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Offshore Power Systems

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Plant Design Report

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AUXILIARY SYSTEMS

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CHAPTER 9

AUXILIARY SYSTEMS

9.1 FUEL STORAGE AND HANDLING

9.1.1 NEW FUEL STORAGE

The new fuel storage facility provides a safe, effective means for storing new fuel from the time it reaches the plant until it is loaded into the reactor.

9.1.1.1 Design Bases

1. The new fuel storage racks accommodate the number of fuel assemblies required for a normal refueling cycle. A total of 72 storage spaces are provided, which is more than needed for the normal replacement of 1/3 core.

2. The fuel is stored in a vertical array with sufficient center to center spacing between assemblies to assure $k_{eff} \leq 0.90$ even if the new fuel pit were flooded with water.

3. The new fuel racks are designed so that it is impossible to insert assemblies in other than the storage cells in the racks, thereby maintaining separation.

4. The design of the racks precludes criticality even with a misplaced fuel assembly on top of or adjacent to the racks.

5. These racks have been designed to withstand DBE, OBE, and handling loads as well as dead loads of the fuel assemblies, and meet ANS Safety Class requirements as shown on Table 3.2-1.

9.1.1.2 System Description

The new fuel storage facility consists of the equipment needed to safely store new fuel until it is required for refueling the reactor. This equipment consists of a storage vault with locked door and specially constructed racks (Figure 9.1-1) located inside the vault.

New fuel assemblies are received and inspected in the fuel building, then placed in the new fuel storage area. Fuel assemblies for the initial core loading are temporarily stored in the spent fuel pit, which is kept dry during this period.

The new fuel storage area is located in the fuel building adjacent to the spent fuel pit. This location facilitates the handling, inspection, and security of new fuel assemblies. This storaging facility is provided with a vertical access from the 94' elevation. (Refer to Figure 1.2-6.)

9.1.1.3 Design Evaluation

The new fuel storage facility stores new fuel assemblies in a dry vertical array on 21" centers. This design assures $k_{eff} \leq 0.90$ even if the facility should be flooded. The racks are so designed as to prevent the insertion of fuel assemblies in other than permitted locations. Violation of procedures by placing one fuel assembly in juxtaposition with any group of assemblies in the racks will not result in criticality. The area is designed for controlled access. Unauthorized personnel are restricted, and all access doors to the fuel assemblies are locked.

The fuel building crane is prevented by interlocks from carrying heavy loads over the new fuel pit. Mechanical anti-derailing devices, mounted on the wheel axles of the overhead crane bridge and trolley, prevent the crane from being dislodged from the rail due to horizontal motion caused by wave action, wind or earthquake. Vertical acceleration due to wave action, wind or earthquake is not large enough to overcome gravity.

9.1.2 SPENT FUEL STORAGE

The spent fuel storage facility provides a safe and effective means of storing spent fuel assemblies and control rods, after their removal from the reactor, and until they are ready for shipment.

9.1.2.1 Design Bases

1. The spent fuel storage racks are sized to store one and one-third core of spent and/or partially spent fuel assemblies.

2. The spent fuel assemblies are stored in vertical cells which are arranged in a geometric array with sufficient center to center distance between assemblies to assure $k_{eff} \leq 0.90$ even if flooded with non-borated water.

3. The spent fuel pit is always flooded with borated water which provides an effective, economic, and transparent radiation shield. A water cover of 20 feet is maintained over the fuel assemblies. This will assure the radiation level at the surface of the water to be $\leq$ 2.5 mr/hr. This borated water also helps to further ensure subcriticality and provides a reliable medium for the removal of residual heat.

4. The spent fuel racks are designed so that it is impossible to insert the assemblies in other than the storage cells, thereby maintaining separation.

5. The design of the racks precludes criticality even with unborated water and a misplaced fuel assembly on top of or adjacent to the racks.

9.1.2.2 System Description

The spent fuel pit is constructed of reinforced concrete and lined with stainless steel plate. The pit has sufficient capacity to store 280 spent fuel assemblies and accompanying control rods, which is more than one and one-third cores. It has space for the storage of a spent one-third core during its normal decay period and for forced unloading of a complete core, if necessary. Control rods are stored in the fuel assemblies. Spent fuel assemblies are handled by the manipulator crane which is located outside the reactor containment during plant operation.

Spent fuel assembly storage racks (Figure 9.1-2) are located on the pit floor. Fuel assemblies are placed in vertical cells, continuously grouped in parallel rows on 21-inch centers in both directions. The racks are designed such that it is impossible to insert fuel assemblies in other than the prescribed locations, thereby ensuring the necessary spacing between assemblies. The rack thus provides a subcritical geometric array, even if the pit were flooded with demineralized non-borated water. Borated water is used to fill the pit at a concentration to match that used in the refueling cavity during refueling. Since there are no gravity drains in the pit, it cannot be drained accidentally. Cooling to remove decay heat generated by the spent fuel is provided by the Spent Fuel Pit Cooling and Cleanup System (Section 9.1.3).

The stationary section spent fuel pit enclosure building forms a tornado missile shield sized to permit the manipulator crane to travel underneath. Access to the spent fuel pit from the new fuel storage area and cask loading area is provided by a vertical rolling door. The other end of the missile shield is provided with a movable three-sided cover which in its extended position extends to the containment biological shield. With the rolling door closed and the movable cover extended, the space above the spent fuel pit is ventilated as described in Section 9.4.2. With the movable cover in the retracted position, the fuel building crane has access to the area immediately outside the containment equipment hatch.

9.1.2.3 Design Evaluation

The spent fuel storage pit is located within and is an integral part of the fuel handling building (see Figure 1.2-6).

The spent fuel racks are individual vertical cells which are fastened together to form a module that is firmly bolted to anchors in the floor of the spent fuel pit. These racks have been designed to withstand DBE, OBE, and handling loads as well as dead load of the fuel assemblies, and meet ANS Safety Class requirements as shown on Table 3.2-1. The spent fuel racks including supports, are made of austenitic stainless steel and are constructed so that it is impossible to insert fuel assemblies except in prescribed locations having a minimum center-to-center spacing of 21 inches in both directions. The spacing is suffieient to assure $k_{eff} \leq 0.90$ even if immersed in unborated water.

The reactor is refueled with equipment that handles the spent fuel assemblies under water from the time they leave the reactor vessel until they are placed in a cask for shipment from the site.

Water level monitoring equipment and the spent fuel pool cooling and cleanup systems are discussed in Subsection 9.1.3.

The fuel building crane handles the new and spent fuel assemblies, and spent fuel casks.

The spent fuel pit enclosure building is of sufficient height, width, and length that it prevents the carrying of large loads over the spent fuel pit; the movements of the fuel building crane are restricted by limit switches so that it is impossible for the crane hook to travel over the spent fuel storage area. The limit switches may be bypassed, if necessary only under administrative control.

Material certification will be provided and materials selection as well as design and fabrication of equipment for the spent fuel pit will comply with all applicable regulations set forth in 10 CFR 50.

9.1.3 SPENT FUEL PIT COOLING AND CLEANUP SYSTEM

The spent fuel pit cooling system removes the decay heat generated by stored spent fuel assemblies from the spent fuel pit water. A secondary function of the spent fuel pit cooling system is to clarify and purify spent fuel pit, transfer canal, and refueling water. The spent fuel pit cooling system design parameters are given in table 9.1.3-1.

9.1.3.1 Design Bases

Spent Fuel Pit Cooling

The spent fuel pit cooling system design provides for the capability of maintaining the bulk fluid temperature of the spent fuel pit below 150^{0}F, with a total loading of 1-1/3 cores (1/3 from the previous years' refueling, plus a complete core from the just accomplished sequential refueling).

System piping is arranged so that failure of any pipeline cannot drain the spent fuel pit below the water level required for radiation shielding. (see Section 12.1).

Water Purification

The system's demineralizer and filter are designed to provide adequate purification to permit occupational access to the spent fuel storage area and maintain optical clarity of the spent fuel pit water. The optical clarity of the spent fuel pit water surface is maintained by use of the system's skimmer, strainer, and skimmer filter.

9.1.3.2 System Description

The spent fuel pit cooling system consists of one heat exchanger and 1 pump, one purification loop with demineralizer and filter, one surface skimmer loop, and associated piping, valving and instrumentation. The cooling train is designed to service the spent fuel pit, with normal design fuel element assembly loading in the pit, and maintain the bulk fluid temperature of the pit below 120^{o}F. The system is shown in Figure 9.3-1.

The spent fuel pit cooling system removes decay heat from fuel stored in the spent fuel pit. Spent fuel is placed in the pit during the refueling sequence, and stored there until it is shipped to an offsite reprocessing facility. The cooling train normally handles the heat loading from 1/3 of a core from the previous refueling. Heat is transferred from the spent fuel pit cooling system, through the heat exchanger to the component cooling water system.

When the cooling train is in operation, water flows from the spent fuel pit to the spent fuel pit pump suction, is pumped through the tube side of the heat exchanger, and is returned to the pit. The suction line, which includes a strainer, is located at an elevation four feet below the normal spent fuel pit water level, while the return line contains an anti-siphon hole near the surface of the water to prevent gravity drainage of the pit.

While the heat removal operation is in process, a portion of the spent fuel pit water may be diverted through a demineralizer and filter to maintain spent fuel pit water clarity and purity. Transfer canal water may also be circulated through the same demineralizer and filter by removing the gate between the canal and the spent fuel pit. This purification loop is sufficient for removing fission products and other contaminants which may be introduced if a leaking fuel assembly is transferred to the spent fuel pool.

The demineralizer and filter may be isolated, by manual valves, from the heat removal portion of the spent fuel pit cooling system. By so doing, the isolated equipment may be used to process the refueling water while spent fuel pit heat removal operations proceed. Connections are provided in the refueling tank such that the refueling water may be pumped from either the refueling water storage tank or the refueling cavity, through the filter and demineralizer, and discharged to either the refueling cavity or the refueling water storage tank.

To further assist in maintaining spent fuel pit water clarity, the water surface is cleaned by a skimmer loop. Water is removed from the surface by the skimmers, pumped through a strainer and filter, and returned to the pool surface at locations remote from the skimmers.

The spent fuel pit is initially filled with water that is at the same boron concentration as that in the refueling water storage tank. Borated water may be supplied from the refueling water storage tank via the refueling water purification pump connection, or by a temporary line from the boric acid blender, located in the chemical and volume control system. Demineralized water can also be added for makeup purposes (i.e., to replace evaporative losses) through a connection in the recirculation return line.

For shielding purposes the spent fuel pit water level is 22 feet above the spent fuel. The pit walls are constructed from concrete and lined with stainless steel. This is sufficient shielding to allow occupational access to operating personnel in the adjacent area (2.5 mr/hr).

The pit water may be separated from the water in the transfer canal by a gate. The gate is installed so that the transfer canal may be drained to allow maintenance of the fuel transfer equipment.

Component Description

Spent fuel pit cooling system codes and classifications are given in table 3.2-1. Equipment design parameters are given in table 9.1.3-2.

Spent Fuel Pit Pumps

The pump is a horizontal, centrifugal unit. The pump is controlled manually from a local station. The pump is used to circulate water through the cooling train from the spent fuel pool.

Spent Fuel Pit Skimmer Pump

The spent fuel pit skimmer pump circulates surface water through a strainer and a filter and returns it to the pit.

Refueling Water Purification Pump

The refueling water purification pump is used to circulate water from the refueling cavity and the refueling water storage tank through the spent fuel pit demineralizer and filter. The pump is operated manually from a local station.

Spent Fuel Pit Heat Exchanger

The heat exchanger is a shell and U-tube type. Spent fuel pit water circulates through the tubes while component cooling water circulates through the shell.

Spent Fuel Pit Demineralizer

The spent fuel pit demineralizer is a flushable, mixed bed demineralizer. The demineralizer is designed to provide adequate fuel pit water purity for occupational access to the pit working area and to maintain visual clarity through the water.

Spent Fuel Pit Filter

The spent fuel pit filter is designed to improve the pit water clarity by removing particles which obscure visibility.

Spent Fuel Pit Skimmer Filter

The spent fuel pit skimmer filter is used to remove floating particles which are not removed by the strainer.

Spent Fuel Pit Strainer

A strainer is located in the spent fuel pit pump suction line for removal of relatively large particles which might otherwise clog the spent fuel pit demineralizer or damage the spent fuel pit pumps.

Spent Fuel Pit Skimmer Strainer

The spent fuel pit skimmer strainer is designed to remove debris from the skimmer process flow.

Spent Fuel Pit Skimmer Heads

Two spent fuel pit skimmer heads are provided to remove water from the surface of the spent fuel pit. The skimmer heads are manually positioned to take water from any elevation from the water surface to four inches below the surface.

Valves

Manual stop valves are used to isolate equipment and manual throttle valves provide flow control. Valves in contact with spent fuel pit water are austenitic stainless steel or equivalent corrosion resistant material.

Piping

All piping in contact with spent fuel pit water is austenitic stainless steel. The piping is welded except where flanged connections are used to facilitate maintenance.

9.1.3.3 Design Evaluation

This manually controlled system may be shut down safely for reasonable time periods for maintenance or replacement of malfunctioning components. The pit is sufficiently large that an extended period of time would be required for the water temperature to reach 212°F if cooling were interrupted (see Table 9.1.3-1). Water is added to compensate for evaporated water from either the makeup water system or the refueling water storage tank.

Only a very small amount of water is interchanged between the refueling canal and the spent fuel pit as fuel assemblies are transferred in the refueling process. Whenever a leaking fuel assembly is transferred from the fuel transfer canal to the spent fuel storage pit, a quantity of fission products will enter the spent fuel cooling water. A purification loop is provided which removes fission products and other contaminants.

from the water. By maintaining radioactivity concentration in the spent fuel pit water at $5 \times 10^{-3} \mu ci/cc$ (β and γ) or less, the dose at the surface of the pool is 2.5 mr/hr or less, thus allowing occupational access to the spent fuel storage area for the plant personnel.

The system and spent fuel pool are designed in accordance with AEC Safety Guide 13.

The probability of draining the water from the spent fuel pit cooling system is low. The only means of draining the cooling system is through such actions as operating a valve on a cooling line and leaving it open when a pump is operating. The spent fuel pit cannot be drained and no spent fuel is uncovered since the spent fuel pit cooling connections enter near the top of the pit. The spent fuel cooling system can be drained for maintenance when required. The temperature and level indicators in the spent fuel pit provide alarms in the control room if the pit water level decreases.

To protect against loss of water in the storage pit, the cooling pump suction connections penetrate the pit wall and terminate near the normal water level so that a break in the pipe will not gravity drain the pit. The cooling water return line does not penetrate the pit wall and is prevented from siphon draining the pit by a hole in the pipe located 6 inches below the normal water level.

The maximum decay heat load with 1 1/3 cores in the spent fuel pit will raise the fuel pit water from 120° to 212°F in 14 hours. Makeup water is available from the makeup water system and the refueling water storage tank to retain satisfactory water shielding of the fuel assemblies.

The active components of this system are in either continuous or intermittent use during normal plant operation, thus, no additional periodic tests are required. Periodic visual inspections and preventive maintenance can be conducted as necessary. All components are accessible for periodic inspection.

9.1.3.4 Instrument Application

The instrumentation for the spent fuel pit cooling system is discussed below. Alarms and indications are provided as noted.

1. Temperature. Instrumentation measures the temperature of the water in the spent fuel pit and gives a local indication as well as an alarm when normal temperatures are exceeded. Instrumentation gives indication of the temperature of the spent fuel pit water as it leaves the spent fuel pit heat exchanger.

2. Pressure. Instrumentation measures and gives indication of the pressures in the spent fuel pit pump suction and discharge lines.

It also provides for measurement of pressures, such that the pressure differential can be found from the indication on the spent fuel pit skimmer filter and spent fuel pit filter.

3. Flow. Instrumentation measures and gives indication of the flow in the outlet line of the spent fuel pit filter.

4. Level. Instrumentation gives both a high and low level alarm for the water level in the spent fuel pit.

TABLE 9.1.3-1

SPENT FUEL PIT COOLING SYSTEM
DESIGN PARAMETERS

Spent fuel pit storage capacity (based on storage racks provided)	1-1/3 cores
Spent fuel pit water volume, gal	3.23×10^5
Nominal boron concentration of the spent fuel pit water, ppm	2000
Design storage case - 1/3 core store	
Decay heat production, Btu/hr	9.1×10^6
Spent fuel pit water temperature, F	120
Maximum storage case - 1 - 1/3 cores stored in the pit (design storage case plus complete unloading of one core)	
Decay heat production, Btu/hr	16.0×10^6
Spent fuel pit water temperature, with cooling in operation, F	150

TABLE 9.1.3-2

SPENT FUEL PIT COOLING SYSTEM EQUIPMENT PARAMETERS

Spent Fuel Pit Pump

Number	1
Design pressure, psig	150
Design temperature, F	200
Design flow, gpm	3000
Minimum Developed head, ft H_2O	125
Material	Stainless Steel

Spent Fuel Pit Skimmer Pump

Number	1
Design pressure, psig	50
Design temperature, F	200
Design flow, gpm	100
Minimum developed head, ft H_2O	50
Material	Stainless Steel

Refueling Water Purification Pump

Number	1
Design pressure, psig	150
Design temperature, °F	200
Design flow, gpm	400
Minimum developed head, ft H_2O	150
Material	Austenitic Stainless Steel

Spent Fuel Pit Heat Exchanger

Number	1	
Design heat transfer, Btu-hr	16.38×10^6	
	Shell	Tube
Design pressure, psig	150	150
Design temperature, ° F	200	200
Design flow, lb/hr	2.00×10^6	1.5×10^6
Inlet temperature, °F	95	120
Outlet temperature, °F	103.2	109.1
Fluid circulated	Component Cooling Water	Spent Fuel Pit Water
Material	Carbon Steel	Stainless Steel

Spent Fuel Pit Demineralizer

Number	1
Design pressure, psig	200
Design temperature, °F	250
Design flow, gpm	100
Resin volume, ft^3	30
Material	Stainless Steel

Spent Fuel Pit Filter

Number	1
Design pressure, psig	150
Design temperature, °F	200
Design flow, gpm	150
Filtration requirement	98% retention of particles above 5 microns
Material, vessel	Stainless Steel

Spent Fuel Pit Skimmer Filter

Number	1
Design pressure, psig	50
Design temperature, °F	200

Spent Fuel Pit Skimmer Filter (cont'd)

Rated flow, gpm	150
Filtration requirement	98% retention of particles above 5 microns
Material, vessel	Stainless Steel

Spent Fuel Pit Strainer

Number	1
Design flow, gpm	3000
Perforation, inches	0.2, slotted
Material	Stainless Steel

Spent Fuel Pit Skimmer Strainer

Number	1
Rated Flow, gpm	100
Design pressure, psig	50
Design temperature, F	200
Perforation, inches	1/8
Material	Stainless Steel

Spent Fuel Pit Skimmer Heads

Number	2
Design flow, gpm	50

Piping and Valves

Design pressure, psig	150
Design temperature, F	200
Material	Stainless Steel

9.1.4 FUEL HANDLING SYSTEM

The fuel handling system is designed to provide a safe, effective means of transporting and handling fuel from the time it reaches the plant until it leaves the plant after post-irradiation cooling. The system is designed to minimize the possibility of mishandling or maloperations that cause fuel assembly damage and/or potential fission product release.

