA	NEMA
Motor Seismic Class	II	II
Ductwork Material / Type	IAW Specification M-526	IAW Specification M-526
Ductwork Standard	SMACNA	SMACNA
Ductwork Seismic Class	II	II

TABLE 9.9-16 ENGINEERED SAFETY FEATURES ROOM AIR RECIRC. SYSTEM FAILURE MODE ANALYSIS

COMPONENT IDENTIFICATION & QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
Cooling coils	Tube or header rupture	Room temperature indication and flow indication on tube side	Loss of cooling	Unit taken out of service	One subsystem out of service	Redundant system available in redundant room. Each room contains a combination of a minimum safety features.
Fan	Fails to operate	Status lights from the control room	Loss of air flow	Same as above	Same as above	Same as above.
Dampers	Damper mispositioned	Room temperature alarm	Loss of cooling	Same as above	Same as above	Dampers are manually secured in position to provide proper flow to all rooms.

TABLE 9.9-17 CONTROL ROOM AIR CONDITIONING SYSTEM FAILURE MODE ANALYSIS

COMPONENT IDENTIFICATION AND QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
Supply fan (F-21A & F-21B)	Fails to operate	Status light on C25A/B	Loss of air flow	Unit out of service	Redundant system operable	Each unit has 100% capacity
Evaporator coil (X-42A & X-42B)	Rupture	Room temperature indicator	Loss of cooling	Same as above	Same as above	Same as above
Exhaust fan (F-31A & F-31B)	Fails to operate	Status light on C25A/B	Loss of air flow	Same as above	Same as above	Same as above
Filtration fan (F-32A & F-32B)	Fails to operate	Status light on C25A/B	Loss of filtered air flow	Same as above	Same as above	Same as above
Condenser fan (F-36A & F-36B)	Fails to operate	Room temperature indicator	Loss of cooling capacity	Same as above	Same as above	Same as above
Compressor (F-22A & F-22B)	Fails to operate	Room temperature indicator	Loss of cooling capacity	Same as above	Same as above	Same as above
Supply outside air damper (2-HV-202)	Fails to close	Status light on C25A	None	None	Redundant damper 2-HV-495 closed	Safe position fails closed
F-21A discharge damper (2-HV-203A)	Fails to operate	Status light on C25A	Air flow affected	Unit out of service	Redundant system operable	Each unit has 100% capacity

TABLE 9.9-17 CONTROL ROOM AIR CONDITIONING SYSTEM FAILURE MODE ANALYSIS (CONTINUED)

COMPONENT IDENTIFICATION AND QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
F-21B discharge damper (2-HV-203B)	Fails to operate	Status light on C25B	Air flow affected	Unit out of service	Redundant system operable	Each unit has 100% capacity
F-21A discharge duct fire damper (2-HV-204A)	N/A See remark	N/A	N/A	N/A	N/A	Fire damper is deemed a passive component
F-21B discharge duct fire damper (2-HV-204B)	N/A See remark	N/A	N/A	N/A	N/A	Fire damper is deemed a passive component
F-31A & F-31B common return duct fire damper (2-HV-205)	N/A See remark	N/A	N/A	N/A	N/A	Fire damper is deemed a passive component
F-31A discharge damper (2-HV-206A)	Fails to operate	Status light on C25A	Air flow affected	Unit out of service	Redundant system operable	Each unit has 100% capacity
F-31B discharge damper (2-HV-206B)	Fails to operate	Status light on C25B	Air flow affected	Unit out of service	Redundant system operable	Each unit has 100% capacity
Exhaust damper to cable vault (2-HV-207)	Fails to close	Status light on C25A	None	None	Redundant damper 2-HV-497 closed	Safe position fails closed

TABLE 9.9-17 CONTROL ROOM AIR CONDITIONING SYSTEM FAILURE MODE ANALYSIS (CONTINUED)

COMPONENT IDENTIFICATION AND QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
Exhaust damper to atmosphere (2-HV-208)	Fails to close	Status light on C25A	None	None	Redundant damper 2-HV-496 closed	Safe position fails closed
Return air volume damper (2-HV-209)	N/A See remark	N/A	N/A	N/A	N/A	Fixed damper passive component
F-32A/B Common intake duct, air damper (2-HV-210)	Fails to close	Status light on C25A	None	None	Manual action	Damper normally open. Needs to close only during emergency fresh air mode.
F-32A/B Common outside air damper for emergency fresh air mode (2-HV-211)	Fails to close	Status light on C25A	None	None	Redundant damper 2-HV-495 closed	Safe position fails closed
F-32A discharge damper (2-HV-212A)	Fails to operate	Status light on C25A	Air flow affected	Unit out of service	Redundant system operable	Each unit has 100% capacity
F-32B discharge damper (2-HV-212B)	Fails to operate	Status light on C25B	Air flow affected	Unit out of service	Redundant system operable	Each unit has 100% capacity

TABLE 9.9-17 CONTROL ROOM AIR CONDITIONING SYSTEM FAILURE MODE ANALYSIS (CONTINUED)

COMPONENT IDENTIFICATION AND QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
Filter cross connect. damper (2-HV-213)	N/A See remark	N/A	N/A	N/A	N/A	PERMANENTLY CLOSED
F-32A & F-32B fresh air intake volume damper (2-HV-234)	N/A See remark	N/A	N/A	N/A	N/A	FIX DAMPER PASSIVE COMPONENT
F-21A/B or F-32A/B outside air damper (2-HV-495)	Fails to close	Status light on C25B	None	None	Redundant dampers to dual path 2-HV-202 & 2-HV-211	Safe position fails closed
Exhaust damper to atmosphere (2-HV-496)	Fails to close	Status light on C25B	None	None	Redundant damper 2-HV-208 closed	Safe position fails closed
Exhaust damper to cable vault (2-HV-497)	Fails to close	Status light on C25B	None	None	Redundant damper 2-HV-207 closed	Safe position fails closed
All control room ductwork	N/A See remark	N/A	N/A	N/A	N/A	Ductwork is seismic Class-1 and deemed a passive component
Fresh Air Intake Volume Damper (2-HV-725)	N/A See remark	N/A	N/A	N/A	N/A	Fixed Damper Passive Component

TABLE 9.9-17 CONTROL ROOM AIR CONDITIONING SYSTEM FAILURE MODE ANALYSIS (CONTINUED)

COMPONENT IDENTIFICATION AND QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
F-32A Discharge Volume Damper (2-HV-726A)	N/A See remark	N/A	N/A	N/A	N/A	Fixed Damper Passive Component
F-32B Discharge Volume Damper (2-HV-726B)	N/A See remark	N/A	N/A	N/A	N/A	Fixed Damper Passive Component
F-21A Discharge Volume Damper (2-HV-727A)	N/A See remark	N/A	N/A	N/A	N/A	Fixed Damper Passive Component
F-21B Discharge Volume Damper (2-HV-727B)	N/A See remark	N/A	N/A	N/A	N/A	Fixed Damper Passive Component
Exhaust Volume Damper to Cable Vault (2-HV-728)	N/A See remark	N/A	N/A	N/A	N/A	Fixed Damper Passive Component

TABLE 9.9-18 DIESEL GENERATOR VENTILATION SYSTEM FAILURE MODE ANALYSIS

COMPONENT IDENTIFICATION & QUANTITY	FAILURE MODE	METHOD OF DETECTION & MONITOR	DETRIMENTAL EFFECT ON SYSTEM	CORRECTIVE ACTION	RESULTANT SYSTEM STATUS	REMARKS
Fans (2) F-38A/B	Fails to start	Status lights in control room	One subsystem inoperable	Repair fan	Redundant system operable	One diesel generator adequate for LOCI operation
Louvers	Clogging of the louvers	None	Same as above	Cleaning the louvers	Same as above	Same as above
Modulating dampers 2-HV-257A/B	Mechanical failure	None	Partial loss of outside air cooling	Repair operator / damper	Same as above	Backup system available in the other generator room
Exhaust dampers 2-HV-255A/B	Mechanical failure	None	Loss of air cooling	Repair operator / damper	Same as above	Same as above
All vital ductwork	N/A See remark	N/A	N/A	N/A	N/A	Ductwork is a passive component and seismic Class-1

TABLE 9.9-19 VITAL SWITCHGEAR VENTILATION SYSTEM COMPONENT DESCRIPTION

AC Switchgear Air Handling Unit (4.16 KV and 6.9 KV Rooms)

	Lower Room at EL. 31'-6"	Upper Room at EL. 56'-6"
Fan	Fan F-134	Fan F-133
Type	Centrifugal	Centrifugal
Flow, CFM	7200 minimum	6000 minimum
Standard	AMCA 211-A	AMCA 211-A
Seismic Class	I	I
Cooling Coil	Coil X182	Coil X183
Type	Service Water	Service Water
Heat transfer (Btu/hr)	192,763	166,879
Code	ASME Section VIII	ASME Section VIII
Seismic class	I	I
Motor	Fan F-134	Fan F-133
Type	Induction	Induction
Horsepower rating (hp)	5	5
Code	NEMA	NEMA
Seismic Class	I	I
Particulate Filter		
Quantity	8	6
Type	Throwaway	Throwaway
Ductwork		
Material/Type	IAW Spec. M-526	IAW Spec M-526
Standard	SMACNA	SMACNA
Seismic Class	I	I

AC Switchgear Fans (480-Volt Unit Loadcenter Rooms, East and West)

	West Room	East Room Exhaust	East Room

TABLE 9.9-19 VITAL SWITCHGEAR VENTILATION SYSTEM COMPONENT DESCRIPTION (CONTINUED)

Fan		Fan F-142	Supply Fan F-52
Type	Vaneaxial	Propeller	Vaneaxial
Flow (CFM)	18,300 minimum	23,000 (nominal rating)	21,000 minimum
Standard	AMCA 211-A	AMCA 211-A	AMCA 211-A
Seismic Class	I	I	I
Cooling Coil			
(West Room)	Coil X-181A/B		
Type	Service Water		
Heat transfer (Btu/hr)	295,641 (nominal rating)		
Code	ASME Section VIII		
Seismic Class	I		
Motor			
Type	Induction	Induction	Induction
Horsepower rating (hp)	25	10	25
Code	NEMA	NEMA	NEMA
Seismic Class	I	I	I
Particulate Filter			
Quantity	9	None	None
Type	Throwaway		
Ductwork			
Material/Type	IAW Spec. M-506	None	IAW Spec. M-506
Standard	SMACNA		SMACNA
Seismic Class	I	N/A	I

D-C Switchgear Air Handling Unit

Fans F-54A/B	
Type	Centrifugal
Flow (cfm)	3500 (minimum)
Standard	AMCA 211-A
Seismic Class	I

TABLE 9.9-19 VITAL SWITCHGEAR VENTILATION SYSTEM COMPONENT DESCRIPTION (CONTINUED)

Motor	
Type	Induction
Horsepower rating (hp)	5
Code	NEMA
Seismic Class	I
Particulate Filter	
Quantity (per unit)	2
Type (prefilter)	Throwaway
Quantity (per unit)	2
Type (primary)	High efficiency (bag)
Ductwork	
Material/Type	IAW Spec. 506
Standard	SMACNA
Seismic Class	I

Vital MCC B51 and B61 Coolers A/C-3, A/C-4

Type	Self-contained A/C unit
Power Supply	480V/3 Ph/60 Hz
Evaporator Fan Data	
Type	Centrifugal
Air Flow	≈500 cfm
Motor HP	1/3
Code	NEMA MG1
Seismic Class	1
Condenser Fan Data	
Type	Propeller
Motor HP	1/2
Code	NEMA MG 1
Seismic Class	1
Evaporator Coil Data	
Type	Direct Expansion

TABLE 9.9-19 VITAL SWITCHGEAR VENTILATION SYSTEM COMPONENT DESCRIPTION (CONTINUED)

Cooling Capacity	24,000 Btu/hr
Standard	ARI 410
Seismic Class	1
Condenser Coil Data	
Type	Air cooled
Standard	ARI 410
Seismic Class	1
Compressor Data	
Type/Refrigerant	Hermetic / R-22
HP nominal	2
Standard	ARI 520
Seismic Class	1

TABLE 9.9-20 AUXILIARY CHILLED WATER SYSTEM COMPONENT DESCRIPTION

Reciprocating Chilled Water Units (X-196A/B) Non-QA

Condenser Flow Rate	277.4 gpm (nominal rating)
Evaporator Flow Rate	183.6 gpm (nominal rating)
Condenser Temperature Rise	10°F (nominal rating)
Evaporator Temperature Drop	12°F (nominal rating)
Heat Removal Rate	91.8 tons (nominal rating)

Chilled Water Pumps (P-149A/B/C)

Type	Centrifugal
TDH	140 feet (nominal rating)
Flow	220 gpm (nominal rating)

TABLE 9.9-21 VITAL CHILLED WATER SYSTEM COMPONENT DESCRIPTION

Reciprocating Chilled Water Units (X-169A/B)

Type	Refrigerant (R-22)
Rating (capacity)	15 Ton (nominal rating)
Standard	ARI 590
Seismic Class	I

Evaporator

Type	Direct expansion, refrigerant
Heat transfer (Btu/hr)	194,000 (nominal rating)

Condenser

Type	Water cooled
Heat transfer (Btu/hr)	234,400 (nominal rating)

Compressor

Type	Semi-hermetic

Chilled Water Pumps (P-122A/B)

Type	Centrifugal
Total Dynamic Head (ft)	108 (nominal rating)
Flow (gpm)	35 (nominal rating)

TABLE 9.9-22 INDOOR DESIGN TEMPERATURES FOR SIGNIFICANT PLANT AREAS

Zone No. / Zone Description6	Maximum Indoor Design Temperature (°F)	Minimum Indoor Design Temperature (°F)
Containment Building Elevation		
General Containment Areas, (Normal Operation Mode 1-4)	120	N/A
General Containment Areas, (Shutdown Mode 5, 6)	120	40
(EQ-C06) Pressurizer Block House (Interior), Elevation 14 foot 6 inches & 38 foot 6 inches	150	N/A
Auxiliary Building		
(EQ-A15) East 480 Volt Load Center, Elevation 36 foot 6 inches	104	32
(EQ-A35) East Vital DC Switchgear Room, Elevation 14 foot 6 inches	104	32
(EQ-A36) West Vital DC Switchgear Room, Elevation 14 foot 6 inches	104	32
(EQ-A42) Control Room, Elevation 36 foot 6 inches	100 * *per TS 3/4.7.6	N/A
(EQ-A28) Emergency Diesel Generator Room “A”, Elevation 14 foot 6 inches	120 (EDG's operating)	N/A (EDG's operating)
	120 (EDG's in standby)	55 (EDG's in standby)
(EQ-A29) Emergency Diesel Generator Room “B”, Elevation 14 foot 6 inches	120 (EDG's operating)	N/A (EDG's operating)
	120 (EDG's in standby)	55 (EDG's in standby)

TABLE 9.9-22 INDOOR DESIGN TEMPERATURES FOR SIGNIFICANT PLANT AREAS (CONTINUED)

Zone No. / Zone Description6	Maximum Indoor Design Temperature (°F)	Minimum Indoor Design Temperature (°F)
(EQ-A02, A03, & A04) ESF Rooms, Elevation (-) 45 foot 6 inches	177.9 (Safety related equipment operating)	N/A (Safety related equipment operating)
	110 (Safety related equipment in standby)	40 (Safety related equipment in standby)
(EQ-A24A & A-24B) MCC B51 & B61 Enclosures, respectively, Elevation 14 foot 6 inches	122	32
(EQ-A27A, B & C) Fuel Handling Area, Elevation 14 foot 6 inches & 38 foot 6 inches	110	40
(EQ-A37) West Battery Room “B” Elevation 14 foot 6 inches	104	60
(EQ-A41) East Battery Room “A” Elevation 14 foot 6 inches	104	60
EQ-A01A, A01A1, A01B, A03A, A05, A06, A08, A14A, A16, A20, A23, A30, A31, A38, A39 Radwaste Potentially Radioactive Areas	110	40
(EQ-A11) Waste Gas Decay Tanks Room, Elevation (-)25 foot 6 inches	110	55
(EQ-A12) Waste Gas Compressors Room, Elevation (-)25 foot 6 inches	110	55
(EQ-A13) Waste Gas Surge Tank Room, Elevation (-)25 foot 6 inches	110	55
(EQ-A14) Boric Acid and Refueling Water Purification Areas, Elevation (-)5 foot 0 inches	110	55

TABLE 9.9-22 INDOOR DESIGN TEMPERATURES FOR SIGNIFICANT PLANT AREAS (CONTINUED)

Zone No. / Zone Description6	Maximum Indoor Design Temperature (°F)	Minimum Indoor Design Temperature (°F)
(EQ-A21) West Boric Acid Evaporator Room, Elevation (-)5 foot 0 inches	110	55
(EQ-A22) East Boric Acid Evaporator Room, Elevation (-)5 foot 0 inches	110	55
(EQ-A24) Boric Acid Batch Tank and Chemical Storage Area, Elevation 14 foot 6 inches	110	55
(EQ-A40) Cable Vault in Auxiliary & Turbine Buildings, Elevation 25 foot 6 inches	104	32
(EQ-A09) Charging Pumps, Elevation (-)25 foot 6 inches	110	40
(EQ-A52) Auxiliary Building/CRACS Mechanical Equipment Room, Elevation 36 foot 6 inches	110	32
(EQ-A49) Auxiliary Building Fan Room (Open to Auxiliary Building Truck Bay), Elevation 36 foot 6 inches	110	32
(EQ-A27D) Enclosure Building Filtration System Equipment Room, Elevation 14 foot 6 inches	110	40
(EQ-A07) Coolant Waste Tanks Room Elevation (-)25 foot 6 inches / (-)5 foot 6 inches	110	40
(EQ-A10) Spent Resin Tank Room, Elevation (-)25 foot 6 inches	110	55
Enclosure Building		

TABLE 9.9-22 INDOOR DESIGN TEMPERATURES FOR SIGNIFICANT PLANT AREAS (CONTINUED)

Zone No. / Zone Description6	Maximum Indoor Design Temperature (°F)	Minimum Indoor Design Temperature (°F)
(EQ-A50) MS Isolation Valve Room, East Penetration Area, Elevation 38 foot 6 inches	120	40
(EQ-A51) MS Isolation Valve Room, West Penetration Area, Elevation 38 foot 6 inches	120	40
(EQ-A26A & A50A) Enclosure Building Upper & Lower Areas, respectively, Elevation 14 foot 6 inches & 38 foot 6 inches	120	40
(EQ-A17) East Piping Penetration Room, Elevation (-)25 foot -6 inches & (-)5 foot 6 inches	120	40
(EQ-A18) West Piping Penetration Room, Elevation (-)5 foot 6 inches	135	40
(EQ-A19) West Piping Penetration Room, Elevation (-)25 foot 6 inches	120	40
(EQ-A25) West Electrical Penetration Room, Elevation 14 foot 6 inches	130	40
(EQ-A26) East Electrical Penetration Room, Elevation 14 foot 6 inches	130	40
Turbine Building		
EQ-T10, T12, T13, A51A General Area All Levels, Bulk Average Temp.	110	40
(EQ-T04) West 480-Volt Load center, Elevation 36 foot 6 inches	104	40

TABLE 9.9-22 INDOOR DESIGN TEMPERATURES FOR SIGNIFICANT PLANT AREAS (CONTINUED)

Zone No. / Zone Description6	Maximum Indoor Design Temperature (°F)	Minimum Indoor Design Temperature (°F)
(EQ-T07) Lower 4160-Volt Switchgear Room, Elevation 36 foot 6 inches	122	40
(EQ-T09N) Turbine Driven Auxiliary Feedwater (TDAFW) Pump Room, Elevation 1 foot 6 inches	135 (TDAFW Pumps in service)	N/A (TDAFW Pumps in service)
	110 (TDAFW Pumps in standby)	40 (TDAFW Pumps in standby)
(EQ-T09S) Motor Driven Auxiliary Feedwater (MDAFW) Pump Room, Elevation 1 foot 6 inches	135 (MDAFW Pumps in service)	N/A (MDAFW Pumps in service)
	110 (MDAFW Pumps in standby)	40 (MDAFW Pumps in standby)
(EQ-T05) West Cable Vault Room, Cable Vault ∇, Elevation 45 foot 6 inches	104	32
(EQ-T06) East Cable Vault Room, Cable Vault │∇, Elevation 45 foot 6 inches	104	32
(EQ-T11) Non-Vital Turbine Battery Room, Elevation 31 foot 6 inches	110	60
Intake Structure		
(EQ-I01) Main Area (large open space), Elevation 14 foot 0 inches	130	40

