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AUXILIARY SYSTEMS

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CHAPTER 9.

AUXILIARY SYSTEMS

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 contribution of, or reliance placed upon the system in relation to the overall plant safety.

The majority of the active components within these systems are located outside of the containment. Those systems with connecting piping or duct work between the containment and the reactor auxiliary building are equipped with containment isolation valves as described in Section 6.2.4.

9.1 FUEL STORAGE AND HANDLING

9.1.1 NEW FUEL STORAGE

9.1.1.1 Design Bases

The new fuel storage rack is designed to:

a) store 100 fuel assemblies

b) provide sufficient spacing between the fuel assemblies to maintain a subcritical array during flooding with nonborated water

c) maintain a subcritical array under all design loadings, including the design basis earthquake

d) preclude the possibility of a fuel assembly being placed between the new fuel cavities

e) maintain a subcriticality of at least 5 percent for the similtaneous occurrence of design bases (b) and (c).

9.1.1.2 System Description

The location of the new fuel storage rack is illustrated in the fuel handling building general arrangement drawings, Figures 1.2-18 and 1.2-19. The new fuel storage rack is shown on Figure 9.1-1.

The method of transferring new fuel into the fuel handling building and placing it into the new fuel storage racks is discussed in Section 9.1.3.

New fuel is stored dry at a floor elevation of 48 feet with the top of the rack at an elevation of 62 feet. Since the maximum flood wave runup is 21.8 feet the racks are not expected to be covered with water under normal or flood conditions; nevertheless, the array of fuel assemblies remains subcritical while flooded with nonborated water.

The new fuel storage racks consist of 100 square cavities fixed together in a large array. The size of the cavities (1'9" x 1'9") is sufficient to hold one fuel assembly in a vertical position. Each cavity has a hinged plate cover.

The supporting structure is designed to limit deflections so that subcriticality is maintained under all anticipated loadings. The clearance between structural framing members is small enough to prevent the wedging of a fuel assembly between adjacent cavities.

The new fuel is subjected to a maximum ambient temperature of 110F.

There is not sufficient room in the new fuel racks to store all the fuel assemblies for the initial loading of the core. The remaining assemblies are stored dry in the spent fuel racks under this circumstance. Section 9.1.2.3 discusses the design of the spent fuel racks.

9.1.1.3 System Evaluation

The new fuel in the storage racks is subcritical by at least 5 percent under the assumption of flooding with nonborated water and 3.7 weight percent enriched uranium.

The new fuel storage racks are designed in accordance with the American Institute of Steel Construction (AISC) Specification for the Design, Fabrication and Erection of Structural Steel for Buildings and meets ANSI Standard N18.2 Paragraph 5.7.4.1.

Lateral loads exerted on the rack support structure are resisted by a vertical bracing system which transmits these forces to the concrete floor or through horizontal members into the concrete walls via anchor bolts. Lateral movement of the rack with any number of fuel assemblies is prevented by these supports for all anticipated loadings.

9.1.2 SPENT FUEL STORAGE

9.1.2.1 Design Bases

The fuel pool is designed to provide safe storage for 1-1/3 cores of spent fuel assemblies, control element assemblies, new fuel during initial core loading and spent fuel shipping cask. The system design includes interlocks, travel limits and other protective devices to minimize the probability of either mishandling or of equipment malfunction that could result in inadvertent damage to a fuel assembly and potential fission product release. Criticality is precluded by spacing of the fuel assemblies which ensures a subcritical array assuming the pool water is unborated. The pool, however, will always contain boric acid at the refueling concentration of $\geq$1720 ppm.

The fuel handling building exterior walls, floors and interior partitions are designed to provide plant personnel with the necessary radiation shielding and to protect the equipment from the effects of adverse atmospheric conditions including winds, temperature, missiles and corrosive environment.

9.1.2.2 System Description

The fuel handling building general arrangement showing the location of the spent fuel storage facilities is given in Figure 1.2-18 and 1.2-19.

The fuel handling building consists of cast-in-place concrete exterior walls with interior walls which are of reinforced concrete construction. It is completely isolated from all other structures. The floors and roof are of beam and girder construction supported by columns. The fuel pool portion of the fuel handling building including the walls and roof directly above the pool is designed to withstand, without penetration, the impact of high velocity external missiles that might occur during the passage of a tornado. The design missiles are discussed in Section 3.5. Details of the structural design and analysis are given in Section 3.8.

The fuel handling building also houses the fuel handling building heating and ventilating equipment, the fuel pool heat exchanger, the fuel pool filter, the fuel pool pumps, and the fuel pool purification pump. In addition, the fuel handling building provides space for the storage of new fuel (refer to Section 9.1.1), a decontamination area for the spent fuel cask, and a miscellaneous equipment area.

As noted above, the fuel pool is located outside the containment in the fuel handling building. It is designed for the underwater storage of 304 spent fuel assemblies (1-1/3 cores), the spent fuel shipping cask and the fuel handling tools. Control element assemblies removed from the core are stored within the fuel assemblies. The pool is lined with stainless steel ASTM Specification A167, Type 304, which is the material for all of the stainless steel components in the fuel pool. This material resists the corrosive effect of boric acid in the fuel pool water.

A leakage detection system is included which consists of a network of stainless steel angles seal welded to the outside of the pool liner walls and floor. In the event that one of the liner plate weld seams develops a leak, the liquid enters the monitor channel system and flows to one of a number of collection points at the base of the pool. The flow is restricted in such a way that it is possible to determine the location at which the leak originated, and steps may be taken to repair it.

The fuel pool contains water with ≥1720 ppm of boron and has the capacity to store one and one-third cores. The capacity of one and one-third cores enables handling the removal of one full core during that period of time when one-third of a core is stored in the fuel pool following a refueling. When in storage racks, the fuel assemblies are spatially distributed so as to preclude criticality in the event of complete accidental dilution of the fuel pool water. The fuel pool water is borated to refueling concentration to assure that mixing of the fuel pool water and refueling cavity water cannot dilute the refueling cavity boron concentration.

Spent fuel assemblies are placed in stainless steel storage racks consisting of vertical cells (modules) grouped in parallel rows with a center-to-center distance of 1.6 ft. The modules are fabricated from welded steel racks. This design permits inspection or replacement of the racks without draining the pool since the modules are removed individually.

The rack assembly is designed to withstand all anticipated loadings, including a dropped fuel assembly on the top. Structural deformations of the racks are limited to preclude any possibility of criticality. The structural design precludes the possibility of a fuel assembly being placed in the spaces between the fuel cavities.

Fuel pool racks are open construction to permit convective cooling of the fuel assemblies. Spent fuel decay heat is removed by the fuel pool system described in Section 9.1.3.

The spent fuel racks are shown on Figure 9.1-2.

Boron concentration in the fuel pool is ≥1720 ppm which is adequate to preclude criticality even with fuel assemblies adjacent to each other and without CEA's. However, no credit is taken for the boron in the water in establishing the safe geometry of the storage racks.

The fuel enrichment selected for determination of the safe geometry is 3.7 percent. This is substantially higher than the enrichment for the initial and future cores. In the analysis to determine allowable edge-to-edge spacing, infinite arrays of fuel assemblies are analyzed with PDQ-5[1], using appropriate terms to account for axial leakage. Standard two-group beginning-of-life constants for fuel assemblies with the maximum enrichment and a temperature of 68 F are used. No boron is assumed to be present in the water. Fast constants for the water between assemblies are generated with the FORM computer program[2] assuming pure water, while thermal constants for the water are obtained using Maxwellian cross sections. The enrichments used in the analysis, provide allowance for future possible changes in the maximum enrichment of the fuel.

The stainless steel structure which supports each individual fuel assembly further reduces k_{eff} for any thickness of water slab. The structural basis for this container has been outlined above. No credit is taken for this reduction in k_{eff}. The geometry criteria is thus conservative.

The spent fuel shipping cask is located in the cask handling area of the pool. The cask is designed such that spent fuel assemblies can be placed in the cask while still maintaining the minimum water level above the fuel assemblies. The cask cover is then placed on the cask and the unit is transferred to the cask washdown (see Figure 1.2-18) area by the cask handling crane.

9.1.2.3 System Evaluation

The modules making up the spent fuel storage racks are grouped in parallel rows with a center-to-center distance of 1.6 ft. This distance maintains a maximum k_{eff} of <0.95 assuming flooding with nonborated water and maximum lateral movement of the assemblies. The storage rack is supported to prevent significant lateral rack movement with any number of fuel assemblies in it under all anticipated loadings including the design basis earthquake. Lateral movement of the fuel assemblies results from the clearance between the assembly and the rack. The above value of k_{eff} reflects consideration of both these types of lateral movement.

The fuel pool is also protected against other occurrences that could theoretically result in a critical assembly. The physical design of the racks prevents inadvertently placing a fuel assembly between the outermost module and the pool wall. Adequate clearance is provided between the top of the CEA in the fuel assembly and the top of the rack to preclude criticality in the event a fuel assembly is dropped and lands in the horizontal position on the top. Rack design also assures adequate convection cooling of a fuel assembly lying horizontally across the top of the racks.

The spent fuel storage racks are designed in accordance with the AISC Specifications except that the normal working stress is limited to 18,000 psi.

In the fuel pool, interlocks prevent movement into the walls while limit switches prevent the spent fuel handling machine from raising the fuel above a height where less than 10.5 ft separates the surface of the water from the top of the active fuel length. Under these conditions and when not refueling, the direct dose rate at the pool surface is less than

2 mrem/hr. This number is calculated using the most active fuel assembly two days after shutdown. If the interlock should fail and if there were no operator action, the fuel handling machine could not raise the assembly above a 9 ft water-to-active-fuel-length height because of the geometry of its design. Under the conditions described above, the dose rate at the surface of the water above the assembly would be 7 mrem/hr. The grappling tool on the spent fuel handling machine is designed so that a fuel assembly cannot be released accidently. The assembly could not be dropped from greater than a height of 9 ft active length below the water. The shielding provided in the fuel handling building is discussed in Section 12.1.2.4. A dividing wall to the top of the spent fuel racks separates the cask storage area of the pool from the spent fuel storage area. The wall prevents the water level from uncovering the spent fuel assemblies even if a dropped fuel cask causes damage to the pool or pool liner in the cask handling area.

The fuel pool meets those portions of Safety Guide 13 which apply to the fuel pool (13.C.1, 2, 4, 5, 7) with the exception of 13.C.4. The fuel handling building is not a controlled leakage facility. Doses from a refueling accident are kept within the limits defined by 10CFR100 without a controlled leakage building as discussed further in Section 9.4.6. The assumptions, evaluation and results of the refueling accident analysis are given in Section 15.4.6. Articles one, two, five and seven are met in the following ways:

a) The spent fuel storage facility is seismic Class I.

b) The spent fuel storage facility is designed against hurricane or tornado winds and missiles generated by the winds from significantly affecting the integrity of the pool. Missiles generated by hurricane or tornado winds are prevented. The fuel handling building is designed in accordance with the ACI Standard Building Code Requirements for Reinforced Concrete, ACI 318-63 Part IVB, Ultimate Strength Design. Details of the structural design and analysis of the fuel handling building are given in Section 3.8.

c) All cranes capable of carrying heavy loads cannot move in the area of the fuel pool. The cask handling crane is restrained from tipping over due to an accident, wind loading, or an earthquake. The fuel pool is designed to withstand dropping of a fuel assembly from the highest elevation that it can be lifted by the spent fuel handling machine.

   The spent fuel cask is handled by a 105 ton capacity fuel handling crane which runs on rails supported on a structural steel frame above the roof of the building. The trolley and end trucks of the fuel handling crane have lugs which prevent the crane from lifting off the rails in the event of a design basis earthquake.

The fuel cask handling crane cannot approach any area above where spent fuel is stored because of the geometrical design of the crane runway, the physical design of the building, and travel limit switch interlock circuitry.

d) Reliable and frequently tested (refer to Section 9.2.5) monitoring equipment will provide local and control room alarm of high radiation and low fuel pool water level. The fuel pool cooling system instrumentation is discussed in Section 9.1.3.3.10.

9.1.2.4 Testing and Inspection

The welded steel spent fuel and new fuel storage racks are liquid penetrant tested for structural adequacy and alignment is periodically checked prior to handling fuel assemblies by operation of all systems by the use of a dummy fuel bundle which has the same weight, center of gravity, exterior size and end geometry as a fuel assembly.

9.1.2.5 Instrumentation Applications

Temperature, water level, and radiation monitoring and alarm instrumentation are provided in the control room and locally to verify that the decay heat from the spent fuel assemblies is being removed. Means are provided to control entry of personnel and to account for the flow of tools in and out of the area. Table 11.2-3 gives the location of the area radiation monitoring in the fuel handling building. The radiation alarms give indication of high, high-high, and radiation alarms.

REFERENCES FOR SECTION 9.1

1. PDQ-5 Program for the Solution of the Two-dimensional Neutron Diffusion - Depletion Problem, Cadwell, W.R., et al., WAPD-TM-477 January 1965.

2. FORM - A Fourier Transform Fast Spectrum Code for the IBM-7090, McGoff, D.J., NAA-SR-Memo 5766, September 1967.

9.1.3 FUEL POOL SYSTEM

9.1.3.1 Design Bases

The fuel pool system is designed to:

a) provide radiation shielded storage of 304 spent fuel assemblies to limit personnel dose rates to less than 2.5 mrem/hr

b) remove decay heat from the spent fuel stored in the pool assuming the spent fuel assemblies to have undergone infinite irradiation and maintain pool water temperature to less than 150F.

c) maintain purity and optical clarity of the fuel pool water

d) maintain purity of the water in the refueling cavity and in the refueling water tank

e) maintain the water level a minimum of 9 ft above the top of the fuel during fuel handling and storage operations.

9.1.3.2 System Description

The P & I diagram of the fuel pool system is shown in Figure 9.1-3. The system process flow data is shown in Table 9.1-1. The cooling portion of the fuel pool system is a closed loop system consisting of two full capacity pumps for normal duty and one full capacity heat exchanger. The fuel pool water is drawn from the fuel pool near the surface and is circulated by the fuel pool pumps through the fuel pool heat exchanger where heat is rejected to the component cooling system. From the outlet of the fuel pool heat exchanger, the cooled fuel pool water is returned to the bottom of the fuel pool via a distribution header at the opposite end of the pool from the intake.

The fuel pool is designed to limit the fuel pool temperature to 150F with one and one-third cores in the pool assuming one full core is placed in the fuel pool seven days after reactor shutdown plus one-third of a core that has been stored in the pool for ninety days. Figure 9.1-4 shows the fission product decay heat curve. During normal operating conditions with one-third of a core in the pool seven days after reactor shutdown, the system maintains a maximum fuel pool temperature of 120F. For this condition, the initial heat load is 9.4×10^6 Btu/hr. For both conditions the design component cooling water inlet temperature is 100F.

The clarity and purity of the water in the fuel pool, refueling cavity, and refueling water tank are maintained by the purification portion of the fuel pool system. The purification loop consists of the fuel pool purification pump, ion exchanger, filter, strainers and surface skimmers. Most of the purification flow is drawn from the bottom of the fuel pool, while a small fraction is drawn through the surface skimmers to remove surface debris. A basket strainer is provided in the purification line to the

TABLE 9.1-1

FUEL POOL SYSTEM PROCESS FLOW DATA

(Refer to Figure 9.1-3 for location of data points)

1. Normal Fuel Pool Cooling

FPS Location	1	2	3
Flow, gpm	1500	1500	1500
Pressure, psig	5	26	24
Temperature, F	120	120	108

2. Maximum Fuel Pool Cooling

FPS Location	1	2	3
Flow, gpm	3000	3000	3000
Pressure, psig	5	32	25
Temperature, F	150	150	129

3. Purification

FPS Location	4a	4b	5	6	7
Flow, gpm	150	-	150	150	150
Pressure, psig	5	-	40	35	20
Temperature, F	120	-	120	120	120

4. Skimming Operations

FPS Location	4a	4b	5	6	7
Flow, gpm	142-150	0-8	150	150	150
Pressure, psig	5	5	40	35	20
Temperature, F	120	120	120	120	120

NOTES: The pressure drop across the filters, strainers, and ion exchangers will vary with loading. The pressure losses are typical.

pump suction to remove any relatively large particulate matter. The fuel pool water is circulated by the pump through a filter, which removes particulates larger than 5 micron size, and through an ion exchanger to remove ionic material. Connections to the refueling water tank and refueling water cavity are provided for purification. Fuel pool water chemistry is given in Table 9.1-2 below.

TABLE 9.1-2

FUEL POOL WATER CHEMISTRY

pH (77F)	4.5 to 10.6
Boric Acid, Maximum, wt %	1.5
Ammonia, Maximum*, ppm	50
Lithium, Maximum*, ppm	2.5
Dissolved Air, Maximum	Saturated
Chloride, Maximum, ppm	0.15
Fluoride, Maximum, ppm	0.1

*Concentrations do not occur simultaneously

Maximum dose rates from a spent fuel assembly as a function of the water height above the top of the active fuel is shown in Figure 9.1-5 and for horizontal water distances in Figure 9.1-6 for various decay times. Long term operation, infinite irradiation, is assumed for the dose rate calculation. An axial power distribution with maximum power at the top and bottom of the fuel was used for the axial dose rate calculations while an axial peak of 1.50 was used for the radial (side) dose rate calculations for shielding requirement as described in Section 12.1. Additionally, both cases assumed a maximum radial fuel assembly peaking factor of 1.38. The decay times are not representative of any particular point in the refueling cycle and are only given to show the dose rate variation with time. Other decay times between 2 days and 60 days can be obtained by interpolation between the existing points.

The fuel pool system is manually controlled from a local control panel. High fuel pool temperature, high and low fuel pool water level, and a low fuel pool pump discharge pressure alarms are annunciated in the control room. Makeup to the fuel pool is provided from the refueling water tank. Overflow protection is provided by transferring the fuel pool water on high level alarm to the refueling water tank via the purification pumps. Spent resins from the fuel pool ion exchanger are sluiced to the waste management system as described in Section 11.5.2. Local sample connections are provided on the influent and effluent of the fuel pool purification filter and the fuel pool ion exchanger effluent for verifying purification performance.

9.1.3.3 Component Description

All piping, valves, instruments, and components except the fuel pool ion exchanger are located in the fuel handling building. The fuel pool ion exchanger is located in the reactor auxiliary building with the CVCS and waste management system ion exchangers. Design data for the major components are indicated in Table 9.1-3.

TABLE 9.1-3

DESIGN DATA FOR FUEL POOL SYSTEM COMPONENTS

1. Heat Exchangers

Quantity	1
Type	Shell and Tube
Tube Side	
Fluid	Fuel Pool Water
Design Temperature, F	250
Design Pressure, psig	75
Normal Operating Conditions	
Flow, gpm	1500
Inlet Temperature, F	120
Outlet Temperature, F	107.5
Materials	ASTM-SA-240, Type 304
Code	ASME III, Class C
Shell Side	
Fluid	Component Cooling Water
Design Temperature, F	250
Design Pressure, psig	150
Normal Operating Conditions	
Flow, gpm	3560
Inlet Temperature, F	100
Outlet Temperature, F	105.3
Materials	Carbon Steel
Code	ASME III, Class C

2. Ion Exchangers

Quantity	1
Type	Mixed Bed, Disposable
Design Pressure, psig	200
Design Temperature, F	250
Normal Operating Temperature, F	120
Vessel Volume, ft^3	55
Resin Volume, ft^3 (useful)	32
Code	ASME III, Class C
Normal Flow Rate, gpm	150
Materials	ASTM-SA-240, Type 304

3. Pumps	Fuel Pool Cooling	Fuel Pool Purification
Quantity	2	1
Type	Centrifugal	Centrifugal
Design Pressure, psig	75	150
Design Temperature, F	250	250
Normal Operating Conditions		
Flow, each, gpm	1500	150
Head, ft	70	165
Fluid Temperature, F	120	120

TABLE 9.1-3

DESIGN DATA FOR FUEL POOL SYSTEM COMPONENTS (Cont)

Seal Type	Mechanical	Mechanical
Horsepower	40	15
Material	ASTM A-351 Gr CF-8M	ASTM A-351 Gr CF-8M

4. Filters

Quantity	1
Type of Elements	Replaceable Cartridge
Retention of 5 micron particles	98%
Design Pressure, psig	100
Design Temperature, F	200
Design Flow, gpm	150
Material	ASTM-SA-240, Type 304
Code	ASME VIII

5. Strainers

	Fuel Pool Purification Pump Suction	Fuel Pool Ion Exchanger
Quantity	1	1
Type	Basket	Wye
Design Flow, gpm	150	150
Design Pressure, psig	100	100
Design Temperature, F	200	200
Screen Size	1/8" perforated	100 U.S. Mesh
Body Material	ASTM A-351	ASTM A-351

6. Fuel Transfer Valve

Type	Gate
Size, in	36
Design Pressure, psig	75
Normal Operating Differential Pressure	34'-6" H_2O
Design Temperature, F	150
Normal Operating Temperature, F	140
Materials	ASTM-A-351 CF-8M
Design Integrated Dose, Rads	1×10^7
Allowable Seat Leakage, cc/hr	72

a) Fuel Pool Heat Exchanger

The fuel pool heat exchanger is a horizontal shell and tube design with a two-pass tube side. A slight pitch, 3° above the horizontal, is provided for complete draining of the heat exchanger. The component cooling water circulates through the shell side, and pool water circulates through the tube side.

b) Fuel Pool Purification Filter

The fuel pool purification filter is located upstream of the fuel pool ion exchanger to remove any particulates in the pool water. The filter retains 98 percent of the particulates larger than 5 micron in size at a flow of 150 gpm. Due to the possible buildup of high activity in the filter, the unit has been designed and installed to provide for removal of the contaminated element assembly with remotely operated handling equipment. The filter drains to the drain collection header in the waste management system.

c) Fuel Pool Ion Exchanger

The ion exchanger removes ionic matter from the water. Mixed bed resin is used with the anion resin converted to the borate form and the cation resin in the hydrogen form. The units are provided with all connections required to replace resins by sluicing. The ion exchanger contains a flow distributor on the inlet to prevent channeling of the resin bed and a resin retention element on the discharge to preclude discharge of resin with the effluent.

d) Fuel Pool Purification Pump Suction Strainer

The fuel pool purification pump suction strainer prevents any relatively large particulates from entering the purification pump. The strainer has a drain connection allowing local draining.

e) Fuel Pool Ion Exchanger Strainer

The wye strainer removes particles larger than 149 microns from the purification flow. Blowdown is directed to the spent resin tank in the waste management system.

f) Fuel Pool Pumps

There are two fuel pool pumps installed for parallel operation. Under normal operating conditions one pump is operational. The pumps are provided with mechanical seals. To increase seal life and reduce maintenance, the seals are cooled by circulating a portion of the pump discharge flow to the seals which returns to the pump suction. The seals are provided with leakoff vent and drain connections.

g) Fuel Pool Purification Pump

The fuel pool purification pump is used for purification and skimming operations. Mechanical seals minimize shaft leakage. To increase seal life and reduce maintenance, the seals are cooled by circulating a portion of the pump discharge flow to the seals which returns to the pump suction. The seals are provided with leakoff vent and drain connections. The internal wetted surfaces of the pump are stainless steel.

h) Piping & Valves

All the piping used in the fuel pool system is stainless steel with welded connections throughout, except for flanged connections at the suction and discharge of the pumps.

All the valves in the fuel pool system are stainless steel, 150-pound class. All valves are manually operated diaphragm type.

9.1.3.4 System Evaluation

a) Cooling System

With one-third of a core in the fuel pool, one fuel pool pump and the fuel pool heat exchanger are in service. With one and one-third cores in the fuel pool, two fuel pool pumps and the heat exchanger are in service. The system is manually controlled and the operation monitored locally. A pressure switch on the fuel pool pump discharge header annunciates low header pressure in the control room. The fuel pool temperature high alarm and the fuel pool water level switch high and low level alarms are annunciated in the control room. In the event the fuel pool pump breakers are opened, an alarm is annunciated in the control room. The component cooling water flow to the fuel pool heat exchanger is initially adjusted to the required flow. Further adjustments of the component cooling water is not required. The component cooling water discharge line has a flow indicator. High and low component cooling water flow alarms are annunciated in the control room.

The fuel pool piping is arranged so that the pool cannot be inadvertently drained to uncover the fuel. All fuel pool piping is arranged to prevent gravity draining the fuel pool. To prevent syphoning of the fuel pool, the fuel pool cooling discharge and purification suction lines have 1/2" and 1/4" holes respectively 1 foot below the normal water level.

The only means of draining the pool below these siphon breaker holes is through an open line in the cooling loop while operating the pool cooling pumps. In such an event the fuel pool water level can be reduced by only 6 feet since the pump suction connection enters near the top of the pool. Adequate shielding and cooling are still provided with the water level at this point. The temperature and level alarms would warn the operator of such an event.

In the case of loss of component cooling water with one and one-third cores stored in the pool under the design conditions of one full core in the pool seven days after shutdown and one-third core in the pool for ninety days after shutdown the temperature would rise from 150F to boiling in 4.8 hours. With one-third of a core in the pool seven days after shutdown it would take 27.6 hours for the pool temperature to rise from 120F to boiling. These values are based on the fuel pool containing 2.8×10^6 pounds of water with one-third core and 2.45×10^6 pounds with one and one-third cores in the fuel pool. If the pool reaches the boiling point (212F) the maximum makeup rate to the fuel pool required to compensate for loss due to boiling is approximately 66 gpm. This makeup rate is within the supply capacity from the refueling water tank. The makeup rate is based on the heat load from one and one-third cores in the pool (32×10^6 Btu/hr). In the unlikely event that makeup was unavailable for 12 hours and the spent fuel pool temperature was 212F, the pool water level would only decrease approximately 5 feet. As a result the fuel would still be covered by approximately 19 feet of water.

b) Purification System

The purification loop is normally run on an intermittent basis when required by the fuel pool water conditions. It is possible to operate with either the ion exchanger or filter bypassed. Local samples permit analysis of ion exchanger and filter efficiencies. A diaphragm valve in the skimmer suction line is throttled to maintain flow balance between the skimmer and normal purification flow. Spent filters and ion exchanger resins are removed to the waste management system described in Section 11.5 for eventual disposal.

9.1.3.5 Testing and Inspection

Each component is inspected and cleaned prior to installation into the system. Demineralized water is used to flush the entire system. Instruments are calibrated and alarm functions are checked for operability and set points during preoperational testing. The system will be operated and tested initially with regard to flow paths, flow capacity, and mechanical operability.

Prior to transferring spent fuel to the pool, the system will be tested to verify satisfactory flow characteristics through the equipment, to demonstrate satisfactory performance of pumps and instruments, to check for leak tightness of piping and equipment, and to verify proper operation of controls. Also, the overall cooling capability will be checked during initial refueling by analyzing pool temperature versus quantity of fuel transferred into the pool and comparing with expected performance. The active components of the system are in either continuous or intermittent use during normal plant operation; thus no additional periodic tests are required. Data will be taken and periodic visual inspections and preventative maintenance will be conducted, as necessary. This periodic inspection will also confirm heat transfer capabilities, purification efficiency, and component differential pressures.

9.1.3.6 Instrumentation Application

Instrumentation is provided to monitor fuel pool temperature and water level together with significant temperature and pressures around the cooling and purification loops. Alarms annunciated in the control room are provided for fuel pool water level, fuel pool temperature and fuel pool pump discharge pressure.

A tabulation of instrument channels is included in Table 9.1-4.

TABLE 9.1-4

FUEL POOL SYSTEM INSTRUMENTATION

System Parameter & Location	Indication Local	Indication Contr Room	Alarm[1] High	Alarm[1] Low	Rec.[1]	Control Function	Inst. Range	Normal Operating Range	Inst. Accuracy
Heat exchanger inlet	*						0-200F		$\pm$10F
Heat exchanger outlet temp.	*						0-200F		$\pm$10F
Fuel pool temp.	*		*						
Fuel pool pump discharge press.	*			*			0-60 psig	40 psig	$\pm$0.3psi
Purification pump suction press.	*						0-30 psig	5-18 psig	$\pm$0.2 psi
Purification pump discharge press.	*						0-100 psig	50 psig	$\pm$0.5 psi
Ion exchanger differential press.	*						0-30 psi	2-10 psi	0.2 psi
Filter differential pressure	*						0-30 psi	1-15 psi	0.2 psi
Fuel pool water level			*	*					

[1]All alarms and recorders are in the control room unless otherwise indicated.

9.1.4 FUEL HANDLING SYSTEM

9.1.4.1 Design Bases

The fuel handling system is designed to:

a) safely handle and store fuel assemblies and control element assemblies

b) safely remove, replace and store reactor internals

c) by means of interlocks, travel limiting devices and other protective devices, minimize the probability of malfunction or operator initiated actions that could cause fuel damage, and potential fission product release or reduction of shielding water coverage

d) conduct all spent fuel transfer and storage operations under water to limit radiation dose levels to less than 2.5 mr/hr at the pool surface

e) operate in water with the chemistry listed in Table 9.1-2

f) operate dry for the initial core loading

g) remain in a safe condition in the event of loss of power

h) withstand containment internal design leak rate test pressure without loss of function

i) remove and install a fuel assembly at each operating location at the most adverse combined tolerance condition for the equipment, core internals and fuel assemblies

j) withstand the loadings induced by the design base earthquake

9.1.4.2 System Description

The fuel handling system is an integrated system of equipment, tools and procedures for refueling the reactor. The system is designed for safe handling and storage of fuel assemblies from receipt of new fuel to shipping of spent fuel. The arrangement of the fuel handling area is shown in Figure 9.1-7.

The equipment is normally used at 12-month intervals for a period of approximately 3 weeks during which time it must operate continuously without maintenance or service.

a) New Fuel Handling

New fuel assemblies are delivered to the site in containers approved by the U.S. Department of Transportation. New fuel assemblies are removed from the shipping containers and placed in the new fuel storage racks using the new fuel handling tool attached to the 5-ton fuel transfer hoist. New CEA's are inserted into the guide tubes of the fuel assemblies while the new fuel is in the storage rack. During reactor refueling operations the new fuel is removed (with CEA's inserted if stored with the fuel) from the new fuel storage racks and transferred to the new fuel elevator.

The new fuel elevator lowers the fuel assembly into the refueling cavity where the spent fuel handling machine transfers the fuel assembly to the fuel pool upending mechanism. Interlocks prevent the spent fuel handling machine from lowering the fuel assembly unless the upender is in the vertical position. After a new fuel assembly has been placed in the upending mechanism, a spent fuel assembly is removed from the other position of the fuel carrier and transferred to a designated position in the spent fuel storage racks.

b) Spent Fuel Handling

The spent fuel handling equipment is designed to handle the spent fuel underwater from the time it leaves the reactor until it is placed in a cask for shipment from the site. Underwater transfer of spent fuel provides a transparent radiation shield, as well as the cooling medium for removal of decay heat. Boric acid is added to the water to ensure subcritical conditions during refueling. The major components of the system are the refueling machine, the CEA change mechanism, the fuel transfer equipment and the spent fuel handling machine. The refueling machine moves fuel assemblies into and out of the core and between the core and the transfer equipment. The CEA change mechanism moves CEA's from one fuel assembly to another. The fuel transfer equipment tilts fuel assemblies from the vertical position to the horizontal, shuttles them through the containment wall to the fuel handling building fuel pool and returns them to the vertical position. The spent fuel handling machine handles fuel between the transfer equipment and the fuel storage racks in the fuel pool.

Special tools and lifting rigs are also used for disassembly of reactor components and are included in the refueling system.

Prior to refueling, the plant is shut down, the water level lowered and reactor coolant is established at refueling temperature. During the cooldown, preparations are begun for the refueling operation.

Refueling operations are initiated with the removal of the missile shield from over the reactor. The control element drive mechanisms are disengaged from their drive shaft extensions by deenergizing the CEDM electromagnetic coils, and both mechanism and in-core instrument cabling disconnected in preparation for head removal. The stud tensioners are used to remove the preload of the vessel head studs. Plugs are installed to protect the empty stud holes and two alignment pins are installed in the vessel flange for subsequent operations. The CEDM cooling shroud is disconnected from the duct work and the vessel vent line removed. The reactor vessel flange is sealed to the bottom of the pool using the refueling cavity seal 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 polar crane, the head is removed to its storage location.

The flange on the transfer tube is removed and, after the refueling cavity is filled the fuel transfer valve is opened to establish a common water level preparatory to refueling.

Using the refueling machine walkway as a work platform, the mechanism drive shaft extensions are disconnected from the CEA's by means of a tool hung from the polar crane. The extension shafts are then locked in place for subsequent removal with the vessel upper guide structure. The upper guide structure lift rig (Figure 9.1-8) is installed and the in-core instrumentation is withdrawn into the upper guide structure and locked in place.

Provision is made in the refueling cavity for the temporary storage of the upper guide structure. After this is removed from the vessel, the refueling machine hoist mechanism is positioned at the desired location over the core. Alignment of the hoist to the top of the fuel assembly is accomplished through the use of a digital readout system and is monitored by closed circuit television. After the fuel hoist is lowered, minor adjustments can be made to properly position the hoist if misalignment is indicated on the monitor. The operator then energizes the actuator assembly which rotates the grapple at the bottom of the hoist and locks thy fuel assembly to the hoist. The hoist motor is started and the fuel assembly withdrawn into the fuel hoist box assembly so that the fuel is protected during transportation to the upending machine. The grapple is designed to preclude inadvertent disengagement as the fuel assembly is lifted vertically from the core. When the fuel assembly has been withdrawn out of the grapple zone, positive locking between the grapple and the fuel assembly is established so that uncoupling is prevented even in the event of inadvertent initiation of an uncoupling signal to the assembly. After removal from the core, the spent fuel assembly is moved underwater to the transfer area of the pool. The spent fuel assembly is lowered into the transfer carriage of the upending machine in the refueling cavity. If the fuel assembly contains a control element assembly, the CEA change mechanism transfers the CEA to a new fuel assembly which will have been brought into the transfer area from the storage area.

The new fuel assembly is removed from the carriage and moved to the reactor as the upending machine rotates the spent assembly to the horizontal position after which a cable drive transports the carriage on tracks through the transfer tube.

Once received in the fuel pool, another upending machine returns the transfer carrier to the vertical position. The spent fuel handling machine transfers a new fuel assembly to the carrier, removes the spent fuel assembly from the transfer carrier and transports it to the spent fuel rack. The new fuel assembly is carried through the transfer tube to the refueling cavity where the refueling machine picks it up and places it in its proper position in the core. The refueling machine is also used to rearrange fuel within the core in accordance with the fuel management program.

Neutron sources described in Chapter 4 are transferred between fuel assemblies at the upender position via a tool manipulated from the refueling machine. Capsules containing serveillance samples are similiarly removed from the reactor vessel using a tool manipulated from the refueling machine which then transports them to the upender station for insertion into a dummy fuel bundle. The transfer carrier transports the dummy assembly with the surveillance capsules to spent fuel storage area for eventual disassembly and disposition.

Dry sipping of fuel assemblies can be conducted, if required, during normal fuel handling operations. A portable control console is installed on the refueling machine with connections to a nitrogen gas supply, the fuel hoist, and the waste management system. Fuel is raised into the hoist box in the normal manner and the water displaced by applying a pressurized gas at the top of the sealed hoist box. When the box is allowed to refill, this gas is passed through a scintillation counter and the gas discharged to the containment vent header. The console contains the necessary controls for gas flow and for recording of gas activity levels. Once the hoist box is reflooded, fuel is discharged in the normal manner.

At the completion of the refueling operation, the fuel transfer valve is closed. The upper guide structure is reinserted in the vessel and the in-core instrumentation placed in position. The drive shaft extensions are reconnected to the CEA's. The water in the refueling cavity is lowered to the level of the vessel flange using one of the low pressure safety injection pumps. Draining of the refueling cavity is completed using the reactor drain pumps.

The head is simultaneously lowered with the water level to the vessel flange until the drive shaft extensions are engaged by the control element drive mechanisms. Lowering of the head is then continued until it is seated. Then the head is bolted down, and the transfer tube closure flange installed. The refueling cavity seal between the reactor vessel flange and the vessel cavity wall is removed. CEDM and in-core instrument cabling is reconnected. The ducting is reconnected to the CEDM cooling shroud, the vessel vent piping installed, and the missile shield placed in position.

After a period of 5 to 6 months for reduction of decay heat and radioactivity level, the spent fuel handling machine transfers the assemblies from the spent fuel racks to the spent fuel cask located in the northeast corner of the pool. The spent fuel cask is placed in the spent fuel cask laydown area by the overhead 105-ton crane. After the cask is loaded with spent fuel assemblies, the head is fastened to the cask for transport to the decontamination area.

In the decontamination area the cask is cleaned to remove surface contamination. After the cask surface contamination is reduced to a safe level the crane loads the spent fuel cask onto the shipping vehicle for transport to the reprocessing plant.

c) Component Description

1) Refueling Machine

The reactor refueling machine is shown in Figure 9.1-9. The refueling machine is a traveling bridge and trolley which is located above the refueling cavity and rides on rails set in the concrete on each side of the pool. Motors on the bridge and trolley accurately position the machine over each fuel assembly location within the reactor core or fuel transfer carrier. The hoist assembly contains an air operated grappling device which, when rotated by the actuator mechanism, engages the fuel assembly to be removed. The hoist assembly and grappling device are raised and lowered by a cable attached to the hoist winch. After the fuel assembly has been raised into the refueling machine, the refueling machine transports the fuel assembly to its designated location.

The controls for the refueling machine are mounted on a console which is located on the refueling machine trolley. Coordinate location of the bridge and trolley is indicated at the console by digital readout devices which are driven by encoders coupled to the guide rails through rack and pinion gears.

During withdrawal or insertion of either a fuel assembly, or a fuel assembly with a control element inserted, the load on the hoist cable is monitored at the console to ensure that movement is not being restricted. Limits are such that damage to the assembly is prevented.

Positive locking between the grapple and the assembly is provided by the engagement of the grapple actuator arm in axial channels running the length of the fuel hoist assembly. Therefore, it is not possible to uncouple even with the inadvertent initiation of an uncoupling signal to the actuator assembly. The drives for both the bridge and trolley provide close control for accurate positioning, and brakes are provided to maintain the position once achieved. Interlocks are installed so that movement of the refueling machine is not possible when the hoist is withdrawing or inserting an assembly. After operation of the hoist, a console-mounted bypass button must be pressed to allow movement of the bridge or trolley.

For operations in the core, the bottom of the hoist assembly is equipped with a spreading device to move the surrounding fuel assemblies to their normal core spacing to ensure clearance for fuel assemblies being installed or removed. An anticollision device at the bottom of the mast assembly prevents damage should the mast be inadvertently driven into an obstruction, and a positive mechanical up-stop is provided to prevent the fuel from being lifted above the minimum safe water cover depth. A system of pointers and scales serves as a backup for the remote repositioning readout equipment. Manually operated handwheels are provided for bridge, trolley and winch motions in the event of a power loss. Manual operation of the grappling device is also possible in the event that air pressure is lost.

2) Upending Machine

Two upending machines are provided, one in the containment refueling cavity and the other in the 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. Hydraulic cylinders, attached to both the upending frame and the support base, rotate the fuel carrier between the vertical and horizontal positions as 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.

3) Fuel Transfer Tube, Valve and Carriage

A fuel transfer tube extending through the containment wall connects the refueling cavity with the fuel pool as shown in Figure 9.1-7. During reactor operation, the transfer tube is closed by means of a blind flange on the containment end of the transfer tube. Prior to filling the refueling cavity, the flange is removed. After a common water level is reached between the refueling cavity and the fuel pool, the fuel transfer valve is opened. The procedure is reversed after refueling is completed.

The 36-inch diameter transfer tube is contained in a 48-inch diameter pipe which is sealed to the containment. The two concentric tubes are sealed to each other at both ends by welding rings and bellows-type expansion joints. The transfer tube valve is flange connected to the 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 gear operator for the valve is designed to allow for movement of the valve due to thermal expansions and still permit operation. The valve is designed for operation from the operating floor. Description of the transfer tube valve is given in Table 9.1-3.

A transfer carriage conveys the fuel assemblies between the refueling cavity and the fuel pool, moving them through the fuel transfer tube on a transfer carriage. 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 at the upending mechanisms. The carriage is pulled by stainless steel cables connected to the carriage and through sheaves to its driving winch mounted on the operating floor. A two-pocket fuel carrier is mounted on the carriage and is pivoted for tilting by the upending machines. The load on the transfer cables is displayed at the master control console. An overload will interrupt the transfer operation. Manual override of the overload cutout allows completion of the transfer. The supports for the replaceable rails on which the transfer carriage rides are welded to the 36-inch diameter transfer tube.

4) CEA Change Mechanism

The CEA change mechanism is shown in Figure 9.1-9. The mechanism that inserts CEA's into and removes CEA's from fuel assemblies is mounted on rails adjacent to the containment side upender and consists of a structural frame, a translation drive, and a grapple hoist. The mechanism can be moved to either of two operating positions above the upender cavities or a third parking position which permits access of the refueling machine to the upender positions. At the bottom of the hoist section an alignment device centers the fuel assembly to the grapple centerline and a finger guide maintains the pattern of the five control rod fingers when the CEA is withdrawn. A rotary grapple engages the CEA for lifting. The grapple rides in a vertical channel section so that inadvertent release of the CEA is not possible. Grapple load is monitored and position readout is provided for both hoisting and translation drives. The operator's control station is located at the edge of the refueling cavity where all operations can be monitored. Interlocks are provided to ensure that translation cannot occur during hoisting, and vice versa. The equipment, including all moving parts, may be lifted off the rail for maintenance or repair.

5) Fuel Handling Tools

Two fuel handling tools are used to move fuel assemblies in the fuel pool area. A short tool is provided for dry transfer of new fuel, and a long tool is provided for underwater handling of both spent and new fuel in the fuel pool. The tools are operated manually from the walkway on the spent fuel handling machine.

6) Reactor Vessel Head Lifting Rig

The reactor vessel head lifting rig is shown in Figure 9.1-11. This 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 three hoists used for handling the reactor vessel stud tensioners.

7) Reactor Internals Handling Equipment

Two lifting rigs are used to remove either the upper guide structure or the core support barrel from the reactor vessel and to raise and lower the in-core instrumentation support plate assembly.

The upper guide structure lifting rig is shown in Figure 9.1-8. This lifting rig consists of a delta spreader beam which supports three columns providing attachment points to the upper guide structure. Attachment to the upper guide structure is accomplished manually from the working platform by means of lifting bolt torque tools. The integral in-core instrumentation hoist connects to an adaptor which is manually attached to the in-core instrumentation structure by utilizing an adaptor torque tool. The in-core instrumentation is then lifted by the polar crane auxiliary 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 core support barrel lifting rig, shown in Figure 9.1-12, is used 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 threaded to the core support barrel flange. This is done manually from the refueling machine bridge by means of the lifting bolt torque tool. Correct positioning of the lifting rig is assured by guide bushings which mate to the reactor vessel guide pins.

8) Stud Tensioners

Three hydraulically operated stud tensioners are used to apply and remove the preload on the reactor vessel head closure studs. These tensioners are suspended from pneumatic 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 the closure nuts are seated, the hydraulic pressure is released which results in the preload necessary to maintain the seal between the reactor vessel and the reactor vessel head.

A portable pumping unit mounted 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 an air valve for operating the pump. A hydraulic gauge showing the pump pressure is also provided as is the hydraulic release valve.

9) Surveillance Capsule Retrieval Tool

A retrieval tool is used during the refueling shutdown for manual removal of the irradiated capsule assemblies of the reactor vessel materials surveillance program described in Section 5.4.4. The surveillance capsule retrieval tool is shown in Figure 9.1-13. The tool is operated from a position on the carriage walkway of the refueling machine. Access to the capsule assembly is achieved by inserting the tool through 3-inch diameter retrieval holes in the core support barrel flange provided at each capsule assembly radial location. A female acme thread at the end of the retrieval tool is mated to the surveillance capsule lock assembly (Figure 5.4-3) by turning the retrieval tool handle. A compressed spring in the lock assembly exerts a high frictional force at the retrieval tool-lock assembly interface to prevent disengagement during retrieval.

The overall length of the tool is 45.5 feet. The tool consists of two parts to facilitate storage. The upper portion is a 2-inch diameter tube and handle. The lower portion of the tool is also a 2-inch tube with a 1-inch outer diameter at the connector end. A 3/4-inch diameter hole in the upper end of the tool permits the polar crane to assist with the retrieval procedure and prevents inadvertent dropping of the tool. The tool is made of aluminum and has a dry weight of 40 pounds.

10) CEA Uncoupling Tool

This tool is approximately 17 feet long and consists basically of two concentric tubes with a conical lead-in at the end to facilitate engagement with the CEDM 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.

11) Underwater Television

A high resolution closed circuit television system is provided to monitor the fuel handling operations inside the containment. The camera is mounted on the refueling machine mast so that the fuel assembly can be sighted prior to and during grappling and removal from the core. The system may be used to initially align the refueling machine position indication system with the actual core location of the fuel assemblies. A portable monitor is provided at the refueling machine control console. The camera, if required for remote surveillance or inspection, can be removed from its mount on the mast and handled separately.

12) Dry Sipping Equipment

A dry sipping system is provided to test irradiated fuel assemblies for cladding defects. This system consists of both permanently mounted components on the refueling machine and a portable control console that is set onto the refueling machine trolley when a dry sipping test is to be performed. The refueling machine fuel hoist box is modified to allow plugging of the recirculation holes and hose connections are added so that pressurized nitrogen gas can replace the cooling water within the hoist box. This gas is vented through a scintillation counter after the soak period has been completed. Temperature detectors are also installed to indicate the temperature of the gas surrounding the suspect fuel assembly. The gas is vented to the gas collection header.

The portable control console contains the sequencing mechanism which first surrounds the fuel assembly with nitrogen and then ports the gas to the integral scintillation counter. Strip chart recorders record the dose rate and also the nitrogen temperature surrounding the fuel assembly and a pressure gauge displays the depth of the water interface in the hoist box. A tank and float valve prevents flow of contaminated water through the console and a high temperature alarm automatically initiates venting which replaces the gas surrounding the fuel assembly with cooling water.

13) 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 upenders. The hydraulic fluid may be either borated or nonborated water.

14) Refueling Pool Seal

A watertight seal (Figure 9.1-4) is provided for installation between the reactor vessel flange and the floor of the refueling cavity. The seal is installed for the refueling operation. Provisions are made to test the seal after installation and before flooding the refueling cavity. Leak rate is monitored during refueling to assure that no sudden change in water level will occur.

9.1.4.3 System Evaluation

a) The single failure mode analysis of the fuel handling equipment is shown in Table 9.1-5.

b) The analysis presented in Section 15.4.3 assumes damage to the entire group of fuel rods in an assembly as a basis for the fuel handling accident. The exclusion boundary doses resulting from a fuel handling accident are within the guidelines of 10 CFR Part 100.

c) Reliability of the fuel handling equipment and the associated instrumentation and controls, is assured through the implementation of preoperational tests and routines. Prior to any fuel loading, the equipment is cycled through its operations using a dummy fuel bundle specifically for this purpose. In addition, the following special features of the equipment assure safe and reliable operation:

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

2) Equipment has 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 will propel it into the water of the refueling cavity or fuel pool, these parts and fasteners are lockwired or otherwise positively captured.

3) 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.

4) Positive mechanical stops prevent the fuel from being lifted above the minimum safe water cover depth and will not cause damage or distortion to the fuel or the fuel handling equipment when engaged at full operating hoist speed.

5) The hoist is provided with a load measuring device with a visual display of the load and interlocks to interrupt hoisting if the load increases by more than 10 percent and interrupt lowering if the load decreases by more than 10 percent.

6) The stresses under the combined deadweight, live, and operating basis earthquake loads do not exceed the allowable stress of the material per AISC requirements. The equipment can withstand the loading induced by the design base earthquake vertical and horizontal loadings which are considered as acting simultaneously in conjunction with normal loads without exceeding minimum material yield stresses as specified by AISC. Where required, keepers are provided to preclude derailment of equipment under seismic loading.

7) Gamma radiation levels in the containment and fuel storage areas are continuously monitored. These monitors provide an audible alarm at the initiating detector indicating an unsafe condition. Continuous monitoring of the count rate provides immediate indication of an abnormal core flux level in the control room and in the containment.

8) There is direct communication between the control room and the refueling machine console during fuel handling operations. This provision allows the control room operator to inform the refueling machine operator of any impending unsafe condition detected from the control room during fuel movement.

TABLE 9.1-5

SINGLE FAILURE MODE ANALYSIS OF FUEL HANDLING EQUIPMENT

Component Identification	Failure Mode	Detrimental Effect On System	Corrective Action	Remarks
R. M. 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	Max. stall torque of motor will not damage bundle.
Fuel Carrier	Wheels lock in transfer tube	Transfer change completed	Switch to 5 hp mode	Load 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 basis	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
R. M. 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	Indexing can be accomplished by back-up scale and pointer
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

TABLE 9.1-5 (Cont.)

SINGLE FAILURE MODE ANALYSIS OF FUEL HANDLING EQUIPMENT

Component Identification	Failure Mode	Detrimental Effect On System	Corrective Action	Remarks
Refueling Machine TV Camera	Electrical Failure	None	Repair non-interferring basis	Not mandatory for fuel handlin
Refueling Machine Electronic Hoist position indication	Electrical Failure	None	Repair non-interferring basis	Redundant mechanical counter provided
CEA Change mechanism	Electrical and air failure	None	Repair	Continue, using manual operator

9) The fuel transfer tube is large enough to provide natural circulation cooling of a fuel assembly in the unlikely event that the transfer carriage should be stopped in the tube. The operator for the fuel transfer tube valve extends from the valve to the operating elevation. Travel stops in the fuel handling equipment limit the travel to restrict withdrawal of the spent fuel assemblies. This limitation, together with water level control, results in the maintenance of a minimum water cover of 9 feet over the active portion of the fuel assembly resulting in a radiation level of 2.5 mr/hr or less at the surface of the water. The depth of water surrounding the fuel transfer canal, transfer tube and spent fuel storage pool is maintained to limit the maximum continuous radiation levels in working areas to 2.5 mr/hr.

10) The arrangement of the fuel handling building has been designed such that the spent fuel cask can not traverse over spent fuel.

11) Miscellaneous design features include - backup hand operation of hoist and traverse drives in the event of power failure, a dual wound transfer system motor to permit applying an increased pull on 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 assembly is drawn by the refueling machine, transfer system upender manual operation by a special tool in the event that the hydraulic system becomes inoperative, and removal of the transfer system components from the refueling cavity for servicing without draining the water from the pool.

9.1.4.4 Tests And Inspections

The entire fuel handling system is tested using a dummy fuel bundle before the system is put into operation.

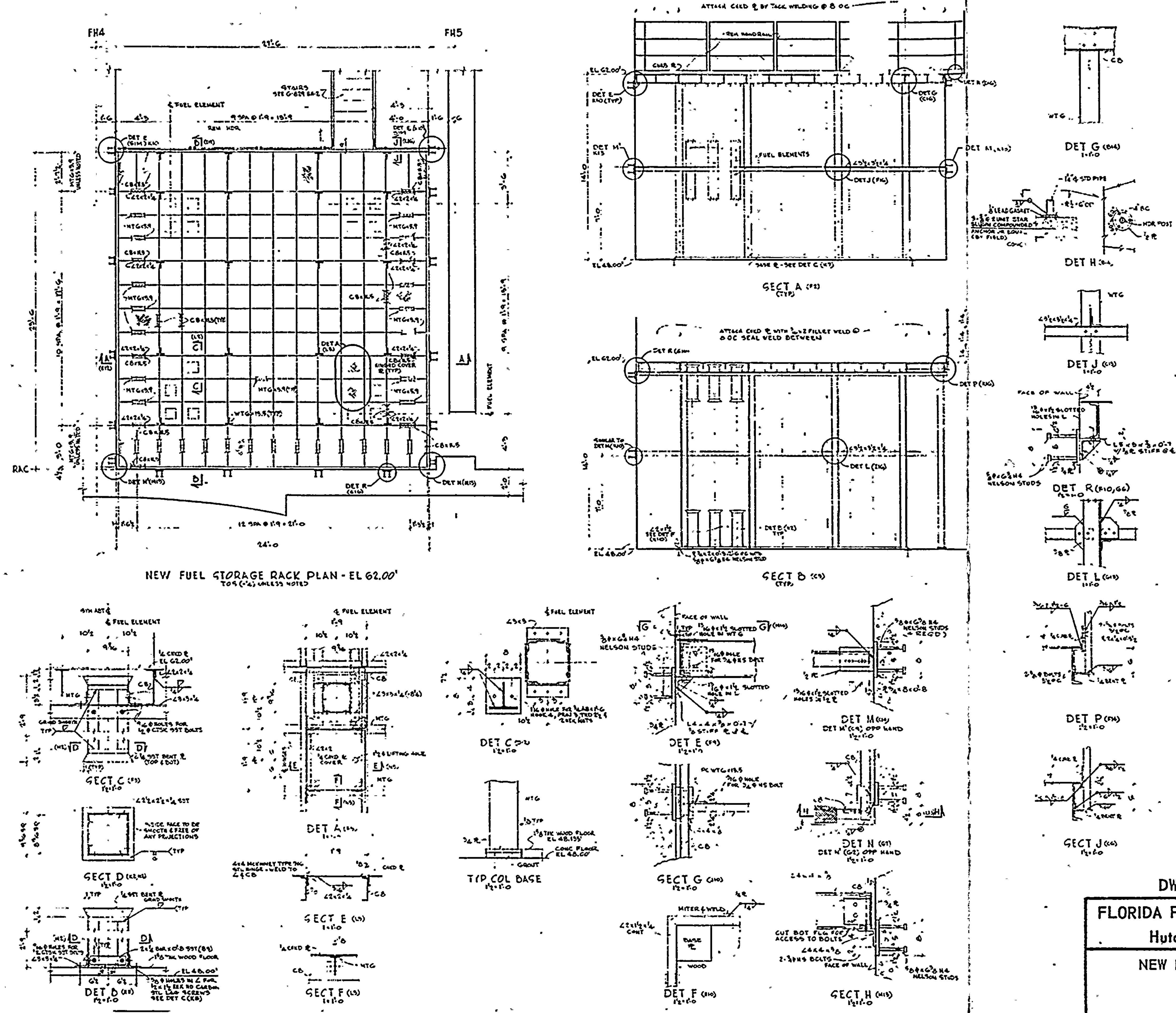
The following specific tests are performed on the individual equipment in addition to the above test. The spent fuel cask crane cables are periodically load tested. Hooks and grapples which are designed to support fuel assemblies are tested at 125 percent of rated load. After the 125 percent load test, they are subjected to liquid penetrant inspection. After installation, the cranes are thoroughly field tested using a dummy fuel bundle.

During manufacture of the fuel handling equipment 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 welds loaded in excess of 10,000 psi. 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 bundle and a dummy CEA, each having the same weight, center of gravity, exterior size and end geometry as an actual fuel 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 tested to 125 percent of maximum working load. Set points 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 set points 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 installed in the plant, the equipment is again tested and the results compared to the results of tests performed at the vendor's plant. Any changes in adjustment and condition which may have ensued from transit to the site are noted. Plant testing permits determination of characteristics which are unique to the actual site installation and therefore cannot be duplicated in the vendor's shop test. Each component is inspected and cleaned prior to installation into the system. Prior to equipment operation recommended maintenance, including any necessary adjustments and calibrations, is performed. Pre-operational tests also include checks of all control circuits including interlocks, safety, and alarm functions.

Fuel Cask Handling Crane Load Testing

Both main and auxiliary hooks will be tested to 125 percent of rated capacity. The crane manufacturer will furnish copies of certified mill test and mechanical test reports covering hooks and hoist ropes.