9.1.4.1 Design Bases

The fuel handling system design is based on the following criteria:

1. Components important to safety can be tested and/or inspected.

2. Adequate radiation shielding is provided in the design of the fuel handling facility.

3. Incidents which could cause abnormal exposures and releases from the fuel handling facility are prevented.

4. A significant reduction in fuel storage coolant inventory under accident conditions is prevented.

5. Adequate monitoring of the fuel handling facility is provided.

6. The fuel handling system components safety classification shall be as shown on Table 3.2-1.

7. Cranes which lift spent fuel have a combination of shielding and limited maximum lift so that the radiation at the surface of the refueling water does not exceed 2.5 mr/hr.

8. Cranes are capable of maneuvering their loads to avoid damage to spent fuel, or equipment necessary to safety.

9. Cranes are prevented by both system design and by interlocks from carrying loads over spent fuel.

10. Fuel handling and lifting devices have provisions to avoid dropping or jamming of fuel assemblies during transfer.

11. Fuel handling system includes provisions for retrieving fuel assemblies in the event of system malfunction.

12. The fuel handling system containment penetration is designed to preserve the integrity of the containment pressure boundary.

13. The design of the lifting and handling devices permits the visibility necessary for safe operation.

9.1.4.2. System Description

The fuel handling facilities (plan at elevation 94 feet, Figure 1.2-6) are generally divided into two areas: The refueling cavity, which is flooded only during plant shutdown for refueling; and the spent fuel pit. These two areas are connected by the fuel transfer canal through which the manipulator crane mast travels while transferring fuel between the reactor and the spent fuel pit.

New fuel assemblies are received and inspected in the fuel building, then stored in the new fuel storage area. A new fuel assembly is removed from the racks by the fuel building crane and placed into the new fuel elevator. The fuel assembly is then lowered to the floor of the new fuel elevator pit where it is removed from the elevator and transferred to the reactor vessel by the manipulator crane. The new fuel storage area is sized to accommodate storage of fuel assemblies normally associated with the replacement of one-third of a core. Fuel assemblies for the initial core loading are temporarily stored in the spent fuel pit, which is kept dry during this period.

In the refueling cavity, fuel assemblies are repositioned or removed from the reactor vessel, transferred through the water and placed in storage racks located in the spent fuel pit by a manipulator crane.

The containment equipment hatch is designed to permit the manipulator crane to travel from the refueling cavity to the spent fuel pit. After a sufficient decay period, the fuel assemblies are removed from the racks by the manipulator crane and loaded into a shipping cask for removal from the plant.

Spent fuel assemblies are handled underwater from the time they leave the reactor vessel until they are placed in a cask for shipment from the plant. The water provides an effective, economic and transparent radiation shield, as well as a reliable medium for removal of residual heat. Boric acid is added to the water to ensure subcritical conditions in the reactor during refueling.

Fuel Handling Facilities

1. Refueling Cavity

The refueling cavity is a reinforced concrete structure lined with stainless steel. When filled with borated water for refueling, it forms a pool with the surface approximately 26 feet, 6 inches above the reactor vessel flange and approximately 19 feet above the refueling canal floor. When an irradiated fuel assembly is being transferred in the refueling canal area, the water depth over the active fuel assembly combined with the shielded mast on the manipulator crane limits the radiation at the surface of the water to 2.5 mr/hr.

The reactor vessel flange is sealed to the bottom of the refueling cavity by a clamped, gasketed seal ring which prevents leakage of refueling water from the cavity. This seal is clamped closed during the flooding of the cavity for refueling operations. The cavity provides storage space for the reactor upper and lower internals, and for miscellaneous refueling tools.

2. <u>Fuel Transfer Canal</u>

The fuel transfer canal is a passageway that extends from the refueling cavity to the spent fuel pit. The canal is formed by concrete shielding walls lined with stainless steel extending upward to the same elevation as the refueling cavity. Removable watertight gates located outside the containment isolate the refueling cavity and spent fuel pit. These gates permit draining the refueling cavity while maintaining a normal spent fuel pit water level.

The fuel transfer canal penetrates the containment through a 34 foot nominal diameter hatch. This hatch is sized to allow the manipulator crane with its shielded mast to pass through. The manipulator crane rails through the penetration are mounted on a removable platform section, which when removed, provides clearance for the hatch cover to be put in place. A removable concrete biological shield is provided outside the hatchway. (Refer to Figure 1.2-6.)

3. Spent Fuel Shipping Cask Loading

A spent fuel cask loading pit is located adjacent to the spent fuel pit. The loading pit is constructed of reinforced concrete and lined with stainless steel plate. The cask loading pit is isolated by the separating wall. The gate slot on the separating wall is only of sufficient depth to allow the manipulator crane access to the cask loading pit. An opening, which is provided with a watertight seal plug, is located in the bottom of the cask loading pit. Cask loading is accomplished through this opening. (Refer to Figures 1.2-3, 1.2-6, and 1.2-12.)

The cask will be placed aboard the plant at the 40' elevation on a transfer cart. After the cask is inspected, it will be moved directly below the cask loading pit seal plug. A flexible watertight seal will then be used to join the cask upper flange and the undersurface of the cask loading pit. Seal tests will be conducted. Following the leak tests the cask loading pit seal plug will be removed and stored. The cask head will then be disengaged from the top of the cask, lifted up through the seal and stored. The cask and the cask pit will be filled with borated demineralized water and the gate between the cask pit and the spent fuel pit will be opened, preparatory to inserting spent fuel into the cask. The seal assembly will again be inspected for leaktightness. Loading of the cask is then initiated. The manipulator crane will be used to load spent fuel assemblies into the cask. After the shipping cask is completely loaded, the cask head will be lowered through the seal assembly, and replaced on the cask. The watertight gate between the spent fuel pit and cask loading pit will be replaced, and the cask loading pit will be drained. The cask loading pit plug will then be re-installed. The seal assembly will be drained, and flushed with demineralized water. After the draining and flushing operation is completed, the seal will be removed. The transfer cart with cask will then be moved back out from the loading area. The cask surfaces will be surveyed, cleaned and decontaminated as required. The cask head bolts are replaced and tightened. The cask is then removed from the platform to the transport barge.

Fuel Handling Equipment

1. Reactor Vessel Head Lifting Device (Figure 9.1-4)

The reactor vessel head lifting device consists of a welded and bolted structural steel frame with suitable rigging to enable the polar crane to lift the head and store it during refueling operations. The lifting device is permanently attached to the reactor vessel head. Attached to the head lifting device are the monorail and hoists for the reactor vessel stud tensioners. The head lifting device also acts as a support for the control rod drive mechanism seismic supports, cable tray and ventilation equipment.

2. Reactor Internals Lifting Device (Figure 9.1-5)

The reactor internals lifting device is a structural frame used with the polar crane to lift the internals from the reactor vessel and place them on their storage stands as necessary during refueling operations.

3. Manipulator Crane (Figure 9.1-6)

The manipulator crane transfers fuel assemblies within the core and also between the core and the spent fuel pit. It is a rectilinear bridge and trolley crane with a shielded vertical mast extending down into the refueling water. The bridge spans the cavity and spent fuel pit. The bridge and trolley motions are used to position the vertical mast over a fuel assembly. The manipulator crane is equipped with a monorail hoist to handle some of the various refueling tools.

A telescopic tube with a pneumatic gripper on the end is lowered down from the mast to grip the fuel assembly. The telescopic gripper tube is long enough to permit the upper end to be contained within the mast when the gripper end contacts the fuel. A winch mounted on the trolley raises the gripper tube and fuel assembly into the shielded mast tube. The fuel is transported to its new position while inside the shielded mast tube.

All controls for the manipulator crane are mounted on a console on the trolley. The bridge is positioned on a coordinate system laid out on one rail. The electrical readout system on the console indicates the position of the bridge. With the aid of a scale, which is read directly by the operator at the console, the trolley is positioned on the bridge structure. The drives for the bridge, trolley and winch are variable speed, including a separate inching control on the winch. Electrical interlocks and limit switches on the bridge and trolley drives protect the equipment. In an emergency, the bridge, trolley and winch can be operated manually by using a handwheel on the motor shaft.

The suspended weight on the gripper tool is monitored by an electrical load cell with indication mounted on the control console. A load in excess of 110 percent of a fuel assembly weight automatically stops the winch drive from moving in the up direction and actuates an overload light on the control console. The gripper is interlocked through a weight-sensing device and also a mechanical spring lock so that it cannot be opened accidentally when supporting a fuel assembly.

The manipulator crane will be designed to prevent disengagement of a fuel assembly from the gripper or derailing of the bridge or trolley during design basis platform motion.

4. <u>Containment Jib Crane (Figure 9.1-7)</u>

The 3000-lb capacity containment jib crane is used in the containment to handle the various tools used to service the reactor during refueling or maintenance. The crane is the wall mounted type, driven by a single speed electric motor and equipped with a brake. The boom carries a two-speed electric, wire rope hoist of the standard headroom series. Control of the boom is from a bulkhead mounted push button station. Control of the hoist is from a pendant push button station suspended from the hoist. The crane is designed in accordance with the latest specifications of the Monorail Manufacturer's Association.

5. <u>Rod Cluster Control Changing Fixture (Figure 9.1-8)</u>

A fixture is mounted on the refueling cavity wall for removing rod cluster control (RCC) elements from spent fuel assemblies and for inserting them into new fuel assemblies. The fixture consists of two main components: a guide tube mounted to the wall for containing and guiding the RCC element; and a wheelmounted carriage for holding the fuel assemblies and positioning fuel assemblies under the guide tube.

6. <u>Upper Internals Storage Stand (Figure 9.1-9)</u>

The upper internals storage stand is a structural stainless steel assembly installed in the refueling cavity and is used to support the upper internals package. During refueling, the stand is under water. Guide studs located on the storage stand properly orient the upper internals.

7. <u>Lower Internals Storage Stand (Figure 9.1-10)</u>

The lower internals storage stand is a structural stainless steel assembly installed in the refueling cavity and is used to support the lower internals package when it is removed from the reactor vessel. During refueling, the stand is under water and does not interfere with refueling operations.

8. Reactor Vessel Stud Tensioner

Stud tensioners are employed to secure the head closure joint at every refueling. The stud tensioner is a hydraulically-operated device which permits preloading and unloading of the reactor vessel closure studs at cold shutdown conditions. Stud tensioners minimize the time required for the tensioning or unloading operations. Three tensioners apply simultaneous uniform load to three studs located 120 degrees apart. Relief valves on each tensioner prevent overtensioning of the studs due to excessive pressure.

Charts which indicate stud elongation and load for a given oil pressure are included in the tensioner operating instructions. In addition, micrometers are provided to measure stud elongation after tensioning.

9. Drive Shaft Unlatching Tool (Figure 9.1-11)

The control rod drive shafts are latched and unlatched to the rod cluster control assembly by means of the control rod drive shaft unlatching tool. All drive shafts are removed as a unit with the reactor vessel upper internals.

10. Rod Cluster Control Thimble Plug Tool (Figure 9.1-12)

This long-handled, manually-operated tool is used in the refueling canal to remove and replace the thimble plug in a fuel assembly. When transferring an RCC element from one fuel assembly to another, a thimble plug is inserted in the fuel assembly from which the RCC was removed.

11. Source Tool

Neutron source rods are guided into their respective fuel assembly thimble location by means of the source tool. The source rods are then attached to burnable poison assemblies or to RCC assemblies.

12. Irradiation Sample Handling Tool (Figure 9.1-13)

Irradiation sample capsule assemblies, located below the reactor vessel flange, are remotely removed from the vessel with this tool.

13. New Control Rod Cluster Handling Tool (Figure 9.1-14)

New unirradiated rod control clusters are inspected in the fuel storage building prior to transfer to the reactor core. This tool is used to facilitate inspection and insertion of these assemblies into new fuel elements.

14. Guide Tube Cover Handling Tool (Figure 9.1-15)

RCC guide tube covers are removed from the upper internals assembly in the event removal of a drive shaft is necessary. The covers are remotely removed and reinserted with this tool.

15. New Fuel Assembly Handling Fixture

This short-handled tool is used to handle new fuel on the operating deck of the fuel storage building to remove the new fuel from the shipping container and to facilitate inspection and storage of the new fuel and loading of fuel into the new fuel elevator.

16. Control Rod Drive Shaft Handling Fixture

New control rod drive shafts are handled with this fixture during initial installation into the upper internals.

17. Stud Hole Plugs and Gaskets

The threaded aluminum stud hole plugs are used to prevent refueling water from entering the reactor vessel closure stud holes.

18. Stud Hole Plug Handling Fixture

Stud hole plugs are inserted through the reactor vessel head flange and threaded into stud holes with this fixture.

19. Guide Studs

Three guide studs are inserted into the reactor vessel flange during refueling. The studs guide the closure head off and onto the vessel, and the internals into and out of the vessel.

20. Load Cell

A load cell is inserted between the polar crane hook and the reactor internals lifting rig to monitor the lifting force during removal of the internals and the reactor vessel head.

21. Spring Scales

Spring scales are used to monitor the lifting forces during unlatching of the control rod from the drive shafts and removal of the guide studs to ensure that no load is imposed on the threads. They are also used for installation and removal of the reactor vessel studs to minimize load imposed on the threads.

22. New Fuel Elevator (Figure 9.1-16)

The new fuel elevator is used exclusively to lower a new fuel assembly to the bottom of the cask loading area where it can be transported by the manipulator crane to the reactor vessel. Spent fuel assemblies are never placed in the elevator.

23. Part Length Drive Shaft Latching Tool (Figure 9.1-17)

The control rod drive shafts are disconnected and connected to the part length rod cluster control assemblies by means of the part length control rod drive shaft latching tool. The tool is suspended from the polar crane and is operated from the control rod drive mechanism seismic support.

24. Burnable Poison Rod Assembly Handling Tool

The burnable poison rod assembly handling tool is used to transfer burnable poison rod assemblies between fuel assemblies or between a fuel assembly and a burnable poison rod assembly storage insert located in the spent fuel racks. This tool is hung from the manipulator crane monorail hoist.

25. Storage Inserts for Burnable Poison Rod Assemblies

These storage inserts are placed in spent fuel racks and are used to store used burnable poison rod assemblies when spent fuel assemblies are not available.

26. Stud, Nut and Washer Carrier

Stud, nut and washer carriers provide a means of moving the reactor vessel studs, nuts and washers from the reactor vessel flange elevation to the operating deck. The carriers also serve as storage racks and provide protection for the studs, nuts and washers during refueling operations.

27. Reactor Cavity Seal Assembly

The reactor cavity seal assembly covers and seals the annulus around the reactor vessel during refueling operations when the refueling cavity is flooded.

28. Neutron Detector Installation Device

This device is a mechanical lifting device attached to a monorail located in the in-core instrumentation tunnel. The device provides a means of handling nuclear instrumentation assemblies which are loaded from the bottom. Access to the tunnel is provided by a shaft from elevation 101.

29. Underwater Lighting

Underwater floodlights illuminate the water-filled cavities during refueling operations. The underwater floodlight poles are located along the walls of the reactor cavity area, internals storage area, and fuel transfer and storage area. Each pole supports two adjustable light fixtures.

30. <u>Reactor Vessel Head Storage Stand (Figure 9.1-18)</u>

During refueling the reactor vessel head is placed on a storage stand which provides access for head inspection and O-ring replacement.

System Operation

The refueling operation is divided into five major phases: (1) preparation; (2) reactor disassembly ; (3) fuel handling; (4) reactor assembly; and (5) preoperational checks, tests and startup. A general description of a typical refueling operation through the five phases is given below:

<u>Phase 1-Preparation</u>

1. The fuel handling equipment and manipulator crane are checked out prior to plant shutdown.

2. The reactor is shut down and cooled to ambient condition.

3. A radiation survey is made and the containment vessel is entered.

4. The refueling cavity cover slabs are removed and stored.

5. The equipment hatch shield slab is removed and stored.

6. The equipment hatch is removed and stored.

7. The spent fuel pit rolling cover is extended to the containment and the rolling door at the opposite end of the spent fuel pit is closed.

Phase II-Reactor Disassembly

1. The control rod drive mechanism cables and cooling air ducts are disconnected and moved to storage.

2. The reactor vessel head insulation is removed and placed in storage.

3. Upper instrumentation thermocouple leads are disconnected. The thermocouple column protective sleeve is installed over the top of the support column.

4. The in-core instrumentation thimble guides are disconnected at the seal table and extracted upward.

5. The reactor vessel-to-cavity seal ring is clamped in place.

6. The reactor vessel head nuts are loosened, using the stud tensioner.

7. The part length control rod drive shafts are disconnected, raised, and locked in place in their drive mechanisms.

8. The reactor vessel head studs and nuts are removed and stored.

9. The guide studs are installed in three stud holes. The remainder of the stud holes are plugged.

10. Final preparation is made of underwater lights and tools

11. The reactor vessel head is unseated and raised slightly by the polar crane.

12. The refueling cavity is filled with borated water to the vessel flange.

13. The head is slowly lifted while water is pumped into the cavity. The water level and vessel head are raised simultaneously, keeping the water level just below the head.

14. The reactor vessel head is removed to a dry storage area.

15. The control rod drive shafts are unlatched, using the drive shaft unlatching tool. A check is made to ensure the drive shafts are fully disconnected from the RCC. The control rod drive shafts remain with the reactor vessel upper internals.

16. The reactor internals lifting rig is lowered into position over the guide studs by the polar crane. The rig is then secured to the support plate of the upper internals package.

17. The reactor vessel upper internals and control rod cluster drive shafts are lifted out of the vessel and stored in the underwater storage stand in the refueling cavity.

18. The watertight gates in the fuel transfer canal are removed and stored.

19. Fuel assemblies and rod control clusters are now free from obstructions and are ready to be removed from the reactor core.

Phase III-Fuel Handling

1. The refueling sequence is started with the manipulator crane.

2. The crane is positioned over a fuel assembly in the most depleted

region of the core.

3. The fuel assembly is lifted to a pre-determined height sufficient to clear the fuel transfer canal floor.

4. If the removed assembly contains a rod control cluster, the assembly is placed in the rod control cluster changing fixture.

5. The rod control cluster is removed from the spent fuel assembly and placed in a new fuel assembly or in a transferred spent fuel assembly previously placed in the changing fixture.

6. The spent fuel assembly is moved from the changing fixture by the manipulator crane to the spent fuel storage racks.

7. The new fuel assembly is transferred to the reactor containment with the manipulator crane.

8. Partially spent fuel assemblies are moved from one region to another region of the reactor core.

9. Any new assembly or transferred fuel assembly that will be placed in a control position is first placed in the control rod cluster changing fixture to receive a control rod cluster from a spent

fuel assembly.

10. The new fuel assemblies are loaded into the vacated region of the core.

11. This procedure is continued until refueling is completed.

Phase IV-Reactor Reassembly

1. The watertight gates are placed in position at the spent fuel pit side of the refueling canal.

2. The reactor vessel upper internals are replaced in the vessel by the polar crane.

3. The control rod drive shafts are relatched to the rod cluster control elements.

4. The old seal rings have been removed from the reactor vessel head, the grooves cleaned and new rings installed.

5. The reactor vessel head is picked up by the polar crane and positioned over the reactor vessel.

6. The reactor vessel head is slowly lowered. Simultaneously, the water level is kept just below the head.

7. When the head is about one foot above the vessel flange, the refueling cavity is completely drained and the flange surface is cleaned.