FIGURE 9.9–1 P&ID CONTAINMENT AND ENCLOSURE BUILDING VENTILATION

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–2 VENTILATION P&IDS (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–2 VENTILATION P&IDS (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–2 VENTILATION P&IDS (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–2 VENTILATION P&IDS (SHEET 4)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–3 P&ID AUXILIARY BUILDING VENTILATION SYSTEM (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–3 P&ID AUXILIARY BUILDING VENTILATION SYSTEM (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–3 P&ID AUXILIARY BUILDING VENTILATION SYSTEM (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–4 P&ID HVAC SYSTEM TURBINE BUILDING, INTAKE STRUCTURE, WAREHOUSE AND DIESEL GENERATOR ROOMS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–4A P&ID CONTROL ROOM AIR CONDITIONING SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–5 CONTROL ELEMENT DRIVE MECHANISM (CEDM) FAN PERFORMANCE CURVE

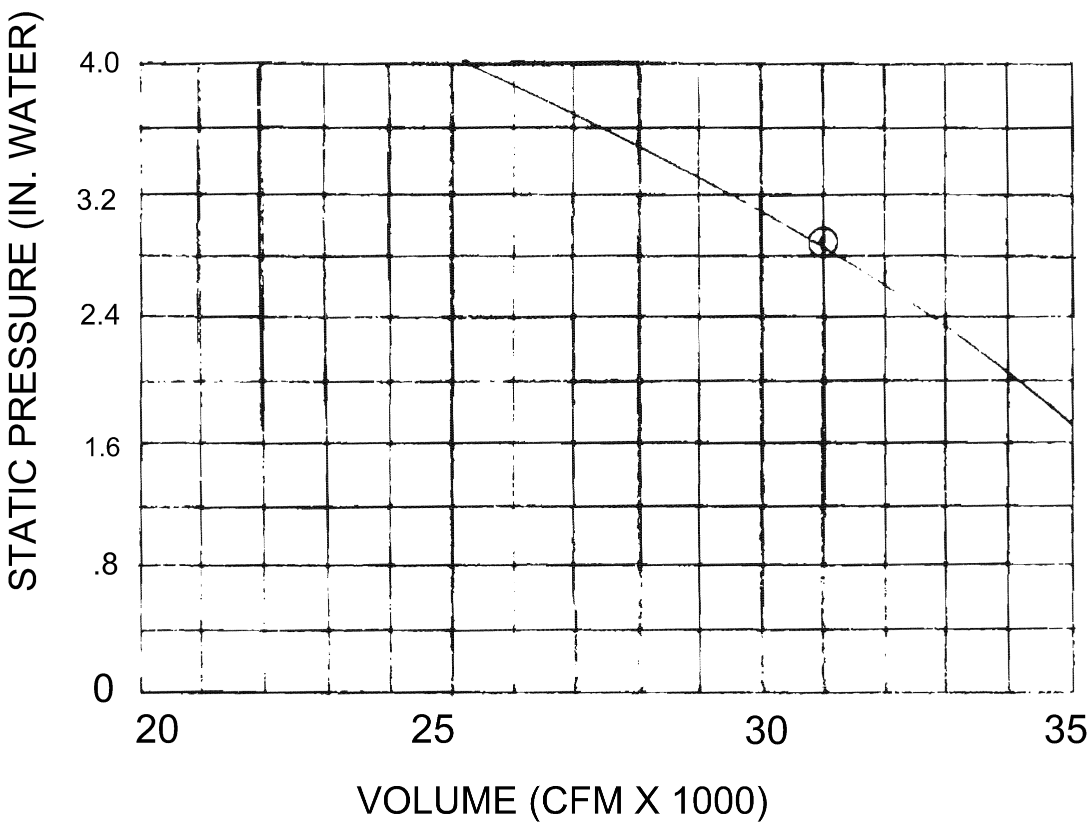


FIGURE 9.9–6 CONTAINMENT PURGE FAN PERFORMANCE CURVE

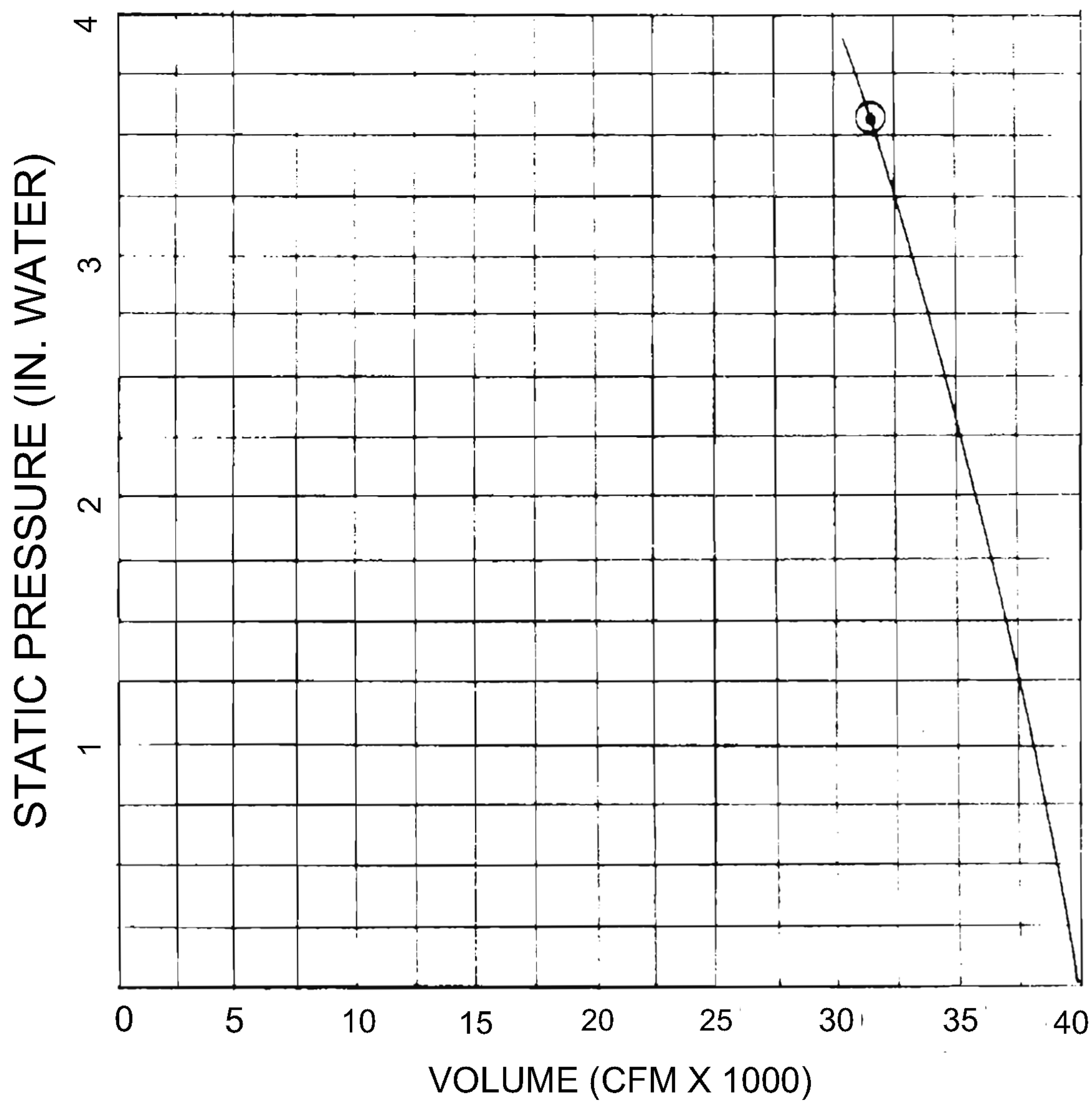