NOTES

℄ OF CELL AT UPPER SUPPORT SHALL LIE WITHIN 1/16 OF ℄ OF CELL AT LOWER SUPPORT

WOOD SHALL BE REDWOOD YARD LUMBER GRADE OF ALL HEARTWOOD IN ACCORDANCE WITH THE "CRA" SPECIFICATIONS. WOOD SHALL BE FIRE RETARDANT AND SUPPLIED BY FIELD

ALL STAINLESS STEEL SHALL CONFORM TO ASTM SPECS A-167, TYPE 304 WITH A "2D FINISH

DESIGN, FABRICATION & ERECTION OF STRUCTURAL STEEL SHALL BE IN ACCORDANCE WITH EBASCO SPEC FLO-8770-761, AND STEEL SHALL BE ASTM A36 UNLESS NOTED

ALL HANDRAILING & POSTS SHALL BE 1¼ Ø HOT DIP GALV STD NPS. POSTS SHALL BE NOT MORE THAN 6-0 ON CTRS. TURNS SHALL BE BENT & NOT MITERED; WELDED AREAS SHALL BE CLEANED & TOUCHED UP WITH ZINC RICH PAINT

CHECKERED PLATES SHALL BE HOT DIP GALV. FOUR WAY SAFETY TREAD. AFTER WELDING, ALL PLATES SHALL BE CLEANED & TOUCHED UP WITH ZINC RICH PAINT

FOR GALVANIZING OF CHKD PL, BOLTS, ETC - SEE EBASCO SPEC FLO-8770-761

ALL ANCHOR BOLTS & EMBEDDED PLATES SHALL BE FURNISHED BY FIELD UNLESS NOTED

STEEL SURFACES UNLESS NOTED SHALL BE BLAST CLEANED IN ACCORDANCE WITH STEEL STRUCTURES PAINTING COUNCIL SPEC "SSPC-SP6" COMMERCIAL BLAST CLEANING. SHOP PAINT SHALL BE ONE COAT 3½ MIL DRY FILM THICKNESS OF CARBO ZINC 11 AS MFD BY THE CARBOLINE COMPANY, APPLIED IN STRICT ACCORDANCE WITH THE MFR INSTRUCTIONS. SURFACES IN CONTACT WITH CONCRETE SHALL NOT BE PAINTED

ALL CONN ¾ Ø HS BOLTS UNLESS NOTED

WELDING OF STAINLESS STEEL SHALL CONFORM TO THE FOLLOWING: AWS A-5.4 CLASS E 308 OR AWS A-5.9 CLASS ER 308 TO JOIN STAINLESS STEEL TO STAINLESS STEEL AND AWS A-5.4 CLASS E 309 OR AWS A-5.9 CLASS ER 309 TO JOIN STAINLESS STEEL TO CARBON STEEL

WELDING SHALL BE DONE USING THE GAS METAL-ARC (MIG) WELDING PROCESS (INERT GAS SHIELDED) GAS TUNGSTEN ARC (TIG) WELDING PROCESS, OR THE SHIELDED METAL-ARC WELDING PROCESS OR OTHER APPROVED PROCESS

REFERENCE DRAWINGS

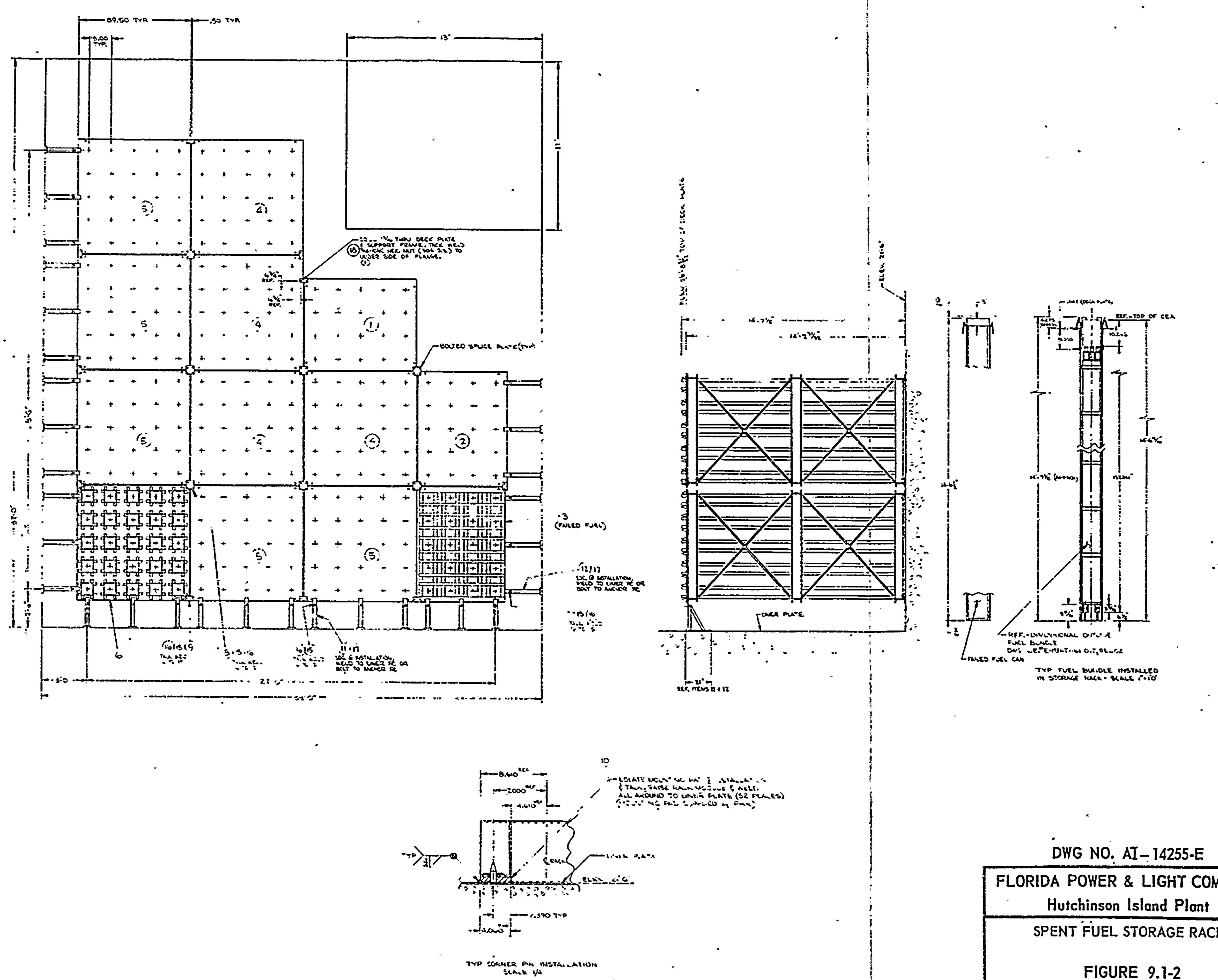
LIST OF DRAWINGS	A-146
FUEL HANDLING BLDG STAIRS & PLATF'M	G-829 SH2

DWG NO. 8770 –G-832

FLORIDA POWER & LIGHT COMPANY
Hutchinson Island Plant

NEW FUEL STORAGE RACKS

FIGURE 9.1-1



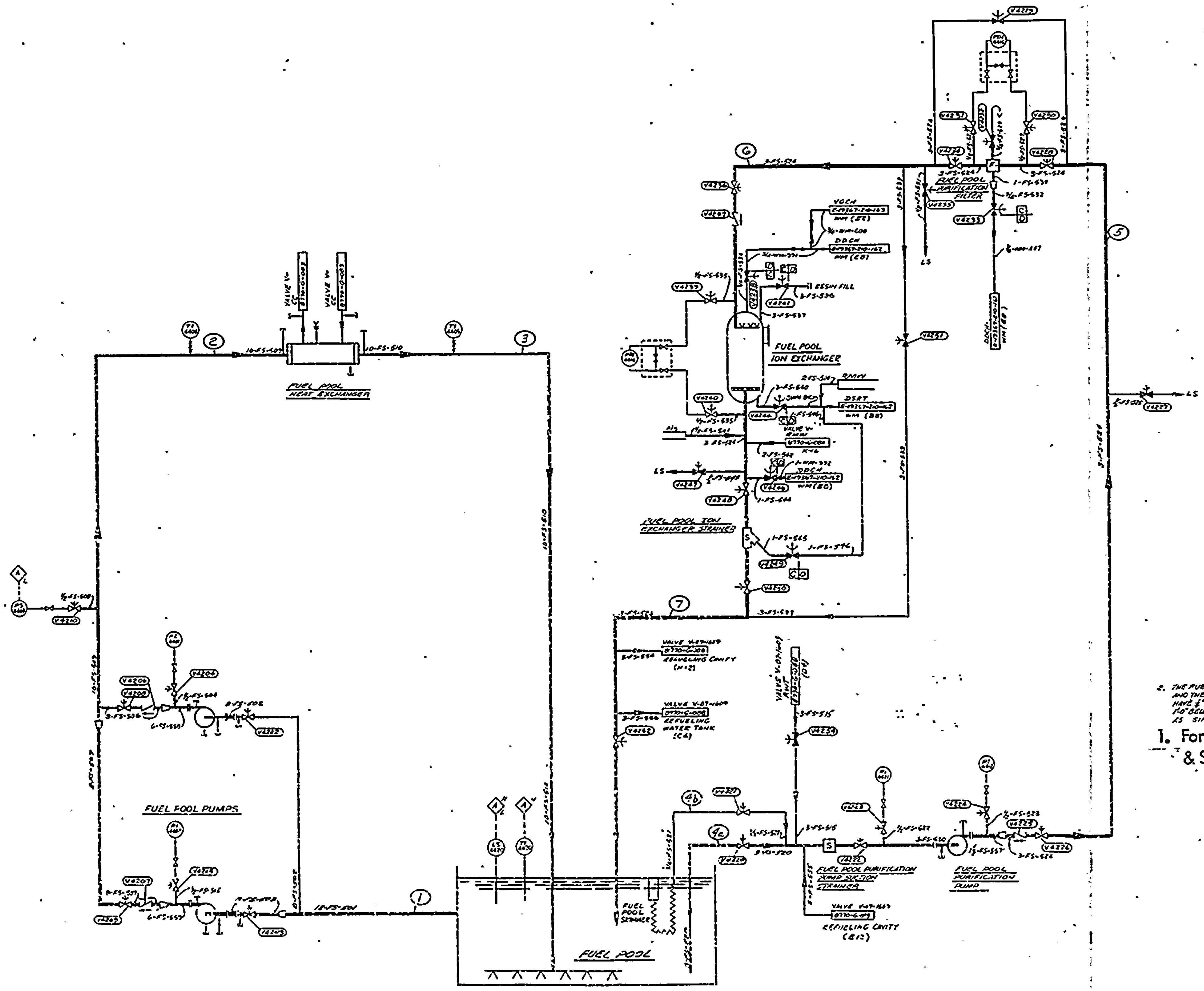
DWG NO. AI-14255-E

FLORIDA POWER & LIGHT COMPANY

Hutchinson Island Plant

SPENT FUEL STORAGE RACKS

FIGURE 9.1-2



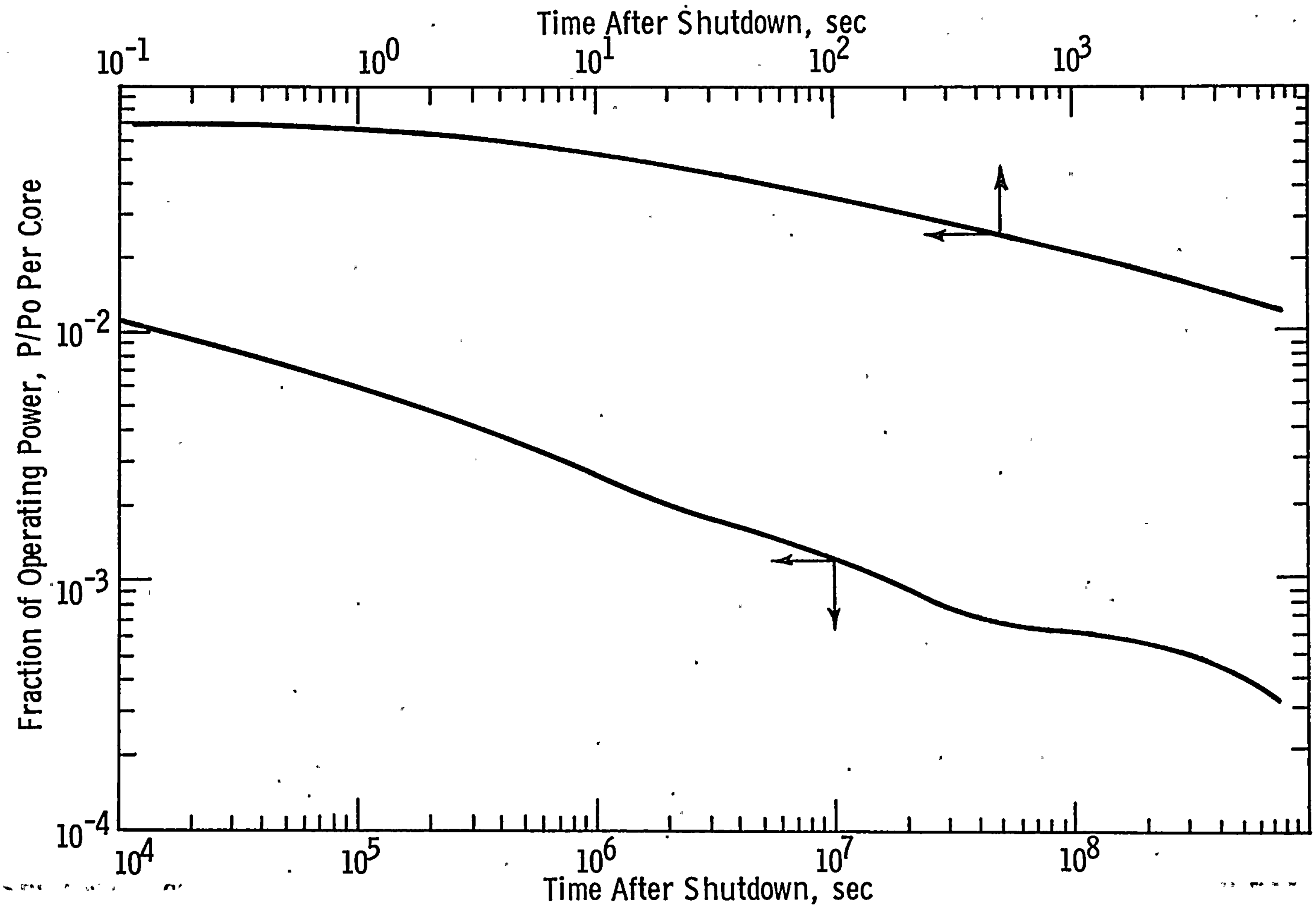
2. THE FUEL POOL PURIFICATION SUCTION LINE (3-FS-5..) AND THE FUEL POOL COOLING RETURN LINE (10-FS-510) HAVE 1/4" AND 1/2" DRILLED HOLES RESPECTIVELY LOCATED 1'-0" BELOW THE NORMAL POOL LEVEL TO SERVE AS SIPHON BREAKERS.

1. For Legend, Abbreviations, & Symbols See Fig. 1.2-20

13-142

REF. DWG. No. E-19367-210-140, REV. 05

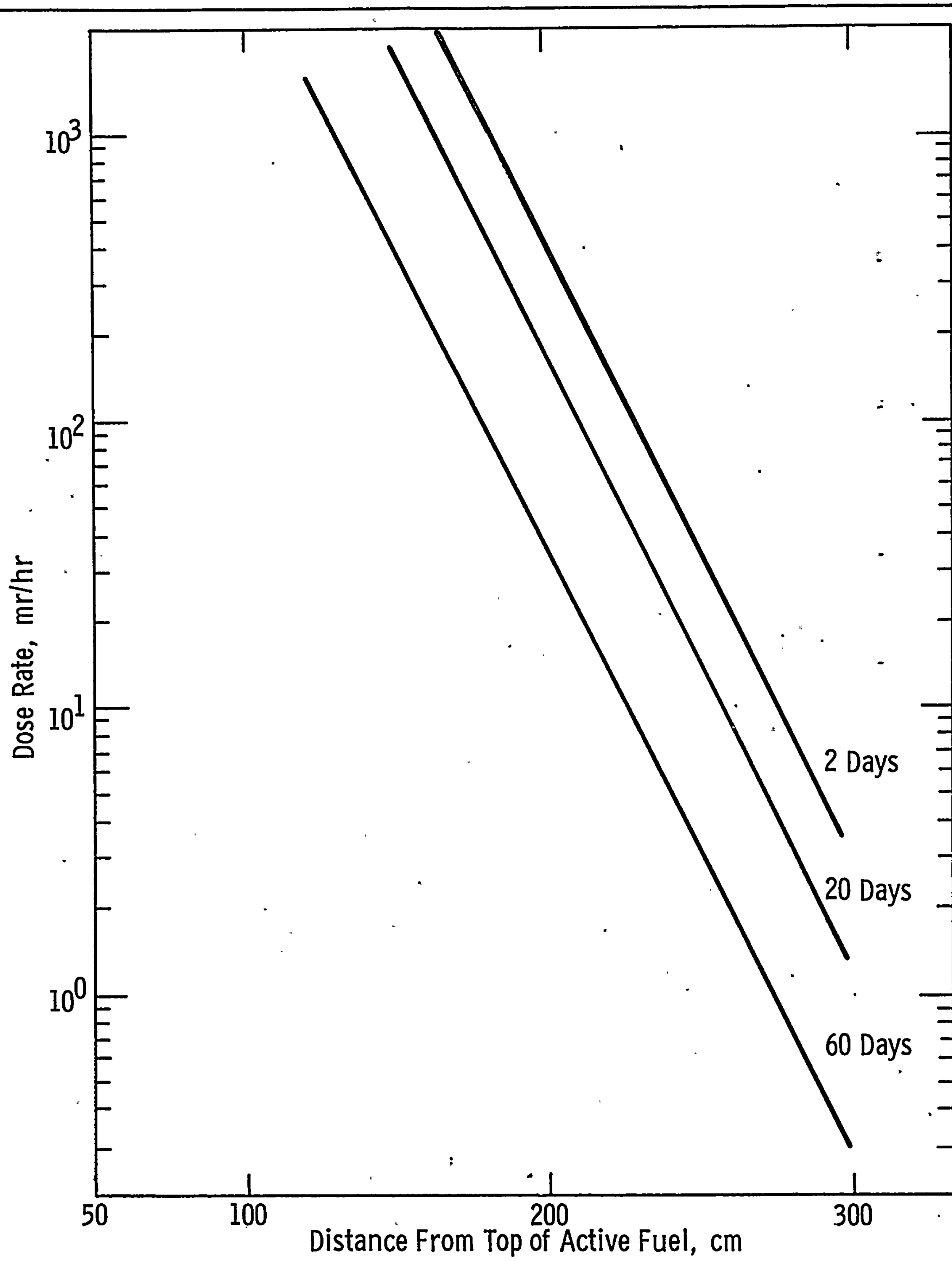
FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Fuel Pool System - P & I Diagram	Figure 9.1-3



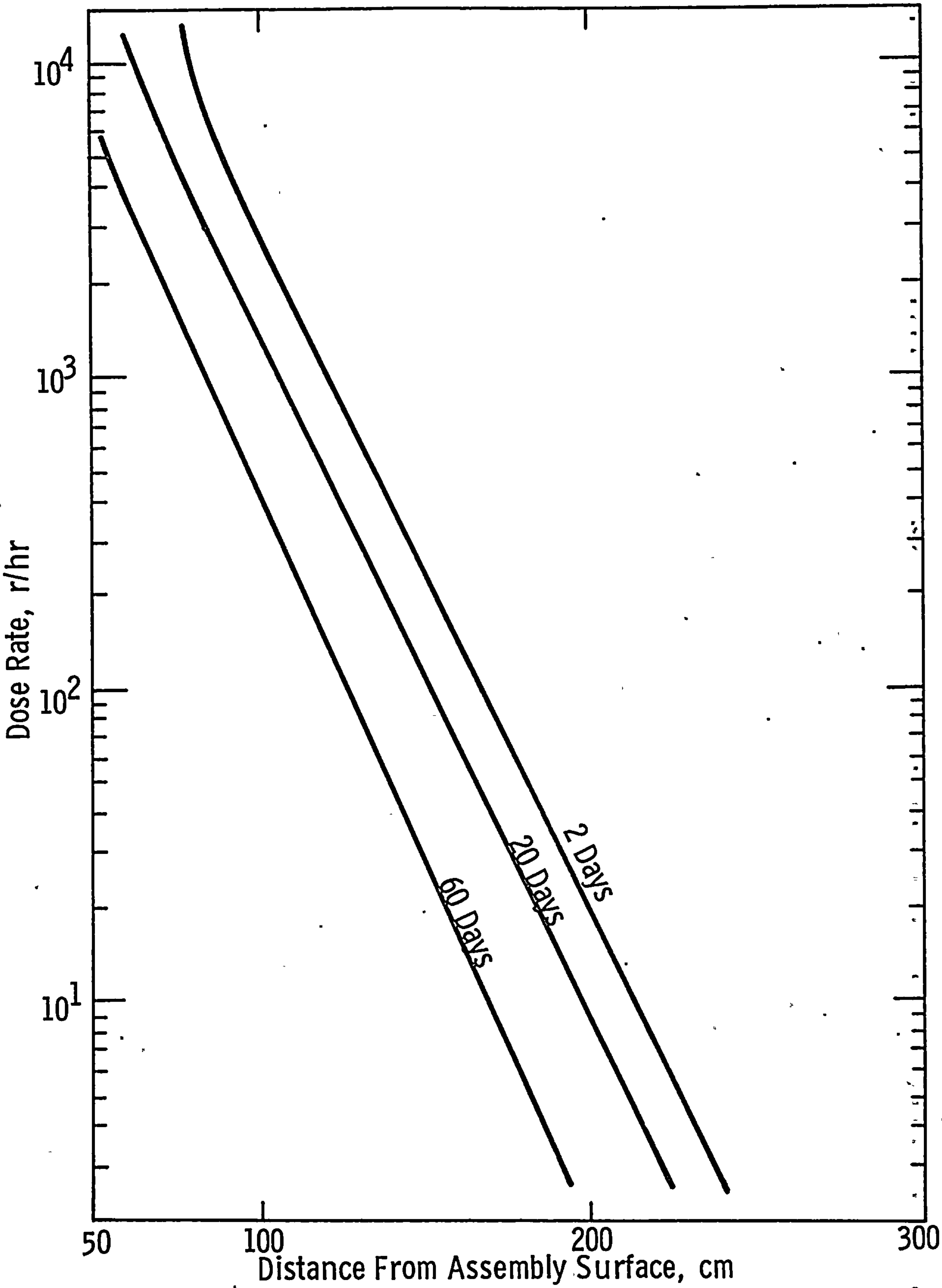
FLORIDA POWER & LIGHT CO.
Hutchinson Island Plant

Fission Product Decay Heat Curve
(Infinite Irradiation)

Figure 9.1-4

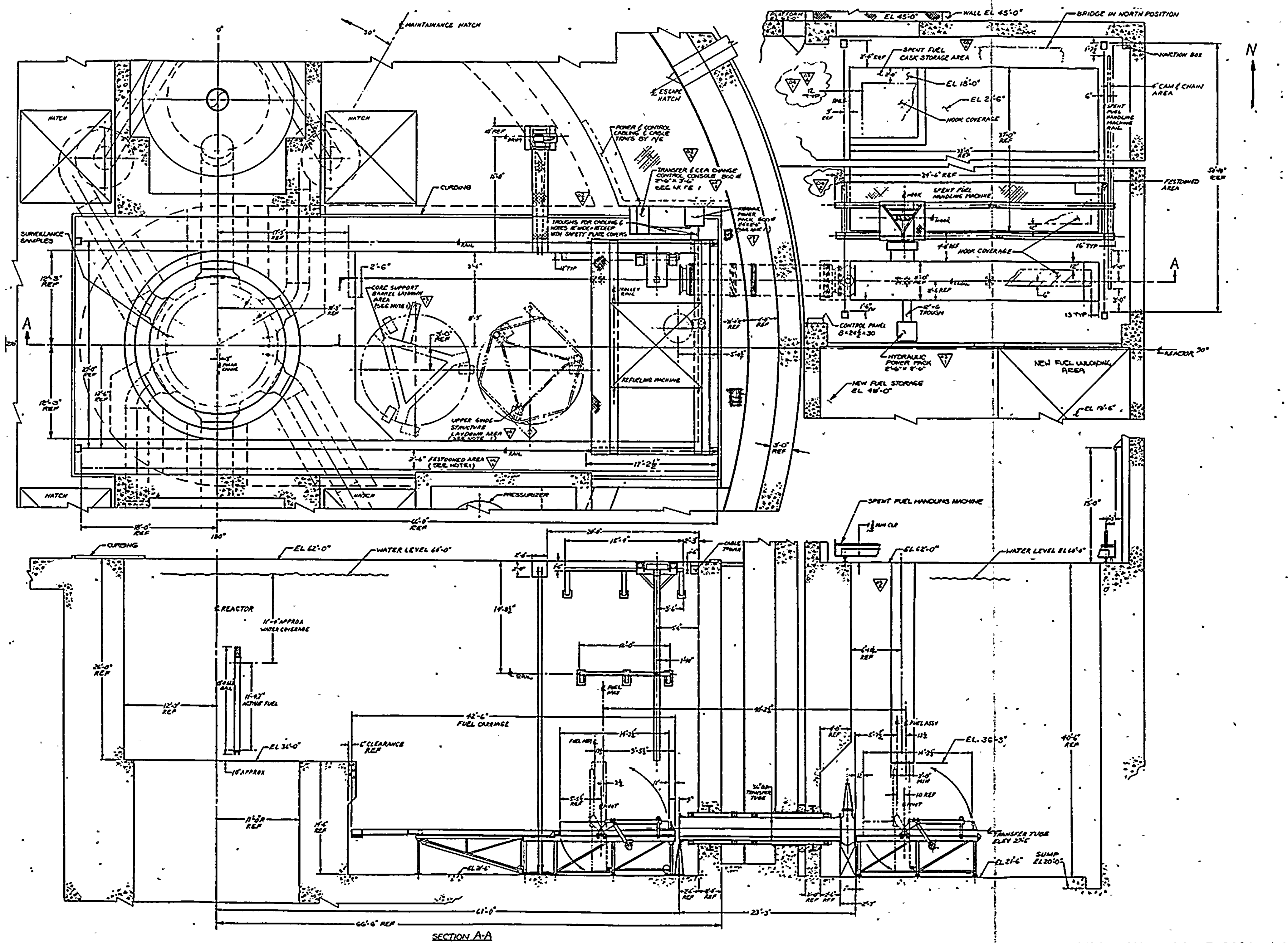


FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Dose Rate Axially From Top of Spent Fuel Assembly in Water	Figure 9.1-5



13-141

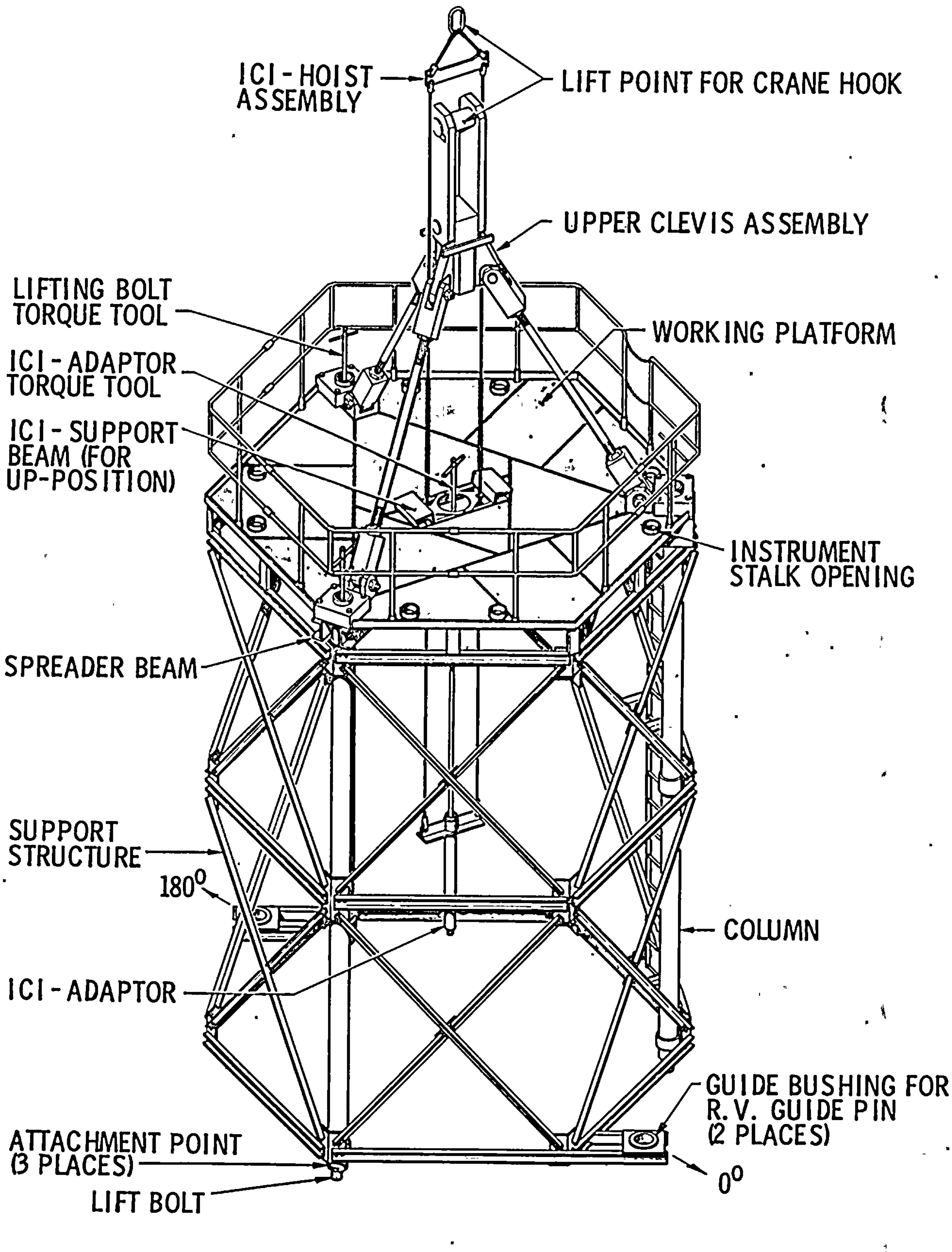
FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Dose Rate From Side - A Single Spent Fuel Assembly in Water	Figure 9.1-6



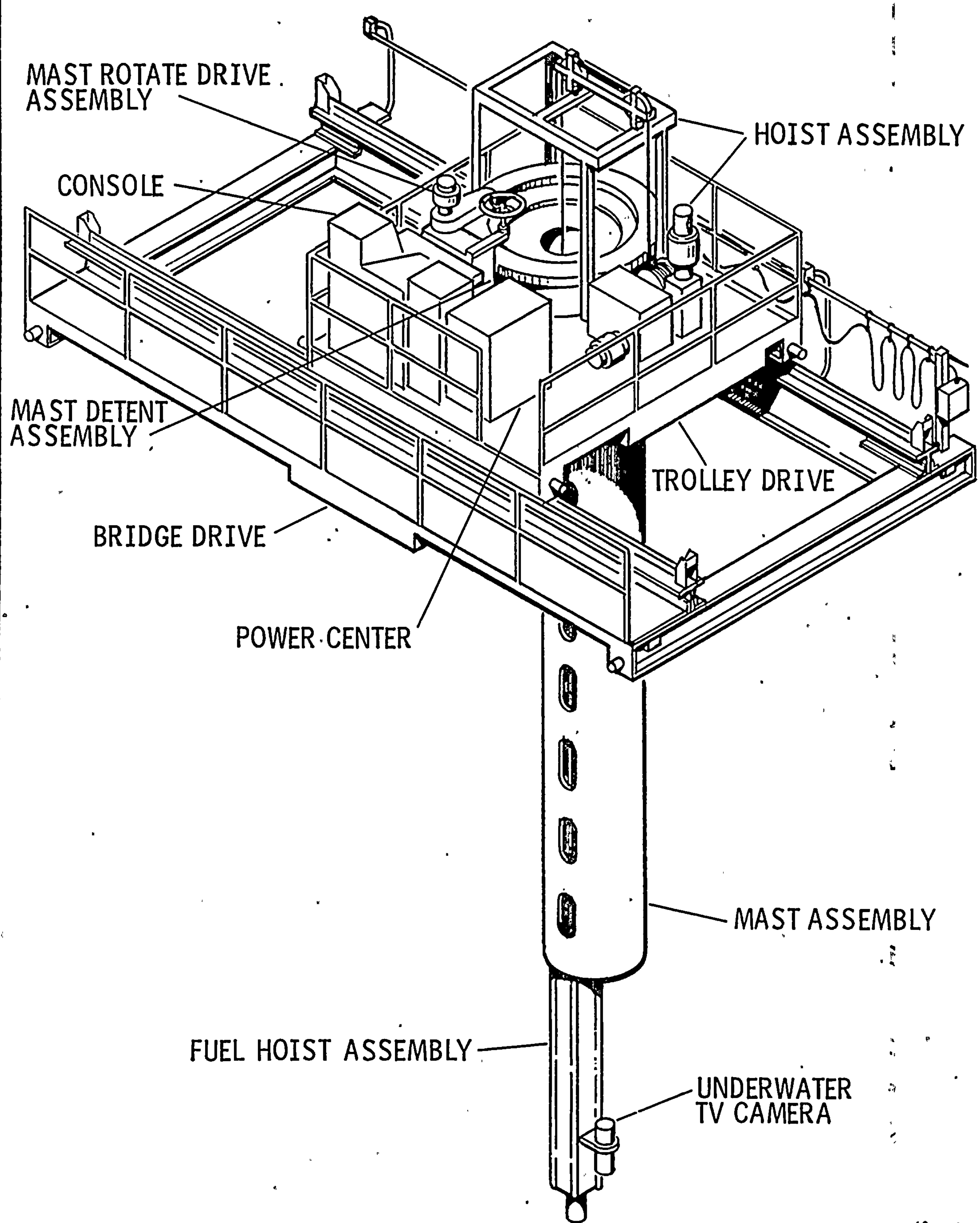
REF. DWG. No. E-19367-230-001, REV. 04

13-143

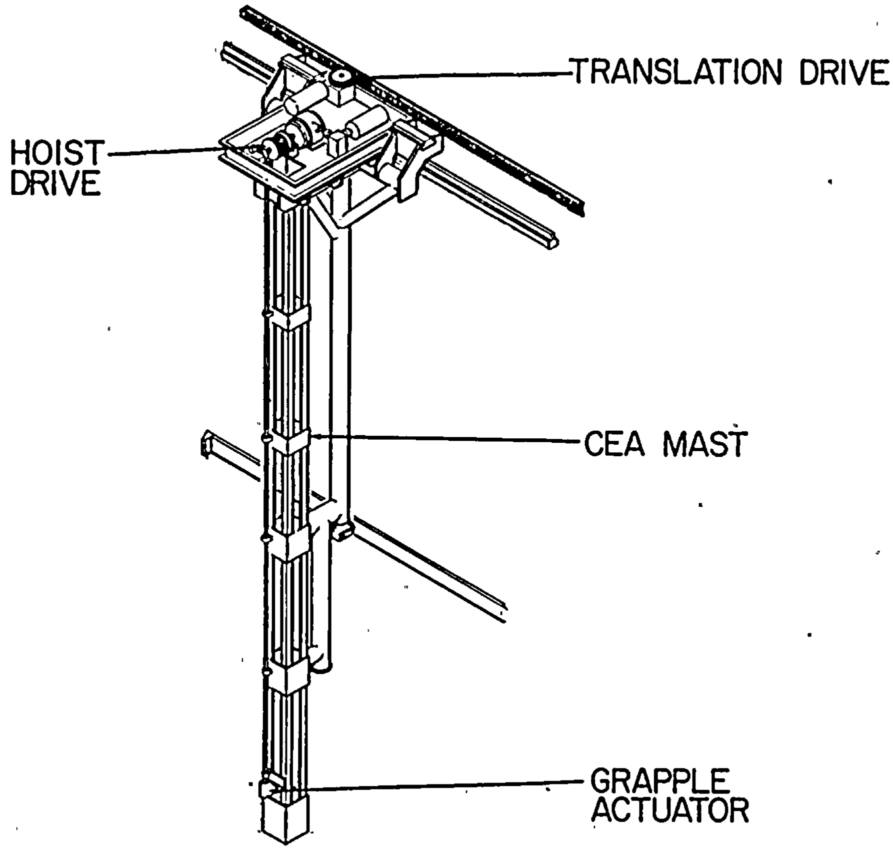
FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Reactor Refueling Arrangement	Figure 9.1-7



FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Upper Guide Structure Lifting Rig	Figure 9.1-8



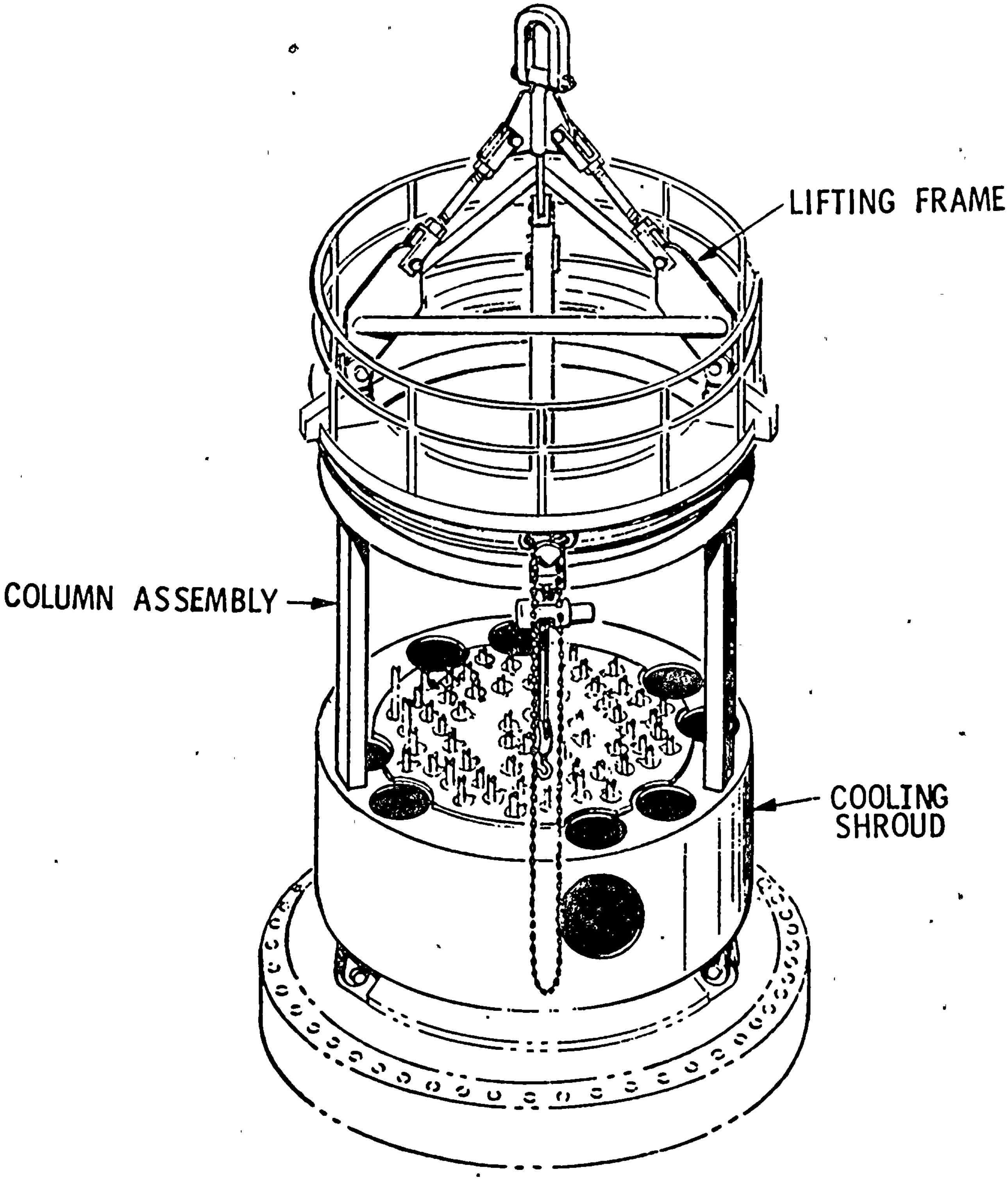
FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Refueling Machine	Figure 9.1-9



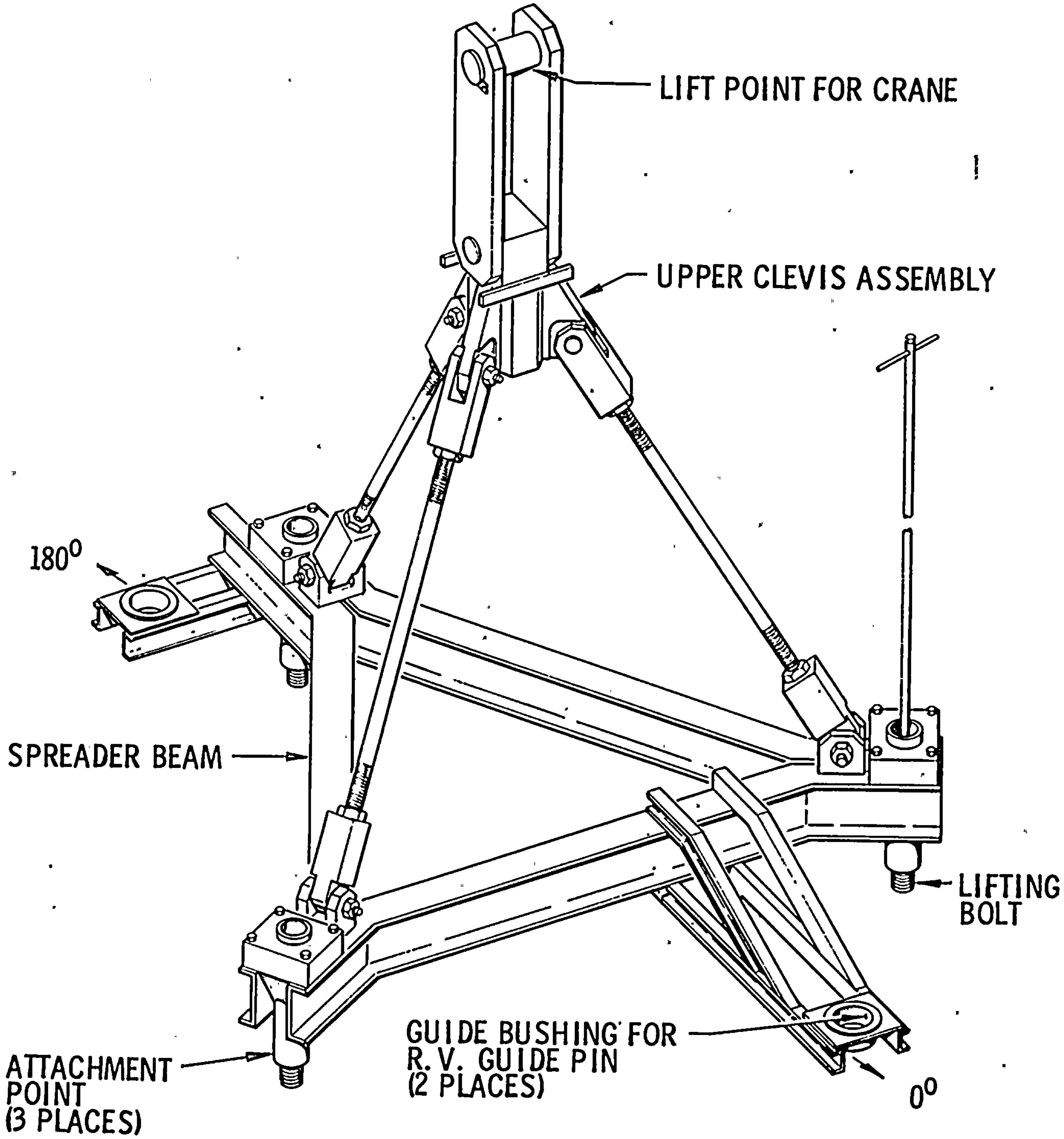
FLORIDA POWER & LIGHT CO.
Hutchinson Island Plant

CEA Change Mechanism

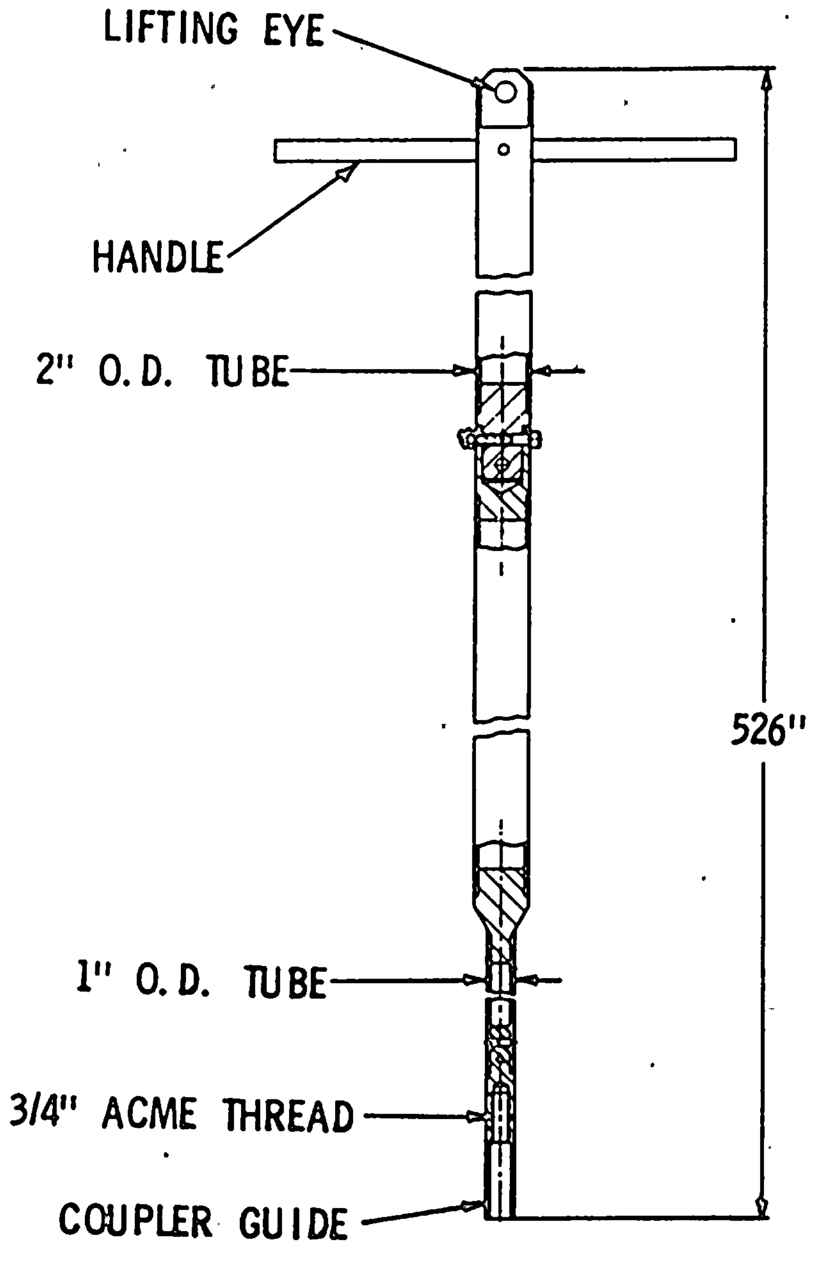
Figure 9.1-10



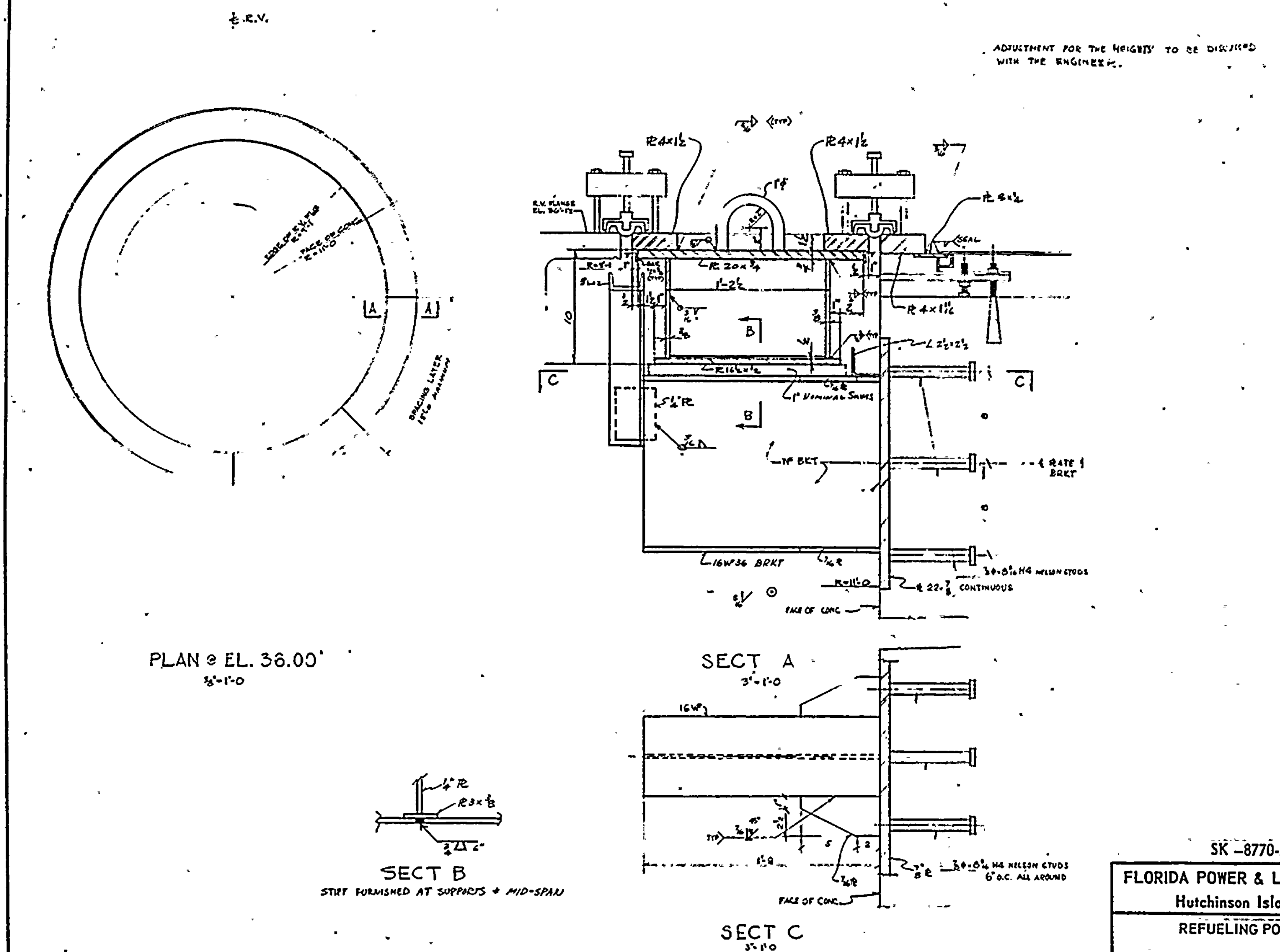
FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Reactor Vessel Head Lifting Rig	Figure 9.1-11



FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Core Support Barrel Lifting Rig	Figure 9.1-12



FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Surveillance Capsule Retrieval Tool	Figure 9. 1-13



SK -8770-A594

FLORIDA POWER & LIGHT COMPANY

Hutchinson Island Plant

REFUELING POOL SEAL

FIGURE 9.1-14

9.2 WATER SYSTEMS

9.2.1 INTAKE COOLING WATER SYSTEM

9.2.1.1 Design Bases

The intake cooling water system is designed to:

a) provide a heat sink for the component cooling and turbine cooling water systems under normal operating and shutdown conditions

b) provide a heat sink for the component cooling system under safe shutdown or LOCA conditions, assuming a single active component failure

c) withstand design basis earthquake loads, tornado loads or maximum flood levels without loss of safety function

d) permit periodic inspection and testing of equipment to assure system integrity and capability

9.2.1.2 System Description

The intake cooling water system is shown in Figure 9.2-1A through 1E. The system consists of three pumps and associated piping and valves. The system removes heat from the component cooling heat exchangers and the turbine cooling heat exchangers and discharges it to the condenser discharge canal. Intake cooling water from the intake structure flows through basket strainers located at the inlets of the component cooling and turbine cooling heat exchangers, passes through the tube side of the exchangers, and flows to the discharge canal.

The intake cooling water system is divided into two redundant supply header systems designated A and B. Both header systems, each aligned with an intake cooling water pump, supply normal plant operating and shutdown requirements. However, during accident conditions, one pump and header is adequate to supply the required cooling water to one component cooling heat exchanger. The turbine cooling water heat exchangers are supplied by nonessential headers which are automatically isolated on SIAS by valves I-MV 21-2 and 21-3. In the event that either pump 1A or 1B fails, intake cooling pump 1S may be aligned with either header A or B by positioning of the pump discharge header cross connect valve.

Both the intake and circulating water pumps require lubricating water. Lubricating water flow to the intake and circulating water pumps is initiated using the domestic water system. After the intake cooling water pumps have started they are used to supply lubricating water for themselves and for the circulating water pumps.

System design data are presented in Table 9.2.1. A description of the intake and discharge structures is given in Section 9.2.3.

TABLE 9.2-1

DESIGN DATA FOR INTAKE COOLING WATER SYSTEM

1. Intake Cooling Pumps	
Type	Single stage, vertical
Quantity	3
Capacity, each, gpm	14,500
Head, feet	130
Design temperature, F	95 (max)-40(min)
Material	
Case	Type 316 SS
Impeller	Type 316 SS
Shaft	Type 316 SS
Motor	600 hp, 4000 v, 3 phase, 60 hz 900 rpm, with 1.15 Service Factor
Motor enclosure	WP II
2. Lube Water Requirements	
Flow, gpm	20
Pressure, psig	10
3. Codes	NEMA, Standards of the Hydraulic Institute ASME Section VIII, ASTM, and ANSI, Nuclear Pump & Valve Code Class III
4. Discharge Piping	
Material (above ground)	
14 inch and larger	3/8 inch wall carbon steel pipe with 1/8 inch cement lining or cast iron
3 inch to 12 inch	Std wall carbon steel pipe with 1/8 inch cement lining
2½ inch and under	Aluminum Brass

TABLE 9.2-1 (Cont'd)

DESIGN DATA FOR INTAKE COOLING WATER SYSTEM

5.	Connections	
	Cement Lined Steel	
	2 inches and smaller	Screwed
	$2\frac{1}{2}$ inches and larger	Flanged
	Cast Iron	
	2 inches and smaller	Flanged
	$2\frac{1}{2}$ inches and larger	Flanged
6.	System design pressure, psig	100
7.	System design temperature, F	125
8.	Valves	
	$2\frac{1}{2}$ inch and smaller	Bronze - screwed
	3 inch and larger	Carbon steel - rubber lined. Flanged and/or wafer.
9.	Code	ANSI - B31.7, Class III - and B31.1

9.2.1.3 System Evaluation

9.2.1.3.1 Performance Requirements and Capabilities

The intake cooling water system is designed to supply sufficient cooling water to the component cooling heat exchangers to fulfill emergency requirements in the event of the design basis LOCA. Each essential header, with one intake cooling water pump operating, fulfills the requirements of one component cooling heat exchanger during normal, shutdown, and LOCA conditions.

The intake cooling water system is sized to ensure adequate heat removal with a design seawater temperature of 95F at plant rated power.

9.2.1.3.2 Single Failure Analysis

Only one intake cooling water pump and one essential header are required to remove the post-accident heat load from one component cooling heat exchanger. Each component cooling heat exchanger is capable of post-accident heat removal duty (Section 9.2.2.3.1). Two redundant full capacity essential headers and three full capacity pumps are provided, one pump and one header for each component cooling heat exchanger to assure adequate cooling capability if one system fails. The third pump can be connected to either heat exchanger. Electrical power for each header system is supplied from a separate emergency power bus such that no single electrical failure can prevent operation of both header systems.

The redundant essential headers are isolated from each other during emergency conditions by two valves (I-SB-21-7) in the tie line connecting the headers. Each essential header is isolated from the nonessential portion of the system by a valve which closes automatically on SIAS. Each header isolation valve receives a signal from a separate SIAS channel, hence, no single failure can cause both valves to remain open. A single failure analysis of the intake cooling water system is presented in Table 9.2-2.

9.2.1.3.3 Service Environment

The intake cooling water pumps and valves are located outdoors and are designed to operate under the following environmental conditions: ambient temperature from 30F to 120F, 100 percent humidity, salt laden atmosphere, torrential rains and hurricane winds. Section 9.2.1.3.4 describes other potential environmental conditions.

A chlorine solution will be fed into the sea water ahead of the intake structure for 15 minutes every other day to control slime formation. The solution enters the circulating water and intake cooling water system in regulated quantities such that the residual chlorine at the condenser outlet will be nominally 1 ppm and no greater than 1½ ppm at any time. The pumps in the intake cooling water system have cathodic protection against corrosion and the system is protected by sacrificial anodes located in the turbine and component cooling water heat exchangers.

TABLE 9.2-2

SINGLE FAILURE ANALYSIS - INTAKE COOLING WATER SYSTEM

Component Identification and Quantity	Failure Mode	Effect on System	Method of Detection	Monitor	Remarks
Off-site power	Lost	ICW pumps trip and automatically restart on emergency diesel generator power.	Various loss-of-power alarms	CRI	One ICW pump & header is adequate to supply the required cooling water to one component cooling HX.
ICW pump suction (3)	Clogged	Loss of suction for one full capacity ICW pump. Operator must stop pump.	Pump header discharge low pressure alarm	CRI	Operator may start standby pump & realign header cross-connect valves I-SB-21-7 (if necessary), to maintain desired flow.
ICW pump (3)	Fails	Loss of one full capacity ICW pump.	Pump header discharge low pressure alarm	CRI	Operator may start standby pump & realign header cross-connect valves I-SB-21-7 (if necessary), to maintain desired flow.
ICW pump discharge header (2)	Ruptures	Loss of one discharge header. Operator must isolate ruptured header by realigning cross-connect valves I-SB-21-7 (if necessary), and ICW pump(s) to maintain desired flow.	Pump discharge header low pressure alarm	CRI	One ICW pump & header is adequate to supply the required cooling water to one component cooling HX.
ICW pump lube water line (1)	Valve I-SB-21-1 inadvertantly closed	Loss of lube water to ICW pumps. Alternate lube water line cross-connect valves can be opened to maintain lube water flow.	Pump lube water line low pressure alarms	CRI	
Turbine cooling water HX isolation valves I-MV-21-2&3 (2)	Valve fails to close upon SIAS	One ICW pump & header will service both one component cooling HX & one turbine cooling HX.	Component cooling HX tubeside outlet flow & temperature indications	CRI	One ICW pump & header is adequate to supply the required cooling water to one component cooling HX.

TABLE 9.2-2 (Cont'd)

Component Identification and Quantity	Failure Mode	Effect on System	Method of Detection	Monitor	Remarks
Component cooling water HX (2)	Inlet strainer clogged	Significant reduction of flow to component cooling HX. Operator must stop ICW pump.	Strainer high differential pressure alarm & HX outlet low flow alarm	CRI	One ICW pump & header is adequate to supply the required cooling water to one component cooling HX. Strainer by-pass line or cross-connect valves I-SB-21-3 from alternate cooling water supply line may be opened downstream of strainer.
Air operated temperature control valves I-TCV-14-4A&B (2)	Lose air supply	Fail open valve - no interruption of cooling water flow.	Temperature & flow(1) indications	CRI	
	Fails to open	One component cooling HX lost.	Temperature & flow(1) indications	CRI	One ICW pump & header is adequate to supply the required cooling water to one component cooling HX.
Diesel generator set (2)	One fails to start	Loss of one ICW pump & header.	Various loss-of-power alarms	CRI	One ICW pump & header is adequate to supply the required cooling water to one component cooling HX.

ICW - Intake cooling water
CRI - Control room indication
HX - Heat exchanger
SIAS - Safety injection actuation signal
(1) - Local indication only

The intake cooling system is designed to withstand the corrosive effect of the sea water circulated. The materials used in the system are compatible with each other.

A brief description of the recirculation operation proposed for limiting marine growth can be found in Section 9.2.3.3. A full description of the proposal can be found in the July 6, 1972 Amendment to the Environmental Report.

9.2.1.3.4 Natural Phenomena

The essential components of the intake cooling water system, i.e., those supplying cooling water to the component cooling heat exchangers, are designed and installed as seismic Class I equipment. That portion of the system supplying cooling water to the turbine cooling water system is non-seismic Class I downstream of the isolation valves. The seismic Class I and non-seismic Class I portions of the system are automatically isolated from each other on SIAS. The intake cooling pumps are located on the intake structure which is designed as seismic Class I. All underground piping is located in seismic Class I fill areas. Seismic qualification of system components has been demonstrated by manufacturer calculations based on the design basis earthquake accelerations. Discussion of seismic qualification of equipment is given in Section 3.7.5.

The equipment of the intake cooling water system is located outdoors. Accordingly, the essential portions of the system are designed to withstand design basis tornado winds of 360 mph. The intake cooling water pumps are 12 ft apart, which allows sufficient separation to prevent all three pumps from being damaged by a single missile. The pumps, heat exchangers and exposed outdoor piping and valves are designed to withstand design basis tornado winds of 360 mph. Protection is provided from missiles by imposing the following spatial separation criteria on redundant components located outdoors:

a) Minimum separation for piping up to a height of 25 ft above yard grade is controlled by the dimensions of an airborne car weighing 4000 lb, 18 ft long, 7 ft wide, travelling at 50 mph; for piping at elevation higher than 25 ft above yard grade, minimum separation is controlled by a 2 in. by 4 in. timber, 10 ft long, travelling at 360 mph.

b) Underground piping minimum separation is 8.7 ft, dictated by tornado missiles. A minimum of 6 ft earth or equivalent concrete cover is provided for protection from the airborne car.

To ensure pump operation under flood conditions, the pump motors are installed above the maximum calculated flood level of +22.8 feet mean low water (MLW). The pump suction columns require 4 ft of minimum submergence to deliver the design capacity of the pumps. This requirement is met under the minimum water level conditions associated with the maximum probable hurricane postulated for the site as discussed in Section 2.4.11.3.

9.2.1.4 Testing and Inspections

The manufacturer of the intake cooling water pumps shop tests each unit over the complete range of hydraulic performance including runout conditions. Shop hydrostatic tests on the pump casings are made at 150 percent of the maximum operating pressure. All fluid boundary castings and forgings are nondestructive tested in accordance with ASME Draft Nuclar Pump and Valve Code, Code Class III.

Prior to installation in the system, each component is inspected and cleaned. The system is flushed with water before being put into normal operation. Preoperational testing consists of calibrating the instruments, testing the automatic controls for actuation at the prescribed set points, and checking the operability and limits of alarm functions.

The intake cooling water system is in service during normal plant operation. System performance is monitored and data is taken periodically to confirm heat transfer capabilities.

The intake cooling water pumps are rotated in service periodically so that their continued availability for emergency conditions is ensured.

9.2.1.5 Instrumentation Application

Table 9.2-3 lists the parameters measured by the intake cooling water system instrumentation. All heat exchangers and pumps are monitored locally as well as in the control room. In every case where safety related equipment is involved more than one parameter is measured to assure design performance of the equipment.

The intake cooling water pumps can be started or stopped either locally or from the control room. The pumps receive a start signal upon SIAS.

The logic and instrumentation for this system is discussed in Section 7.4.1.9.

All valves in the system are manually operated with three exceptions. The turbine cooling water system is automatically valved off of the intake cooling water on receipt of an SIAS. This operation can also be initiated with a local hand switch. The second automatic valve in the system is the butterfly valve (one in each header) at the outlet of the component cooling water heat exchanger. This valve automatically controls outlet water flow from the exchanger. It is modulated opened and closed according to the outlet water temperature of the shell side of the component cooling water heat exchanger. The third valve is located at the outlet of the turbine cooling water heat exchangers. This valve is temperature controlled from the shell outlet side of the heat exchanger and controls intake cooling water flow.