8. The reactor vessel head is seated. Stud hole plugs and guide studs are removed.

9. The head studs and nuts are replaced and retorqued.

10. The part length control rod drive shafts are unlocked, lowered, and connected to the part-length control rods.

11. The vessel head insulation and instrumentation are replaced.

12. The electrical leads and cooling air ducts are reconnected to the control rod mechanisms.

13. The in-core instrumentation thimble guides are reinserted into the core and sealed at the seal table.

14. The reactor vessel-to-cavity seal ring is unclamped.

15. A leak test is performed on the reactor coolant system.

16. The control rod drive mechanisms are checked out for proper operation.

17. The refueling cavity cover slabs are replaced.

18. The equipment hatch is replaced on the equipment opening.

19. The equipment hatch shield slab is replaced.

Phase V-Preoperational Checks, Tests and Startup

Preoperational physics tests are performed as necessary.

9.1.4.3 Design Evaluation

Fuel handling equipment and the manipulator crane are tested prior to each refueling.

During core unloading and loading, the boron concentration shall be sufficient to maintain the clean, cold fully loaded core subcritical by at least ten per cent $\frac{\Delta K}{K}$ with all control rod assemblies inserted. At the same concentration the core shall also be at least one per cent $\frac{\Delta K}{K}$ subcritical with all control rod assemblies withdrawn. The same boron concentration is maintained in the refueling cavity. Periodic checks of the boron concentration shall be made.

At least one residual heat removal pump is available for operation during normal refueling to provide flow through the reactor core and maintain uniform boron concentration.

During all phases of spent fuel transfer to the fuel storage racks, the gamma dose rate at the surface of the water shall be 2.5 mr/hr or less.

All fuel handling facilities are contained and are designed to preclude an accidental release of radioactivity. Monitoring and alarm instrumentation is provided to detect excessive radiation levels and to detect conditions which might result in the loss of capability to remove decay heat.

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 in the control room of reactor neutron flux provides immediate indication of an abnormal core flux level.

Direct communication between the control room and the manipulator crane is available whenever changes in core configuration are taking place. This provision allows the control room operator to inform the manipulator operator of any impending unsafe condition detected from the main control board indicators during fuel movement.

In no case will the failure of any fuel handling system interlock, or combination thereof, result in a more severe event than that described in Section 15.4.

The spent fuel pit is designed to withstand the design basis accident without loss of significant pool water or damage to stored fuel. The spent fuel pit has no gravity drains. The pit cannot be drained to the point of minimum shielding violation by the rupture of any pipe. The postulated spent fuel cask drop accident cannot drain the spent fuel pit since the cask loading area is physically separated from the spent fuel pit.

The spent fuel pit is completely enclosed by a building which is sized to permit the manipulator crane to travel within it. This enclosure building serves to provide appropriate ventilation and filtration to limit the potential release of radioactive iodine and other radioactive materials in the event of a fuel drop accident. Access to the spent fuel pit from the cask loading and new fuel storage area is provided by a vertical rolling door. The other end of the enclosure building is provided with a movable three sided cover which in its extended position extends to the containment biological shield. With the rolling door extended the area is ventilated as described in section 9.4.2. The stationary section of the spent fuel enclosure building forms a tornado missile shield.

The spent fuel pit enclosure building is of sufficient height, width, and length that it is impossible to carry any loads over or in the vicinity of the spent fuel pit. In addition, limit switches restrict the movements of the fuel building crane so that it is impossible for the crane hook to traverse the spent fuel pit.

Fuel Handling Equipment

The maximum design stress for the handling equipment and for all components involved in gripping, supporting or hoisting the reactor components and fuel assemblies is one-fifth ultimate strength of the material.

The fuel handling equipment seismic design is described in Section 3.7.

Electrical interlocks and limit switches on the bridge and trolley drives of the manipulator crane protect the equipment. In an emergency, the bridge, trolley and winch can be operated manually using a handwheel on the motor shafts.

The load on the gripper tool is monitored by an electric load cell indicator mounted on the control console. A load in excess of 110 per cent of a fuel assembly weight stops the winch drive from moving in the up direction. The gripper is interlocked through a weight sensing device and also a mechanical spring lock so that it cannot be opened when supporting a fuel assembly. This is in keeping with the overall fail-safe design approach used in the design of the manipulator crane.

The manipulator crane is provided with the following interlocks to help assure safe operation:

1. Travel limit switches on the bridge and trolley drives.

2. Bridge, trolley and winch drives which are mutually interlocked to prevent simultaneous operation of any two drives.

3. A position safety switch, the gripper tube up position switch, must be actuated in order to operate the bridge and trolley main motor drives.

4. An interlock which prevents the opening of a solenoid valve in

the air line to the gripper except when zero load is indicated by a load cell. As backup protection for this interlock, the mechanical weight actuated lock in the gripper prevents operation of the gripper under load even if air pressure is applied to the operating cylinder.

5. The excessive suspended weight switch opens the hoist drive circuit in the up direction when the loading is excessive.

6. An interlock on the hoist drive circuit for the up direction permits the hoist to be operated only when either the open or closed indicating switch on the gripper is actuated.

7. An interlock of the bridge and trolley drives prevents the bridge drive from traveling beyond the edge of the core unless the trolley is aligned with the transfer canal centerline.

8. The manipulator crane is designed to prevent disengagement of a fuel assembly from the gripper or derailing of the bridge or trolley during the design basis platform motion.

9. The main and auxiliary hoists are equipped with two independent braking systems. A solenoid release - spring set electric brake

is mounted on the motor shaft. This brake operates in the normal manner to release upon application of current to the motor and to set when current is interrupted. The second brake is a mechanically actuated load brake internal to the hoist gear box that sets if the load starts to overhaul the hoist. It is necessary to apply torque from the motor to raise or lower the load. In raising, the motor cams the brake open; in lowering, the motor slips the brake allowing the load to lower. This brake actuates upon loss of torque from the motor for any reason and is not dependent on any electrical circuits. On the main hoist the motor brake is rated at 350 per cent operating load and the mechanical brake at 300 per cent.

All equipment necessary for the refueling operation will be designed to function safely at each point in the refueling cycle up to a specified value of combined platform motions. This value will be such that the probability of exceeding it, and possibly interrupting the refueling process, will be acceptably low. The refueling operation will not be attempted if platform motion exceeds the above mentioned value. In the event that this value is exceeded after the refueling cycle has begun, then the actual handling of the fuel will be halted and the fuel elements and all fuel handling equipment will be safely secured.

9.1.4.4 Testing and Inspection

As part of normal plant operations, the fuel handling equipment is inspected for operating conditions prior to each fuel handling operation. During the operational testing of this equipment, procedures are followed that will demonstrate the prescribed performance of the fuel handling system interlocks.

15. Safeguard room coolers
16. Instrument air compressors
17. Control room and rack process condensing units
18. Generator seal oil cooler
19. Reactor coolant drain tank heat exchanger
20. Recycle evaporator

Circulation of the component cooling water is through the shell side in all of the above heat exchangers.

Auxiliary Raw Water System

The ARW System (Figure 9.2-2) is designed to supply cooling water to the CCW heat exchangers. These are the only components served by this system. The system is required to operate following an accident and/or loss of offsite power. Seawater is circulated on the tube side of the CCW heat exchangers at a pressure lower than the CCW system pressure to preclude leakage into the CCW System.

General design bases for the Auxiliary Raw Water System are as follows:

1. Three independent trains each supplying sea water cooling to a component cooling water heat exchanger.

2. Maximum seawater inlet temperature - 85°F.

9.2.1.2 System Description and Component Design Bases

Component Cooling Water System

Component Cooling Heat Exchangers

The component cooling heat exchangers provide the heat transfer between the CCW System and the ARW System. The raw water, which has the greater tendency to foul, circulates through straight tubes in the heat exchanger to facilitate cleaning. The raw water has a high chloride content which is detrimental to the stainless steel components requiring cooling water.

Therefore, the component cooling water is maintained at a higher pressure in the heat exchanger than the raw water, in order to prevent raw water inleakage to the CCW System.

The capacity of the component cooling heat exchanger is dependent on several design conditions. The system is designed to handle the maximum heat loads generated during normal operating modes; however, the most limiting heat transfer duty placed on the heat exchanger occurs at twenty hours after normal plant shutdown and in presence of a seawater temperature of 85°F. At this time, the reactor coolant is required to have been cooled to at least 140°F; thus, the available temperature difference for heat transfer has been decreased substantially. The minimum available component cooling water temperature at this time is 95°F.

Table 9.2.1-4 details the load requirements at this time. Once the component cooling water system's capacity is determined on this basis, its adequacy is confirmed for the various other plant operational modes.

Component Cooling Pumps

The component cooling pumps circulate component cooling water through the component cooling heat exchangers and then to the various plant heat loads. Three 9000 gpm pumps are provided. Since a component cooling pump may require maintenance because of constant usage, a standby pump is included in the system design. In specifying the component cooling pump flow capacity, the various operational modes of the plant are considered. Tables 9.2.1-1 through 9.2.1-7 describe the various flow requirements.

Component Cooling Surge Tank

The component cooling surge tank accommodates surges resulting from component coolant thermal expansion and contraction and, in addition, collects any water which may leak into the system from components which are being cooled. The surge tank also contains a supply of water to provide a continuous component cooling water supply until a leaking cooling line can be isolated. Water chemistry control of the component cooling water system is accomplished by chemical additions to the surge tank. Makeup water is taken from the primary makeup water system as required, and delivered to the surge tank. The surge tank is at the highest point in the system to facilitate proper filling and venting of the system.

The capacity of the component cooling surge tank is based on its functional requirements described above. The tank volume accommodates thermal transients in the cooling water as well as providing time for the operator to react when inleakage or outleakage develops in the system.

Auxiliary Raw Water System

The ARW System provides sea water to the CCW heat exchangers. The system is composed of three 60 per cent capacity independent loops, with the exception of a common discharge. Each loop flow is adjusted to approximately 18,000 gpm with the remainder of the 20,000 gpm being used for bypass, miniflow and as a supply for the screen wash pump. The raw (sea) water circulates through the tube side of the CCW heat exchangers.

Auxiliary Raw Water Pumps

Three 20,000 gpm centrifugal pumps are provided, each in series with a CCW heat exchanger. These are low head (100 ft.) high volume pumps constructed with appropriate materials to resist seawater corrosion.

Intake Equipment

There are three sets of intake equipment one for each ARW pump suction. The intake equipment consists of bar screens, a self-cleaning strainer and transition connection from the rectangular intake opening in the hull. The bar screen is a fixed screen to prevent large debris from entering the pump suction. The self-cleaning strainer is sized to prevent small marine life and debris from contaminating the system. The strainers are equipped with differential pressure readout locally and in the main control room. Operation of each strainer and back wash pump is initiated locally by manual on-off switching.

Each intake is equipped with a set of guide rails to accommodate a sealing plate which is used if the pump suction must be dewatered.

9.2.1.3 Instrumentation and Control Requirements

9.2.1.3.1 Component Cooling Water System

Several automatic control functions are necessary in the system design. If during normal operation of the plant the component cooling pump becomes inoperative, instrumentation and control logic will provide for the automatic starting of the standby pump. Secondly, if the component cooling water radiation level becomes excessive due to inleakage of reactor coolant, the vent of the component cooling surge tank will be automatically closed by a signal generated from the radiation monitor(s) on the loop. If leakage develops from the thermal barrier of a reactor coolant pump into the component cooling water, a high flow signal isolates the cooling water return header at the containment boundary.

Sufficient flow and temperature indication are provided for leak detection and flow distribution according to the component need. Total flow and temperature indication is also provided. Indication of the outlet temperature of the component cooling heat exchanger is provided to verify that the supply cooling temperature to the reactor coolant pumps does not exceed 120°F during cooldown of the plant.

9.2.1.3.2 Auxiliary Raw Water System

No automatic control functions are necessary in this system. Local pressure gages are provided to confirm proper ARW pump performance. A flow indicator is provided for the miniflow line. The ARW outlet temperature can be monitored on the CCW heat exchanger outlet to verify the heat exchanger performance.

Chemistry Requirements:

The following is a list which specifies component cooling water chemistry for normal operation of the plant.

1. Corrosion inhibitor	K_2CrO_4 or $K_2Cr_2O_7$ 1000 ppm CrO_4 = for first week after filling system; 175 to 225 ppm CrO_4 = thereafter
2. pH at 25°C	8.0 to 8.5
3. Chloride, ppm, max.	0.15
4. Fluoride, ppm, max.	0.1
5. Makeup water	Same quality as for Reactor Coolant System

The raw (sea) water chemistry is adjusted by continuously injecting sodium hypochlorite solution into the suction intakes to maintain 1.0 to 2.0 ppm free chlorine concentration.

9.2.1.4 Design Evaluation

9.2.1.4.1 Component Cooling Water System

The equipment receiving cooling flow is arranged in parallel circuits with the component cooling pumps and component cooling heat exchangers at a common supply and return location for the various cooling circuits. The component cooling heat exchangers are placed at the discharge of the component cooling pumps in order to provide a higher component cooling water pressure with respect to raw water pressure for the previously mentioned chloride inleakage problem. The surge tank is connected to the suction piping of the component cooling pumps.

For a cold shutdown of the plant, all equipment in the component cooling water system is necessary in order to meet the 20 hour 140°F criterion. No redundancy is required in the system because postulated outages of equipment result only in an extended cooldown period.

The component cooling heat exchangers, component cooling pumps, component cooling surge tank, and all associated isolation valves are readily accessible for maintenance and operation. The CCW and ARW systems service components necessary to take the plant to a cold shutdown condition.

Tables 9.2.1-1 through 9.2.1-7, listed below, describe the heat loads and cooling flows of components during various normal operational modes of the plant:

Table 9.2.1-1: Plant startup

Table 9.2.1-2: Normal operation

Table 9.2.1-3: Plant shutdown at 4 hour

Table 9.2.1-4: Plant shutdown at 20 hours

Table 9.2.1-5: Refueling

Table 9.2.1-6: Hot standby

Table 9.2.1-7: Cooldown at 20 hours

9.2.1.4.2 Auxiliary Raw Water System

The cooling water is circulated through the tube side of the CCW heat exchangers. Each CCW heat exchanger is supplied by an ARW pump and flow circuit; there is no cross-connection. The pump suctions are located approximately 20 feet below the normal sea water level and therefore will be flooded. Design ΔT for the ARW System water is 5°F. This is based on a design inlet of 85°F which is a conservative figure for most sea water temperatures. The ARW System is capable of exchanging the maximum heat load the CCW will encounter (i.e., 278×10^6 Btu/hr) during the initial phase of RHR operation. During plant cooldown, the ARW temperature rise will exceed 5°F but will be less than 10°F. Normal heat loads, as tabulated in Table 9.2.1-2, will result in the normal 5°F ΔT.

TABLE 9.2.1-1

PLANT STARTUP

Equipment	Number In Service	Heat load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Exchangers	1 (1)	37.4×10^6	37.4×10^6 (1)	5000	5000 (1)
Spent Fuel Heat Exchangers	1	12×10^6 (4)	12×10^6	3600	3600
Letdown Heat Exchanger	1	15.0×10^6	15.0×10^6	1000	1000
Excess Letdown Heat Exchanger	1	4.6×10^6	4.6×10^6	230	230
Reactor Coolant Pumps	4	1.2×10^6	4.8×10^6	200	800
Seal Water Heat Exchangers	1	2.5×10^6	2.5×10^6	210	210
Boric Acid Evaporator	1	8.13×10^6	8.13×10^6	1200	1200
Boric Acid Evaporator Condenser Cooler	1	(2)	(2)	80	80
Waste Evaporator Condenser	1	1.0×10^6	1.0×10^6	90	90
Waste Gas Compressors	2	$.135 \times 10^6$	$.27 \times 10^6$	25	50
Sample Heat Exchangers	3	$.212 \times 10^6$	$.636 \times 10^6$	14	42

TABLE 9.2.1-1

PLANT STARTUP (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Removal Pumps	2	$.07 \times 10^6$	$.14 \times 10^6$	15	30(3)
Reciprocating Charging Pump	---	---	---	120	120(5)
Centrifugal Charging Pumps	2	$.5 \times 10^6$	1.0×10^6	100	200
Lower Compartment Fan Coolers	4	---	10×10^6	1250	5000
Component Cooling Water Pump Room Cooler	2	---	$.180 \times 10^6$	82	164
Instrument Air Compressors	2	---	$.26 \times 10^6$	----	50
Control Room and Process Rack Room Condensing Unit	2	1.2×10^6	2.40×10^6	200	400
Steam Generator Blowdown Sample Coolers	4	---	$.25 \times 10^6$	7	20
Generator Seal Oil Cooler	1	---	1.28×10^6	----	360
Reactor Coolant Drain Tank	1	---	1.4×10^6	----	225

TABLE 9.2.1-1

PLANT STARTUP (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Waste Gas Recombiner	2	---	---	30	60
Safeguards Area Coolers	2	$.160 \times 10^6$	$.32 \times 10^6$	160	320
	4	$.36 \times 10^6$	1.44×10^6	180	720
TOTAL REQUIRED			105×10^6		20,047
TOTAL AVAILABLE			135×10^6		27,000

Notes:

(1) Discontinued after Reactor Coolant Pumps started.

(2) Included in Boric Acid Evaporator load.

(3) Both pumps received cooling flow.

(4) Spent fuel pit design assumes heat load for 1/3 of a full core stored in spent fuel pit, with maximum water temperature of 120°F. One and one-third cores will raise maximum water temperature to 150°F.

(5) Maximum intermittent load; not normally expected.

TABLE 9.2.1-2

NORMAL OPERATION

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Exchangers	----	----	----	----	----
Spent Fuel Pit Heat Exchanger	1	12.0×10^6	12.0×10^6	3600	3600
Letdown Heat Exchanger	1	15.0×10^6	15.0×10^6	1000	1000
Excess Letdown Heat Exchanger	----	----	----	----	-----
Reactor Coolant Pumps	4	1.2×10^6	4.8×10^6	200	800
Seal Water Heat Exchanger	1	2.5×10^6	2.5×10^6	210	210
Boric Acid Evaporator	1	8.13×10^6	8.13×10^6	1200	1200
Boric Acid Evaporator Condenser Cooler	1	(1)	(1)	160	160
Waste Evaporator Condenser	1	1.0×10^6	1.0×10^6	90	90
Waste Gas Compressors	2	$.135 \times 10^6$	$.27 \times 10^6$	25	50
Sample Heat Exchangers	3	$.212 \times 10^6$	$.636 \times 10^6$	14	42

TABLE 9.2.1-2

NORMAL OPERATION (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Removal Pumps	----	----	----	15	30
Reciprocating Charging Pump	1	$.45 \times 10^6$	$.45 \times 10^6$	100	100
Centrifugal Charging Pumps	----	----	----	100	200
Lower Compartment Fan Coolers	4	----	10×10^6	1250	5000
Component Cooling Water Pump Room Cooler	1	----	$.180 \times 10^6$	82	164
Instrument Air Compressors	2	----	$.26 \times 10^6$	----	50
Control Room and Process Rack Room Condensing Unit	2	1.2×10^6	2.40×10^6	200	400
Steam Generator Blowdown Sample Coolers	4	----	$.250 \times 10^6$	----	28
Generator Seal Oil Cooler	1	----	1.28×10^6	----	360
Reactor Coolant Drain Tank	1	----	1.4×10^6	----	780

TABLE 9.2.1-2

NORMAL OPERATION (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Waste Gas Recombiner	2	----	----	30	60
Safeguards Area Coolers					
	2	$.160 \times 10^6$	$.320 \times 10^6$	160	320
	4	$.36 \times 10^6$	1.44×10^6	180	720
TOTAL REQUIRED			62.676×10^6		15,357

Notes:

(1) Included in boric acid evaporator load.