FIGURE 9.9–7 CONTAINMENT AUXILIARY CIRCULATION FAN PERFORMANCE CURVE

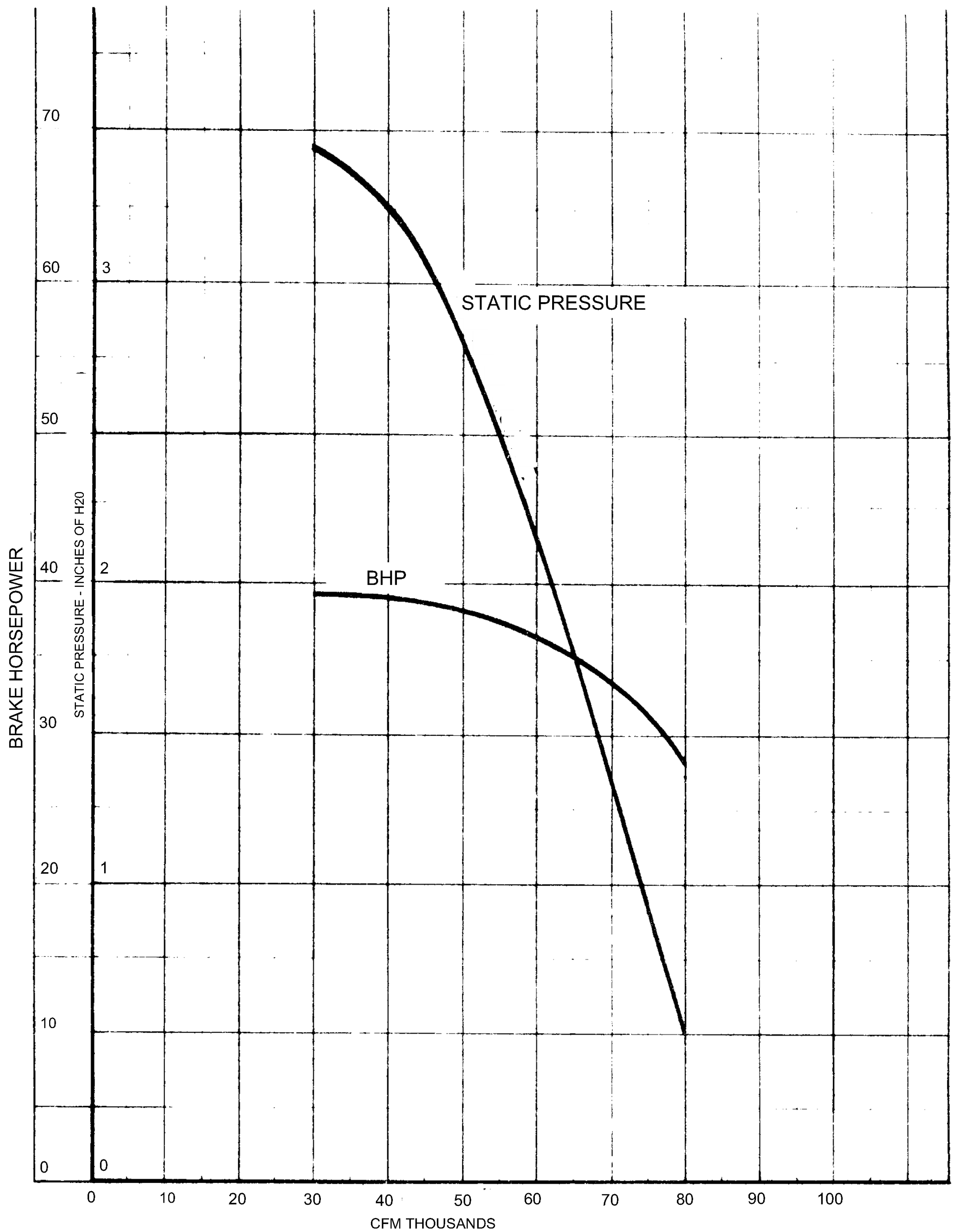


FIGURE 9.9–8 CONTAINMENT PENETRATION COOLING FAN PERFORMANCE CURVE

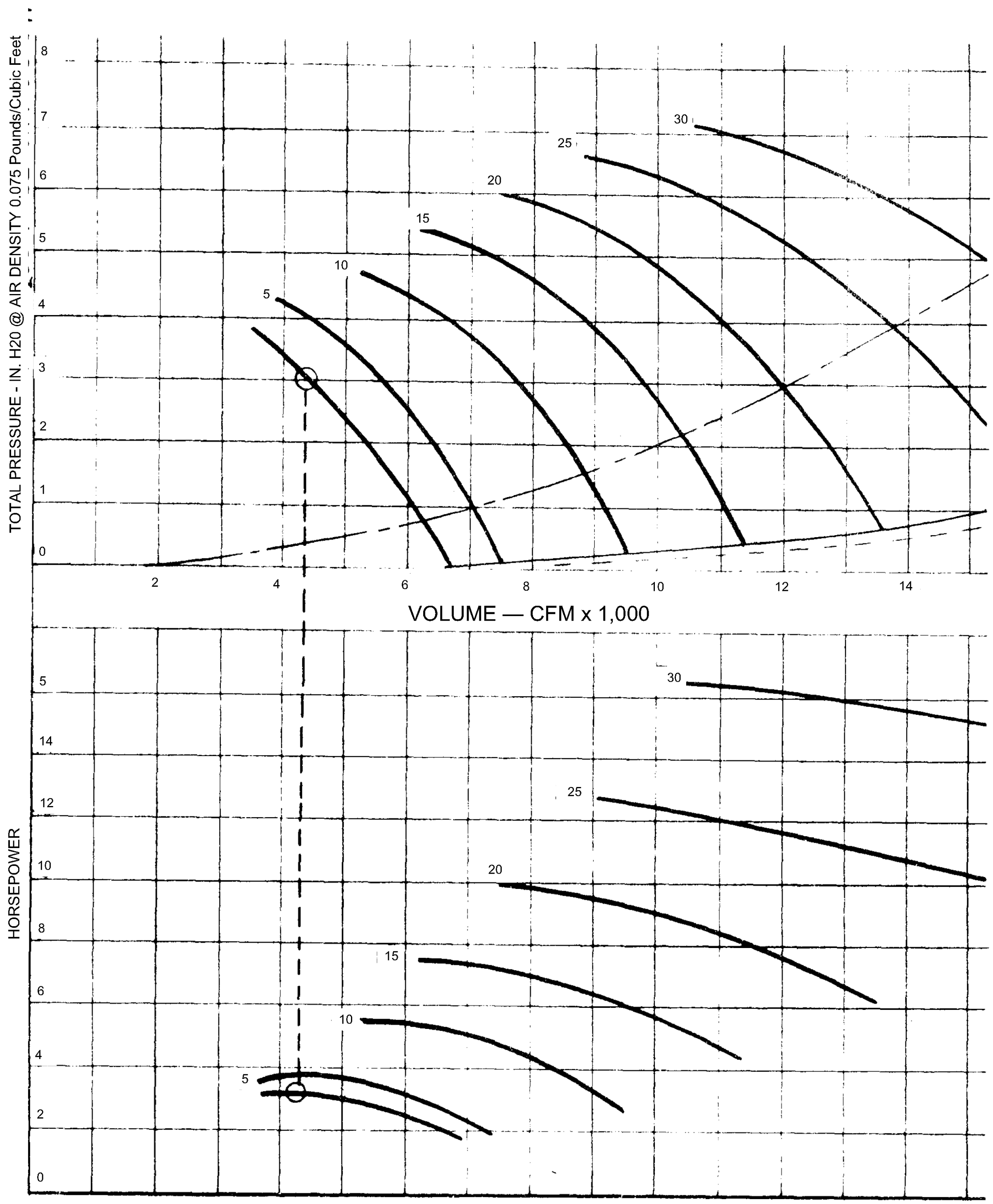


FIGURE 9.9–9 RADWASTE VENTILATION FAN PERFORMANCE CURVE

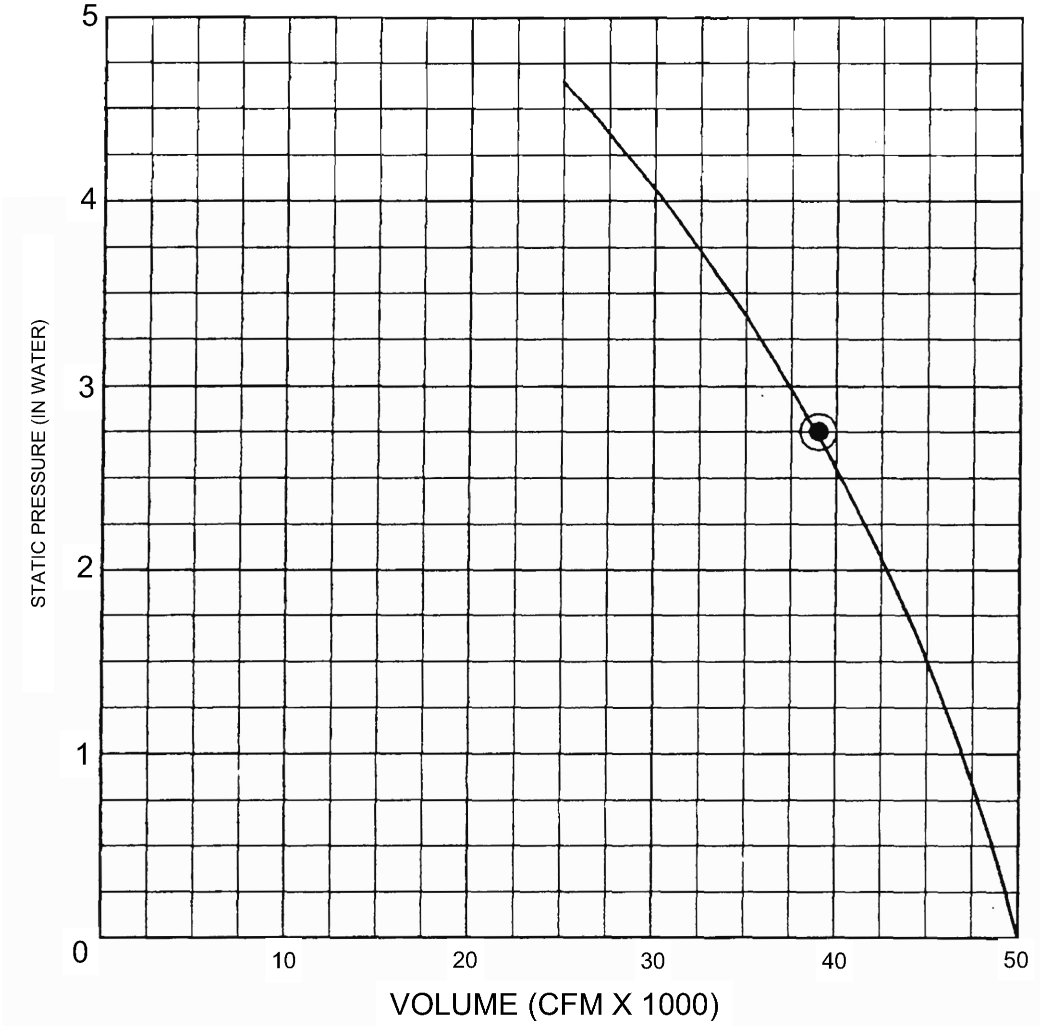


FIGURE 9.9–10 LOGIC DIAGRAM RADWASTE AREA SUPPLY FAN

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.9–11 NON-RADIOACTIVE SUPPLY FAN PERFORMANCE CURVE

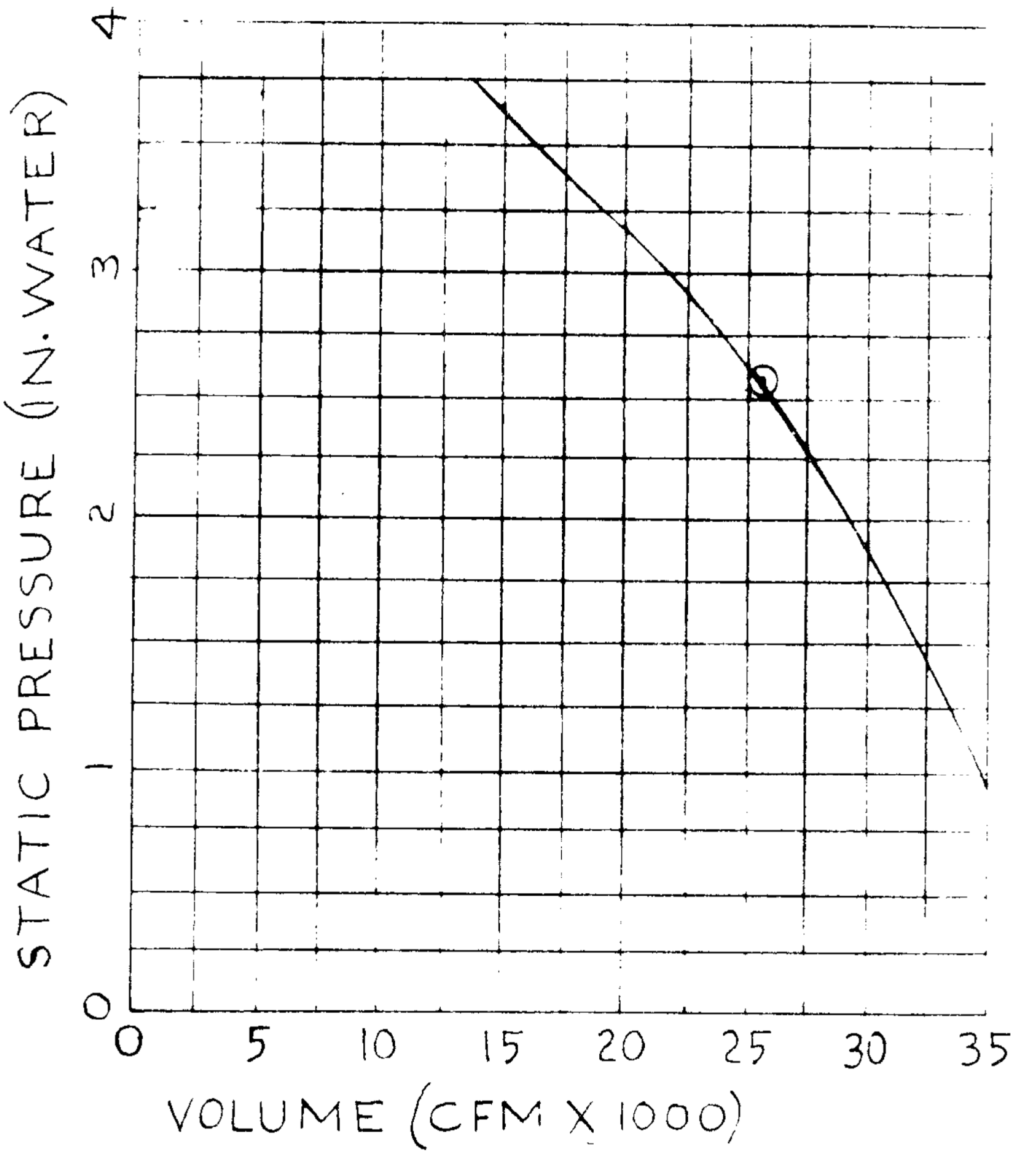


FIGURE 9.9–12 NON-RADIOACTIVE EXHAUST FAN PERFORMANCE CURVE

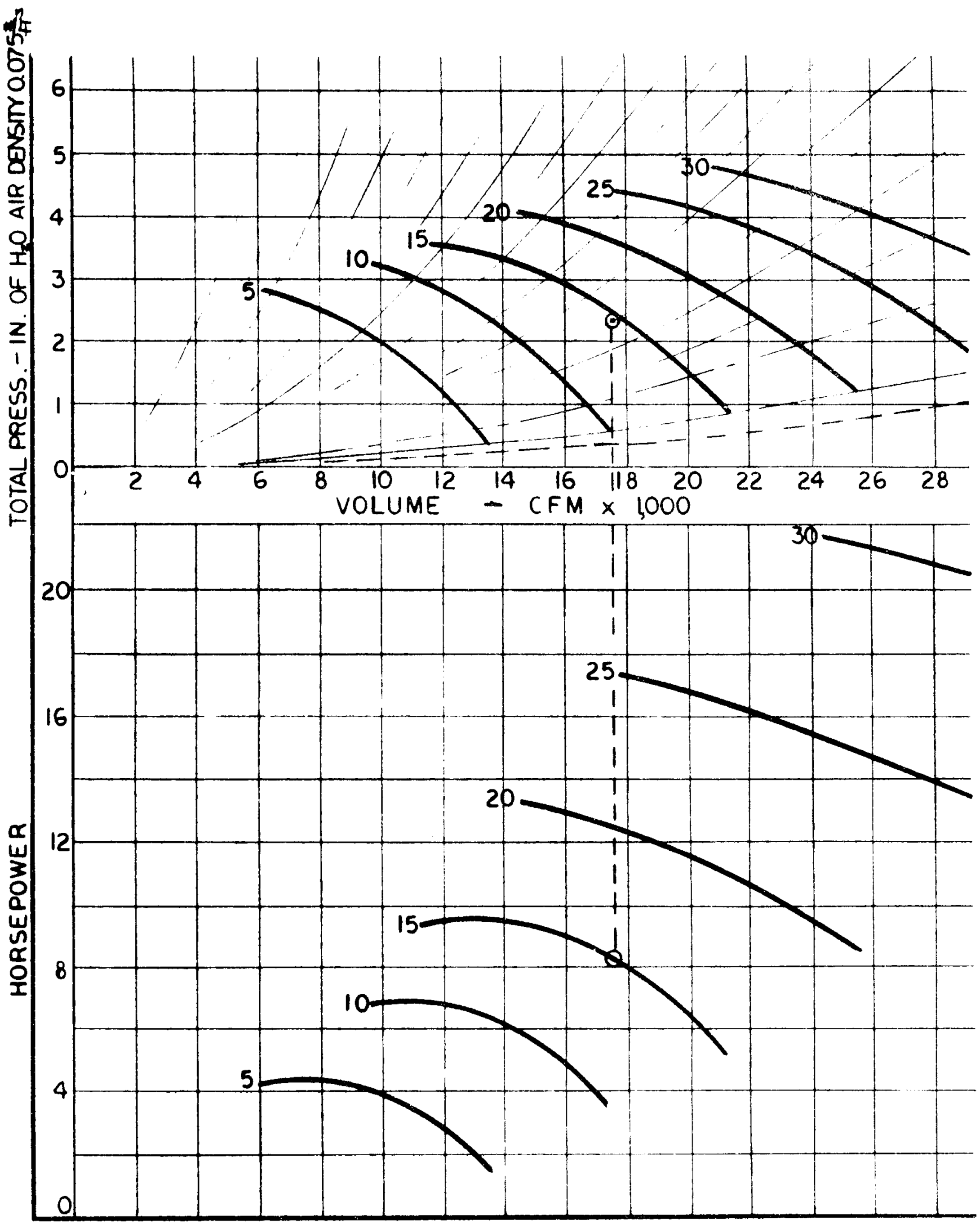


FIGURE 9.9–13 BATTERY ROOM EXHAUST FAN PERFORMANCE CURVE

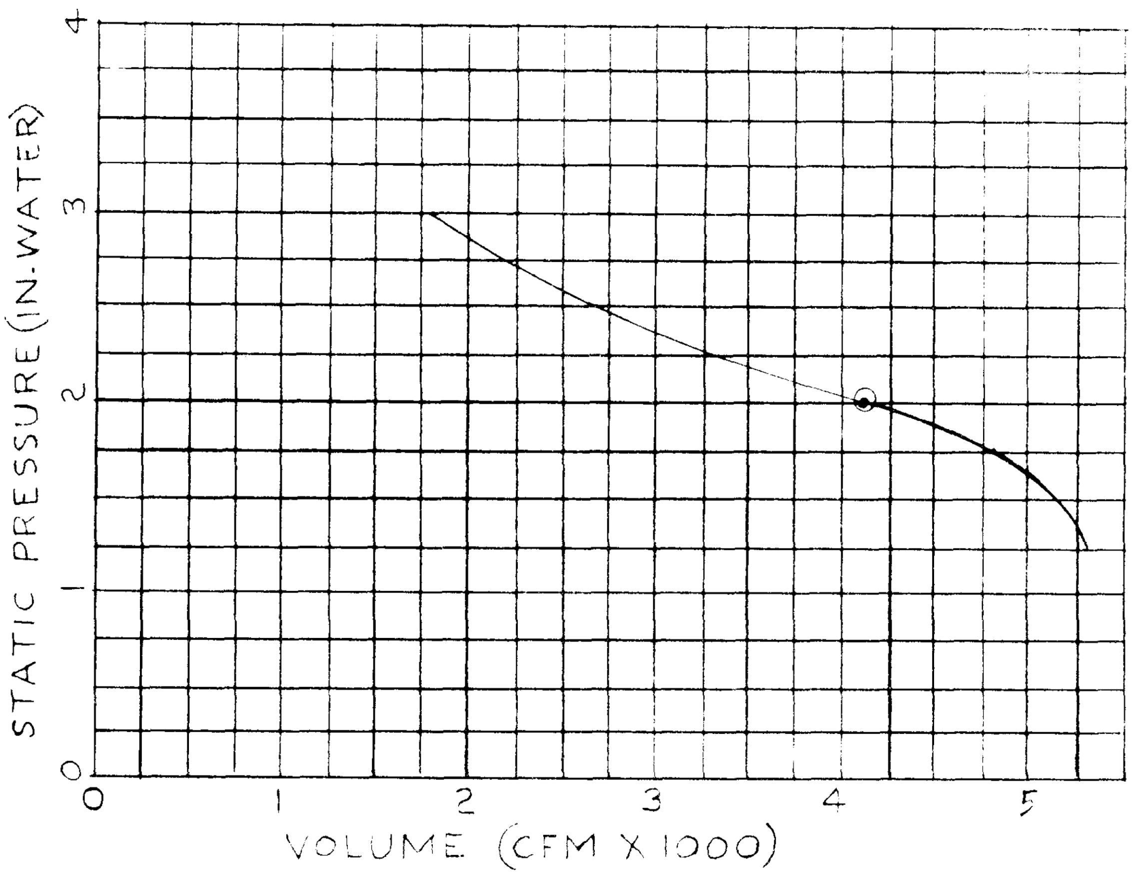


FIGURE 9.9–14 CABLE VAULT TRANSFER FAN PERFORMANCE CURVE

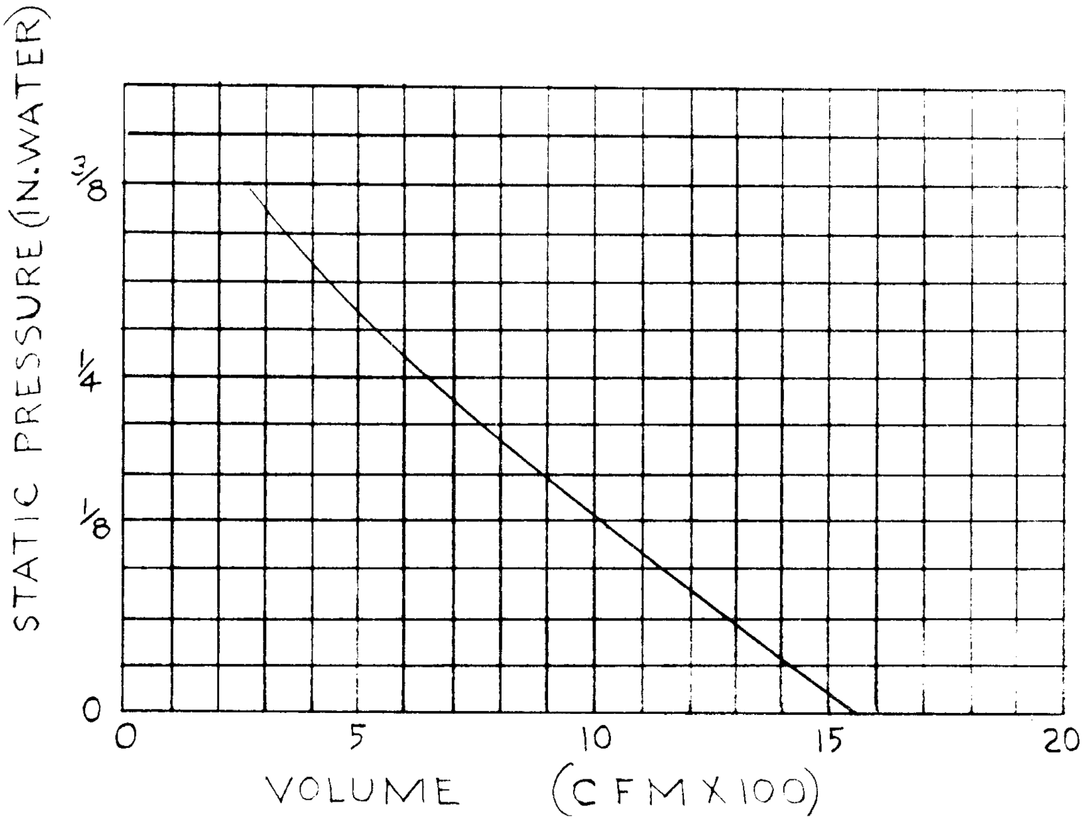


FIGURE 9.9–15 ENGINEERED SAFETY FEATURES ROOM FAN PERFORMANCE CURVE

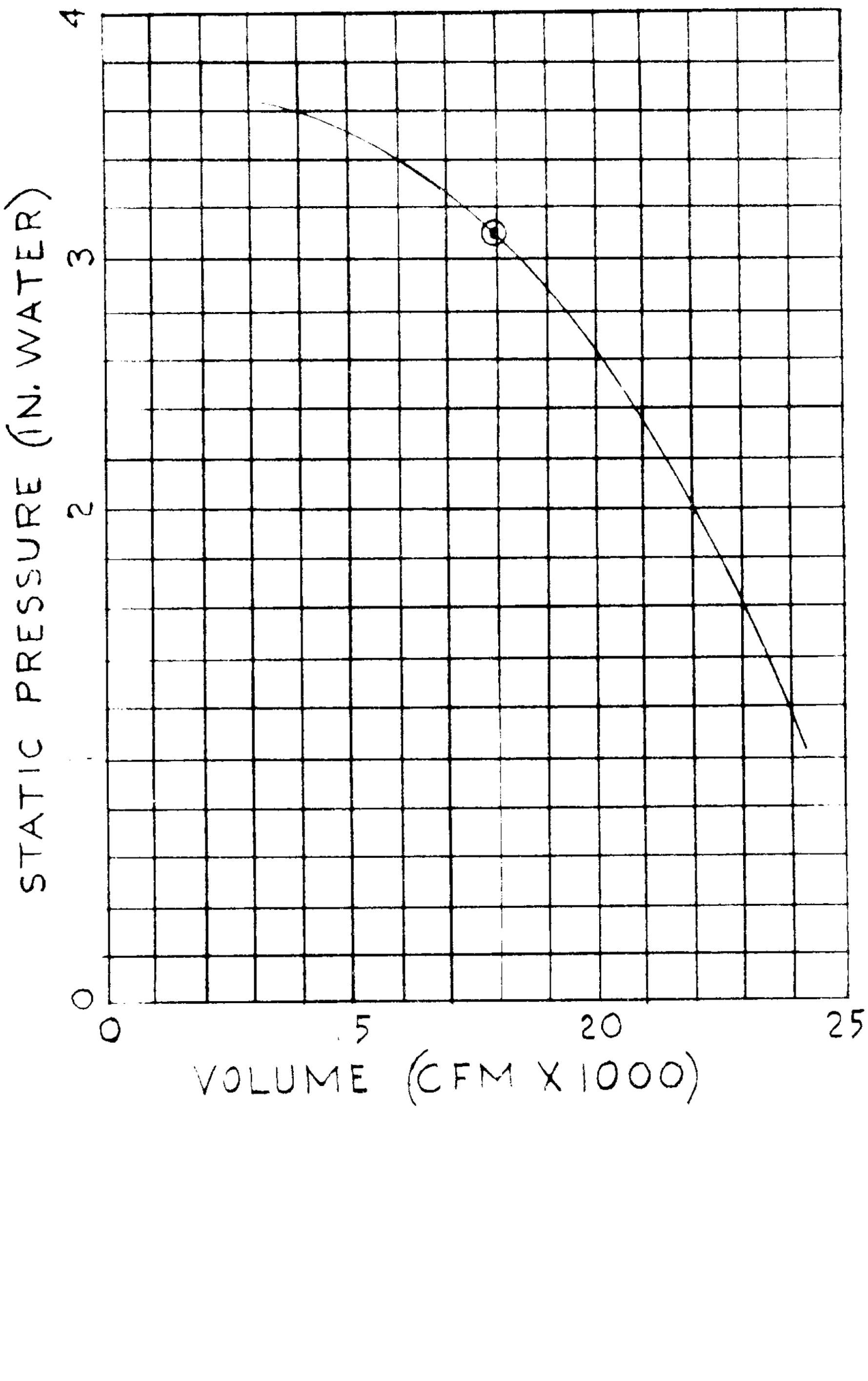


FIGURE 9.9–16 FUEL HANDLING SUPPLY FAN PERFORMANCE CURVE

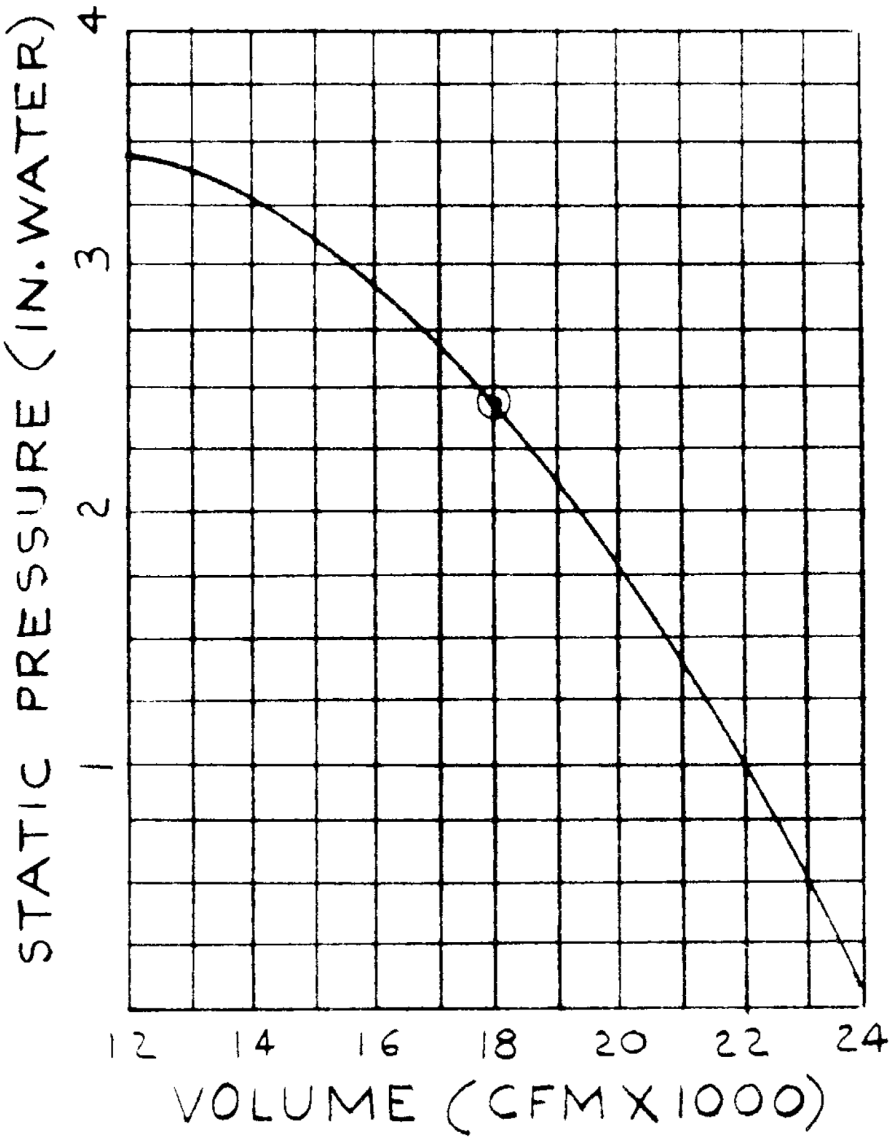


FIGURE 9.9–17 DELETED

FIGURE 9.9–18 MAIN EXHAUST FAN PERFORMANCE CURVE

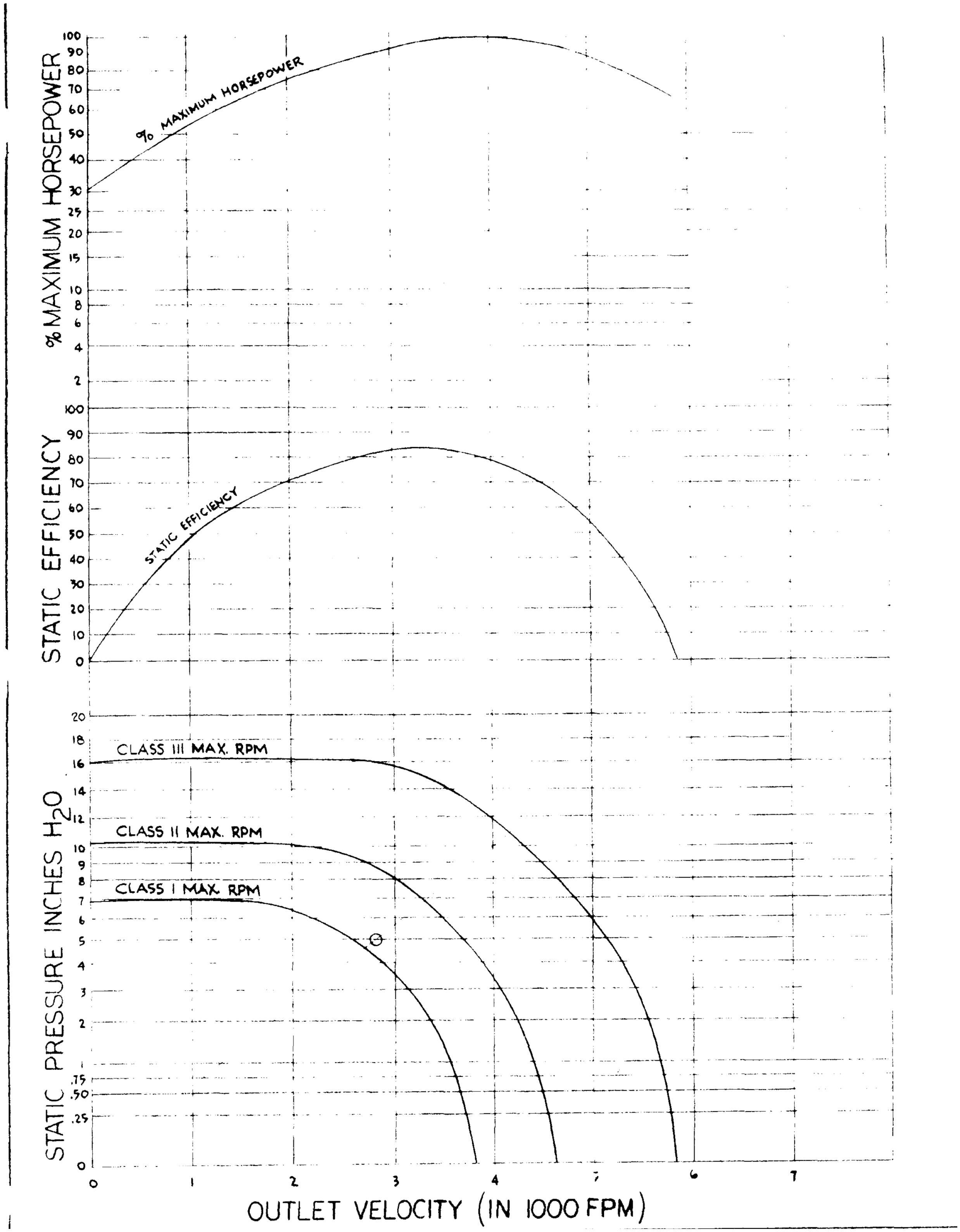