TABLE 9.2-3

INTAKE COOLING WATER SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm (1)		(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Intake Cooling Water:									
1) Intake canal temperature					*		30-130F	95F(max)	± 3.0%
2) Pump discharge pressure	*						0-100 psig	50 psig	± 0.5%
3) Lubricating water flow upstream of pump	*						0-25gpm	10-20gpm	± 1.0%
4) Lubricating water pressure upstream of pump				*		Upon startup controls make-up water flow via PCV-21-26	0-100 psig	10-15 psig (min)	± 0.5%
5) Lubricating water strainer differential pressure upstream of pump	*		*				0-3 psi	2 psi	± 0.5%
6) Pump discharge header pressure		*		*			0-100 psig	50 psig	± 1.0%
Turbine Cooling Water HX Tube Side (2)									
1) Inlet strainer differential pressure	*		*				0-3 psi	2 psi	± 0.5%
2) Inlet water temperature	*						0-100 psig	30-40 psig	± 0.5%
3) Inlet water pressure	*						0-200F	95F	± 1.0%
4) Outlet water pressure	*						0-100 psig	17.5-27.5 psig	± 0.5%
5) Outlet water temperature	*				*		Local 0-200F ------ Control room 30-130F	103.5F	Local ± 1.0% ------ Control Room ± 3.0%
6) Outlet water flow	*						0-10,500gpm	6250 gpm	± 1.0%

TABLE 9.2-3

INTAKE COOLING WATER SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm(1)		Recording(1)	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Component Cooling Water									
HX Tube Side(3)									
1) Inlet strainer differential pressure	*		*				0-3 psi	2 psi	± 0.5%
2) Inlet water pressure	*						0-100 psig	25-30 psig	± 0.5%
3) Inlet water temperature	*						0-200F	95F	± 1.5%
4) Outlet water pressure	*						0-100 psig	13.5-18.5 psig	± 0.5%
5) Outlet water temperature	*				*		0-200F	130F(max)	± 1.0%
6) Outlet water flow	*			*			0-20000 gpm	8250-16,500 gpm	± 1.5%
Discharge Canal Water Temperature					*		50-130F	50-120F	± 1.0%

(1) All alarms and recordings are in the control room unless otherwise indicated.

(2) Turgine cooling water HX shell side instrumentation is included in Table 9.2-12.

(3) Component cooling water HX shell side instrumentation is included in Table 9.2-7.

9.2.2 COMPONENT COOLING SYSTEM

9.2.2.1 Design Bases

The component cooling system is designed to:

a) provide a heat sink for auxiliary systems under normal operating and shutdown conditions

b) provide an intermediate barrier between the reactor coolant and the intake cooling water systems

c) provide a heat sink for safety related components associated with reactor decay heat removal for safe shutdown or LOCA conditions, assuming a single failure

d) withstand design basis earthquake loads, tornado loads or maximum flood levels without loss of safety function

e) permit periodic inspection and testing of components to assure system integrity and capability

9.2.2.2 System Description

The component cooling system is a closed loop cooling water system that utilizes demineralized water (buffered with Calgon and sodium dichromate, a corrosion inhibitor) to cool various components as shown schematically in Figure 9.2-2. The component cooling system consists of two heat exchangers, three pumps, one surge tank, a chemical addition tank, and associated piping, valves and instrumentation.

The component cooling system is arranged as two redundant essential supply header systems (designated A and B) each with a pump and heat exchanger and the capability to supply the minimum safety feature requirements during plant shutdown or LOCA conditions. The nonessential supply header (designated N) which is connected to both essential headers during normal operation is automatically isolated from both by valve closure on a safety injection actuation signal (SIAS). During normal operation, the nonessential header supplies cooling water to the following components: fuel pool heat exchanger, sample heat exchangers, boric acid concentrators, waste concentrator, waste gas compressors, letdown heat exchanger, control element drive mechanism air coolers and the reactor coolant pump motors.

The A and B headers serve the following components:

Header A	Header B
Shutdown heat exchanger 1A	Shutdown heat exchanger 1B
Containment fan cooler 1A	Containment fan cooler 1C
Containment fan cooler 1B	Containment fan cooler 1D

Low pressure safety injection pump 1A	Low pressure safety injection pump 1B
High pressure safety injection pump 1A	High pressure safety injection pump 1B
Containment spray pump 1A	Containment spray pump 1B

High pressure safety injection pump 1C is normally supplied by either header A or header B, depending on the alignment of the manual cross connect valves.

The A and B header systems are isolated from each other during accident conditions. Pump 1A serves header A and Pump 1B serves header B. Pump 1S may be aligned with either header A or B by means of the cross connection valving on the suction and discharge sides of the pumps.

Both the A and the B supply header systems pump demineralized cooling water through the shell side of their respective component cooling heat exchangers, through the components being cooled and back to their respective pumps. The surge tank is connected to the suction side of the pumps and is designed to accommodate volumetric thermal expansion and contraction in the system and to maintain a static pressure head at each pump suction. Demineralized makeup water is added to the surge tank through an automatic level control system by the condensate pump discharge. Provisions are also made to supply makeup from the fire protection system. Although both essential headers share the surge tank, a baffle divides the lower portion of the tank into two separate compartments, each associated with one of the two essential headers. The cylindrical tank is 11 ft long and is mounted horizontally. It has a 5.5 ft diameter with a baffle height of 2.5 ft. Makeup water is added when the level falls below 36 inches and a low level alarm is initiated in the control room at 29 inches. Makeup water is stopped at a surge tank level of 48 inches and a high level alarm is initiated in the control room at 54 inches. Level indication on the tank is provided on each side of the baffle. There is also a level gauge mounted on each side of the tank for local indication of tank level.

Leakage of reactor coolant into the component cooling water system can be detected by an increasing level in the surge tank. A 1 gpm leak into the tank causes a high level alarm in 8 hours (based on an initial tank level of 40 inches in the 66 in. high tank). Section 5.2.4 gives a description of leak detection by surge tank level and by radiation in the component cooling water system. Any overflow or drainage from the component cooling surge tank is collected by the auxiliary building drain system and routed to the chemical drain tank. The material in this tank is treated by the waste management system as described in Section 11.2.3.2.

A chemical additive tank in the system permits addition of the proper corrosion inhibitor. Sodium dichromate is added to maintain a concentration of 200-300 ppm. A radiation monitor is provided in each of the redundant headers on the outlet side of the heat exchangers. Should the activity in the system rise above 4 x 10^{-4} μ Ci/cc, a high radiation alarm is actuated in the control room and the atmospheric vent valve of the surge tank is automatically closed. The system then operates unvented with relief to the waste mangement system for overpressure protection.

The valves used in the component cooling system are carbon steel and although the cooling water is not radioactive, welded construction is used, where possible, to minimize the possibility of leakage. Self-actuated spring-loaded relief valves are provided for overpressure protection on the shutdown, sample, and letdown heat exchanger inlets as well as on the inlets to the containment cooling units and waste gas compressors. All component cooling cooling system piping is carbon steel.

Design data for component cooling system components are tabulated in Table 9.2-4.

9.2.2.3 System Evaluation

9.2.2.3.1 Performance Requirements and Capabilities

The component cooling system is capable of providing sufficient cooling capacity to cool reactor coolant system and auxiliary systems components with two pumps and one heat exchanger in operation, although, during normal operation, flow is estabilished through both heat exchangers. Two pumps and two heat exchangers are used during normal plant shutdown; however, if only one heat exchanger is available, the cooldown rate is decreased but plant safety is not jeopardized. Table 9.2-5 lists operating flow rates and calculated heat loads for all the auxiliary equipment cooled by the component cooling system.

Safety related equipment cooling requirements are met following a postulated LOCA with only one pump and one heat exchanger operating, even though both essential header systems are available.

The component cooling pumps are connected to separate emergency electrical buses (see Figure 8.2-3) which can be energized by the diesel generators. The A and B pumps are connected to the respective A or B emergency bus counterparts and the third pump is connected to the AB bus which is manually connected to either the A or B diesel generator bus.

9.2.2.3.2 Single Failure Analysis

The component cooling system is arranged into two redundant and independent essential supply systems, each with a pump and heat exchanger and the capability to supply the minimum complement of safety related equipment required for safe shutdown of LOCA conditions.

TABLE 9.2-4

DESIGN DATA FOR COMPONENT COOLING SYSTEM COMPONENTS

1. Component Cooling Pumps

Type	Centrifugal, horizontal split, double suction pumps
Quantity	3
Capacity, each, gpm	8500
Head, feet	177 to 182
Design pressure, psi	150
Design temperature, F	185
Material	
Case	ASTM A-216-Gr-WCB steel
Impeller	ASTM A-216-Gr-WCB steel
Shaft	SAE 4140 stainless steel
Motor	450 hp, 4000 V, 60 hz, 3 phase, 1800 rpm
Enclosure	WP II
Codes	Motor: NEMA, Pump: Standards of the Hydraulic Institute; ASME Sections VIII and IX Draft Nuclear Pump & Valve Code Class III

2. Component Cooling Water Heat Exchangers

Type	Horizontal, counterflow, straight tubes rolled into tubesheets		
Quantity	2		
Flow, lb/hr		Shell side	Tube side
	Normal	$5.55\text{x}10^6$	$8.50\text{x}10^6$
	Shutdown (Max)	$7.35\text{x}10^6$	$8.50\text{x}10^6$
Design duty, each, Btu/hr	55.0×10^6 (normal) 165.0×10^6 (3.5 hrs after shut-down)		

TABLE 9.2-4 (Cont'd)

	65.0×10^6 (27.5 hrs after shutdown) 118.0×10^6 (Maximum long term cooling following a LOCA)
Heat transfer area, each, ft^2	18,250
Design pressure, psig	Shell side: 150; Tube side: 90
Design temperature, F	Shell side: 185; Tube side: 150
Material	
Shell	Carbon steel ASTM A 515, Gr 70
Tubes	Aluminum Brass SB 111 Alloy #687
Tubes Sheets	Aluminum Bronze ASTM B-171 Type D
Codes	ASME Section VIII, TEMA Class R ASME Section III Class I

3. Surge Tank

Type	Horizontal
Quantity	1
Design pressure, psig	100
Design temperature, F	150
Volume, gallons	2000
Material	
Shell	ASTM A-283 Gr C steel
Dished head	ASTM A-283 Gr C steel
Baffle	ASTM A-283 Gr C steel
Code	ASME Section III, Class I

4. Chemical Addition Tank

Type	Vertical
Quantity	1

TABLE 9.2-4 (Cont'd)

Design pressure, psig	150
Design temperature, F	200
Volume, gal	50
Material	Carbon steel
Code	ASME Section VIII

5 <u>Piping, Fittings and Valves</u>

Piping material	Carbon steel, ASTM A 106 Gr B Seamless
Design pressure, psig	150
Design temperature, F	200
Construction:	
2-1/2" and larger	Butt welded except at flanged connections
2" and smaller	Socket welded or screwed except at flanged connections
Valves:	
2-1/2" and larger	
Gate and globe	Carbon steel, butt weld ends NSI 150 psi
Check and butterfly	Carbon steel, flanged, ANSI 150 psi
2" and smaller	Carbon steel, socket weld ends, ANSI 150 to 600 psi
Codes	ANSI B31.1 and ANSI B31.7, Class III Penetration Piping is designed fabricated to ANSI B31.7 Class I & II
	Draft Nuclear Pump & Valve Code Class I, II & III as applicable

TABLE 9.2-5

OPERATING FLOW RATES AND CALCULATED HEAT LOADS
FOR ALL AUXILIARY EQUIPMENT
COOLED BY THE COMPONENT COOLING SYSTEM

Equipment Description	Heat Load/Unit (Btu x 10^6)	Flow/Unit (gpm)
Reactor coolant pump motor oil cooler & seal jacket cooler	0.66	115
Reactor coolant pump motor air cooler	0.82	175
Shutdown heat exchanger	130 (1) 29	4850 (1) 4850
Letdown heat exchanger	20.5 (2) 2.61	1275 (2) 150
CEA magnetic drives	2.23	200
Fuel pool heat exchanger	32	3560
High pressure safety injection pumps	negligible	10
Low pressure safety injection pumps	negligible	10
Containment spray pumps	negligible	10
Boric acid evaporator condensate cooler	11.5	775
Waste evaporator condensate cooler	1.15	115
Waste gas compressor aftercooler jacket	negligible	1.0
Containment fan cooler	60 (3) 0.75	1200 (3) 1200
Sample heat exchanger	0.52	35

(1) The maximum heat load of 130×10^6 Btu/hr occurs 3 1/2 hours after shutdown and reduces gradually to 29×10^6 Btu/hr after 27 1/2 hours after shutdown. During refueling operations the heat load on the heat exchanger is expected to be 29×10^6 Btu/hr per shutdown heat exchanger.

(2) Maximum heat load of 20.5×10^6 Btu/hr occurs during load change only. Normal steady power heat load is only 2.61×10^6 Btu/hr. However to accommodate the load changes without increase in temperature 1275 gpm has been considered with a heat load of 20.5×10^6 Btu/hr.

(3) Normal containment heat load is 2.25×10^6 Btu/hr with a maximum of 240×10^6 Btu/hr occurring during accident conditions.

Automatic valves isolate the nonessential header from the two essential headers in the event of an accident. Upon occurence of a LOCA, the valves connecting each essential header to the nonessential header (at the two cross connect points) also close automatically on SIAS there by isolating the essential headers from each other. Each of the two valves at a cross connection receives a signal from a separate SIAS channel so that no single failure can cause both valves to remain open. If one essential header should fail, the remaining redundant essential header assures availability of at least one set of equipment and piping for accident service.

The cooling water surge tank is common to both essential headers but is partitioned to provide independence. Consequently, there is no single failure that could prevent the component cooling system from performing its safety function. The single failure analysis is presented in Table 9.2-6.

9.2.2.3.3 Service Environment

The component cooling system pumps, heat exchangers and portions of the piping and valves are located outdoors. These components are designed to operate under the following environmental conditions: ambient air temperature from 30 F to 120 F, 100 percent humidity, salt laden atmosphere, torrential rains and hurricane winds. Section 9.2.2.3.4 describes other potential environmental conditions resulting from extreme natural phenomena.

Other system components are located within the reactor auxiliary building and are designed for the normal ambient expected in the building. No system active components are located in areas of high radioactivity.

Except for seismic Class I piping serving the containment fan coolers, there are no essential components located within the containment vessel. Containment post-accident environment will not affect operation of the component cooling system.

9.2.2.3.4 Natural Phenomena

All components of the component cooling system including cooling water pumps, heat exchangers and piping which are essential for safe shutdown or to mitigate the effects of a LOCA are designed and installed as seismic Class I equipment. The nonessential portions of the system are not seismic Class I and are isolated automatically from the seismic Class I portions upon SIAS. The isolation valves are seismic Class I.

The pumps and heat exchangers are located outdoors on a seismic Class I foundation. Seismic Qualification of system components has been demonstrated by manufacturer calculations and is discussed in Section 3.7.5.

Table 9.2-6

SINGLE FAILURE ANALYSIS - COMPONENT COOLING SYSTEM

Component Identification and Quantity	Failure Mode	Effect on System	Method of Detection	Monitor	Remarks
Off-site power	Lost	CCS pumps trip and automatically restart on emergency diesel generator power.	Various loss-of power alarms	CRI	One CCS pump & one CCS HX are adequate to cool reactor coolant system & auxiliary systems in an emergency.
CCS pump suction line (3)	Valve I-SB-14 inadvertently closed	Loss of suction for one CCS pump. Operator must stop pump.	CCS HX outlet high temperature alarm	CRI	Operator may start standby pump & realign header cross-connect valves I-MV-14-1 or 2 (if necessary) to maintain desired flow.
CCS pump (3)	Fails	Loss of one full capacity CCS pump.	CCS HX outlet high temperature alarm	CRI	Operator may start standby pump & realign header cross-connect valves I-MV-14-1 or 2 (if necessary) to maintain desired flow.
CCS HX outlet Line (2)	Valve I-SB-14-1A or 1C inadvertently closed	Loss of one essential supply header system.	CCS HX outlet low pressure & low flow alarms	CRI	Two CCS pumps & one HX are adequate to cool reactor coolant system & auxiliary systems during normal operation. Operator may realign cross-connect valves 1-MV-14-1 or 2 with two CCS pumps to maintain desired flow.
Essential headers A & B (2)	Ruptures	Loss of essential CCS supply system.	Various loss of flow & low pressure alarms	CRI	One CCS pump & one CCS HX are adequate to cool reactor coolant system & auxiliary systems in an emergency.

TABLE 9.2-6 (Cont'd)

Component Identification and Quality	Failure Mode	Effect on System	Method of Detection	Monitor	Remarks
Nonessential supply header main isolation valve (pneumatic) (4) I-HCV-14-8A/B I-HCV-14-9/10	Loses air supply	Fail closed valves - flow discontinued through nonessential supply header N. Essential supply headers A & B isolated from each other.	Valve position indicating lights	CRI	Safety related equipment cooling requirements are available from two redundant & independent supply systems A & B.
	Valve fails to close upon SIAS	Remaining valves will effectively isolate nonessential supply header N.	Valve position indicating lights	CRI	Safety related equipment cooling requirements are available from two redundant & independent supply systems A & B.
CCS surge tank air operated level control valve LCV-14-1 (1)	Loses air supply	Fail closed valve - temporary loss of makeup water to surge tank.	CCS surge tank low level alarm	CRI	Bypass valve V-14-430 must be opened and makeup regulated manually to maintain desired water level.
	Fails to open	Temporary loss of makeup water to surge tank.	CCS surge tank low level alarm	CRI	Bypass valve V-14-430 must be opened and makeup regulated manually to maintain desired water level.
CCS surge tank (1)	Loss of makeup water from condensate pumps	Temporary loss of makeup water to surge tank.	CCS surge tank low level alarm	CRI	Valve V-15-610 can be opened to supply required makeup water from the fire protection system.
Diesel generator set (2)	Fails to start	Loss of one essential CCS supply system	Various loss-of power alarms	CRI	Safety related equipment cooling requirements will be met with one CCS pump & one HX operating in an emergency. Standby pump may be manually connected to available generator bus.

CCS - Component cooling system
CRI - Control room indication
HX - Heat exchanger
SIAS - Safety injection actuation signal

The spatial separation criteria for component cooling water equipment is the same as discussed in Section 9.2.1.3.4.

Indoor components such as the surge tank and portions of the piping and valves are protected from tornado winds and missiles since they are housed within the reactor auxiliary building.

Component cooling system equipment susceptible to flood damage is protected to 22 ft above mean low water (MLW) which is greater than the calculated maximum flood elevation attainable as discussed in Section 2.4.

9.2.2.4 Testing and Inspection

Hydrostatic tests to 150 percent of design pressure are performed on the heat exchangers. Performance tests to demonstrate design requirements are conducted and heat transfer characteristics are verified. Eddy current tests of all tubes are performed in accordance with ASTM B-11, Paragraph 10, for entire tube cross sections. All pressure containing welds are checked by radiographic examination.

Hydrostatic test to 150 percent of maximum operating head is performed on each pump casing. Performance tests are performed on each pump in accordance with the latest design code standards to establish pump characteristics. Nondestructive testing is performed on welds, forgings and castings in accordance with the requirements of ASME B31.7 and the Draft Nuclear Pump and Valve Code, Code Class III.

The component cooling system is operated and tested initially with regard to flow paths, flow capacity and mechanically operability. Pumps are tested to demonstrate head and capacity. All automatic and manual sequences and control functions are tested to ensure design operability. See Section 14.1.1.1 for a discussion of plant preoperational tests.

The component cooling system is in service during normal plant operation and system performance is monitored and data taken periodically to confirm heat transfer capabilities.

9.2.2.5 Instrumentation Application

Table 9.2-7 gives a functional listing of component cooling water instrumentation.

The pumps and heat exchangers have diverse parameters measured to confirm the correct operation of the equipment involved. The monitoring of flow, temperature and pressure at the points indicated in Table 9.2-7 and Figure 9.2-2 provides the control room the information for operating the essential and normal header systems.

The valves in the component cooling water system allow:

a) isolation of the nonessential (N) header from the A and B headers on SIAS

b) routing of component cooling water through the shutdown heat exchangers on SIAS

c) isolation of the reactor coolant pumps and control and drive coolers on SIAS

d) routing of component cooling water surge tank ventilation to the waste management system upon a high component cooling water radiation signal

e) controlling the level in the component cooling water surge tank

f) directing of discharge of the 1S component cooling water pump to either the A or B header and

g) controlling of flow to the containment cooling units

The component cooling water pumps can be started and stopped both locally and from the control room. The pumps receive a start signal on SIAS. The logic and instrumentation is discussed in Section 7.4.1.8.

TABLE 9.2-7

COMPONENT COOLING SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm (1)		Recording (1)	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Component Cooling Water HX Shell Side (2)									
1) Inlet temperature.	*						0-200F	110F	± 1.0%
2) Outlet temperature	*		*		*	Modulates temperature controlled butterfly valve on tube side of HX discharge	0-200F	100F	± 1.0%
3) Outlet pressure	*	*		*			0-150psig	80 psig	± 0.5%
4) Outlet flow		*	*	*			0-15,000 gpm	5600-11200 gpm	± 1.0%
5) Outlet radiation (3)			*			On high radiation, closes component cooling water source tank vent valve and routes the water vapor through the waste management system	10^{-6}ci/cc to 10^{-2}ci/cc	0	10^{-6} Ci/cc to Cs^{137} in a 2mR per hr field of 1.25 mev background radiation
Shutdown HX Shell Side: (4)									
1) Outlet temperature	*	*					0-200F	150F	± 1.0%
2) Outlet flow		*	*	*			0-6000gpm	4850 gpm	± 1.5%
Fuel Pool HX:									
1) Outlet temperature	*	*					0-200F	110-120F	± 1.0%
2) Outlet flow	*	*	*	*			0-3800 gpm	1600-3560 gpm	± 1.5%

TABLE 9.2-7 (Cont'd)

COMPONENT COOLING SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm (1)		Recording (1)	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Containment Cooling Unit:									
1) Outlet temperature		*					0-600F	102F	± 3.0%
2) Outlet flow	*			*			0-1500 gpm	1200 gpm	± 3.0%
Control Element Drive Mechanism Air Cooler:									
1) Outlet temperature		*					0-600F	115F	± 3.0%
2) Outlet flow	*			*			0-250 gpm	200 gpm	± 3.0%
Reactor Coolant Pump Cooling Water Outlet Flow									
Component Cooling Water Surge Tank									
1) Level	*		*	*		Controls valving make-up flow into tanks via LCV 14-1	Sight glass	36-48"	-
2) Integrated make-up flow							-	-	-
High Pressure Safety Injection Pump Cooling Water									
1) Outlet temperature	*						0-200F	95F	±1.0%
2) Outlet flow	*						Rotometer	10 gpm	-
Containment Spray Pumps Cooling Water									
1) Outlet temperature	*						0-200F	95F	± 1.0%
2) Outlet flow	*						Rotometer	10 gpm	-

TABLE 9.2-7 (cont'd)

COMPONENT COOLING SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm [1]		Recording [1]	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Low Pressure Safety Pump Injection Pump Cooling Water									
1) Outlet temperature	*						0-200F	95F	± 1.0%
2) Outlet flow	*						Rotometer	10 gpm	-
Boric Acid Concentrator Cooling Water									
1) Outlet flow	*						0-1000 gpm	775 gpm	± 2.0%
2) Outlet temperature	*						Rotometer	115 gpm	-
Waste Concentrator Cooling Water									
1) Outlet temperature	*						0-200F	120F	± 0.5%
2) Outlet flow	*						Rotometer	115 gpm	-
Waste Gas Compressors Cooling Water									
1) Outlet temperature	*						0-200F	100F	± 1.0%
2) Outlet flow	*						Rotometer	1gpm	-
Component Cooling Water Pump Discharge Pressure	*						0-150psig	100psig	0.5%

TABLE 9.2-7 (Cont'd)

COMPONENT COOLING SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm (1)		Recording (1)	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Letdown HX:									
1) Outlet temperature		*					0-600F	135F (Max)	± 3.0%
2) Outlet flow		*	*	*			0-1500 gpm	150 gpm	± 1.0%

(1) All alarms and recordings are in the control room unless otherwise indicated

(2) Component cooling water HX tube side instrumentation is contained in Table 9.2-3

(3) Local radiation recorder

(4) Shutdown HX tube side instrumentation is contained in Table 6.2-11
HX - Heat Exchanger

9.2.3 CIRCULATING WATER SYSTEMS

9.2.3.1 Design Bases

The circulating water system is designed to provide a heat sink for the main condenser under normal operating and shutdown conditions. The system serves no safety function since it is not required to achieve safe shutdown or to mitigate the consequences of a LOCA.

9.2.3.2 System Description

The circulating water system is shown schematically on Figure 9.2-1A. The general plan and profile of the system is shown on Figures 9.2-1B through 9.2-1E.

The circulating water system consists of two intake pipes which connect the Atlantic Ocean to the intake canal, an intake structure, four circulating water pumps, a discharge canal and a discharge pipe.

The intake cooling water will be taken from the ocean through two 10.5 ft ID reinforced concrete pipes, 1200 feet offshore. The intake pipes are buried at the (-18) ft mean low water (MLW) contour to prevent interference with natural littoral processes. Each pipe has a "velocity cap" to minimize fish entrapment. There is about 8 feet of water above each cap and the velocity of intake water is less than 1 ft/sec.

The intake pipes are located approximately 2300 ft south of the discharge pipe. They are buried from the intake points for a distance of about 1600 ft beneath the ocean bottom and under the beach, terminating in a canal on the west side of the sand dunes. After passing through the inlet pipes at about 6 fps, the circulating water is conveyed in the canal about 900 ft to State Road A1A and passes under a bridge. After passing under the bridge the water is then conveyed in a canal at about 0.3 to 0.5 fps for approximately 4000 ft to the plant intake structure. This reinforced concrete structure consists of four bays. The water in each bay passes through trash racks and traveling screens which remove debris from the water before it reaches the circulating water and other pumps. The approach velocity to each bay is less than 1 fps. The circulating water pumps discharge into four buried conduits to the condenser.

The water leaving the condenser, at a temperature rise of about 21 F for normal full load operation, flows from the discharge water boxes to the seal well. From the seal well, the discharged condenser cooling water is transported approximately 500 ft in a buried pipeline and then about 580 ft in a canal to State Road A1A. The water is conveyed under the road bridge. Once past A1A, the cooling water travels about 1155 ft in a canal to a discharge structure, located on the western side of the sand dune. From the canal discharge structure, the cooling water discharge is carried about 1425 ft in a 12 ft diameter pipeline buried under the beach and under the ocean. The pipeline terminates at a depth of (-18) ft MLW and at a distance of about 1200 ft from shore.

The outlet of the 12 ft diameter discharge pipe is split into a Y-type high velocity jet discharge (see Figure 9.2-3) designed to limit the circulating water surface temperature to 5 F above ambient. Based on the design power heat dissipation of 6.1 x 10^9 Btu/hr for the unit the isotherm areas from the discharge are:

a) 2 F - 150 acres

b) 3 F - 25 acres

c) 5 F - 1/4 acre

Both ports in the "Y" are 7.5 ft in diameter and result in a horizontal discharge of about 13 fps. A short sloping trench will be excavated from the inverts of the ports, daylighting at the natural ocean bottom. The trench is lined to prevent scour from the jet discharge.

System design data are presented in Table 9.2-8.

9.2.3.3 System Evaluation

The four circulating water pumps are each sized to provide 25 percent of the cooling water flow for the turbine condenser. The pumps are sized for the maximum condenser heat load and provide sufficient head (40 ft) to overcome system frictional losses. The dimensions of the intake bays are designed to give a low velocity profile through the traveling screens and to provide sufficient submergence for the pump required NPSH. The circulating water, screen wash, and intake pumps are arranged in each bay to eliminate the adverse effects of vortices, and to provide flow path and suction velocities to each pump. Three of the four bays contain intake cooling water pumps and two bays contain screen wash pumps. The pumps are located at different elevations in the bays. The suction for the intake cooling water pumps is at the -18.5 ft level followed by the suction for the circulating cooling water pumps at el. -16.0 ft and finally by the screen wash pumps at el. -5.5 ft. The intake and discharge piping are separated by 2300 ft of ocean to prevent recirculation of heated water.

A chlorine solution will be fed into the sea ahead of the intake structure for approximately 2 hours each week in order to control slime formation. The solution in the circulating and intake cooling water systems is added in regulated quantities so that the residual chlorine at the condenser outlet will be nominally 1 ppm and no greater than 1½ ppm.

A program for controlling marine growth in the intake structure has been developed whereby discharge water is heated to 122-125 F and diverted into each of the intake pipelines for approximately 4 hours once each month. Sluice gates are provided to permit routing of water directly from the discharge canal to the intake canal. The principal constraints designed for in the defouling program are:

TABLE 9.2-8

DESIGN DATA FOR CIRCULATING WATER SYSTEM COMPONENTS

1. Circulating Water Pumps

Type	Single stage, vertical removable element, mixed flow
Quantity	4
Capacity, each, gpm	121,000
Head, feet	40
Material	
Case	2 percent Ni-Cast Iron, ASTM-A-48 C130
Impeller	ASTM A-296 CF8M
Shaft	ASTM A-276 Type 316 SS
Motor	Constant speed, 1500 hp, 4000V, 60hz, 3 phase, 360 rpm, with 1.15 Service Factor
Enclosure	WP II
Codes	NEMA, Standards of the Hydraulic Institute, ASME Section VIII.

2. Traveling Water Screens

Type	Vertical, through-flow
Quantity	4
Screen velocity, ft/min	10.0, 5.4, 3.2, 2.5
Material	
Screen	Copper
Frame	Steel, hot dipped galvanized

3. Screen Wash Pumps

Type	Five stage, vertical, turbine, wet pit
Quantity	2

TABLE 9.2-8 (cont'd)

Capacity, each, gpm	1060
Head, feet	250
Material	
Case	2 percent Ni cast iron
Impeller	Type 316 SS
Shaft	Type 316 SS
Motor	100 hp, 460 v, 3 phase, 60 hz, 1760 rpm
Enclosure	TEFC
Codes	NEMA, Standards of the Hydraulic Institute, ASME Section VIII.

4. Piping, Fittings and Valves

Pressure, psig	50
Temperature, F	125
Pipe material*	
Below ground	Concrete
Above ground	Cast iron, rubber lined
Valves	
3 inches and above	Cast iron, flanged
2½ inches and below	Bronze, screwed and/or flanged
Code	ANSI B31-1

*All pipes 3 inches and above

1) limiting the temperature of the water discharged to the ocean to no greater than that discharged during normal plant operation

2) limiting the velocity of the water drawn into the intake pipeline to 1 ft/sec

3) limiting the rise in the intake canal so as not to adversely affect marine life

The recirculation operation is under strict administrative control and is subject to refinement after test operation. Further details of the recirculation operation are discussed in the July 6, 1972 amendment to the Hutchinson Island Environmental Report.

9.2.3.4 Testing and Inspection

Prior to installation in the system, each component is inspected and cleaned.

Preoperational testing consists of calibrating the instruments, testing the automatic controls for actuation at the proper set points, and checking the operability and limits of alarm functions. Automatic actuation of system components is tested periodically to confirm operability. The circulating water system is in service during normal plant operation. System performance is monitored and data is taken periodically to confirm heat transfer characteristics.

9.2.3.5 Instrumentation Application

The circulating water system is continuously monitored by measuring the condenser inlet and outlet temperature and the effluent chlorine content.

Table 9.2-9 lists the system parameters that are measured and Figure 9.2-1A shows the system instrumentation. Diverse parameters (discharge pressure and temperature, and suction pressure) are measured on the circulating water pumps to establish that they are operating correctly.

The circulating water pumps can be started from either the control room or locally at the pumps. A pump start permissive circuit prevents starting unless:

1) there is bearing lubricating water flow, and
2) the valve in the discharge line is opened at least 10 percent.
3) the valves at the water box are full open

TABLE 9.2-9

CIRCULATING WATER SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		(1) Alarm		(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Circulating Water Pumps									
1) Discharge pressure	*						0-50 psig	16.4 psig	±0.5%
2) Lubricating water flow	*			*			0-12 gpm	20 gpm	±1.0%
3) Lubricating water pressure				*		Pump start permissive	-	30 psig	-
4) Seal water pressure				*			0-100 psig	30 psig	±0.5%
Discharge Valve Position		*				Pump start permissive for minimum opening	-	-	-
Condenser									
1) Inlet temperature (one leg on each condenser)					*		30-130F	95F	±3.0%
2) Discharge temperature					*		30-130F	119F	±3.0%
3) Chlorine residual					*		0-10 ppm	-	±1.0%

(1) All alarms and recordings are in the control room unless otherwise indicated.

9.2.4 TURBINE COOLING WATER SYSTEM

9.2.4.1 Design Bases

The turbine cooling water system is designed to provide a heat sink for power cycle equipment during normal operation and normal shutdown. The system serves no safety function since it is not required to achieve safe shutdown or to mitigate the consequences of a LOCA. It is completely independent of, and has no connection with the component cooling system.

9.2.4.2 System Description

The turbine cooling system is a closed loop system which uses demineralized water buffered with sodium dichromate to remove heat from the turbine and other components in the power cycle (See Figure 9.2-4).

The water is circulated by two turbine cooling water pumps and the heat removed is transferred to the intake cooling water system through the two turbine cooling water heat exchangers. Turbine cooling water circulates through the shell side of the heat exchangers.

A surge tank open to the atmosphere is connected to the turbine cooling water system. The tank level is automatically controlled (by level switches and a level control valve) and makeup is from the main condensate system. Control room alarm is initiated on both high and low water level. Sodium dichromate is used as a corrosion inhibitor in the turbine cooling water system. The concentration of inhibitor is not critical (usually about 200-300 ppm) and is not automatically regulated. The turbine cooling water chemistry is measured periodically and an inhibitor added when needed from the chemical additive tank located above the surge tank water level.

The turbine plant components cooled by the turbine cooling water system include:

a) Turbine lube oil coolers

b) Turbine electro-hydraulic fluid coolers

c) Hydrogen seal oil coolers

d) Isolated phase bus air coolers

e) Hydrogen coolers

f) Exciter air cooling units

g) Heater drain pumps seal and stuffing box coolers

h) Feedwater pump oil coolers

i) Condensate pump motor bearing coolers

j) Instrument and service air compressor jackets, aftercoolers, and instrument air dryer cooler

k) Sample coolers, secondary system

Components (a), (c), (e) and (f) listed above are provided with automatic temperature control valves in the cooler outlet piping.

System component design data are presented in Table 9.2-10.

9.2.4.3 System Evaluation

Each of the two pumps and heat exchangers in the turbine cooling system is designed to provide 60 percent of total system capacity. Table 9.2-11 lists operating flow rates and calculated heat loads for the turbine plant components cooled by the turbine water system. The turbine cooling water system is supplied with makeup through the condensate system and also through a double valved connection to the domestic service water system. Flow through the turbine cooling water heat exchangers is monitored downstream by a local flow meter.

Turbine cooling water is not needed to shut down the turbine.

9.2.4.4 Testing and Inspection

Prior to installation in the system, each component is inspected and cleaned.

Preoperational testing consists of calibrating the instruments, testing the automatic controls for actuation at the proper set points, checking the operability and limits of alarm functions, and setting the safety valves.

The turbine cooling water system is in service during normal plant operation. System performance is monitored and data taken periodically to confirm mechanical, hydraulic, and heat transfer characteristics.

9.2.4.5 Instrumentation Application

Table 9.2-12 lists the parameters measured to monitor the turbine cooling water system.

The turbine cooling water pumps can be started and stopped either locally or from the control room.

There are a number of temperature controlled valves in the system which control flow through the:

a) turbine lube oil coolers
b) hydrogen seal oil unit coolers (air side cooler)
c) hydrogen seal oil unit (hydrogen side cooler)
d) hydrogen coolers
e) exciter cooling air units

TABLE 9.2-10

DESIGN DATA FOR TURBINE COOLING WATER SYSTEM COMPONENTS

1. Turbine Cooling Water Heat Exchangers

Type	Horizontal, straight tube, single pass
Quantity	2
Design duty, each, Btu/hr	26.5×10^6
Heat transfer area, each, ft^2	8400
Design pressure, psig	150 shell side, 90 tube side
Design temperature, F	150 shell side, 150 tube side
Material	
Shell	ASTM A-515 Gr 70
Tubes	Aluminum Brass SB111 Alloy #687
Tube Sheet	Aluminum Bronze ASTM B171-Type D
Codes	TEMA, Class C, ASTM Section VIII & Section IX

2. Turbine Cooling Water Pumps

Type	Horizontal Centrifugal
Quantity	2
Capacity, each, gpm	5100
Head, feet	152
Material	
Case	Cast Iron
Impeller	Bronze
Shaft	Steel
Motor	250 hp, 4000 v, 3 phase, 60 Hz, 1180 rpm

TABLE 9.2-10 (cont'd)

Enclosure	WP-II
Codes	NEMA, Standards of Hydraulic Institute, ASME VIII

3. Turbine Cooling Water Surge Tank

Type	Horizontal
Quantity	1
Design pressure	Atmospheric
Design temperature, F	125
Volume, gallons	1000
Material	ASTM A-283 Gr C
Code	ASME Section VIII

4. Chemical Additive Tank

Type	Vertical
Quantity	1
Design pressure, psig	150
Design temperature, F	200
Volume, gallons	50
Material	Carbon steel
Code	ASME Section VIII

TABLE 9.2-11

TURBINE PLANT COMPONENTS OPERATING FLOW RATES AND CALCULATED HEAT LOADS

Component Description	Flow/Unit (gpm)	Heat Load/Unit (Btu x 10^6)
Turbine lube oil coolers	2900 gpm	7.5
Turbine E-H fluid coolers	40	Negligible
Hydrogen seal oil units	100	0.26
Isolated phase bus air coolers	62.5	Negligible
Hydrogen coolers	4500	40.0
Exciter air cooler units	200	1.09
Heater drain pumps seal & stuffing box coolers	20	Negligible
Feedwater pumps oil coolers	20	Negligible
Condensate pumps motor bearing coolers	10	Negligible
Instrument air compressor	20	
Station air compressor	15	1.0
Air dryer	10	
Sample cooler, secondary system	100	Negligible

TABLE 9.2-12

TURBINE COOLING WATER SYSTEM INSTRUMENTATION APPLICATIONS

System Parameter & Location	Indication		Alarm (1)		Recording (1)	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Turbine Cooling Water Pump									
1) Suction pressure	*						0-60 psig	10-15 psig	±0.5%
2) Outlet pressure	*						0-150 psig	70-75 psig	±0.5%
Turbine Cooling Water HX Shellside (2)									
1) Outlet temperature	*	*	*			Controls intake cooling water flow through tube side of HX by means of temperature control valves TCV-13-2A,2B	0-200F	95F	±1.0%
2) Outlet header pressure				*			0-200 psig	70 psig	±1.0%
Turbine Electro-Hydraulic Fluid Coolers-									
1) Outlet flow	*						Rotometer	40gpm	-
2) Outlet temperature	*						0-200F	100F	±1.0%
Turbine Lube Oil Coolers									
1) Outlet temperature	*						0-200F	110F	±1.0%
1) Inlet header flow	*						0-3500 gpm	2900gpm	±2.0%
Hydrogen Seal Oil Unit Coolers									
1) Air side coolers									
a) Inlet flow	*						0-300gpm	260gpm	±2.0%
b) Outlet temperature	*						0-200F	110F	±1.0%

TABLE 9.2-12 (Cont'd)

TURBINE COOLING WATER SYSTEM INSTRUMENTATION APPLICATIONS

System Parameter & Location	Indication		Alarm(1)		(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
2) Hydrogen side coolers									
a) Inlet flow	*						0-120 gpm	100 gpm	±2.0%
b) Outlet temperature	*						0-200F	106F	±1.0%
Hydrogen Coolers									
1) Inlet header flow	*						0-5500 gpm	4500 gpm	±2.0%
2) Outlet temperature	*						0-200F	120F	±1.0%
Exciter Cooler Air Units									
1) Inlet header flow	*						0-250 gpm	200 gpm	±2.0%
2) Inlet header pressure	*						0-150 psig	50 psig	±0.5%
3) Outboard exciter cooler outlet temperature	*						0-200F	111F	±1.0%
4) Inboard exciter cooler outlet temperature	*						0-200F	111F	±1.0%
Isolated Phase Bus Air Coolers									
1) Inlet header flow	*						0-75 gpm	63 gpm	±1.0%
2) Outlet temperature	*						0-200F	100F	±1.0%
Instrument Air Compressor									
1) Cooling water jacket									
a) Outlet temperature	*		*				0-200F	120F	±1.0%
b) Outlet flow	*						Rotometer	10 gpm	-
2) Aftercooler									
a) Outlet temperature	*		*				0-200F	140F	±1.0%
b) Outlet flow	*						Rotometer	10 gpm	-

TABLE 9.2-12 (Cont'd)

TURBINE COOLING WATER SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm (1)		(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Instrument Dryer Cooler									
a) Outlet temperature	*						0-200F	140F	±1.0%
b) Outlet flow	*						Rotometer	10 gpm	-
Station Air Compressor									
1) Cooling water jacket									
a) Outlet temperature	*		*				0-200F	120F	±1.0%
b) Outlet flow	*						Rotometer	15 gpm	-
2) Aftercooler									
a) Outlet temperature	*		*				0-200F	140F	±1.0%
b) Outlet flow	*						Rotometer	10 gpm	-
Condensate Pumps & Motor Cooling									
1) Motor outlet									
a) temperature	*						0-200F	110F	±1.0%
b) flow	*						Rotometer	10 gpm	-
2) Stuffing Box Outlet									
a) temperature	*						0-200F	110F	±1.0%
b) flow	*						Rotometer	10 gpm	-
Feedwater Pumps Oil Coolers									
1) Outlet flow	*						Rotometer	20 gpm	-

TABLE 9.2-12 (Cont'd)

TURBINE COOLING WATER SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm (1)		(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
2) Outlet temperature	*						0-200F	110F	±1.0%
Heater Drain Pumps									
1) Seal cooler outlet									
a) temperature	*						0-200F	110F	±1.0%
b) flow	*						Rotometer	10 gpm	-
2) Stuffing Box Outlet									
a) temperature	*						0-200F	110F	±1.0%
b) flow	*						Rotometer	10 gpm	-
Turbine Cooling Water Surge Tank									
1) Level	*		*	*		Regulate flow to tank from condensate pump by means of level control valve LCV-13-1	Sight glass	Centerline of tank	-
2) Integrated makeup (gal)	*						-	-	-

(1) All alarms and recordings are in the control room unless otherwise indicated.

(2) Turbine cooline HX tube side instrumentation is contained in Table 9.2-3.

HX - Heat exchanger

9.2.5 MAKEUP WATER SYSTEM

9.2.5.1 Design Bases

The function of the makeup water system is to supply treated, demineralized water of the required quality for makeup use to various systems of the plant, including the reactor coolant system and the condensate and feedwater system.

The makeup water system serves no safety function, since it is not required to achieve safe shutdown or mitigate the consequences of a LOCA.

9.2.5.2 System Description

At the plant site, water from the city of Fort Pierce is stored in two 500,000 gal city water storage tanks. Water from these tanks is supplied to the fire protection system, domestic water system and the makeup water system. The makeup water system is shown schematically on Figure 9.2-5 and equipment design parameters given in Table 9.2-13.

Water for the makeup system is pumped by two city water transfer pumps through the water treatment system which consists of sand pressure filters, organic scavengers, cation demineralizers, anion demineralizers and mixed bed demineralizers. The demineralized water then flows to the condensate storage tank (Section 9.2.8) for use in the condensate and feedwater system.

Water required for reactor coolant system makeup flows from the mixed bed demineralizer outlet to a vacuum degasifier. From the degasifier, the water is pumped by two degasifier water pumps to the primary water storage tank. The water is maintained degasified by use of a diaphragm. Water from this tank is supplied as makeup to the chemical volume and control system by means of two primary water pumps. The chemical volume and control system maintains reactor coolant system inventory by charging primary makeup water to the reactor coolant system. The primary water pumps also supply makeup water to the waste management system.

9.2.5.3 System Evaluation

The makeup water system serves no safety function. Each of the two city water transfer pumps, the two degasifier water pumps and the two primary water pumps are 100 percent capacity. The various components of the water treatment system also have redundant capabilities, namely four sand pressure filters, two 100 percent capacity organic scavengers, two 100 percent capacity cation demineralizers, three 100 percent capacity anion demineralizers and two 100 percent capacity mixed bed demineralizers.

Adequate volume of water is always stored in the condensate storage tank to ensure availability of water for the auxiliary feedwater pumps.

TABLE 9.2-13

DESIGN DATA FOR MAKEUP WATER SYSTEM COMPONENTS

1. Water Treatment System

Pressure Filters	
Quantity	4
Diameter, feet	8
Pressure, psig	100
Filtering media	Sand
Organic Scavengers	
Quantity	2
Diameter, feet	6.5
Pressure, psig	100
Cation Demineralizer	
Quantity	2
Diameter, feet	8
Pressure, psig	100
Anion Demineralizer	
Quantity	2
Diameter, feet	2
Pressure, psig	100
Mixed Bed Demineralizer	
Quantity	2
Diameter, feet	6.5
Pressure, psig	100

TABLE 9.2-13 (cont'd)

2.	Vacuum Degasifier	
	Quantity	1
	Flow rate, gpm	200
	Pressure, inches of vacuum Hg	30
3.	Degasifier Water Pumps	
	Flow rate, gpm	200
	Quantity	2
	TDH, feet	110
4.	City Water Transfer Pumps	
	Flow rate, gpm	750
5.	Primary Water Storage Tank	
	Quantity	1
	Capacity, gallons	150,000
	Material	Carbon steel, Tarset epoxy lined
	Design pressure	Atmospheric
	Code	AWWA - D100
6.	Primary Water Pump	
	Quantity	2
	Capacity, each, gpm	300
	Type	Horizontal centrifugal
	Head, feet	250
	Material	Stainless steel

9.2.5.4 Testing and Inspection

Each component is inspected and cleaned prior to installation into the system. The system is operated and tested initially to ensure its proper operation, instruments have been calibrated, and automatic controls have been tested for actuation at the proper set points.

9.2.5.5 Instrumentation Application

The instrumentation in the makeup water system is listed in Table 9.2-14. The instrumentation monitors and controls the water level of the primary water tank and monitors operation of the primary water pump. The primary water pump can be started by hand switch in the control room or by local pushbutton. The standby primary water pump is automatically started on low pump discharge header pressure.

The flow of water into the primary water tank is controlled by a level control valve in the intake header to the tank. The pressurizer quench tank makeup header is isolated on a CIS signal (see Table 6.2-1 for data on isolation valves) by valve closure. Isolation can also be accomplished by local hand switch closure of the valve.

TABLE 9.2-14

MAKEUP WATER SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		(1) Alarm		(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Primary Water Tank Level (2)	*	*	*	*		Control operation of valve connecting degasifier water pump discharge to primary water tank	0-30 ft.	Full make-up - 4 ft.	±1.0%
Primary Water Pump									
1) Discharge header pressure				*		Start standby primary pump on low pressure	0-100 psig	110 psig	±1.0%
2) Discharge pressure	*						0-200 psig	110 psig	±0.5%

1) All alarms and recordings are in the control room unless otherwise indicated.
2) Alarms in both control room and water treatment panel.

9.2.6 POTABLE AND SANITARY WATER SYSTEMS

The potable and sanitary water system is shown on Figure 9.2-5 and system design data are given on Table 9.2-15.

The potable and sanitary water system serve no safety function since they are not required to achieve safe shutdown or to mitigate the consequences of a LOCA.

The potable and sanitary water required for plant use is taken directly from the water supply for the city of Fort Pierce and stored in the two 500,000 gallon city water storage tanks. It is distributed throughout the plant without any additional water treatment. The system is pressurized with a hydropneumatic tank and a set of pumps which assure that minimum pressure is available to supply water. It is designed to meet the drinking and miscellaneous requirements of the full complement of the plant staff. All plant sanitary water is routed to septic tanks. All sanitary water used at the plant is potable.

The system is tested and cleaned before being put into operation.

TABLE 9.2-15

DESIGN DATA FOR POTABLE AND SANITARY WATER SYSTEM COMPONENTS

1. Hydropneumatic Tank	
Material	Carbon steel
Capacity, gallons	4000 (approximate)
Length, ft-in	19 - 5
Diameter, ft-in	6 - 0
Design pressure, psig	200
Design temp, F	150
Code	ASME Section VIII
2. Domestic Water Pump	
Type	Horizontal centrifugal
Number	2
Capacity, gpm	350
Discharge Pressure, psig	125
Material:	
Discharge Head	Ductile iron
Impeller	Cast iron
Motor	50 HP/460 Volts/3 Phase/60 hz
Codes	Motor: NEMA
	Pump: Standards of the Hydraulic Institute

9.2.7 ULTIMATE HEAT SINK

9.2.7.1 Design Bases

The ultimate heat sink has sufficient cooling water capacity to dissipate reactor decay heat during normal and emergency shutdown conditions. Specifically, the ultimate heat sink can:

a) provide sufficient cooling water for more than 30 days to permit and maintain safe shutdown, or to permit control of a LOCA

b) withstand the effects of the design basis earthquake (DBE), tornado, or flooding effects without loss of safety function, assuming a single failure of a man-made structural feature.

9.2.7.2 System Description

Two water sources comprise the ultimate heat sink for the plant, the Atlantic Ocean and Big Mud Creek/Indian River. The retaining structures associated with the latter source are designed to seismic Class I requirements. The retaining structure and conduits associated with the Atlantic Ocean are not designed to function after a design basis earthquake; however, they can withstand all other severe natural phenomena associated with the site. The stability of the intake canal slopes is discussed in Section 2.5.5.

The primary source of cooling water for dissipating reactor decay heat during normal or emergency shutdown is the Atlantic Ocean via the circulating water system intake, described in Sections 9.2.3 and 3.8.1. Two 10.5 ft I.D. reinforced concrete pipes take ocean water from about 1200 ft off shore. The pipes are buried at the -18 ft MLW contour. The preferred source of cooling water for dissipating reactor heat following a LOCA is also the Atlantic Ocean source. However, if the LOCA were accompanied by the DBE, the possibility would exist for the intake canal to become impassable due to failure of nonseismic Class I structures. Consequently, a second source, designed to withstand the DBE, is connected to the intake structure for use as a backup. This source is Big Mud Creek which is a natural body of water extending easterly from the Indian River just north of the plant site.

The Indian River is connected to the Atlantic Ocean by two inlets, one at Fort Pierce to the north and one at St. Lucie to the south. The Intercoastal Waterway, with a 12 foot deep channel, runs north-south in the Indian River. A 60 ft wide by 20 ft deep (-20 ft MLW) channel has been dredged from the Intercoastal Waterway into Big Mud Creek. The creek itself is dredged to a minimum elevation of -40 ft MLW with a minimum 250 ft width.

The intake structure is connected to Big Mud Creek by two 48 inch diameter conduits with a centerline elevation of -6 feet MLW and are supported on piles extending to elevation -60 ft. Each pipe is sized to pass the water required for normal and emergency shutdown operations, approximately 14,500 gpm. During power operation, the conduits are sealed by a float operated valve which prevents flow from Big Mud Creek into the intake structure. When the water level in the canal falls below -6 ft MLW, the float operator opens the valve.

Each set of piles, pipe cradle and pipe for the secondary source are designed as a single structure for seismic earthquake loads with the soil liquefied from elevation -60 ft. to elevation 0 ft. The liquefied soil is treated as a 90 lb/ft^3 liquid. The structure and piles have a horizontal loading of 1/10th of the liquefied soil pressure applied to the structure. The 1/10th factor is a static load factor and corresponds to the DBE acceleration of 0.1g. The soil is above ground water level and acts as dead load on the structure. The soil above the structure to elevation +18 feet is considered as supported by the structures and lateral loadings equivalent to 1/10 of the dead weight of the soil are applied to the structure in combination with the liquefied soil conditions.

9.2.7.3 System Evaluation

The ultimate heat sink concept for the plant complies completely with the Regulatory Position of AEC Safety Guide 27.

To provide a high level of assurance that cooling water is available for dissipation of decay heat following reactor shutdown or after an accident, two cooling water sources are connected to the plant intake structure. The primary heat sink is provided by the Atlantic Ocean as described in Section 9.2.3; the secondary heat sink is provided by Big Mud Creek. Each water source is capable of performing the safety functions required of the ultimate heat sink. The intake structure and the adjacent soils for the first 60 feet in front of the intake bays are seismic Class I.

The system connecting Big Mud Creek to the intake structure consists of two independent emergency cooling water pipes. Each pipe is designed to provide sufficient cooling water to achieve safe plant shutdown or mitigate the consequences of a LOCA in the event of loss of cooling water from the primary source. The pipes are designed to remain operable during and following a DBE or tornado. The two conduits are completely redundant and are separated sufficiently that loss of one pipe does not induce failure of its redundant counterpart or compromise the ability of the sink to accomplish its safety function.

There is sufficient water between the Ft. Pierce and St. Lucie inlets from the Atlantic Ocean to the Indian River to allow the required ultimate heat sink functions for much more than 30 days. The ultimate heat sink is capable of withstanding each of the most severe natural phenomena expected at the site concurrent with a single failure of a man made structural feature without loss of cooling capability. The intake canal by itself can supply the required quantity of emergency cooling water for at least 20 hours after occurrence of the most severe natural phenomena (liquefaction) and a single failure of a man-made structure.

9.2.8 CONDENSATE STORAGE FACILITIES

The condensate storage system is schematically shown in Figure 10.1-2.

The condensate storage system consists of a 250,000 gallon condensate storage tank which serves as a source of feedwater for the auxiliary feedwater system. The tank also serves as a source of makeup water for condenser hotwell and return for excess hotwell water under normal operations.

Approximately 110,000 gallons of water are required for cooldown of the unit to 320 F, the temperature needed to start operation of the shutdown cooling system. Alarms are sounded in the control room and at the water treatment panel on low and high level. A low-low level is alarmed in the control room to prevent overheating of the auxiliary feedwater pumps should the condensate level drop to minimum pump suction requirements. The low level alarm is initiated at a tank volume of 125,000 gallons and the low-low level alarm at 5,000 gallons.

Refer to Section 10.4.7 for further discussion of the auxiliary feedwater system emergency condensate requirements.

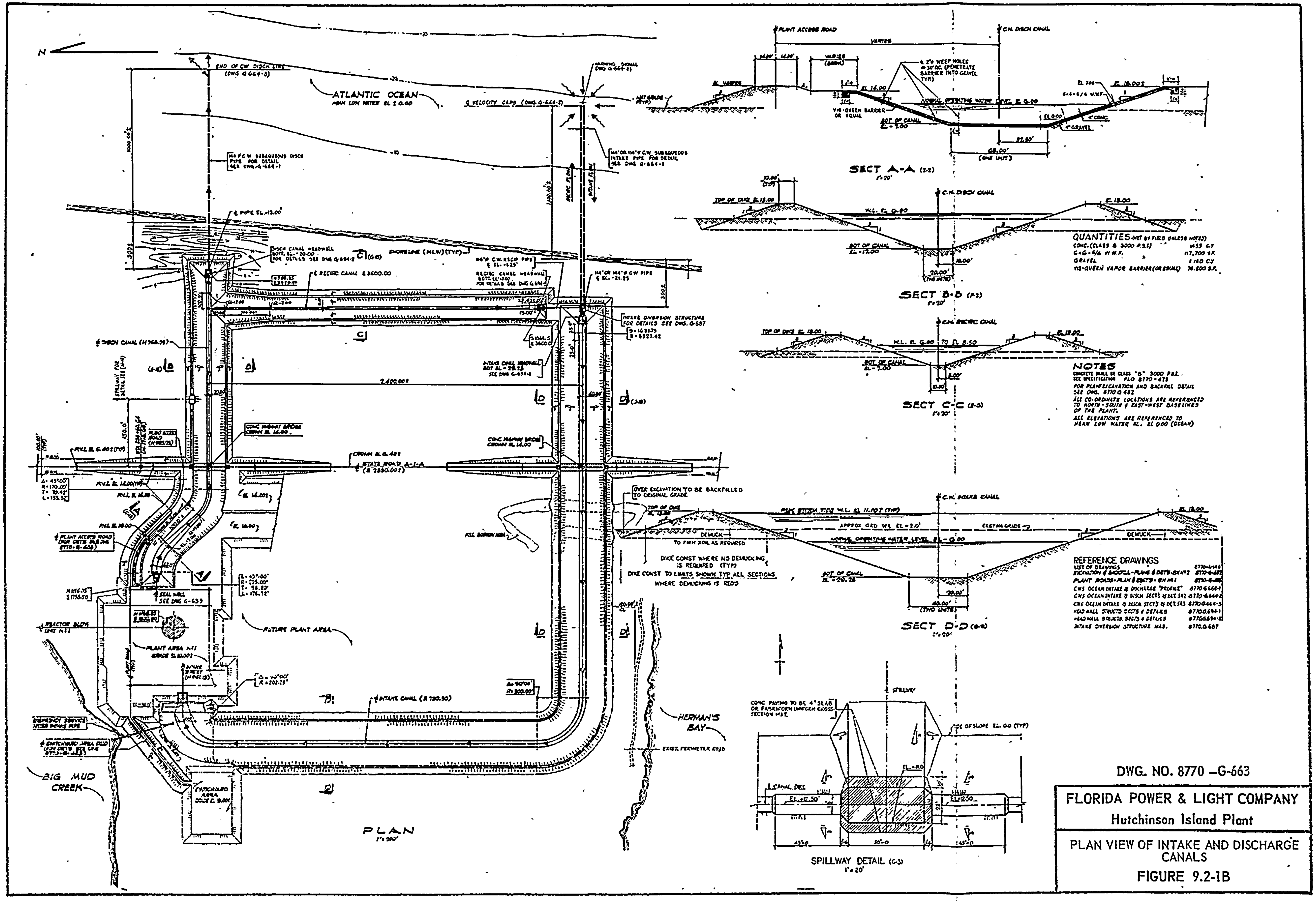
The condensate water is expected to contain insignificant radioactivity; therefore, no provision has been made to measure radioactivity release from this source. Periodic grab samples are taken and analyzed to ensure that there is no activity buildup in the tank. The tank is designed as seismic Class I and is enclosed in a concrete missile barrier. A discussion of the seismic requirements for the condensate system piping is given in Section 9.4-6.

Design data for the condensate storage tank is given in Table 9.2-16.