TABLE 9.2.1-3

INITIAL PLANT SHUTDOWN AT FOUR HOURS
(Residual Heat Removal Initiated)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Exchangers	2	120×10^6	240×10^6	5000	10,000
Spent Fuel Pit Heat Exchangers (1)	----	----	----	----	----
Letdown Heat Exchanger	1	1.2×10^6	1.2×10^6	300	300
Excess Letdown Heat Exchanger	----	----	----	----	----
Reactor Coolant Pumps	1	1.2×10^6	1.2×10^6	200	800(2)
Seal Water Heat Exchanger	1	$.75 \times 10^6$	$.75 \times 10^6$	60	60
Boric Acid Evaporator	1	8.13×10^6	8.13×10^6	1825	1825
Boric Acid Evaporator Condenser Cooler	1	(3)	(3)	160	160
Waste Evaporator Condenser	----	----	----	----	----
Waste Gas Compressors	----	----	----	----	----
Sample Heat Exchangers	3	$.2 \times 10^6$	1.4×10^6	14	42

TABLE 9.2.1-3

INITIAL PLANT SHUTDOWN AT FOUR HOURS (CONT)
(Residual Heat Removal Initiated)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Removal Pumps	2	$.075 \times 10^6$	$.15 \times 10^6$	15	30
Reciprocating Charging Pump	----	----	----	----	----
Centrifugal Charging Pumps	1	$.45 \times 10^6$	$.45 \times 10^6$	100	200
Lower Compartment Fan Coolers	4	----	10×10^6	1250	5000
Component Cooling Water Pump Room Cooler	1	----	$.180 \times 10^6$	82	164
Instrument Air Compressors	2	----	$.26 \times 10^6$	----	50
Control Room and Rack Process Condensing Unit	2	1.2×10^6	2.40×10^6	200	400
Steam Generator Blowdown Sample Coolers	4	----	$.250 \times 10^6$	----	28
Generator Seal Oil Cooler	1	----	1.28×10^6	----	360
Reactor Coolant Drain Tank	1	----	1.4×10^6	----	225

TABLE 9.2.1-3

PLANT SHUTDOWN AT FOUR HOURS (CONT)
(Residual Heat Removal Initiated)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Waste Gas Recombiner	2	----	----	30	60
Safeguards Area Coolers					
	2	$.160 \times 10^6$	$.320 \times 10^6$	160	320
	4	$.36 \times 10^6$	1.44×10^6	180	720
TOTAL REQUIRED			278.04×10^6		20,774

Notes:

(1) Cooling flow not normally required for 20 hour cooldown period; however, if cooling does become mandatory, the cooling flow to the boric acid evaporator is reduced to compensate for spent fuel pit heat exchanger load.

(2) All pumps receive cooling flow, although only one pump is in operation.

(3) Included in boric acid evaporator load.

(4) Cooling flow to both pumps, although only one is in operation.

TABLE 9.2.1-4

PLANT SHUTDOWN AT TWENTY HOURS

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Exchangers	2	37.4×10^6	74.8×10^6	5000	10,000
Spent Fuel Pit Heat Exchangers (4)	----	----	----	----	----
Letdown Heat Exchangers	1	1.2×10^6	1.2×10^6	300	300
Excess Letdown Heat Exchangers	----	----	----	----	----
Reactor Coolant Pumps (5)	----	----	----	200	800(1)
Seal Water Heat Exchanger	1	$.75 \times 10^6$	$.75 \times 10^6$	60	60
Boric Acid Evaporator	1	(2)	(2)	160	160
Waste Evaporator Condenser	----	----	-----	----	----
Sample Heat Exchangers	3	$.212 \times 10^6$	$.636 \times 10^6$	14	42
Residual Heat Removal Pumps	2	$.075 \times 10^6$	$.15 \times 10^6$	15	30

TABLE 9.2.1-4

PLANT SHUTDOWN AT TWENTY HOURS (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Reciprocating Charging Pump	----	----	----	100	100
Centrifugal Charging Pumps	1	$.45 \times 10^6$	$.45 \times 10^6$	100	200 (3)
Lower Compartment Fan Coolers	4	----	10×10^6	1250	5000
Component Cooling Water Pump Room Cooler	1	----	$.180 \times 10^6$	82	164
Instrument Air Compressors	2	----	$.26 \times 10^6$	----	50
Control Room and Rack Process Condensing Unit	2	1.2×10^6	2.40×10^6	200	400
Steam Generator Blowdown Sample Coolers	4	----	$.25 \times 10^6$	----	28
Generator Seal Oil Cooler	1	----	1.28×10^6	----	360
Reactor Coolant Drain Tank	1	----	1.4×10^6	----	225

TABLE 9.2.1-4

PLANT SHUTDOWN AT TWENTY HOURS (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Waste Gas Recombiner	2	----	----	30	60
Safeguards Area Coolers					
	2	$.160 \times 10^6$	$.320 \times 10^6$	160	320
	4	$.360 \times 10^6$	1.44×10^6	180	720
TOTAL REQUIRED			103.540×10^6		19.047

Notes:

(1) All pumps receive cooling flow, although no pumps in service.

(2) Included in boric acid evaporator load.

(3) Cooling flow to both pumps, although only one is in operation.

(4) Cooling flow not normally required for 20 hour cooldown period; however, if cooling does become mandatory, the cooling flow to the boric acid evaporator is reduced to compensate for spent fuel pit heat exchanger load.

(5) Reactor coolant pumps are shut off when reactor coolant is approximately 160°F to 170°F.

TABLE 9.2.1-5

REFUELING

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Exchangers	2[1]	25×10^6	50×10^6[2]	5000[1]	10,000[1]
Spent Fuel Pit Heat Exchanger	1	12×10^6	12×10^6	3600	3600
Letdown Heat Exchanger	1	1.2×10^6	1.2×10^6	300	300
Excess Letdown Heat Exchanger	----	----	----	----	----
Reactor Coolant Pumps	----	----	----	----	(3)
Seal Water Heat Exchanger	1	$.75 \times 10^6$	$.75 \times 10^6$	60	60
Boric Acid Evaporator	1	8.13×10^6	8.13×10^6	1200	1200
Boric Acid Evaporator Condenser Cooler	1	(4)	(4)	160	160
Waste Evaporator Condenser	----	----	----	----	----
Waste Gas Compressors	----	----	----	----	----
Sample Heat Exchangers	1	$.2 \times 10^6$	$.2 \times 10^6$	14	14

TABLE 9.2.1-5

REFUELING (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Removal Pumps	----	----	----	100	100
Centrifugal Charging Pumps	1	$.45 \times 10^6$	$.45 \times 10^6$	100	200 (5)
Lower Compartment Fan Coolers	4	----	10×10^6	1250	5000
Component Cooling Water Pump Room Coolers	1	----	$.180 \times 10^6$	82	164
Instrument Air Compressors	2	----	$.26 \times 10^6$	----	50
Control Room and Process Rack Room Condensing Unit	2	1.2×10^6	2.40×10^6	200	400
Steam Generator Blowdown Sample Coolers	1	----	$.065 \times 10^6$	7	7
Generator Seal Oil Cooler	1	----	1.28×10^6	----	360
Reactor Coolant Drain Tank	1	----	1.4×10^6	----	225

TABLE 9.2.1-5

REFUELING (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Waste Gas Recombiner	2	----	----	30	60
Safeguards Area Coolers					
	2	$.160 \times 10^6$	$.320 \times 10^6$	160	320
	4	$.360 \times 10^6$	1.44×10^6	180	720
TOTAL REQUIRED			88.51×10^6		21,990

Notes:

(1) Number in service is reduces when fuel is transferred to spent fuel pit.

(2) Average load during refueling period, considering residual heat decreasing as a function of time.

(3) Flow may be continued, but there is no heat load.

(4) Included in boric acid evaporator load.

(5) Cooling flow to both pumps, although only one is in operation.

TABLE 9.2.1-6

HOT STANDBY

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Exchangers	----	----	----	-----	----
Spent Fuel Pit Heat Exchanger	1	12×10^6	12×10^6	3600	3600
Letdown Heat Exchanger	1	1.2×10^6	1.2×10^6	300	300
Excess Letdown Heat Exchanger	-----	-----	----	-----	----
Reactor Coolant Pumps	4	1.2×10^6	4.8×10^6	200	800
Seal Water Heat Exchanger	1	2.5×10^6	2.5×10^6	210	210
Boric Acid Evaporator	----	----	----	----	----
Boric Acid Evaporator Condenser Cooler	----	----	----	----	----
Waste Evaporator Condenser	----	----	----	----	----
Waste Gas Compressors	----	----	----	----	----
Sample Heat Exchangers	3	$.212 \times 10^6$	$.636 \times 10^6$	14	42

TABLE 9.2.1-6

HOT STANDBY (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Removal Pumps	----	-----	-----	15	30
Reciprocating Charging Pump	1	$.45 \times 10^6$	$.45 \times 10^6$	100	100
Centrifugal Charging Pumps	----	----	-----	100	200
Lower Compartment Fan Coolers	4	----	10×10^6	1250	5000
Component Cooling Water Pump Room Cooler	2	----	$.180 \times 10^6$	82	164
Instrument Air Compressors	2	----	$.26 \times 10^6$	----	50
Control Room and Process Rack Room Condensing Unit	2	1.2×10^6	2.40×10^6	200	400
Steam Generator Blowdown Sample Coolers	4	----	$.250 \times 10^6$	----	28
Generator Seal Oil Cooler	1	----	1.28×10^6	----	360
Reactor Coolant Drain Tank	1	----	1.4×10^6	----	225

TABLE 9.2.1-6

HOT STANDBY (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Waste Gas Recombiner	2	----	----	30	60
Safeguards Area Coolers					
	2	$.160 \times 10^6$	$.320 \times 10^6$	160	320
	4	$.36 \times 10^6$	1.44×10^6	180	720
TOTAL REQUIRED			39.472×10^6		12,087

TABLE 9.2.1-7

COOLDOWN AT TWENTY HOURS

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Exchangers	2	37.4×10^6	74.8×10^6	5000	10,000
Spent Fuel Pit Heat Exchanger	----	----	----	----	----
Letdown Heat Exchanger	1	1.2×10^6	1.2×10^6	300	300
Excess Letdown Heat Exchanger	----	----	----	----	----
Reactor Coolant Pumps	----	-----	----	200	800
Seal Water Heat Exchanger	1	$.75 \times 10^6$	$.75 \times 10^6$	60	60
Boric Acid Evaporator	----	----	----	----	----
Boric Acid Evaporator Condenser Cooler	----	----	----	---	----
Waste Evaporator Condenser	----	----	----	----	----
Waste Gas Compressors	---	-----	-----	----	-----
Sample Heat Exchangers	3	$.212 \times 10^6$	$.636 \times 10^6$	14	42

TABLE 9.2.1-7

COOLDOWN AT TWENTY HOURS (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Residual Heat Removal Pumps	2	$.075 \times 10^6$	$.15 \times 10^6$	15	30
Reciprocating Charging Pump	----	----	----	100	100
Centrifugal Charging Pumps	1	$.45 \times 10^6$	$.45 \times 10^6$	100	200
Lower Compartment Fan Coolers	4	---	10×10^6	1250	5000
Component Cooling Water Pump Room Cooler	2	---	$.180 \times 10^6$	82	164
Instrument Air Compressors	2	---	$.25 \times 10^6$	----	50
Control Room and Process Rack Room Condensing Unit	2	1.2×10^6	2.40×10^6	200	400
Steam Generator Blowdown Sample Coolers	4	---	$.250 \times 10^6$	7	28
Generator Seal Oil Cooler	1	---	1.28×10^6	----	360

TABLE 9.2.1-7

COOLDOWN AT TWENTY HOURS (CONT)

Equipment	Number In Service	Heat Load, Each Btu/hr	Total Heat Load Btu/hr	Required Flow Each, gpm	Total Flow gpm
Reactor Coolant Drain TAnk	1	-----	1.4×10^6	----	225
Waste Gas Recombiner	2	----	----	30	60
Safeguards Area Coolers					
	2	$.160 \times 10^6$	$.320 \times 10^6$	160	320
	4	$.360 \times 10^6$	1.44×10^6	180	720
TOTAL REQUIRED			95.490×10^6		18,857

9.2.2 ESSENTIAL COOLING WATER SYSTEMS

The Essential Cooling Water Systems are comprised of two separate mutually dependent systems, the Essential Service Water System and the Essential Raw Water System. These two systems operate together to furnish cooling water to essential safeguard components.

9.2.2.1 Essential Service Water System

9.2.2.1.1 Design Bases

The Essential Service Water System (ESW) is a closed system circulating treated cooling water to essential safeguard components required immediately following a safety injection signal and/or loss of off-site electrical power. Heat from the safeguards components is transferred by the ESW system to the Essential Raw Water System (ERW) via the ESW heat exchangers. The ERW system supplies seawater to transfer heat from the ESW system to the ocean (ultimate heat sink). The ESW system provides an intermediate barrier between reactor coolant and seawater.

The ESW system operates only under accident conditions (safety injection signal and/or loss of off-site electrical power). The system does not operate during normal plant operation, except as required for testing.

The design of the ESW system as a system to be used only during accident conditions specifies a relatively small system (as compared to the Component Cooling Water System) capable of supplying cooling water to those components required immediately after a safety injection signal and/or loss of offsite electrical power. Use of this relatively small system reduces pumping requirements, and therefore reduces the power requirements of each diesel train during the automatic loading sequence following a safety injection signal or loss of off-site electrical power.

The ESW system supplies cooling water to essential components at a maximum temperature of 95°F with a maximum seawater temperature of 85°F.

The ESW system is designed and classified as ANS Safety Class 3, except for those portions which penetrate the containment which are classified as ANS Safety Class 2.

9.2.2.1.2 System Description

The ESW System shown in Figure 9.2-3 consists of four trains. Each of the four trains contains its own pump, heat exchanger, surge tank, piping, valves, and instrumentation required for operation. The major system components (ESW pumps and heat exchangers) are located in the plant safeguards area at elevation 21' 4".

Equipment cooled by the ESW system during accident conditions is listed in Table 9.2.2-1. Equipment listed in Table 9.2.2-1, which is required for normal operations (startup, power operation, cooldown), is cooled by the Component Cooling Water System (CCW). Engineered safety class valving and circuitry are provided to transfer these loads automatically from the CCW system to the ESW system immediately following a safety injection signal and/or loss of off-site electrical power. Power for the electrically operated valves is supplied by the safeguard bus associated with the particular train of the ESW system in which the valve is located.

Table 9.2.2-2 lists the components cooled by the ESW system and specifies the minimum number of these cooled components that are required during accident conditions. Table 9.2.2-3 lists the heat load and flow requirements of the ESW system during safety injection and during loss of off-site electrical power. The component distribution is such that if one complete train is lost, the three remaining operational trains provide sufficient cooling to the required safeguards components. Thus, a single failure will not prevent the system from performing its design function.

The ESW system circulates treated water to prevent corrosion of the system and its cooled components. The chemistry requirements of the water are listed in Table 9.2.2-4. In each train the cooling water is circulated by the pump through the shell-side of the ESW heat exchangers, to the

TABLE 9.2.2-1

ESSENTIAL SERVICE WATER SYSTEM

COMPONENTS AND OPERATING CONDITIONS

Cooling Load	Normal Operations (1)	Loss of Off-Site Electrical Power	Safety Injection
Emergency Diesel Coolers (2)		X	X
Generator Seal Oil Cooler	X	X	X
Safeguards pumps (3)			X
Reactor Coolant Pump Thermal Barriers	X	X	
Emergency Control Air Compressors		X	X
Emergency Relocation Area Coolers		X	X
Control Room and Process Rack Room Condensing Unit (4)	X	X	X
Residual Heat Removal Pumps (3)	X		X
Safeguards Area Coolers (5)	X	X	X
Safeguards Area Coolers (6)		X	X

NOTES:

(1) Equipment listed which is required during normal operations (start-up, power operation, cooldown) will be cooled normally by the CCW. Appropriate valving is provided in the ESW to transfer these loads automatically from the CCW to the ESW immediately following Safety Injection and/or loss of off-site power.

NOTES (CONT.)

(2) In order to establish the required cooling water flow to the emergency diesels, the essential service water pumps are started early in the safeguards sequence.

(3) Cooling water for bearings and shaft seals of two high head safety injection pumps, two residual heat removal pumps, two safety injection pumps and four containment spray pumps.

(4) These coolers provide chilled water for the control room and process rack room air conditioning equipment, which is required to be in service at all times.

(5) These cooler units are provided to remove heat generated by the following equipment.

a) Auxiliary Raw Water pump motors
b) Component Cooling Water pump motors
c) Component Cooling Water heat exchangers
d) Fire pump motors
e) Auxiliary feed pump motors
f) Essential raw water pump motors
g) Essential service water pump motors

(6) These cooler units are put into operation to remove heat generated by the following equipment during accident conditions:

a) Containment spray heat exchangers
b) RHR pump motors
c) RHR heat exchanger
d) Containment spray pump motors
e) Safety injection pump motors
f) High Head Safety injection pump motors

TABLE 9.2.2-2

ESSENTIAL SERVICE WATER SYSTEM LOAD REQUIREMENTS

Component	Number Installed	No. Required During Safety Injection	No. Required During Loss Of Off-Site Power
Emergency Diesel Coolers	4	3	3
Generator seal oil cooler (1)	1	1	1
Containment spray pumps	4	3	0
Residual heat removal pumps	2	1	0
High head safety injection pumps	2	1	0
Safety injection pumps	2	1	0
Reactor coolant pump thermal barriers (2)(3)	1	0	1
Emergency Control Air compressors	2	1	1
Control room and process rack room condensing units	2	1	1
Emergency relocation area coolers	2	1	1
Safeguard area coolers	4	3	3

NOTES:

(1) The required flow to the generator seal oil cooler can be supplied by either Train No. 1 or Train No. 4 independently.

(2) There are four reactor coolant pump thermal barriers arranged as one heat load.

(3) The required flow to the reactor coolant pump thermal barrier can be supplied by either Train No. 2 or Train No. 3 independently.