FIGURE 9.9–19 CONTROL ROOM AIR CONDITIONING FAN PERFORMANCE CURVE

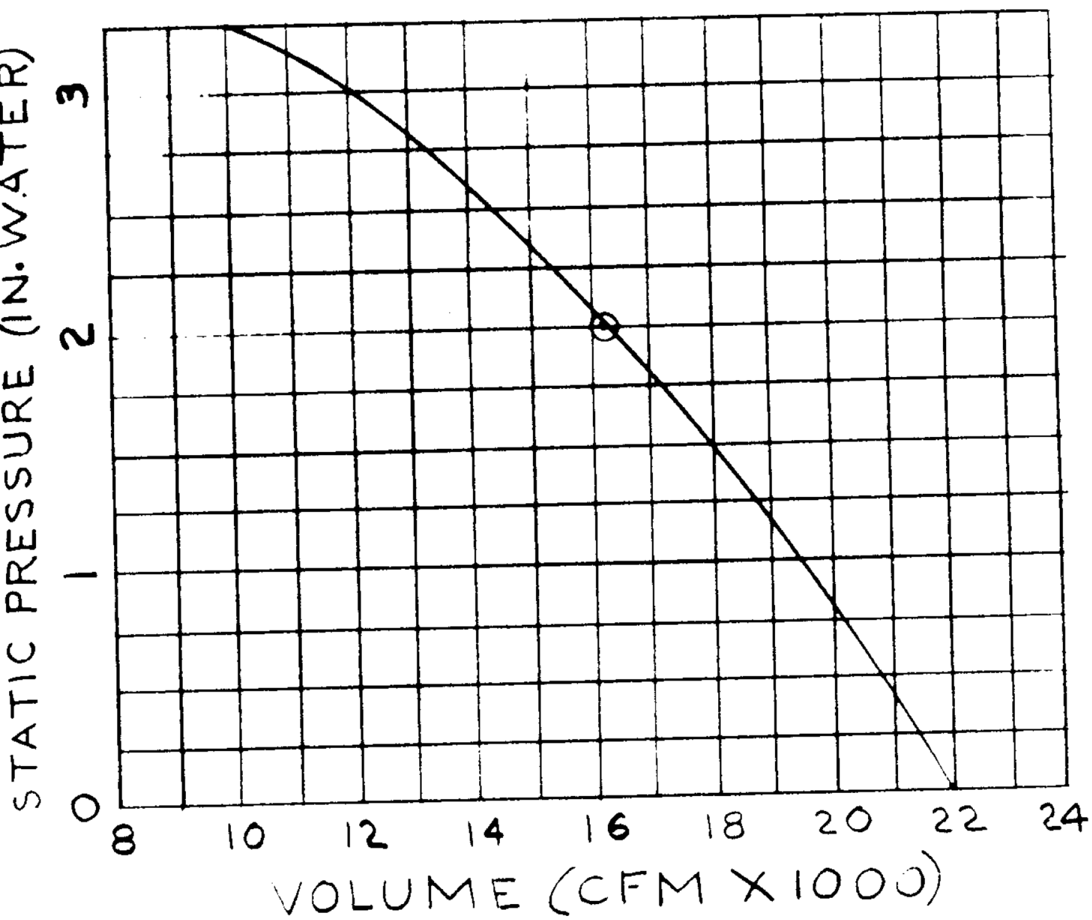


FIGURE 9.9–20 AIR COOLED CONDENSER FAN PERFORMANCE CURVE

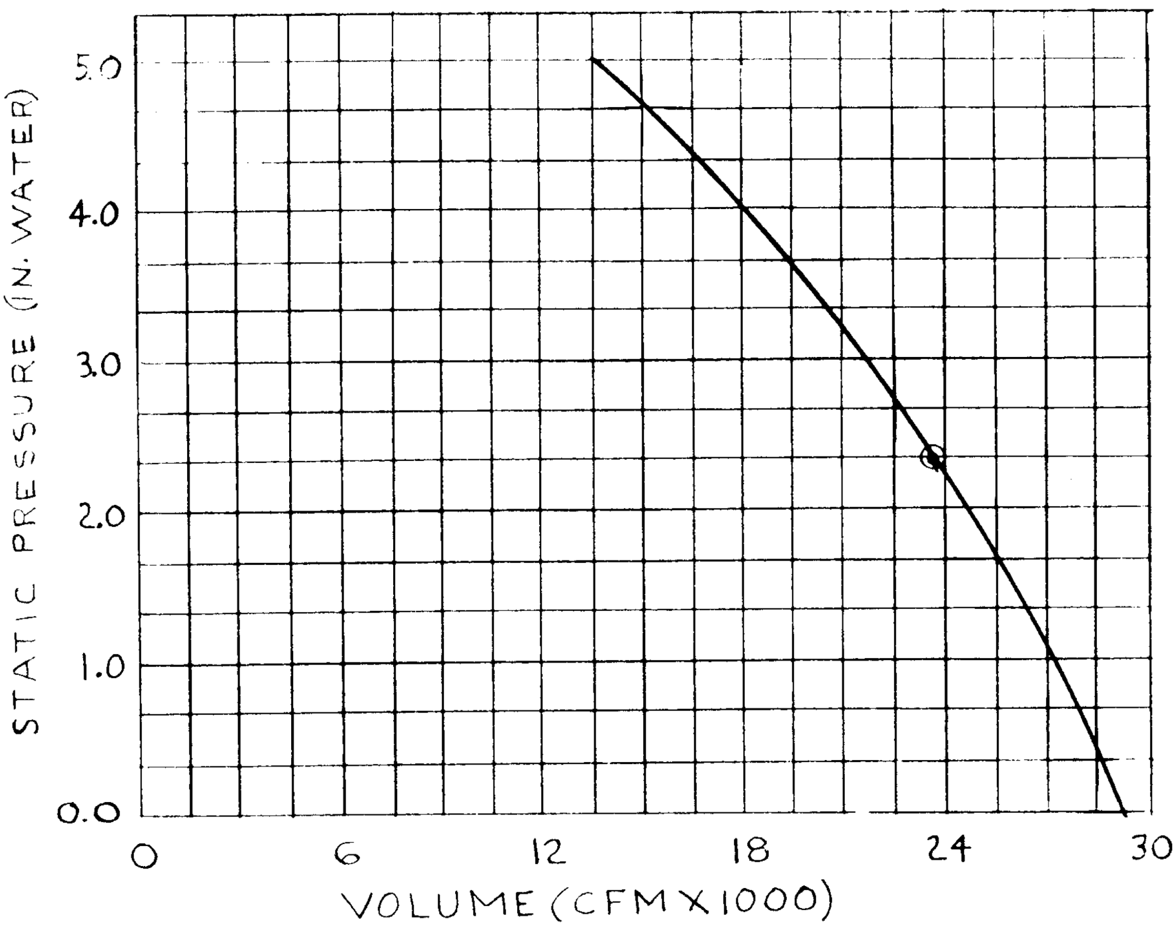


FIGURE 9.9–21 CONTROL ROOM EXHAUST FAN PERFORMANCE CURVE

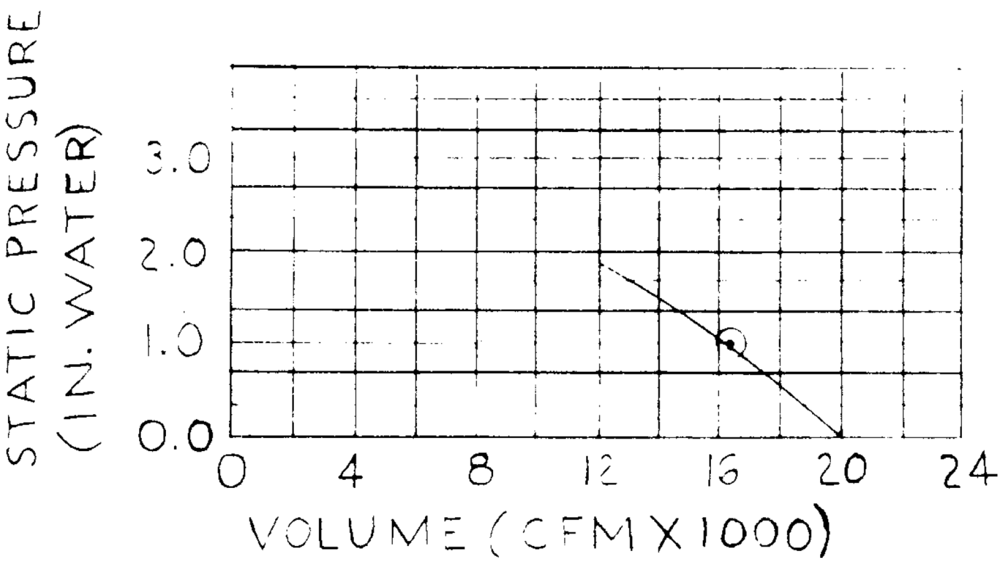


FIGURE 9.9–22 CONTROL ROOM FILTRATION SYSTEM FAN PERFORMANCE CURVE

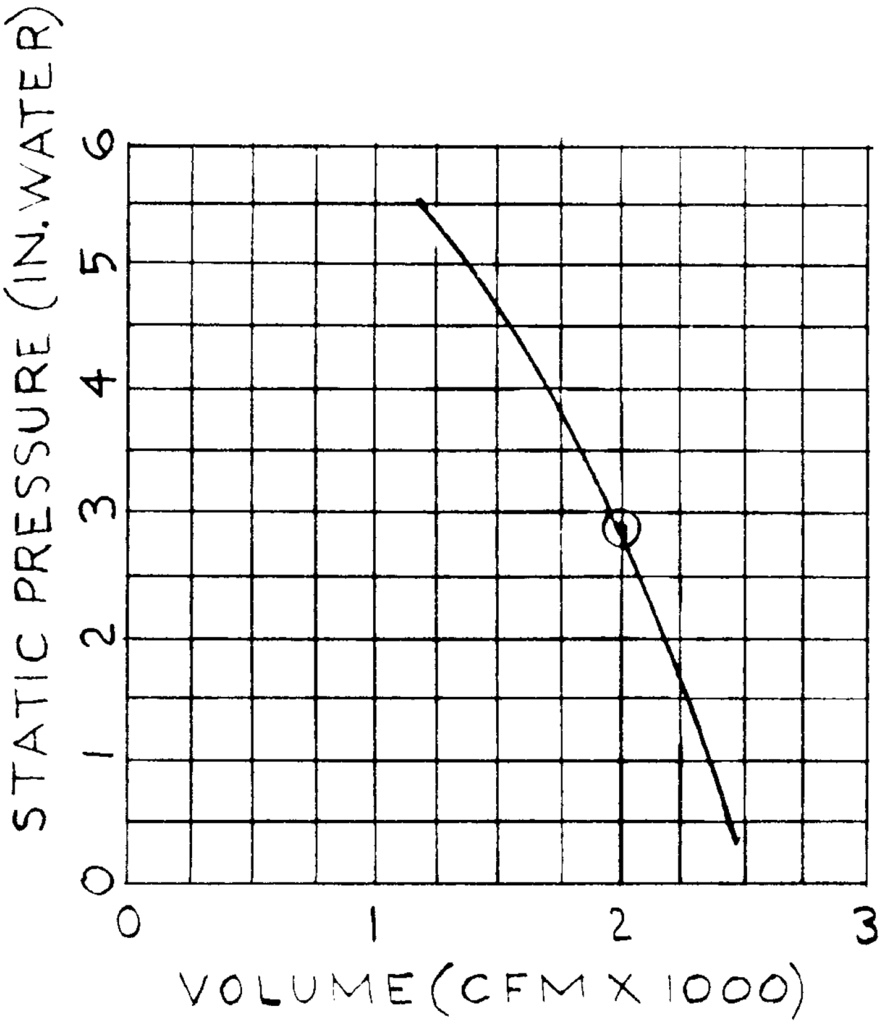


FIGURE 9.9–23 DIESEL GENERATOR ROOM SUPPLY FAN PERFORMANCE CURVE

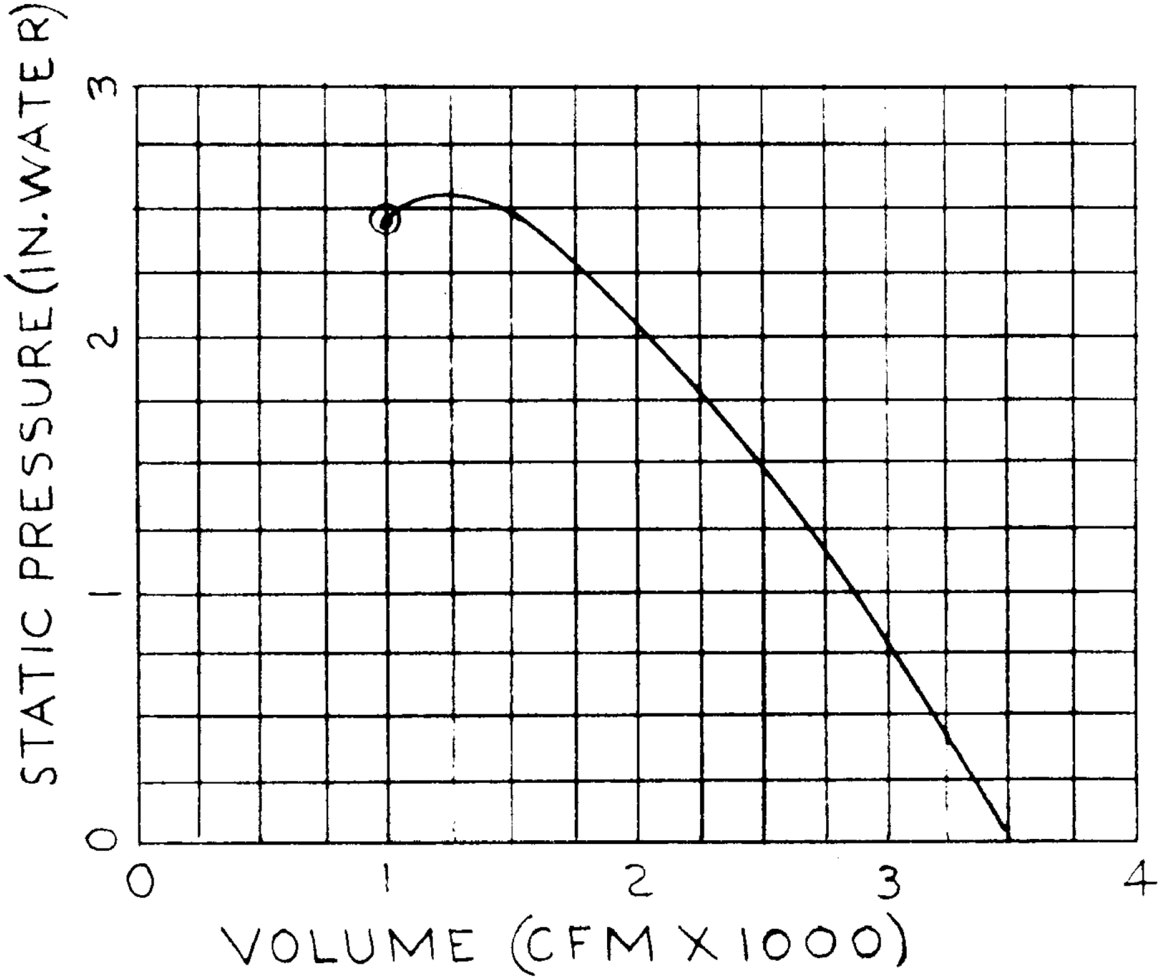


FIGURE 9.9–24 DIESEL GENERATOR FAN PERFORMANCE CURVE

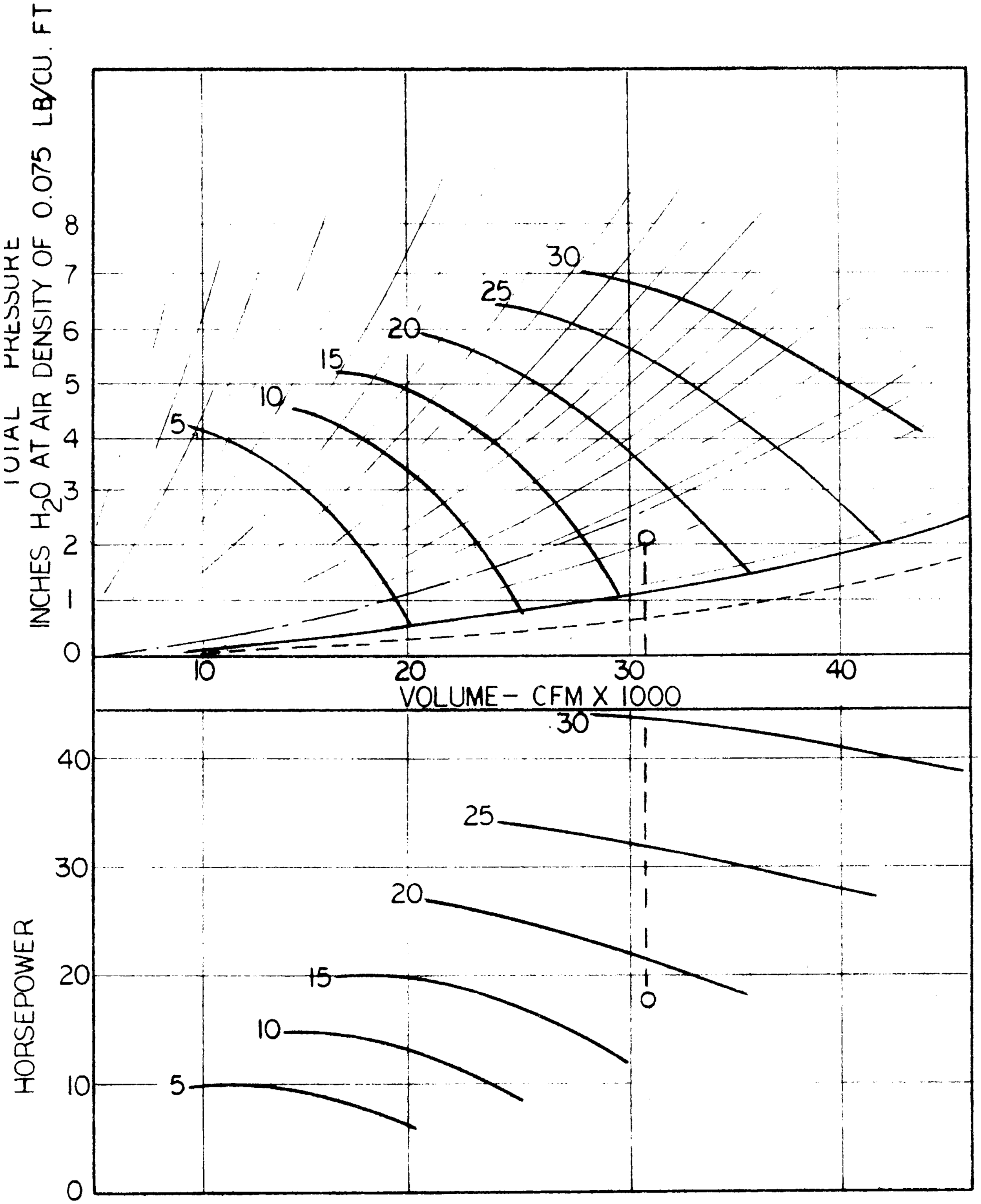


FIGURE 9.9–25 TURBINE BUILDING SUPPLY FAN PERFORMANCE CURVE

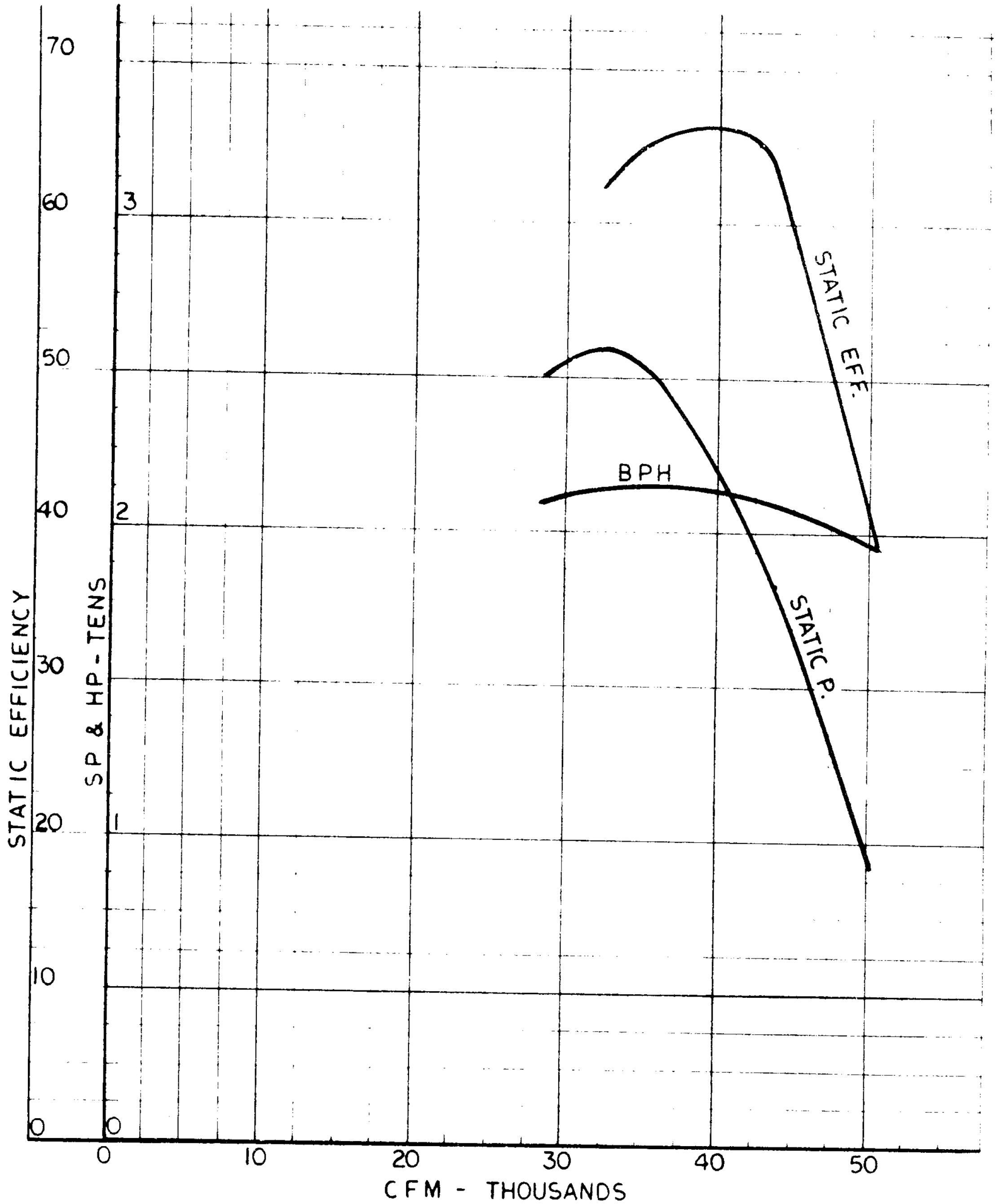


FIGURE 9.9–26 TURBINE BUILDING EXHAUST FAN PERFORMANCE CURVE

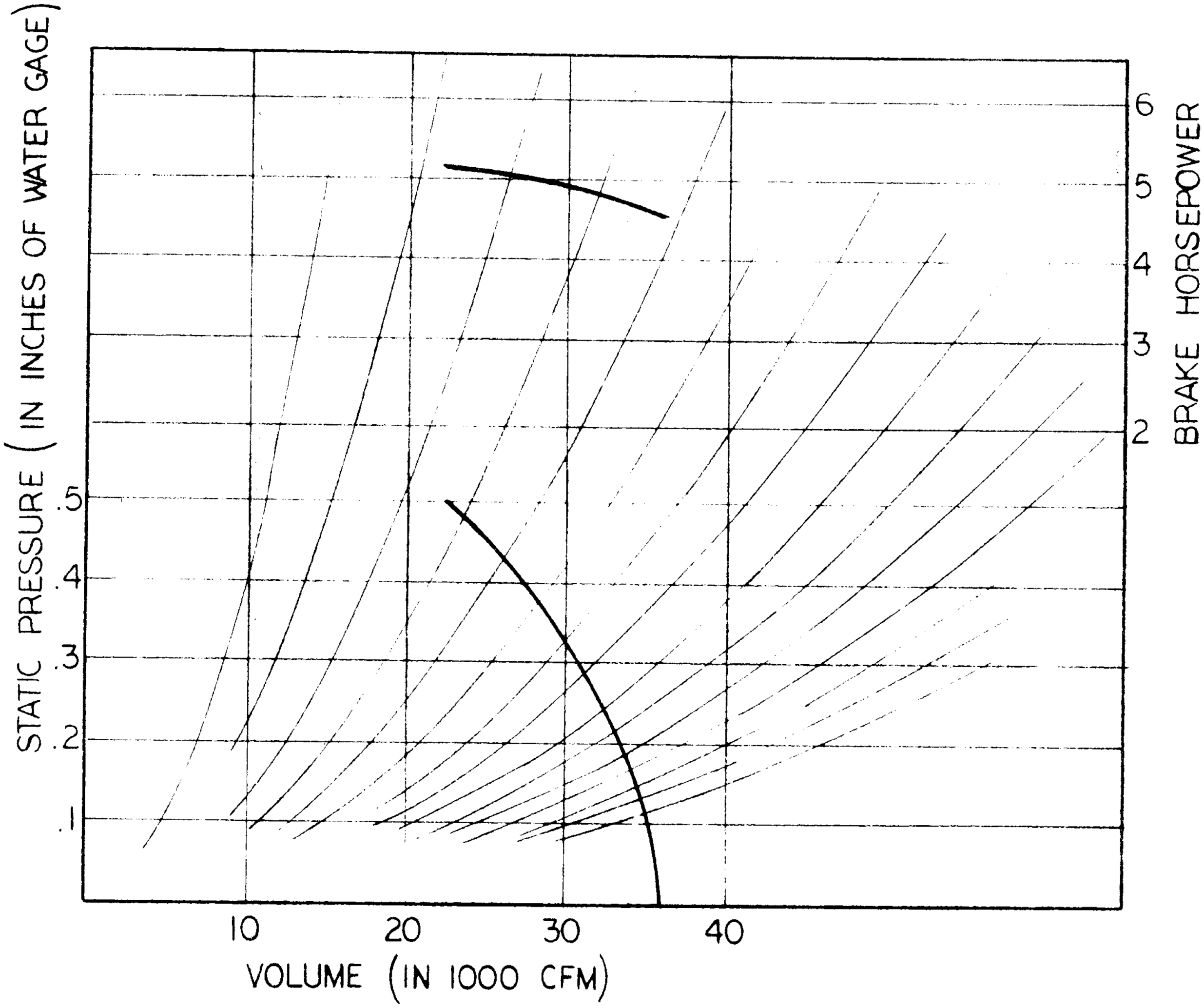


FIGURE 9.9–27 ELECTRICAL ROOM SUPPLY FAN PERFORMANCE CURVE

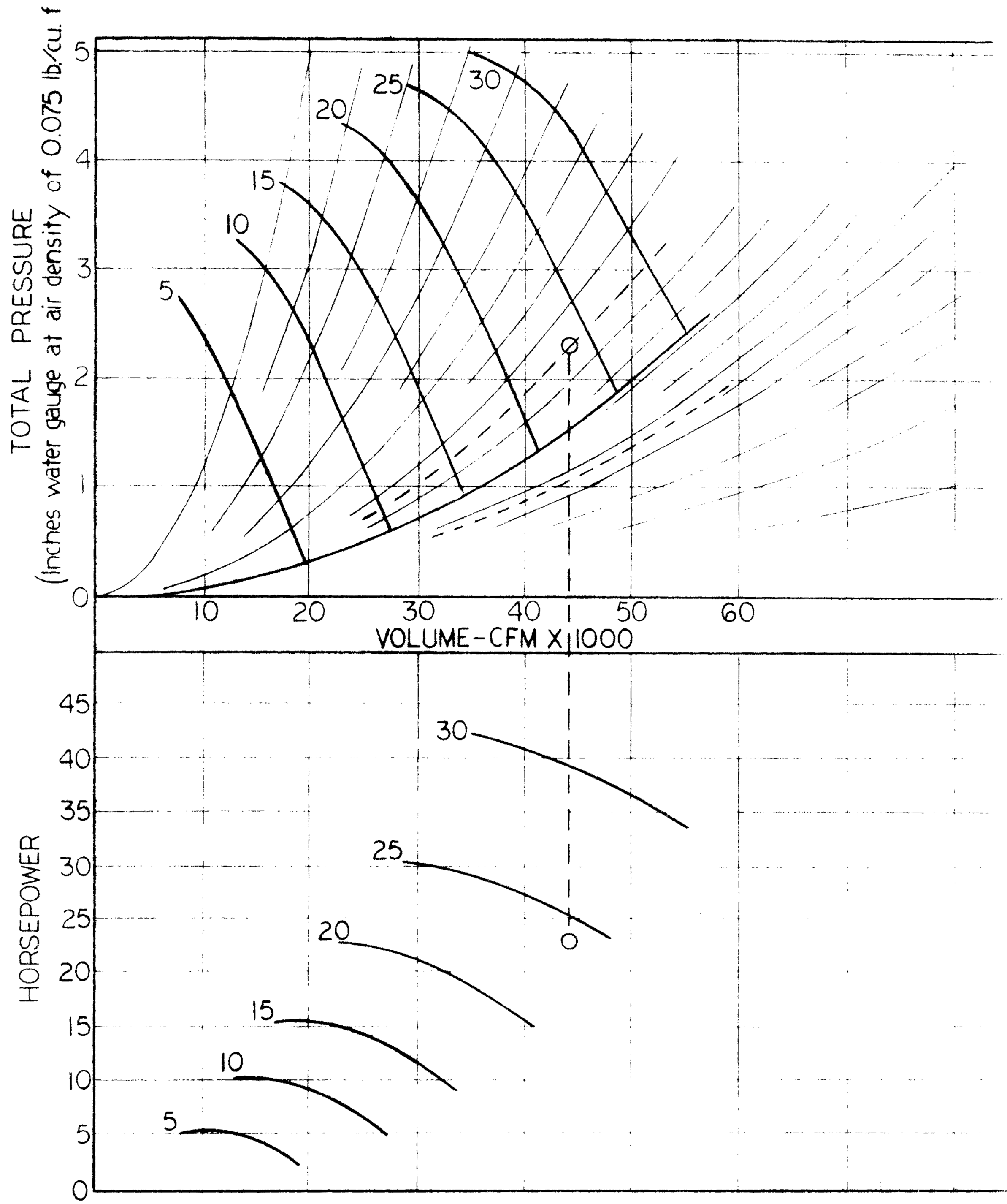


FIGURE 9.9–28 ACCESS CONTROL AREA AIR CONDITIONING FAN PERFORMANCE CURVE

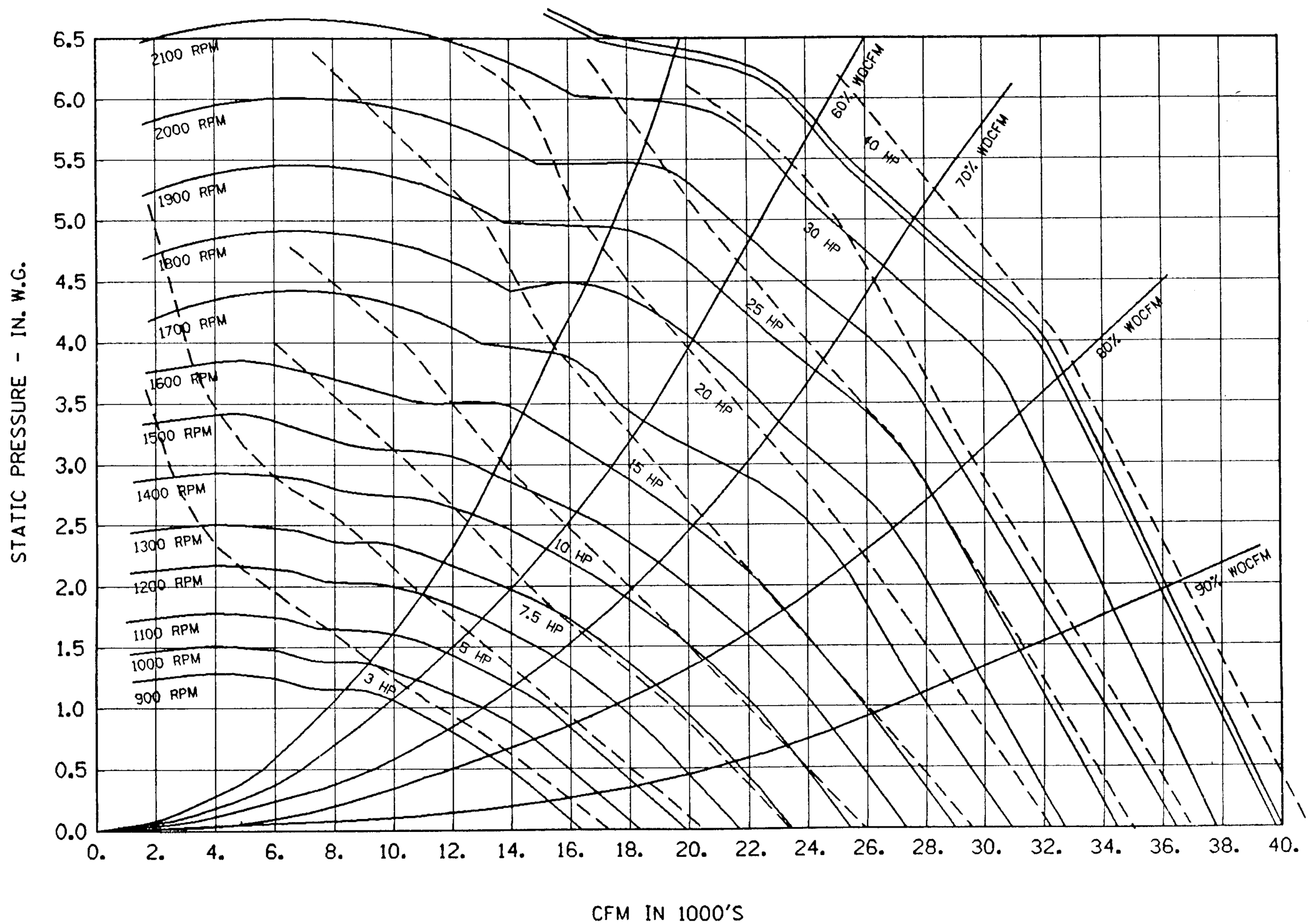


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FIGURE 9.9–29 DELETED

FIGURE 9.9–30 DELETED

FIGURE 9.9–31 P&ID TURBINE BUILDING, INTAKE STRUCTURE, WAREHOUSE AND DIESEL GENERATOR ROOM CHILLED WATER SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

9.10 FIRE PROTECTION SYSTEM

The Millstone Nuclear Power Station Fire Protection Program Manual, (Reference 9.10-1), has been developed to ensure that any single fire will not cause an unacceptable risk to public health and safety, will not prevent the performance of necessary safe shutdown functions, and will not significantly increase the risk of radioactive release to the environment.

A Fire Protection Program has been established at Millstone Unit 2. This program establishes the fire protection policy for the protection of structures, systems, and components important to the safety of the plant and the procedures, equipment, and personnel required to implement the program. For details, refer to the Station Procedure for the Millstone Fire Protection Program (Reference 9.10-4).

The Fire Protection Program is under the direction of an individual who has been delegated authority commensurate with the responsibilities of the position. Refer to the Fire Protection Program Manual.