TABLE 9.2-16

DESIGN DATA FOR CONDENSATE STORAGE TANK

Capacity, gallons	250,000
Operating pressure	Atmospheric
Operating temperature, F	30-120
Design pressure	Atmospheric
Design temperature, F	125
Material	Epoxy lined carbon steel
Seismic design	Class I
Code	AWWA-D100



DWG. NO. 8770 –G-663

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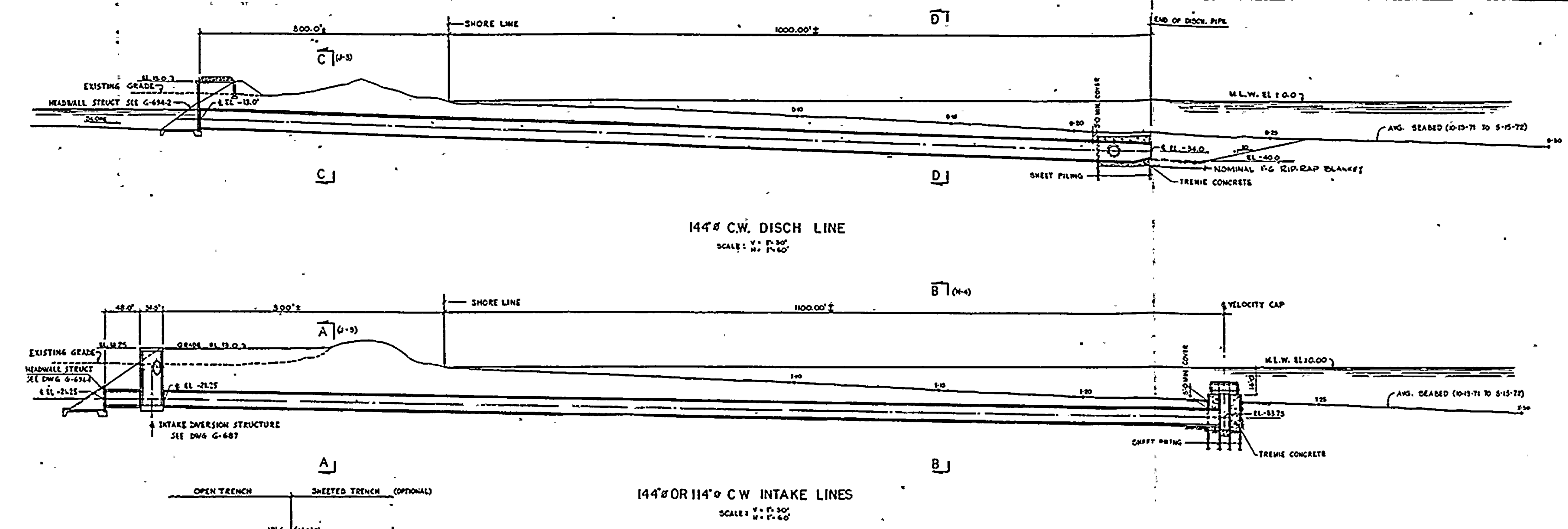
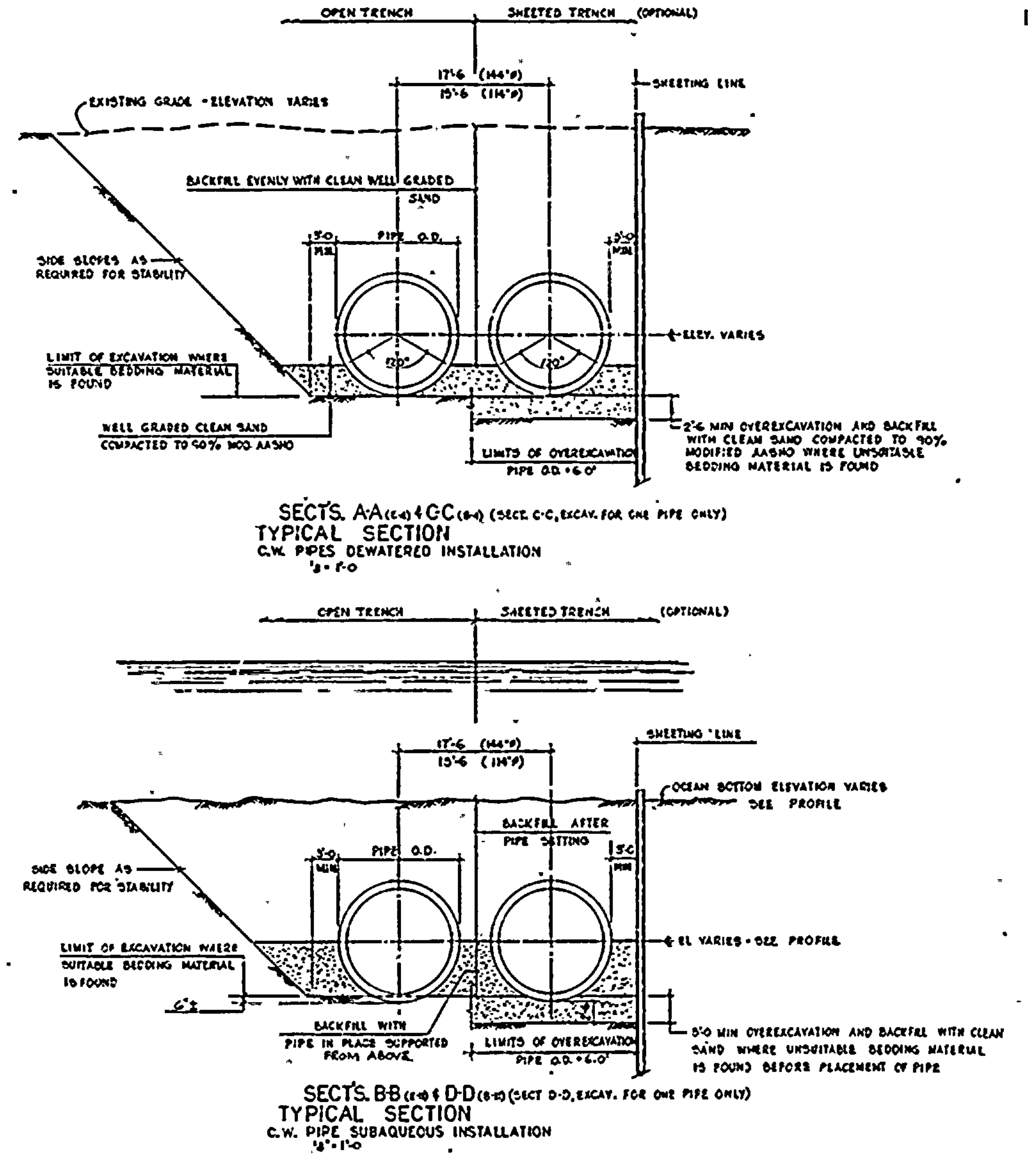
PLAN VIEW OF INTAKE AND DISCHARGE CANALS

FIGURE 9.2-1B





REFERENCE DRAWINGS

LIST OF DRAWINGS	8770-A-146
CWS OCEAN INTAKE & DISCHARGE "PLAN"	8770-G-663
HEADWALL STRUCT'S SECT'S & DETAILS	8770-G-694-1
HEADWALL STRUCT'S SECT'S & DETAILS	8770-G-694-2
INTAKE DIVERSION STRUCT MAS	8770-G-687

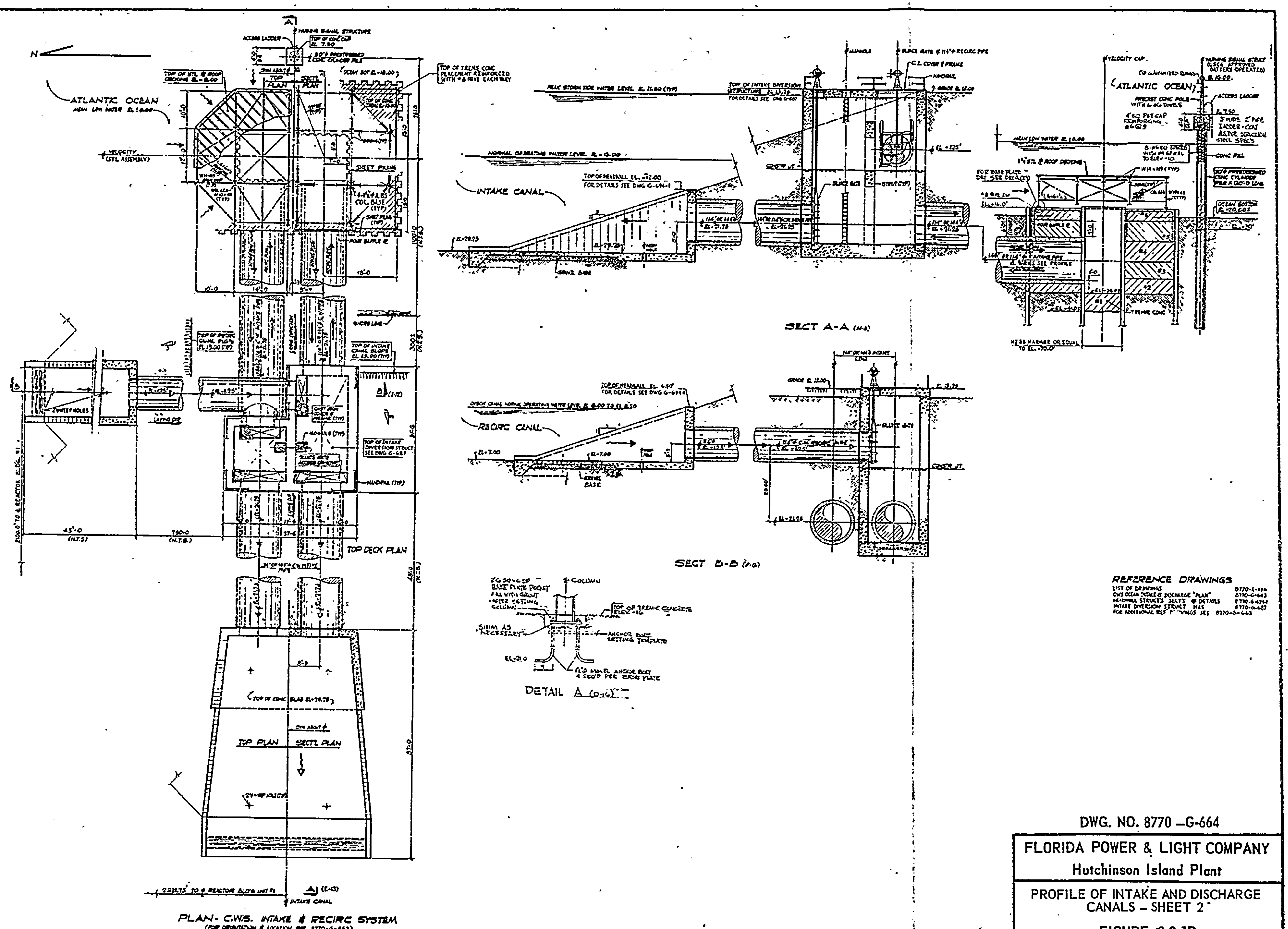
DWG. NO. 8770 – G-664

FLORIDA POWER & LIGHT COMPANY

Hutchinson Island Plant

PROFILE OF INTAKE AND DISCHARGE CANALS – SHEET 1

FIGURE 9.2-1C



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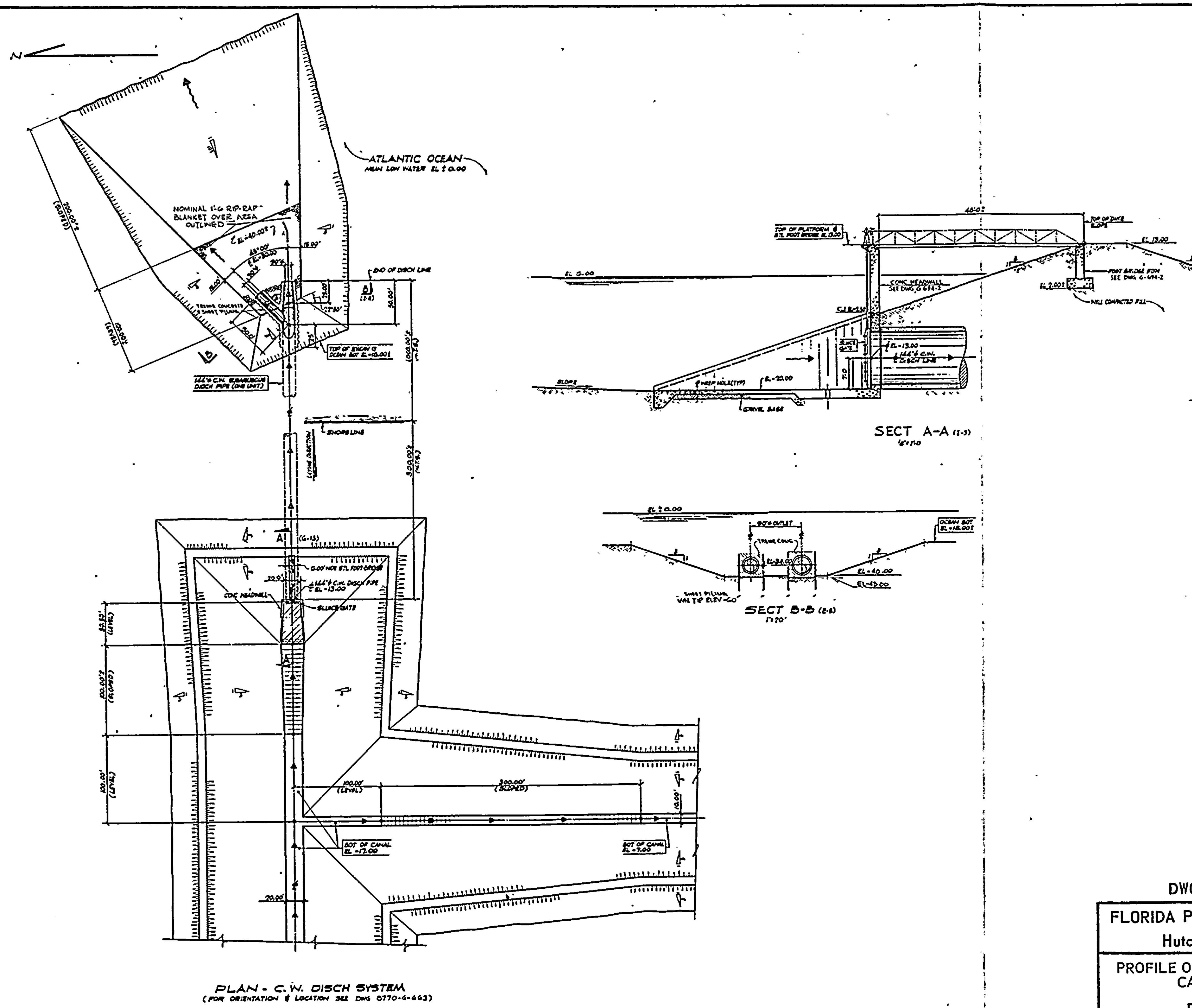
PROFILE OF INTAKE AND DISCHARGE CANALS - SHEET 2

FIGURE 9.2-1D



NOTES

CONCRETE SHALL BE CLASS "B" 3000 PSI
SEE SPECIFICATION FLO 8770-473
FOR ADDITIONAL NOTES SEE DWG 8770-G-663

REFERENCE DRAWINGS

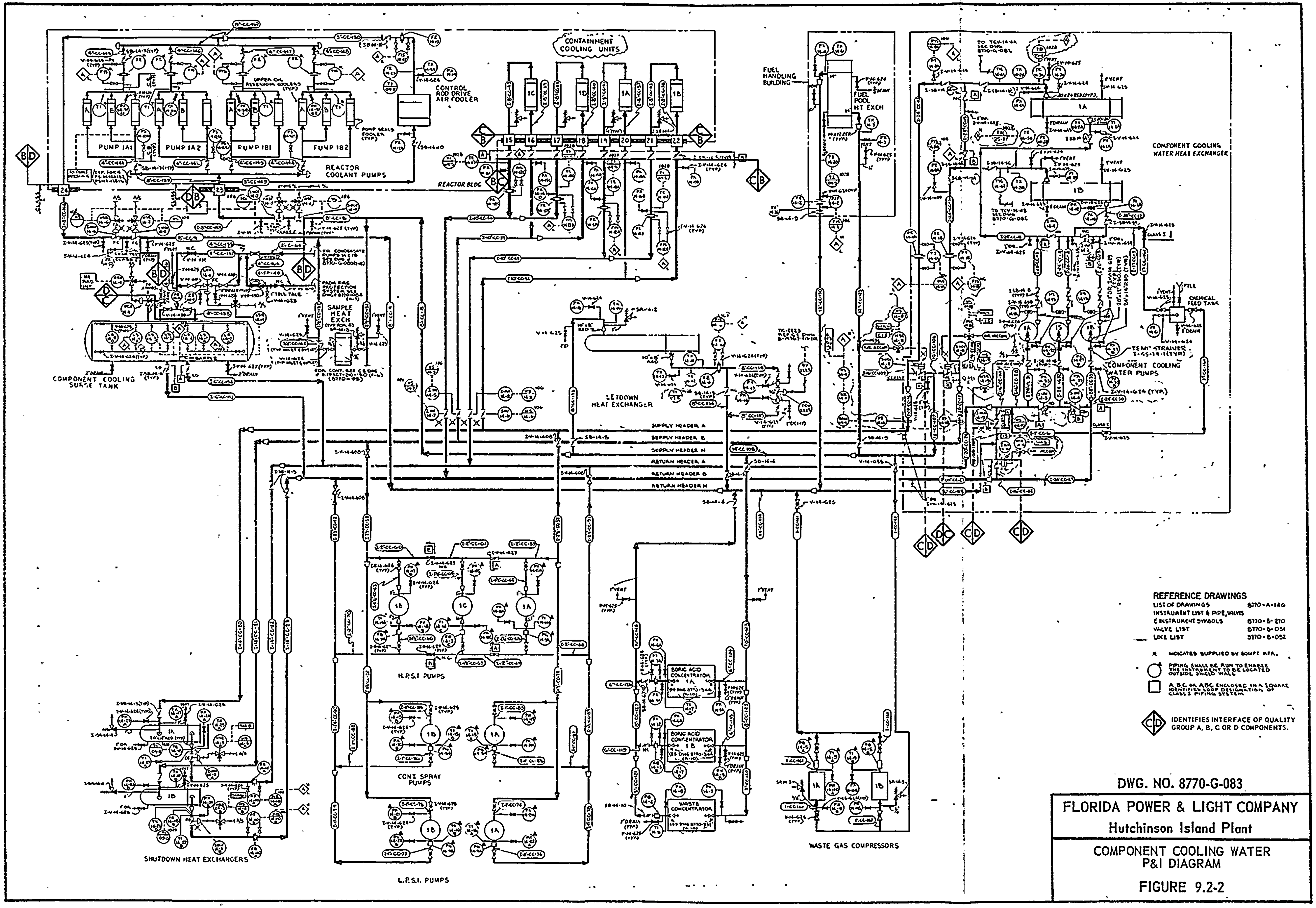
LIST OF DRAWINGS 8770-A-146
CWS OCEAN INTAKE & DISCHARGE "PLAN" 8770-G-663
HEADWALL STRUCT'S SECTS & DETAILS
MAS & REINF. SH 2 8770-G-6942
FOR ADDITIONAL REF DWGS SEE 8770-G-663

DWG. NO. 8770 -G-664

FLORIDA POWER & LIGHT COMPANY
Hutchinson Island Plant

PROFILE OF INTAKE AND DISCHARGE CANALS - SHEET 3

FIGURE 9.2-1E



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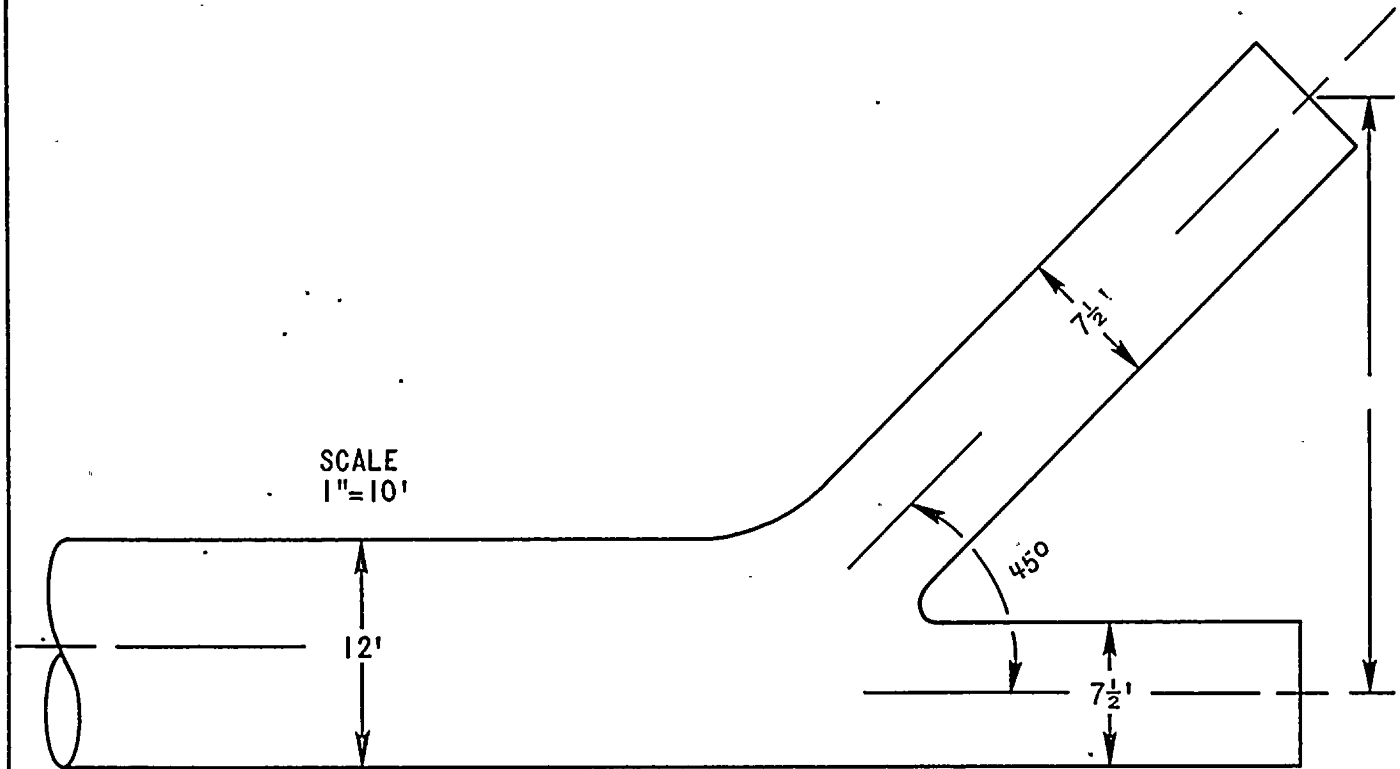
COMPONENT COOLING WATER
P&I DIAGRAM

FIGURE 9.2-2



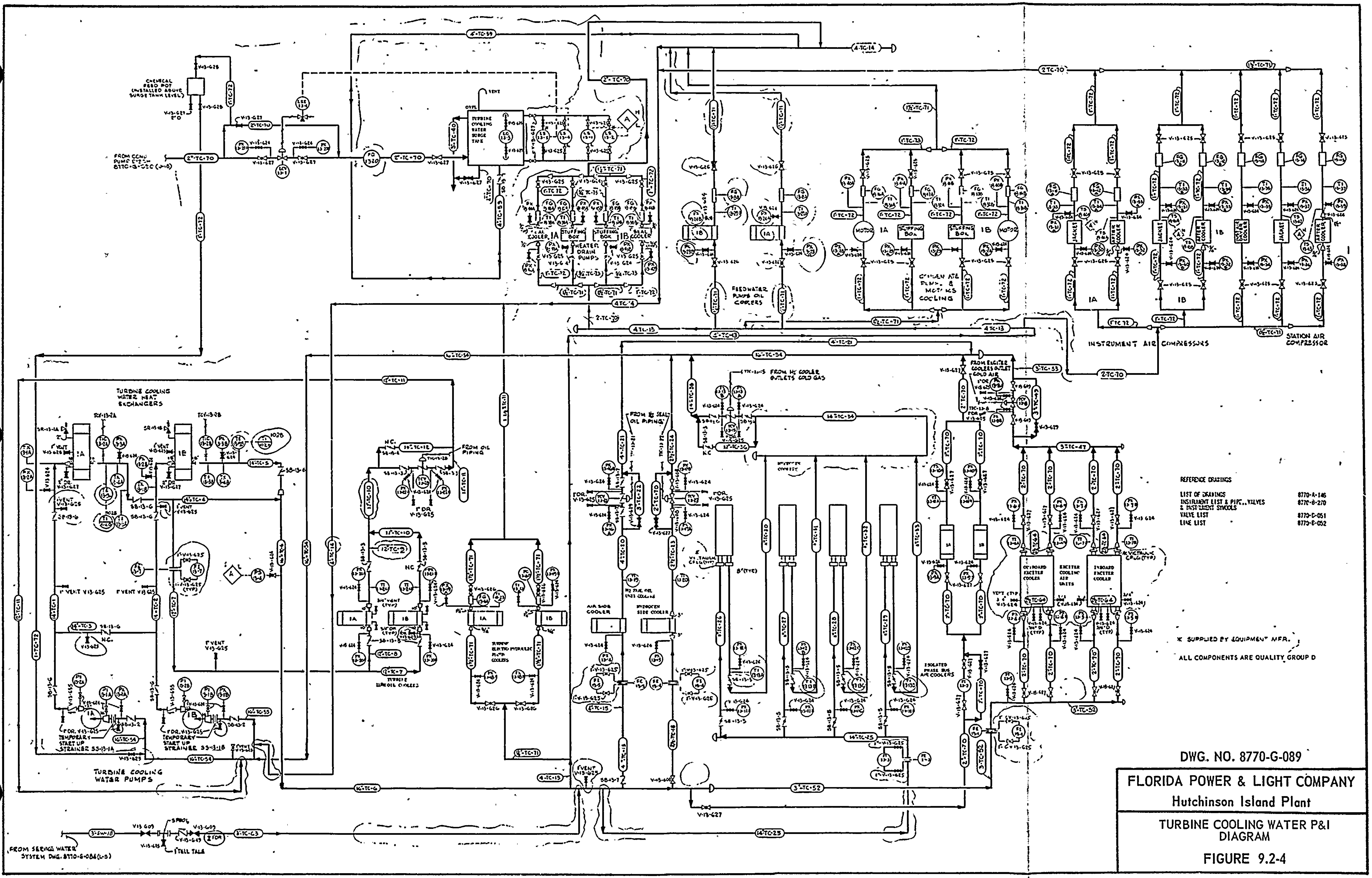
FLORIDA POWER & LIGHT COMPANY

HUTCHINSON ISLAND PLANT

UNIT 1

DETAIL OF 'Y' OUTFALL FOR CIRCULATING WATER DISCHARGE

FIGURE 9:2-3



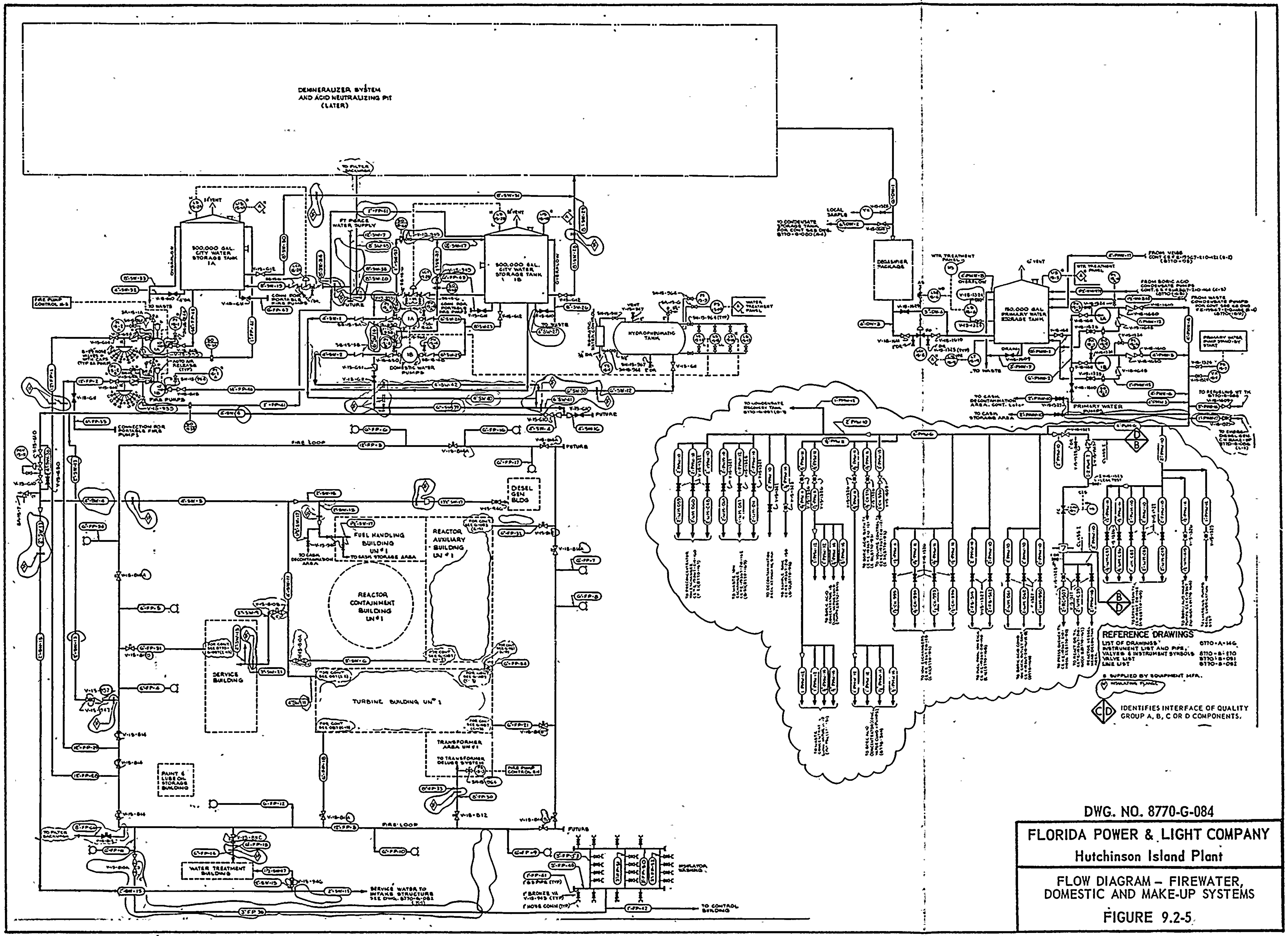
DWG. NO. 8770-G-089

FLORIDA POWER & LIGHT COMPANY

Hutchinson Island Plant

TURBINE COOLING WATER P&I DIAGRAM

FIGURE 9.2-4



DWG. NO. 8770-G-084

FLORIDA POWER & LIGHT COMPANY
Hutchinson Island Plant

FLOW DIAGRAM – FIREWATER, DOMESTIC AND MAKE-UP SYSTEMS

FIGURE 9.2-5

9.3 PROCESS AUXILIARIES

9.3.1 COMPRESSED AIR SYSTEM

9.3.1.1 Design Bases

The compressed air system consisting of the instrument and service air systems is designed to provide a reliable supply of dry, oil-free air for pneumatic instruments and controls, and pneumatically operated valves and the necessary service air for normal plant operation and maintenance. The system serves no safety function since it is not required to achieve safe shutdown or to mitigate the consequences of a LOCA.

The design of the system is based on an instrument air requirement of 155 scfm and a service air requirement of 500 scfm.

9.3.1.2 System Description

The compressed air system is shown schematically in Figure 9.3-1 and equipment design parameters are given in Table 9.3-1.

The instrument air system incorporates two full capacity nonlubricated compressors, each having a separate inlet filter, aftercooler and moisture separator. The instrument air compressors discharge to a single header connected to an air receiver and air dryer and filter assembly. The compressed air header is divided into branch lines supplying the containment, intake structure, service building, water treatment area, turbine building, tank storage areas, fuel handling building and reactor auxiliary building. The various air-operated valves and pneumatic instruments and controls are supplied from the header.

Normal operation requires one instrument air compressor to maintain air receiver pressure between 90-100 psig, with the other compressor starting automatically if the instrument air receiver pressure falls below 85 psig.

The service air system consists of one 100 percent capacity service air compressor with inlet filter, an aftercooler and moisture separator, air receiver and distribution piping. The receiver outlet header is divided into branch lines supplying service air to the containment area, intake structure, fuel handling building, reactor auxiliary building, service building, water treatment area and storage tank areas. Service air is used for the operation of pneumatic tools and equipment used for plant maintenance.

Normal operation requires the service air compressor to maintain service air receiver pressure between 90-100 psig. Cross connect capability exists between the instrument air and service air systems. The cross connect consists of a flexible coupling used to reduce noise and vibrations associated with the reciprocating action of the compressors.

9.3.1.3 System Evaluation

The power supply for the compressor motors is from the normal power distribution system. If a loss of offsite power occurs, the buses can be manually connected to the emergency diesel generators.

Instrument air system redundancy is provided by the two instrument air compressor units plus the cross connect capability to the service air system. A total loss of system is highly unlikely during normal operation.

TABLE 9.3-1

DESIGN DATA FOR COMPRESSED AIR SYSTEM COMPONENTS

1. Instrument Air System

Air Compressor

Type	Horizontal, non-lubricated reciprocating, double acting single stage
Quantity	2
Design capacity, scfm	162
Discharge pressure, psig	100
Motor	40 hp, 3 phase, 60 Hz, 460 v
Enclosure	Totally enclosed fan cooled
Code	ASME Section VIII, NEMA

Intake Filter Silencer

Type	Dry type, Air Maze
Quantity	2
Base size, inches	6

Aftercooler and Moisture Separator

Type	Shell and tube
Quantity	2
Code	TEMA Class C. ASME Section VIII

Air Receiver

Type	Vertical
Quantity	1
Design pressure, psig	125
Design Temperature, F	125
Actual volume, ft^3	96
Code	ASME Section VIII

Prefilters

Type	Baffles & Vanes
Quantity	2
Capacity, scfm	385
Filtration	100% removal of all entrained particulate 10 microns in size and larger

Air Dryer

Type	Electrically Heated
Desiccant	Activated alumina desiccant
Quantity	1
Capacity, scfm	155
Outlet moisture content with saturated air inlet	-40F dew point at 100 psig

TABLE 9.3-1 (cont'd)

Afterfilters

Type	Cartridge
Quantity	6
Capacity, scfm, each	30
Filtration	100% removal of all particulates over 0.9 microns

Piping and Valves

Valves	150 lb ANSI for 2-1/2" and larger. 600 lb ANSI for 2" and smaller.
Piping	Seamless ASTM A-106, Grade B (2-1/2" thru 6")
Code	ANSI B31.1.0 (ANSI B31.7 - penetration piping)

2. Service Air System

Air Compressor

Type	Horizontal, reciprocating, two stage
Quantity	1
Design Capacity, scfm	518
Discharge pressure, psig	100
Motor	125 hp, 3 phase, 60 Hz, 460 v
Enclosure	Totally enclosed fan cooled
Code	ASME Section VIII, NEMA

Intake Filter Silencer

Type	Dry Type
Quantity	1

Aftercooler and Moisture Separator

Type	Shell and tube
Quantity	1
Code	TEMA Class C, ASME Section VIII

Air Receiver

Type	Vertical
Quantity	1
Design pressure, psig	125
Actual volume, ft^3	151
Code	ASME Section VIII

TABLE 9.3-1 (cont'd)

Piping and Valving

Valves	150 psi ANSI for 2-1/2" and larger, 600 psi ANSI for 2" and smaller
Piping	Seamless ASTM A-106, Grade B (2-1/2" thru 6")
Code	ANSI B31.1.0 (ANSI B31.7 - penetration piping)

All safety related air-operated valves are designed to fail in the position required to perform their safety function in the event a loss of air supply occurs. The single exception to this rule applies to the containment vacuum relief valves which perform both a containment isolation function and vacuum relief function. These valves fail closed on loss of air. They are provided with accumulators to assure a reliable source of air in the event of loss of instrument air. The accumulator and piping for operation of the valves are designated as Seismic Class I. A check valve is provided at the interface with the instrument air system. See Section 3.8.2.1.11 for further discussion of these valves. Other containment isolation valve positions on power failure are indicated in Table 6.2-1. All safety related instruments and controls are non-pneumatic except for (1) the air operated temperature control valve used to regulate intake water flow to the component cooling heat exchangers and (2) the electropneumatic transducers used to regulate auxiliary feedwater flow to the steam generators. Temperature controlling transducers cause the control valves to fail fully open on loss of air supply.

Complete loss of instrument or service air during full power operation or under accident conditions in no way reduces the ability of the reactor protective system or the engineered safety features and their supporting systems to safely shut down the reactor or to mitigate the consequences of an accident.

9.3.1.4 Testing and Inspection

The systems are inspected and cleaned prior to service. 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 plant operational testing. The system is operated and tested initially with regard to flow paths, flow capacity, and mechanical operability.

The compressed air system is in service during normal plant operation. System performance will therefore be checked by the performance of the components utilizing instrument or service air.

9.3.1.5 Instrument Application

Table 9.3-2 lists the parameters used to monitor compressed air system operation.

The station and instrument air compressors are automatically started and stopped to maintain the air receiver pressure within the range of 90-100 psig. The compressors can also be started manually by local push button.

The operation of automatic valves in the compressed air system is discussed in Section 9.3.1.3.

TABLE 9.3-2

COMPRESSED AIR SYSTEM INSTRUMENT APPLICATION

System Parameter & Location	Indication		Alarm (1)		Recording (1)	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Instrument Air Compressor									
1) Discharge temperature	*		*				50-500F	425F	± 1.0%
2) Discharge pressure	*						0-200psig	100-105psig	± 0.5%
Instrument Aftercooler									
1) Discharge temperature	*						0-200F	115F	± 1.0%
2) Discharge pressure	*						0-200psig	100 psig	± 0.5%
3) Separator level	*						Sight glass	-	-
Instrument Receiver Pressure	*		*	*		1) Controls instrument air compressor operation 2) Second compressor cut-in. at 85 psig; cut-out at 95 psig	0-200psig	100psig	±0.5%
Instrument Prefilter									
1) Inlet pressure	*						0-150psig	100psig	± 2.0%
2) Outlet pressure	*						0-150psig	98-100psig	± 2.0%
Instrument Dryer									
1) Inlet pressure	*						0-150psig	98-100psig	± 2.0%
2) Inlet temperature	*						0-200F	115F	± 2.0%
3) Outlet temperature	*						0-200F	100F	± 2.0%

(1) All alarms and recordings are in the control room unless otherwise indicated.

TABLE 9.3-2 (Cont'd)

COMPRESSED AIR SYSTEM INSTRUMENT APPLICATION

System Parameter & Location	Indication		Alarm (1)		Recording (1)	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
4) Outlet pressure	*						Local 0-200psig Control Room 0-150 psig	95 psig	Local ± 0.5% Control Room ± 3.0%
<u>Afterfilter Package</u>									
<u>Outlet Pressure</u>	*	*		*			0-200psig	80-100psig	± 0.5%
<u>Station Air Compressor</u>									
1) Outlet pressure	*						0-200psig	100psig	± 0.5%
2) Outlet temperature	*		*				50-500F	425F	± 1.0%
<u>Station Aftercooler</u>									
1) Outlet pressure	*						0-200psig	100psig	± 0.5%
2) Outlet temperature	*						0-200F	125F	± 1.0%
<u>Station Air Receiver</u>									
<u>Pressure</u>	*		*	*		Controls station air compressor	0-200psig	100psig	± 0.5%
<u>Discharge Air Header</u>									
<u>Pressure</u>		*		*			0-150psig	100psig	± 1.5%

(1) All alarms and recordings are in the control room unless otherwise indicated.

9.3.2 SAMPLING SYSTEM

9.3.2.1 Design Bases

The sampling system provides the means to obtain samples from the reactor coolant and auxiliary systems during plant startup, power operation and plant shutdown for chemical and radiochemical laboratory analysis. The results of analyses performed on these samples form the basis for regulating the boron concentration, monitoring the fuel integrity, evaluating the ion exchanger and filter performance, specifying chemical additions and maintaining the proper hydrogen concentration in the reactor.

9.3.2.2 System Description

The piping and instrumentation diagram for the sampling system is shown in Figure 9.3-2. Tables 9.3-3 and 9.3-4 list the sample flow rates and system design data, respectively.

Typical analyses performed on the reactor coolant and auxiliary systems include tests for boron concentration, fission and corrosion product activity levels and concentration, dissolved gas and corrosion product concentrations, chloride concentration, coolant pH and conductivity levels. Typically the samples are collected on a periodic basis. The sampling room, located at floor elevation 19.5 ft in the reactor auxiliary building, uses instrumentation to monitor the temperature and pressure of each of the samples.

The sample sink, which is located within the sampling hood, has a raised edge to contain any spilled liquid. To minimize the possibility of spillage all samples are either collected in plastic containers or in a sample vessel. The sink is provided with a hood equipped with a fan exhausting to the plant vent.

In order to assure that a representative sample is obtained, the sampling lines are purged prior to withdrawing the sample. The pressure and flow rate of each of the purge flows is locally indicated. The duration of the purge will be sufficient to turn over a minimum of two sample line volumes.

The sample volume varies according to the type of analysis to be performed. For instance, the hot leg sample may be collected in the sample vessel which has a volume of 1000 cc. From this sample, the amounts of O_2, H_2 and dissolved fission gases may be determined. The hot leg sample may also be collected at the sample sink where the sample volume required for a boron or chloride concentration analysis would be approximately 250 ml while a crud concentration analysis sample volume could be as large as 5 liters.

9.3.2.2.1 Sampling

The sampling points have been selected to obtain all the required chemical and radiological information necessary for monitoring and regulating plant chemistry. Separate transfer lines from the various sampling points to the

TABLE 9.3-3

SAMPLING SYSTEM FLOW RATES

Nominal flow rates at standard conditions, gpm

Pressurizer Steam Space	0.5
Pressurizer Surge Line	1.0
Reactor Coolant System Hot Leg	1.0
Shutdown Cooling Suction Line	1.0
High-Pressure Safety Injection Pump Miniflow Line	1.0
CVCS Purification Filter 1A Inlet	1.0
CVCS Purification Filter 1A Outlet	1.0
CVCS Purification Filter 1B Outlet	1.0
CVCS Purification Ion Exchanger Series Flow Line	1.0
Steam Generator Blowdown Line	1.0

TABLE 9.3-4

DESIGN DATA FOR SAMPLE SYSTEM COMPONENTS

1. Sample Heat Exchanger

Quantity	4 (Identical units)
Type	Shell and Tube, Vertical
Tube Side (Sampling)	
Fluid	Reactor Coolant
Design Pressure, psig	6000
Pressure Drop, psi	55 @ 250 lbs/hr
Material	Ni Ci Fe
Shell Side (Cooling Water)	
Fluid	Component Cooling Water
Design Pressure, psig	375
Pressure Drop, psi	3 @ 3 gpm
Material	Ni Ci Fe

2. Sample Vessel

Quantity	2
Internal Volume, cc	1000
Design Pressure, psig	2485
Design Temperature, F	250
Normal Operating Pressure, psig	2235
Normal Operating Temperature, F	120
Material	Stainless Steel (316)
Fluid	Reactor Coolant

3. Relief Valves

a. Relief Valve in Hot Leg Sample Line (V-5109)	
Set Pressure, psig	75
Accumulation, %	10
Backpressure Buildup, psi	35
Superimposed Backpressure, psi	25
Capacity, gpm for water @ 100F	8.0
Normal Fluid Temperature, F	120
Maximum Fluid Temperature, F	250
b. Relief Valve in Pressurizer Steam Sample Line (V-5124)	
Set Pressure, psig	75
Accumulation, %	10
Backpressure Buildup, psi	35
Superimposed Buildup, psi	25
Capacity, gpm for water @ 100F	8.0
Normal Fluid Temperature, F	120
Maximum Fluid Temperature, F	250

4. Hood Fan

Type	Centrifugal
Motor Horsepower, hp	1/4
Fan Speed, rpm	1725
Flow Rate, scfm	515

sample sink or sample vessel are provided to allow for simultaneous sampling. Specific samples and sampling points and criteria used in designing the sample lines are described below:

a) Reactor Coolant System Samples

Reactor coolant system samples are taken from hot leg loop 1A, the pressurizer surge line and the pressurizer steam space.

1) Hot Leg Sample - The hot leg is sampled to check reactor coolant chemistry and radioactivity. The hot leg sample tubing is arranged to include a delay coil so that the overall transient time from the loop to the containment wall is sufficient to permit the decay of short lived radionuclides. In particular, a delay time of at least 90 seconds inside the containment is allowed for N-16 because of its high energy gamma emission. This delay time is selected to allow normal access to the sampling room.

   The two types of samples which may be collected from the hot leg of the reactor coolant system are (1) a high pressure, low temperature sample collected in a sample vessel and used for determining the amounts of O_2, N_2, He, H_2 and fission gases, and (2) a low pressure, low temperature sample collected at the sampling sink and used for determining the chloride and boron concentration.

   A high pressure ($\sim$2235 psig) and high temperature ($\sim$600F) sample from the hot leg of the reactor coolant system is routed to the sampling system where it is cooled to 120F or less in a sample heat exchanger and then may be reduced in pressure by a throttling valve (V-5107) to approximately 25 psig. The flow rate for the sample is approximately 1.0 gpm.

   Before sampling, a purge flow is established by bypassing the sample vessel to assure that a representative sample is obtained. A portion of the flow is then either drawn to the sample sink where a sample is collected or the flow is diverted to the sample vessel where a high pressure sample is isolated and collected.

2) Pressurizer Surge Line Sample - This sample is taken at the sample sink to check the boron concentration in the pressurizer surge line. A high pressure, low temperature sample is not required because the boron concentration analysis is normally the only test to be performed.

   The high pressure ($\sim$ 2235 psig), high temperature ($\sim$ 650F) sample from the pressurizer surge line is routed to the sampling room where it is cooled to 120F or less in a sample heat exchanger and then reduced in pressure across a throttling valve (V-5111) to approximately 25 psig. The flow rate is approximately 1.0 gpm. The sample normally flows through a purge line to the volume control tank or to the waste management system flash tank (if the volume control tank is not available) until sufficient volume has passes to permit the collection of a representative sample. A portion of the flow is drawn via the grab sample valve (V-5139) and a sample is collected. The purge flow is normally directed to the volume control tank in the chemical and volume control system to minimize waste generation. The pressure and flow rate to the volume control tank is locally indicated.

3) Pressurizer Steam Space Sample - This sample is taken to give a representative sample of fission products and noncondensable gases in the pressurizer steam space. A high pressure, low temperature sample can be collected in a sample vessel or a low pressure, low temperature sample can be collected in the sample sink as described above. The sample flow rate is 0.5 gpm.

Grab samples can also be obtained with the sample vessels disconnected by using the sample vessel bypass lines (V-5106) or (V-5120). The sample vessel bypass lines are used during the initial portion of the sample line purging operation to minimize sample vessel contamination.

b) Safety Injection System Samples

The safety injection system sample is taken to check the boron concentration of the water during the recirculation period following a LOCA. The pressure in the high pressure safety injection pump miniflow line varies from 120 psig to 200 psig depending on the operation of the safety injection pumps. The temperature in this line has a maximum value of 300F. The flow rate to the sampling system is approximately 1.0 gpm.

At the sample room, the flow is routed through a sample heat exchanger where the temperature is reduced to about 120F and through a throttling valve (V-5128) where the pressure is reduced to approximately 25 psig. After the sampling lines are purged, a sample is collected at the sample sink.

c) Shutdown Cooling System Samples

The shutdown cooling suction line sample allows verification of the reactor coolant boron concentration prior to and during shutdown cooling. The pressure at the shutdown cooling sample point can be as high as 300 psig and the temperature can be as high as 350F. The maximum flow rate to the sampling room is approximately 1.0 gpm. At the sampling room, the temperature and pressure (V-5128) are reduced to about 120F and 25 psig, respectively. After the sample lines have been purged, a sample is collected at the sample sink.

d) Chemical and Volume Control System Samples

Sample points for the chemical and volume control system are located at purification filter 1A inlet and outlet, at the outlet of purification filter 1B (outlet of the ion exchangers) and in the purification ion exchanger series flow line. The samples at the purification filter 1A inlet and outlet provide a means to determine the particulate activity decontamination factor (DF) for crud activity of the filter. The purification filter 1A inlet sample (letdown flow) can also be a backup to the hot leg sample. The sample at the outlet of purification filter 1B together with the ion exchanger inlet sample (same as the purification filter 1A outlet sample) gives a decontamination factor of soluble activity for the ion exchanger unit, and the combined ion exchanger and filter 1B DF ofr particulate activity. The purification ion exchanger series flow line sample together with the samples from the inlet and outlet of the ion exchangers gives the decontamination factor for each ion exchanger if two ion exchangers are being operated in series.

The samples from the chemical and volume control system are at a temperature of 120F and a pressure of approximately 25 psig. Since these are the approximate operating conditions of the sampling system at the sampling room, no further reduction in temperature or pressure is required. The flow rate to the sampling room is approximately 1 gpm. After the sample lines have been purged a sample is collected at the sample sink. Purging can be to the flash tank rather than to the volume control tank to obtain an adequate flow rate due to the low differential head available.

e) Steam Generator Blowdown System Samples

The samples taken from the steam generator blowdown system are used to continuously monitor the steam generator conductivity, pH, and radiation levels. A low pressure, low temperature sample can also be taken at the sample sink in order to monitor steam generator chemistry.

Steam generator blowdown samples are taken from the blowdown line of each steam generator. These high pressure (∿ 885 psig), high temperature (∿ 550F) samples are individually routed to the sample heat exchangers and cooled to approximately 120F. The pressure of the samples is then reduced to about 25 psig by a throttling valve. The sample flow rates are approximately 1.0 gpm.

Each sample is containuously monitored for conductivity and pH. Grab samples can be obtained at the sample sink. These sample lines are contaihuously monitored for radiation. All continuous discharges are directed to the steam generator blowdown tank for disposal or processing.

9.3.2.2.2 Component Description

The major components of the sampling system are described below. The sample sink, work area and sampling lines are constructed of stainless steel to minimize any potential corrosion problems.

a. Sample Heat Exchangers

The sample heat exchangers are tube-in-shell, vertical counter flow type. Sample fluid enters the tube side at the top of the heat exchanger and the cooled samples are taken from the bottom. Component cooling water, which must be flowing before the sample fluid is introduced into the heat exchanger, enters the shell side at the bottom of the sample heat exchanger and exists at the top.

b) Sample Vessel

The sample vessels are located inside the sample hood over the sample sink. Each vessel consists of a 1000 cc stainless steel sampling cylinder with isolation valves and quick disconnect couplings. The sample vessel allows the operator to collect a high pressure, low temperature liquid or gas sample from which dissolved gases and fission gas activities can be determined.

c) Sample Sink and Hood

The sample sink is located within the sample hood. All grab samples are obtained within the sample hood and over the sample sink. A demineralized water line is routed to the sink for flushing purposes. The sample sink drains to the chemical drain tank. The sink perimeter has a raised edge to contain spilled liquid. The entrance to the sample hood is shaped so that the air drawn into the hood by the hood fan will enter in a smooth, uniform and unbroken pattern, thereby minimizing the possibility of local airborne activity outside the hood.

d) Sample Delay Line

A delay line, consisting of 150 feet of tubing, is of sufficient length to keep the reactor coolant sample flow inside the containment for a sufficient period of time to allow for the decay of radionuclides, particularly nigrogen-16. This delay line permits normal access to the sample room.

9.3.2.3 System Evaluation

The sampling system is designed to provide a means of obtaining samples from the reactor coolant and auxiliary systems for chemical and radiochemical laboratory analysis. Safety features are provided to protect plant personnel and to prevent the spread of contamination from the sampling room when samples are being collected. The system is designed to limit radioactivity releases below the 10 CFR 20 limits under normal and failure conditions. The temperature and pressure of the various samples are reduced to minimize the possibility of local airborne activity. Instrumentation is provided in the sampling room to monitor the temperature and pressure of the samples before they are collected. Samples are normally taken only when the hood fan is operating. The sampling room ventilation system provides a backup means of maintaining the low airborne activity levels.

The sample lines penetrating the containment are each equipped with two pneumatically operated isolation valves which close on actuation of the containment isolation signal (CIS). The containment isolation valves in the letdown line also close on CIS thereby stopping flow from the chemical and volume control system to the sampling system. The containment isolation valves are also designed to fail closed on loss of air supply. Remote control of these valves is provided to isolate any line failure which might occur outside of the containment. Should any of the remotely operated valves in the sampling system fail to close after a sample has been taken, backup manual valves in the sampling room may be closed. The sample system tubing components and valves are capable of operating at source pressure ($\sim$ 2485 psig) and temperature (650F) up to and including the grab sample valves. The sample sink drains to the chemical drain tank. Any leakage from the grab sample valves in the sample sink drains to this tank. The work area around the sink provides adequate space for sample collection and storage. The sink perimeter has a raised edge to contain spilled liquid.

The throttling valves in the sampling system have a limited flow coefficient (C_v) range. This range is based on the flow required and the differential head available under all operating conditions. This limits the sample flow rate to the required value and prevents excessively high flow.

9.3.2.4 Testing and Inspection

The system is inspected and cleaned prior to service. Demineralized water is used to flush each part of the system. The system is operated and tested initially with regard to flow paths, flow rate, thermal capacity and mechanical operability. Instruments are calibrated during plant hot functional testing. The set points of the relief valves are also checked at this time.

During plant startup the sampling system is hydrostatically tested by opening the valves that connect the reactor coolant system to the sampling system and observing the pressures and temperatures as the heatup continues.

9.3.2.5 Instrument Application

Table 9.3-5 lists the parameters used to monitor the sampling system operation.

TABLE 9.3-5

SAMPLING SYSTEM INSTRUMENTATION

System Parameter & Location	Indication		Alarm[1]		Rec.[1]	Control Function	Inst. Range	Normal Operating Range	Inst. Accuracy
	Local	Contr Room	High	Low					
Heat Exchanger Outlet Temperature	*						0-400 F	120 F	± 20 F
Sample Vessel Inlet Pressure	*						0-3000 psig	2250 psig	± 15 psig
Sample Vessel Outlet Pressure	*						0-100 psig	0-60 psig	± 0.5 psig
Sample Flow	*						0-3 GPM	0.7 GPM	± 0.1 GPM

[1] All alarms and recorders are in the control room unless otherwise indicated.

9.3.3 EQUIPMENT AND FLOOR DRAINAGE SYSTEM

9.3.3.1 Design Bases

The equipment and floor drainage system is designed to collect leakage or spillage from equipment located in the containment, reactor auxiliary and fuel handling buildings.

9.3.3.2 System Description

The equipment drains inside the containment are routed to the reactor drain tank and the floor drains to the reactor cavity sump. In both cases, the collected drainage is then routed to the waste management system for either reuse storage in the primary water tank or discharged to the discharge canal after sampling depending upon the quality of the water.

There are four drain tanks in the reactor auxiliary building: two laundry drain tanks, one chemical drain tank and one equipment drain tank. Table 9.3-6 lists the drains which are routed to each tank.

The ECCS room sumps collect floor and equipment drains from floor el -0.5 ft from some of the drains in adjoining areas. The sumps have automatic level controls for transfer of liquid waste to the equipment drain tank.

The chemical drain sump collects water from the floor drains surrounding the chemical drain tank and pump. This liquid is transferred to the chemical drain tank by the sump pump.

Laundry wastes from the service and reactor auxiliary buildings which are not potentially radioactive are routed to the on-site septic tank facility. The laundry drain sump collects potentially radioactive laundry waste from the floor drains in the laundry equipment cavity. The liquid is automatically transferred to the laundry drain tanks by the sump pump. The water in the laundry drain tank is sampled and if activity levels are low, the water is filtered and discharged into the circulating water discharge header. The water in the discharge header (which is made up of laundry, waste condensate and boric acid condensate water) is monitored for radiation. The flow to the circulating water discharge canal is stopped by valve (FCV-6627X, FCV-6627Y) closure on high radiation alarm.

The header valve can also be closed from the control room. The chemical and equipment drain tank water is pumped through a filter to the waste concentrator. The water in the drain tanks is sampled at its respective tank pump discharge prior to release.

Storm, floor and equipment drains that are not potentially radioactive are routed to a settling basin.

TABLE 9.3-6

DRAINS ROUTED TO DRAIN TANKS

1. Equipment Drain Tanks

   Miscellaneous valve leakoffs
   Miscellaneous pump leakoffs
   CVCS equipment drains
   Safety injection system drains
   Fuel pool drains
   Waste management system drains
   Blowdown tank
   CVCS ion exchangers
   Waste management system ion exchangers
   Fuel pool ion exchangers
   Preconcentrator ion exchangers
   Boric Acid condensate ion exchangers

2. Laundry Drain Tanks

   Hot showers
   Hot sinks
   Laundry pumps
   Laundry drain sump pump
   Laundry sump

3. Chemical Drain Tanks

   Sample sink
   Component cooling drains
   Decontamination room drains
   Chemical laboratory drains
   Cask decontamination area drains
   Fuel handling building sump pump
   Chemical drain sump pump

9.3.3.3 System Evaluation

Floor drains within the reactor auxiliary building are embedded so that leakage from the lines is contained within the building. Equipment and floor drains containing potentially radioactive fluids are made of stainless steel. Non-radioactive drains are galvanized steel above ground and cast iron below ground.

The radiological consequences of effluents from the equipment and floor drainage system are discussed in Chapter 11. A table of sources and volumes of waste are given in Table 11.2-1.

9.3.3.4 Instrumentation Application

The parameters used in equipment and floor drainage system is given in the Waste Management System Instrument Application

9.3.4 CHEMICAL AND VOLUME CONTROL SYSTEM

9.3.4.1 Design Bases

The chemical and volume control system is designed to:

a) maintain the chemistry and purity of the reactor coolant within the limits specified in Table 9.3-8

b) maintain the required volume of water in the reactor coolant system by compensating for coolant contraction or expansion due to plant step load changes of ±10 percent of full power and ramp changes of ±5 percent of full power per minute between 15 and 100 percent power and for reactor coolant losses or additions

c) accept out-flow from the reactor coolant system when the reactor coolant is heated at the administrative rate of 75F/hr and to provide the required makeup when the reactor coolant is cooled at the administrative rate of 75F/hr using two charging pumps

d) accommodate the reactor coolant system water inventory change for a full-to-zero power decrease with no makeup system operation and with the volume control tank initially at the normal operating level band

e) inject concentrated boric acid into the reactor coolant system upon a safety injection actuation signal (SIAS)

f) control the boron concentration in the reactor coolant system to obtain optimum control element assembly (CEA) positioning to compensate for reactivity changes associated with large changes in reactor coolant temperature, core burnup, and xenon concentration variations, and to provide shutdown margin for maintenance and refueling operations

g) inject boron in sufficient quantity to counteract the maximum reactivity increase due to cooldown at 75F/hr and xenon decay using one charging pump

h) automatically divert the letdown flow to the waste management system (WMS) when the volume control tank is at the highest permissible level

i) provide continuous on-line measurement of reactor coolant boron concentration and radioactivity due to fission and corrosion products

j) assure that the radioactivity due to corrosion and fission products in the reactor coolant system does not exceed Technical Specification limits for an assumed 1 percent failed fuel condition

k) provide auxiliary pressurizer spray for operator control of the reactor coolant system pressure during the final stages of shutdown and to allow for the cooling of the pressurizer

l) collect the controlled bleedoff from the reactor coolant pump seals

m) provide a means for functionally testing the check valves which isolate the safety injection system from the reactor coolant system

n) leak test the reactor coolant system

o) withstand the environmental conditions as presented in Section 3.11

p) withstand the expected transients given in Table 9.3-9 without any adverse effects.

9.3.4.2 System Description

9.3.4.2.1 Normal Operation

The chemical and volume control system (CVCS) is shown on the simplified diagram, Figure 9.3-3, and on the piping and instrumentation drawings, Figures 9.3-4 and 9.3-5. The system parameters are given in Table 9.3-10.

The normal flow path of reactor coolant through the system is indicated by the heavy lines in Figures 9.3-4 and 9.3-5.

Normal operation includes hot standby operation and power generation when the reactor coolant system is at normal operating pressure and temperature.

Coolant flow from the cold leg in Loop 1B1 of the reactor coolant system passes through the tube side of the regenerative heat exchanger for an initial temperature reduction. The cooled fluid is reduced to the operating pressure of the letdown heat exchanger by one of two letdown control valves (LCV2110P, LCV2110Q). The final reduction to the operating temperature and pressure of the purification system is made by the letdown heat exchanger and one of two letdown backpressure valves (PCV2201P, PCV2201Q). The flow then passes through a prefilter, one of three ion exchangers, a strainer, another filter, an afterfilter, and is sprayed into the volume control tank.

The charging pumps take suction from the volume control tank and pump the coolant into the reactor coolant system. One charging pump is normally in operation and one letdown control valve is controlled to maintain an exact balance between letdown flow rate plus reactor coolant pump bleedoff flow rate and charging flow rate. The charging flow passes 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.

A makeup system provides for changes in reactor coolant boron concentration and for reactor coolant chemistry control. Concentrated boric acid solution, prepared in an electrically heated batching tank, is stored in two boric acid makeup tanks. Two boric acid makeup pumps are used to transfer the concentrated boric acid for mixing with reactor makeup water in a predetermined ratio to produce the desired boron concentration. The controlled boric acid solution is then directed into the volume control tank. A chemical addition tank and metering pump are used to transfer chemical additives to the suction of the charging pumps. Boric acid recovered from the waste management system (WMS) boric acid concentrator is returned to the boric acid makeup tanks.

The volume of water in the reactor coolant system is automatically controlled by water level instrumentation mounted on the pressurizer. The pressurizer level set point is programmed to vary as a function of reactor power in order to minimize the transfer of fluid between the reactor coolant system and the chemical and volume control system during power changes. This linear relationship is shown in Figure 5.5-4. Reactor power is determined by the reactor coolant average temperature across a steam generator. A level error signal is obtained by comparing the programmed level set point with the measured pressurizer water level. Water level control is achieved by automatic control of the constant speed charging pumps and one letdown control valve in accordance with the pressurizer level control program shown in Figure 5.5-5. One letdown control valve is normally controlled by the pressurizer level control program to obtain a letdown flow equal to the charging flow produced by one charging pump minus the total reactor coolant pump controlled bleedoff flow. Large changes in pressurizer water level due to power changes or abnormal operations result in automatic operation of one or both of the standby charging pumps and/or modulation of one letdown control valve. The rate of letdown flow is controlled by the letdown control valve which is positioned by the pressurizer level control signal.