TABLE 9.2.2-3

ESSENTIAL SERVICE WATER FLOWS AND HEAT LOAD REQUIREMENTS

A. ESW HEAT LOAD DURING LOCA ($X10^6$ $\frac{BTU}{HR}$)

Component	Train Number #1	#2	#3	#4
Emergency Diesel Gen.	4.70	4.70	4.70	4.70
Generator Seal Oil Cooler(1)	1.28			1.28
CSS Pumps	.08	.08	.08	.08
RHR Pumps	.08	.08		
High Head SI Pumps	.28		.28	
SI Pumps		.08		.08
RCP Thermal Barrier				
Emergency Cont. Air Comp.	.05	.05		
Control Room & Process Rack Room Condensing Unit		1.38	1.38	
Safeguard Area Coolers	.36	.36	.36	.36
Safeguard Area Coolers	.32	.32	.19	.19
Emergency Relocation Area Units	____	.42	____	.42
Total Heat Load	7.13	7.47	6.99	7.11
Design Heat Capacity of each ESW Heat Exchanger	10.0	10.0	10.0	10.0

(1) The required heat load of the Generator Seal Oil Cooler can be removed by either Train No. 1 or Train No. 4 independently.

TABLE 9.2.2-3 (CONT)

B. ESW FLOW REQUIREMENTS DURING LOCA

Component	Train Number #1	#2	#3	#4
Emergency Diesel Gen.	400	400	400	400
Generator Seal Oil Cooler(1)	360			360
CSS Pumps	20	20	20	20
RHR Pumps	15	15		
High Head SI Pumps	30		30	
SI Pumps		30		30
RCP Thermal Barrier				
Emergency Cont. Air Comp.	5	5		
Control Room & Process Rack Room Condensing Unit		200	200	
Safeguard Area Coolers	180	180	180	180
Safeguard Area Coolers	160	160	100	100
Emergency Relocation Area units	___	80	___	80
Total (gpm)	1170	1090	930	1180
Design Flow of each ESW Train (gpm)	1300	1300	1300	1300

(1) The required flow of 360 gpm to the Generator Seal Oil Cooler can be supplied by either Train No. 1 or Train No. 4 independently.

TABLE 9.2.2-3 (CONT)

C. ESW HEAT LOAD DURING LOSS-OF-OFF-SITE POWER ($\times 10^6$ $\frac{BTU}{HR}$)

Component	Train Number #1	#2	#3	#4
Emergency Diesel Gen.	4.70	4.70	4.70	4.70
Generator Seal Oil Cooler	1.28			1.28
CSS Pumps	(1)	(1)	(1)	(1)
RHR Pumps				
High Head SI Pumps	(1)		(1)	
SI Pumps		(1)		(1)
RCP Thermal Barrier		1.76(2)	1.76(2)	
Emergency Cont. Air Comp	.05	.05		
Control Room & Process Rack Room Condensing Unit		1.38	1.38	
Safeguard Area Coolers	.36	.36	.36	.36
Safeguard Area Coolers			(1)	(1)
Emergency Relocation Area Units	___	(1)	___	(1)
Total Heat Load	6.39	8.25	8.20	6.34
Design Heat Capacity of each ESW Heat Exchanger	10.0	10.0	10.0	10.6

(1) Flow provided to component, but not required for cooling.

(2) The required flow of 200 GPM can be supplied by either Train No. 2 or Train No. 3 independently.

TABLE 9.2.2-3 (CONT)

D. ESW FLOW REQUIREMENTS DURING LOSS-OF-OFF-SITE POWER

Component	#1	Train Number #2	#3	#4
Emergency Diesel Gen.	400	400	400	400
Generated Seal Oil Cooler	360			360
CSS Pumps	20(1)	20(1)	20(1)	20(1)
RHR Pumps				
High Head SI Pumps	30(1)		30(1)	
SI Pumps		30(1)		30(1)
RCP Thermal Barrier		200	200	
Emergency Cont. Air Comp.	5	5		
Control Room & Process Rack Room Condensing Unit		200	200	
Safeguard Area Coolers	180	180	180	180
Safeguard Area Coolers			100(1)	100(1)
Emergency Relocation Area Units	____	80(1)	____	80(1)
Total GPM	995	1115	1130	1180
Design Flow of Each ESW Train (GPM)	1300	1300	1300	1300

(1) Flow Provided to component, but not required for cooling.

TABLE 9.2.2-4

ESSENTIAL SERVICE WATER SYSTEM WATER CHEMISTRY

Corrosion inhibitor	K_2CrO_4 or $K_2Cr_2O_7$ - 1000 ppm (CrO_4) for first week after filling system; 175-225 ppm (CrO_4) thereafter.
pH at 25° C	8.0 to 8.5
Chloride, maximum, ppm	0.15
Fluoride, maximum, ppm	0.1
Makeup water	Same quality as listed for the Reactor Coolant System

components and back to the pump suction. A surge tank is provided for each train and is connected to the pump suction line to provide adequate net positive suction head. The surge tank accommodates expansion and contraction of the system water due to temperature changes or in-leakage, as well as providing a continuous water supply until a small leak in the system can be isolated. An overflow line is provided between the surge tanks of trains No. 2 and 3, and trains No. 1 and 4. The overflow line is located at a tank elevation such that the normal operating water level will be maintained in the two connected surge tanks during operation, and yet prevent loss of water from one surge tank from affecting the normal operating level of the other tank. Since the surge tanks are normally vented to the atmosphere, each train has an installed scintillation crystal photo-multiplier detector. This detector continuously monitors for activity indicative of a reactor coolant leak from any of the components served by the system. A high activity condition automatically shuts the affected train's surge tank vent valve and sounds an alarm in the control room. Thus, a release of activity is prevented and the operator is alerted to the condition.

The ESW system trains Nos.1 and No. 4 are identical, as are trains Nos. 2 and 3. Trains Nos. 2 and 3 provide cooling water to the reactor coolant pump thermal barriers, and either train can supply sufficient water to provide the required cooling if one of the two trains is lost. The same is true of trains Nos. 1 and 4, which have a common cooling load of the generator seal oil cooler. Trains Nos. 2 and 3 (and trains Nos. 1 and 4) are interconnected after the valve sequencing operation takes place following the safety injection signal and/or loss of off-site electrical power. In order to limit the time that the above trains are interconnected, it will be operating procedure to isolate one of the two trains from the common load after the ESW has come on the line and is operating properly (selection of which train to isolate is at the operator's discretion.) Automatic protection isolates trains nos. 2 and 3 (and trains Nos. 1 and 4) from their respective common loads in the event of a leak affecting one or both trains. Isolation valves to and from the reactor coolant pump thermal barrier are actuated by the level detectors of the surge tanks in trains Nos. 2 and 3. Should a low-low level occur in either surge tank (trains Nos. 2 or 3), all four reactor coolant pump thermal barrier isolation valves shut. Thus, if the cause of the low level is a leak in the common piping of the reactor coolant pump thermal barrier, trains Nos. 2 and 3 are isolated from each other and both trains remain in service. If the cause of the low level in the surge tank is not due to a leak in the common piping, the operator can return cooling water to the reactor coolant pump thermal barrier from the unaffected train. The same isolation protection as described above is provide for the generator seal oil cooler of trains Nos. 1 and 4.

ESW system component design data are listed in Table 9.2.2-5.

TABLE 9.2.2-5

ESSENTIAL SERVICE WATER SYSTEM COMPONENT DATA

System

Design flow, gpm	1300 (each subsystem)	
Design pressure, psig	150	
Design temperature, ^{o}F	150	
Piping material	Carbon Steel	

Heat Exchangers

Number	4	
Type	Shell and straight tube	
Design heat duty, Btu/hr.	10×10^6	
	Shell Side	Tube Side
Fluid	Service water	Seawater
Design flow, gpm	1300	4000
Inlet temperature, ^{o}F	110	85
Outlet temperature, ^{o}F	95	90
Design pressure, psig	150	150
Design temperature, ^{o}F	200	200
Material	Carbon steel	90-10 Copper-Nickel

TABLE 9.2.2-5 (CONT)

ESSENTIAL SERVICE WATER SYSTEM COMPONENT DATA

Pumps	
Number	4
Type	Single-stage, centrifugal
Design flow, gpm	1300
Design head, ft.	125
Horsepower, hp	60
Material:	
Casing	Cast Carbon Steel
Impeller	Cast Iron
Shaft	Carbon Steel
Surge Tanks	
Number	4
Type	Vertical cylindrical tank, closed top with atmospheric vent and chemical addition port
Volume, cu. ft.	200
Design temperature, ^{o}F	150
Design pressure, psig	150
Material	Carbon Steel

The ESW heat exchangers are of the shell and tube type. Essential Service Water flows through the shell side of the heat exchanger at a higher pressure than the Essential Raw Water in the tubes. Thus, any leakage would be of Essential Service Water to the seawater.

The ESW pumps are horizontal centrifugal units. The pump motors receive electrical power from the diesel generators or normal station power.

The ESW surge tank in each train has a connection to the Makeup Water System to provide makeup water. In addition to piping connections, each tank is provided with a means for adding a chemical corrosion inhibitor to the ESW system. Each surge tank has level indicating equipment which alarms in the control room to warn of a high or low level condition. Redundant level monitoring equipment also provides a low-low level alarm which automatically isolates selected components as mentioned above.

All ESW system piping is carbon steel with welded joints and connections, except at components which might require removal for maintenance.

9.2.2.1.3 Design Evaluation

The ESW system is composed of four trains, of which, three are required to operate to provide sufficient cooling water to essential equipment required during safety injection and/or loss of off-site electrical power. Table 9.2.2-6 provides a failure analysis which demonstrates that adequate safety margins are included in the size and number of components to preclude the possibility of a single failure from adversely affecting operation of safeguards equipment.

The ESW pumps are automatically placed on emergency diesel power and started in the event of loss of off-site power; therefore, the minimum safeguards requirements are met with regard to the supply of essential service water.

To minimize the possibility of leakage from piping, valves, and equipment, welded construction is used wherever possible. The ESW could become contaminated with radioactive water due to a leaking cooling coil from the thermal barrier on a reactor coolant pump. Tube or coil leaks in components being cooled are detected by the installed radiation monitor. Equipment vent and drain lines outside the containment have manual valves which are normally closed unless the equipment is being vented or drained for maintenance or repair operations.

The relief valve protecting the reactor coolant pump thermal barrier and its associated piping is designed to relieve thermal expansion if the cooling line is isolated when the Reactor Coolant System is hot. The

TABLE 9.2.2-6

SINGLE FAILURE ANALYSIS OF THE ESSENTIAL SERVICE WATER SYSTEM

Component	Malfunction	Effect on Safety-Related Systems	Comments
1. ESW pump	Stops pumping	No effect	Four pumps are provided (one per train). Three of four trains required to meet minimum safeguards.
2. ESW supply or return isolation valves for Generator Seal Oil Cooler	Fails to Open	No Effect	Either of two trains can supply sufficient flow to Generator Seal Oil Cooler. Valves have manual operators.
3. CCW supply or return Valve for Generator Seal Oil Cooler	Fails to Shut	No Effect	Check valve in supply line prevents flow from ESW system to CCW system. Stop valves in supply and return lines have manual operators.
4. ESW supply or return valves for Control room and Process Rack Room Condensing Unit.	Fails to Open	No Effect	Two Condensing units provided on separate trains. Only one condensing unit required to meet minimum safeguards.
5. CCW supply or return valves for Control Room and Process Rack Room Condensing Unit	Fails to Shut	No Effect	Check valve in supply line prevents flow from ESW system to CCW system. Stop valves in supply and return lines have manual operators.

TABLE 9.2.2-6

SINGLE FAILURE ANALYSIS OF THE ESSENTIAL SERVICE WATER SYSTEM

Component	Malfunction	Effect on Safety-Related Systems	Comments
6. ESW Heat Exchanger	Heat Exchanger fails	No Effect	Four heat exchangers provided(one per train). Three of four trains required to meet minimum safeguards.

cooling water piping from the check valve upstream of the barrier to the valve downstream which closes on high flow is designed for primary system pressure. If the thermal barrier ruptures, the line is automatically isolated and the relief valve accommodates thermal expansion of the fluid in the isolated section. Discharged water is directed to the waste holdup tank.

The relief valve on the essential service water surge tank of trains Nos. 2 and 3 is sized to relieve the maximum flow rate of water which enters the surge tank following a rupture of a reactor coolant pump thermal barrier cooling coil, should this system not be isolated. The pressure setpoint is less than the design pressure of the essential service water surge tank. The discharge of these valves is directed to the waste holdup tank. The relief valves on the surge tank of trains Nos. 1 and 4 are the same size as those for trains Nos. 2 and 3 for uniformity purposes and provide adequate relief protection.

The ESW pumps, heat exchangers, and associated valves, piping and instrumentation are located outside the containment and are therefore available for maintenance and inspection during power operation. The exceptions to the above are the cooling lines for the reactor coolant pump thermal barriers which are automatically isolated on a "P" signal.
The ESW supply line to the reactor coolant pump thermal barrier contains a check valve inside containment and remote operated valves

outside the containment. The return line has two remote operated valves outside the containment.

Motor operated valves are provided to transfer automatically selected essential components normally cooled by the CCW system to the ESW system during safety injection and/or loss of off-site electrical power. Electrical power to operate these valves is provided by the emergency diesel generator associated with the particular train of the ESW system in which the valve functions. All motor operated valves can be operated manually if required.

9.2.2.1.4 Tests and Inspections

Since the ESW system is a stand-by system that is required to start up and come on the line automatically during accident conditions, provisions are provided to test the automatic startup of the pumps and the opening and/or closing of the valves. Tests and inspections of individual components in the system can be conducted as follows:

1. Pumps and Drive Motors
   Each train of the ESW system is provided with a by-pass line and flow indicator to permit testing of the ESW pump. The pump can be started and run for sufficient time to assure proper operability. While operating, pump flow, discharge pressure, and suction pressure can be checked and recorded.

2. Manual Valves

Each valve outside containment can be cycled and checked for proper operation and condition.

3. Motor Operated Valves

Each valve can be operated electrically and manually to check for proper operation and condition. Position indicators or indicating lights can be observed.

4. Level Indicators and Controls

Level sensing devices and their control and/or indicating functions can be checked by using portable d/p testing equipment.

5. Flow Detectors

Flow detectors and their control and/or indicating functions can be checked by using portable d/p testing equipment.

6. Pressure Gauges and Thermometers

Thermometers and pressure gauges can be removed and tested using test devices. Some pressure gauges can be tested in place where test connections are provided.

9.2.2.1.5 Instrumentation and Application

Figure 9.2-3 shows the instruments that are provided for the ESW system. The instrumentation provided is intended to provide both indication and control of system operation. The following specific instrumentation is provided.

1. Surge Tank Level Detectors

   These detectors provide both level indication and alarms in the control room.

2. Temperature Detectors

   Detectors are provided at the inlet and outlet of the ESW heat exchangers to monitor heat exchanger performance. In addition, the outlet detector provides a high temperature alarm in the control room as an indication of improper ERW or ESW flows. Local detectors are also provided downstream of various cooled components as an indication of proper cooling water flow.

3. Pressure Detectors

   Detectors are provided for the ESW pump suction and discharge to monitor pump performance. The pump discharge detector provides a low pressure alarm in the control room as an indication of improper pump operation.

4. Flow Detectors

   Various flow detectors are provided to indicate flow to cooled components. A flow detector on the outlet cooling line from the Reactor Coolant Pump thermal barriers isolates flow from the thermal barriers in the event of a high flow condition which is indicative of a rupture of the thermal barrier.

5. Valve Position Indication

   Valve position indicator lights are provided for the operator to determine the proper position and operation of motor operated valves.

9.2.2.2 Essential Raw Water System

9.2.2.2.1 Design Bases

The Essential Raw Water System (ERW) provides seawater at a maximum temperature of 85°F to the Essential Service Water (ESW) heat exchangers following safety injection and/or loss of off-site electrical power. The ERW system does not operate during normal plant operation, except as required for testing.

The entire ERW system is designed and classified as ANS Safety Class 3.

9.2.2.2.2 System Description

The ERW system, shown in Figure 9.2-4, consists of four independent trains. Each of the four trains are identical and consist of a pump, duplex strainer, piping, valves and instrumentation. The major components of the ERW system are located in the plant safeguards area at elevation 7'6" and 21'4". Each train of the ERW system has two sets of seawater intakes to provide water from the breakwater basin. The intakes are circular openings flush with the platform hull and fitted with coarse screens similar to those used for ship intakes. The screens are made of a fiber-glass material so that they will be light-weight to facilitate removal and handling underwater. The intake has a sea chest which necks down in diameter from the opening at the hull to the point at which it joins the system suction piping. One suction intake line extends horizontally to the edge of the platform and the other vertically to the platform bottom. The intake piping joins together in a "tee" and the common pipe penetrates the safeguard compartment and connects to an in-line duplex strainer at the pump suction. The discharge piping of each train penetrates the compartment bulkhead and extends to the side of the platform.

Each train of the ERW system is normally isolated and filled with fresh water to minimize marine growth and corrosion of system components. A 350 gallon head tank connected to the ERW pump suction piping, is provided for each ERW train. The head tank is located at an elevation approximately 5 feet above the normal platform waterline. The purpose of the head tank is:

1. Maintain a head of fresh water on each ERW train, when it is not in operation, which is greater than the external seawater head (approximately 5 feet). Thus, any hull isolation valve leakage will be of freshwater from the ERW system to the sea, thereby preventing seawater from entering the system.

2. Maintain points in the ERW system, which are higher than the platform water level, full of fresh water when the system is not in operation.

3. Provide a continuous vent path from high points in the ERW system.

A vent header runs from high points in the ERW system to the top of the head tank, which is continuously vented to the atmosphere. The vent header ensures that the ERW system remains free of air and non-condensible gases both during system operation and shutdown. During system operation a small amount of water will continuously flow through the vent header to the head tank, and back to the pump suction. Level indication and a low level alarm are provided for the head tank to indicate possible system leakage during stand-by conditions.

Piping connections are provided from each train of the ERW system to the trim tank located between bulkheads I-K and bulkheads 1-2. These connections are provided to test the ERW system as described in Section 9.2.2.2-4, using fresh water. Trains Nos. 1 and 2 have connections to provide a source of raw water to the Auxiliary Feedwater System in the event the normal supply of auxiliary feedwater is not available.

The ERW system is designed to supply cooling water to the ESW heat exchangers and to the Containment Spray (CSS) heat exchangers during safety injection and/or loss of off-site electrical power. The system does not operate during normal plant operation (startup, power operations, cooldown). During safety injection and/or loss of off-site power conditions, the ERW system isolation valves will open and the pumps will start automatically to provide cooling water (seawater) flow. Cooling water is provided to the CSS heat exchangers during loss of off-site power even though it is not required. A radiation detector is installed downstream of the CSS heat exchanger in each train to detect possible radioactive leakage from the heat exchangers to the ERW system. The detector alarms in the control room to alert operating personnel of the condition.

The ERW system component design data are listed in Table 9.2.2-7.

The pumps which circulate seawater through the ERW system are horizontal single stage centrifugal units. The pump motors receive electrical power from the diesel generators or normal station power.