9.10.1 DESIGN BASES

To achieve and maintain a high level of confidence for the Fire Protection Program, it has been organized and is administered using the defense in depth concept. The defense-in-depth concept assures that if any level of fire protection fails, another level is available to provide the required defense. In fire protection terms, this defense in depth concept consists of the following levels:

a. Preventing fires from starting.

b. Early detection of fires that do start and controlling and/or extinguishing them quickly so as to limit their damage.

c. Designing the safety system so that if a fire should start in spite of the fire prevention program, and if it should burn for a considerable period of time in spite of fire suppression activities, it will not prevent the safe shutdown of the plant.

None of these levels can be perfect or complete, but strengthening any one level can compensate in some measure for weaknesses, known or unknown, in the others.

9.10.2 SYSTEM DESCRIPTION

9.10.2.1 Site Water Supply System

The underground fire protection water supply consists of a 12 inch cement lined iron pipe in a loop arrangement around Millstone Units 1, 2, and 3. Post-indicating type valves in the piping loop permit partial pipeline isolation without interrupting service to the entire system.

The supply system services individually valved lines feeding fixed pipe water suppression systems (sprinklers, water spray, and standpipes) throughout the plant. Hydrants are located on an approximate 250 foot spacing arrangement or are otherwise strategically located for fire fighting purposes. Hydrant hose houses, equipped for 2.5 and 1.5 inch hose stream service, are located near the hydrants.

The Millstone Station Fire Water Loop is supplied from two 250,000 gallon ground level suction tanks. The tanks are automatically filled through a domestic water line fed from the city water system. This line is a 12 inch city feed with a 10 inch meter, bypass line, and two backflow preventers. The city supply is capable of refilling the fire water tanks in eight hours. Valves on the interconnected tank suction lines provide the capability to manually isolate each tank in the event of failure of a tank or its piping system. The fire protection water supply system is independent of service and sanitary water piping systems.

Two fire pump houses contain the station's three fire pumps each rated at 2,000 gpm at 100 psi. All three pumps can take suction from either or both tanks and have individual connections to the underground supply system. All three fire pumps have separate control panels supplied from separate power supplies. Pump running and trouble signals for P-82 are available in the Unit 3 Control Room. All pumps and fire water tank level alarms are in the Unit 3 Control Room.

The Unit 3 (Building 123) Fire Pumphouse contains the electric fire pump (M7-8), the diesel driven fire pump (M7-7), and the 50 gpm electric jockey pump (M7-11). The Unit 2 (Building 124) Fire Pumphouse is a separate structure adjacent to Building 123 and contains the other electric fire pump (P-82). These pumphouses are adjacent and independent of each other with the exception of sharing a common barrier.

System operation is such that the 50 gpm electric jockey pump (M7-11) maintains system pressure by automatically starting when line pressure drops to approximately 105 psig and will run until pressure reaches 120 psig as indicated by a line pressure switch. An electric interlock between the jockey pump and the M7-7 and M7-8 pump exists which stops the jockey pump when either pump starts. A hydro-pneumatic tank is provided in the system to prevent short cycling of the jockey pump. The electric driven fire pump (P-82) is driven by an AC motor from the 480V load center Bus 22D. This pump is activated by a pressure switch set at 95 psig. In the event this switch or pump fails to operate and line pressure continues to drop, the electric pump (M7-8) is activated by a separate pressure switch set at 85 psig. This pump is driven by an AC motor powered from the MP3 480V Load Center Bus 32Q. In the event this switch or pump fails to operate, or system demand overwhelms this capacity and line pressure continues to drop, the Diesel Driven Fire Pump (M7-7) is activated by a separate pressure switch set at 75 psig. The diesel driven fire pump is electrically independent with its own self contained redundant battery system for starting. A battery charger is provided for maintaining the batteries charged.

The P-82 motor driven pump automatically stops after system pressure is maintained at 100 psi for 5 minutes. Once started, the M7-7 and M7-8 fire pumps remain in operation until manually stopped.

If a major fire in any location of the Millstone Unit 2 site should occur, the combined water tanks and makeup water capacity would provide an adequate water supply for Millstone Unit 2. The necessary pressure and flow would be maintained through the use of any two of the three station fire pumps.

The site fire water system can be connected to the auxiliary feedwater system to provide an alternate source of water in the event that the primary source of water in the condensate storage tank is depleted and cannot be adequately replenished. The combination of the two storage tanks with the potential for replenishment from the city water supply provide multiple, reliable sources of water with which to feed the steam generators and remove decay heat over an indefinite period of time. The Technical Requirements Manual ensures the availability of fire water.

In case of a loss of off site power and service water, fire water may be provided for cooling one EDG via a cross-connection to the service water supply to the EDGs.

9.10.2.1.1 Water Suppression Systems

1. Sprinkler and Waterspray Systems

   Sprinkler and waterspray systems, provided in various areas of the plant where in-situ combustible loading warrants such protection, have been designed using the guidance of National Fire Protection Association (NFPA) Standard Number 13, for the Installation of Sprinkler Systems or NFPA Standard Number 15 for Waterspray Fixed Systems.

   Water systems are provided in the following design arrangement:

   - Automatic wet-pipe sprinkler;
   - Automatic fixed waterspray; and
   - Automatic preaction sprinkler.

   The individual system details and general locations are indicated in the Fire Hazards Analysis (FHA) (Reference 9.10-2).

2. Automatic Wet Pipe Sprinkler Systems

   Wet-pipe sprinkler systems have closed sprinkler heads, and an alarm check valve or alarm flow switch. All systems are provided with an outside screw and yoke (OS&Y) isolation valve between the supply connections and system distribution piping.

3. Automatic Fixed Waterspray Systems

   Fixed waterspray systems are of the automatic design. All systems have a deluge valve located between the supply header and the distribution piping. An OS&Y isolation valve or post indicating valve (PIV) is used on all systems. Upon actuation of the deluge valve, water flows into the distribution piping and discharges from all spray heads.

Automatic operation is initiated by a single zone heat detection circuit installed in the hazard area.

4. Automatic Preaction Sprinkler Systems

Preaction type sprinkler systems are of the automatic design. All systems have a deluge/preaction valve located between the supply header and the distribution piping. Where appropriate, distribution piping is supervised by monitoring air pressure. An OS&Y isolation valve or PIV is used on all systems. Upon actuation of the deluge/preaction valve, water flows into the distribution piping. Upon actuation of each individual sprinkler head, water is discharged. Automatic operation is initiated by single zone heat detection circuit installed in the hazard area.

9.10.2.1.2 Gaseous Suppression Systems

1. Carbon Dioxide Systems

The Main Generator Exciter enclosure is protected with a total flooding carbon dioxide system. This system is automatically discharged by activation of two heat detectors provided in the enclosure. The system can also be manually activated by use of a manual pull station. The carbon dioxide suppression systems are designed using the guidance of NFPA12.

2. Halon Systems

Total flooding Halon 1301 fire suppression systems are provided for the Old Computer Room (A-26) subfloor and the New Computer Room (A-27), Z1 and Z2 DC Switchgear Rooms.

The Halon suppression systems are designed using the guidance of NFPA 12A, Halon 1301 Suppression Systems.

9.10.2.1.3 Portable Suppression Capabilities

1. Hose Stream Coverage

Hose stream coverage is available to all fire areas of the plant from stand pipe connections to fixed 1.5 inch hose stations or by use of 2.5 inch diameter hose with gated wye connections available from outside hose houses.

Hose station locations are listed in the Millstone Unit 2 Technical Requirements Manual (TRM) (Reference 9.10-6).

2. Portable Extinguishers

Selection and placement of portable fire extinguishers are in accordance with the intent of the guidelines of NFPA Standard Number 10, Standard for Portable Fire Extinguishers. All extinguishers utilized are Underwriters Laboratories (UL) listed.

9.10.2.1.4 Fire Detection and Alarm Systems

The fire detection and alarm systems installed in the plant are designed in general compliance with NFPA Standard Number 72D, Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems.

Fire detection systems are used for early warning detection and in some cases may have the capability to actuate water suppression systems.

Detection devices consist of rate-of-rise, fixed temperature, line type, and rate compensated heat detectors, and smoke detectors. Smoke detectors employ either the ionization or photoelectric principle. Specific application of these detectors in each fire area is detailed in the FHA.

In general, the installation of detector units is in accordance with the intent of the guidelines set forth in NFPA Standard Number 72E, Standard on Automatic Fire Detectors.

Fire/smoke detectors, as with waterflow indicators, CO_2 and Halon actuation indicators and valve tamper devices are arranged to transmit signals to local alarm panels and a water suppression system control panel, if applicable. Actuation signals are also transmitted through the local alarm panels to control panels in the Control Room. Trouble signals for these devices are transmitted in a similar manner.

The alarm system also monitors other miscellaneous fire protection system (FPS) features such as CO_2 system trouble, Halon system trouble, and preaction sprinkler system air pressure.

9.10.2.1.5 Ventilation Systems and Smoke Removal

Removal of the products of combustion from any specific plant area requires the use of the normal plant ventilation system. Millstone Unit 2 relies mainly on power venting to satisfy the recommended smoke and heat venting guidelines set forth. No ventilation system was designed for the sole purpose of exhausting smoke or corrosive gases. In all areas where airborne activity could exist, the ventilation is monitored prior to release.

The ventilation and filtration systems of safety related or potential radiation release areas are discussed in detail for the cable spreading area, switchgear rooms, battery rooms, 480V load centers, containment, intake structure, auxiliary building, fuel handling area, auxiliary feedwater pump room, control room, engineered safety features room, diesel rooms, and enclosure building in FSAR Section 9.9, "Plant Ventilation Systems".

9.10.3 SAFETY EVALUATION AND FIRE HAZARDS ANALYSIS

9.10.3.1 Evaluation Criteria

An evaluation of the overall Fire Protection Program as indicated by the FHA, found that the program does provide reasonable assurance that a fire will not cause an unacceptable risk to the public health and safety. The fire protection program accomplishes this by assuring a fire will not prevent the performance of necessary safe shutdown functions and will not significantly increase the risk of radioactive release to the environment. Therefore, the Fire Protection Program meets the basic requirements of General Design Criteria (GDC) 3 and 5. Appendix A to Branch Technical Position (BTP) APCSB 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants," provides the implementing criteria for GDC 3 and gives the general guidelines used to review Millstone Unit 2. Appendix A to BTP APCSB 9.5.1 provides the guidelines acceptable to the NRC staff for implementing the following criteria:

a. GDC 3 (10 CFR 50, Appendix A) - Fire Protection.

b. Defense-in-Depth Criterion: For each fire hazard, a suitable combination of fire prevention, fire detection and suppression capability, and ability to withstand safely the effects of a fire is provided. Both equipment and procedural aspects of each are considered.

c. Single-Failure Criterion: No single active failure shall result in complete loss of protection of both the primary (fixed installed systems) and backup fire suppression capability (standpipe/extinguishers).

d. Fire Suppression System Capacity and Capability: Fire suppression capability is provided, with capacity adequate to extinguish any fire that can credibly occur and have no significant adverse effects on equipment and components important to safety.

e. Backup Fire Suppression Capability: Total reliance for fire protection is not placed on a single automatic fire suppression system. Appropriate backup fire suppression capability is provided in the form of portable fire extinguishers or hose stations.

f. Acceptability of Manual Fire Suppression: When it can be shown that safe-shutdown capability is independent of any credible fire, manual fire fighting capability is sufficient to protect safety-related systems.

In addition to the specific guidance of the BTP, the evaluation considered the adequacy of the Fire Protection Program on the effects of potential fire hazards throughout the plant based on sound fire protection engineering practices and judgments.

9.10.3.2 Fire Hazard Analysis Methodology

Fire Protection was evaluated by conducting an FHA of individual fire areas and fire zones within the plant.

A detailed description of the analysis method is given in the following summary:

1. Plant design features related to fire safety were determined. These include the overall plant layout, type, and location of combustible materials, type of construction and its fire resistant characteristics, fire detection, and fire suppression systems, separation distance, etc.

2. Areas containing equipment and components important to safety were identified. These areas and adjacent areas with fire hazard potential were subdivided into fire areas and zones within areas on the basis of existing fire barrier boundaries and other logical physical divisions or equipment groupings. For each fire area/zone, the following were determined:

    a. Total heat potential (Btu/ft^2) in the area/zone, assuming total combustion of cable insulation, oil, charcoal, and other identifiable combustibles including transients.

    b. Fire severity is determined by the material burned and its rate of burning. To evaluate the fire resistance needed for any fire barrier, a fire severity (duration) is developed for each area. Severity is measured in terms of temperature and fire duration. Once the total heat potential (Btu/ft^2) of an area or zone has been computed and has been corrected to be equivalent to wood, an equivalent fire severity may be determined.

       To determine an equivalent fire severity, Table 5-9B, Estimated Fire Severity for Offices and Light Commercial Occupancies, NFPA, Fire Protection Handbook, Fifteenth Edition, has been adopted for this analysis.

    c. Safety related equipment and safe shutdown equipment and systems in the area.

    d. Fire detection and suppression systems.

    e. Fire area/zone boundaries.

3. For each area/zone, the adequacy of existing fire detection and fire suppression systems was evaluated considering the combustibility of materials, potential ignition sources, and the concentration of combustible materials.

4. Plant features were evaluated that impact directly or indirectly on the plant fire brigade's ability to reach and effectively fight credible fires.

The specific analysis results for each fire area or zone are provided in the FHA.

The NFPA Standard Time-Temperature Curve is representative of the severity of a fire completely burning out of brick, wood-joisted building and its contents. The curve has been adopted by the American National Standards Institute (ANSI) and the American Society for Testing and Materials (ASTM) in ANSI/ASTM E 119, Standard Methods of Fire Tests of Building Construction and Materials. This curve has been used in the fire hazard analysis to evaluate fire duration.

9.10.3.3 Fire Areas and Zones

The plant arrangement is divided into fire areas and fire zones for the purposes of conducting the FHA. Fire areas are defined as plant areas bounded by fire rated assemblies of either three hour rated construction or lesser fire resistance as specifically identified and justified in the FHA. For this analysis a fire area may also be defined by physical separation of combustible materials and built in fire suppression features which will contain a fire to an area of origin. Examples of built in features include water curtains and gaseous fire suppression systems.

Fire zones are zones within fire areas that are used to more thoroughly describe the fire area. Fire zones may or may not be bounded by fire-rated construction.

For the purposes of the FHA, the fire areas and fire zones were divided in accordance with the original divisions in the 1977 FHA. These divisions provide a clear indication of the combustibles within a location and their effect on equivalent fire severity. The Millstone Unit 2 Appendix R analysis uses different fire area divisions based on separation requirements. The safe shutdown evaluation relies only on fire areas to determine the effects of fire on safe shutdown. These divisions result in large fire areas that do not permit accurate fire loading and equivalent fire severity analysis. Therefore, from a fire protection standpoint, the divisions in the FHA provide more indicative results with a broader range of uses.

Drawings provided in the FHA show fire zone/area division and serve as reference for this section.

9.10.3.4 Fire Hazard Analysis Results

The FHA results for each fire area are contained in the FHA (Reference 9.10-2).

9.10.4 INSPECTION AND TESTING

Administrative controls are provided through existing Plant Administrative Procedures, Operating Procedures and the Quality Assurance Program to ensure that the Fire Protection Program and equipment is properly maintained. This includes Quality Assurance (QA) audits of the program implementation, conduct of periodic test inspections, and remedial actions for systems and barriers out of service. This program emphasizes those elements of fire protection that are associated with safe shutdown and their significance when evaluating program and equipment deficiencies.

All fire protection equipment and systems are subject to periodic inspections and tests in accordance with the intent of National Fire Codes and the Fire Protection Program.

The technical requirements found in Millstone Unit 2 TRM (Reference 9.10-6) describe the limiting condition for operation and surveillance requirements for the FPS. These technical requirements ensure the FPS is properly maintained and operated.

Equipment out of service including fire suppression, detection, and barriers are controlled through the administrative program and appropriate remedial actions taken. The program requires all impairments to FPS to be identified and appropriate notification given to the Fire Protection System Engineer for evaluation.

As conditions warrant, remedial actions include compensatory measures to ensure adequate level of fire protection in addition to timely efforts to effect repairs and restore equipment to service.

9.10.5 PERSONNEL QUALIFICATION AND TESTING

9.10.5.1 Fire Protection Organization

Formulation, implementation, and assessment of the effectiveness of the Fire Protection Program are delegated as indicated in Reference 9.10-1, the Fire Protection Program Manual.

The responsibilities for Appendix R coordination (including related technical reviews and maintenance of Appendix R Compliance Reports), conduct of FHAs, engineering and design for FPSs, development of specific fire fighting procedures, inspection programs, maintenance, training (including formal Fire Brigade and Fire Watch training), drills and risk management are discussed in Reference 9.10-1.

9.10.5.2 Fire Brigade and Training

The Millstone Site Fire Brigade consists of a minimum of a Shift Leader and four Fire Brigade personnel. The Fire Brigade Shift Leader is qualified to provide direction and support concerning plant operations and priorities for their assigned unit. When a specific unit does not have a Fire Brigade Shift Leader, a Fire Brigade Advisor from that unit is required in addition to the five member Fire Brigade.

Members of the Fire Brigade are trained by the Nuclear Training Department. A list of Fire Brigade training programs is located in Reference 9.10-5.

Site Fire Brigade personnel are responsible for responding to all fires, fire alarms, and fire drills. To ensure availability, a minimum of a Shift Leader and four Fire Brigade personnel shall remain in the owner controlled area and shall not engage in any activity which would require a relief in order to respond to a fire (e.g., continuous fire watch).

If assistance is needed to fight a fire, additional equipment and manpower is supplied by the off site local fire departments. Within a 5 mile radius of the plant there are numerous local volunteer fire companies. Letters of commitment to supply public fire department assistance have been obtained from these fire companies.

The Shift Leader coordinates the Site Fire Brigade activities, and ensures proper communications and coordination of support for the local fire department chief or officer in charge once on site, and other on site activities (e.g., Radiological Protection & Chemistry, and Security).

Nuclear Training coordinates with the Site Fire Marshal and periodically familiarizes local fire department personnel with the Station's layout and fire fighting equipment. The Site Fire Marshal coordinates with the Site Fire Brigade and all Unit Shift Managers, informing them of the status of the site fire protection equipment, should equipment become inoperable or unavailable.

Fire Protection drills shall be planned and critiqued by Nuclear Training and members of the management staff responsible for plant fire protection. Performance deficiencies of the Fire Brigade or of individual Fire Brigade personnel shall be remedied by scheduling additional training for the Site Fire Brigade or individuals.

9.10.5.3 Quality Assurance

The QA Program has been applied via the Fire Protection Program Manual to the FPSs, components, and programs providing fire detection and suppression capabilities to those areas of the plant that are important to safety.

9.10.6 SAFETY SHUTDOWN DESIGN BASES

Paragraph 50.48(b) of 10 CFR 50, which became effective on February 17, 1981, requires all nuclear plants licensed to operate prior to January 1, 1979 to comply with specific portions of Section III of Appendix R to 10 CFR 50, in addition to any previous fire protection Safety Evaluation Reports (SERs). One of the applicable sections, Section III.G, requires that fire protection features be provided for those systems, structures, and components important to safe shutdown. These features must be capable of limiting fire damage so that:

1. One train of systems necessary to achieve and maintain hot shutdown conditions from either the Main Control Room or the Emergency Control Station(s) is free of fire damage; and

2. Systems necessary to achieve and maintain cold shutdown from either the Main Control Room or the Emergency Control Station(s) can be repaired with 72 hours.

Section III.L of Appendix R and Generic Letters 81-12 and 86-10 provide additional guidance on the NRC Staff's requirements for this safe shutdown capability.

Section III.G established "design basis protective features" as criteria for the protection of safe shutdown capability and offered the following compliance alternatives to operating plant licensees:

1. Separation of redundant safe shutdown systems outside of containment by either three hour rated barriers, one hour rated barriers plus automatic suppression and detection, or 20 feet of horizontal separation free of intervening combustibles or hazards plus automatic suppression and detection (Section III.G.2, 10 CFR 50 Appendix R)

2. An alternate or dedicated shutdown system and fixed suppression (Section III.G.3, 10 CFR 50 Appendix R)

3. A combination of measures that are shown by analysis to provide an equivalent level of protection (10 CFR 50.48(c)[6] exemption request)

9.10.6.1 Safety Functions

Specific safe shutdown functions necessary to satisfy Appendix R criteria are as follows:

1. Reactor Reactivity Control Function

2. Reactor Coolant Makeup Control Function

3. Reactor Heat Removal Function

4. Process Monitoring Function

5. Supporting Functions

The selection of these functions is based on safe shutdown performance goals identified in BTP CMEB 9.5-1 Section C.5.c(2).