An automatic system maintains the water level in the volume control tank. The letdown flow is automatically diverted to the waste management system when the highest permissible water level is reached in the volume control tank. The makeup system is normally set to the automatic mode of operation, and a volume control tank low level signal causes a preset solution of concentrated boric acid and reactor makeup water to be introduced into the volume control tank. A low-low level signal automatically closes the outlet valve on the volume control tank and switches the charging pump suction to the refueling water tank.

The boronometer supplements normal chemical analysis and utilizes the neutron absorptionometry technique to continuously monitor the concentration of the boron-10 isotope in the reactor coolant as sampled from the letdown line. A neutron source is positioned in the center of a cylindrical pressure vessel. Four neutron detectors located concentrically around the outer edge of the pressure vessel produce pulses whose rate varies inversely with the B-10 concentration. The pulse rate signal is integrated to improve statistical accuracy and passed to a signal generator which produces a signal proportional to boron concentration. This signal is scaled and applied to a front panel meter located in the control room.

A portion of the response time of the boronometer is due to the time it takes for coolant to be transported from the reactor coolant system to the instrument. With a letdown rate of 40 gpm, and a flow rate of 1.0 gpm through the process radiation monitor and the boronometer, a response time of about four minutes exists from the reactor coolant system to the boronometer. The time constant of the mixing process within the boronometer is about 15 minutes with a 0.5 gpm flow rate. With an added response time of less than one minute for the instrument electronics, the total system will require about twenty minutes to reach equilibrium following a step change in boron concentration. This system response time is adequate considering the relatively slow rate of boron concentration change in the reactor coolant.

The accuracy of the boronometer is ±25 ppm of the actual boron concentration over the total range of 0 - 2150 ppm. Measured repeatability will be better than ±10 ppm throughout the range of expected variations in power supply voltage and environmental conditions. Tests run on a prototype unit in the C-E test facility have verified the accuracy limits specified above.

TABLE 9.3-8

REACTOR COOLANT AND REACTOR MAKEUP WATER CHEMISTRY

Variable	Reactor Coolant		Reactor Makeup Water
	During Passivation	Operational	
Total solids (excluding Additives), ppm max.	0.5	0.5	0.5
pH at 77F	10.0-10.4	4.5-10.2	6.0-8.0
Chloride, ppm Cl^- max.	0.15	0.15	0.15
Fluoride, ppm F^-, max.	0.10	0.10	0.10
Hydrogen as H_2, scc/kg	0(1)	10-50	-
Dissolved O_2, ppm max. (2)	0.1	0.1	Deaerated
Lithium as Li^7, ppm	0	0.1-0.5	-
Boron as boric acid ppm	0(3)	0-2150	-
Hydrazine, ppm	30-50	<10(4)	-
Conductivity, μmhos/cm	(5)	<20	<2
Carbon dioxide (77F)	-	-	Deaerated

(1) Nitrogen overpressure is used in the CVCS volume control tank during passivation operations to exclude oxygen.

(2) At temperature below 150F, no upper limit on dissolved O_2 is specified.

(3) Boric acid to be added to the reactor coolant system prior to fuel loading. Following the boric acid addition, hydrazine and ammonia concentrations are reduced to maintain a reactor coolant conductivity of less than 20 μmhos/cm.

(4) After preconditioning, hydrazine is added only during subcritical heatup at 1-1/2 times the measured oxygen concentration.

(5) Depends on the concentrations of N_2H_4 and NH_3 in the coolant.

TABLE 9.3-9

DESIGN TRANSIENTS
Regenerative and Letdown Heat Exchangers

Transient	Cycles in 40 Years	Variation Level Initial		Variation Level Final	Rate	Letdown Flow Initial - Final (GPM)	Charging Flow (GPM)
		RCS					
Plant Startup	500	70F Atmos.	- -	532F 2250 psia	75F/hr	56 - 150 in 8.6 hrs 150 - 40 in 3 hrs	44
Step Power Change	2000	90%	-	100%		40 - 90 90 - 40 in 40 min	44
Step Power Change	2000	100%	-	90%		40 - 73; 73 - 30 in 20 min	44 (88 briefly)
Ramp Power Change	15000	15%	-	100%	5%/min	40 - 121 in 17 min 121 - 40 in 17 min	44
Ramp Power Change	15000	100%	-	15%	-5%/min	40 - 30; 30 - 40 in 27 min	44-88-132; 132-88-44 in 20 min
Turbine Trip	400	100%	-	0%		40 - 30; 30 - 40 in 35 min	44-88-132; 132-88-44 in 15 min
Loss of Load	40	100%	-	0%		40 - 30; 30 - 40 in 35 min	44-88-132; 132-88-44 in 15 min
Loss of Flow	40	100%	-	0%		40 - 30; 30 - 40 in 35 min	44-88-132; 132-88-44 in 15 min

TABLE 9.3-9 (Cont.)

Transient	Cycles in 40 Years	Variation Level Initial - Final	Rate	Letdown Flow Initial - Final	Charging Flow
Loss of Secondary Pressure	5	-		40-30-0 in 12 sec	44-132
Maximum Purification	1000	-		40-84-128; 128-84-40	44-88-132; 132-88-44
Low-Low Volume Control Tank Response	80	Charging Flow Temp. 120F - 40F in 10 sec		40	44
Loss of Charging	100	-		40 - 0 0 - 40	44-0 0-44
Loss of Letdown	50	-		40 - 0 0-128-40 25 min after restart	44
Short Term Isolation - Regen. Ht. Exch.	400	-		40 - 0 0 - 40	44-0 0-44
Long Term Isolation - Regen. Ht. Exch.	800	R.H. Exch. Temp. ? - 125F		40 - 0 0 - 40	44-0 0-44
Plant Cooldown	500	RCS 532F - 70F 2250 psia-Atmos.		30 - 100 in 11 hrs 100 - 30 (rapidly)	132 132-44

TABLE 9.3-10

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 from reactor coolant system, F	550
Normal charging temperature to reactor coolant system loop, F	395
Ion exchanger operating temperature, F	120

The boronometer electronics are constructed of modern solid state components in a design utilizing printed circuits. This type of construction has proved to be highly reliable in operation.

The chemistry and purity of the reactor coolant are controlled to ensure the following:

a) The plant is accessible for maintenance and operation without excessive radiation exposure to the operating personnel

b) Long term operation of the plant is achieved without excessive fouling of heat transfer surfaces

c) The corrosion rate of the materials in contact with the reactor coolant is kept at a minimum.

Chemistry control of the reactor coolant consists of removal of oxygen by hydrazine scavenging during startup and reduction of oxygen concentration during power operation by maintaining excess hydrogen concentration in the reactor coolant. A chemical addition tank and metering pump are used to transfer hydrazine to the suction side of the charging pumps for injection into the reactor coolant system, while hydrogen concentration in the reactor coolant system is controlled by maintaining a hydrogen overpressure in the volume control tank.

During the preoperational test period, 30 to 50 ppm hydrazine is maintained in the reactor coolant whenever the reactor coolant temperature is below 150F. This is done to prevent halide-induced corrosion attack of stainless steel surfaces which can occur in the presence of significant quantities of dissolved oxygen. During heatup, any dissolved oxygen is scavenged by hydrazine thus eliminating one necessary ingredient for halide-induced corrosion. Elimination of oxygen on heatup also minimizes the potential for general corrosion. At higher temperatures, the hydrazine decomposes, not necessarily completely, producing ammonia and a high pH which aids in the development of passive oxide films on reactor coolant system surfaces that minimize corrosion product release. The corrosion rates of Ni-Cr-Fe Alloy-600 and 300 series stainless steels decrease with time when exposed to prescribed reactor coolant chemistry conditions which rates approach low steady state values within approximately 200 days.

By the end of the preoperational test period, any fluorides or chlorides are removed from the system and concentrations in the coolant are maintained at low levels by reactor coolant purification and demineralized makeup water addition. High hydrazine concentration is not required to inhibit halide-induced corrosion, but hydrazine, added at 1.5 times the oxygen concentration, is still used during heatup to scavenge oxygen. This assures complete removal of oxygen on heatup while minimizing ammonia and nitrogen generation when hot and at power. When at power, oxygen is controlled to a very low concentration by maintaining excess dissolved hydrogen in the coolant. The excess hydrogen forces the water decomposition/synthesis reaction in the reactor core to water rather than hydrogen and oxygen. Any oxygen in the makeup water is also removed by this process.

Since operating with a basic pH control agent results in lower general corrosion release rates from the reactor coolant system materials, and because the alkali metal lithium is generated in significant quantities by the core neutron flux through the reaction $B^{10}(n,\alpha)Li^{7}$, lithium is selected 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 the decrease in boron concentration. However, even though lithium is the choice for pH control, there exists a threshold for accelerated attack on zircaloy at approximately 35 ppm lithium and therefore, the lithium concentration limits are specified as 0 to 0.5 ppm to provide a wide margin between the upper operating limit and the threshold for attack in the event any concentrating phenomena exist.

Early in core life lithium production is the greatest and periodic removal by ion exchange is required to control the concentration below the upper limit. Late in core life lithium additions may be necessary if lithium concentration is to be held near the upper limit, but this is not considered essential as indicated by the lower lithium concentration limit of zero. Lithium is removed along with cesium by intermittent operation on an ion exchanger while a second ion exchanger is operated continuously for the removal of fission and corrosion products. The resin beds remove soluble nuclides by the ion exchange mechanism. Insoluble particles are removed by the impingement of these particles on the surface of the resin beads. A cartridge type prefilter, located upstream of the ion exchangers, removes insoluble articles. A strainer downstream of the ion exchangers protects against the gross release of resin to the coolant in the event of an ion exchanger retention element failure.

The boron concentration is controlled to obtain optimum CEA positioning to compensate for reactivity changes associated with changes in coolant temperature, core burnup, xenon concentration variations and to provide shutdown margin for maintenance and refueling operations or emergencies.

The normal method of adjusting boron concentration is by the technique of feed and bleed. To change concentration, the makeup system supplies either reactor makeup water or concentrated boric acid to the volume control tank, and the letdown stream is diverted to the waste management system. Toward the end of a core cycle, the quantities of waste produced due to feed and bleed operations become excessive due to the low boron concentration and the deborating ion exchanger is used to reduce the reactor coolant system boron concentration. The deboration ion exchanger uses an anion resin which is converted to a borate form as boron is removed from the bleed stream.

Two boric acid makeup tanks and two boric acid pumps supply boric acid to the reactor coolant system via the volume control tank and charging pumps. There are four modes of makeup system operation. In the dilute mode, a preset quantity of reactor makeup water is added into the volume control tank at a preset rate. In the borate mode, a preset quantity of concentrated boric acid is introduced at a preset rate. In the manual mode, the flow rates of the reactor makeup water and the concentrated boric acid are preset manually to give any boric acid solution between zero and concentrated boric acid. This latter mode is primarily used for makeup and filling the safety injection tanks and the refueling water tank. In the automatic mode, a preset boric acid solution is automatically mixed and introduced into the volume control tank upon demand from the volume control tank level program. The preset solution concentration is adjusted periodically by the operator to match the boric acid concentration being maintained in the reactor coolant system.

The location numbers on the chemical and volume control system P&ID, Figures 9.3-4 and 9.3-5, indicate the process flow reference points in the system. Table 9.3-11 is a tabulation of the 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.

9.3.4.2.2 Components

The major components of the CVCS are described below:

a) Regenerative heat exchanger -
The regenerative heat exchanger located in the containment above floor elevation 16.0 feet conserves reactor coolant system thermal energy by transferring heat from the letdown stream to the charging stream. The heat exchanger is designed to maintain a letdown outlet temperature below 450F under all normal operating conditions. The design characteristics of the regenerative heat exchanger are given in Table 9.3-12.

b) Letdown heat exchanger -
The letdown heat exchanger located in the auxiliary building on floor elevation 19.5 feet uses component cooling water to cool the letdown flow from the outlet temperature of the regenerative heat exchanger to a temperature compatible with long term operation of the purification system ion exchangers. The unit is sized to cool the maximum letdown flow rate from the maximum outlet temperature of the regenerative heat exchanger (450F). To prevent possible damage to the heat exchanger by excessive component cooling water flow the flow control valves are preset to limit the flow to 1500 GPM maximum. The cooling water flow rate is indicated and alarmed on high flow in the control room. The design characteristics of the letdown heat exchanger are given in Table 9.3-13.

c) Purification filters -
Purification filter 1A located in the auxiliary building on floor elevation 19.5 feet removes insoluble particulates from the reactor coolant prior to entering the ion exchanger.[5] Purification Filter 1B downstream of the ion exchangers and strainer, is the same as Filter 1A and serves to retain any resin fines that may be released from the ion exchangers. The unit is designed to pass the maximum letdown flow without exceeding the allowable differential pressure across

the filter cartridge in the maximum fouled condition. Due to the buildup of high activity levels during normal operation, the unit is designed for remote removal of the contaminated cartridge assembly. The design characteristics of the filters are given in Table 9.3-14.

d) <u>Purification and deborating ion exchangers</u> -
The two mixed bed purification ion exchangers are each sized for the maximum letdown flow rate. One purification ion exchanger is used intermittently to control the lithium and cesium concentration in the reactor coolant system and the other for normal constant operation. The units contain both anion and cation resins in a 3/1 ratio and both ion exchangers are provided with all connections required to replace and mix the resins by liquid and air sluicing. The deborating ion exchanger is identical to the purification ion exchangers in size and construction and is sized to contain sufficient anion resin to control the reactor coolant system boron concentration from 30 ppm to the end of core cycle. The design characteristics of the ion exchangers are given in Table 9.3-15. The three ion exchangers are located in the auxiliary building on floor elevation 19.5 feet.

TABLE 9.3-11

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	7a	7b	8	9
Flow, gpm	40	40	40	40	40	39	1	1/2	1/2	40	40
Press., psig	2110	2090	465	460	25	22	25	24	24	21	20
Temp., F	550	262	262	120	120	120	120	120	120	120	120

CVCS INTERMEDIATE PURIFICATION OPERATION   Two Charging Pumps in Operation

CVCS Location	1	2	3	4	5	6	7	7a	7b	8	9
Flow, gpm	84	84	84	84	84	83	1	1/2	1/2	84	84
Press., psig	2075	2005	475	460	43	40	43	42	42	38	35
Temp., F	550	334	334	120	120	120	120	120	120	120	120

CVCS MAXIMUM PURIFICATION OPERATION   Three Charging Pumps in Operation

CVCS Location:	1	2	3	4	5	6	7	7a	7b	8	9
Flow, gpm	128	128	128	128	128	127	1	3/4	3/4	128	128
Press., psig	1995	1785	495	460	75	68	75	74	74	64	57
Temp, F	550	375	375	120	120	120	120	120	120	120	120

NOTES:

The pressure drop across the purification prefilter, afterfilter, and ion exchanger varies with loading. The pressure drops shown are typical.

The pressure in the volume control tank varies and affects the pressures at locations 5 through 11 and 14a through 14g proportionally.

CVCS location numbers are shown on Figures 9.3-4 and 9.3-5.

TABLE 9.3-11 (Cont.)

CHEMICAL AND VOLUME CONTROL SYSTEM PROCESS FLOW DATA

CVCS NORMAL PURIFICATION OPERATION One Charging Pump in Operation

CVCS Location:	10	10a	10b	10c	11	12	13	14 (a,b,c,d)	14e	14f	14g
Flow gpm	40	40	40	44	44	44	44	1	0	4	4
Press., psig	19	18	15	15	15	2235	2225	100	100	100	16
Temp, F	120	120	120	120	120	120	395	120	120	120	120

CVCS INTERMEDIATE PURIFICATION OPERATION Two Charging Pumps in Operation

CVCS Location:	10	10a	10b	10c	11	12	13	14 (a,b,c,d)	14e	14f	14g
Flow, gpm	84	84	84	88	88	88	88	1	0	4	4
Press., psig	33	30	15	15	15	2280	2255	100	100	100	16
Temp., F	120	120	120	120	120	120	340	120	120	120	120

CVCS MAXIMUM PURIFICATION OPERATION Three Charging Pumps in Operation

CVCS Location:	10	10a	10b	10c	11	12	13	14 (a,b,c,d)	14e	14f	14g
Flow, gpm	128	128	128	132	132	132	132	1	0	4	4
Press., psig	54	47	15	15	15	2385	2335	100	100	100	16
Temp., F	120	120	120	120	120	120	310	120	120	120	120

NOTES:

The pressure drop across the purification prefilter, afterfilter, and ion exchanger varies with loading. The pressure drops shown are typical.
The pressure in the volume control tank varies and affects the pressures at locations 5 through 11 and 14a through 14g proportionally.
CVCS location numbers are shown on Figures 9.3-4 and 9.3-5.

TABLE 9.3-11 (Cont)

CHEMICAL AND VOLUME CONTROL SYSTEM PROCESS FLOW DATA

CVCS MAKEUP SYSTEM OPERATION - AUTOMATIC MODE   Blended Boric Acid Concentration= 925 ppm

CVCS Location:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Flow, gpm	174	174	10	10	0	10	140	140	150	0	0	0	164	154	10	10	0	0
Press., psig	7	91	91	86	15	20	140	20	20	12	91	15	91	91	91	20	7	7
Temp., F	140	140	140	140	160	140	60	60	65	70	160	160	140	140	140	140	160	160

CVCS MAKEUP SYSTEM OPERATION - BORATE MODE   Three Charging Pumps Operating

CVCS Location:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30.	31	32
Flow, gpm	180	180	16	16	0	16	0	0	16	0	0	0	164	154	10	10	0	0
Press., psig	7	90	90	76	15	20	165	20	20	12	90	15	90	90	90	20	7	7
Temp., F	140	140	140	140	160	140	60	60	140	70	140	160	140	140	140	140	160	160

CVCS MAKEUP SYSTEM OPERATION - DILUTE MODE   Three Charging Pumps Operating

CVCS Location:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Flow, gpm	160	160	0	0	0	0	128	128	128	0	0	0	160	150	10	10	0	0
Press., psig	7	88	88	88	15	20	142	20	20	12	88	15	88	88	88	20	7	7
Temp., F	140	140	160	160	160	160	60	60	60	70	160	160	140	140	140	140	160	160

NOTES:

The date shown for the various modes of operation is typical.
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 relief valve lifts.
CVCS location numbers are shown on Figures 9.3-4 and 9.3-5.

TABLE 9.3-11 (Cont.)

CHEMICAL AND VOLUME CONTROL SYSTEM PROCESS FLOW DATA

CVCS MAKEUP SYSTEM OPERATION - MANUAL MODE   Blended Boric Acid Concentration = 2300 ppm

CVCS Location:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Flow, gpm	174	174	10	10	0	10	50	50	60	0	0	0	164	154	10	10	0	0
Press., psig	7	91	91	86	15	20	155	20	20	12	91	15	91	91	91	20	7	7
Temp., F	140	140	140	140	160	140	60	60	75	70	160	160	140	140	140	140	160	160

CVCS MAKEUP SYSTEM OPERATION - EMERGENCY BORATION (SIAS)   Via boric acid makeup pump and one pump is operating
Three charging pumps operating
Two boric acid makeup pumps operating

CVCS Location:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Flow, gpm	142	142	132	0	0	0	0	0	0	0	132	132	10	0	10	10	0	0
Press., psig	7	97	97	97	97	15	165	15	15	12	97	92	97	97	97	20	7	7
Temp., F	140	140	140	160	160	160	60	60	160	70	140	140	140	160	140	140	160	160

CVCS MAKEUP SYSTEM OPERATION - EMERGENCY BORATION (SIAS)   Via Gravity Feed

CVCS Location:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Flow, gpm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66	66
Press., psig	7	7	7	7	5	15	165	15	15	12	7	5	7	7	7	7	7	7
Temp., F	160	160	160	160	160	160	60	60	160	70	160	160	160	160	160	160	140	140

CVCS MAKEUP SYSTEM OPERATION - SHUTDOWN BORATION

CVCS Location:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Flow, gpm	180	180	16	0	0	0	0	0	0	0	16	16	164	154	10	10	0	0
Press., psig	7	90	90	90	90	15	165	15	15	12	90	89	90	90	90	90	7	7
Temp., F	140	140	140	160	160	160	60	60	160	70	140	140	140	140	140	140	160	160

NOTES:

The data shown for the various modes of operation is typical.
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.
CVCS location numbers are shown on Figures 9.3-4 and 9.3-5.

TABLE 9.3-12

REGENERATIVE HEAT EXCHANGER DESIGN DATA

1) Design Parameters

Quantity	1
Type	Shell and Tube, Vertical
Code	ASME Section III Class C, Tema-R
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 at 128 gpm, psi	99
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	
Shell	ASME SA-182, F 304
Tubes	ASME SA-213, TP 304
Baffles	ASME SA-240, TP 304
Tube Sheet	ASME SA-182, F 304
Channel	ASME SA-312, TP 304
Pressure loss at 132 gpm, psi	45
Normal flow, gpm	44
Design flow, gpm	132

2) Operating Parameters

Tube Side - Letdown	Normal	Minimum Letdown/ Maximum Charging	Maximum Letdown/ Maximum Charging	Maximum Letdown/ Minimum Charging
Flow - gpm @ 120F	40	30	128	128
Inlet Temp. - F	550	550	550	550
Outlet Temp. - F	262	165	375	450
Shell Side - Charging				
Flow - gpm @ 120F	44	132	132	44
Inlet Temp. - F	120	120	120	120
Outlet Temp. - F	395	212	310	452

TABLE 9.3-13

LETDOWN HEAT EXCHANGER DESIGN DATA

1) Design Parameters

Quantity	1
Type	Shell and Tube Horizontal
Tube side- letdown	
Code	TEMA-R And ASME Section III, Class C
Fluid	Reactor Coolant, 1 wt % Boric Acid Maximum
Design pressure, psig	650
Design temperature, F	550
Pressure loss at 128 gpm, psi	50
Normal flow, gpm	40
Design, gpm	128
Materials	
Shell	ASME SA-53 Carbon Steel
Tubes	ASME SA-213, Type 304
Cover	ASME SA-106 Gr B, Carbon Steel
Tubesheet	ASME SA-182, F 304
Channel	ASME SA-240, Type 304
Shell Side- cooling water	
Code	TEMA-R and ASME Section VIII
Fluid	Component Cooling Water
Design pressure, psig	150
Design Temperature, F	250
Materials	Carbon Steel
Normal flow, gpm	157
Design flow, gpm	1200

2) Operating Parameters

Tube Side- Letdown	Normal	Minimum Letdown/ Maximum Charging	Maximum Letdown/ Maximum Charging	Maximum Letdown/ Minimum Charging
Flow - gpm @120F	40	30	128	218
Inlet Temp, F	262	165	375	450
Outlet Temp, F	120	120	128	128
Shell Side (Cooling Water)				
Flow - gpm @120F	157	21	1200	1200
Inlet Temp, F	95	65	95	95
Outlet Temp, F	131	130	121	130

TABLE 9.3-14

PURIFICATION FILTERS DESIGN DATA

Quantity	2
Type elements	Wound (Tag 1A and 1B) Cartridges
Retention for 2 micron and larger particles, % by wt	95
Normal operating temperature, F	120
Design pressure, psig	200
Maximum allowable pressure loss clean, psi @ 128 gpm	5
Maximum allowable pressure Loss, loaded, psi at 128 gpm	35
Design temperature, F	250
Design flow, gpm	128
Normal flow, gpm	40
Code	ASME III, 1968 Edition through Winter 1969 Addenda Class C
Materials, wetted	SA-240 Type 304 Stainless Steel
Fluid, wt % boric acid, maximum	1

TABLE 9.3-15

PURIFICATION AND DEBORATING ION EXCHANGERS DESIGN DATA

Quantity	2 purification, 1 deborating
Type	Flushable
Design pressure, psig	200
Design temperature, F	250
Normal operating temperature, F	120
Resin volume, ft^3 each (total)	36.2
Resin volume, ft^3 each (useful)	32.0
Normal flow, gpm	40
Maximum flow, gpm	128
Code for vessel	ASME III, 1968 Edition, Winter 1969 Addenda, Class C
Retention screen size	80 U. S. Mesh
Material	Stainless Steel, SA-240, Type 304
Fluid, wt % boric acid, maximum	1
Resin type	Cation/anion mixed bed for purification, anion bed for deborating

e) <u>Volume Control Tank</u> -

The volume control tank, located in the reactor auxiliary building on floor elevation 19.5 ft, accumulates letdown water 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. The tank is sized to store sufficient liquid volume below the normal operating band to allow a swing from full power to zero power without makeup to the volume control tank and such that sufficient useful volume is above the normal operating band to permit the accumulation of approximately 500 gallons of water during dilution operations. The accumulated water is normally sufficient to provide normal plant leakage makeup between dilution operations. The tank is provided with hydrogen and nitrogen gas supplies and a vent to the waste management system to enable venting of hydrogen, nitrogen and fission gases. The volume control tank is initially purged with nitrogen and a hydrogen overpressure is established. The design characteristics of the volume control tank are given in Table 9.3-16.

TABLE 9.3-16

<u>VOLUME CONTROL TANK DESIGN DATA</u>

Quantity	1
Type	Vertical, Cylindrical
Internal volume, gallons	4700
Design pressure, internal, psig	75
Design pressure, external, psig	15
Design Temperature, F	250
Normal operating pressure, psig	15
Normal operating temperature, F	120
Normal spray flow, gpm	40
Blanket gas - during plant operation	Hydrogen
Code	ASME III, Class C
Fluid, wt % boric acid, maximum	12
Material	ASME SA-240 Type 304

f) <u>Charging Pumps</u> -

The charging pumps, located in the reactor auxiliary building on floor elevation -0.50 ft, take suction from the volume control tank on the floor level above and return the purification flow to the reactor coolant system during plant steady state operations. Normally one pump is running to balance the letdown purification flow rate plus the reactor coolant pump controlled bleedoff flow rate. The second and third pumps are automatically started or stopped as pressurizer level decreases or increases due to plant load transients.

The pumps are positive displacement type with an integral leakage collection system. Vent, drain and flushing connections are provided to minimize radiation levels during maintenance operations. The pressure containing portions of the pump and internals are austenitic stainless steel materials for compatibility with boric acid. The pump design characteristics are given in Table 9.3-17.

TABLE 9.3-17

CHARGING PUMPS DESIGN DATA

Quantity	3
Type	Positive Displacement, Triplex
Design pressure, psig	2735
Design temperature, F	250
Capacity, gpm	44
Normal discharge pressure, psig	2300
Normal suction pressure, psig	15 to 20
Normal temperature of pumped fluid, F	120
NPSH required, psia	9.0
Driver rating, hp	100
Materials in contact with pumped fluid	SA-182, F 316
Fluid, wt % boric acid, maximum	12

g) Boric Acid Makeup Tanks -

Two boric acid makeup tanks, located between reactor auxiliary building floor levels -.50 ft and 19.5 ft, provide a source of boric acid solution (7.9 weight percent minimum) for injection into the reactor coolant system. Each tank is insulated and has redundant strap-on electrical heaters. Each tank is capable of storing boric acid in concentrations up to 12 weight percent. Each tank contains sufficient boric acid below the normal makeup band to bring the plant to a cold 5 percent $\Delta\rho$ subcritical shutdown condition. The total volume of both tanks is sufficient to bring the reactor coolant system to refueling concentration, $\geq$1720 ppm boron, before initiation of a cooldown for refueling. The tanks have a combined volume to provide for the complete recovery of the boric acid in the reactor coolant at beginning of life as concentrated 7.9 weight percent boric acid. The design characteristics of the tanks are given in Table 9.3-18.

TABLE 9.3-18

BORIC ACID MAKEUP TANKS DESIGN DATA

Quantity	2
Volume, gal each	11,200
Design pressure, psig	15
Design temperature, F	200
Normal operating temperature, F	160
Type heater	6 Electrical Strap-on Heaters, 2.25 kw Total each (2 banks of 3 each)
Fluid, wt % boric acid, maximum	8.25
Material	ASME SA-240 Type 304
Code	ASME III, Class C

h) Boric Acid Batching Tank -

The boric acid batching tank, located on reactor auxiliary building floor level 43.0 ft, and above the boric acid makeup tanks, is used for the preparation of concentrated boric acid which is batch gravity drained to the makeup tanks. The tank is designed to permit handling of up to 12 weight percent boric acid. The tank is heated and insulated and supplies demineralized water for mixing the boric acid solution. Sampling provisions, mixer, temperature controller and electric immersion heaters are an integral part of the batching system. The design characteristics of the tanks are given in Table 9.3-19.

TABLE 9.3-19

BORIC ACID BATCHING TANK DESIGN DATA

Quantity	1
Internal volume, gal	550
Design pressure	Atmospheric
Design temperature, F	200
Normal operating temperature, F	160
Type heater	Electrical Immersion
Number of heaters	3
Heater capacity, kw each	15
Fluid, wt % boric acid maximum	12
Material	ASME SA-240 Type 304
Code	None

i) Boric Acid Makeup Pumps -

The boric acid makeup pumps, located in the auxiliary building on the floor at elevation -0.5 feet, take suction from the overhead boric acid makeup tanks and provide boric acid to the makeup subsystem and to the charging pump suction header. The capacity of each pump is greater than the combined capacity of all three charging pumps. The boric acid makeup pumps are also used to recirculate makeup tank contents, to pump from one makeup tank to the other, and to supply makeup to the refueling water tank. The pumps are single stage centrifugal pumps with mechanical seals and liquid and vapor leakage collection connections. The pumps are heat traced and insulated. The design characteristics of the pumps are given in Table 9.3-20.

TABLE 9.3-20

BORIC ACID MAKEUP PUMPS DESIGN DATA

Quantity	2
Type	Centrifugal, Horizontal
Design pressure, psig	150
Design temperature, F	250
Design head, ft	225
Design flow, gpm	142
Normal operating temperature, F	150
NPSH required, ft	8
Motor horsepower	25
Motor voltage/phase/Hz	440/3/60
Fluid, wt % boric acid, maximum	12
Material in contact with liquid	Austenitic Stainless Steel
Code	Draft ASME Code for Pumps and Valves for Nuclear Power, November 1968, Class 2

j) Chemical Addition Tank and Metering Pump -

The chemical addition tank and metering pump, both located on reactor auxiliary building floor elevation 19.5 ft, provide a means to inject chemicals into the charging pump suction header. Reactor makeup water is supplied for chemical dilution and flushing operations. The design characteristics of the tank are given in Table 9.3-21. The tank size and pump capacity are based on the maximum service requirement of hydrazine injection for oxygen scavenging on plant startup. The design characteristics of the metering pump are given in Table 9.3-22.

TABLE 9.3-21

CHEMICAL ADDITION TANK DESIGN DATA

Quantity	1
Internal volume, gals	12
Design pressure	Atmospheric
Design temperature, F	250
Normal operating temperature	Ambient
Materials	Austenitic Stainless Steel
Code	None

TABLE 9.3-22

METERING PUMP DESIGN DATA

Quantity	1
Type	Piston-diaphragm
Design pressure, psi	150
Design Temperature, F	150
Design flow, gph	0-40
Normal discharge pressure, psig	15.0
Fluid	Hydrazine (N_2H_4) or Lithium Hydroxide
Horsepower	1/2
Diaphragm material	Teflon
Code	None

k) Process Radiation Monitor (R-2202)

The process radiation monitor described in Section 11.4, is in the 1/2 inch line bypassing purification filter 1A, provides a continuous recording in the control room of reactor coolant gross gamma radiation and specific fission product gamma activity. A high alarm indicates an increase in coolant activity above the setpoint within 5 minutes of the event. The design characteristics of the pressure boundary of the monitor are given in Table 9.3-23.

TABLE 9.3-23

PROCESS RADIATION MONITOR DESIGN DATA

Quantity	1
Type	Gamma scintillation
Design pressure, psig	200
Design temperature, F	250
Normal operating temperature, F	120
Normal flow rate, gpm	0.5
Measurement range, μCi/cc, I-135	10^{-4} to 10^{2}
Code	ASME III, Class C

1) Boronometer (A-2203)

The boronometer, described in Section 7.5.14 is in a 1/2 inch pipe line in parallel with the process radiation monitor, and provides a continuous recording in the control room of reactor coolant boron concentration. Periodically adjusted high and low alarms warn the operator of deviations beyond the alarm set point. The principal of operation is neutron absorption. The unit is provided with shielding as required to limit external radiation level from its PuBe source to a low value. All portions of the unit that contact reactor coolant are constructed of austenitic stainless steel. The design characteristics of the boronometer pressure boundary are given in Table 9.3-24.

TABLE 9.3-24

BORONOMETER DESIGN DATA

Quantity	1
Vessel design temperature, F	250
Vessel design pressure, psig	200
Normal operating temperature, F	120
Normal flow rate, gpm	0.5
Range of measurement, boron, ppm	0-2150
Accuracy, ppm	± 25
Code for vessel	ASME III, Class C, 1968 Edition through Winter 1969 Addenda
Size, inlet and outlet, in	1/2 flanged

m) Relief Valves

To assure safe operation of the CVCS overpressure protection is provided by relief valves throughout the system. The following is a description of the relief valves in the system.

1) Intermediate pressure letdown relief valve, V-2345

The relief valve downstream of the letdown control valves protects the intermediate pressure letdown piping and letdown heat exchanger from overpressure. The valve capacity is equal to the capacity of one letdown control valve in the wide open position during normal operation. The other letdown control valve must be closed and isolated before plant pressure exceeds 1500 psig as required by Technical Specification 16.3.2. The relief valve set pressure is equal to the design pressure (650 psig) of the intermediate pressure letdown piping and letdown heat exchanger.

2) Low-pressure letdown relief valve, V-2354

The relief valve downstream of the letdown backpressure control valves protects the low pressure piping, purification filters, ion exchangers and letdown strainer from overpressure. The valve capacity is equal to capacity of intermediate pressure letdown relief valve V-2345. The set pressure is equal to the design pressure (200 psig) of the low pressure piping and components.

3) Charging pump discharge relief valves, V-2324, V-2325, V-2326

The relief valves on the discharge side of the charging pumps are sized to pass the maximum rated flow of the associated pump with maximum backpressure without exceeding the maximum rated total head for the pump assembly. The valves are set to open when the discharge pressure exceeds the reactor coolant system design pressure (2485) by 10 percent.

4) Charging pump suction relief valves, V-2315, V-2318, V-2321

The relief valves on the suction side of the charging pumps are sized to pass the maximum fluid thermal expansion rate that would occur if the pump were operated with the suction and discharge isolation valves closed. The set pressure is less than design pressure of charging pump suction piping.

5) Charging line thermal relief valve, V-2435

The relief valve on the charging line downstream of the regenerative heat exchanger is sized to relieve the maximum fluid thermal expansion rate that would occur if hot letdown flow continued after charging flow was stopped by closing the charging line distribution valves. The valve is a spring-loaded check valve.

6) Volume control tank relief valve, V-2115

The relief valve on the volume control tank is sized to pass a liquid flow rate equal to the sum of the following flow rates: the maximum operating flow rate from the reactor coolant pump controlled bleedoff line; the maximum letdown flow rate possible without actuating the high flow alarm on the letdown flow indicator; the design purge flow rate of the sampling system; and the maximum flow rate that the boric acid makeup system can produce with relief pressure in the volume control tank. The set pressure is equal to the design pressure of the volume control tank.

7) Reactor makeup water relief valve, V-2185

The relief valve on the reactor makeup water line is sized to pass the maximum capacity of the reactor makeup water pumps with the volume control tank pressure at its design value. The set pressure is less than the volume control tank design pressure

(75 psig) to ensure that the valve will open before the volume control tank relief valve opens.

8) Volume control tank gas supply relief valve, V-2105

The relief valve is sized to exceed the combined maximum capacity of the nitrogen and hydrogen gas regulators. The set pressure is lower than the volume control tank design pressure.

9) Reactor coolant pump controlled bleedoff header relief valve, V-2199

The relief valve at the reactor coolant pump controlled bleedoff header allows the controlled bleedoff flow to continue to the quench tank in the event that a valve in the line to the volume control tank is closed and does not serve an overpressure protection function. The valve is sized to pass the flow rate required to assure closure of one excess flow check valve in the event of failure of the seals in one reactor coolant pump plus the normal bleedoff from the other reactor coolant pumps. The maximum relief valve opening pressure is less than the controlled bleedoff high-high pressure alarm.

10) Heat traced piping thermal relief valves

Relief valves are provided for those portions of the boric acid system that are heat traced and which can be individually isolated. The set pressure is equal to or less than the design pressure of the system piping. Each valve is sized to relieve the maximum fluid thermal expansion rate that could occur if maximum duplicate heat tracing power were inadvertently applied to the isolated line.

n) Piping and valves -

The piping of the chemical and volume control system is austenitic stainless steel. The cooling water side of the letdown heat exchanger is carbon steel. All piping is in accordance with the code for pressure piping of the USA Standard, USASI-B31.1, or B31.7, as applicable.

All valves except the diaphragm type have backseats to limit stem leakage when in the open position. Diaphragm-type valves are used to prevent radioactive gas leakage from the volume control tank and also for resin sluicing operations for the ion exchangers. Manually operated valves for radioactive service with nominal sizes larger than two inches are provided with a double-packed stem and intermediate lantern ring with a leakoff connection. All actuator operated valves for liquid service have stem leakoffs.

o) Electrical Heaters -

Electrical heat tracing is installed in duplicate on all piping, valves, pumps and other line-mounted components that may potentially contain concentrated boric acid solution for a significant period of time. The heat tracing is designed to prevent precipitation of boric acid due to cooling. The portions of the system that are heat traced are indicated on the piping and instrumentation diagrams, Figures 9.3-4 and 9.3-5.

The heat tracing is designed to maintain the fluid temperature of the traced components at 160±5F with insulation designed as described below. This criterion assures that the boric acid will be at least 25F above the saturation temperature for 12 weight percent boric acid solution.

Two independent full capacity strap-on-type heater banks are installed on each boric acid makeup tank. The heaters are sized to compensate for heat loss through the tank insulation to the surroundings when the tank is filled to its maximum operating level with boric acid at its maximum temperature. Each heater bank is operated by an independent controller.

The batching tank is provided with corrosion resistant electrical immersion heaters. The heaters are sized to supply sufficient heat in 6 hours to increase the temperature of 500 gallons of 12 weight percent boric solution from 40F to 160F including the heat of solution required to dissolve the boric acid granules. The boric acid is not added to the tank until the demineralized water temperature exceeds the final saturation temperature by at least 20F.

p) <u>Thermal Insulation</u>

Thermal insulation protects personnel from contact with high temperature piping, valves, and components. Equipment and sections of the system that are insulated are the regenerative heat exchanger, the charging and auxiliary spray lines downstream of the regenerative heat exchanger and the letdown line from the reactor coolant loop to the letdown heat exchanger. Thermal insulation on these sections is designed to limit the insulation surface temperature to 140F based on ambient temperature of 80F and the maximum expected piping and component temperature. Electrically heat traced piping, valves, pumps, and other components are insulated to limit the insulation surface temperature to 120F based on an ambient temperature of 80F and a component temperature of 160F.

Thermal insulation on the batching tank is designed to limit heat losses to 15.0 Btu/hr-ft^2 based on a tank temperature of 160F and an ambient temperature of 70F. Thermal insulation with ion chloride content that does not cause chloride stress corrosion or that contains a chloride stress corrosion inhibitor is used on all stainless steel surfaces and on any insulated surfaces adjacent to stainless steel surfaces where moisture from that insulation could reach the stainless steel.

9.3.4.2.3 Plant Startup

Plant startup is the series of operations which bring the plant from a cold shutdown condition to a hot standby condition at normal operating pressure and zero power temperature with the reactor critical at a low power level.

The charging pumps and letdown backpressure valves are used during initial phases of reactor coolant system heatup to maintain the reactor coolant system pressure until the pressurizer steam bubble is established. One charging pump will normally operate during plant startup to cool the letdown fluid to maintain design pressure and temperature limits in the letdown portion of the system.

During the heatup, the pressurizer water level is controlled manually using the backpressure control valves and the letdown control valves. The letdown flow is automatically diverted to the waste management system when the high level limit is reached in the volume control tank.

The reactor coolant system boron concentration may be reduced during heatup in accordance with shutdown margin limitations. The shutdown group of control rods must be in the fully withdrawn position before any dilution of reactor coolant system boron concentration is started. The makeup controller is operated in the dilute mode to inject a predetermined amount of reactor makeup water at a preset rate. Compliance with the shutdown margin limitations is verified by sample analysis and boronometer ndication. Technical Specification 16.3.2 has been set to define those conditions of the CVCS necessary to assure safe reactor operation and shutdown.

9.3.4.2.4 Normal Operation

Normal operation includes hot standby operation and power generation when the reactor coolant system is at normal operating pressure and temperature.

9.3.4.2.5 Plant 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 for maintenance or refueling.

Prior to plant cooldown, the gas space of the volume control tank is vented to the flash tank to reduce dissolved hydrogen concentration and fission gas activity. The purification rate may be increased to accelerate the degasification, ion exchange and filtration processes. Addition of chemicals is not normally required during plant shutdown.

The boron concentration in the reactor coolant is increased to the cold shutdown value prior to the cooldown of the plant. This is done to assure sufficient shutdown margin throughout the cooldown period. However, the shutdown group of CEA's is not inserted into the core until the cooldown is completed and the correct boron concentration in the reactor coolant is verified by sample analysis.

During the cooldown, the charging pumps, letdown control valves, and letdown backpressure valves are used to adjust and maintain the pressurizer water level. High charging flow results in a low level in the volume control tank which initiates automatic makeup at the selected shutdown boron concentration. If the shutdown is for refueling, which requires a higher boron concentration than the cold shutdown value, the suction of the charging pumps is connected to the refueling water tanks during plant cooldown. This is required because the automatic blending line from the boron system cannot supply the refueling boron concentration at maximum charging flow. All or a portion of the charging flow may be used for auxiliary spray to cool the pressurizer if the reactor coolant system pressure is below that allowable for reactor coolant pump operation.

9.3.4.3 System Evaluation

9.3.4.3.1 Performance Requirements and Capabilities

The normal amount of boric acid stored solution in either of the boric acid makeup tanks is sufficient to bring the plant to a 5 percent $\Delta\rho$ subcritical cold shutdown condition at any time during plant life. The refueling water tank is a redundant source of borated water.

The charging pumps are used to inject concentrated boric acid into the reactor coolant system. With one pump normally in operation, the other charging pumps are automatically started by the pressurizer level control or by the safety injection actuation signal (SIAS). The safety injection actuation signal also causes the charging pump suction to be switched from the volume control tank to the boric acid pump discharge. Should the pumped boric acid supply be unavailable, the charging pumps are also lined up for gravity feed from the boric acid makeup tanks. Should the charging line inside the reactor containment building be inoperative for any reason, the line may be isolated outside of the reactor containment, and the charging flow may be injected via the safety injection system. The malfunction or failure of one active component does not reduce the ability to borate the reactor coolant system since an alternate flow path is always available for emergency boration.

If the letdown temperature exceeds the maximum operating temperature of the resin in the ion exchangers (140F) the flow will automatically bypass the ion exchangers, the process radiation monitor, and the boronometer.

The charging pumps, boric acid makeup pumps, boric acid makeup tank heaters and all related automatic control valves are connected to an emergency bus should the normal power supply system fail. There are two emergency diesel generator sets available for this service and the components are aligned to the diesels as designated below:

Component	Diesel A	Diesel B
Charging Pump No. 1A and seal system	X	
Charging Pump No. 1B and seal system		X
Charging Pump No. 1C and seal system		swing bus
Boric acid makeup pump No. 1A	X	
Boric acid makeup pump No. 1B	X	
Boric acid gravity feed valve V-2508		X
Boric acid gravity feed valve V-2509		X
Boric acid makeup tank No. 1A heater No. 1	X	
Boric acid makeup tank No. 1A heater No. 2		X
Boric acid makeup tank No. 1B heater No. 1		X
Boric acid makeup tank No. 1B heater No. 2	X	
Heat tracing system No. 1A	X	
Heat tracing system No. 1B		X
Boric acid makeup pump supply valve V-2514	X	
Volume control tank discharge valve V-2501		X
Letdown stop valve V-2515		X
Letdown stop valve V-2516	X	
Controlled bleedoff stop valve V-2505		X
Boric acid recirculation valve V-2510	X	
Boric acid recirculation valve V-2511	X	
Boric acid makeup stop valve V-2512		X

The boric acid solution is stored in heated and insulated tanks, and is piped in heat-traced and insulated lines to preclude precipitation of the boric acid. Two independent and redundant heating systems are provided for the boric acid tanks and piping. Automatic temperature controls and independent alarm circuits are included in the heating system.

The heat tracing is appropriately sectionalized taking into account system redundancy requirements and components that may be removed from the system for maintenance. Each heat tracing section has a duplicate full capacity set of heater elements and controls. An independent alarm system is provided with temperature sensors appropriately spaced within each section to detect a malfunction of the operating heat tracing anywhere within that section. Each sensor is annunciated separately on a local panel. A malfunction anywhere in the heat tracing annunciates an alarm in the control room. In the event of a malfunction, switchover to the redundant heat tracing for the affected section is done manually. The separate alarm system provides annunciation at the control room in the event of loss of electric power to the heat tracing.

Frequently used, manually operated valves located in high radiation or inaccessible areas are provided with extension stem handwheels terminating in low radiation and accessible control areas. Manually operated valves are provided with locking provisions if unauthorized operation of the valve is considered a potential hazard to plant operation or personnel safety.

Leakage can be detected by the gamma sensitive area radiation monitors which are located in strategic areas throughout the plant. The gamma flux level seen by each detector is indicated, annunciated and recorded in the control room. Any significant leakage from the CVCS annunciates one of these alarms.

The chemical and volume control system can also monitor the total reactor coolant system water inventory. With no leakage in the reactor coolant system the level in the volume control tank remains constant during steady state plant operation. Therefore, a decreasing level in the volume control tank alerts the operator to a possible leak. A more detailed discussion of leakage detection systems is presented in Section 5.2.4.

9.3.4.3.2 Single Failure Analysis

Shown in Table 9.3-25 is a single failure analysis for the chemical and volume control system. At least one failure is postulated for each major component. Additionally, various line breaks throughout the system are also considered. In each case the possible cause of such a failure is presented as well as the local effects, detection methods and compensating provision.

9.3.4.3.3 Testing and Inspections

Each component is inspected and cleaned prior to installation in the system. Demineralized water is used to flush the system.

Instruments are recalibrated during startup testing. Automatic controls are tested for actuation at the proper set points. Alarm functions are checked for operability and limits during preoperational testing. The safety valve settings are checked.

TABLE 9.3-25

SINGLE FAILURE ANALYSIS - CHEMICAL AND VOLUME CONTROL SYSTEM

No.	Component/ Location	Failure Mode	Cause	Symptoms and Local Effects	Method of Detection	Inherent Compensating Provision(s)
1	Regenerative Heat Exchanger (RHX)	Decrease in ability Transfer heat	Excessive fouling or crud deposition	High temperature in letdown line	High temperature alarm from TIC-2221	(1) Hot flow will automatically bypass IX's, PRM and boronometer (2) TIC-2221 will shut valve V-2515 and stop letdown flow
	Regenerative Heat Exchanger (RHX)	Shell to tube leakage	Corrosion and/or manufacturing defect	Eventual out of spec. boron concentration Abnormally high boronometer reading during boration and low reading during dilution Also heat exchanger temperature disparities	Isolate letdown and measure flow on FIA-2212 while charging. Perform only during shutdown	Safe plant shutdown not affected. Charging via SIS filling pressurizer, letdown via reactor coolant pumps
2	Letdown Heat Exchanger (LHX)	Decrease in ability to transfer heat	Excessive fouling or crud deposition	High temperature in letdown line or abnormally high cooling water flow rate	High temperature alarm and indication from TIC-2224 and high temperature reading from TIC-2223	Hot flow will automatically bypass IX's
	Letdown Heat Exchanger (LHX)	Cross Leakage	Corrosion and/or manufacturing defect	Radioactivity will be transferred to CCS	Activity monitor in CCS will sound alarm	Safe plant shutdown not affected
3	Line, between TIC-2221 and LCV-2110P (outside containment)	Rupture	Faulty weld	High temperature in letdown line	High temperature alarm from TIC-2221 and low pressure alarm from PA-2201	TIC-2221 will shut valve V-2515 and stop letdown flow
4	Line, between LHX and TIC-2224	Rupture	Faulty weld	Loss of pressure in letdown line	Low pressure alarm from PA-2201 and high temp. alarm TIC-2221	TIC-2221 will close letdown stop valve V-2515

Abbreviations of components listed at end of table

TABLE 9.3-25

SINGLE FAILURE ANALYSIS - CHEMICAL AND VOLUME CONTROL SYSTEM

No.	Component/ Location	Failure Mode	Cause	Symptoms and Local Effects	Method of Detection	Inherent Compensating Provision(s)
5	Purification Filter	Clogs	Contamination	High differential pressure across filter	ΔP sensor, PDI-2202 will actuate alarm	Bypass line will facilitate cartridge replacement
	Purification Filter	Cartridge rupture	Excessive differential pressure	Contamination of IX's, PRM and boronometer	None for small breaks, for larger breaks the reading of PDI-2202 will be lower than normal Also periodic sampling for activity buildup	Bypass line will facilitate cartridge replacement
6	Radiation Monitor	Fails to detect high levels of radiation	Electrical malfunction	May allow a buildup of contamination	Laboratory analysis of coolant sample	Backup by sampling system and local samples
	Radiation Monitor	False indication of high level of radiation	Electrical malfunction	Alarm	Laboratory analysis of coolant sample	Backup by sampling system and local samples
7	Boronometer	False alarm for high or low concentration	Electrical malfunction	Alarm, and no abnormal control rod positions	Laboratory analysis of coolant sample	Backup sampling system
8	Purification Ion Exchanger	Fails to remove contamination	Resin exhausted	Buildup in RCS activity	Alarm from PRM and laboratory sample analysis	Bypass ion exchangers during replacement of resin

TABLE 9.3-25

SINGLE FAILURE ANALYSIS - CHEMICAL AND VOLUME CONTROL SYSTEM

No.	Component/ Location	Failure Mode	Cause	Symptoms and Local Effects	Method of Detection	Inherent Compensating Provision(s)
9	Deborating Ion Exchanger	Fails to remove boron from coolant	Resin exhaustion	Unable to maintain power at end of core cycle	High boronometer reading, coolant sample, and decreasing power	Bypass and replace resin in ion exchanger
10	Charging Pumps	Fails to provide suffi- cient flow to RCS	Seal failure, electrical malfunction, or low NPSH	High letdown temp at TIC-2221, and low charging flow rate at FIA-2212, and low pressurizer liquid level	Low level in pressurizer, low flow alarm at pump outlet (FIA-2212)	Low level in pressurizer will start second and third pump
11	Line, Makeup to Volume Control Tank (VCT)	Rupture	Faulty weld	Possible loss of makeup, activity release from VCT, VCT low pressure	Low VCT level alarm, possible annunciation of area radiation monitors, VCT low pressure alarm	VCT level controller LC-2227 will close VCT discharge valve and open valve to refueling water tank
12	Boric Acid Batching Tank Heater and Controller	Fails off	Electrical malfunction	Precipitation, inability to mix boric acid	TIC-2213 will indi- cate low temperature	Sufficient reserve in makeup tanks is available until malfunction is is corrected
	Boric Acid Batching Tank Heater and Controller	Fails on	Electrical malfunction	Overheating of boric acid in batching tank	TIC-2213 will indi- cate high temperature	Isolate and repair, sufficient reserve in makeup tanks
13	Boric Acid Batching Tank Mixer	Fails to start	Electrical malfunction	Unable to batch boric acid solution	Visual	Isolate and repair, sufficient reserve in makeup tanks
14	Boric Acid Makeup tank	Leak	Faulty weld or connection	Loss of boric acid	Level indication and alarm	Redundant standby tank
15	Line, Discharge Boric Acid Makeup Tank	Leak	Faulty weld or connection	Loss of boric acid	Level indication and alarm	Redundant standby tank

TABLE 9.3-25

SINGLE FAILURE ANALYSIS - CHEMICAL AND VOLUME CONTROL SYSTEM

No.	Component/ Location	Failure Mode	Cause	Symptoms and Local Effects	Method of Detection	Inherent Compensating Provision(s)
16	Boric Acid Makeup Pump	Fails to start	Electrical malfunction or shaft break	Loss of flow	Pump discharge pressure low alarm	Redundant standby pump, gravity feed or use refueling water tank
17	Line, Boric Acid Pump Discharge	Rupture	Faulty weld	Loss of boric acid	Pump discharge pressure low alarm	Redundant standby pump, and boric acid from refueling water tank.
18	Line, Gravity feed to charging pump suction	Rupture	Faulty weld	Loss of boric acid	Boric acid makeup tank level indication and alarm	Alternate flow path of boric acid available from refueling water tank
19	Heat Tracing	Fails off	Electrical malfunction	Decrease in temperature in heat traced sections	Any malfunction of heat tracing annunciates an alarm in the control room	Redundant standby heat tracing and controls
20	Volume Control Tank (VCT)	Rupture	Faulty weld	Loss of liquid and radioactive gases	Pressure and level indication and alarms on VCT, and radiation alarm in auxiliary building	Charging pump suction will automatically be supplied by refueling water tank on low level in VCT
21	Line, Discharge of VCT	Rupture	Faulty weld	Loss of coolant, radioactive gases and liquids released and low VCT pressure	Pressure and level indications and alarms in VCT	VCT discharge valve will close on low VCT level and charging pump suction will switch to refueling water tank
22	Line, Refueling Water Tank to CVCS	Rupture	Faulty weld	Loss of RWT contents	Level alarm in RWT	Ability to borate the RCS with contents of makeup tanks not affected. Isolation valve at tank

TABLE 9.3-25

SINGLE FAILURE ANALYSIS - CHEMICAL AND VOLUME CONTROL SYSTEM

No.	Component/ Location	Failure Mode	Cause	Symptoms and Local Effects	Method of Detection	Inherent Compensating Provision(s)
23	Line, Charging Pump Discharge	Rupture	Faulty weld	Loss of pressure, Loss of coolant	Low pressure alarm (PIA-2212) and low flow alarm (FIA-2212)	Isolate, charge through HPSI header
24	Line, VCT to charging pump	Rupture	Faulty weld	Loss of charging capability, loss of coolant and radioactive gases	VCT low pressure alarm, low charging pressure alarm and low flow alarm	Trip charging pump, place plant in blackout condition and perform emergency shutdown using SIS

ABBREVIATIONS

RHX- Regenerative heat exchanger
LHX- Letdown heat exchanger
IX - Ion exchanger
PRM- Process radiation monitor
SIS- Safety injection system
CCS- Component cooling system
RCS- Reactor coolant system
VCT- Volume control tank
RWT- Refueling water tank

The system is operated and tested initially with regard to flow paths, flow capacity and mechanical operability. Pumps are tested at the vendor's plant to demonstrate head and capacity.

Prior to preoperational testing, the components of the chemical and volume control system are tested for operability. The components and subsystems checked include the following:

a) operation of all automatic and remote controlled valves

b) boric acid makeup pumps

c) nitrogen and hydrogen pressurization systems

d) charging pump operational check

e) check of miscellaneous valve functions, alarms and interlocks

f) instrumentation on the boric acid makeup tanks, volume control tank and boric acid batching tank

g) installation of all valves for proper flow direction.

The system is tested for integrated operation during preoperational testing. Any defects in operation that could affect plant safety are corrected before full loadings. As part of normal plant operation, tests and inspections, data tabulation and instrument calibrations are made to evaluate the condition and performance of the chemical and volume control system equipment. Data is taken periodically during normal plant operation to confirm heat transfer capabilities and purification efficiency.

The charging pumps permit leak testing of the reactor coolant system during plant startup operations and connections are provided to install a hydrostatic test pump in parallel with the charging pumps.

A charging pump is periodically used to check the operability and leak tightness of the check valves which isolate the reactor coolant from the safety injection system.

9.3.4.3.4 Natural Phenomena

The chemical and volume control system components are located in the reactor auxiliary building and the containment and, therefore, would not be subject to the natural phenomena described in Chapter 3 other than seismic which is discussed in Section 3.7. The reactor auxiliary building arrangement showing the chemical and volume control system components is shown in Figures 1.2-12 through 1.2-17.

9.3.4.4 Instrument Application

Table 9.3-26 lists the parameters used to monitor the chemical and volume control system.

TABLE 9.3-26

CHEMICAL AND VOLUME CONTROL SYSTEM INSTRUMENT APPLICATION

System Parameter and Location	Indication Local	Indication Contr Room	Alarm[1] High	Alarm[1] Low	Rec.[1]	Control Function	Inst. Range	Normal Operating Range	Inst. Accuracy
B.A. Makeup Tank Temp.	*		*	*		Heaters	50-200F	140-160F	±1.0%
B.A. Batching Tank Temp.	*					Heaters	50-200F	140-160F	±1.0%
Letdown Temp. After Regen Hx		*	*			Letdown Flow	100-600F	263F	±2.5F
Letdown Temp After Letdown Hx		*				Component Cooling Water	50-200F	120F	±0.8F
Letdown Temp.		*	*			Process Radiation and Boronometer Isolation Valve, Ion Exchanger Bypass Valve.	50-200F	120F	±0.8F
Volume Control Tank Temp.		*	*				0-200F	120F	±1.0F
Regen. Hx Shell Temp.		*					0-600F	395F	±3.0F
Letdown Pressure		*	*	*		Backpressure Control Valves	0-600psig	460psig	±3.6psig
Purif. Filter	*		*				0-40psid	1-30psid	±0.2psid
Ion Exchanger	*						0-40psid	1-15psid	±0.2psid
Letdown Strainer	*		*				0-40psid	1-4psid	±0.2psid
B.A. Pump Discharge Press.	*			*			0-160psig	55-110psig	±0.8psig

[1] All alarms and recorders are in the control room unless otherwise indicated.

TABLE 9.3-26 (Cont.)

CHEMICAL AND VOLUME CONTROL SYSTEM INSTRUMENT APPLICATION

System Parameter and Location	Indication Local	Indication Contr Room	Alarm[1] High	Alarm[1] Low	Rec.[1]	Control Function	Inst. Range	Normal Operating Range	Inst. Accuracy
B.A. Strainer	*						0-20psid	0.25-5.0 psid	0.1psid
Charging Pump Header Press		*		*			0-3000psig	2300psig	±15psig
RCP Bleedoff Header Press		*	*				0-300psig	100psig	±1.5psig
Charging Pump Suction Press	*					Charging Pump Permissive	0-150psia	15psia	±0.8psia
Volume Control Tank Press		*	*	*			0-75psig	15psig	±0.4psia
Charging Pump Seal Lube Press	*			*			0-30psig	5.5-6.0 psig	
B.A. Makeup Tank	*	*	*	*			0-100%	53-96%	±0.5%
Volume Control Tank Level		*	*	*		Level Replenishment, Bypass to WMS, Tank Isolation	0-100%	72-85.6%	±0.5%
Chg. Pump Lube Oil Level	*			*				50%	
Chg. Pump Sump Tank Level	*						0-100%	87.5%	
Letdown Flow		*	*				0-140gpm	40gpm	±7.0gpm
Boron & Process Rad. Flow	*			*			0.2-3.0gpm	1.0gpm	±0.1gpm
Boron Flow		*	*	*	*	VCT Level, Boron Conc.	0-30gpm	0-16gpm	±3.0gpm

[1]All alarms and recorders are in the control room unless otherwise indicated.

TABLE 9.3-26 (Cont.)

CHEMICAL AND VOLUME CONTROL SYSTEM INSTRUMENT APPLICATION

System Parameter and Location	Indication Local	Indication Contr Room	Alarm[1] High	Alarm[1] Low	Rec.[1]	Control Function	Inst. Range	Normal Operating Range	Inst. Accuracy
		*				Boron Conc. Maint.	0-999,999 gal.		±1.0%
Demineralized Water Flow		*	*	*	*	VCT Level, Boron Conc.	0-150gpm	0-150gpm	±7.5gpm
		*				Maintenance Boron Conc. Maint.	0-999,999 gal.		±1.0%
Charging Flow		*		*			0-150gpm	44gpm	±75gpm
Chg. Pump Lube Oil Flow	*								
Boron Concentration		*	*	*	*		0-2050ppm	Variable	±25ppm
Process Radiation		*	*		*		$10-10^6$ μCi/cc	10μCi/cc	±50%

[1] All alarms and recorders are in the control room unless otherwise indicated.