The ERW system duplex strainers can be shifted manually when required, and

TABLE 9.2.2-7

ESSENTIAL RAW WATER SYSTEM COMPONENT DATA

System

Design flow, gpm	7500 (each subsystem)
Design pressure, psi	150
Design inlet temperature, ^{o}F	85
Design temperature, ^{o}F	150
Fluid	Seawater (system normally filled with fresh water when not in operation).
Piping material	Carbon steel between hull isolation valves. 90-10 Cu-Ni between hull and hull isolation valves.
Intake screen	Fiberglass

Pumps

Number	4
Type	Single-stage, centrifugal
Design flow, gpm	7500
Design head, ft.	100
Horsepower, hp	250

TABLE 9.2.2-7 (CONT)

Pumps (cont)

Material	
Casing	Stainless steel
Impeller	Stainless steel
Shaft	Stainless steel

Strainers

Number	4
Type	Duplex
Design flow, gpm	7500
Design pressure drop, psi	.95 (clean strainer)
Strainer capability	Particles $\geq$ 1/4 inch

Head Tank

Number	1
Capacity, gal.	350
Design pressure, psi	Atmospheric pressure
Material	Carbon Steel

the dirty element cleaned without interrupting flow. The strainer differential pressure is monitored by a differential pressure detector which alarms in the control room to indicate the onset of strainer clogging and to alert operating personnel to shift strainers.

All ERW piping between the hull isolation valves is carbon steel. The pipe between the hull and the normally closed isolation valves, which is exposed to seawater, is 90-10 Cu-Ni alloy. The sea chest is constructed of the same material as the platform hull and protected by the hull's cathodic protection system.

9.2.2.2.3 Design Evaluation

The ERW system is composed of four trains, of which three are required to operate to provide sufficient cooling water during safety injection and/or loss of off-site electrical power. Table 9.2.2-8 provides a failure analysis which demonstrates that adequate safety margins are included in the number of components to preclude the possibility of a single failure adversely affecting operation of safeguards equipment.

The ERW pumps are automatically placed on diesel power and started in the event of loss of off-site electrical power. Motor operated hull isolation valves receive electrical power from the diesel generator associated with the particular train of the ERW system in which the valve functions. All motor operated valves can be operated manually if required.

TABLE 9.2.2-8

SINGLE FAILURE ANALYSIS OF THE ESSENTIAL RAW WATER SYSTEM

Component	Malfunction	Effect on Safety-Related Systems	Comments
1. ERW Pump	Stops pumping	No effect	Four pumps are provided (one per train). Three of four trains required to meet minimum safeguards.
2. ERW Intake or Discharge Hull Isolation Valve	Fails to Open	No effect	Only three of four trains required to meet minimum safeguards. Valves have manual operators.
3. ERW Intake	Becomes clogged	No effect	Each ERW train is equipped with two full size intakes.

The ERW pumps and associated valves, piping and instrumentation are located in the plant safeguard areas and are, therefore, available for maintenance and inspection during power operation. To minimize the possibility of system leakage from piping, valves, and equipment, welded construction is used wherever possible. The ERW system could become contaminated with radioactive water due to a leaking CSS heat exchanger during an accident. Leaks are detected by a radiation monitor downstream of each CSS heat exchanger and alarms in the control room. Operating personnel can then take action to isolate the leak and prevent spread of activity to the outside environment.

Excessive corrosion or marine fouling of the ERW system carbon steel piping inside of the hull isolation valves is prevented by filling that portion of the system with fresh water when it is not in use. Provisions are provided to test the ERW system with fresh water from the platform trim system, thus precluding the use of seawater for test purposes. Local samples may be taken from the fresh water periodically to ensure that a high chloride content does not exist in the system. The portion of piping between the isolation valves and the hull, which is constantly exposed to seawater, is constructed of 90-10 Cu-Ni. 90-10 Cu-Ni alloy is very resistant to seawater corrosion and also possesses a unique anti-fouling characteristic. The section of 90-10 Cu-Ni piping will be electrically insulated from the carbon steel piping to prevent galvanic corrosion between the two metals. The sea chest strainer is made of a fiberglass material which is corrosion resistant. The strainer will be coated/ painted with an anti-fouling material. The light weight of the fiberglass strainer permits removal by divers at periodical intervals to clean and re-coat the strainer with anti-fouling material as required.

An assured source of cooling water (seawater) is provided within the breakwater basin which is open to the sea. Two full ERW system capacity intakes are provided per train to assure a supply of seawater in the event one intake is blocked. The basin will be monitored for excess silting and if it occurs, dredging will be performed to maintain proper water depth.

9.2.2.2.4 Test and Inspections

Since the ERW system is a stand-by system that is required to startup and come on the line automatically during accident conditions, provisions are made to test the automatic startup of the pumps and the opening or closing of motor operated valves. A means of flow testing the ERW system using fresh water from the platform's trim system (Section 9.6.2) is provided. The platform trim tank between bulkheads I-K, and bulkheads 1-2 has a maximum water capacity of 3700 tons, and a nominal operating capacity of 1850 tons. Piping is routed from this trim tank to the suction side of each ERW pump (downstream of the hull valve) and from the ERW discharge (upstream of the hull valve) back to the trim tank. Sketch 1 of Figure 9.2 shows the piping and valve arrangement. To line up the ERW system for test (see sketch 1), valves # 5 and #6 are opened: valves #2 and #3 are closed. The automatic functions of the system can then be tested by initiating a test signal which opens motor operated valves #1 and # 4, and starts the ERW pump. Fresh water will be circulated from the trim tank, through the ERW system, and back to the trim tank. The ERW pump can be run for a sufficient time to assure proper operability. While operating pump flow, discharge pressure, and suction pressure can be checked and recorded.

Sufficient cooling water exists in the trim tank to test one diesel at a time for one hour in each ERW/ESW train without appreciably increasing the water temperature in the trim tank.

During ERW system testing as described above, the water level in the head tank and the line connecting the head tank to the ERW pump suction will fall to approximately the water level of the trim tank. To refill the head tank prior to completion of the test, the valve in the line between the head tank and the ERW pump suction is closed, and water flowing through the vent header refills the head tank to its normal shutdown level

After refilling the head tank, the test is terminated and the system valves are realigned to the normal stand-by configuration.

Tests and inspections of individual components in the ERW system can be conducted as follows:

1. Manual Valves:

   Each valve can be cycled and checked for proper operation and condition.

2. Level Indicators:

   Level sensing devices and their indicating and alarm functions can be checked by using portable d/p testing equipment.

3. Flow Detectors:

   Flow detectors can be checked and calibrated by using portable d/p testing equipment.

4. Pressure Gauges and Thermometers:

   Thermometers and pressure gauges can be removed and tested using test devices. Some pressure gauges can be tested in place when test connections are provided.

To verify that the ERW intakes are clean and will permit flow, divers will periodically inspect the intake areas and clean them if required.

9.2.2.2.5 Instrumentation and Application

Figure 9.2-4 shows the instruments that are provided for the ERW system. The instrumentation provided is intended to provide indication of proper system operation. The following specific instrumentation is provided.

1. Head Tank Level Detectors:

   These detectors provide both level indication and alarms in the control room.

2. Temperature Detectors:

   Local temperature detectors are provided at the outlet of the ESW and CSS heat exchangers to monitor heat exchanger performance.

3. Pressure Detectors:

   Detectors are provided for the ERW pump suction and discharge to monitor pump performance. The pump discharge detector provides a low pressure alarm in the control room as an indication of improper pump operation. A differential pressure detector monitors the d/p across the ERW strainer and alarms in the control room if a high d/p occurs.

4. Flow Detectors:

   Flow detectors are provided to indicate proper flow to cooled components.

5. Valve Position Indication:

   Valve position indicator lights are provided for the motor operated hull isolation valves to monitor proper valve position and operation.

6. Radiation Detector:

   Each train of the ERW system has a radiation detector installed downstream of the CSS heat exchanger to monitor for possible radioactive leakage and to alarm in the control room if a high activity condition exists.

9.2.3 MAKEUP WATER SYSTEM

9.2.3.1 Design Bases

High purity water is required for normal plant operation to replace any system losses and for filling various systems before plant startup. Makeup water quality is defined by impurity limits as indicated in Subsection 9.2.3.3. In addition to satisfying the water quality and volumetric requirements for plant operation, the makeup system will provide potable water for plant personnel.

The source of raw water for the makeup system is seawater which has impurities as defined in Table 9.2.3-2. These impurities are separated from the raw water by processes of distillation and demineralization included in the design of the makeup system.

The makeup system design production capability is based on the various water requirements of the plant's systems. The water demands of these systems result in a maximum design capability of 380 gpm. The makeup system is capable of providing a continuous flow that varies from approximately 80 gpm to the maximum design output of 380 gpm.

9.2.3.2 System Description

Raw water that is to be desalted is provided at low pressure by the non-essential raw water system. The separation of salts from the ocean water is accomplished by a distillation process in flash evaporators. The raw water is initially preheated and mixed with sulfuric acid to convert the raw water alkalinity to carbon dioxide (approximately 120 ppm acid) to control scaling or fouling of heat exchanger surfaces. The treated water is then routed to the deaerating section of the evaporator where oxygen and carbon dioxide are removed and vented to the atmosphere. The deaerated raw water is pumped to a brine heating section where it is heated to slightly above its boiling point and routed to a flash chamber where the heated water flashes. The vapor is condensed in a separate section, cooled and the product water or distillate pumped from the evaporator. The concentrated raw water that remains after the flashing step is either recycled or pumped from the evaporator and returned to the raw water source. Steam for heating the raw water in the brine heater section is obtained from either the plant's auxiliary steam boiler or one of two low pressure turbine extraction points when the plant is operating. The returned condensate is monitored for tube leakage with conductivity instrumentation. Cooling water is obtained from either the condensate feedwater system or the nonessential raw water system.

The distillate or product water produced by the flash evaporator is normally of very high purity. If operating transients should occur there will be some carryover of salts which will reduce the quality of the product water to below acceptable limits. The carryover of salts is detected by conductivity instrumentation which will divert the high conductivity water to the non-essential raw water discharge.

To insure that high purity water is produced for the plant, the product water can be processed by routing it through one of two mixed bed demineralizers if necessary. These mixed bed demineralizers will remove salts carried over from the flash evaporators and provide water having a conductivity of less than one micromho/cm. Water for potable use and water for the plant's trim tanks will not be demineralized but will be supplied directly from the flash evaporator. Flow diagrams for the makeup system are shown on Figure 9.2-5, sheets 1 and 2.

Waste liquids from the demineralizers due to sulfuric acid and sodium hydroxide caustic regeneration of the ion exchange resins are collected in a waste neutralizing tank. The collected liquids are mixed, the pH determined, and, if necessary, acid or caustic is added to neutralize the batch. After neutralization, the batch is returned to the raw water source via the non-essential raw water system.

9.2.3.3 Design Evaluation

A combination of distillation and demineralization processes for desalting the raw water is provided to produce a high purity makeup water which will inhibit corrosion, fouling of heat transfer surfaces of blockage of small flow paths. Also, the redundancy of equipment and the use of process equipment with proven operational history in utility service provides assurance that production capability is always available. For example, continuous operation capability to produce 190 gpm from the makeup water system will be furnished from either one of the two sets of equipment. Two - 190 gpm evaporators will be provided. Either one of the two demineralizers will process 380 gpm of the product water.

The minimum quality of water produced by the makeup system is defined in Table 9.2.3-1.

TABLE 9.2.3-1

MAKEUP WATER QUALITY

Total Dissolved Solids	0.5 ppm
Chlorides	0.15 ppm
pH at 25°C	6-8
Conductivity at 25°C	< 1.0 μ MHO/CM
Insoluble or Filterable Solids	0.5 ppm (Collected 0.45 Micron Filter Paper)

9.2.3.4 Tests and Inspections

The system equipment will be tested and inspected to ensure system integrity, completeness, conformance with code requirements and purchase specifications. The following tests will be conducted:

9.2.3.4.1 Mechanical

1. Hydro tests at vendor's shops and inspections for conformance with code and purchase specifications and "spark" tests for detecting imperfections in coatings or lining of tanks.

2. Hydro tests after installation.

9.2.3.4.2 Instruments and Electrical Components

1. When applicable and/or feasible (e.g., where instruments are assembled in control panels) instruments, controls and electrical circuits will be functionally tested at vendor shops.

2. After installation, all components will be tested for performance and conformance to specifications.

9.2.3.4.3 System Testing

The performance of the system will be tested after installation. The water quality and volumetric output will be determined.

9.2.3.5 Instrumentation Application

The design of the flash evaporator instrumentation for automatic operation is based on a system of flow and level controls. Control of the product water flow or output of the evaporator will be from either a local panel or the main Control Room. The output flow rate feeds back to various flow and level controllers to provide the operating conditions to meet the output demand. Control of the quality of the product water is based on conductivity. Carryover of salts due to maloperation will result in an increase in conductivity causing the product water to be diverted and returned to the raw water source. Concentrated brine blowdown will be controlled by conductivity to limit the return of raw water to about twice the concentration of seawater before dilution in the non-essential raw water discharge. The pH of this waste stream will be maintained in a range of about 6 to 8 before dilution.

Operation and regeneration of the mixed bed demineralizer will be automatic with manual override. System instrumentation will be contained in a local panel. Conductivity instrumentation will monitor the demineralized water quality and provide an alarm on exhaustion of the resin bed. Local samples of water can also be obtained for laboratory analysis and more accurate control of water quality. Neutralization of the regeneration waste stream before discharge and dilution will be controlled by pH instrumentation. A local sample can be obtained before discharging for more detailed laboratory analysis of the water.

TABLE 9.2.3-2

ELEMENTS PRESENT IN SEAWATER[1,2] (DISSOLVED GASES NOT INCLUDED)

Element	Milligrams per kilogram (parts per million)
Chlorine	18,980
Sodium	10,561
Magnesium	1,272
Sulfur	884
Calcium	400
Potassium	380
Bromine	65
Carbon	28
Strontium	13
Boron	4.6
Silicon	0.02-4.0
Fluorine	1.4

[1] Based on The Oceans by H. U. Sverdrup, M. W. Johnson, and R. H. Fleming (1942) pp. 176-177.

[2] Trace quantities less than 1 ppm have been omitted

9.2.4 NON-ESSENTIAL COOLING WATER SYSTEMS

9.2.4.1 Non-Essential Service Water System

The Non-Essential Service Water (NSW) System provides cooling water to several plant systems during normal operation.

9.2.4.1.1 Design Basis

The Non-Essential Service Water (NSW) System removes waste heat from the components listed in Table 9.2.4-1 during normal plant operation. The system is classified non-nuclear safety except for the piping between the isolation valves which penetrates the containment. These penetrations are classified ANS Safety Class 2.

9.2.4.1.2 System Description

The Non-Essential Service Water (NSW) System is represented schematically in Figure 9.2-6. A list of components cooled by the system is given in Table 9.2.4-1. The system is closed loop containing four pumps, each discharging to a heat exchanger which is cooled by the Non-Essential Raw Water (NRW) System. Service water after passing through the heat exchanger discharges via a common supply header to each of the components listed in Table 9.2.4-1. After performing its cooling function, water is returned to the pumps via a common return header. The system also includes a surge tank, booster pumps, associated piping, valves and instrumentation.

The surge tank is connected to the pump suction header and provides sufficient volume (to accommodate thermal expansion and contraction) as well as adequate suction head for the pumps. This tank is equipped with level instrumentation and connections for liquid sampling, venting, and adding makeup water and chemicals. Another connection routes the combined flow of the non-essential service water pump "mini-flow" lines into the tank for continuous chemical and thermal mixing within the tank.

The booster pumps are needed to provide the additional pressure required to circulate cooling water from the supply header through the ice condenser water chiller packages and the containment upper compartment fan coolers.

The NSW system circulates treated cooling water to prevent corrosion. Water chemistry requirements are listed in Table 9.2.3-4.

9.2.4.2 Non-Essential Raw Water System

The Non-Essential Raw Water (NRW) System provides cooling water for the Non-Essential Service Water System heat exchangers, and provides makeup water to the flash evaporators.

9.2.4.2.1 Design Basis

The Non-Essential Raw Water (NRW) System acts as the heat sink for the Non-Essential Service Water (NSW) System. This system is not required to operate following an accident or loss of external power. This system also supplies seawater makeup to the flash evaporator.

9.2.4.2.2 System Description

The Non-Essential Raw Water System, represented schematically in Figure 9.2-7, is a once-through system which uses seawater as the cooling medium. The system consists of seawater intake chambers, trash racks, screens, cooling water pumps, piping and instrumentation. Design data for the equipment are listed in Table 9.2.4-2. Seawater enters the chamber through trash racks and screens and is pumped to the Non-Essential Service Water heat exchanger. Seawater passes through the heat exchanger tubes and is discharged to the same catchment basin into which the condenser cooling water is discharged. This system can be manually transferred onto the emergency power system for long-term operation following an accident or external loss of power. The system has four pumps, but operates with only three, leaving one for standby.

TABLE 9.2.4-1

NON-ESSENTIAL SERVICE WATER SYSTEM COMPONENTS

Component	Number
Main Transformer Oil Coolers	2
Station Auxiliary Transformer Oil Coolers	2
Stator Water Coolers	2
Exciter Coolers	2
Steam Generator Blowdown Heat Exchanger	4
Isolated Phase Bus Duct Cooler	1
Hydrogen Coolers	4
Flash Evaporator Pump Glands	-
Turbine Plant Sample Coolers	8
Electro-Hydraulic Oil Coolers	2
Turbine Lube Oil Coolers	2
Reactor Coolant Pump Motor Air Coolers	4
Instrumentation Room Coolers	2
Upper Compartment Fan Coolers	2
Thermal Regeneration Cooler	1
Ice Condenser Water Chiller Package	2
Service Building Water Chillers	2

TABLE 9.2.4-2

NON-ESSENTIAL COOLING WATER COMPONENT DESIGN DATA

NON-ESSENTIAL SERVICE WATER SYSTEM

System	
Design flow, gpm	36,000
Design pressure, psig	150
Design temperature, °F	150
Piping material	Carbon steel
Pumps	
Number	4
Type	Horizontal, single-stage, centrifugal
Design flow, gpm	9,000
Design head, ft.	125
Horsepower	350
Casing material	Carbon steel
Heat Exchangers	
Number	4
Type	Shell and straight tube
Design heat load, btu/hr	45×10^6

TABLE 9.2.4-2 (CONT)

Heat Exchangers (Continued)

	Fluid	
	Shell Side Service Water	Tube Side Seawater
Design flow, gmp	9,000	18,000
Inlet temperature, °F	105	85
Outlet temperature, °F	95	90
Design pressure, psig	150	150
Design temperature, °F	200	200
Material	Carbon steel	90-10 Cu-Ni

Surge Tank

Type	Vertical, cylindrical
Volume, cu. ft.	500
Design temperature, °F	150
Design pressure	Atmospheric
Material	Carbon steel

Ice Condenser Water Chiller Booster Pumps

Number	2
Type	Horizontal, centrifugal
Design flow, gpm	110
Design head, ft.	100
Horsepower	7.5
Casing material	Ductile iron or equivalent

TABLE 9.2.4-2 (CONT)

Upper Compartment Fan Coolers Booster Pump

Number	1
Type	Horizontal, centrifugal
Design flow, gpm	150
Design head, ft.	100
Horsepower	7.5
Casing material	Ductile iron or equivalent

TABLE 9.2.4-2 (CONT)

NON-ESSENTIAL RAW WATER SYSTEM

System	
Design flow, gpm	60,000
Design pressure, psig	100
Design inlet temperature, °F	85
Pumps	
Number	4
Type	Vertical, centrifugal, single, stage
Design flow, gpm	20,000
Design head, ft.	100
Horsepower	700
Casing material	Ductile iron or equivalent
Traveling Screens	
Number	4
Design flow, gpm	20,000
Mesh opening size, inches	3/8

TABLE 9.2.4-2 (CONT)

Flash Evaporator Flow Data	
Makeup at max. design output, gpm (each evaporator)	190
Cooling flow at max. design output, gpm (each evaporator)	4,200 [1]

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(1) During normal plant operation, cooling for the flash evaporators is supplied by the condensate-feedwater system.