The safe shutdown functions, described above, assure that the reactor will be safely shut down, cooled down, and maintained in a cold shutdown condition. The achievement of safe shutdown conditions precludes the occurrence of an unrecoverable plant condition, e.g., uncontrolled primary depressurization, loss of decay heat removal capability, or a breach of the reactor coolant system (RCS) boundaries.

9.10.6.2 Analysis of Safe Shutdown Systems and Components

The exact location, duration, and magnitude of potential fires at the plant cannot be predicated in advance. To ensure that safe shutdown can be achieved following any postulated fire, Millstone Unit 2 has been divided into fire shutdown areas. The maximum credible fire was considered for each fire shutdown area. An engineering evaluation was then conducted to ensure that a fire originating in any one area would not spread to an adjacent fire shutdown area.

All unprotected electrically operated equipment within the affected fire area was assumed to be damaged by the fire. An analysis was then done to confirm that sufficient plant systems remained operable to allow plant operators to achieve safe shutdown. Where necessary, equipment modifications were made, credit was taken for manual operation of remotely actuated valves, and operating and repair procedures were generated, to allow this goal to be achieved. By repeating this process for each fire shutdown area, a set of fire shutdown systems, components and procedures was produced. This set is adequate to ensure that safe shutdown can be achieved and maintained regardless of the location of the fire.

The above approach is considered to be very conservative. In reality, existing fire detection and suppression systems, and mitigating actions by the fire brigade, would limit the extent of fire damage. Thus, additional systems would be functional, and the operators would have additional flexibility in dealing with the effects of a fire.

Initial Assumptions

1. The station is operating at 100% power upon the occurrence of a fire.

2. The reactor is tripped either manually or automatically.

3. The analysis assumes both a loss of off site power and availability of off site power, whichever poses the more severe shutdown condition.

4. No additional single failure is considered other than the loss of off site power, those failures directly attributable to the fire, and spurious operations that can be postulated to occur as a result of the fire.

5. No component or system required for safe shutdown is assumed to be out of service.

Safe Shutdown Systems

The following safe shutdown systems were identified and analyzed to determine which portions needed to remain operational and which needed to be isolated and remain isolated to meet the safe shutdown functions.

- Auxiliary Feedwater (AF)
- Reactor Coolant
- Main Steam
- Safety Injection
- Chemical and Volume Control

- Service Water
- Reactor Building Closed Cooling Water (RBCCW)
- Condensate Storage Tank (CST)
- Diesel Generator (DG)
- Shutdown Cooling
- Ventilation and Area Coolers
- Emergency AC and DC Electrical Distribution

Millstone Unit 2 10 CFR 50 Appendix R Compliance Review (Reference 9.10-3) describes the inherent features of the system which are required to achieve hot/cold shutdown and their performance during the design basis fire in each of the Appendix R fire areas.

Safe Shutdown Components

A list of safe shutdown components was developed based on the identified safe shutdown systems. Reference 9.10-3 provides a list of all safe shutdown equipment and instrumentation with their fire area locations.

9.10.6.3 Safe Shutdown Analysis

Based on the identified safe shutdown systems and components, a list of all associated power and control cables were identified and their routing documented on a fire area basis.

After completion of the above tasks and the evaluation of the various scenarios for shutting down the plant, a worst case failure analysis was developed for each fire area. The worst case fire in each area is considered a fire that disables all unprotected equipment and systems in that area. The results of the safe shutdown analysis for each fire area is provided in the safe shutdown matrix provided in Reference 9.10-3. If safe shutdown cables exist in a fire area, a circuit failure analysis was performed to determine the impact, if any, on safe shutdown. In some instances manual operator actions were used to mitigate or replace the function of cable assumed to be lost in the worst case fire. The matrices also address required operator corrective actions which have to be performed to allow shutdown for the worst case fire within any fire area. Reference 9.10-3 also provides a summary list of safe shutdown methods by fire area.

Circuit Failure Analysis

A circuit failure analysis was performed when equipment/components, or cables for a component, are in a fire area and:

1. The equipment/component is required to change position or be operable to perform its function, or

2. Spuriously the equipment/component actuates thereby preventing the system from performing its required function.

The circuit failure analysis evaluated the effects of fire induced failures (hot shorts, shorts-to-grounds, and open circuits) on that portion of the circuit that is located in the fire area in accordance with Generic Letters 81-12, 86-10, and Information Notice 84-09.

Associated Circuit Analysis

Associated circuits are considered as those cables (safety-related, nonsafety-related, Class 1E or Non-1E) that have physical separation less than that required by Section IIIG.2 of Appendix R and are associated with safe shutdown circuits in one of three ways:

- Common bus
- Spurious signals
- Common enclosure

To determine the interaction of associated circuits with shutdown systems, a fire area approach was utilized in which components and cables of components were identified for each fire area. Types of cables analyzed were power, control, and instrument cables.

Protection between associated circuits of concern and shutdown circuits are addressed below for each concern:

1. Common Bus Concern

   Safety and nonsafety buses for Millstone Unit 2 were reviewed for those circuits which had a common power source with shutdown equipment, to ensure that the power source supply of the shutdown circuits are electrically protected.

   a. For the power sources of concern, the trip characteristics of primary and secondary electrical protection devices were reviewed to insure proper coordination.

   b. The NRC's Generic Letter 86-10, question 5.3.8, "Short Circuit Coordination Studies," requests that the licensees consider the impact of high impedance faults on the shutdown capability. Simultaneous high impedance faults (below the trip point for the breaker on each individual circuit) were considered for all fire areas and area addressed in the shutdown matrices of Reference 9.10-3.

c. A program has been established to ensure that the overall coordination is maintained.

2. Spurious Operation Concern

Where equipment/components were subject to spurious operation which would affect the capability to safely shut down, various means of isolation and/or manual actions are utilized, such as prefire opening of circuit breakers, isolation of control circuits by transfer or isolation switches, or de-energizing and manually operating valves post fire. Valve 2-SI-651 has the disconnect switch in its power circuit locked open during plant heatup, while in Mode 4 prior to proceeding to Mode 3. The disconnect switch is not re-closed (except for periodic testing/maintenance) until the plant attains Mode 4 again. Valves 2-MS-65A and 2-MS-65B have their MCC Power enabled at lockable disconnect switches ("on" position to operate) during plant start up while in Mode 2 or 3 prior to proceeding to Mode 1. The disconnect switches are not put back to the "on" position (except for periodic testing/maintenance) or until the plant attains Mode 2, 3, 4, 5 or 6 again. Valve 2-MS-202 has a disconnect switch at its MCC that is "off" during plant start up while in Mode 4 prior to proceeding to Mode 3. The disconnect keys are kept in the control room and the disconnect switches are not put back in the "on" position (except for periodic testing/maintenance) until the plant attains Mode 4, 5 or 6 again.

Spurious Signal Concern, Current Transformers

A current transformer study was performed to determine the applications of where secondary circuits of current transformers were routed between fire areas and were susceptible to fire-induced open circuit failures. Two generic applications resulted from the review, in one case, current transformers were used for protective relaying, and in the other case, current transformers were used for remote reading of current loads. The type JCS-0 current transformers are utilized at both the 4160V level and the 480V level. Manufacturer data on testing of both the current transformers and their secondary circuit wiring has indicated that under open circuit conditions, caused by fire, damage will not result in a breakdown of either component.

3. For Common Enclosure Concern

By utilizing the fire area approach, all shutdown equipment and associated cables within a fire area had to be identified and considered subject to a fire induced failure, unless otherwise justified.

9.10.6.4 Reactor Inventory Isolation and Hi/Low Pressure Interfaces

Those systems that penetrate the RCS that are open to other systems and could cause diversion or loss of reactor inventory must be able to be isolated and remain isolated. Isolation is essential for those fire areas where fire could result in the loss of short term reactor inventory makeup capability.

The systems which interface with the RCS and could divert inventory are as follows:

- Chemical and Volume Control Charging Lines
- Chemical and Volume Control Letdown Line
- Pressurizer Vent
- Pressurizer Power Operated Relief Valve (PORV) Lines
- Shutdown Cooling System
- Pressurizer Safety Valve Lines
- Auxiliary Spray Line
- Primary Drain Header
- Reactor Head Vent
- Low-Pressure Safety Injection (LPSI)
- Sampling System

Some systems have been designed with flow check or nonreturn valves to ensure that they would not cause the diversion of reactor vessel inventory. For these systems, the valves which provide this isolation function are provided in Reference 9.10-3.

The remaining systems are not provided with these passive fail safe means of ensuring isolation. The methods which are utilized to provide and maintain isolation of these remaining interfacing systems are also provided in Reference 9.10-3.

9.10.6.5 Exemptions from the Specific Requirements of Appendix R to 10 CFR 50, III.G.2, III.G.3, III.J and III.O

The following exemptions from the requirements of Appendix R have been granted:

1. Exemption from 10 CFR 50 III.J requirement to provide eight hour battery powered emergency lighting in general yard areas. The exemption allows the use of security lights to illuminate outdoor areas to access the Vital Bus 14H Enclosure (formerly Emergency Bus 24F), Intake Structure and Refueling Water Storage Tank (RWST) Pipe Chase Enclosure.

2. Exemption from 10 CFR 50 III.G.2 requirement to provide a three hour rated barrier in the Auxiliary Building between the Boric Acid Tank-Chemical Addition Area (R-1) and MCC B61 (R-2). The exemption allows crediting the steel environmental enclosure for MCC B61, and a water curtain installed to protect the enclosure from fires in this area, as a fire barrier between MCC B61 and the Auxiliary Building.

3. Exemption from the requirement of Section III.O that requires the Reactor Coolant Pump Oil Collection System be designed to withstand the Safe Shutdown Earthquake (SSE). The exemption was based on the RCP lubricating oil system being seismically qualified with oil leaks not expected as a result of an SSE. Also, the oil collection system is designed such that dropping of components during a SSE should not cause loss of operability of safety-related equipment nor cause a fire, the systems would not degrade safety features within containment.

4. Exemption from 10 CFR 50 III.G.2 requirement to provide 20 foot horizontal separation (with no intervening combustibles) between redundant Auxiliary Feedwater Valves (2-FW-43A,B) located in the Turbine Building (R-3). The exemption concludes that fire damage to these valves would either cause them to fail open in their required position, or cause them to fail closed, but capable of being opened.

5. Exemption from 10 CFR 50 III.G.2 criteria for separation of redundant charging pump trains located in the Charging Pump Room (R-4). The exemption credits the following for assuring the availability of at least one charging pump for a Charging Pump Room fire:

   - low fire loading,
   - partial height concrete walls,
   - approximate 18 foot horizontal separation between pumps,
   - oil spill containment curbing between the pump cubicles,
   - existing area fire detection system,
   - rerouting of the “B” and “C” charging pump (Facility Z2) cables outside fire area R-4.

6. Exemption from 10 CFR 50 III.G.3 requirement to provide a fixed suppression system in an area which relies upon alternative shutdown capability, the Intake Structure (R-16). This exemption was granted on the basis that low combustible loading, limited intervening combustibles, 19 feet of horizontal separation between the redundant service water pumps and existing fire protection features would be sufficient to limit the potential for fire damage to safe shutdown

equipment in this area and an alternate safe shutdown capability (independent from this area of concern) is available to power hot shutdown equipment via the Unit 3 cross tie capability.

7. Exemption from 10 CFR 50 III.G.3 requirement to provide a fixed suppression system in an area which relies upon alternative shutdown capability, the East 480V Switchgear Room (R-11). This exemption was granted on the basis that low combustible loading, existing fire protection features and the close proximity of the control room which enhances early detection and manual suppression capability would be sufficient to limit the potential for fire damage to safe shutdown equipment in this area and an alternate safe shutdown capability (independent from this area of concern) is available to power hot shutdown equipment via the Unit 3 cross tie capability. Additional considerations for granting this exemption related to the potential water suppression system effects on electrical components, and gaseous suppression system effects on control room habitability.

8. Exemption from 10 CFR 50, Appendix R, III.J requirement to provide eight hour battery powered emergency lighting for access/egress to Unit 3 Alternate AC diesel generator (alternate AC source for fires in specifically identified Unit 2 Appendix R fire areas) based on the use of yard security lighting.

9.10.7 REFERENCES

9.10-1 Millstone Nuclear Power Station Fire Protection Program Manual.

9.10-2 Fire Hazard Analysis Millstone Unit 2, latest revision.

9.10-3 Millstone Unit 2 10 CFR 50 Appendix R Compliance Review, March 1987

9.10-4 Nuclear Fleet Administrative Procedure, CM-AA-FPA-100, “Fire Protection/Appendix R (Fire Safe Shutdown) Program”

9.10-5 Millstone Nuclear Power Station, Station Procedure TQ-1, Personnel Qualification and Training

9.10-6 Millstone 2 Technical Requirements Manual

FIGURE 9.10–1 DELETED

FIGURE 9.10–2 P&ID DOMESTIC WATER (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.10–2 P&ID DOMESTIC WATER (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

9.11 COMPRESSED AIR SYSTEM

9.11.1 DESIGN BASES

9.11.1.1 Functional Requirements

The compressed air system provides a reliable supply of clean, dry, oil free, air for the pneumatic instruments, operators and controls. In addition, the system provides the necessary air requirements for normal maintenance.

9.11.1.2 Design Criteria

The following criteria have been used in the design of the compressed air system:

a. The instrument air system shall have two subsystems, each capable of providing the total air requirements of the unit.

b. The instrument air system shall have suitable subsystem and component alignments to assure operation of a complete subsystem with associated components.

c. Capabilities shall be provided to assure instrument air system operation with on site power (assuming off site power is not available) or with off site electrical power.

d. The instrument and station air system shall be designed to permit periodic inspection of important components, such as air compressors, receiver tanks, dryers, after filters, piping, and valves to maintain the integrity and capability of the system.

9.11.2 SYSTEM DESCRIPTION

9.11.2.1 System

The compressed air system is shown schematically in Figure 9.11–1 and 9.11–2. The system incorporates two full capacity and one double capacity non lubricated compressors for instrument air, each having a separate inlet filter, aftercooler and moisture separator. The two full capacity Ingersoll-Rand instrument air compressors each have separate dedicated air dryer/filter assemblies and an air receiver. The double capacity instrument air compressor has a separate, dedicated air receiver and instrument air dryer and filter assembly. All three compressor subsystems supply the instrument air header which then divides into branch lines supplying the intake structure, condensate storage tank area, turbine building, main steam dump valves, containment structure, auxiliary building, enclosure building, diesel generator rooms, primary water storage tank area, and refueling water storage tank area.

One full capacity station air compressor with an inlet filter, aftercooler, and moisture separator discharges to the station air receiver. The receiver outlet header is divided into branch lines supplying the intake structure, condensate storage tank area, turbine building, containment structure, auxiliary building, primary water storage tank area, refueling water storage tank area, and the condensate polishing facility. Station Air also supplies Instrument Air to the condensate polishing facility via a cross-tie with a dedicated air dryer located in the condensate polishing facility. A system cross-tie between Unit 3 service air and Unit 2 station air headers is also provided. In addition, manual cross ties are provided which allow the instrument air compressors to be used to supplement the station air supply during periods of heavy use.

An emergency backup cross tie from the station air header automatically supplies air to the instrument air system if instrument air pressure falls below 85 psig. Local controls isolate station air loads when station air is acting as the emergency backup supply to the instrument air system.

A remotely operated manual cross tie within the containment can provide station air to the containment instrument air branch line if the line pressure drops below 80 psig. In addition, a third instrument air receiver is located in the containment structure to provide a 30 minute supply of air in the event that both station and instrument branch lines fail.

The design of the compressed air system is based on an estimated station air requirement of 600 scfm and a minimum instrument air requirement of 217 scfm.

Table 9.11-2 gives information on the gas receiver tanks with the exception that tank rupture is not considered because the receiver tanks have been designed, per ASME Section VIII, for pressures greater than the maximum supply pressures, and each individual tank is provided with an ASME Section VIII safety relief valve. As shown on the above-referenced table, all the gas receiver tanks are in compliance with Section 1910.169 of OSHA.

9.11.2.2 Components

The major components and associated fabrication and performance data are listed in Table 9.11-1.

9.11.3 SYSTEM OPERATION

9.11.3.1 Normal Operation

A continuous supply of instrument air is provided to regulate the controllers and controlled devices. Either of the following configurations is acceptable and can be considered normal operation: The double capacity instrument air compressor supplies both the instrument air and station air systems through available cross tie valves and the other instrument air compressors are on automatic standby, or the station air compressor and one instrument air compressor operate and the other instrument air compressors are on automatic standby.

9.11.3.2 Emergency Conditions

The station or instrument air system can be utilized to provide makeup air for the containment during the long term post-accident hydrogen purge operation (Section 6.6). The instrument and station air systems are connected to the containment air monitoring system containment penetrations (Figure 9.9–2). A globe valve and flow element on each connection provide manual flow regulation.

Air-operated containment isolation valves are designed to assume the safe position by spring action following a loss of instrument air pressure at the valve operators or electric power to the valve operator solenoid valves. Generally, containment isolation valves for nonessential process systems are designed to fail closed and remain tightly closed. Valves for essential processes are designed to fail open to assure proper system alignment. Valves which must close and be capable of opening as the hydrogen purge valves are provided with accumulator tanks to assure an air supply. Valves required to maintain a fixed position are designed to fail “as is.” Where identified, inaccessible valves that must be capable of operating after a design basis loss-of-coolant accident are also provided with backup air bottles to assure an air supply.

9.11.4 AVAILABILITY AND RELIABILITY

9.11.4.1 Special Features

The power supply for the compressor motors is the normal distribution system. The power supply for the full capacity instrument air motors is backed up by the emergency diesel generators with each compressor on a separate channel (Section 8.3). The double capacity compressor has nonvital power supplies and is not relied upon for emergency operation.

Instrument air is primarily used as motive power for valve actuation and is not used in any reactor indication, control, or protective circuit. The overall unit is designed to assure that valve failures occurring upon loss of air are consistent with the capability to maintain the unit in a safe condition.

9.11.4.2 Tests and Inspections

Each component is inspected and cleaned prior to installation in the system. Instruments are calibrated during testing, and automatic controls are tested for actuation at the proper set points. Alarm functions are checked for operability and limits during operational testing. The system is operated and tested initially with regard to flow paths, flow capacity and mechanical operability.

Flow orifices, thermometers and pressure gauges are provided for local system monitoring.

The compressed air system undergoes an acceptance test prior to startup. The test procedure is described in Chapter 13.