9.3.5 SHUTDOWN COOLING SYSTEM

9.3.5.1 Design Bases

The shutdown cooling system is designed to:

a) reduce the temperature of the reactor coolant from 300 F to refueling water temperature and maintain this temperature during refueling assuming a single active failure

b) remove post-LOCA decay heat during the recirculation mode of safety injection system operation to preclude containment pressure and temperature from exceeding their design values assuming a single failure

c) control reactor coolant temperature during the early stages of plant start-up

d) withstand design basis earthquake loads without loss of function

e) withstand the post-LOCA short and long term environmental and corrosion conditions without loss of function.

9.3.5.2 System Description

The shutdown cooling system is shown schematically in Figure 9.3-6. System component design data are given in Table 9.3-27 and the shutdown heat exchanger design data are given in Table 9.3-28. The safety injection pump design data are given in Table 6.1-3. System instrumentation utilization is described in Section 7.4.1.3. The shutdown cooling system uses portions of the reactor coolant system, safety injection system and the containment spray system in accomplishing its design functions.

9.3.5.2.1 Normal Operation

During normal power operation, there are no components of the system in operation.

9.3.5.2.2 Plant Shutdown

Plant shutdown is the series of operations which bring the reactor from a hot standby condition of 2235 psig and 532F to a cold shutdown condition of zero psig and 135F. Cooldown from hot standby to 300F is accomplished through the steam dump and bypass system in conjunction with either the feedwater or auxiliary feedwater system as discussed in Chapter 10.

Shutdown cooling is initiated when the reactor coolant system conditions drop below the design pressure and temperature of the shutdown cooling equipment. At this time the system is aligned for shutdown cooling. In the shutdown cooling mode, reactor coolant is circulated using the low pressure safety injection pumps. The flow path from the pump discharge runs through motor-operated valve V-3658 and manual valve V-3452 (normally locked closed) and manual valve V-3453 (normally

TABLE 9.3-27

SHUTDOWN COOLING SYSTEM DESIGN DATA

Code - piping - valves	Code for Pressure Piping, USAF B31.1, 1967 draft ASME Code for Pumps and Valves for Nuclear Power, November 1968
Shutdown Cooling System Start-up	Approximately 3.5 hours after reactor shutdown or trip
Design Pressure, psig	500
Design Temperature, F	350
Reactor Coolant System Cool-down Rate (At initiation of Shutdown Cooling)	75F/hr
Refueling Temperature, F	135
Material - Piping and Valves	Austenitic Stainless Steel
Nominal Shutdown Cooling Flow, gpm	6000 (Total)

TABLE 9.3-28

SHUTDOWN HEAT EXCHANGER DESIGN DATA

	Shutdown Cooling Mode
Tube Side	
Flow, Million lb/hr	1.5
Inlet Temperature F	135
Outlet Temperature F	116.3
Shell Side	
Flow, Million lb/hr	2.41
Design Temperature, F	-
Inlet Temperature, F	100
Design Pressure, psig	-
Outlet Temperature, F	111.6

Piping and valves are provided in the chemical and volume control system 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 chemical and volume control system 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 and provides monitoring of boron level using the boronometer

9.3.5.2.3 Plant Start-Up

The shutdown cooling function is used during the early stages of plant start-up to control reactor coolant temperature. Heat generated by reactor coolant pumps and by core decay heat is removed as required by the shutdown cooling system. Prior to commencing plant heatup the interconnections to the reactor coolant system are isolated and the safety injection system is aligned for emergency operation. The four isolation valves in the shutdown cooling suction lines are closed.

9.3.5.2.4 Refueling

The transfer of refueling water from the refueling water 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 refueling water tank 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.

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 refueling water tank. A connection is provided from the shutdown cooling heat exchanger discharge to the refueling water tank for this purpose. The low pressure safety injection pumps are used for the transfer operation.

9.3.5.2.5 Emergency Operation

The shutdown cooling system heat exchangers are used during the recirculation phase of safety injection system operation following a LOCA. Heat is removed from the containment sump water through the shutdown cooling heat exchangers by means of the containment spray pumps. 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. The cooling system also provides the capability of diverting a portion of the cooled water from the containment spray system to the suction of the high pressure safety injection pumps for injection of cooler water into the core. For further discussion refer to Sections 6.2 and 6.3.

locked open); through the shutdown cooling heat exchangers; through manual valves V-3456 and V-3457 (normally locked open) and air-operated valve HCV-3657 (normally locked closed); to the low pressure safety injection header; and enters the reactor coolant system through the four safety injection nozzles. The circulating fluid flows through the core and is returned from the reactor coolant system to the low pressure safety injection pump suction through two shutdown cooling lines. One shutdown cooling line is located in each reactor vessel hot leg pipe. In returning to the pumps, the fluid passes through normally locked closed motor-operated isolation valves V-3651 and V-3652 in the line from loop 1B and motor-operated valves V-3480 and V-3481 in the line from loop 1A. The isolation valves in the suction lines are interlocked to prevent inadvertent opening and to automatically close whenever the reactor coolant system pressure exceeds the design pressure of the shutdown cooling system. Both valves in each of the suction lines are independently controlled by separate instrumentation channels. The interlock on these valves is further described in Section 7.6.1.1.

The component cooling system is the heat sink to which the reactor coolant residual heat is rejected. Each shutdown heat exchanger receives cooling water to its shell side from a separate component cooling system essential header. The shutdown heat exchangers are sized to establish refueling water temperature (135F) with the design component cooling water temperature (100F) 27-1/2 hours after shutdown following an assumed infinite period of reactor operation.

The minimize thermal shock on the low pressure safety injection pumps, shutdown heat exchangers and piping, a low flow is established by opening warmup valves V-3400 and V-3484. The low pressure safety injection pumps are then warmed to reactor coolant temperature by cracking open one low pressure injection valve. The shutdown cooling heat exchangers are warmed by slowly opening valve HCV-3657. When the shutdown cooling heat exchangers are warmed up the remaining three low pressure injection valves are opened. The initial cooldown rate is maintained at 75F per hour or less. The cooldown rate is controlled by adjusting the flow rate through the heat exchangers with the throttle valve on the discharge of heat exchangers. The shutdown cooling flow indicator-controller (FIC-3306) maintains a constant total shutdown cooling flow rate to the core by adjusting the heat exchanger bypass flow to compensate for changes in flow rate through the heat exchangers. During initial cooldown the temperature differences for heat transfer are large, thus only a portion of the total shutdown flow is diverted through the heat exchangers. As cooldown proceeds the temperature differences become less and the flow rate through the heat exchangers is increased. The flow is increased periodically until the system reaches refueling temperature. At this time full shutdown cooling flow is through the heat exchangers.

Shutdown cooling is continued through the entire period of plant shutdown to maintain a refueling water temperature of 135F or less.

9.3.5.3 System Evaluation

9.3.5.3.1 Performance Requirements and Capabilities

When the reactor coolant system pressure falls below 1700 psig the SIAS is manually blocked. The SIAS is automatically unblocked any time the reactor coolant system pressure rises above 1700 psig. When reactor coolant pressure falls below 400 psig the safety injection tank isolation valves are closed. Prior to placing the system in operation the boron concentration is verified at various sample points in the safety injection system. Should the concentration be too low, recirculation to the refueling water tank is used to bring it to refueling conditions.

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

Pressure relief valves are provided to protect sections of piping from pressure increases due to the thermal expansion of the contained water and inadvertant cross connections with other pressure sources. The relief valves are shown in Figure 9.3-6.

Control valves are equipped with two sets of packing and intermediate leakoff connections that discharge to the waste management system. Manual valves have backseats to limit stem leakage when in the open position.

Manual isolation valves are provided to isolate equipment for maintenance. Throttle valves are provided for remote manual control of heat exchanger tube side flow. Check valves prevent shutdown cooling reverse flow through the low pressure safety injection pumps.

Leakage within the emergency core cooling system equipment room described in Section 6.2.2 normally drains to the room sump. From there it is pumped to the waste management system. Should a gross gasket failure or equipment failure occur which cannot be directly isolated, the spillage flows to the room sump. The sump pumps in each room will handle leakage for short periods of time. If leakages are greater than pump capacity or if gaseous radiation releases are greater than liquid waste system capabilities, the room is isolated. Room isolation is accomplished by stopping the pumps in that room and closing the sump isolation valve.

If a tube-to-shell leak develops in the shutdown heat exchanger, the water level in the component cooling system surge tank gives a high level alarm as described in Section 9.2.2. If the in-flow completely fills the surge tank, the excess flow is discharged to the waste management system.

The shutdown cooling system components are designed to operate in the environment to which they would be exposed following a LOCA. Refer to Section 3.11. To ensure long term performance of the shutdown cooling system without degradation due to corrosion, only materials compatible with the pumped fluid are used. The possibility of chloride-induced stress corrosion of austenitic stainless steel is minimized by use of insulation material with low soluble chloride content. During long term operation chloride stress corrosion due to recirculation of the containment sump water is minimized since the shutdown cooling system is not highly stressed.

9.3.5.3.2 Single Failure Analysis

The failure of any single active or passive component in the shutdown cooling system during recirculation following a LOCA will not result in a loss of cooling capability. Sufficient isolation capabilities, interconnections and redundancy of components are provided to ensure adequate reactor core cooling. This is further discussed in Section 6.3.

The single failure of an active component during shutdown cooling operation will not result in a loss of cooling capability. The reactor coolant system can be brought to refueling temperature using one low pressure safety injection pump and one shutdown heat exchanger, but the cooldown process would be considerably longer than the specified 27-1/2 hours time period.

To control the rate of reactor coolant system cooldown, reactor coolant is bypassed around the shutdown cooling heat exchangers. This allows maintaining a constant total shutdown cooling flow to the core. Loss of the automatic control function will not reduce the shutdown cooling system cooling capability. The automatic flow control facilitates cooldown, but its function may be duplicated by operator action. The flow may be controlled by manual operation using the low pressure safety injection pump discharge pressure (utilizing the certified pump characteristic performance curve) as an indication of system flow rate.

A single failure of passive component during shutdown cooling will result in the interruption of the cooldown but will not result in a loss of core cooling. Should a portion of the shutdown cooling system piping outside of the containment sustain a failure during cooldown from 300F, the shutdown cooling system can be isolated while core decay heat is removed by the main steam and feedwater systems. The reactor coolant system is then maintained in this partial cooldown condition (approximately 300F) while repairs are affected on the shutdown cooling system. A failure of a shutdown cooling suction line will not interrup cooldown, since the second suction line will permit continued cooldown at a reduced rate.

Continued core cooling in the event of a passive failure, occurring after the reactor vessel head has been removed, is provided by manual alignment and initiation of the safety injection system. The safety injection tank isolation valves and high pressure safety injection control valves are opened, the high pressure safety injection pumps are started and the shutdown cooling system is isolated. The containment cooling system is used to remove core decay heat. These actions, initiated from the control room, will ensure the continuation of core cooling.

9.3.5.3.3 Testing and Inspection

Preoperational tests are conducted to verify proper operation of the shutdown cooling system. The preoperational tests include calibration of instrumentation, testing of the automatic flow control, verification of adequate shutdown cooling flow and verification of the operability of all associated valves.

To ensure availability of the shutdown cooling system, components of the system are periodically tested. As described in Section 6.3.4, the low pressure safety injection pumps, air and motor operated valves, instrumentation and check valves associated with the safety injection system are tested on a quarterly basis. These system and component tests together with shutdown cooling heat exchanger thermal performance data taken during refueling are sufficient to demonstrate the operability of the shutdown cooling system.

9.3.5.3.4 Natural Phenomena

Since the shutdown cooling system is essential for a safe shutdown of the reactor, it is a seismic Class I component and designed to remain functional in the event of a design basis earthquake.

Components of the system are located within the reactor auxiliary building or the containment and therefore would not be subject to natural perturbations other than seismism.

9.3.5.4 Instrument Application

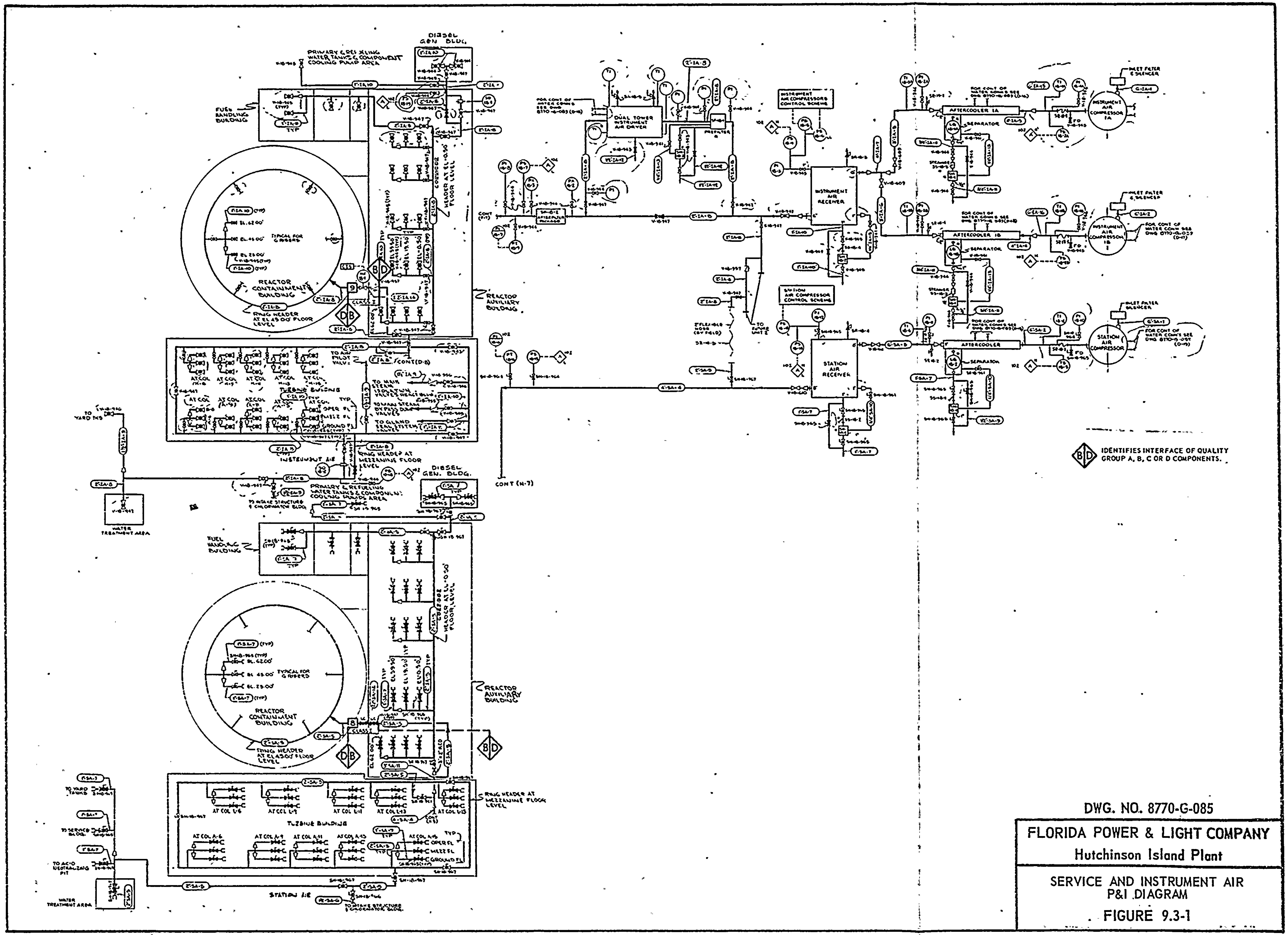
Table 9.3-29 lists the parameters used to monitor the shutdown cooling system.

TABLE 9.3-29

SHUTDOWN COOLING SYSTEM INSTRUMENT APPLICATION

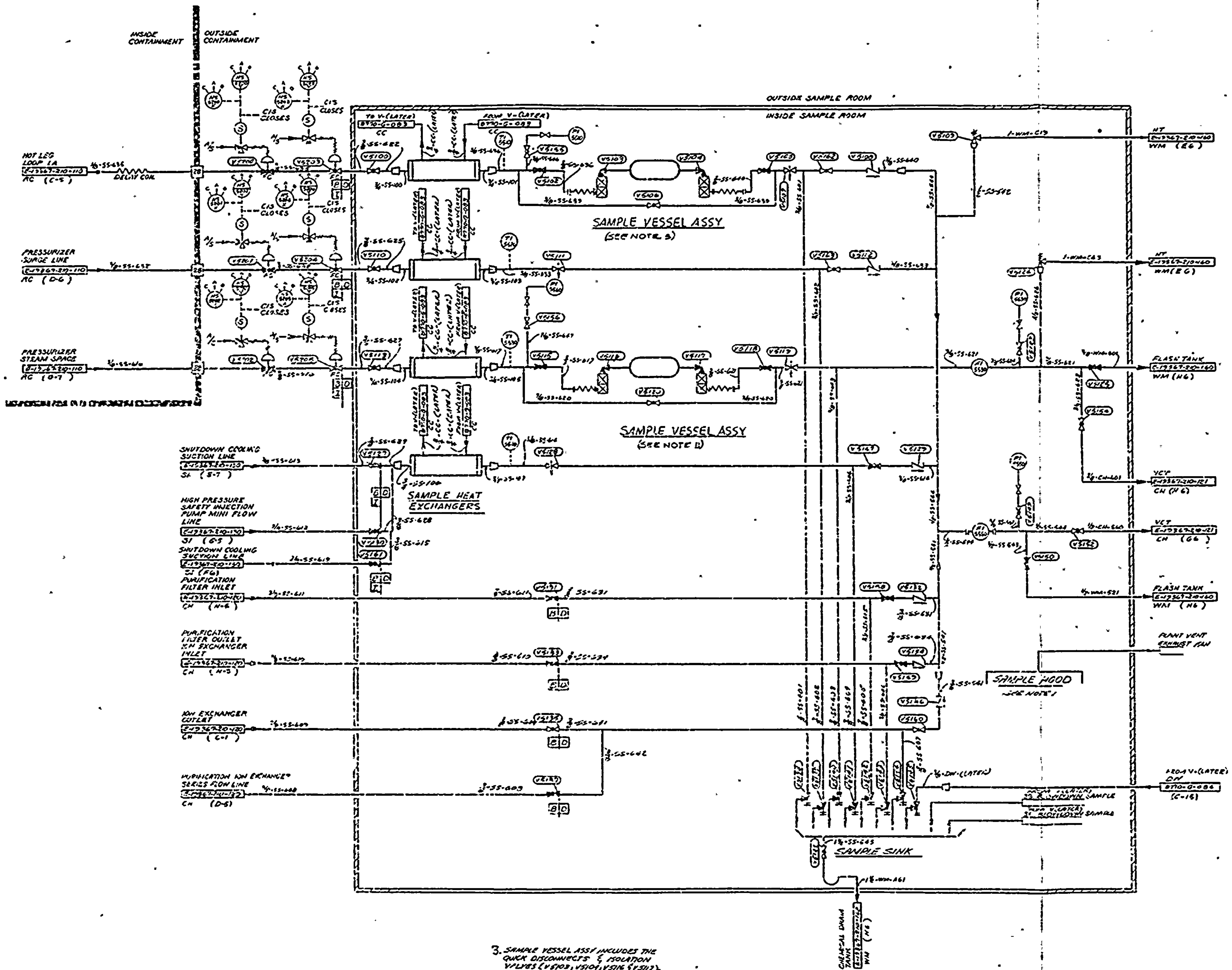
System Parameter and Location	Indication		Alarm[1]		Rec.[1]	Control Function	Inst. Range	Normal Operating Range	Inst. Accuracy
	Local	Contr Room	High	Low					
Heat Exchanger Inlet Temperature					*		0-400F	Variable	±8.0F
Heat Exchanger Outlet Temperature		*					0-400F	Variable	±8.0F
Shutdown Cooling Return Temperature					*		0-400F	Variable	±8.0F
Heat Exchanger Inlet Pressure		*					0-500psig	300psig	±2.5psig
Shutdown Cooling Return Flow		*				Heat Exchanger Bypass Valve	0-8000	Variable	±40
Heat Exchanger Flow		*				Heat Exchanger Bypass Valve	0-100	Variable	±0.5

[1] All alarms and recorders are in the control room unless otherwise indicated.



SERVICE AND INSTRUMENT AIR P&I DIAGRAM

FIGURE 9.3-1



3. SAMPLE VESSEL ASSY INCLUDES THE QUICK DISCONNECTS & ISOLATION VALVES (V5103, V5104, V5116 & V5117).

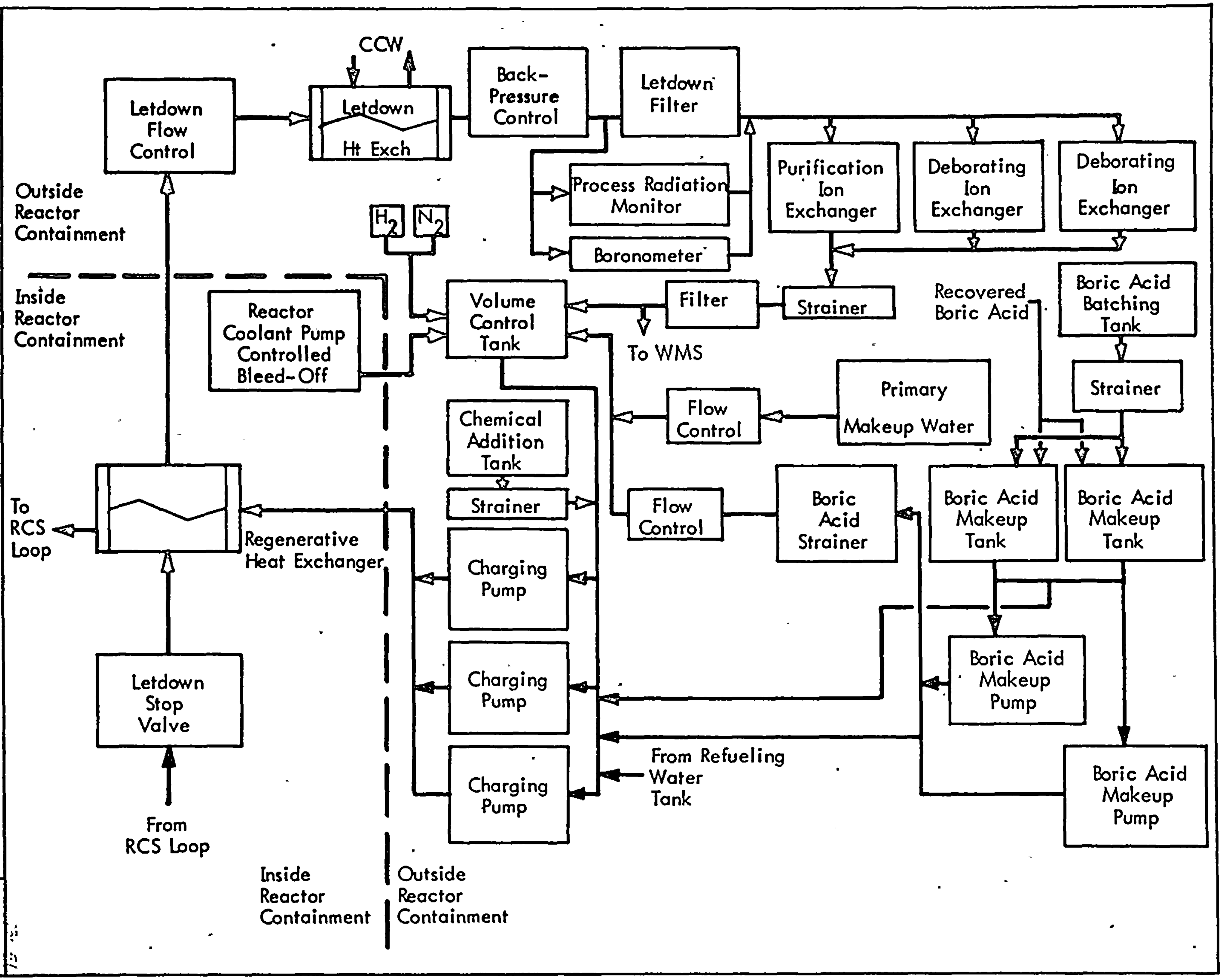
2. SAMPLE VESSEL ASSEMBLIES & SAMPLE SINK ARE INSIDE SAMPLE HOOD.

1. For Legend, Abbreviations, & Symbols See Fig. 1.2-20

13-150

REF: DWG. No. E-19367-210-150, REV. 05

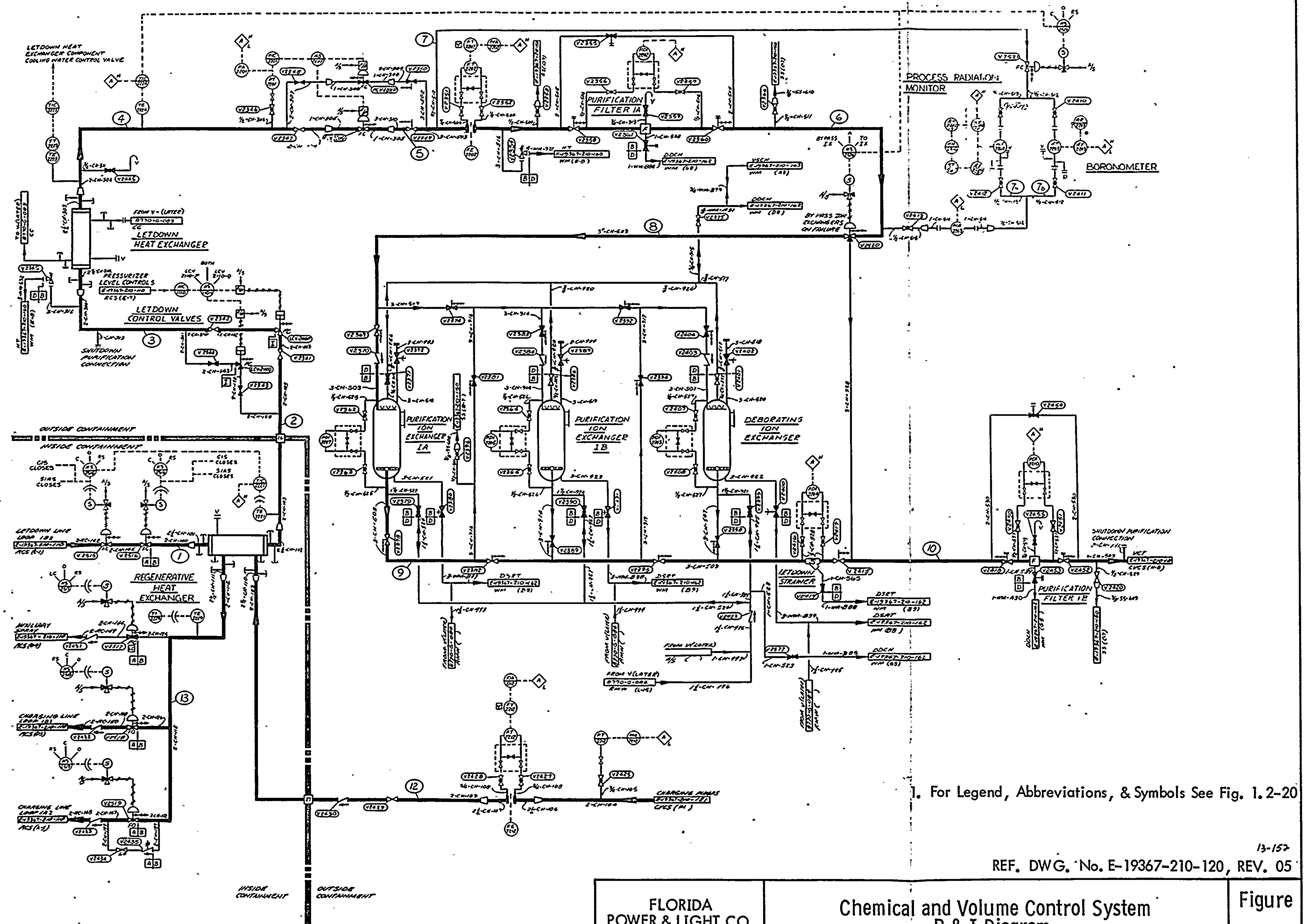
FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Sampling System - P & I Diagram	Figure 9.3-2



FLORIDA POWER & LIGHT CO.
Hutchinson Island Plant

Chemical and Volume Control System Flow Schematic (Normal Operation)

Figure 9.3-3



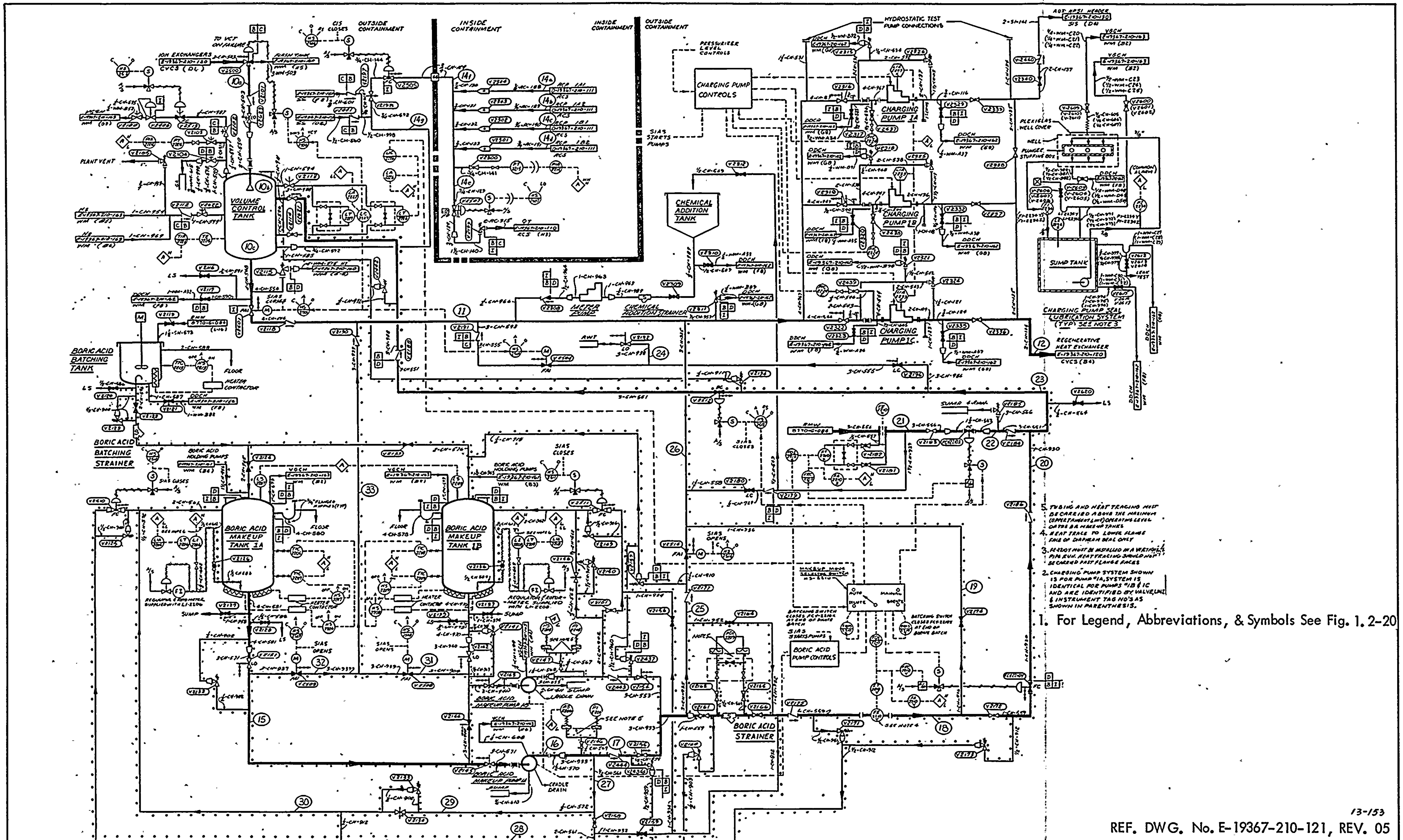
1. For Legend, Abbreviations, & Symbols See Fig. 1.2-20

13-157

REF. DWG. No. E-19367-210-120, REV. 05

FLORIDA POWER & LIGHT CO. Hutchinson Island Plant	Chemical and Volume Control System P & I Diagram	Figure 9.3-4

13-1

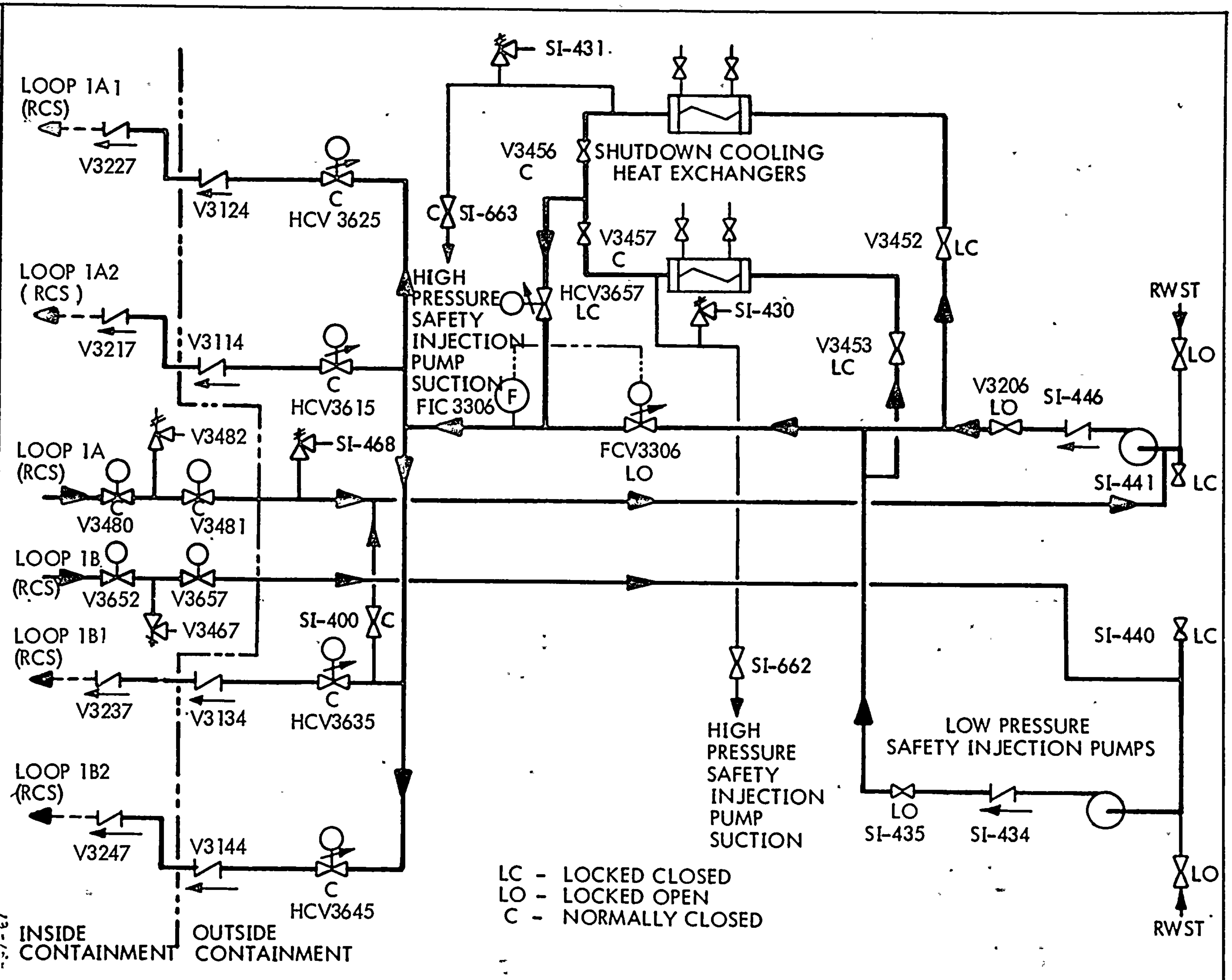


FLORIDA POWER & LIGHT CO.
Hutchinson Island Plant

Chemical and Volume Control System
P & I Diagram

Figure 9.3-5

FLORIDA POWER & LIGHT CO.
Hutchinson Island Plant



Shutdown Cooling Flow Diagram

Figure 9.3-6

9.4 AIR CONDITIONING, HEATING, COOLING AND VENTILATION SYSTEMS

9.4.1 CONTROL ROOM VENTILATION

9.4.1.1 Design Bases

The control room ventilation system is designed to:

a) limit control room doses due to airborne activity to within GDC 19 limits

b) maintain the ambient temperature required for personnel comfort during normal conditions

c) permit personnel occupancy and proper functioning of instrumentation and control during all normal and LOCA conditions assuming a single active failure

d) withstand design basis earthquake loads without loss of function.

9.4.1.2 System Description

The control room ventilation system flow diagram is shown on Figure 9.4-1 and the P & I diagram is shown on Figure 9.4-2. System design data is given in Table 9.4-1.

The control room is air conditioned by two redundant 100 percent capacity units. Figure 9.4-1 shows 3 units, HVA-3C being reserved for the addition of a second plant. One unit is normally running with the second unit in a standby status available for manual actuation in the event of a failure of the operating unit. The normal operating conditions in the control room are those recommended by ASHRAE for comfort air conditioning. The control room temperature reaches a maximum of 113F in the unlikely event that both units fail and no outside air makeup is available. This temperature is based on full equipment load, emergency lighting, eight control room personnel and 93F ambient conditions outside. The analysis assumed a temperature of 110F in the adjacent heating and ventilating room and 104F in the electrical equipment room below. Solar heat gain into the control room was also considered. Under the conditions described above, the maximum temperature in the control room is reached in 54 min after loss of cooling.

The control room ventilation system consists of split system air conditioners (i.e., an indoor and outdoor section), a ducted air intake and air distribution system, and a filter train with HEPA filters and charcoal adsorbers with two redundant booster centrifugal fans. The indoor section is located at elevation 43 ft and includes a cabinet type centrifugal fan, a direct expansion refrigerant cooling coil, heating coil and filters. The outdoor section is a single assembly which includes a refrigerant condensing coil and fans, and refrigerant compressors. The indoor section is seismic Class I while the outdoor section is not.

TABLE 9.4-1

DESIGN DATA FOR CONTROL ROOM VENTILATION SYSTEM COMPONENTS

1. Air Conditioners (HVA-3A,B,C)	
Quantity	2; 1 running, 1 standby
Type	split system, direct expansion with air cooled condensers
Air flow, each, cfm	7500
Fan static pressure, in. wg	1.25
Outside intake air flow, cfm	750
2. Booster Fans (HVE-13 A,B)	
Quantity per bank	2
Type	Centrifugal
Material	Steel
Air flow, cfm	2000
Fan static pressure, in. wg.	3.5
Fan performance, each	
Capacity, cfm	2000
Static pressure, in. wg.	4
3. Motors	
Quantity	1
Type	Electric, 2 HP
Insulation	Class B, powerhouse
Enclosure & ventilation	Open, drip-proof
4. HEPA Filters (HVE-13)	
Quantity per bank	2
Air flow, cfm	2000
Cell size, in.	24 wide x 24 high x 11½ deep
Cell arrangement	1 wide x 2 high mounted on structural frame
Max. resistance, clean, in. wg.	3.0
Efficiency, percent	99.97 percent when tested with 0.3 micron DOP

TABLE 9.4-1 (Cont'd)

Material	Glass asbestos paper separated by aluminum inserts, supported on cadmium plated steel frame
Code	UL-586, Class 1

5. Charcoal Adsorbers (HVE-13)

Quantity per bank	6
Air flow, cfm	2000
Cell size, in.	24 wide x 8 high x 30 deep
Cell arrangement	1 wide x 6 high mounted on structural cradle frame
Max. air resistance, in. wg.	1.15
Efficiency, percent	99.9 minimum of iodine with 5 percent in the form of methyl iodide (CH_3I), when operating at 70 percent relative humidity and 150 F
Loading capacity	6000 gm of stable iodine and 360 gm of radioactive iodine including 30 gm of CH_3I
Adsorber material	Activated coconut shell charcoal
Enclosure	Stainless steel type 304L ASTM
Gaskets	Neoprene ASTM D1056 Grade SCE-43
Frame	Steel ASTM - A36

6. Ducts

Material	Galvanized steel

Control room air is drawn into the indoor air handling section through a return air duct system and roughing filters, and is either heated or cooled as required. Conditioned air is directed back to the control room through a supply air duct system. Outside air makeup is effected through either of two outside air intakes located in the north and south walls of the reactor auxiliary building.

One air conditioner unit is normally in operation with the selected intake damper open.

On receipt of a containment isolation signal (CIS), the booster fans are automatically started and the charcoal filter train dampers are opened. Outside air intake is isolated by the redundant dampers (FCV-14-,-15,-16, -17) located in the outside air makeup ducts. The control room air is recirculated through the HEPA filters and charcoal adsorbers. Air flow through the units is monitored and loss of flow conditions is annunciated. Position of air intake isolation valves, fan inlet dampers and filter inlet damper is indicated in the control room.

As long as the outside air intakes are open the control room is maintained at a slightly positive pressure. After the outside air intake dampers are closed by a CIS, the pressure differential is reduced. The operator can select which outside air intake to open by observing the two radiation monitors located in each air intake duct.

Should a loss of off-site power occur the air conditioner units can be powered by the emergency diesel generator sets. The engineered safety features and reactor protective system instrumentation and controls contained within the control room are specified to remain operable over a temperature range of 40 to 140 F and a humidity range of 40 to 95 percent. The vendor is required to submit test data verifying this fact.

The control room radiation monitor is a Geiger-Müller counter with a range of 0.1 to 1000 mR/hr which audibly alarms any exposure above 0.5 mR/hr. The operator can manually open the charcoal filter train dampers and start the booster fans in any instance where such action might be necessary and no CIS signal has been received. The system is not designed to detect airborne containments other than radiation.

9.4.1.3 System Evaluation

Control room ventilation system components essential to safety are designed and installed in accordance with seismic Class I requirements. The control room air conditioning outdoor section is not seismic Class I. Purchase specifications require manufacturers to submit type test or calculational data to verify the capability of the equipment to function during and following a design basis earthquake. Refer to Section 3.7.5 for a discussion of seismic qualification.

Only one booster fan and HEPA filter are required for ventilation and filtration of the control room air under post-accident conditions. Electrical power for each booster fan, damper and outside air intake isolation valve is supplied from a separate emergency power bus to prevent a single electrical failure from disabling both units.

9.4.1.4 Testing And Inspection

Preoperational tests are performed on the system to ensure meeting performance and design basis requirements. All automatic and manual sequences are tested to ensure proper operation.

Manufacturers tests include:

a) pressure testing HEPA filter casings at 30 in. wg vacuum for distortion

b) pressure testing casings at 2 psig for leaks

c) performing filtration tests to verify filter design performance for filtration, air flow capacity, air flow resistance, moisture and overpressure resistance and shock and vibration

d) verifying charcoal adsorber design efficency

9.4.1.5 Instrumentation Application

Table 9.4-2 lists the measured parameters for monitoring the performance of the control room ventilation system.

The air conditioners, centrifugal fans and outside air intake dampers are controlled by remote manual operation in the control room. The outside air intake dampers can also be opened or closed by manual operation.

TABLE 9.4-2

CONTROL ROOM VENTILATION SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		(1) Alarm		(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Control Room									
1) Temperature		*				Start air conditioners at 75F	-	75F	-
Booster Fan									
1) Inlet damper position		*					-	-	-
2) Outlet flow				*			-	2000 cfm	-
Indoor Unit									
1) Outlet flow				*			-	7500 cfm	-
Outside Air Intake Position		*					-	-	-
HEPA Filter Damper Position		*					-	-	-

(1) All alarms and recordings are in control room unless otherwise indicated.

9.4.2 REACTOR AUXILIARY BUILDING VENTILATION SYSTEMS

9.4.2.1 Design Bases

The reactor auxiliary building ventilation systems are designed to:

a) provide ventilation to permit proper functioning of equipment during normal operation

b) provide air flow from areas of low potential radioactivity to areas of higher potential radioactivity

c) provide an air supply for cooling of safety related equipment assuming a single active failure

d) withstand design basis earthquake loads without loss of its cooling function of safety related equipment

9.4.2.2 Description

The reactor auxiliary building ventilation systems consist of the main ventilation and various auxiliary systems which are shown on Figure 9.4-1. The main system ventilates equipment areas such as pump rooms, the waste management system processing and storage areas, chemical and volume control system equipment rooms, and all potentially contaminated areas. The main ventilation system exhausts through the plant vent.

The electrical switchgear rooms and the battery rooms are served by the electrical equipment room ventilation system. Personnel areas such as locker rooms, offices, the machine shop, and laboratory are served by various miscellaneous ventilation systems. Laboratory areas are exhausted by the main reactor auxiliary building exhaust system. The reactor auxiliary building ventilation air flow is shown in Figure 9.4-1. The system P&I diagrams are shown on Figures 9.4-2 and 9.4-3.

9.4.2.2.1 Reactor Auxiliary Building Main Ventilation System

The system consists of an air supply subsystem and an air exhaust air system (HVE-10A,B). Air supply is effected through wall louvers, roughing filters, steam heating coils, two 100 percent capacity centrifugal fans (HVS-4A,B) and duct distribution systems. Component data are given in Table 9.4-3.

The air supply system provides the cooling requirements for the low and high pressure safety injection pumps and the containment spray pumps, and is designed as seismic Class I. Upon loss of normal power, the system is automatically connected to the on-site emergency diesel generator sets. Main supply fan HVS-4A is powered from bus 1A-2 and fan HVS-4B from bus 1B-2.

The air exhaust system includes a 100 percent capacity bank of prefilters and HEPA filters, two 100 percent capacity exhaust fans (HVE-10A,B) and duct exhaust system. The exhaust system serves no safety function. Under accident conditions the engineered safety features pump rooms are exhausted by the ECCS area ventilation system described in Section 9.4.3.

TABLE 9.4-3

DESIGN DATA FOR REACTOR AUXILIARY BUILDING VENTILATION SYSTEM COMPONENTS

1. Reactor Auxiliary Building Main Supply System (HVS-4A & B)

Number of fans installed	2
Number of fans normally operating	1
Fan capacity, each, cfm	69,015
Fan static pressure, in. wg	3
Fan motor HP	60
No. of filters	72

2. Reactor Auxiliary Building Main Exhaust System (HVE-10A & B)

Number of fans installed	2
Number of fans normally operating	1
Fan capacity, cfm	70,600
Fan static pressure, in. wg	6
Fan motor HP	125
No. of prefilters	72
No. of HEPA filters	72

3. Electrical Equipment and Battery Room Ventilation Supply System (HVS-5A & B)

Number of fans installed	2
Number of fans normally operating	2
Fan capacity, each, cfm	26,000
Fan static pressure, in. wg	1.5
Fan motor HP	15
No. of filters	48

4. Electrical Equipment Room Exhaust System

Number of fans installed	
a) Room 1A (RV-3 & 4)	2
b) Room 1B (HVE-11 & 12)	2
c) Room 1A/B (HVE-18 & 19)	2
Number of fans normally operating	
a) Room 1A	2
b) Room 1B	2
c) Room 1A/B	2
Fan capacity, cfm each	
a) Room 1A	8,500
b) Room 1B	16,500
c) Room 1A/B	10,000

TABLE 9.4-3(Continued)

Fan static pressure, in. wg	
a) Room 1A	0.25
b) Room 1B	0.25
c) Room 1A/B	0.25
Fan motor, HP	
a) Room 1A	1.5
b) Room 1B	2
c) Room 1A/B	1.5
No. of prefilters	None

5. Battery Room Exhaust System
(data given is identical for both rooms)(RV-1 & 2)

Number of fans installed	1
Number of fans normally operating	1
Fan capacity, cfm	1,000
Fan static pressure, in. wg	0.25
Fan motor, HP	0.166
No. of prefilters	None

6. Locker Area and Machine Shop Ventilation Supply System (HVS-3)

Number of fans installed	1
Number of fans normally operating	1
Fan capacity, cfm	10,225
Exhaust static pressure, in. wg	1.25
Fan motor, HP	5
No. of filters	None

7. Locker Area Exhaust System (HVE-4)

Number of fans installed	1
Number of fans normally operating	1
Fan capacity, cfm	1,850
Fan static pressure, in. wg	0.5
Fan motor, HP	0.5
No. of filters	None

8. Machine Shop Area Exhaust system (HVE-5)

Number of fans installed	1
Number of fans normally operating	1
Fan capacity, cfm	7,000
Fan static pressure, in. wg	3.5
Fan motor, HP	7.5
No. of prefilters	6
No. of HEPA filters	6

TABLE 9.4-3(Continued)

9. Health Physics, First Aid and Cold Laboratory Room Ventilation Supply System (HVA-2, ACC-2)

Number of air conditioners installed	1
Number of air conditioners normally operating	1
Fan capacity, cfm	2,150
Exhaust static pressure, in. wg	1
Fan motor, HP	1.5
Filter area, ft^2	4

10. Counting, Instrument and Radio Chem. Room Ventilation Supply System (HVA-1, ACC-1)

Number of air conditioners installed	1
Number of air conditioners normally operating	1
Fan capacity, cfm	6,050
Exhaust static pressure, in. wg	1.25
Fan motor, HP	2
No. of filters	9

Note: All air conditioners are split system direct expansion units with air cooled condensers.

The reactor auxiliary building main ventilation system provides a minimum of four air changes per hour for each of the rooms in the building. Ventilation rate is sized to achieve the design ambient maximum temperature of 104 F in the equipment areas with an outside air temperature of 93 F.

The exhaust from potentially contaminated areas is discharged to the plant vent. Exhaust from other areas is directed outside the building. Refer to Section 12.2 for a discussion of the reactor auxiliary building radiation monitoring system.

9.4.2.2.2 Reactor Auxiliary Building Electrical Equipment and Battery Room Ventilation System

Electrical Equipment rooms 1A and 1B are ventilated by a system which includes a louvered intake, steam heating coils, 2 supply fans (HVS-5A,B), a duct distribution system and exhaust fans. Equipment room 1A is exhausted by power roof ventilators RV-3 and 4. Equipment room 1B is exhausted through the walls by fans HVE-11 and 12. Room 1A/B, located below rooms 1A and 1B at elevation 19.5 ft, draws outside intake air through the walls and exhausts air via fans HVE-18 and 19 located in the wall.

In the event of a failure of one supply fan, the second fan operates at 2/3 capacity, which is sufficient to cool all three equipment rooms and both battery rooms.

Upon loss of off-site power, the system is automatically connected to the on-site emergency diesel generator sets. Each electrical room exhaust fan is connected to separate emergency buses, as are the battery room exhaust fans. The supply fans are similarly connected to separate buses.

Ventilator air flow rates for the electrical and battery rooms are sized to achieve a temperature less than 104 F with an outside air temperature of 93 F. Electrical equipment room temperatures exceeding 110 F are annunciated in the control room. This ventilation system is safety related since it is required for proper functioning of the emergency electrical distribution equipment.

System component design data are given in Table 9.4-3.

9.4.2.2.3 Reactor Auxiliary Building Miscellaneous Ventilation Systems

The design data for the miscellaneous ventilation systems are shown in Table 9.4-3. Flow diagrams are shown on Figures 9.4-1 and P&I diagrams on Figures 9.4-2 and 9.4-3.

The locker and machine shop areas are ventilated by supply fan HVS-3 and exhausted by fans HVE-4 and HVE-5 respectively. Locker area air is clean and is exhausted directly to the atmosphere. Machine shop air is passed through a prefilter and HEPA filter before being vented to the atmosphere.

The cold laboratory, first aid room and health physics office are serviced by split system air conditioner ACC-2. Air is supplied from an outside air intake by fan HVA-2. Air is then directed to the corridor and exhausted by the main ventilation system.

The counting room, instrument calibration and repair shop, and radiological chemical lab are serviced by split system air conditioner ACC-1 and fan HVA-1. Air from these rooms is exhausted via the radiological chemical lab to the main ventilation system.

9.4.2.3 System Evaluation

Plant ventilation systems required for the operation of safety related components meet the same requirements for redundancy, independence, emergency power, quality assurance, and natural phenomena as the safety systems which they serve.

Where redundant safety related components (such as emergency electrical switchgear) require ventilation for proper operation, each redundant component is served by a separate ventilation fan and associated dampers and controls. In this way failure of a single active ventilation component can affect operation of only one of the redundant safety related components. Each of the redundant ventilation components and its controls are powered from a separate emergency bus which is part of the same emergency electrical load group as the components which it serves.

All ventilation system components required to perform safety functions are designed and installed as seismic Class I equipment and are located in seismic Class I structures. Purchase specifications require manufacturers to submit type test or calculational data to verify the capability of the equipment to function during and following a design basis earthquake. Seismic qualification of Class I components is discussed further in Section 3.7.5.

Battery room ventilation has been sized to avoid buildup of hydrogen.

9.4.2.4 Testing and Inspection

Manufacturer tests include:

a) pressure testing HEPA filter casings at 30 in. wg vacuum for distortion

b) pressure testing casings at 2 psig for leaks

c) performing filtration tests to verify filter design performance for filtration, air flow capacity, air flow resistance, moisture and overpressure resistance, and shock and vibration

d) verifying charcoal adsorber design efficiency

9.4.2.5 Instrumentation Application

Table 9.4-4 lists the parameters used to monitor and control auxiliary building ventilation systems. The only automatically controlled valves control flow to steam coils. These coils heat the supply air for the main subsystem, electrical equipment battery rooms, and the locker area and machine shop areas.

The reactor auxiliary building vent systems (including the engineered safety features area which is discussed in Section 9.4.3) receive SIAS signals. Table 9.4-5 lists components receiving an SIAS and the control function of that signal. The function of the SIAS is to provide the proper flow path for supply air to the engineered safety features area and to draw all exhaust air from this system through the HEPA and charcoal filter bank. Section 9.4.3 discusses the ECCS area ventilation system.

Components which can be manually operated and/or which have operational interlocks are listed in Table 9.4-5.

System instrumentation design and logic is discussed in Section 7.7.

TABLE 9.4-4

AUXILIARY BUILDING VENTILATION SYSTEMS INSTRUMENTATION APPLICATION

System Parameter & Location	Indication: Local	Indication: Control Room	Alarm (1): High	Alarm (1): Low	Recording (1)	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
Main Supply System									
1) Inlet temperature	*					Control flow to inlet air steam coils by means of valve modulation	0-85F	55F	±2.0%
2) Fan outlet flow				*			-	69,015 cfm	-
Pump Room A & B									
1) Temperature			*		*		0-150F	55-105F	±2.0%
ECCS Exhaust Fans									
1) HEPA filter differential pressure		*	*				0 to -10 in. H_2O	-1 to -3 in. H_2O	±1.0%
2) Outlet flow				*			-	30,000 cfm	-
Main Exhaust System									
1) HEPA filter differential pressure						Alarm or control room indication	0 to -10 in. H_2O	-1 to -3 in. H_2O	±1.0%
2) Exhaust flow							-	70,600 cfm	-
Electrical Equipment & Battery Room Vent System									
1) Supply system air intake temperature	*					Control steam flow to steam coils via valve modulation	0-150F	55-110F	±2.0%
2) Electrical equipment room temperature			*				0-130F	55-110F	±2.0%
Locker Area & Machine Shop Ventilation System									
1) Room temperature						Control flow to steam coils via valve modulation	0-95F	70F	±2.0%

TABLE 9.4-4 (Continued)

AUXILIARY BUILDING VENTILATION SYSTEMS INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm (1)		Recording (1)	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
<u>Radio Chem Lab Count Room & Instrument Shop Vent System</u> 1) Room temperature						Control air conditioner via "on-off" heating cooling thermostat	55-95F	75F	±2.0%

(1) All alarms and recordings are in the control room unless otherwise indicated.

TABLE 9.4-5

AUXILIARY BUILDING COMPONENTS WITH SIAS, INTERLOCKS OR MANUAL CONTROLS

Component	Manual Control		SIAS		Interlock	SIAS Control Function
	Local	Control Room	Yes	No		
1. Main supply fans (HVS 4A,4B)		*	*			Start
Main supply steam valve	*			*		
2. Supply air dampers to engineered safety features pump room (D1,D2,D3,D4)			*		HVE 9A,9B	Open
3. Supply air dampers to pipe tunnel (D8A,8B)			*		HVE 9A,9B	Close
4. Supply air(1) dampers to selected areas (D7A,7B,D11A,11B)			*		HVE 9A,9B	Close
5. Exhaust air dampers for engineered safety features pump room (D9A,9B)			*		HVE 9A,9B	Close
6. Main exhaust air dampers for pipe tunnel (D-12A,12B)			*		HVE 9A,9B	Close
7. Main exhaust dampers for shutdown heat exchangers (D-5A,5B, D-6A,6B)			*		HVE 9A,9B	Close
8. Main exhaust a) fans (HVE-10A,10B)		*		*	None	None
b) inlet dampers		*		*	None	None

(1) Selected areas: specific branch ducts to corridor as shown on Fig. 9.4-1

TABLE 9.4-5 (Cont'd)

Component	Manual Control: Local	Manual Control: Control Room	SIAS: Yes	SIAS: No	Interlock	SIAS Control Function
9. ECCS area exhaust a) fans (HVE-9A,9B)		*	*		None	Start
b) fan inlet dampers (D-14,D-16)		*	*		None	Start
c) fan outlet dampers (L-7A,7B)		*	*		None	Open
<u>Electrical and battery room vent systems</u>						
1. Steam coil valve	*			*	None	None
2. Supply fans (HVE-5A,5B)	*			*	None	None
3. Room 1A exhaust fans (RV-3,4) and dampers (L-9,10)	*			*	None	None
4. Room 1B fans (HVE-11,12) and dampers (L-9,10)	*			*	None	None
5. Battery room exhaust fans (RV-1,RV-2)	*				None	None
<u>Locker areas and machine shop vent system</u>						
1. Steam coil valve	*			*	HVE-3 HVE-5	None
2. Supply fan (HVS-3)	*			*	HVE-3 HVE-5	None
3. Locker room exhaust fan (HVE-4) and damper (L-5)	*			*	HVS-3 HVE-5	None
4. Machine shop exhaust fan (HVE-5) and damper (L-6)	*			*	HVS-3	None
<u>Radio chem lab. count room and instrument room.....a/c system</u>						
1. A/C fan	*			*	None	None

9.4.3 EMERGENCY CORE COOLING SYSTEM AREA VENTILATION SYSTEM

9.4.3.1 Design Bases

The emergency core cooling system (ECCS) area ventilation system is designed to provide post-LOCA filtration and adsorption of fission products in the exhaust air from areas of the reactor auxiliary building which contain the following equipment:

a) containment isolation valves

b) low pressure safety injection pumps

c) high pressure safety injection pumps

d) containment spray pumps

e) shutdown heat exchangers

f) piping which contains recirculating containment sump water following a LOCA

9.4.3.2 System Description

The ECCS area ventilation system air flow diagram is shown on Figure 9.4-1, the P & I diagram on Figure 9.4-2 and design data on Table 9.4-6.

The air exhaust system consists of two redundant centrifugal exhaust fans (HVE-9A, B), HEPA and charcoal filter banks, and associated duct work dampers and controls. The exhausted air is vented to the outside atmosphere.

Under normal operation, the reactor auxiliary building main ventilation supply and exhaust system provides the necessary ventilation of the ECCS pump rooms. Under accident conditions when several or all of the pumps are operating, the air supply to the nonessential section of the reactor auxiliary building is directed to the pump rooms to provide the additional cooling air requirement. Dampers are positioned automatically on SIAS signal to provide the proper flow path for supply air to the ECCS area. Simultaneously, the exhaust fans are energized and dampers in the exhaust ductwork are positioned to allow the fans to draw all exhaust air from the area through the HEPA and charcoal filter bank before discharge to the atmosphere. Table 9.4-5 lists the components actuated on SIAS and gives the control function of the SIAS on that component.

The ventilation system is sized to maintain a slightly negative pressure of between 1/4 and 1 inch wg in the ECCS area with respect to surrounding areas of the reactor auxiliary building. Access into the ECCS area from other parts of the reactor auxiliary building is through gasketed self-closing or locked closed doors. Opening of locked doors is under administrative controls.