TABLE 9.2.4-3

NON-ESSENTIAL SERVICE WATER SYSTEM WATER CHEMISTRY

Corrosion inhibitors	K_2CrO_4 or $K_2Cr_2O_7$ 1000 ppm (CrO_4) for the first week after filling system; 175-225 ppm (CrO_4) thereafter
pH @ 25 C	8.0 to 8.5
Chloride ppm, maximum	0.15
Floride ppm, maximum	0.1
Make-up water	Same quality as listed for the Reactor Coolant System

9.2.5 CONDENSATE STORAGE FACILITY

9.2.5.1 Condensate Storage Tank

9.2.5.1.1 Design Basis

The condensate storage tank compensates for fluid losses due to steam generator blowdown, loss of flash evaporator output during low loads and the shrinkage of fluid inventory during load changes.

The condensate storage tank is designated non-nuclear safety class.

9.2.5.1.2 Description

The condensate storage tank is a built-in tank which is part of the platform structure below the turbine area. The storage capacity is 500,000 gallons. Corrosion protection for the interior of the condensate storage tank is provided by means of a coating system.

Remote and local tank level indications are provided with high/low alarms in the Control Room.

9.2.5.1.3 Tests and Inspection

Only visual inspection is required.

9.2.5.2 Auxiliary Feedwater Storage Tanks

9.2.5.2.1 Design Bases

The auxiliary feedwater storage tanks are designed to provide reserve feedwater supply for emergency shutdown residual heat removal should the main condensate feedwater system not be available. The auxiliary feedwater storage capacity is sized to provide feedwater for sixteen hours of operation prior to initiation of RHR System operation.

The auxiliary feedwater tanks are designated ANS Safety Class 3 and are designed in accordance with ASME Section 3.

9.2.5.2.2 Description

Two auxiliary feedwater tanks each rated at 175,000 gallons are located in two watertight compartments in the safeguards area at the 40 foot level. These tanks are used solely by the auxiliary feedwater system to remove residual heat under emergency conditions. In addition to this supply, water from the condensate storage tank of the main condensate feedwater system can be transferred by manual operation to the auxiliary feedwater tanks; this flow path also provides a route through which condensate can be supplied by the plant flash evaporators. No credit is taken in the sizing of the auxiliary feedwater tanks for the provisions of transfer of condensate to the auxiliary feedwater storage tanks. In an extreme case when all feedwater sources are exhausted, seawater from the essential raw water system can be delivered to the auxiliary feedwater pump suction headers. Remote and local level indications for the auxiliary feedwater tanks are provided and high and low water levels are alarmed in the Control Room. Corrosion protection for the interior of the auxiliary feedwater storage tanks is provided by means of a coating system.

9.2.5.2.3 Tests and Inspection

Visual inspection only is required.

9.3 PROCESS AUXILIARIES

9.3.1 COMPRESSED AIR SYSTEMS

9.3.1.1 Design Bases

These systems provide dry and clean air for instrumentation and control purposes as well as for general plant services. They also assure a continuous supply of control air to vital equipment needed to bring the plant to a safe shutdown condition following an accident.

Service and instrument air is oil-free with no particulates greater than 10 microns. Control air has a design atmospheric dewpoint of minus 40°F.

The emergency instrument air system meets ANS Safety Class 3 requirements as shown on Table 3.2-1. The service and instrument air systems have no ANS Safety classification except for the penetrations through the containment which are designed to ANS Safety Class 2.

9.3.1.2 System Description

Figure 9.3-1 (Sheets 1 thru 3) shows the flow arrangement of these systems which comprise the instrument, service, and emergency instrument air systems. The instrument and service air systems consist of two plant air compressors and their accessories, each having an aftercooler, a moisture separator, and an air receiver on its discharge, and a redundant filter-dryer set in the instrument line, all of which are located at elevation 40' in the turbine building. Each plant air compressor has a capacity of 1350 scfm at 110 psig discharge pressure. The emergency instrument air system consists of two redundant emergency instrument air compressors, each having an aftercooler, a moisture separator, an air receiver, and a filter-dryer set on its independent discharge. Each emergency compressor has a capacity of 50 scfm at 110 psig discharge pressure. These components are located in two of the safeguards compartments.

One of the plant air compressors is operated to satisfy the normal requirements of both service and instrument air. The other compressor serves as a 100 percent standby. It starts automatically when the air receiver pressure drops to a predetermined setpoint.

The common discharge header supplies air to the service and instrument air headers. The service air header provides air to various terminal points as shown on Figure 9.3-1. Air to the instrument header passes through a redundant filter-dryer set which cleans and dries the air to the desired quality. When there is an excessive pressure drop across the duty set, the standby filter-dryer set automatically goes into service. The former set is then manually shutdown and isolated for repair.

In case of an accident one of the redundant emergency instrument air systems supplies the requirements of all the vital equipment. The other system serves as a full backup. Each of the emergency compressors is automatically loaded on an engineered safeguards bus. One compressor can be manually stopped afterward at the discretion of the operator and will re-start automatically when the emergency instrument air header drops to a preset value.

The Component Cooling Water System provides cooling water to the intercoolers, oil coolers, and aftercoolers of the plant air compressors. The Essential Service Water System supplies the cooling requirements of the emergency control air compressor jackets and aftercoolers.

A containment isolation signal closes the containment isolation valve installed in the penetration line of the instrument air system.

9.3.1.3 Design Evaluation

9.3.1.3.1 Power Failure

Two separate electrical buses feed the motor drivers of the two plant air compressors, respectively. In case of power failure in one source, the other source is still available. In the event all electrical power is interrupted, the plant air compressors stop operating. Air operated valves throughout the plant are arranged to position themselves in a manner to preserve the safety of plant and personnel. Vital valves needed to bring the plant to a safe shutdown are assured supply from the emergency instrument air system.

9.3.1.3.2 Main Dryer Failure

The duty dryer can be regularly inspected so that the desiccant can be replaced before full deterioration. In case the desiccant is exhausted before regular inspection, a high effluent moisture content is annunciated in the control room. The standby dryer can then be manually placed in service. In the exceptional case of both trains having trouble, a manual valve is opened to bypass the train.

9.3.1.3.3 Main Filter Clogging

In case the duty filter clogs, a high differential pressure across the filter-dryer set initiates an alarm and automatically places the standby set into service.

9.3.1.3.4 Emergency Dryer-Filter Set Failure

Regular inspection of the dryers can be carried out to detect desiccant deterioration. In case of excessive pressure drop across the duty dryer-filter set "A", the resultant low header pressure starts standby emergency air compressor "B", placing emergency system "B" in service.

9.3.1.3.5 Service Air Header Leakage

In case of excessive service air header leakage a shut-off valve in the service air header closes, routing all available air to the instruments. A pressure switch in the instrument air header closes the shut-off valve when the header pressure drops to a preset value.

9.3.1.3.6 Air Cleanliness Requirements

The filters remove dust and dirt 10 microns in diameter and greater. All compressors are of the non-lubricated type to provide oil free air.

9.3.1.4 Testing and Inspections

The compressed air systems performance can be observed during plant normal operation. Emergency air compressor "A" can be tested at any time by manually placing it on the line. Emergency air compressor "B" can be tested by lowering the pressure in the automatic starting switch sensing line.

9.3.2 PROCESS SAMPLING SYSTEMS

9.3.2.1 NSSS Sampling System

9.3.2.1.1 Design Bases

The NSSS Sampling System provides means to obtain representative liquid and gas samples from various fluid systems for chemical and radiochemical laboratory analysis. Results of analysis provide guidance in the operation of the reactor coolant system, residual heat removal system, safety injection system, and chemical and volume control system. Typical information obtained includes reactor coolant boron and chloride concentrations; fission product radioactivity level; hydrogen, oxygen, and fission gas content; corrosion product and chemical additive concentrations.

The sampling system is designed for manual and intermittent operation for conditions ranging from full power operation to cold shutdown. Access to the containment is not required for sampling. Adequate safety features are provided to protect laboratory personnel and to prevent the spread of contamination from the sampling room when samples are being drawn.

The sampling system is not required to function during an emergency nor to take action to prevent an emergency condition.

The sampling system design meets the applicable safety class, code class, and quality control level requirements as shown in Chapter 3, Table 3.2-1.

9.3.2.1.2 System Description

The NSSS sampling system is shown in Figure 9.3-2. Samples from the following locations are collected in the sample room.

Inside the Containment

Pressurizer Steam Space.

Pressurizer Liquid Space.

Hot Legs of two different loops (Reactor Coolant System).

Each of four accumulators (Safety Injection System).

Outside the Containment

Two residual heat removal lines.

Upstream and downstream of demineralizers in the Chemical and Volume Control System (CVC) letdown line.

Volume control tank space.

Local connections are provided for individual systems outside the containment. These connections are not considered part of the NSSS sampling system.

All sample lines have manual valves required for component isolation and flow control, as well as a local sample valve in the sampling room. In addition, each sample line originating from within the containment has a remote, air-operated sample valve close to the source, and two containment isolation valves, one located inside and the other outside the containment. Samples originating outside the containment have a manual valve and a remote air-operated sample valve located close to the source.

Each sample line originating from within the containment also has a sample heat exchanger and a sample vessel, except the sample lines from the accumulators. The residual heat removal samples pass through the same heat exchanger and sample vessel as provided for the hot leg reactor coolant samples. The reactor coolant loop hot leg sample lines also have a common delay coil located inside the containment to provide decay of the short-lived radioactive isotope N-16.

Liquid samples originating upstream and downstream of the demineralizers in the CVC pass through a common line to the sample sink.

A gaseous sample from the volume control tank in the CVC is collected in a sample vessel after purging sufficient volume of the gases to the gaseous waste treatment system vent header.

All the liquid samples are piped to the sampling sink located in the auxiliary building sampling room. The sink drain discharges to the liquid waste treatment system. The sampling sink and the sample vessels are enclosed in a hood provided with piping penetrations and a building exhaust.

9.3.2.1.3 Design Evaluation

9.3.2.1.3.1 Main Characteristics

The sampling system is designed for manual operation on an intermittent basis, under conditions ranging from full power operation to cold shutdown. The system is not required to function during an emergency nor to take action to prevent an emergency condition.

Sample lines penetrating the containment are provided with isolation valves which close on the receipt of a containment isolation signal.

Reduction of sample pressure and temperature is accomplished outside the containment to facilitate maintenance of the sample stream mechanical components and instrumentation.

The dose rate outside the containment due to short-lived isotopes is limited by passing the hot leg reactor coolant samples through the delay coil located inside the containment. This permits access to the sampling room.

All sample lines are austenitic stainless steel tubing designed for high pressure service. The design sample flow rate is 0.42 gpm. To reduce the quantity of purge fluid, pipe internal diameters are kept to a minimum. Lines are so located as to provide safe operations and maintenance.

Leakage of radioactive reactor coolant from this system within the containment is collected in the containment sump. Leakage of radioactive material from this system outside the containment is collected via miscellaneous drains in the liquid waste treatment system. The hood covering the sample vessel and the sink is provided with off-gas vents to the auxiliary building ventilation system.

9.3.2.1.3.2 Component Design

Sample Heat Exchangers

The sample heat exchangers are of the shell and coil tube type. Sample flow circulates through the tube side, while component cooling water circulates through the shell. Each heat exchanger is designed to cool samples to less than 127^{o} F. The heat exchanger shell is constructed of carbon steel and the coil tube is constructed of austenitic stainless steel.

Delay Coil

The delay coil in the hot leg reactor coolant sample line has sufficient length to provide at least a 40-second sample transit time within the containment. Additional delay is provided by the sample line. This allows for decay of the short-lived isotope, N-16, to a level which permits access to the sampling room.

Sample Vessels

The sample vessels are designed to receive liquid or gas samples at reactor coolant system design pressure and 650^{o} F. The sample vessels are sized to contain liquid with sufficient dissolved gas to perform the required chemical, radiochemical, dissolved hydrogen, or fission gas analyses.

Integral isolation valves and quick-disconnect couplings provide safe and fast disconnection of each sample vessel. The vessel, valves, and couplings are all made of austenitic stainless steel.

Sampling Sink

The sampling sink is in a hooded enclosure equipped with an exhaust ventilator. The sink perimeter has a raised edge to contain any spilled liquid. The work area around the sink and the enclosure is large enough for sample collection and storage for radiation monitoring equipment. The enclosure is penetrated by sample lines from the reactor plant and a makeup water line, all of which discharge into the sampling sink. The sink and the work area are stainless steel.

The above components as well as piping, fittings and valves are designed in accord with appropriate ANS Safety Class and ASME Code Class as listed in Table 3.2-1.

9.3.2.1.3.3 Sampling Techniques

The system design includes consideration of purging requirements, and sample size to get a representative sample while providing for the safety of operating personnel.

The remote air-operated valves located close to the source points are operated from the sample room. This avoids operator exposure to a high radiation area and limits the length of sample piping that will be normally filled with radioactive fluids.

Prior to collecting a sample, sample lines are purged of stagnant water and undissolved solids by flushing with process water for sufficient time to ensure that a representative sample is obtained. Rinsing of the sample container is required to avoid external contaminants.

The gas samples are collected in a steel sample vessel with valves on each end. Purging of the sample vessel is required to obtain a representative gas sample.

9.3.2.1.4 Testing and Inspection

Each component is inspected and cleaned prior to installation in the system. The system is operated and tested initially with regard to flow paths, flow capacity and leakage.

9.3.2.1.5 Instrumentation

For the convenience of the operator, all instrumentation is located in the sampling room. Local temperature indicators downstream of the sample heat exchangers indicate the temperature of the sample to assure that it is sufficiently low before diverting it to the sample sink.

Local pressure indicators downstream of the sampling vessel are used as a guide for adjustment of the throttling valves.

A local flow indicator on the purge line to the volume control tank is used to monitor the liquid sample flow rate.

A local flow indicator on the volume control tank gas sample line provides indication that the volume control tank gas sample is flowing at the correct rate.

9.3.2.2. Containment Post-Accident Sampling System

9.3.2.2.1 Design Basis

The Containment Post-Accident Sampling (PAS) System is designed to provide representative samples of the containment post-accident atmosphere within 24 hours after the accident. The samples are analyzed to determine hydrogen content and gaseous levels for use in controlling hydrogen concentration as described in Section 6.2.5, and to limit radiation exposure.

9.3.2.2.2 System Description

The Containment Post-Accident Sampling System (Figure 9.3-3) provides the ability to sample the containment atmosphere following an accident. Containment air samples can be taken from five sample points. Two sample points are located at the discharge of the post-accident air recirculation fans. These sample points provide samples of the upper compartment atmosphere. Three lower compartment sample points are uniformly spaced along the row of ice condenser inlet doors. From each sample point, a sample line is routed independently via a separate penetration through the containment and shield building to the PAS station. The PAS station is located adjacent to the containment in the shielded control area at elevation 94 ft. Outside the containment, the sample flows through containment isolation valves located immediately adjacent to the penetration. These isolation valves are operated manually from behind protective shielding by means of extension handles. Inside the PAS station, the sample flows through a second set of containment isolation valves, which also serve as selector valves for the sample flow path desired. Downstream of the second isolation valve is a removable sample vessel which is equipped with isolation valves and installed in the flow path by means of quick-disconnect couplings. A vacuum/compressor pump immediately downstream of the sample vessel provides the pressure differential between the sample pickup and return points inside the containment to insure adequate sample flow. Each return line is equipped with two containment isolation valves in series. The first (upstream) valve is located in the PAS station, with the second (downstream) valve located as close as possible to the shield buidling, and operable from behind protective shielding by means of extension handles. The return lines terminate the containment at a location above the post-accident flood line in a configuration arranged to prevent flow obstruction.

During post-accident operation, a containment air sample may be obtained from any of the five sample points. The removable sample vessel is installed in the sample line, and the appropiate containment isolation and selector valves are open. The vacuum pump is started and the lines purged. The pump is then stopped and the isolation valves closed. The sample vessel is then removed for analysis.

The PAS system component design data are listed in Table 9.3.2-1. The containment isolation valves are manually operated Saunders patent valves of stainless steel with diaphragms suitable for operation without leakage in water saturated radioactive air. The test connection valves and the isolation valves for the removable sample vessel are soft seated instrumentation globe valves with metallic diaphragms.

Sample runs are fabricated of stainless steel tube with a nominal design rating of 150 psig and 300^{0} F.

9.3.2.2.3 Design Evaluation

The PAS System is designed as an engineered safety feature. Containment isolation valves and portions of the sample lines penetrating containment are classified as ANS Safety Class 2; the balance of the system is classified as shown on Table 3.2-1.

Separation of sample lines in the containment prevent a single accident form incapacitating more than one sample line. Sufficient sample redundancy is provided by the five sample points, which are located in high air recirculating areas (ice condenser inlet door area and post-accident recirculation fan discharges). Sample line velocities are designed to be high enough to permit rapid purging of the lines before sampling and to provide turbulence for adequate mixing.

To prevent the accumulation of condensate or water in the sample lines, which could obstruct air or gas flow during sampling operations, the sample tubing runs are designed to be free draining by sloping them downward from the sample station outside the containment to both the sample inlet and outlet inside containment. Also no U-bend traps are in the sample tubing.

Containment isolation criteria are met by the two normally locked closed manual isolation valves on each line penetrating the containment.

There are no PAS instrumentation or controls located inside containment which can malfunction and prevent system operation. An installed standby vaccuum pump is provided. A spare sample vessel is provided and is easily accessible for installation in the event of a failure of a sample vessel.

The PAS sample station is located near the containment within the shielded control area. This location prevents undue exposure of the operator to direct radiation, and minimizes head loss and radiation associated with the sample tubing.

9.3.2.2.4 Testing and Inspections

The containment isolation valves in the supply and return lines will be tested in accordance with the isolation valve testing requirements contained in Appendix J to 10 CFR Part 50.

System components and piping will be tested to insured compliance with required codes and regulations.

9.3.2.2.5 Instrumentation and Applications

The PAS system includes no instrumentation on controls located inside the containment which can malfunction and prevent system operation. A simple sight flow indicator is installed at the PAS station to indicate a possible plugged sample line.