TABLE 9.11-1 COMPRESSED AIR SYSTEM COMPONENT DESCRIPTION

Instrument Air Compressor - Mark Number F-3D

Quantity	One
Type	Rotary Screw, oil-free type
Capacity (acfm) at 115 psig	640 at 100 °F, 14.7 psia, 40 % RH
Design discharge pressure (psig)	125
Cooling medium	Air cooled
Motor	150 hp, 460 V, 3 phase, 60 HZ, variable speed
Seismic Class	II
Safety Relief Valve Setpoint	165 psig

Instrument Air Receiver - Mark Number T-51A

Type	Vertical
Design pressure (psig)	135 psig at +20 to 500°F
Actual volume (feet)	150
Code	ASME Section VIII
Seismic Class	II
Safety Relief Valves (2)	
Setpoint, Capacity	135 psig, 3196 cfm at 60°F each

Instrument Air Dryer - Mark Number T-52C/D

Type	Heatless - dual tower - purge type - desiccant
Quantity	370 lbs of desiccant per tower (2)
Capacity (acfm) at 115 psig	650 at 123°F, 100% R.H. inlet conditions
Outlet moisture content with saturated air inlet	-40°F DP at line pressure
Seismic Class	II
Safety Relief Valve Setpoint	135 psig
Design Pressure (psig)	150 psig at 450°F

TABLE 9.11-1 COMPRESSED AIR SYSTEM COMPONENT DESCRIPTION (CONTINUED)

Instrument Air System

Air Compressor - Mark Number F-3E, F-3F

Type	Rotary-screw, oil free type
Quantity	2
Capacity (scfm)	237
Discharge pressure (psig)	100
Cooling medium	Air cooled
Motor	60 hp, 460 volt, 3 phase 60 Hz
Seismic Class	II

Air Receiver - Mark Number T-51

Manufacturer	Ingersoll-Rand
Type	Vertical
Quantity	1 per 2 compressors
Design pressure (psig)	125
Actual volume (feet)	160
Code	ASME Section VIII
Seismic Class	II

Piping and Valves

Seismic Class	II

Station Air System

Air Compressor - Mark Number F-2

Type	Horizontal nonlubricated reciprocating type
Quantity	1
Capacity (scfm)	630
Discharge pressure (psig)	100
Cooling medium	Water, 16.7 gpm

TABLE 9.11-1 COMPRESSED AIR SYSTEM COMPONENT DESCRIPTION (CONTINUED)

Motor	150 hp, 460 volt, 3 phase, 60 Hz
Seismic Class	II

Aftercooler and Moisture Separator - Mark Number X-27

Type	Shell and tube
Quantity	1
Code	ASME Section VIII
Seismic Class	II

Air Receiver Mark Number T-50

Type	Vertical
Quantity	1
Design pressure (psig)	125
Actual volume (feet)	160
Code	ASME Section VIII
Seismic Class	II

Piping and Valves

Seismic Class	II

Instrument Air Dryer - Mark Number T-52E1/E2

Type	Dual tower, heated blower purge, dessicant, regenerative.
Dessicant/Vessel	43.25 inches of activated Alumina.
Capacity (scfm) at 100 psig	300 at 100°F inlet air temperature.
Outlet moisture content	-40°F DP at line pressure.
Purge Rate	24 scfm for one hour out of four hour cycle with cooldown feature enabled.
Seismic Class	II
Safety Relief Setpoint	165 psig

TABLE 9.11-1 COMPRESSED AIR SYSTEM COMPONENT DESCRIPTION (CONTINUED)

Instrument Air Dryer - Mark Number T-52F1/F2

Type	Dual tower, heated blower purge, dessicant, regenerative.
Dessicant/Vessel	43.25 inches of activated Alumina.
Capacity (scfm) at 100 psig	300 at 100°F inlet air temperature.
Outlet moisture content	-40°F DP at line pressure.
Purge Rate	24 scfm for one hour out of four hour cycle with cooldown feature enabled.
Seismic Class	II
Safety Relief Setpoint	165 psig

Condensate Polishing Facility Instrument Air Dryer - Mark Number T-IAS-DRYER1

Type	Dual tower, heatless, desiccant, regenerative.
Dessicant/Vessel	40 inches of activated Alumina.
Capacity (scfm) at 100 psig	90 at 100°F inlet air temperature.
Outlet moisture content	-40°F DP at line pressure.
Purge Rate	24 scfm for one hour out of four hour cycle with cooldown feature enabled.
Seismic Class	Non-seismic
Safety Relief Setpoint	165 psig

Instrument Air Receiver - Mark Number T51E

Type	Vertical
Design Pressure (psig)	155 at 400°F
Actual volume (gallons / feet)	1060 / 142
Code	ASME Section VIII
Seismic Class	II
Safety Relief Valve Setpoint / Capacity	135 psig / 250 scfm

TABLE 9.11-1 COMPRESSED AIR SYSTEM COMPONENT DESCRIPTION (CONTINUED)

Instrument Air Receiver - Mark Number T51F

Type	Vertical
Design Pressure (psig)	155 at 400°F
Actual volume (gallons / feet)	1060 / 142
Code	ASME Section VIII
Seismic Class	II
Safety Relief Valve Setpoint / Capacity	135 psig / 250 scfm

TABLE 9.11-2 GAS RECEIVER TANKS SAFETY EVALUATION

TANK NAME	TANK NUMBER	DESIGN PRESSURE (PSIG)	OPERATING PRESSURE (PSIG)	MAXIMUM GAS SUPPLY PRESSURE (PSIG)	LOCATION	PROTECTIVE MEASURES TO PREVENT TANK FAILURES	DEVIATIONS FROM OSHA SECTION 1910.169
Station air receiver tank	T-50	125	100	100	FSAR Figure 1.2–5 Zone (D-5)	Gas supply pressure is 25 psi less than design pressure of tank, tank has relief valve set at 125 psig.	None
Instrument air receiver tank	T-51	125	110	110	FSAR Figure 1.2–5 Zone (E-6)	Gas maximum supply pressure is 15 psi less than design pressure of tank, tank has relief valve set at 125 psig.	None
Containment instrument air receiver tank	T-89	125	100	100	FSAR Figure 1.2–6 Zone (E-8)	Gas supply pressure is 25 psi less than design pressure of tank, tank has relief valve set at 125 psig.	None

TABLE 9.11-2 GAS RECEIVER TANKS SAFETY EVALUATION (CONTINUED)

TANK NAME	TANK NUMBER	DESIGN PRESSURE (PSIG)	OPERATING PRESSURE (PSIG)	MAXIMUM GAS SUPPLY PRESSURE (PSIG)	LOCATION	PROTECTIVE MEASURES TO PREVENT TANK FAILURES	DEVIATIONS FROM OSHA SECTION 1910.169
Instrument air receiver tank	T-51A	135	120	120	FSAR Figure 1.2–5 Zone (C-12)	Gas maximum supply pressure is 15 psi less than design pressure of tank; tank has two relief valves set at 135 psig. Note - factory hydrostatic tested at 203 psig.	None
Instrument air receiver tank	T-51E	155	110	129	FSAR Figure 1.2–5 Zone (C-10)	Gas maximum supply pressure is 26 psi less than design pressure of tank, tank has relief valve set at 135 psig.	None
Instrument air receiver tank	T-51F	155	110	129	FSAR Figure 1.2–5 Zone (C-10)	Gas maximum supply pressure is 26 psi less than design pressure of tank, tank has relief valve set at 135 psig.	None

FIGURE 9.11–1 P&ID INSTRUMENT AIR SYSTEM COMPRESSORS F-3E AND F-3F

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.11–2 P&ID INSTRUMENT AIR SYSTEM COMPRESSORS F-3D

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

9.12 WATER TREATMENT SYSTEM

9.12.1 DESIGN BASES

9.12.1.1 Functional Requirements

The function of the common makeup water treatment system is to provide makeup, demineralized, deoxygenated water for Millstone Unit 2 and Unit 3 nuclear steam supply system (NSSS) and its auxiliary systems, and to provide demineralized makeup water to Millstone Unit 2 and Unit 3 secondary systems.

9.12.1.2 Design Criteria

The following criteria have been used in the design of the common water treatment system:

a. The vendor makeup water demineralizer section of the water treatment system shall provide up to 400 gpm to meet the demands of Units 1, 2, & 3.

b. The water treatment system shall be designed to permit periodic inspection of important components such as pumps, demineralizers, tanks, filters, valves and piping to ensure the integrity and capability of the system.

c. The water treatment components shall be designed to operate within the environment to which they are exposed.

9.12.2 SYSTEM DESCRIPTION

9.12.2.1 System

The water treatment system is shown schematically in Figures 9.12–1 and 9.10–2.

Domestic (city) water is supplied to vendor demineralization equipment through a back flow prevention valve to prevent chemical contamination of the domestic water supply. The common water treatment facility supplies deoxygenated water to the Unit 2 condensate storage tank via the separate eight inch supply header and to all other tanks in Units 2 and 3 via the cross tie header.

Primary make-up water is deoxygenated before it is transferred to the PWST.

To prevent freezing, the water temperature in the outdoor PWST is maintained at 50°F minimum by means of a circulation system which uses a primary circulation pump and a primary water heat exchanger.

Millstone Unit 2 NSSS and its auxiliary systems requiring demineralized, deoxygenated makeup water obtain it from the PWST. The demineralized, deoxygenated water is transferred from the PWST to the components requiring makeup water by one of two primary water transfer pumps (PWTP). During normal operation, one of the PWTP will always be in operation whether makeup water is required or not. When makeup water is not required, 40 gpm will be recirculated back to the PWST.

The Primary Water Heat Exchanger return line to the PWST is a suction connection that provides a make-up water source alternative. This suction connection is a defense-in-depth design feature that is available for coping with an extended loss of AC power (ELAP) event. The location of this BDB PWST FLEX suction connection is shown on Figure 9.12–1.

The common water treatment system is sized to provide the makeup water requirements for Millstone Units 1, 2 & 3.

Millstone Unit 2 secondary systems requiring demineralized makeup water obtain it from the CST (Section 10.4.5.3). Millstone Unit 3 systems and other Millstone Unit 2 systems obtain makeup water via the cross-tie header.

The common water treatment system contracted capacity is 576,000 gpd (400 gpm) of demineralized water. The contracted capacity is based on normal start-up steam generator blowdown requirements of any one of the Units to meet chemistry specifications.

During periods when the makeup water requirements exceed the normal makeup water flowrates for either Unit, the common water treatment facility has the capability to divert additional water as required.

The design chemical analysis of demineralized water from the vendor water treatment system is as follows:

Silica, maximum (ppb)	10
Conductivity, maximum (umhos/cm)	0.1
Dissolved oxygen, maximum (ppm)	0.1
Sodium, maximum (ppb)	1
Chloride, maximum (ppb)	1
Sulfate, maximum (ppb)	2
Calcium, maximum (ppb)	2
Magnesium, maximum (ppb)	2
Aluminum, maximum (ppb)	10
Total organic carbon (ppb)	50

9.12.2.2 Components

A description of the water treatment system components is given in Table 9.12-1.

9.12.3 SYSTEM OPERATION

9.12.3.1 Normal Operation

During normal unit operation, continuous blowdown from both steam generators requires the common water treatment facility to provide makeup water to the CST. Makeup water flow is manually aligned to the CST, and can be concurrently aligned to any of the other tanks in Unit 2 or Unit 3.

If the makeup water requirement exceeds the normal operating flow rates for either Unit, such as chemistry holds during startup, the common water treatment facility has the capability to divert the additional water as needed.

The operation of the water treatment system is controlled and monitored with the following instrumentation:

a. Pressure indication on the discharge of each pump.

b. Level controllers, indicators, and high/low alarms on the PWST.

c. Temperature-indicating controller and high/low alarm on primary water storage.

d. Flow switch and flow controller on the primary water pump discharge.

9.12.4 AVAILABILITY AND RELIABILITY

9.12.4.1 Special Features

Utilization of vendor supplied and operated make-up water equipment allows for changes in that equipment to remain current with water treatment technology and changing water supply conditions. Key components are supplied with sufficient redundancy to allow for equipment breakdowns, and flexible connections between components allows for rapid change outs and versatility for changing system demands. Additionally, off-site demineralizer regenerations eliminates neutralization and discharge of regenerate waste.

Outside make-up water supply lines are insulated with redundant heat tracing to prevent line freeze-up.

The makeup water from the PWST is supplied to the various systems by redundant PWTPs.

Pressure vessels are provided with relief valves for overpressure protection.

A Back Flow Preventor (BFP) prevents contaminants from entering the domestic (city) water supply.

9.12.4.2 Tests and Inspections

The pressure vessels in the Unit 2 water treatment system are inspected and tested per American Society of Mechanical Engineers (ASME) Code Section VIII and are furnished with an ASME Code Stamp and Reports.

Each component is inspected and cleaned prior to installation into the system. The water treatment system undergoes an acceptance test prior to startup; the detailed test procedure is described in Chapter 13.

Major components of the system, such as pumps, tanks and heat exchangers, are accessible for periodic inspection during normal operation.

Instruments are calibrated during testing. Automatic controls are tested for actuation at the proper set points. Alarm functions are checked for operability and limits during preoperational testing.

The system is operated and tested initially with regard to flow paths, flow capacity and mechanical operability.

Local sample points are provided for obtaining samples for laboratory testing of the water quality during normal operation.

TABLE 9.12-1 WATER TREATMENT SYSTEM COMPONENTS

Domestic Water Storage Tank	
Manufacturer	Richmond Engineering Co
Type	Vertical
Quantity	1
Design pressure (psig)	15
Design temperature (°F)	100
Volume (gal)	275
Materials Shell and head	ASTM A-285 Gr C
Code	ASME Section VIII & IV
Seismic Class	II
Primary Water Storage Tank	
Manufacturer	Richmond Engineering
Type	Vertical
Quantity	1
Design pressure	Atmospheric
Design temperature (°F)	100
Net capacity (gal)	150,000
Material	SA-240, Type 304
Code	AWWA-D100
Seismic Class	II
Primary Water Circulation Pump	
Pump manufacturer	Ingersoll-Rand
Model	3 x 2 x 6 VOC
Type	Inline centrifugal
Quantity	1
Capacity (gpm)	100
Head (feet)	25
Net Positive Suction Head required / available (feet)	3 / 25
Materials	
Casing	ASTM A-296 Gr CF8M
Impeller	ASTM A-296 Gr CF8M
Shaft	ASTM A-276 - Type 316

TABLE 9.12-1 WATER TREATMENT SYSTEM COMPONENTS (CONTINUED)

Motor manufacturer	General Electric
Motor	1.5 hp, 460 V, 60 Hz, 1750 rpm
Codes	Motor: NEMA Pumps: Hydraulic Institute Standards
Seismic Class	II
Primary Water Storage Tank Heat Exchanger	
Manufacturer	Perfex Corporation
Model	AE4
Type	Horizontal, U tube
Quantity	1
Design duty (Btu/hr)	540,000
Heat transfer area (square feet)	6.1
Design pressure (psig)	Shell side: 75 tube side: 75
Design temperature (°F)	Shell side: 350 tube side: 325
Material	
Shell	ASTM A-106 Gr B
Tubes	ASTM A-249 Gr TP304
Tube sheet	ASTM A-240 Type 304
Channel	ASTM A-312 Type 304
Codes	TEMA Class C ASME Section VIII
Seismic Class	II
Primary Water Transfer Pumps	
Pump manufacturer	Ingersoll-Rand
Model	3 x 1-1/2 x 8 VOC
Type	Inline centrifugal
Quantity	2
Capacity P22A (gpm)	200
Capacity P22B (gpm)	188
Head (feet)	190
Net Positive Suction Head required / available (feet	10 / 37)
Materials	
Casing	ASTM A-296 Gr CF8M
Impeller	ASTM A-296 Gr CF8M
Shaft	ASTM A-276 Type 316

TABLE 9.12-1 WATER TREATMENT SYSTEM COMPONENTS (CONTINUED)

Motor manufacturer	General Electric
Motor	20 hp, 460 V, 60 Hz, 3 phase, 3550 rpm
Codes	Motor: NEMA Pump: Hydraulic Standards Institute
Seismic Class	II

Piping, Fittings and Valves

Standard	ANSI B31.1.0, Standards for Power Piping
Seismic Class	II

FIGURE 9.12–1 P&ID DIAGRAM WATER TREATMENT SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

9.13 AUXILIARY STEAM SYSTEM

9.13.1 DESIGN BASES

9.13.1.1 Functional Requirements

The auxiliary steam system functions to maintain a suitable environment for equipment and plant operating personnel during normal operation and shutdown conditions. The Unit 2 auxiliary steam system receives steam from Unit 3 via a crosstie between the Units. Because the Unit 3 auxiliary steam system operates at 150 psig and the Unit 2 auxiliary steam system operates at 50 psig, a pressure reducing valve station, including isolation and relief valves are installed. In addition a condensate return line from the Unit 2 auxiliary feedwater surge tank is routed to the Unit 3 condensate system. Condensate is routed to the auxiliary boiler deaerator, when the Unit 3 auxiliary boilers are supplying auxiliary steam, or to the Unit 3 condensate surge tank when Unit 3 main steam is supplying auxiliary steam.

9.13.1.2 Design Criteria

The following criteria have been used in the design of the auxiliary steam system:

a. The system shall be designed to permit periodic inspection of important components, such as piping and valves to assure the integrity and capability of the system.

b. The components of the system shall be designed to operate in the environment to which exposed.

The following criteria have been used in the design of the Auxiliary Steam Detection and Isolation (ASDI) system (Section 7.10):

a. The system shall have a redundant, safety related independent detection and isolation subsystems.

b. The system shall have suitable subsystem and component alignments to assure operation of the complete subsystem with its associated components.

c. Capabilities shall be provided to assure the system isolation function with onsite power (assuming offsite power is not available) or with offsite electrical power.

d. A single failure in either subsystem shall not affect the functional capability of the other subsystem.

e. The system shall be designed to permit periodic inspection of important components, such as temperature detectors and automatic isolation valves to assure the integrity and capability of the system.

f. The ASDI system shall be designed to permit appropriate periodic functional testing to assure the operability and performance of the active components of the system, and the operability of the system as a whole. Under conditions as close to the design as practical, performance shall be demonstrated of the full operational sequence that activates applicable portions of the detection and isolation system.

g. The components of the ASDI system shall be designed to operate in the most severe auxiliary steam line break environment to which it is exposed.

9.13.2 SYSTEM DESCRIPTION

9.13.2.1 System

The auxiliary steam and ASDI are shown schematically in Figure 9.13–1.

The auxiliary steam system is provided for building heating and freeze protection for outdoor water storage tanks. Temporary electric heating has been provided to the fire water storage tanks while auxiliary steam supply is unavailable.

Steam for the auxiliary steam system is provided via a crosstie connection to Unit 3. Because the Unit 3 auxiliary steam system operates at 150 psig and the Unit 2 auxiliary steam system operates at 50 psig, a pressure reducing valve station, including isolation and relief valves are installed. The pressure reducing valve station consists of two pressure reducing valves installed in parallel and supplied with upstream and downstream isolation valves. The isolation valves are located at the crosstie between the Unit 3 auxiliary steam system supply to Unit 2. The pressure reducing valve station is located in the Condensate Polishing facility in line 3-ASS-008-15-4 downstream of isolation valve 2-ASS-3. This pressure reducing valve station regulates Unit 3 auxiliary steam system mass flow to Unit 2. The pressure reducing valve station is comprised of a two inch pressure reducing valve, four inch pressure reducing valve, isolation valves, pressure sensing line, and a dual operated controller. This configuration allows the two inch valve to regulate auxiliary steam system mass flow from between 0 and 8,999 lb/hr as long as the downstream pressure sensing line indicates an operating pressure of 50 psig or higher. When the downstream operating pressure falls below 50 psig, the four inch pressure valve will modulate to allow up to the additional required 35,682 lb/hr auxiliary mass flow required for Unit 2 use.

A safety relief valve located downstream of the pressure reducing valve station provides downstream pressure protection for Unit 2 system piping and connected equipment.

In addition a condensate return line from the Unit 2 auxiliary feedwater surge tank is routed to the Unit 2 condensate system. Condensate is routed to the auxiliary boiler deaerator, when the Unit 3 auxiliary boilers are supplying auxiliary steam, or to the Unit 3 condensate surge tank when Unit 3 main steam is supplying auxiliary steam.

9.13.2.2 Auxiliary Steam Detection and Isolation System

The ASDI System is described in Section 7.10.

9.13.3 SYSTEM OPERATION

9.13.3.1 Normal Operation

The auxiliary steam system is manually initiated by operator action from a locally mounted control panel.

Operation of the auxiliary steam system is classified as non-nuclear safety consistent with ANSI/ANS 59.2 1985, Safety Criteria for HVAC Systems Located Outside Primary Containment.

9.13.4 AVAILABILITY AND RELIABILITY

9.13.4.1 Tests and Inspections

The ASDI system is incorporated with provisions for online testing (Section 7.10).

FIGURE 9.13–1 P&ID AUXILIARY STEAM AND CONDENSATE (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.13–1 P&ID AUXILIARY STEAM AND CONDENSATE (SHEET 2)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.13–1 P&ID AUXILIARY STEAM AND CONDENSATE (SHEET 3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.13–1 P&ID AUXILIARY STEAM AND CONDENSATE (SHEET 4)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-2 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.