TABLE 9.4-6

DESIGN DATA FOR ECCS AREA VENTILATION SYSTEM COMPONENTS

1. Fans

Quantity	2
Capacity, cfm	30,000
Static pressure, in. wg	6 (HVE-9A), 5 (HVE-9B)
Actual air flow at inlet, cfm	30,000
Air density, lb/ft^3	0.075
Code	Class III
Type, both systems	Centrifugal, variable pitch belt, air foil, non-overloading

2. Motors

Quantity	2
Type	Horizontal, 40 HP, 460 volt, 3 phase, 60 cycle
Insulation	Class B powerhouse
Enclosure & ventilation	Open, drip-proof

3. HEPA Filters

Quantity, per bank	30
Air flow, cfm	30,000
Cell size, in.	24 x 24 x 11½
Cell arrangement	5 wide x 6 high
Max resistance, clean, in. wg	1.0
Max resistance, loaded, in. wg	3.0
Efficiency	99.97% with 0.3 micron DOP smoke
Material	Glass asbestos paper separated by aluminum inserts, supported on cadmium plated steel frame
Code	UL-586, Class 1

4. Charcoal Adsorbers

Quantity per bank	90
Air flow, cfm	30,000
Cell size, in.	24 x 8 x 30
Cell arrangement	6 wide x 15 high
Max air resistance, in. wg	1.15
Efficiency	99.9% min of iodines with 5% in the form of methyl iodine, when operating at 70 percent relative humidity and 150 F

TABLE 9.4-6 (cont'd)

Loading capacity, gm	6000 gm stable iodine and 360 gm of radioactive iodine including 30 gm of CH_3I including 30 gm of methyl iodine
Maximum residence time, sec	0.25
Material adsorber	activated coconut shell charcoal
Enclosure	stainless steel type 304L ASTM
Gaskets	Neoprene ASTM D1056, Grade SCE -43
Frame	Steel ASTM-A36

5. Ducts

Material	galvanized sheet metal, ASME A-525 Class E

Piping penetrations into the enclosed area are provided with flexible rubber seals which limit the amount of in-leakage. The seals permit differential movement between the piping and the wall due to thermally or seismically induced motion.

9.4.3.3 System Evaluation

The ECCS area ventilation system components meet the same requirements for redundancy, independence, emergency power, quality assurance, and natural phenomena as the safety systems which they serve.

Redundant safety related components such as the safety injection pumps, shutdown heat exchangers or containment spray pumps require ventilation for proper operation; each redundant component is served by a separate ventilation fan and associated dampers and controls. In this way failure of a single active ventilation component can affect operation of only one of the redundant safety related components. Each of the redundant ventilation components and its controls is powered from a separate emergency bus.

Dampers connecting the ECCS area ventilation system with other parts of the auxiliary building main exhaust and supply systems fail in the closed position upon loss of control air or power. Dampers which align flow from the area through the charcoal filter train and exhaust fans fail in the open position.

The ventilation system is sized to maintain a slightly negative pressure in the engineered safety features area with respect to surrounding areas of the auxiliary building. Ductwork conveying air to the HEPA and charcoal filters will also be at negative pressure.

Upon loss of normal power, the system will be automatically connected to the emergency power source if required to operate. The fans and dampers associated with each of the separate filter trains are powered from separate buses and receive actuation signals from separate SIAS channels. No single failure will prevent both trains from operating.

All ventilation system components are designed and installed as seismic Class I equipment and are located in seismic Class I structures. Purchase specifications require manufacturers to submit type test, or calculational data to verify the capability of the equipment to function during and following a design basis earthquake.

Charcoal filter components receive factory and fluid tests similar to those described for the shield building ventilation system in Section 6.2.3.4.

9.4.3.4 Testing and Inspection

Preoperational tests will be performed on the system to ensure that it is capable of meeting its performance and design basis requirements. All automatic and manual sequences are tested to ensure proper operation.

Manufacturers tests include:

a) pressure testing HEPA filter casings at 30 in. wg vacuum for distortion

b) pressure testing casings at 2 psig for leaks

c) performing filtration tests to verify filter design performance for filtration, air flow capacity, air flow resistance, moisture and overpressure resistance, and shock and vibration

d) verifying charcoal adsorber design efficiency

9.4.3.5 Instrumentation Application

Table 9.4-4 lists the parameters used to monitor and control system operation. The function of the instrumentation is to monitor pressure across the HEPA filters and alarm low exhaust fan flow. The operator manually starts the standby unit on a low flow alarm.

Table 9.4-5 lists the ECCS area vent system components that are actuated by an SIAS and the control function of the SIAS.

Both exhaust fans are automatically started on SIAS, but the operator can manually shut one fan down and place it on standby.

The logic and system instrumentation is discussed in Section 7.7.4.

9.4.4 RADWASTE AREA VENTILATION

The radwaste area is located inside the reactor auxiliary building and is serviced by the reactor building main ventilation system, which is discussed in Section 9.4.2.

9.4.5 TURBINE BUILDING VENTILATION

The turbine building is an open structure with no ventilation system for the equipment areas except for the switchgear room and chemical storage areas which are enclosed. The areas are ventilated by wall mounted exhaust fans.

The turbine building ventilation system serves no safety function. System design data is given on Table 9.4-7.

9.4.6 FUEL HANDLING BUILDING VENTILATION

The fuel handling building ventilation system is designed to reduce plant personnel doses by preventing the accumulation of airborne radioactivity in the fuel handling building due to diffusion of fission products from the spent fuel pool. The system is also designed to allow operation of the spent fuel cooling equipment contained within the fuel handling building.

The system serves no safety function since it is not required to limit off-site doses resulting from a refueling accident to within the limits of 10CFR100. Accordingly, exception is taken to Item 4 of the regulatory position of AEC Safety Guide 13. The exclusion distance and meteorology for this site sufficiently limit refueling accident doses without reliance on ventilation and filtration systems. The assumptions, evaluation, and results of the refueling accident analysis are given in Section 15.4.3.

The fuel handling building ventilation system consists of two separate supply systems and two separate exhaust systems. The system flow diagram is shown on Figure 9.4-1 and the system piping and instrumentation diagram is given on Figure 9.4-2.

Each supply system consists of a hooded wall intake, an air handling unit with filters, steam coils and fan section, and a duct distribution system. One system supplies air to the fuel pool area and the other system supplies air to the lower areas.

The fuel pool area air is exhausted through air inlets around the periphery of the fuel pool. Air is discharged by two 100 percent capacity centrifugal fans to the atmosphere through a prefilter and HEPA filter bank.

Air exhaust from the lower areas is passed through a prefilter and HEPA filter bank before being discharged by a centrifugal fan to the atmosphere.

TABLE 9.4-7

DESIGN DATA FOR TURBINE BUILDING, FUEL POOL, AND DIESEL GENERATOR BUILDING HEATING AND VENTILATION SYSTEM COMPONENTS

1. Turbine Building Air Exhaust System

Switchgear Room	
Number of fans installed (HVE-18 & 19)	2
Number of fans normally operating	2
Fan capacity, cfm, each	10,000
Fan static pressure, in. wg	0.25
Fan motor HP	1.5
No. of filters	none
Chemical Storage	
Number of fans installed (HVE-20)	1
Number of fans normally operating	1
Fan capacity cfm, each	250
Fan static pressure, in. wg	0.125
Fan motor HP	0.166
No. of filters	none

2. Diesel Genenerator Building Air Exhaust Systems (data given is identical for both rooms)

Number of fans installed (RV-5 & 6)	1
Number of fans normally generating	none
Fan capacity, cfm	5000
Fan static pressure, in. wg	0
Fan motor HP	0.5
No. of filters	none

TABLE 9.4-7 (cont'd)

3. Heating and Ventilation Room Air Exhaust System

Number of fans installed (HVE-17)	1
Number of fans normally operating	1
Fan capacity, cfm	2500
Fan static pressure, in. wg	0.33
Fan motor HP	0.5
No. of filters	none

4. Fuel Pool Air Supply System

	Fuel Pool Area (HVS-6)	Lower Area (HVS-7)
Number of fans sections installed (HVS-6 & 7)	1	1
Number of fans normally running	1	1
Fan capacity, cfm	9800	8300
External static pressure, in. wg	1	0.75
Fan motor HP	5	5
No. of filters	6	6

5. Fuel Pool Air Exhaust System

Number of fans installed (HVE-16A & B, HVE-15)	2	1
Number of fans normally running	1	1
Fan capacity, cfm	10,000	8,100
Fan static pressure, in. wg	5	4
Fan motor HP	15	7.5
No. of prefilters	9	9
No. of HEPA filters	9	9

Radiological considerations of system operation are discussed in Sections 11.1.2.4 and 12.2.2.5.

The sole system instrumentation function is to alert the control room on fuel pool air exhaust fan low flow.

The fuel pool air exhaust fans are controlled manually from the control room. The fan inlet dampers are opened and closed on the same control signal as the exhaust fans. These dampers are air operated and fail closed on loss of power or compressed air.

The fuel pool air supply fan is controlled from a local switch with fan status lights provided in the control room. The operation of the supply fan is interlocked with the operation of the fuel pool exhaust fans.

Fuel handling building air temperature is thermostatically kept at a minimum of 60 F. Flow to the steam coils in the air intake system is controlled by operation of the steam flow valves in the supply system inlets. These valves can be manually controlled by a local switch.

Preoperational tests are performed on the system to ensure meeting performance and design basis requirments. This system is in service during normal plant operation and so is monitored continuously through its performance.

9.4.7 DIESEL GENERATOR BUILDING VENTILATION SYSTEM

The diesel generator building ventilation system is designed to provide ambient conditions suitable for occupancy when the emergency generators are not in operation. A power roof ventilator located in each room is sized(5000 cfm) for four air changes per hour. The system serves no safety function since it is not required for operation of the emergency generators. When the diesel generators are in operation, the fans serving the engine cooling system radiators also provide ventilation air flow through the building.

There are no automatically controlled valves in this system. There is only one piece of equipment to be controlled, the power roof ventilator, and it is actuated manually from a local switch.

9.4.8 CONTAINMENT VESSEL VENTILATION SYSTEM

The major ventilation systems located inside the containment vessel are listed below. Each system is designated according to the scheme used for identification purposes as shown on the P&I diagram, Figure 9.4-3.

Scheme	System
A	Containment Purge System
B	Containment Vacuum Relief
C	Containment Fan Coolers
D	Airborne Radioactive Removal Units
E	Reactor Support Cooling System
F	CEDM Cooling System
G	Reactor Cavity Cooling System
H	Hydrogen Purge System

A system closely related to the containment vessel ventilation systems is Scheme I, the shield building ventilation system (Section 6.2.3).

Schemes A and D are designed to limit doses to plant personnel and are discussed in Section 12.2. The remaining schemes with the exception of E and G are discussed in Section 6.2.

The system flow diagram is shown on Figure 9.4-1 and design data for schemes E and G are given in Table 9.4-8.

9.4.8.1 Reactor Cavity Cooling System

The reactor cavity cooling system is designed to ventilate the annular space between the reactor vessel and the concrete primary shield wall to a maximum of 150F. The purpose of the cooling system is to limit thermal growth of the supporting steel work and minimize the possibility of concrete dehydration and consequent faulting. The system also cools the reactor vessel insulation.

Basic components consist of two axial fans, each sized for 100 percent capacity, and a ducted air supply system. Cooled air is drawn from the fan cooler ring header and directed into the annular space formed between the reactor vessel and the primary shield wall.

During normal operation only one fan is operated while the other acts as a standby. Each fan can be started manually from the control room. An air flow switch in the discharge of each fan annunciates on low flow after a 10 second time delay.

TABLE 9.4-8

DESIGN DATA FOR REACTOR SUPPORT COOLING SYSTEM
AND REACTOR CAVITY COOLING SYSTEM

1. Reactor Support Cooling System

Number of fans installed (HVE-3A & 3B)	2, one standby
Number of fans normally operating	1
Fan capacity, cfm, each	9000
Fan static pressure, in. wg	9
Fan motor HP	20

2. Reactor Cavity Cooling System

Number of fans installed (HVS-2A & 2B)	2, one standby
Number of fans normally operating	1
Fan capacity, cfm, each	20,000
Fan static pressure, in. wg	1.5
Fan motor HP	10

Ambient temperatures are recorded from two locations 180^{o} apart and alarmed at 150F.

All system components are suitable for operation in 120F ambient and 1 rad/hr radiation dose rate environments.

9.4.8.2 Reactor Support Cooling System

The purpose of the reactor support cooling system (in conjunction with the reactor cavity cooling system) is to limit the temperature of the supporting steelwork to 150F, thus restricting thermal growth. The system is designed to restrict heat transfer from the reactor vessel at 600F to the supporting steelwork at 150F.

The basic system components consist of two centrifugal fans, each sized for 100 percent capacity plus the distribution ductwork. Air is drawn from the space at approximately 120F and directed to the steelwork requirig cooling.

During normal operation, one fan is run at a time, while the other acts as a standby. Each fan is started manually from the control room. An air flow switch in the discharge of each fan annunciates an alarm on low flow after a 10 second time delay.

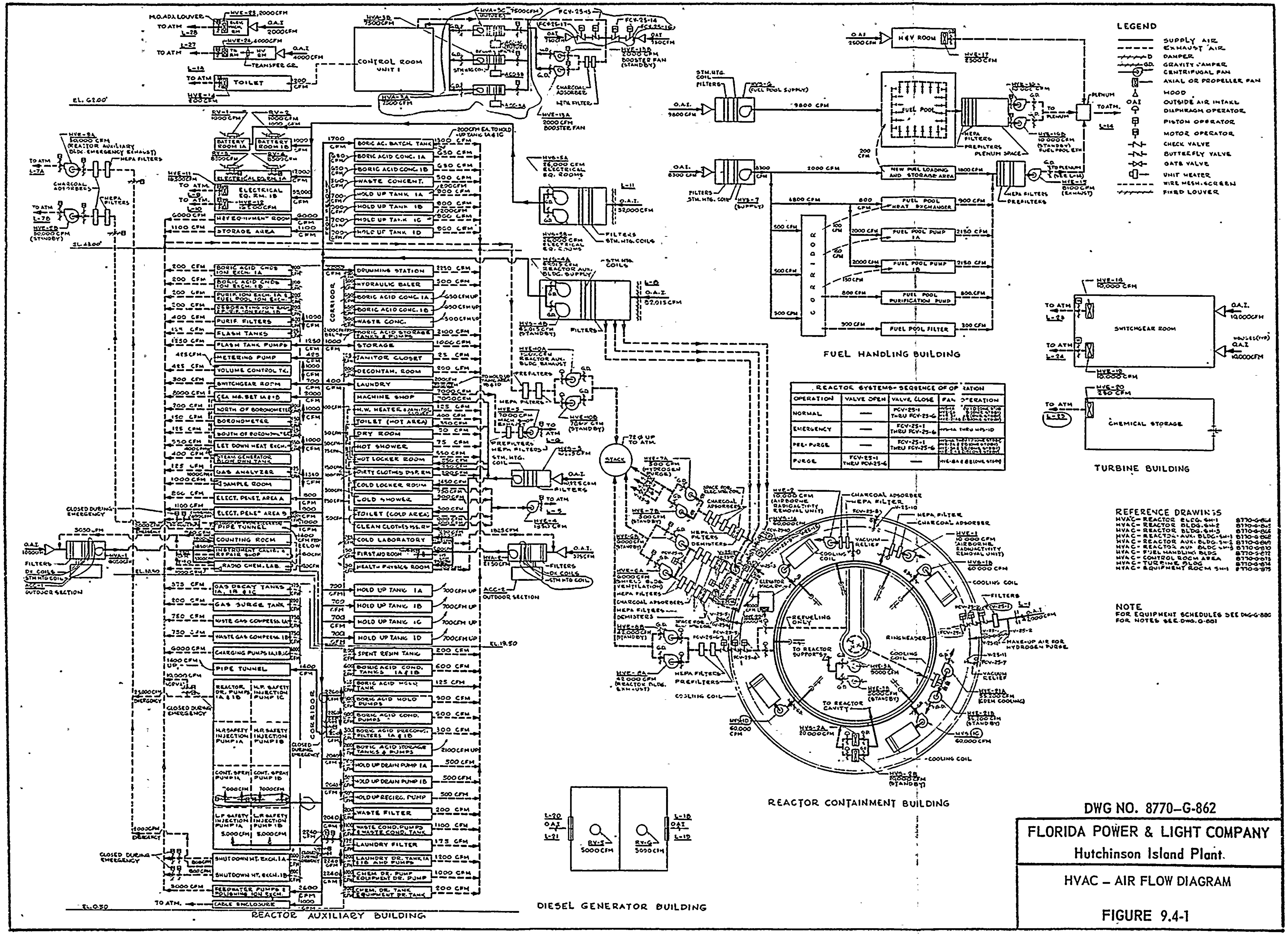
All system components are suitable for operation in 120F ambient and 1 rad/hr radiation dose rate environments.

The temperature of each reactor support is monitored by a temperature recorder and annunciates on temperatures above 200F.

9.4.8.3 Testing and Inspection

Preoperational tests are performed on the systems to ensure that they are capable of meeting performance and design basis requirements.

This system is in service during normal plant operation and system performance is monitored continuously.



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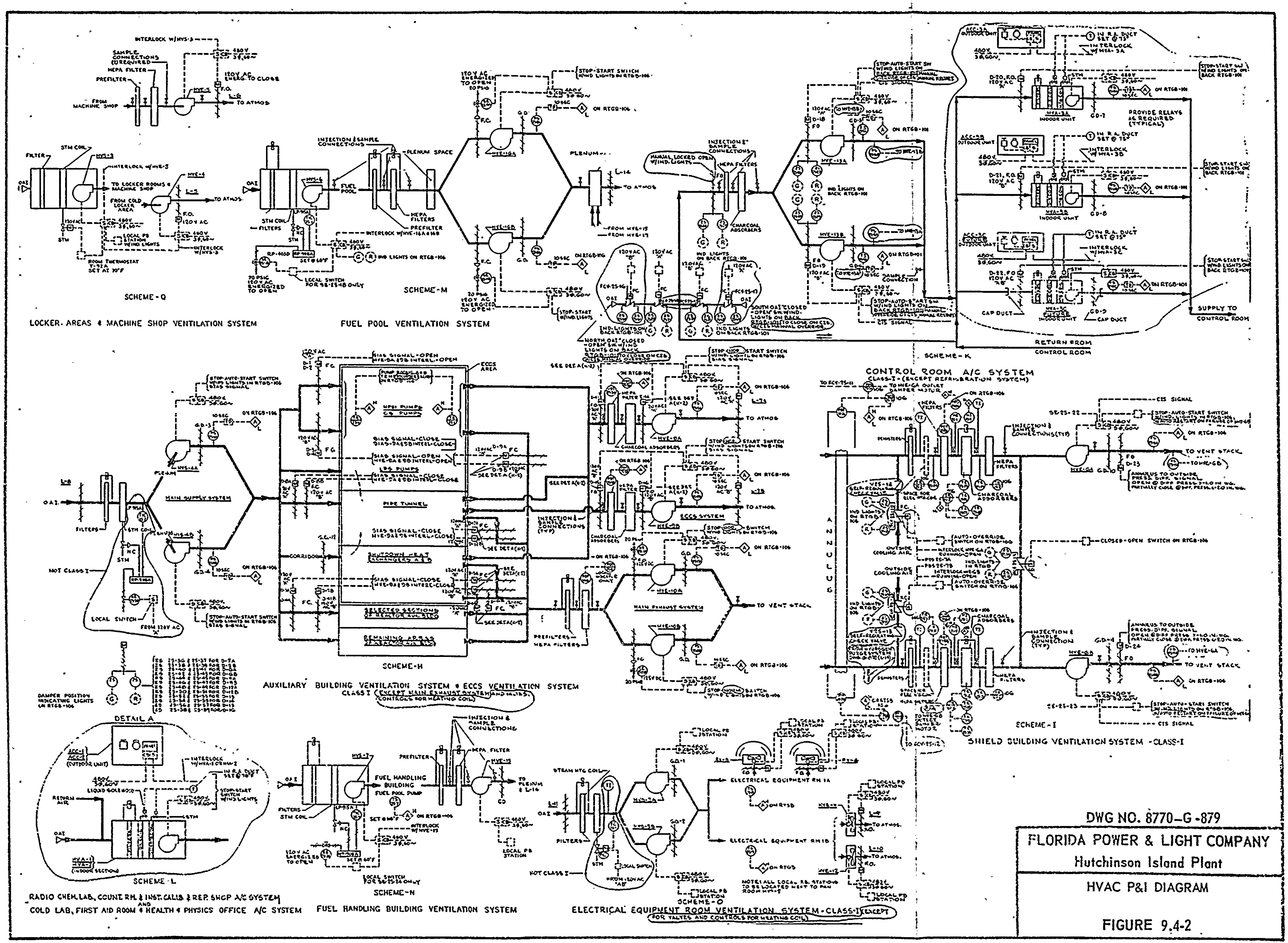
Hutchinson Island Plant

HVAC – AIR FLOW DIAGRAM

FIGURE 9.4-1



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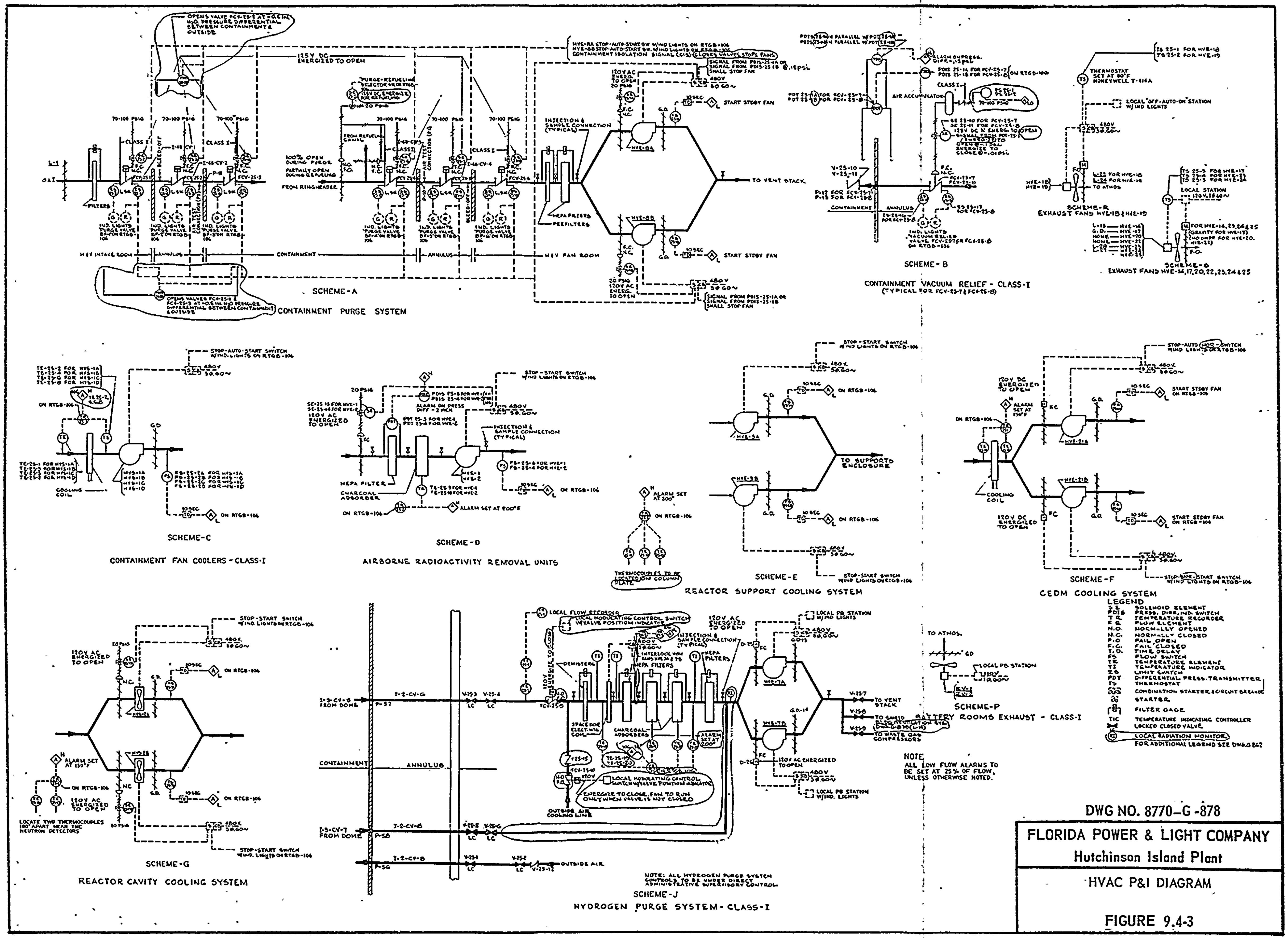
Hutchinson Island Plant

HVAC P&I DIAGRAM

FIGURE 9.4-2



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FLORIDA POWER & LIGHT COMPANY
Hutchinson Island Plant

HVAC P&I DIAGRAM

FIGURE 9.4-3

9.5 OTHER AUXILIARY SYSTEMS

9.5.1 FIRE PROTECTION SYSTEM

9.5.1.1 Design Bases

Equipment and facilities for fire protection, including detection, alarm and extinguishment, are provided to protect plant equipment, structures and personnel from fire or explosion. Both wet and dry types of fire fighting/suppression equipment are provided. Fire prevention is emphasized by using noncombustible and fire resistant materials wherever practical and minimizing the exposure of combustible materials to fire hazards.

The system is designed so that its inadvertent operation does not produce an unsafe plant condition. The system is not designed to withstand design basis earthquake loads; however, its failure does not prevent the proper operation of safety related systems and components.

The fire protection system is designed to comply with the applicable codes and regulations of the State of Florida.

9.5.1.2 System Description

The fire protection system supplies city water to plant fire hydrants, deluge systems and hose racks in the various areas of the plant for fire fighting purposes. The fire water system as illustrated in Figures 9.2-5 and 9.5-1 is comprised of a 12 in. diameter underground fire loop around the plant, with hydrants spaced approximately 200 ft apart. Fire mains and hose reels extend to various locations in the turbine and auxiliary buildings to provide coverage for fighting plant fires. Other fire mains supply water to the deluge systems serving the main, auxiliary and start-up transformers. Post indicator isolation valves for sectionalizing the header increase reliability of fire water supply in case of a fire main break.

The fire protection system, when not operating, is kept pressurized by the domestic water hydropneumatic tank (refer to Section 9.2.5). The tank pressure is maintained in the range of 95 to 125 psig by the domestic water pumps. If the transformer deluge system or a fire hose is actuated causing system pressure to decrease, both fire pumps starts automatically when header pressure drops to 85 psig. The two motor driven fire pumps draw suction from two city water storage tanks (500,000 gallons each) and discharge into the fire loop. A 500 gpm fire pump (portable, gasoline engine) is also provided.

Readily accessible 1-1/2 inch hose lines and continuous flow type hose reels are distributed throughout the plant except within the containment and the new and spent fuel storage area, so that all areas are within reach of a fog nozzle when attached to not more than 75 foot lengths of hose. Portable chemical fire extinguishers are provided at key locations including the control room, new fuel storage area, cable and relay room, and containment areas. The extinguishing media utilized are pressurized water, CO_2 and dry chemicals as appropriate for the service requirements of the area. The electrical transformers located in the transformer yard are suitably spaced from one another or separated by masonry walls as are the main unit transformers. All transformers except the auxiliary transformers have heat sensors which activate their respective deluge systems. A local panel contains the alarms from the fire detection monitoring system. All local alarms are annunciated in the control room.

The fire protection system also provides water from the fire main for insulator washing.

Design data for components in the fire protection system are given in Table 9.5-1.

9.5.1.3 . <u>System Evaluation</u>

The plant fire protection system is designed such that failure of any component of the system will not cause an accident or significant release of radioactivity to the environment and will not impair the ability of redundant equipment to safely shutdown and isolate the reactor or limit release of radioactivity to the environment in the event of a postulated accident.

Compartments containing only electrical equipment do not contain fire lines. Portable extinguishers are located in or adjacent to these compartments and throughout the plant to combat electrical fires.

Fire protection lines are not in areas which house safety related equipment such as the engineered safety features pump room. Floor drains to these rooms are routed to sumps in the auxiliary building where accumulated water is pumped to the floor drain tanks. The sumps are provided with high level alarms. Should the sump pumps be unable to prevent rising level due to flooding, the alarms allow for corrective action by the operator.

Electric motors for Class I equipment are drip proof and electrical controls are contained in weatherproof, drip proof enclosures which prevent damage from water impingement.

Since the fire protection system and reactor auxiliary building are designed to prevent flooding of redundant safety related equipment in the event of fire line damage, the system is not designed to seismic Class I standards. The floor drain sump level alarm instrumentation is seismic Class I.

Two 100 percent capacity motor driven fire pumps with minimum recirculation lines to prevent pump overheating are provided. The two 2500 gpm motor driven fire pumps are connected to separate electrical power buses. If a loss of off-site power occurs, the buses can be manually connected to the emergency diesel generator sets. Additional backup is provided by a 500 gpm portable gasoline engine driven fire pump.

Low header pressure alarms are provided in the control room.

The use of the hydropneumatic tank for small makeup and the maintenance of a system pressure helps prevent frequent starting of the motor driven pumps.

TABLE 9.5-1

DESIGN DATA FOR FIRE PROTECTION SYSTEM COMPONENTS

1. Fire Pump, Electrically Driven

Type	Horizontal centrifugal
Number	2
Capacity, gpm	2,500
Discharge pressure, psig	125
Material:	
Discharge head	Cast iron
Impeller	Bronze
Motor	250 HP/460 Volts/3 Phase/60 hz
Codes	Motor: NEMA Pump: Standards of the Hydraulic Institute and NFPA

2. Fire Pump Gasoline Engine-Driven

Type	Horizontal centrifugal
Number	1
Capacity, gpm	500
Discharge pressure, psig	125
Material:	
Discharge head	Cast iron
Impeller	Bronze
Codes	Pump: Standards of the Hydraulic Institute and NFPA
Engine HP (Continuous)	85

3. Domestic Water Pump

Type	Horizontal centrifugal
Number	2
Capacity, gpm	350
Discharge pressure, psig	125
Material:	
Discharge head	Ductile iron
Impeller	Cast iron
Motor	50 HP/460 Volts/3 Phase/60 hz
Codes	Motor: NEMA Pump: Standards of the Hydraulic Institute

TABLE 9.5-1(Continued)

4. Piping, Fittings And Valves

	UNDERGROUND	ABOVEGROUND
Material	Cast iron	Carbon steel
Design pressure, psig	200	200
Design temperature, F	110	110
Construction	Mechanical joint	Welded & screwed
Valves	Cast iron	Cast iron
	Mechanical joint	Flanged
	175 psi	175 psi
	U. L. label	U. L. label

5. Hydropneumatic Tank

Material	Carbon steel
Capacity, gallons	3000
Length	19' - 5"
Diameter	6' - 0
Design pressure, lb	200
Design temp, F	150
Code	ASME Section VIII

9.5.1.4 Testing and Inspection

The fire protection system is provided with test hose valves for periodic testing. All equipment is accessible for periodic inspection.

All pumping equipment is shop tested to assure that specifications are met.

The systems are operated and tested initially with regard to flow path, transfer capability and mechanical operability. The transfer capability will be tested periodically.

9.5.1.5 Instrumentation Application

The parameters used to monitor and control the fire protection system are listed in Table 9.5-2.

The system fire pumps are started automatically by low pressure signals as indicated on Table 9.5-2. Once started, the pumps continue to operate until they are shut down manually.

The domestic water pumps are controlled by level signals from the city water storage tank. These pumps can also be started and stopped locally.

The only automatically operated valves in the fire protection system are those used for transformer deluge.

TABLE 9.5-2

FIRE PROTECTION SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication		Alarm (1)		(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Domestic Water Pump Outlet Pressure	*						0-200psig	125 psig	± 0.5%
Hydropneumatic Tank									
1) Pressure (2)	*			*			0-200 psig	95-125 psig	± 0.5%
2) Level	*					Control domestic water pump operation via low, low-low & high level signals	Sight glass	1-2.5 ft above bottom	-
Fire Pump									
1) Suction pressure	*						0-20 psig	8.2 psig	± 1.0%
2) Outlet discharge pressure	*						0-200 psig	125 psig	± 1.0%
Transformer									
1) Deluge system pressure						Start fire pump when pressure drops to 85 psig	0-200 psig	125 psig	± 1.0%
2) Temperature (3)						Start transformer deluge	-	-	-
Diesel Generator Building									
1) Temperature (4)							-	95F	-

(1) All alarms and recordings are in the control room unless otherwise indicated.

(2) Alarm located at water treatment panel.

(3) For all tranformers in transformer yard except auxiliary transformer.

(4) Local building alarm.

9.5.2 COMMUNICATIONS SYSTEMS

9.5.2.1 Design Bases

The communications systems are designed to assure reliable and diverse intraplant communications and outside telephone service for normal operation and emergency conditions.

9.5.2.2 System Description

9.5.2.2.1 Intraplant Communications

Intraplant communications facilities are as follows:

a) A low level intraplant paging and communication (PA) system with two independent communications channels, one page and one party.

   The PA system is composed of handset stations, speakers (horn and cone type), speaker amplifiers, and associated cabling and hardware all mounted in suitable enclosures and located throughout the plant to provide full plant coverage.

b) A sound powered communications system for operating, testing, and maintenance purposes.

   The sound powered communications system consists of headsets, remote jack stations, central monitoring station and patchboard, together with associated cabling/wiring and hardware. Jack stations are located to facilitate periodic testing and maintenance of equipment.

   The sound powered communication system requires no external power. The power necessary for communication is derived from the spoken voice.

c) An interoffice communications system with a private automatic exchange (PAX) system for telephone and code calling communications.

   The PAX system consists of a central switching unit and supporting equipment together with associated cabling/wiring, telephone sets, code call chimes, horns, lights, and switching devices all mounted in enclosures located throughout the plant and offices.

d) Radiation and fire alarms are incorporated into the PAX system. Each alarm is a distinct signal generated from a different tone generator, and is initiated by operator action. The signals are applied to horns located throughout the station.

9.5.2.2.2 External Communications

Ten Bell Telephone System lines plus two additional lines for telemetering, load control and supervisory control, are provided for external communications via phones located in the control room and service building.

In the event of complete loss of all plant telephone service, a telephone line is provided for voice communication between the plant control and the System Load Dispatch Office. This is in addition to the normal plant telephone service.

As back-up to the telephone lines, a two-way radio facility (operating on 37.7 megahertz) is maintained between the control room and Florida Power & Light Company's Riviera Plant which maintains radio and telephone contact with the System Load Dispatch Office. The System Load Dispatch Office has direct telephone lines and either patched, or indirect radio contact with all plants and radio equipped vehicles in the Florida Power & Light Company System. The emergency power supply for the two-way radio is from the 120 volt ac vital instrument power system described in Section 8.3.1.1.6.

9.5.2.3 System Evaluation

Communication facilities of the types described are conventional and have a history of reliable operation at Florida Power & Light Company Plants.

The availability of the PA and PAX systems is assured by powering the systems from the vital ac bus which has three alternate supplies:

a) inverter, fed from an emergency MCC

b) voltage regulating transformer, fed from emergency MCC

c) dc power from station battery

In the event of a loss of the normal off-site power sources, the communications system will remain operable since it can be powered from the station batteries. The diverse means of communications available ensure that no single active failure will prevent operation of the communications system. The PA, PAX and sound powered communication systems interconnecting cable is segregated to prevent common mode failure.

9.5.2.4 Testing and Inspection

Most of the communication systems are in routine use and this provides a check of their continued availability. Those systems not frequently used will be tested at periodic intervals to assure operability when required.

9.5.3 LIGHTING SYSTEMS

There are two lighting systems, the normal ac system and the emergency dc system. The normal ac lighting system is designed to provide indoor illumination levels in accordance with recommended levels published in the Illuminating Engineering Society Handbook (4th Edition). The normal ac system also provides outdoor lighting levels for orderly maintenance of plant equipment and for surveillance of the plant exclusion area. All indoor lighting is fluorescent except in the containment and fuel pool area where incandescent fixtures are used. The housing for the fixtures inside the containment are made of ferrous or brass material.

The outdoor lighting is provided by high intensity mercury discharge lights controlled by a photo-electric cell. A control room selector switch allows manual or photo-electric operation of the lighting. Specific outdoor lighting (e.g. doorway lighting) is locally switched.

The essential ac lighting consists of two (A and B) physically and electrically separate systems. Either of these two systems will provide the necessary indoor and outdoor lighting, to allow orderly maintenance and continuance of plant operation. Section 8.3.1 gives a detailed description of the on-site power system.

Upon failure of off-site power, the essential lighting circuits are powered by the diesel generator sets through the emergency portion of the auxiliary bus. The building egress areas are part of the essential lighting system. In the case where neither the A or B emergency system is operating (as during the time between loss of off-site power and the assumption of the lighting load by the diesel generator sets) there are battery packs which supply an additional backup source. These packs provide four hours of additional lighting with complete loss of ac power.

The control room is supplied with emergency dc lighting. There are two physically and electrically separate A and B systems energized from separate station batteries through separate conduits, fixtures and panels. Section 8.3.2 discusses the dc power system in detail. The lighting system is automatically energized by fail closed relays located within the control room.

Lighting supports inside the control room have been designed as seismic Class I.

9.5.4 DIESEL GENERATOR FUEL OIL SYSTEM

9.5.4.1 Design Bases

The diesel generator fuel oil system is designed to:

a) provide oil storage capacity for at least seven days full load operation of one emergency diesel generator set

b) maintain fuel supply to at least one diesel generator set, assuming a single active or passive failure

c) withstand design basis earthquake loads without loss of function

d) withstand maximum flood levels and tornado wind loading without loss of function

9.5.4.2 System Description

The diesel fuel oil system is shown in Figure 9.5-2 and design data is found in Table 9.5-3.

The diesel generator fuel oil system is used to transfer diesel fuel oil from the on-site storage tanks to the day tanks which supply the emergency diesel generator sets.

Two completely redundant subsystems are provided, each consisting of a diesel oil storage tank, transfer pump, day tank, interconnecting piping and valves and associated instrumentation and controls. Subsystem A serves diesel generator 1A and subsystem B serves diesel generator 1B. All electrical power necessary for operation of each subsystem is supplied from the associated diesel generator bus.

The main components of the system are the following:

a) Day tanks - Two tanks in each redundant system are interconnected to provide a total of 400 gallons of fuel to each diesel generator set. The tanks have capacity for two full hours of full power operation of the diesel generator set.

b) Diesel oil storage tank - Tanks (20,000 gallons each) are provided in the system. Both diesel generator sets can operate for four days on 40,000 gallons. One set can operate for eight days on this same amount.

c) Fuel oil transfer pump - One 25 gpm pump in each system to transfer oil from the storage to the day tanks.

d) Interconnecting piping and valves - Cross connection lines with locked closed valves are provided for transferring oil between the redundant systems. The cross connection lines are provided at both the pump suction and discharge.

The diesel fuel oil system is located on an outdoor platform except for the day tank and its associated instrumentation. The diesel oil transfer pumps are located above the maximum flood level to ensure their operation during floods.

TABLE 9.5-3

DESIGN DATA FOR DIESEL GENERATOR FUEL OIL SYSTEM

1.	Material	Carbon Steel
2.	Pressure, psig	
	Suction	50
	Discharge	100
3.	Temperature, F	
	Suction	120
	Discharge	120
4.	Pipe sizes	
	2½ inches and over	Schedule 40
	2 inches and under	Schedule 40
5.	Connections	
	2½ inches and larger	Butt weld
	2 inches and smaller	Socket weld
6.	Valves	
	2½ inches and larger	Butt weld and/or flanged
	2 inches and smaller	Socket welded
7.	Code	ANSI B 31.7 Class III

9.5.4.3 System Evaluation

The design of the diesel generator fuel oil systems provides electrical and physical separation of components to assure that the system can withstand a single active failure. The pumps, tanks and other equipment in the system are designed for seismic Class I service. The equipment is designed to withstand the normal outdoor conditions of heat, humidity, and salt spray prevalent at the site. The system can also withstand tornado winds of 360 mph. The redundant fuel oil systems are far enough apart to prevent simultaneous damage by a single missile.

9.5.4.4 Testing and Inspection

The components are inspected and cleaned prior to installation into 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 plant preoperational testing. Automatic actuation of system components is tested periodically in accordance with Section 16.4.8 of the Technical Specifications.

9.5.4.5 Instrumentation Application

Table 9.5-4 lists the measured parameters for monitoring the performance of the diesel generator fuel oil system.

Each diesel oil transfer pump has its own STOP/AUTO/RUN selector switch. Each pump is controlled by the level of its corresponding day tanks. The transfer pump is stopped on a high level signal whether it is operating in the automatic or manual (run) mode. If the pump is in the manual mode and is stopped by the level switch, the signal can be overridden by putting the pump in the automatic mode. This override capability permits manual transfer of fuel oil to either tank through each pump.

TABLE 9.5-4

DIESEL GENERATOR FUEL OIL SYSTEM INSTRUMENTATION APPLICATION

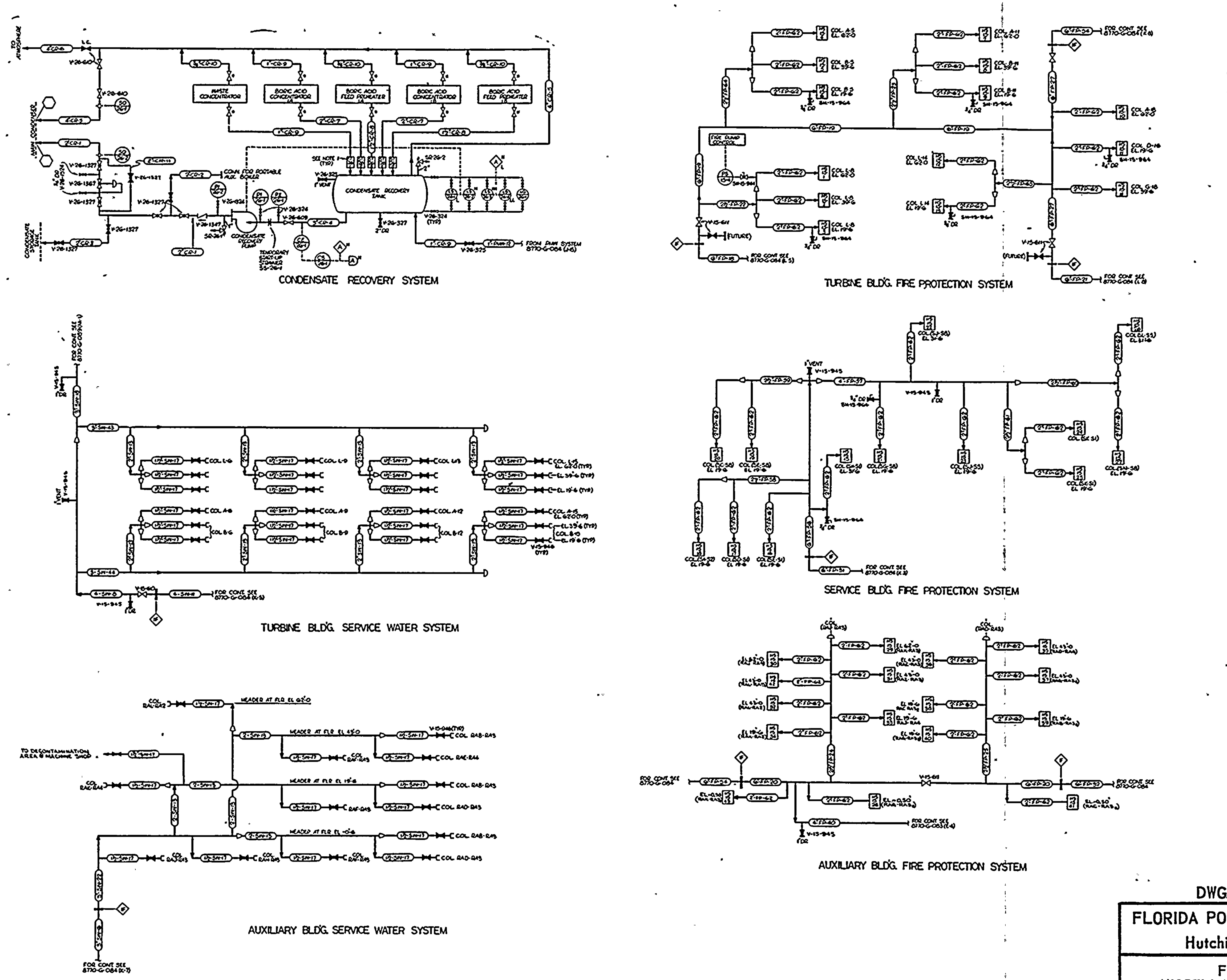
System Parameter & Location	Indication		Alarm (1)		(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
	Local	Control Room	High	Low					
Diesel Oil Storage Tank Level (2)	*			*			0-20ft	Full-4 ft Full-50%	±3.0%
Day Tank Level (3)	*		*	*		1) Control operation of diesel oil transfer pump 2) Stop pump on high level when pump is in manual mode (4)	0-100%	Full	±3.0%

(1) All alarms and recordings are in the control room unless otherwise indicated.

(2) Local alarms only.

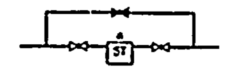
(3) Local alarm and control from diesel generator panel alarm to control room.

(4) This "stop" can be overridden by switching pump to "automatic" mode.



NOTES:

1) THE SYMBOL ST REPRESENTS THE TRAP ARRANGEMENT SHOWN BELOW.



TRAP NO'S	VALVE NO'S	LINE NO'S
ST-26-1	V-26-325	1"-CR-9
ST-26-2	V-26-327	2"-CR-7
ST-26-3	V-26-326	1½"-CR-8
ST-26-4	V-26-327	2"-CR-7
ST-26-5	V-26-326	1½"-CR-8

REFERENCE DRAWINGS

LIST OF DRAWINGS	8770-A-446
INSTRUMENT LIST AND PIPE VALVES & INSTRUMENT SYMBOLS	8770-B-270
VALVE LIST	8770-B-051
LINE LIST	8770-B-052

- • SUPPLIED BY OTHERS
- ⬡ CONDENSER NOZZLE NO. SEE DWG. 8770-304
- HS HOSE STATION (BY FIELD)
- IF INSULATING FLANGE

ALL COMPONENTS ARE QUALITY GROUP D

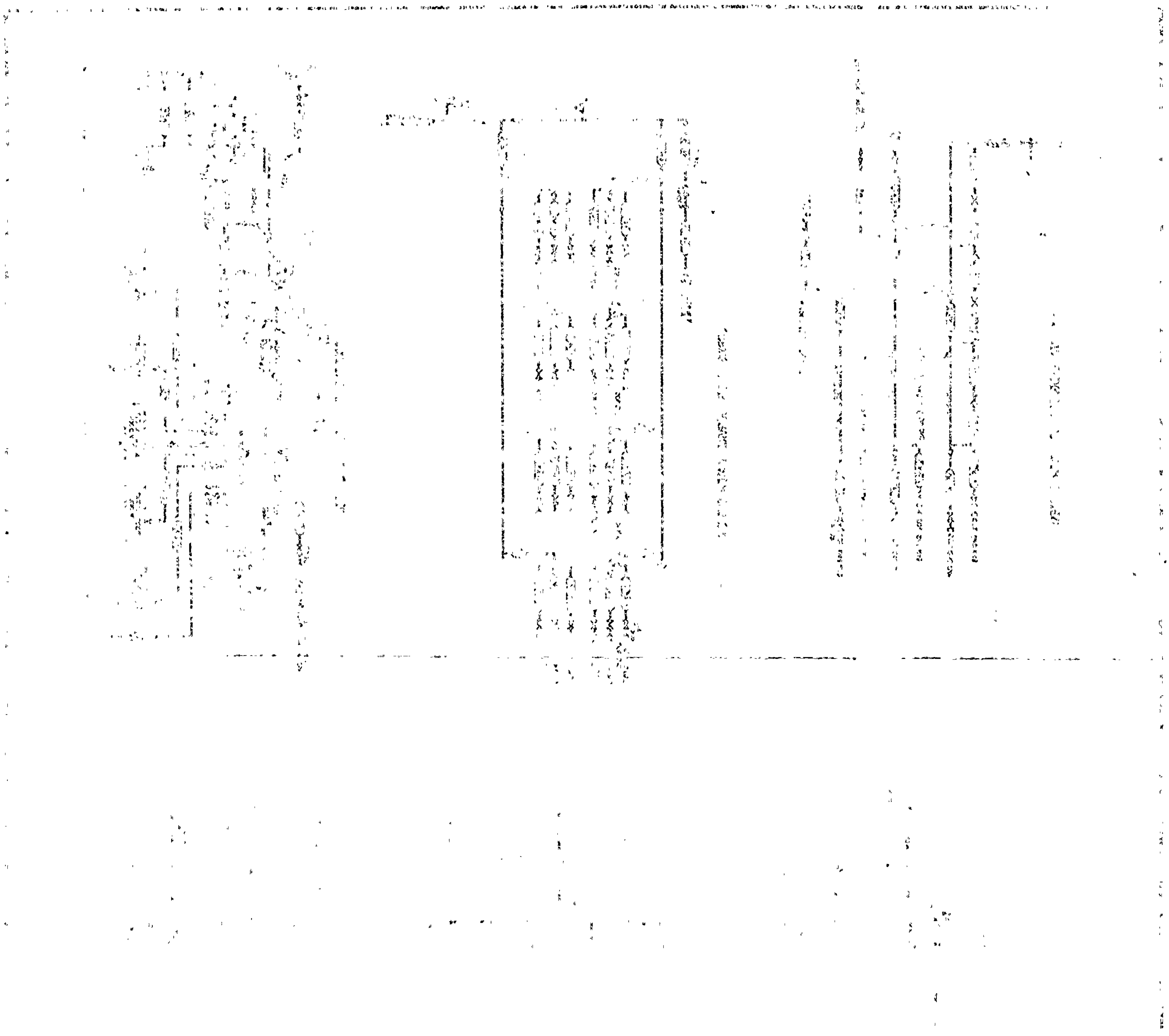
DWG. NO. 8770-G-087

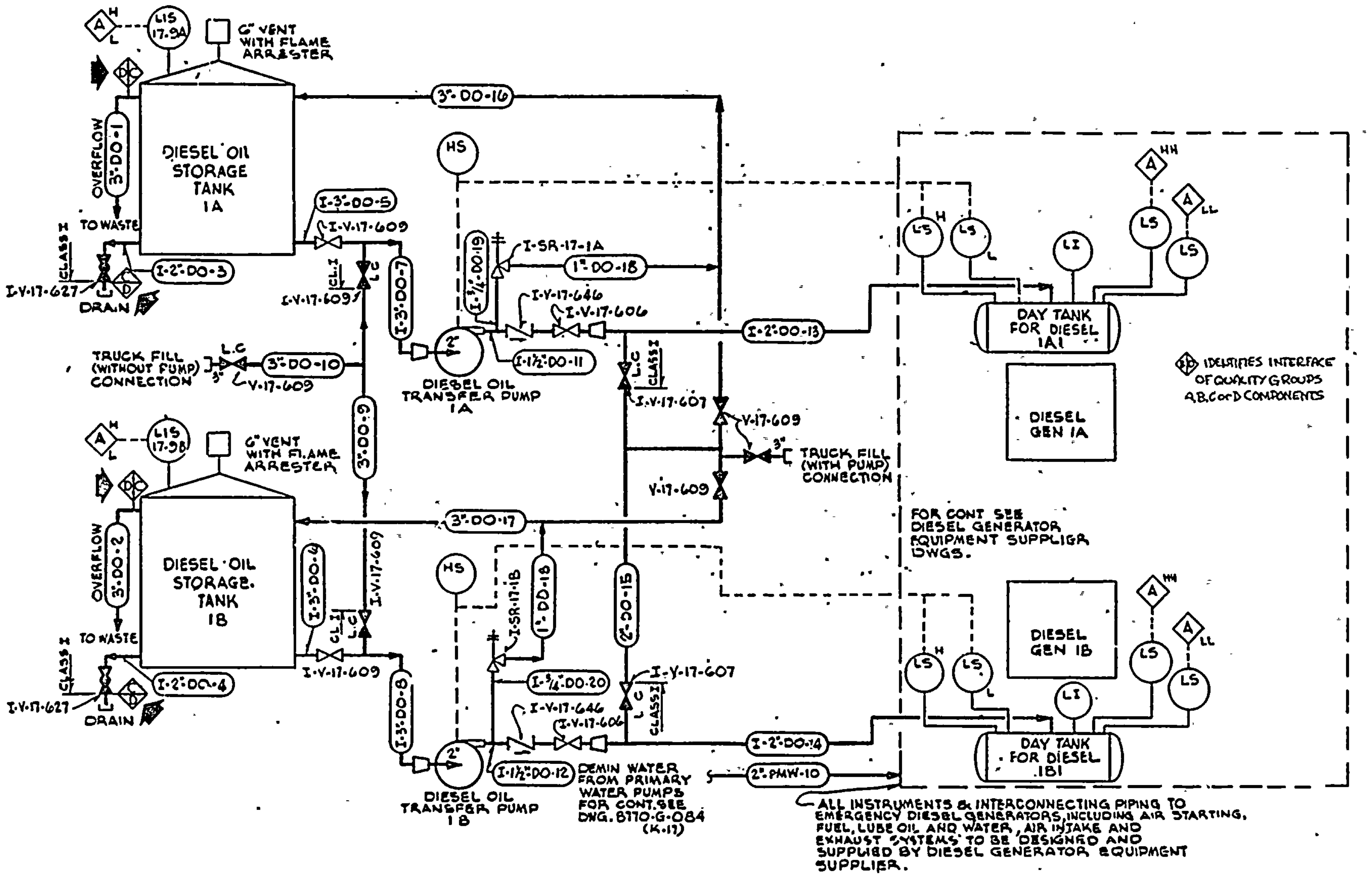
FLORIDA POWER & LIGHT COMPANY

Hutchinson Island Plant

FLOW DIAGRAM
MISCELLANEOUS SYSTEMS SH. 2

FIGURE 9.5-1.





DWG. NO. 8770-G-086

IDENTIFIES INTERFACE OF QUALITY GROUP A, B, C OR D COMPONENTS.

FLORIDA POWER & LIGHT COMPANY
Hutchinson Island Plant

DIESEL GENERATOR FUEL OIL P&I DIAGRAM

FIGURE 9.5-2

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CHAPTER 10

STEAM AND POWER CONVERSION SYSTEM

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CHAPTER 10

STEAM AND POWER CONVERSION SYSTEM

10.1 SUMMARY DESCRIPTION

The steam and power conversion system is designed to convert thermal energy in the form of steam, as produced in the two steam generators, into electrical energy by means of a regenerative cycle turbine-generator. The turbine consists of a high pressure turbine element, four moisture-separator/reheater assemblies, and two low pressure turbine elements all aligned in tandem. After expanding in the turbine, the steam is consed in the main condenser and the energy which is unusable in the thermal cycle is rejected to the circulating water system. The condensate is collected in a hotwell. Noncondensible gases in the steam are removed by the steam jet air ejectors. The condensate is returned to the steam generators by means of two condensate pumps and two steam generator feedwater pumps. The feedwater passes through five stages of heat exchangers (i.e., high and low pressure heaters) arranged in two parallel trains where it is heated by steam extracted from various stages of the turbine. The drains from the first three stages of low pressure heaters are eventually cascaded back to the condenser hotwell, and the drains from the fourth stage low pressure heaters and the fifth stage high pressure heaters are returned to the feedwater system by two heater drain pumps. Heat produced in the reactor core is transferred from the reactor coolant to the water in the steam generators producing steam for use in the turbine. In the event of a turbine trip, the heat transferred from the reactor coolant to the steam generators is dissipated through the steam dump and bypass system to the condenser and/or through the atmospheric dump valves.

Safety related features of the steam and power conversion system include steam line isolation and auxiliary feedwater supply. These features are discussed in Section 10.3 and 10.5, respectively.

Design data as well as design codes applied to system components are given in Table 10.1-1. The system P&I diagrams are shown on Figures 10.1-1, 2 and 3.

TABLE 10.1-1

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

1. Turbine-Generator	
a. Turbine	
Throttle flow, max. guaranteed, lb/hr	10,446,749
Throttle flow, max. calculated, lb/hr	10,971,649
Throttle pressure (rating/VWO)*, psia	765/765
Steam moisture, max., percent	0.40
KW @ rating, KW	841,926
KW @ VWO, max. calculated, KW	876,543
Turbine back-pressure, in. Hg abs	3.2
No. of extractions	5
b. Generator	
Rating, KVA	1,000,000
Power factor	0.85
Voltage, volts	22,000
Frequency/Phase, Hz	60/3
Hydrogen pressure, psig	60
2. Main Feedwater Pumps	
Type	two-stage centrifugal, horizontally split case, single suction, double volute
Quantity	2
Capacity each, gpm	14,100
Head, feet	1,780
Design fluid temperature, F	380

*VWO - valve wide open

TABLE 10.1-1 (continued)

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

Material		
Case	11-13 Cr Steel	
Impeller	ASTM A-296, Gr CA 15	
Shaft	ASTM A-276, Type 410 HT	
Driver	Constant Speed, 3-ph, 60 cycle, Electric Motor, 7000 hp, 3560 rpm, 6600 v, 1.15 S.F.	
Codes	ASME Section VIII through Summer 1969 addenda	
3. Auxiliary Feedwater Pumps	Motor Driven	Steam Trubine Driven
Type	Single suction, horizontal, split, double volute, horizontal centrifugal	
Stages	9	8
Quantity	2	1
Capacity each, gpm	*325	**600
Head, feet	2660	2660
Design fluid temperature, F	120	120

S.F. - service factor

* includes minimum recirculation flow of 75 gpm

** includes minimum recirculation flow of 100 gpm

TABLE 10.1-1 (continued)

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

	Motor Driven	Turbine Driven
Material		
Case	ASTM-351-52-T Gr CF8	ASTM-351-52-T Gr CF8
Impeller	ASTM A-296, Gr CA 15	ASTM A-296, Gr CA 15
Shaft	ASTM A-276, Type 410 HT	ASTM A-276, Type 410 HT
Driver	Constant Speed 3-ph 60 cycle, electric motor, 350 hp, 3570 rpm, 4000 v, 1.15 S.F.	Single stage, non-condensing steam turbine, 575 hp, 2000 to 3600 rpm.
Seismic requirements	Class I	Class I
Codes	ASME Sections III, 1971 class 3.	

4. Condensate Pumps

Type	Vertical centrifugal, 8-stage, can type
Quantity	2
Capacity each, gpm	10,200
Head, feet	1,230
Fluid temperature, F	117.3
Material	
Case	ASTM A-48, C1.30
Impeller	ASTM A-48, C1.30
Shaft	ASTM A-276, 410 HT

TABLE 10.1-1 (continued)

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

	Driver	Constant speed, 3-ph, 60 cycle, electric motor, 4000 hp, 1190 rpm, 4000 v, 1.15 S.F.
	Codes	ASME Sections VIII through Winter 1969 addenda.
5.	Heater Drain Pumps	
	Type	Vertical centrifugal 10-stage can type
	Quantity	2
	Capacity each, gpm	4390 (including minimum recirculation of 140 gpm)
	Head, feet	840
	Fluid temperature, F	320
	Material	
	Case	13-4 Cr-Ni Steel
	Impeller	13-4 Cr-Ni Steel
	Shaft	ASTM A-276, Type 410 HT
	Driver	Constant speed, 3-ph, 60 cycle, electric motor, 1250 hp, 1760 rpm, 4000 v, 1.15 S.F.
	Codes	ASME Sections VIII through Summer 1969 addenda.
6.	Main Condenser	
	Type	Two shell, single pass with divided water boxes, surface condenser

TABLE 10.1-1 (continued)

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

Design duty, Btu/hr	5.850×10^9
Heat transfer area, ft^2	546,000
Design pressure, psig	Shell: 15 psig and 30 in. Hg vacuum Water Box: 25
Condenser Flow, max. guaranteed, lb/hr	7,820,492
Condenser Flow, max. expected, lb/hr	8,212,960
Material	
Shell	ASTM A-285, Gr C
Tubes	ASTM B-111, admiralty brass in main section 70-30 annealed Cu-Ni in air cooler section
Tube Sheets	ASTM B-171
Codes	Heat Exchanger Institute Standards for Steam Surface Condensers 1965

7. Steam Jet Air Ejector

a. Inter-Condenser

Type	single pass
Heat Transfer Area, ft^2	415
Design Pressure	
Tube side, psig	750
Shell side, psig	25
Material	
Shell	ASTM-A285, Gr C
Tubes	316 S.S. ASTM A249
Tube Sheets	316 S.S. ASTM A240

TABLE 10.1-1 (continued)

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

Codes	Heat Exchange Institute Steam Jet Ejector Standard, Third Edition, 1956
b. After-Condenser	
Type	single pass
Heat Transfer Area, ft^2	160
Design Pressure	
Tube side, psig	750
Shell side, psig	25
Material	
Shell	ASTM-A285, Gr C
Tube	316 S.S. (ASTM A249)
Tube Sheets	316 S.S. (ASTM A2490)
Codes	Heat Exchange Institute Steam Jet Ejector Standard, Third Edition, 1956

8. Feedwater Heaters

Heater Numbers	1A&1B,2A&2B,3A&3B	4A&4B	5A&5B
Type	Closed, U-tube	Closed, U-tube	Closed, U-tube
Material			
Shell	ASTM A-515-70	ASTM A-515-70	ASTM A-515-70
Tubes	Admiralty	ASTM B-111 Ann.	ASTM-5B-163
Tube Sheets	ASTM A-105-II	ASTM A-105-II	ASTM A-266-II
Feedwater flow, lb/hr	7,818,000	11,164,100	11,164,100
Codes	ASME Section VIII through summer 1969 addenda; Heat Exchange Institute Standards for Closed Feedwater Heaters, 1968		

TABLE 10.1-1 (continued)

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

9. Drain Coolers

Cooler Numbers	A&B
Type	Straight Tube
Material	
Shell	ASTM A-515-70
Tubes	ASTM SB-111
Tube sheets	ASTM A-105-II
Feedwater flow (lb/hr)	7,818,000
Codes	ASME Section VIII through summer 1969 addenda; Heat Exchange Institute Standards for closed Feedwater Heaters, 1968

Heater No.	Design duty each (Btu/hr)	Design press. (psig) Shell	Tube	Design temp. (F) Shell	Tube	Heat transfer area each (ft^2)
1A,1B	258.2×10^6	50 & V	750	300	300	18,740
2A,2B	165.4×10^6	50 & V	750	300	300	12,695
3A,3B	224.5×10^6	75 & V	750	320	320	12,390
4A,4B	393.2×10^6	300	750	422	422	18,130
5A,5B	331.0×10^6	425	1875	460	460	21,335
Drain Cooler No.						
A,B	127.1×10^6	300	750	422	422	4,710

10. Piping and Valves

a. Piping	Material	Codes
Main Steam*	ASTM A-155, GR KC-65 CL I	ANSI B31,7, CL II, 1969
Main Steam to Auxiliary Feed Pumps	ASTM A-106, GR B	ANSI B31,7, CL III, 1969
Feedwater*	ASTM A-106, CR B	ANSI B31,7, CL II, 1969

TABLE 10.1-1 (continued)

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

Balance of Piping		ANSI B31.1, 1967
Auxiliary Feed Pumps		
Suction-above ground	ASTM A-106, GR B	ANSI B31.7, CL III, 1969
Suction-under ground	TYPE 316 SS	ANSI B31.7, CL III, 1969
Discharge	ASTM A-106, GR B	ANSI B31.7, CL III, 1969

*To first steam isolation valve

b. Main Steam Isolation Valves (I-HCV-08-1A,B)

Type	Stop & check
Quantity	2, 1 per main steam line
Design Pressure, psig	985
Design Temperature, F	550
Materials	
Body & bonnet	ASTM A216, Gr WCB
Steam	ASTM A182, Gr F6
Backseat, seats & discs	ASTM A182, GR F6
Code	ASME Draft Pump and Valve Code, Class II, 1968

c. Main Steam Safety Valves

Refer to Table 5.5-2.

d. Atmospheric Dump Valves (I-V-08-312)

Type	Globe, angle body
Quantity	2, 1 per main steam line
Design Pressure, psig	985
Design Temperature, F	550

TABLE 10.1-1 (continued)

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

Materials	
Body & bonnet	ASTM A216, Gr WCB (carbon steel) ASTM A351, Gr F8 or F8M (stainless steel)
Stem	ASTM A182, Gr F6
Basket, seats & discs	ASTM A182, Gr F6
Code	ASME Draft Pump and Valve Code, Class II, 1968

e. Steam Dump Valves (PCV-8802, 8803, 8804, 8805)

Number	4
Type	Globe
Operator	Pneumatic
Size/Class	10 in., 600 lb ANSI
Materials	
Body	ASTM A-216 Carbon Steel
Bonnet	ASTM A-216 Carbon Steel
Seat, Plug	ASTM A-276, Type CA40
Code	ANSI B16.5-1968

f. Steam Bypass Valve (PCV-8861)

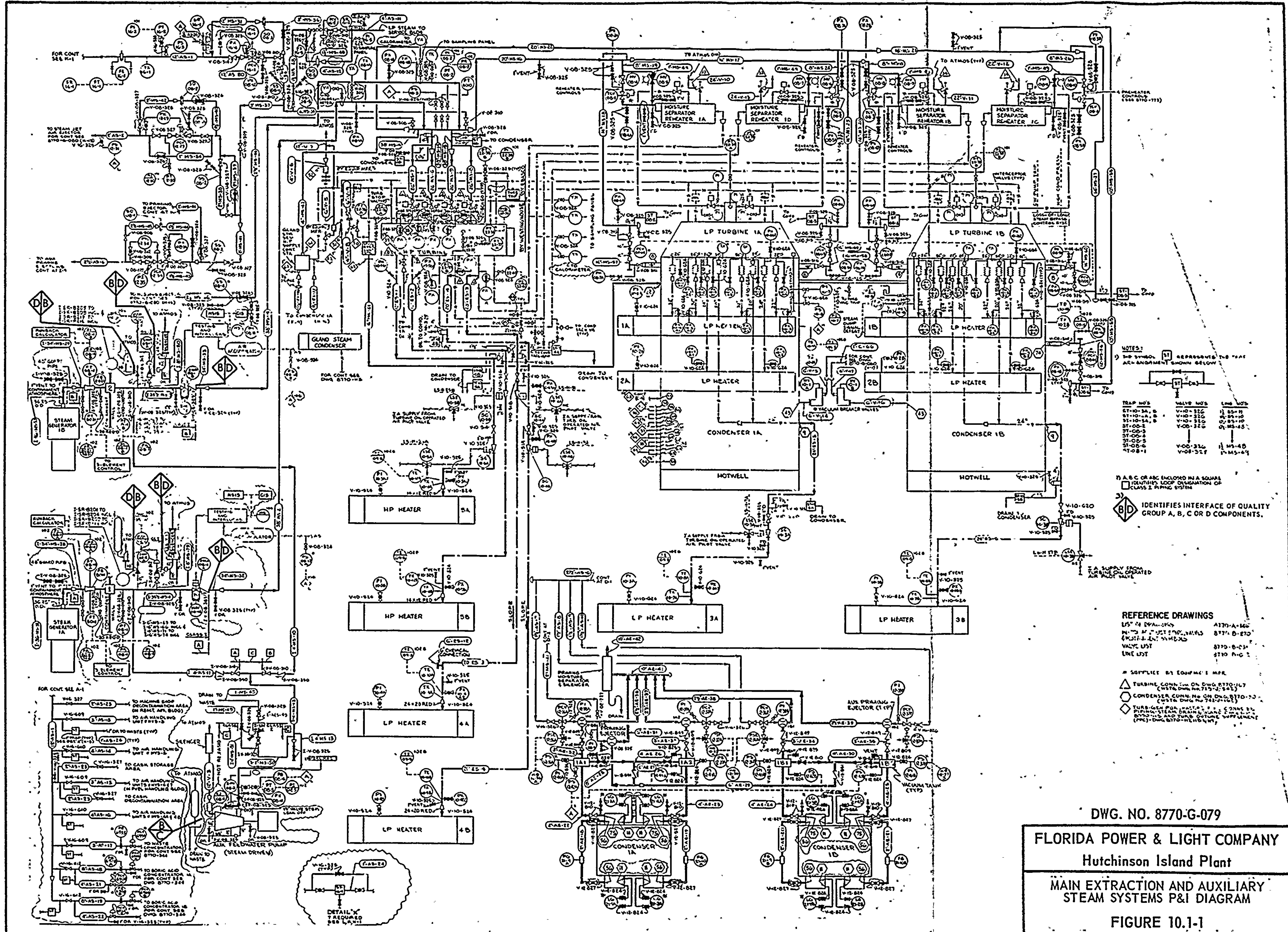
Number	1
Type	Globe
Operator	Pneumatic
Size/Class	8 in., 600 lb ANSI
Materials	
Body Bonnet	ASTM A-216 Carbon Steel
Seat, Plug	ASTM A-296, Type CA40
Code	ANSI B16.5-1968

TABLE 10.1-1 (continued)

DESIGN DATA FOR STEAM AND POWER CONVERSION SYSTEM COMPONENTS

g. Steam Flow Elements (FE-8011, FE-8021)

Number	2
Type	Venturi
Pipe I.D., inches	31.50
Venturi Throat I.D., inches	20.757
Diameter Ratio	0.659
Area Ratio	0.434
Materials	
Pipe	ASTM A-155, Gr Kc-65 Class I
Venturi	ASTM A-240 Tp 304 at Throat ASTM A-515 Gr 55 at inlet & outlet
Code	ANSI B31.7 Class II, 1969



DWG. NO. 8770-G-079

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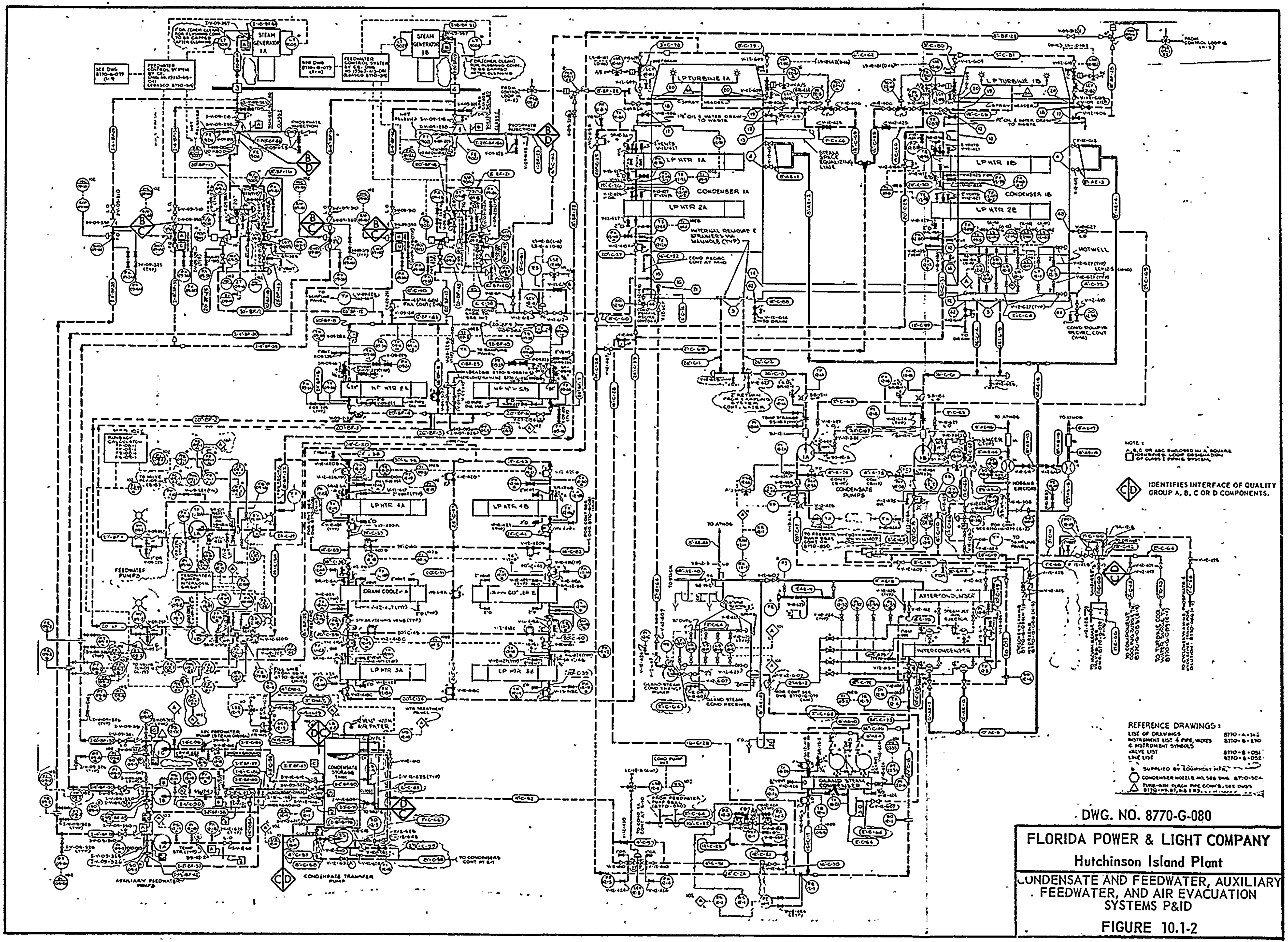
Hutchinson Island Plant

MAIN EXTRACTION AND AUXILIARY STEAM SYSTEMS P&I DIAGRAM

FIGURE 10.1-1



DWG. NO. 8770-G-080

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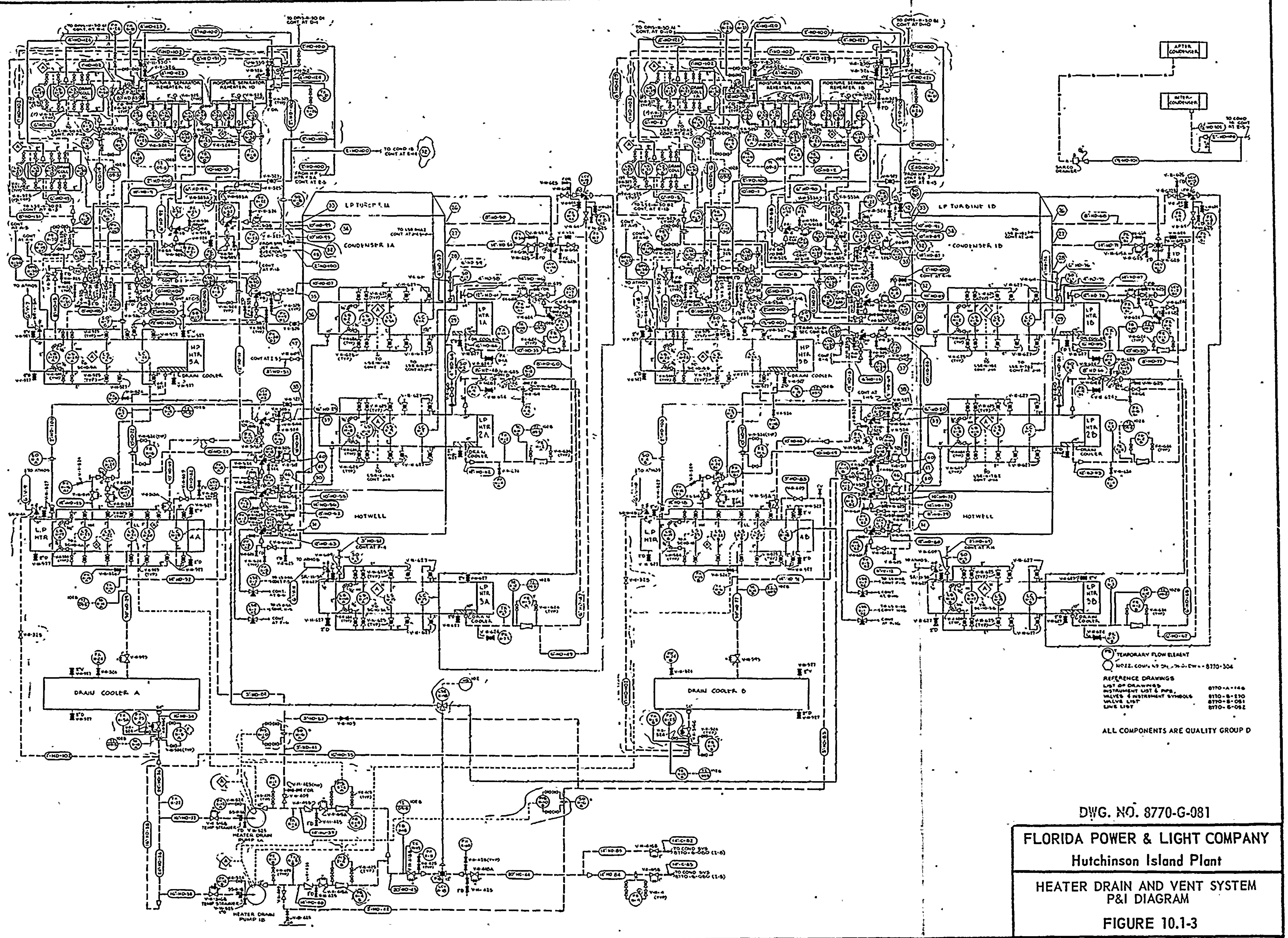
Hutchinson Island Plant

CONDENSATE AND FEEDWATER, AUXILIARY FEEDWATER, AND AIR EVACUATION SYSTEMS P&ID

FIGURE 10.1-2



DWG. NO. 8770-G-081

FLORIDA POWER & LIGHT COMPANY
Hutchinson Island Plant

HEATER DRAIN AND VENT SYSTEM
P&I DIAGRAM

FIGURE 10.1-3

10.2 TURBINE-GENERATOR

The turbine-generator is intended for load following operation and is designed for load changes from 15 to 100 percent power and 100 to 15 percent power at a maximum rate of 5 percent per minute and at greater rates over smaller load change increments, up to a step change of 10 percent. The turbine-generator has a guaranteed gross rating of 842 Mwe when operating at zero percent makeup with five stages of feedwater heaters in service. It has a maximum calculated rating of 877 Mwe. Table 10.1-1 lists other pertinent performance characteristics.

The turbine is a Westinghouse Electric Corporation, tandem-compound, four-flow exhaust, 1800 rpm unit with 44-inch last row blades, and has moisture separation and reheat between the high pressure and the two low pressure elements. The ac generator and brushless-type exciter are direct-connected to the turbine-generator shaft. The turbine consists of one double-flow high pressure element in tandem with two double-flow low pressure elements.

There are four horizontal-axis, cylindrical-shell, combination moisture-separator/reheater (MSR) assemblies located alongside the low pressure elements on the turbine building operating floor. This equipment receives steam from the exhaust of the high pressure turbine element. Internal manifolds in the lower section of these assemblies distribute the wet steam and allow it to rise through a chevron type moisture-separator where the moisture is removed. Steam extracted from the main steam line upstream of the turbine enters each MSR assembly, passes through the reheater tube bundle and leaves as condensate. The steam leaving the separator rises past the reheater tube bundle where it is reheated to 485 F when operating at full power; the steam is reheated to 498 F at 25 percent power. This reheated steam passes through nozzles in the top of the assemblies, flows to the low pressure turbine elements and finally exhausts to the condenser (see Figure 10.1-1).

The turbine is equipped with an automatic stop and emergency trip system which trips the stop and control valves to a closed position in the event of turbine overspeed, low bearing oil pressure, low vacuum, or thrust bearing failure. An electric solenoid trip valve is provided for remote manual trips and for various automatic trips. The turbine control system is discussed in Section 7.7-3. Upon occurrence of a turbine trip, a signal is supplied to the reactor protective system to trip the reactor. The logic circuitry for this trip function is discussed in Section 7.2.

A turbine lube oil system supplies oil for lubricating the turbine-generator and exciter bearings. A bypass stream of turbine lubricating oil flows continuously through an oil conditioner to remove water and other impurities.

The generator is a hydrogen-cooled, rotor-and-stator unit rated at 1000 mva with the capability to accept the gross rated output of the turbine at rated steam conditions. The generator shaft seals are oil sealed to prevent hydrogen leakage.

The main extraction and auxiliary steam system P&I diagram is shown on Figure 10.4-1.

The heating steam for the feedwater heaters is extracted from the turbine as follows: Extractions for the high pressure heaters (5A & 5B) and low pressure heaters (4A & 4B) are from the high pressure turbine element; the extractions for the remaining low pressure heaters (1A & 1B, 2A & 2B, 3A & 3B) are from the low pressure turbine elements. High pressure heaters 5A and 5B are drained into low pressure heaters 4A and 4B; the drains from the low pressure heaters 4A and 4B are directed to the drain coolers. The condensate accumulated in the drain coolers is then pumped by the two heater drain pumps back to the condensate and feedwater system upstream of heaters 4A and 4B. Shell drains from the remaining low pressure heaters are normally cascaded to the next lower pressure heaters and ultimately to the condenser. Alternate drains are also provided to automatically drain all the heaters directly to the condenser when a condition of high heater water level occurs. In addition, heaters 5A and 5B collect the drains from the reheater drain collectors and heaters 4A and 4B collect the drains from the moisture-separator drain pots.

The turbine-generator unit as well as other steam handling components of the steam and power conversion system are not expected to contain significant radioactive concentrations. Refer to Table 10.2-1 for expected radioactivity concentrations in the system.

Refer to Sections 11.2.5 and 11.3.5 for discussion of radiation concentrations and expected releases of radioactivity during operation. The anticipated operating radioactive concentrations in the system do not require shielding or access control in the turbine building.

TABLE 10.2-1

EXPECTED RADIOACTIVITY CONCENTRATIONS IN THE STEAM AND POWER CONVERSION SYSTEM

BLOWDOWN RATE	1.39000E-01	(GALLONS/MINUTE)	7.40729E-08	(SEC-1)
LEAKAGE RATE OF STEAM GENERATOR	0.00000E 00	(LBS/HR)	0.00000E 00	(SEC-1)
LEAKAGE RATE OF TURBINE	2.00000E 01	(LBS/HR)	5.30277E-08	(SEC-1)
LEAKAGE RATE OF CONDENSER	0.00000E 00	(LBS/HR)	0.00000E 00	(SEC-1)
X/Q	1.73000E-06	(SEC/CUBIC METER)		

ISOTOPES ********	ACTIVITIES IN (CURIES) STEAM GENERATOR ***************	ACTIVITIES IN (CURIES) TURBINE *************	ACTIVITIES IN (CURIES) CONDENSER *************	SPECIFIC ACTIVITIES IN (CURIES/LBS) STEAM GENERATOR ***************	SPECIFIC ACTIVITIES IN (CURIES/LBS) TURBINE *******	SPECIFIC ACTIVITIES IN (CURIES/LBS) CONDENSER *********
H-3	1.03457E-01	5.93579E-02	7.17819E-01	3.96388E-07	5.66570E-07	5.66550E-07
BR-84	8.78636E-06	2.48059E-07	2.38516E-06	3.36642E-11	2.36772E-12	1.88254E-12
KR-85M	1.09058E-05	6.24387E-06	0.00000E 00	4.17646E-11	5.95976E-11	0.00000E 00
KR-85	2.82835E-06	1.62275E-06	0.00000E 00	1.08366E-11	1.54891E-11	0.00000E 00
KR-87	5.87763E-06	3.34841E-06	0.00000E 00	2.25196E-11	3.19605E-11	0.00000E 00
KR-88	1.89899E-05	1.08590E-05	0.00000E 00	7.27583E-11	1.03649E-10	0.00000E 00
RB-88	2.76188E-04	7.68823E-06	6.78639E-05	1.05819E-09	7.33841E-11	5.35627E-11
RB-89	6.07944E-06	1.68484E-07	1.42939E-06	2.32929E-11	1.60818E-12	1.12817E-12
SR-89	1.12419E-03	3.22496E-05	3.89814E-04	4.30724E-09	3.07824E-10	3.07667E-10
SR-90	4.77660E-05	1.37084E-06	1.65692E-05	1.83088E-10	1.30846E-11	1.30775E-11
Y-90	1.76650E-09	1.48812E-11	5.97808E-12	6.76820E-15	1.42041E-16	4.71829E-18
SR-91	6.96845E-05	1.99876E-06	2.41181E-05	2.66990E-10	1.90782E-11	1.90356E-11
Y-91	1.73205E-02	4.96873E-04	6.00545E-03	6.63621E-08	4.74265E-09	4.73990E-09
MO-99	4.13479E-02	1.18599E-03	1.43118E-02	1.56421E-07	1.13203E-08	1.12958E-08
RU-103	5.55346E-04	1.59312E-05	1.92545E-04	2.12777E-09	1.52063E-10	1.51969E-10
RU-106	5.38191E-05	1.54391E-06	1.86618E-05	2.06203E-10	1.47366E-11	1.47291E-11
TE-129	3.14912E-03	9.03383E-05	1.09181E-03	1.20656E-08	8.62278E-10	8.61728E-10
I-129	1.69018E-08	4.84866E-10	5.86079E-09	6.47580E-14	4.62804E-15	4.62572E-15
I-131	1.99509E-01	5.72306E-03	6.91372E-02	7.64401E-07	5.46266E-08	5.45676E-08
XE-131M	1.08720E-05	6.23755E-06	0.00000E 00	4.16553E-11	5.95374E-11	0.00000E 00
TE-132	7.74327E-03	2.22106E-04	2.68089E-03	2.96677E-08	2.12000E-09	2.11593E-09
I-132	2.54265E-02	7.29326E-04	8.80313E-03	9.74197E-08	6.96143E-09	6.94801E-09
I-133	3.81197E-01	1.09306E-02	1.31420E-01	1.46053E-06	1.04333E-07	1.03725E-07
XE-133	1.32952E-03	7.62750E-04	0.00000E 00	5.09396E-09	7.28044E-09	0.00000E 00
TE-134	6.97137E-06	1.97634E-07	2.08799E-06	2.67102E-11	1.88641E-12	1.64798E-12
I-134	2.98483E-05	8.47296E-07	9.07954E-06	1.14361E-10	8.06744E-12	7.16617E-12
CS-134	6.09436E-01	1.74830E-02	2.11323E-01	2.33500E-06	1.66875E-07	1.66790E-07
I-135	1.66881E-02	4.78076E-04	5.68414E-03	6.39390E-08	4.56323E-09	4.48630E-09
XE-135	1.87002E-07	1.07182E-07	0.00000E 00	7.16482E-13	1.02305E-12	0.00000E 00
CS-136	2.33023E-02	6.68456E-04	8.07710E-03	8.92807E-08	6.38041E-09	6.37498E-09
CS-137	8.41658E-02	2.41446E-03	2.91849E-02	3.22474E-07	2.30462E-08	2.30346E-08
XE-138	4.74886E-06	2.62317E-06	0.00000E 00	1.81949E-11	2.50381E-11	0.00000E 00
CS-138	1.16783E-06	3.29483E-08	3.31013E-07	4.47446E-12	3.14492E-13	2.61257E-13
BA-140	4.25994E-04	1.22202E-05	1.47659E-04	1.63216E-09	1.16642E-10	1.16543E-10
LA-140	7.41132E-05	2.12561E-06	2.56223E-05	2.83959E-10	2.02689E-11	2.02228E-11
PR-143	4.31730E-04	1.23846E-05	1.49649E-04	1.65414E-09	1.18212E-10	1.18113E-10
CE-144	8.77927E-04	2.51852E-05	3.04420E-04	3.36371E-09	2.40393E-10	2.40268E-10
*CO-60	1.19845E-03	3.43802E-05	4.15568E-04	4.59178E-09	3.28159E-10	3.27994E-10
*FE-59	3.08348E-05	8.84557E-07	1.06910E-05	1.18141E-10	8.44308E-12	8.43804E-12
*CO-58	6.98030E-03	2.00244E-04	2.42029E-03	2.67444E-08	1.91133E-09	1.91025E-09
*MN-54	5.87675E-05	1.68587E-06	2.03776E-05	2.25163E-10	1.60916E-11	1.60833E-11
*CR-51	4.31776E-05	1.23863E-06	1.49693E-05	1.65432E-10	1.18227E-11	1.18148E-11
*ZR-95	5.56779E-10	1.50966E-11	1.07237E-10	2.13325E-15	1.44096E-16	8.46389E-17

* Corrosion products

10.3 MAIN STEAM SUPPLY SYSTEM

10.3.1 DESIGN BASES

The main steam piping system has the following safety design bases:

a) Provide containment isolation in the event of a loss of coolant accident

b) Prevent uncontrolled blowdown of both steam generators in the event of a steam line rupture accident

c) Provide means for reactor coolant system decay heat removal in the event of a loss of off-site power

d) Provide system integrity by design to seismic Class I standards for those components serving a containment isolation function and/or other safety function

e) Provide over-pressure protection for the steam generators and main steam supply system

10.3.2 SYSTEM DESCRIPTION

The main steam supply system is shown in Figure 10.1-1.

Each of the two steam generators supplies steam to the turbine through a separate 34-inch O.D. main steam line. The main steam line containment penetrations are designed with the flexibility to accommodate the expansions and contractions of the containment vessel. The steam lines, which are anchored on the outside of the penetration assemblies, have enough flexibility to accommodate the expansions and contractions of the steam generators and the lines up to the anchor point. The design of the main steam line penetration assemblies is discussed in Section 3.8.2.

There are eight spring-loaded main steam safety valves located outside the containment in each main steam line upstream of the isolation valve which discharge to atmosphere when actuated. Refer to Section 5.5 for a detailed description of these valves.

An atmospheric dump valve, operated manually from the control room, is connected to each main steam line upstream of the steam line isolation valve. Together the two valves have the capacity to dissipate decay heat at the level existing immediately following reactor shutdown, with an adequate margin to initiate cooling at 75 F/hr down to approximately 325 F. Cooling beyond this would be accomplished at a lower rate. Using both valves, the plant can be cooled down to 300 F in about 3½ hours. During normal start-up, shutdown and load change operations, secondary steam will not be released to the atmosphere. The steam dump and bypass system, which uses the condenser as a heat sink, will be utilized.

Additional cooldown capability is provided by the steam dump and bypass system which consists of four dump lines and one bypass line. These lines connect to the steam lines going to the moisture-separator/reheater tube bundles and discharge through control valves to the condenser.

The two main steam lines are cross connected between the isolation valves and the turbine stop valves. Steam from the common header is supplied to the high pressure turbine leads, four moisture-separator/reheater assemblies, turbine gland steam sealing system, auxiliary steam system, steam jet air ejectors, and water box priming ejectors. Each steam turbine lead has an automatic turbine stop valve and a steam turbine governing control valve upstream of the turbine.

Each of the two main steam lines is provided with one main steam line isolation valve assembly consisting of an air operated stop valve but welded to a check valve. The assembly is located outside the reactor containment structure and as near to it as practical. The isolation stop valve, mounted on the steam generator side of the assembly, is used to prevent steam from flowing from the steam generator to the turbine inlet manifold. The check valve is used to prevent backflow if the steam generator pressure drops below the turbine inlet manifold pressure.

The isolation stop valves will close automatically on a main steam isolation signal (MSIS), which is actuated on steam generator low pressure, to prevent rapid flashing and blowdown of water in the shell side of the steam generator in the event of a steam line break, and thus avoid a rapid uncontrolled cooldown of the reactor coolant system. The isolation valve assemblies also prevent simultaneous release to the containment of the contents of the secondary sides of both steam generators in the event of the rupture of one main steam line inside the containment vessel. The check valve in the assembly prevents backflow through the cross connection. The isolation valves can be remote manually operated from the control room.

The isolation stop valves will fail in the open position on loss of electric power to the solenoid valve and in the closed position on loss of air supply. An air accumulator tank is provided to hold the stop valves open for at least 8 hours after a loss of normal air supply, unless the valves are tripped or closed. The isolation stop valves have limit switches for valve operation and open/close position indication in the control room. A pressure switch will initiate an alarm in the control room in the event of low pressure in the air accumulator system. The trip circuitry for the main steam isolation valves is discussed further in Section 7.3.

10.3.3 SYSTEM EVALUATION

The steam and power conversion system is designed to meet its safety design bases under conditions postulated to exist for each of the abnormal incidents for which it must perform a safety function.

The main steam system from the steam generator up to and including the main steam line isolation valves is designed as seismic Class I. This portion of the system provides a containment isolation function in case of a loss of coolant accident. Each main steam line isolation valve receives a closure signal upon MSIS actuation. Further information on the isolation function of this system is given in Table 6.2-16.

The main steam system is designed to prevent blowdown of both steam generators in the event of a postulated steam line break accident. If the break should occur downstream of the main steam line isolation valves, low steam generator pressure signals will cause closure of the main steam line isolation valves. The system is designed such that no single failure will cause both isolation valves to remain open. If the break should occur upstream of the steam line isolation valve of a steam generator, blowdown of the other steam generator by backflow will be prevented by the check valve in the broken steam line. If the check valve should fail to close, blowdown of the intact steam generator will still be prevented by the steam line isolation valve in the unbroken steam line. A steam flow element, venturi type, in each main steam line upstream of the main steam isolation valves is a component of the feedwater control system and also acts as a flow restrictor to impede the discharge of steam into the containment following a postulated steam line break accident. Further discussion of the control circuitry for the main steam line isolation valves is given in Section 7.3.

The main steam system piping is arranged and restrained such that a rupture of one steam line cannot cause rupture of the other steam line, damage containment or prevent reactor system residual heat removal through the intact steam generator. This is done by the placing of pipe whip restraints and a guard pipe around the main steam line as it penetrates the containment. Further discussion of the design and analysis of the main steam line piping is given in Sections 3.7.3 and 3.9.2.

Operating instrumentation is adequate to permit the operators to monitor individual component and system performance as well as secondary system radioactivity.

10.3.4 TESTING AND INSPECTION

Inservice inspection and preoperational testing requirements are provided for as described in Chapter 16 and Chapter 14 respectively. Testing of system performance can be accomplished during normal operation.

Qualification testing of system components is in accordance with requirements of the design codes listed in Table 10.1-1.

10.4 OTHER FEATURES OF STEAM AND POWER CONVERSION SYSTEM

Except for a portion of the feedwater system piping, the features, components and systems described in this section serve no safety function since they are not required for safe shutdown or to mitigate the effects of a LOCA and their failure will not result in the release of significant uncontrolled radioactivity.

10.4.1 MAIN CONDENSER

The main condenser is of the deaerating type and is sized to condense exhaust steam from the main turbine under full load conditions. The condenser consists of two 50 percent capacity, divided-water-box, surface condensers of the single pass type with tubes arranged perpendicular to the turbine shaft. The condenser shells are connected to the low pressure turbine exhausts by belt type, rubber expansion joints.

The condenser hotwell is a storage reservoir for the deaerated condensate which supplies the condensate pumps. The storage capacity of the hotwell is sufficient for four minutes of operation at maximum throttle flow. The hotwell supply of condensate is backed up by the condensate storage tank from which condensate may be admitted into the condenser for deaeration.

The surface condenser water boxes were shop hydrostatically tested to 30 psig. After installation, the condenser was tested for leak tightness by filling with water to a level above the turbine exhaust flange. Field tests run to demonstrate performance are governed by the provisions of ASME Power Test Code for Steam-Condensing Apparatus.

Refer to Table 10.2-1 for a listing of expected condenser radioactivity inventory during normal operation.

10.4.2 MAIN CONDENSER EVACUATION SYSTEM

The main condenser evacuation system is shown on Figures 10.1-1 and 2. The main condenser evacuation system consists of two hogging ejectors, a steam jet air ejector with associated inter-and after-condensers, manifolds, valves and piping. The system is designed to establish and maintain condenser vacuum during start-up and normal operation.

During start-up, the two hogging ejectors evacuate a combined turbine and main condenser (empty hotwell) steam space of 142,000 cu ft within a period of 60 minutes and thereafter maintain a condenser pressure of 5 in. Hg absolute. The steam-air mixture from the hogging ejectors is discharged to the atmosphere via discharge silencers. As start-up progresses, condenser evacuation is maintained by the two-stage, twin-element, steam jet air ejector. The steam jet air ejector is designed to achieve a condenser vacuum of 3.5 to 1 in. Hg absolute during normal operation.

The steam jet air ejector passes the evacuated mixture of air and water vapor through its inter- and after-condensers where most of the water vapor is condensed and the remaining noncondensable gases are discharged to atmosphere. Noncondensable gases from the steam jet air ejector and the gland steam condenser are monitored for radioactivity prior to being discharged to atmosphere. The presence of radioactivity would indicate a reactor coolant-to-secondary system leak in the steam generators and gases having a concentration greater than 0.8μ Ci/cc, instead of being directly discharged to atmosphere, would be diverted for discharge through the plant vent. Refer to Section 11.4.

Low condenser vacuum will cause a turbine trip as discussed in Section 7.7.

10.4.3 TURBINE GLAND STEAM SYSTEM

The turbine gland steam system is shown on Figure 10.1-2.

The turbine gland steam system controls the steam pressure to the turbine glands to maintain adequate sealing under all conditions of turbine operation. The system consists of individually controlled diaphragm operated valves, relief valves, and a gland steam condenser.

The design of the diaphragm operated valves is "fail safe" such that failure of any valve will not endanger the turbine.

Gland steam is supplied from the main steam system. At high plant loads, the spillage from the high pressure turbine element glands provides more steam than the low pressure turbine element glands require. The excess steam is relieved to the turbine condenser through a pressure regulating valve.

Noncondensable gases from the gland steam condenser are monitored for radioactivity. If radioactivity is detected, these gases are routed to the plant vent instead of being directly discharged to atmosphere. Refer to Section 11.4.3.11.

10.4.4 STEAM DUMP AND BYPASS SYSTEM

The steam dump and bypass system is shown on Figure 10.1-1.

The main function of the steam dump and bypass system is to limit the pressure rise in the steam generators to avoid opening the main steam safety valves. If the turbine cannot accept all the steam being produced in the steam generators, for example in the event of a turbine trip or partial loss of electrical load on the generator, an alternate heat removal path is provided to remove the sensible heat in the reactor coolant and the reactor decay heat to limit the pressure rise in the steam generators. Steam dump and bypass valves, located downstream of the main steam isolation valves, connect the main steam header outside containment directly to the main condenser and are programmed to bypass steam directly to the condenser when such a high pressure condition should arise. The system is designed to enable the plant to accept a loss of electrical load on the generator of 45 percent of full power, without tripping the turbine.

The system is also used to remove reactor decay heat following a reactor shutdown or during hot standby conditions.

The dump valves are positioned by the reactor coolant average temperature error signal. A quick-opening signal is provided which opens the four dump valves and the turbine bypass valve fully until the reactor coolant average temperature signal begins to modulate the valves. The turbine bypass valve is modulated by either secondary steam pressure or reactor coolant average temperature, whichever signal is higher. The valves are designed to fail closed upon loss of actuator power or control signal. To prevent opening the main steam safety valves, the control program partially reopens the condenser dump valves in case the bypass valve inadvertently closes while at hot standby conditions. In the event of a loss of condenser vacuum, the valves close automatically. The system controls are designed for either automatic operation or remote manual control. The controls and instrumentation are described in Section 7.7.

The total capacity of the dump valves and turbine bypass valve is 40 percent and 5 percent, respectively, of reactor full power. This flow is sufficient to control the secondary steam pressure following a turbine trip at full power and thus avoid lifting the spring-loaded safety valves.

The steam dump and bypass system has no safety functions since overpressure protection is provided by ASME Code safety valves. Consequently, design of the system to seismic Class I or limiting environmental conditions is not required.

During plant shutdown with off-site power available, one dump valve is remote manually positioned to remove reactor decay heat, pump heat, and reactor coolant system sensible heat to reduce the reactor coolant temperature. Since steam pressure decreases as the system temperature is reduced, dump valve flow capacity becomes limited at low pressures and additional dump valves are opened to finish the cooldown at the design rate until shutdown cooling is initiated.

For plant shutdown without off-site power, the atmospheric dump valves may be used to remove reactor decay and sensible heat by venting steam from the steam generators directly to the atmosphere.

Preoperational testing will be performed to demonstrate that the system operates to control reactor coolant temperature during turbine load transients. Refer to Section 14.1.

10.4.5 CIRCULATING WATER SYSTEM

The circulating water system is designed to provide a sink for the removal of heat from the main condenser under normal operating and shutdown conditions. The system is discussed in Section 9.2.3.

10.4.6 CONDENSATE AND FEEDWATER SYSTEM

The condensate and feedwater system is designed to supply heated condensate to the steam generators for steam production.

The feedwater and condensate systems are shown in Figure 10.1-2. The heater drain and vent systems are shown in Figure 10.1-3.

Refer to Figure 10.1-2 for the following discussion: The feedwater cycle is a closed regenerative system with deaeration accomplished in the main condenser. Condensate from the hotwell is pumped by two vertical, can-type, motor-driven centrifugal condensate pumps (operating in parallel) through the steam jet air ejector inter-and after-condensers, the gland steam condenser, three stages of low pressure heaters (two heaters per stage), the low pressure drain coolers, and a fourth stage low pressure heaters to the suction of two horizontal, motor-driven, multi-stage feedwater pumps (operating in parallel). The feedwater is then pumped through one stage of high pressure feedwater heaters to the steam generators. At low loads minimum condensate flow for condensing the supply steam for the steam jet air ejectors and gland steam condenser is maintained by recirculating condensate downstream of the gland steam condenser to the main condenser. Each feedwater pump is protected from overheating during start-up and reduced load operation by a recirculation control system which discharges to the main condenser.

The feedwater heaters are of the U-tube type and are arranged in two parallel streams. Each stream carries approximately half of the feedwater flow and consists of our low pressure heaters and one high pressure heater. The two lowest pressure heaters are mounted in the neck of the main condenser. Bypasses and crossties between the split streams are provided for flexibility in operation.

Each steam generator feedwater line is provided with a three-element controller which combines the steam generator steam signal, feedwater flow signal and steam generator water level. The output of each three-element controller actuates the 100 percent capacity feedwater regulating valve to effect the desired feedwater flow to each steam generator. In addition to the air operated feedwater regulating valve there is a remote manually operated 15 percent capacity bypass valve and a 100 percent capacity motor operated bypass valve used for backup in case of outage of the regulating unit. Refer to Section 7.7 for a complete description of steam and feedwater control.

Cyclohexylamine and hydrazine are added to the condensate at the condensate pump discharge to control pH and oxygen, respectively. Phosphate is injected into the steam generators for water conditioning. No other additives are contemplated.

The condensate and feedwater system is not designed to seismic Class I standards except for the piping from the steam generator to the first check valve outside containment. Details of isolation provisions are contained in Table 6.2-16. The auxiliary feedwater system described in Section 10.5 is used to achieve safe plant shutdown by removal of reactor decay heat from the steam generators in the event of loss of the normal feedwater system or loss of off-site power.

The main feed pumps, heater drain pumps and the condensate pumps are tested at the manufacturer's shop, in the presence of the purchaser's inspector, to demonstrate sucessful operation and performance of the equipment. Hydrostatic and performance tests were governed by the provisions of the ASME Power Test Codes for Centrifugal Pumps and the Hydraulic Institute Test Code for Centrifugal Pumps.

Performance tests for feedwater heaters will be conducted during operation in accordance with the ASME Power Test Code for Feedwater Heaters No. PTC 12.1. Shop Hydrostatic tests at 1-1/2 times the design pressure on shell, tube side and external drain receiver were performed at a minimum temperature of 60 F.

Preoperational testing of this system as an integrated unit is discussed in Section 14.1 and is designed to verify pump, valve and control operability and setpoints, and to verify design head capacity characteristics of pumps.

10.4.7 STEAM GENERATOR BLOWDOWN SYSTEM

The steam generator blowdown system is shown in Figure 10.4-1.

The steam generator blowdown system is designed to control radioactivity levels associated with nonvolatile radionuclides, and to maintain purity standards established for the steam generators.

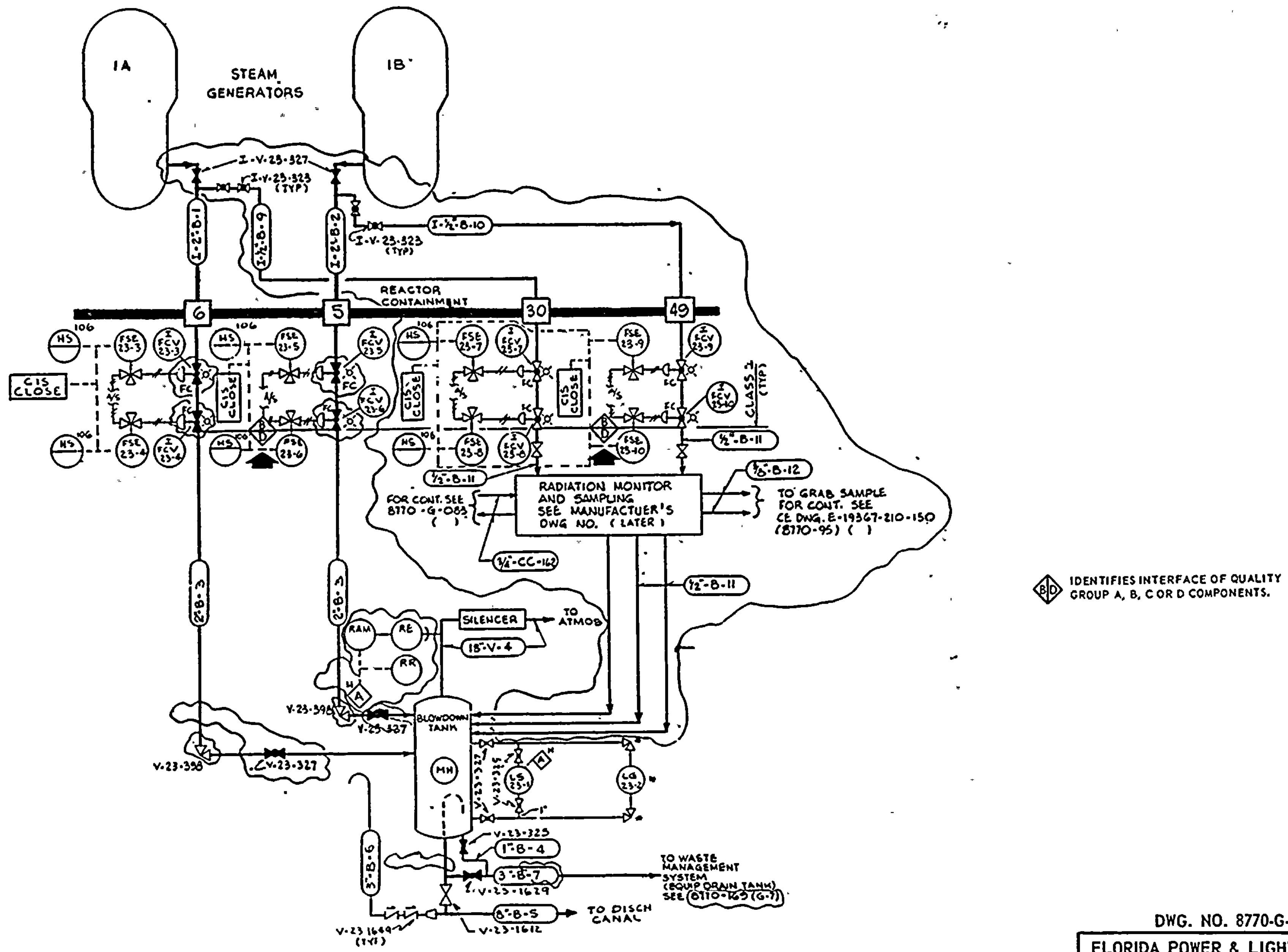
Each steam generator has a blowdown line that discharges to the blowdown tank. Each line is provided with two automatic isolation valves outside containment that close on CIS. The steam generator discharge is accumulated in the blowdown tank and routed either to the waste management system or to the discharge canal. A sampling line permits continuous sampling of steam generator activity to identify and alarm conditions threatening violation of technical specification limits. The maximum total allowable primary-to-secondary leakage rate is listed in the technical specifications.

A radioactivity monitor is located in each steam generator sample line. When a radioactivity level exceeding the technical specification limit is detected, an alarm is annunciated in the control room and the liquid effluent from the steam generators is diverted to the radioactive waste management system by the control room operator.

Radioactivity monitoring and processing is more fully discussed in Section 11.4.3.9.

Refer to the Section 11.2.5 for an evaluation of radioactivity discharge rates, a failure analysis of system components, system performance during abnormally high primary-to-secondary leakage, and an analysis of steam generator shell side radioactivity concentration during system isolation.

Preoperational testing of the steam generator blowdown system is discussed in Table 14.1-1.



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STEAM GENERATOR BLOWDOWN SYSTEM P&I DIAGRAM

FIGURE 10.4-1

STEAM GENERATOR BLOWDOWN SYSTEM

10.5 AUXILIARY FEEDWATER SYSTEM

10.5.1 DESIGN BASES

The auxiliary feedwater system is designed to:

a) Provide feedwater for the removal of sensible and decay heat from the reactor coolant system

b) Provide sufficient feedwater capacity to permit plant cooldown to 300 F, assuming a single active failure and loss of off-site power

c) Withstand design basis earthquake loads without loss of function

10.5.2 SYSTEM DESCRIPTION

The major active components of the system consist of one full flow capacity and two 50 percent flow capacity auxiliary feedwater pumps. The larger pump is driven by a noncondensing steam turbine. The turbine will receive steam from the main steam lines upstream of the isolation valves and exhaust to atmosphere. The two motor driven pumps are powered from the emergency generators in case of a loss of normal power. The pumps take suction from the condensate storage tank and discharge to the steam generators. Refer to Figure 10.1-2.

The turbine-driven pump is capable of supplying auxiliary feedwater flow to the steam generators for the total expected range of steam generator pressure (985 psig to 50 psig) by means of a variable speed turbine driver controlled by a variable speed hydraulic governor. The turbine operates through a speed range of 3600 to 200 rpm when supplied with saturated steam from 985 to 50 psig respectively.

Each motor-driven pump supplies feedwater to one steam generator. The turbine-driven pump supplies feedwater to both steam generators by means of two separate lines each with its own control valve. The control of auxiliary feedwater flow and steam generator level is accomplished by means of control-room operated control valves.

During normal operation, feedwater is supplied to the steam generators by the feedwater system. If this system is unavailable due to loss of feedwater pumps or off-site power an alarm is sounded in the control room. The operator then has 10 minutes in which to start the auxiliary feedwater pumps and open the flow control valves to the steam generators. If the auxiliary feedwater pumps were operating when off-site power was lost, the pumps would automatically restart using diesel generator power. Refer to Section 7.4.1.4 for further discussion of system circuitry.

The steam generated during decay heat removal and cooldown after a loss of off-site power will be discharged through the atmospheric dump valves, except for that steam used by the auxiliary feed pump. If off-site power and the main condenser are available, the condenser will be used as a heat sink.

10.5.3 SYSTEM EVALUATION

The auxiliary feedwater system is designed to provide feedwater for the removal of sensible and decay heat from the reactor coolant system. The system can cool the reactor coolant system to 300 F in the event the main condensate pumps or the main feedwater pumps are inoperative due to pump failures or to a loss of normal electric power. The auxiliary feedwater system may also be used for normal system cooldown to 300 F. Reactor decay heat and sensible heat are transferred to the steam generators by natural circulation of the reactor coolant if power is not available for the reactor coolant circulating pumps.

The storage capacity of the condensate storage tank is 250,000 gallons, a sufficient quantity to meet the requirements for decay heat removal and cooldown of the nuclear steam supply system. Figure 10.5-1 represents auxiliary feedwater requirements after a loss of normal feedwater. Approximately 110,000 gallons of water are required to permit cooldown to 300 F following a reactor trip.

Figure 10.5-1 indicates that 138,000 gallons are used for 8 hours of hot standby following a reactor trip. This includes 28,000 gallons to raise the water level to the normal operating level. It would be at a lower level because of the time lapse in initiation of the auxiliary feedwater system following loss of main feed pumps.

The auxiliary feedwater system is designed to provide a means of reactor coolant system cooldown for emergency plant shutdown in the event of a loss of off-site power. The motor-driven auxiliary feedwater pumps can be powered from the emergency diesel generators. The turbine driven pump requires no external source of electrical power for its operation. The auxiliary feedwater system is designed as seismic Class I and is capable of withstanding tornado wind loading. The auxiliary feedwater system is protected from flooding by placing all system components susceptible to flooding damage above the probable maximum flood level.

The system is designed such that no single active failure can prevent plant cooldown to 300 F in the event of a loss of off-site power. Refer to Table 10.5-1.

10.5.4 TESTING AND INSPECTION

Auxiliary feed pumps were tested with cold water at the manufacturer's shop, in the presence of the purchaser's inspector, to demonstrate successful operation and performance of the equipment. Performance tests were governed by the provisions of the ASME Power Test Codes for Centrifugal Pumps (PTC 8.2) and the Hydraulic Institute Test Code for Centrifugal Pumps. Pump casings underwent hydrostatic tests at 150 percent of maximum operating head.

The auxiliary feedwater pump and noncondensing turbine manufacturers have supplied calculations which substantiate that the equipment will not suffer loss of function due to design bases earthquake loadings.

Both motor-driven pumps and associated controls will be given preoperational tests after erection and before plant start-up. All three of the auxiliary feed pumps can be tested during normal operation by recirculating to the condensate storage tank through miniflow lines. The system will be tested periodically as described in Section 16.4.10.

10.5.5 INSTRUMENTATION APPLICATION

Refer to Section 7.4 for a description of the auxiliary feedwater system controls and instrumentation required for safe plant shutdown.

The controls and instrumentation for this system are shown in the system P&ID, Figure 10.2-3, and tabulated in Table 10.5-2.

TABLE 10.5-1

SINGLE FAILURE ANALYSIS - AUXILIARY FEEDWATER SYSTEM

Component Identification and Quantity	Failure Mode	Effect on System	Method of Detection	Monitor (1)	Remarks
Off-Site Power	Lost	Main feedwater system lost. Operator must switch to auxiliary feedwater system to permit plant cooldown to 300F.	Various loss of power alarms.	CRI	Two 50% capacity motor driven pumps powered by the emergency diesel generator sets operate supplemented by one 100% capacity steam turbine driven pump.
Auxiliary Feedwater Pump Suction Line (2)	Valve inadvertantly closed.	No feedwater flow. Operator must switch to alternative feedwater supply.	Pump suction line low pressure alarm.	CRI	The remaining open line supplies either the 100% capacity steam turbine driven pump or the two 50% capacity motor driven pumps.
Steam turbine driven pump steam inlet valve (2)	Sticks closed	No feedwater flow. Operator must switch to alternate feedwater supply.	No discharge line flow or pressure indication.	CRI	Two 50% capacity motor driven pumps available.
Motor driven pump (2).	Fails to start	Loss of one 50% capacity motor driven pump.	No discharge line flow or pressure indication.	CRI	100% capacity steam turbine driven pump and on 50% capacity motor driven pump available.
Pneumatic Flow Control Valve (4)	Lose air supply	Fail open valves - no interruption of feedwater flow	Feedwater flow indication	CRI	
	Fails to open	One feedwater line lost	Feedwater flow indication	CRI	Remaining three lines available for delivering required feedwater to steam generators.
Diesel Generator Set (2)	Fails to start	Loss of one 50% capacity motor driven pump.	No discharge line flow or pressure indication.	CRI	100% capacity steam turbine driven pump and on 50% capacity motor driven pump available.

(1) CRI-control room indication

TABLE 10.5-2

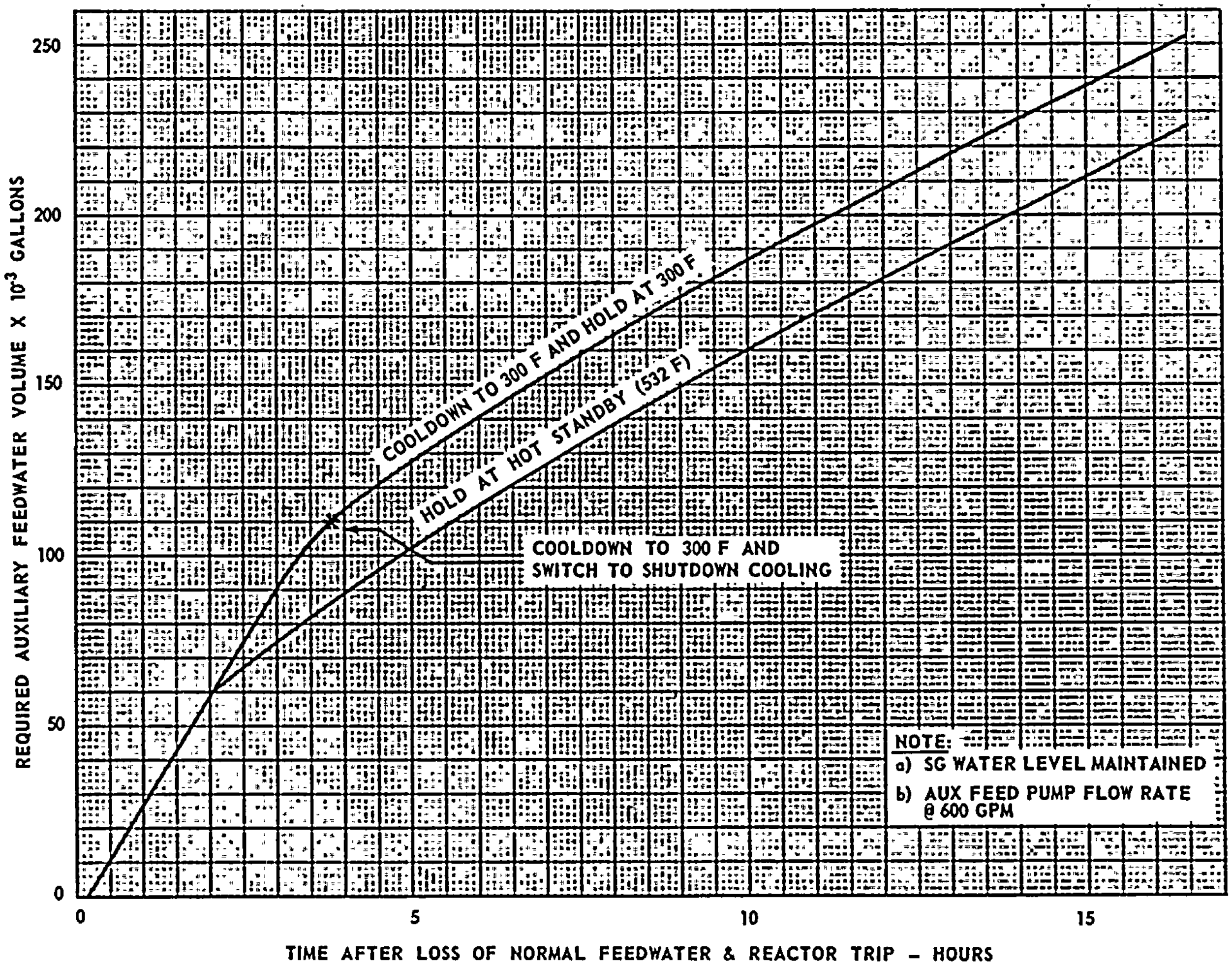
AUXILIARY FEEDWATER SYSTEM INSTRUMENTATION APPLICATION

System Parameter & Location	Indication Local	Indication Control Room	Alarm(1) High	Alarm(1) Low	(1) Recording	Control Function	Instrument Range	Normal Operating Range	Instrument Accuracy
Condensate Storage Tank Level (2)	*	*	*	*		Regulates flow from demineralized water system to maintain minimum condensate tank level.		Full-4 ft. min. vol. 200,000 gal.	
Aux. Feedwater Pumps									
1. Steam pressure at turbine inlet (3)		*		*			0-1200 psig	985 - 50 psig	
2. Pump suction pressure	*			*			0-20 psig	11.5 psig	± 0.5 %
3. Pump discharge pressure	*	*					0-2500 psig	1200 psig	± 0.5%
4. Pump discharge flow		*				Flow is manually regulated from control room	0-300 gpm	Motor driven 325gpm Steam-driven 600gpm	
5. Pump speed (3)		*						3600 - 2000rpm	

(1) All alarms and recordings are in the control room unless otherwise indicated.

(2) A low-low level alarm is provided in control room; high & low level alarms provided on water treatment panel.

(3) For turbine driven pump only.



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AUXILIARY FEEDWATER REQUIRED AFTER LOSS OF NORMAL FEEDWATER

FIGURE 10.5-1