TABLE 9.3.2-1

CONTAINMENT POST-ACCIDENT SAMPLING SYSTEM

Sample Vessel

Number	2
Number required for operation	1
Design Pressure, psig	150
Design Temperature, ^{o}F	300
Material of Construction	Stainless Steel

Vacuum Pump

Number	2
Number required for operation	1
Capacity, SCFM Max.	5

9.3.2.3 Steam Systems Sampling System (SSS)

9.3.2.3.1 **Design Bases**

The functional requirements of this system are: (1) to provide process information on the chemical characteristics of the operating fluids in the steam-feedwater cycle in order to assure compliance with water chemistry specifications and thereby minimize corrosion, (2) to detect material failures which result in contamination of the secondary side with either reactor coolant or seawater, and (3) to determine equipment performance (e.g., steam generator carryover). To obtain this process information, fluid samples are obtained from various locations in the steam-feedwater cycle and analyzed for different chemical characteristics either by manual laboratory techniques or by automatic process instrumentation.

Samples from various steam-feedwater cycle and auxiliary systems locations will be representative of the fluids contained in the piping, vessels or other equipment conveying the liquid. Sample lines, therefore, will be as short as practical to reduce hold up time and to minimize plate out or settling where particulates or insolubles in the fluid are to be measured. Sizing of sample lines and valves will result in turbulent flow. In addition, sample probes or nozzles will be installed in process piping 2 ½" and larger to avoid pipe wall effects in obtaining a representative sample.

Hazards associated with high temperature and pressure and radioactivity will be avoided. Where required, high temperature samples will be cooled to less than 120°F. Where samples are required from high pressure locations, pressure reducing valves and/or orifices will be installed. Samples containing radioactivity will be routed to a controlled area and collected at a sample sink in a ventilated enclosure (hood). To minimize airborne activity, ventilation will be provided to maintain an adequate air velocity through the face of the hood.

Samples lines will be provided with shut off valves as close as practical to the process sample location. Sample lines will be either type 304 or 316 stainless steel. The SSS is classified as non-nuclear safety.

9.3.2.3.2 System Description

The SSS flow diagram is shown in Figure 9.3.14, Sheets 1 and 2. The system consists of the piping, valves, heat exchangers (sample coolers) and other equipment for collecting process fluid samples. It also includes the in-stream chemical analyzers required for the routine determination of various water system properties such as conductivity, pH, hydrazine and oxygen. Local temperature and pressure indicators are provided to monitor samples originating from the high temperature, high pressure sources. The various samples taken are processed and analyzed in accordance with the methods described below.

Steam Generator Blowdown Line Sampling

Sampling lines are connected to the blowdown lines downstream of the blowdown heat exchangers.

Upstream isolation valves in the blowdown lines close automatically on either a containment isolation signal or a high blowdown sample radioactivity signal. Override capability is provided to enable these valves to be reopened (under administrative control), to permit sampling in conjunction with assessing steam generator primary to secondary leakage, and to operate the blowdown treatment system. (Refer to Steam Generator Blowdown System, Subsection 10.4.7).

The sample flow from each blowdown line is cooled and routed through a conductivity cell and a pH analyzer connected in series. Cooled samples of both treated and untreated blowdown system effluent are passed through radiation monitors to the steam generator holdup and sample tanks. Connections are provided for flushing the radiation monitors.

Main Steam Sampling

Sample points are located outside the containment in each of the main steam lines. Steam sample flow follows two parallel paths; one portion is cooled and depressurized and piped directly to the sampling sink, the other portion after cooling and depressurization is piped through an in-stream cation conductivity analyzer.

Condenser Hotwell Sampling

The sample lines from each of the six main condenser hotwells are equipped with remotely operated valves for isolation and sample selection. These lines combine to form a common suction header for two sample pumps. Either pump is used to provide sample flow through an in-stream conductivity cell and also directly to the sampling sink.

Condensate Pump Discharge Sampling

The condensate pump discharge sample is drawn from the pump discharge header at a point upstream of the chemical feed injection points. One flow path routes the sample flow through a pressure reducing valve and then to a cation conductivity cell, pH analyzer and dissolved oxygen analyzer arranged in parallel. A second flow path routes the sample through a pressure-reducing orifice directly to the sampling sink.

Flash Evaporator Sampling

Samples are drawn from three separate points on the flash evaporator piping, as follows:

1. A sample point is located at the distillate pump discharge. Sample flow is either directly to the sample sink or through a cooler and conductivity cell.

2. The brine heater drain sample tap is located downstream of the discharge pump. Sample flow is routed through coolers either directly to the sample sink or through a conductivity cell.

3. A brine recycle sample is obtained through a tap downstream of the recycle pump. Sample flow is routed through coolers either directly to the sampling sink or through a pH electrode.

High Pressure Feedwater Heater Outlet Sampling

Feedwater is sampled at the high pressure heater discharge. The sample flow is cooled and reduced in pressure, then piped through a conductivity cell, pH electrode, and hydrazine analyzer arranged in parallel. Alternatively, this sample can flow directly to the sampling sink via a cooler and pressure-reducing orifice.

Auxiliary Boiler Condensate Sampling

Auxiliary boiler condensate is sampled at the condensate pump discharge heater, upstream of the chemical feed injection point. Sample flow can be routed through a conductivity cell, through a dissolved oxygen analyzer, or directly to the sampling sink.

Auxiliary Boiler Blowdown Sampling

Sample flow is taken from the blowdown line close to the auxiliary boiler and routed through a cooler, then through a cation conductivity cell or to the sampling sink.

Domestic Water Sampling

Sample flow from the Domestic Water System is piped directly to the sampling sink where it is analyzed for impurities and residual chlorine.

Space Heating Condensate Line

Samples are taken from the space heating condensate line at the reboiler feed pump discharge header. Samples are piped directly to the sampling sink for analysis.

9.3.2.3.3 Design Evaluation

The SSS is not required to function during an emergency or to take direct action to prevent an emergency condition. The sampling system is designed for compatibility with all plant operating conditions. System design provides for manual sample collection and/or in-line monitoring, where appropriate.

9.3.2.3.4 Tests and Inspections

Sampling system components and equipment will be inspected prior to installation. Instrument calibration and system functional testing will assure system operability.

9.3.2.3.5 Instrumentation Application

Instrumentation used in the SSS for measuring liquid chemical variables is of conventional design, proven by previous application in the power industry. Variables to be measured include conductivity, pH, dissolved oxygen and hydrazine. Standard commercial process instrumentation is readily available for measuring these variables on a continuous or semi-continuous basis.

9.3.3 EQUIPMENT AND FLOOR DRAINAGE SYSTEM

9.3.3.1 Design Bases

The Equipment and Floor Drainage System is a subsystem of the Liquid Waste Treatment System described in Section 11.2. It collects liquid drains and relief valve discharges from various sources within the controlled access areas on different floors of the Floating Nuclear Plant. These sources include valve and pump leakoffs; equipment drains and relief valve discharges; floor drains, and sump pump discharges. All these liquids are transferred to the Liquid Waste Treatment System. The system also collects gaseous vents and reliefs from various equipment. These gases are directed to the plant exhaust for release as described in Section 12.4.

9.3.3.2 System Description

Figures 9.3-4 through 9.3-6 show the equipment and floor drainage system and list the equipment which generate effluents received by separate headers. The system comprises the following subsystems.

1. Drain header (DH) subsystem - Figure 9.3-5

2. Relief valve header (RVH) subsystem - Figure 9.3-6

3. Floor drain (D) subsystem - Figure 9.3-4

4. Chloride drain (CD) subsystem - Figure 9.3-6

5. Vent header (VH) subsystem - Figure 9.3-4

The drain header (DH) collects potentially radioactive liquid drains and discharges into the waste holdup tanks.

The relief valve header (RVH) receives liquid effluents from the relief valves located in the controlled access areas. The characteristics of the effluents in the relief valve header are similar to those in the drain header (DH). The relief valve header discharges into the waste holdup tanks.

The floor drain header(D) carries normal floor drains from controlled access areas and includes any drains which may be radioactive as well as chemically contaminated. These drains are transferred to the floor drain tank.

The two chloride drain headers (CD) collect all those drains which normally have a very low level of radioactivity. However, they are normally contaminated with chemicals, mainly chlorides or detergents. One of the CD headers collects laundry and hot shower drains from controlled access areas, and transfers them into the laundry and hot shower tank. The second CD header receives the decontamination washdown drains and other potential chloride drains including the discharges from the sump pumps located in the four safeguards areas. This header discharges into the cask decontamination drain tank.

The vent header (VH) collects gaseous vents and reliefs, and is piped to the plant exhaust.

9.3.3.3 Design Evaluation

The equipment and floor drainage system is a passive system required to function during all modes of plant operation. The segregation of these drains facilitates proper processing in the liquid waste treatment system. Plugging or pressurizing of the headers is minimized by installation of large size main headers with straight flow paths and a minimum slope of 1/8" per foot. Each header is flushed and inspected with regard to leak-tightness, flow capacity, and flow path.

All the main headers of the equipment and floor drainage system are shielded. The drain header (DH) and the relief valve header (RVH) are specified as ANS Safety Class 3. All other headers of the system are non-nuclear safety class.

9.3.4 CHEMICAL AND VOLUME CONTROL SYSTEM

The Chemical and Volume Control System (CVC) is presented in RESAR-3, Section 9.3.4. However, the following changes are incorporated in the CVC as used for the Floating Nuclear Plant. The system flow diagrams are shown on Figures 9.3-7 through 9.3-11.

1. The centrifugal charging pumps in the CVC do not take suction from the refueling water storage tank, nor do they perform any emergency core cooling function. The high-head safety injection pumps provided in the Safety Injection System perform the safety functions specified for the centrifugal charging pumps in RESAR-3, Section 9.3.4. During a loss-of-coolant accident, the chemical and volume control system is completely isolated. This change affects RESAR-3, pp. 9.3-4, 8, 10, 14, 16, 20, 26, and 43.

2. The supply of reactor makeup water is included as a part of the CVC. Figure 9.3-11 depicts the reactor makeup water subsystem delineating the sources and users of the reactor makeup water. The subsystem comprises two reactor makeup water storage tanks, two reactor makeup water pumps, and the associated piping, valves, and instruments. The parameters of the tanks and the pumps are listed in Table 9.3.4-1.

TABLE 9.3.4-1

PARAMETERS* OF THE CVC COMPONENTS NOT INCLUDED IN RESAR-3

Reactor Makeup Water Pumps

Number	2
Design Pressure, psig	150
Design Temperature, or	200
Design flow, gpm	150
Design head, ft.	250
Material	Austenitic Stainless Steel

Reactor Makeup Water Storage Tanks **

Number	2
Capacity, gallons	56,000
Design pressure	Atmosphere
Design temperature, ^{o}F	200
Material	Austenitic Stainless Steel

Resin Fill Tank

Number	1
Capcity, cu. ft.	8
Design pressure	Atmospheric
Design temperature, ^{o}F	200
Material	Austenitic Stainless Steel

Chemical Mixing Tank

Number	1
Capacity, gallons	5
Design pressure, psig	150
Design temperature, ^{o}F	200
Material	Austenitic Stainless Steel

* The ANS Safety Classes for these components are given in Table 3.2-1.
** Diaphragm required.

3. Two reactor coolant filters and two boric acid filters are provided instead of one reactor coolant filter and one boric acid filter as indicated in the RESAR 3. However, the parameters of these filters remain the same as listed in the Table 9.3-3 of RESAR-3. (This change affects RESAR-3, pp. 9.3-67 and 69.)

One resin fill tank is included as part of the CVC. This tank is mounted on the monorail over the series of demineralizers, and serves to fill the demineralizers with appropriate resins. Table 9.3.4-1 lists the parameters of the resin fill tank. The Table also lists the parameters of the chemical mixing tank.

9.3.5 BORON RECYCLE SYSTEM

The Boron Recycle System processes reactor coolant liquid effluent to meet the chemical requirements of reactor grade water. Changes in reactor coolant boron concentration for reactivity control due to load following are handled by the Chemical and Volume Control System. Radioactive waste liquids are processed by the Liquid Waste Treatment System.

The Boron Recycle System removes radioactivity by ion exchange, filtration, and gas stripping. Evaporation is used to recover boric acid and to produce reactor grade makeup water. Figure 9.3-12 is the system flow diagram.

9.3.5.1. Design Bases

The Boron Recycle System is designed to handle the maximum reactor coolant letdown flow rate. The holdup capacity is based on the surge from a cold shutdown and subsequent startup. Equipment design codes are listed in Section 3.2.2, Table 3.2-1. The processing equipment is designed to produce reactor grade quality makeup water and 4% by weight boric acid.

Most of the system influent liquid is from the Reactor Coolant System and results from the following operations:

1. Dilution to compensate for the loss in core reactivity (fuel burnup)

from approximately 1200 ppm boron to 100 ppm boron near the end of core life (dilution from 100 ppm to 10 ppm boron is handled by the Chemical and Volume Control System boron thermal regeneration demineralizers).

2. Cold shutdowns and startups. Three cold shutdowns are assumed during the core life.

3. Hot shutdowns and startups. Four hot shutdowns are assumed during the core life.

4. Refueling shutdown and startup.

The Boron Recycle System also receives liquid from the following sources:

5. Chemical and Volume Control System volume control tank relief valve.

6. Chemical and Volume Control System boric acid tanks. This connection is provided for transfering the contents of the boric acid tanks if they are drained for maintenance. The boric acid concentration is first reduced by the blender with dilution from the reactor makeup water storage tanks. This is done to prevent precipitation of the boric acid in the unheated recycle holdup tanks.

7. Emergency Core Cooling System flush of concentrated boric acid.

8. Boron Recycle System and Liquid Waste Treatment System evaporator distillate tanks. This connection allows recycling of distillate.

9. Liquid Waste Treatment System reactor coolant drain tank. This connection allows processing of reactor coolant leakage and drains from inside containment.

10. Equipment leakoffs and drains. This connection allows processing of reactor coolant leakage and drains from outside containment.

All portions of the Boron Recycle System which contain a concentrated boric acid solution of 4% by weight are located in heated compartments. Redundant thermostatic controls and a low temperature alarm are provided to assure the temperature is maintained at a minimum of 65°F. Portions of the system which contain a concentrated boric acid solution of 12% by weight have redundant heat tracing.

9.3.5.2 System Description

The Boron Recycle System process and instrumentation diagram is shown on Figure 9.3-12. Two 100 percent redundant flow paths and trains of processing equipment are provided. The normal flow path is through a recycle evaporator feed demineralizer and filter to a recycle holdup tank. Most of the soluble and particulate radioactivity is removed by this operation. When sufficient liquid to warrant evaporator operation has accumulated in the recycle holdup tank, the alternate flow path is placed in operation. Normally, one of the recycle holdup tank pumps directs the liquid to the recycle evaporator.

The evaporator strips any gases which may remain, produces reactor grade water quality distillate (evaporator overhead), and produces a 4% by weight boric acid solution concentrate (evaporator bottoms). The distillate flows through the recycle evaporator distillate demineralizer and filter to the recycle evaporator distillate tank. This flow path is piped in parallel with the flow path from the Liquid Waste Treatment System evaporator distillate flow path. The liquid is normally transferred to the Chemical and Volume Control System for reuse in the Reactor Coolant System.

The evaporator bottoms gradually increase in boric acid concentration. When a 4% by weight solution is obtained, the concentrate is pumped from the evaporator. The flow is normally through the recycle evaporator concentrates filter to the Chemical and Volume Control System boric acid tanks.

9.3.5.2.1 Component Description

The Boron Recycle System equipment parameters are given in Table 9.3.5-1.

Recycle Evaporator Package

The recycle evaporator package consists of several major components as follows:

1. Feed preheater
2. Gas stripper
3. Feed tank-evaporator
4. Absorption tower
5. Evaporator condenser
6. Distillate cooler
7. Vent condenser
8. Concentrates pumps
9. Distillate Pumps

The influent liquid passes through the feed preheater and the gas stripper to the feed tank-evaporator. The gas stripper is a packed column. The stripping steam containing the entrained gases flows to the vent condenser. The condensed steam is returned to the gas stripper and the gases are displaced to the Gaseous Waste Treatment System.

The feed tank-evaporator boils off the liquid by steam coils. The vapors flow through the absorption tower where boron and other entrained impurities are removed. They flow back to the feed tank-evaporator. When boric acid concentration reaches 4% by weight, the contents are pumped out. The purified vapors are condensed as distillate in the evaporator condenser. The distillate then flows through the distillate cooler and from the evaporator package.

Tanks

The Boron Recycle System tanks are two recycle holdup tanks, a recycle evaporator reagent tank, and a recycle evaporator distillate tank. The recycle holdup tanks collect reactor coolant effluents for processing. Each tank is located in a watertight compartment which will retain the contents of the tank in the event of tank leakage. Lines penetrating the compartment are either arranged or valved so that a pipe leakage cannot result in uncontrolled spillage. Each tank has a diaphragm to prevent air entering the tank and to prevent the hydrogen-fission gas mixture from leaving the tank. The air above the diaphragm is vented to the plant vent header.

A five gallon recycle evaporator reagent tank is provided for adding chemicals to the evaporator. Chemicals are manually added to the tank. Water from the reactor makeup water storage tank can be used for mixing and providing a head for injection. Chemicals added are normally antifoaming agents but may be for pH control or decontamination.

The recycle evaporator distillate tank is identical to the Waste Treatment System waste evaporator distillate tank. It collects the recycle evaporator distillate and is provided with a diaphragm to exclude air.

Demineralizers

Three demineralizers are provided in the Boron Recycle System to remove soluble products. The two recycle feed demineralizers are 100% redundant and piped in parallel. Their purpose is to reduce the radioactivity of the fluid.

The recycle evaporator distillate demineralizer is identical to the Waste Treatment System waste evaporator distillate demineralizer and is piped in parallel with it. The purpose of these demineralizers is to remove any trace amounts of boron.

or radioactivity carryover from the evaporator distillate.

The demineralizers will not be regenerated. When high pressure drop or effluent samples indicate the need for resin replacement, the spent resin will be sluiced to the Waste Treatment System. New resin is supplied from the Chemical and Volume Control System resin fill tank.

Pumps

The Boron Recycle System has three identical pumps which are similar to the smaller Liquid Waste Treatment System pumps. The two recycle evaporator feed pumps transfer liquid from the recycle holdup tanks. The recycle evaporator distillate pump directs flow from the recycle evaporator distillate tank.

Filters

The recycle evaporator feed filters, concentrates filter, and distillate filter are provided in the Boron Recycle System. Their purpose is to remove particulates, primarily resin fines from the demineralizers. The need for filter replacement is indicated by high pressure drop.

Valves and Piping

Valves and piping are stainless steel. Most valves are the diaphragm type. The recycle holdup tank vent eductor is designed to pull gases from under the recycle holdup tank diaphragm; a Gaseous Waste Treatment System waste gas compressor provides the motive force.

9.3.5.2.2 System Operations

The Boron Recycle System is manually operated except for the automatic protective functions. The system is valved to receive a continuous flow into the recycle holdup tanks. There are three parallel flow paths available with various interconnections. The normal flow paths are through one of the recycle evaporator feed demineralizers and filters to a recycle holdup tank. The third flow path is directly from the influent header to a recycle holdup tank. This flow path is initiated automatically by a three way valve if either high temperature in the influent header or high demineralizer pressure drop is detected.

One of the demineralizers is valved in service while the other acts as a standby. When the in-service demineralizer pressure drop indicates the need for resin replacement or the effluent sample indicates unsatisfactory decontamination factor performance, the demineralizer is valved out of service. The standby demineralizer becomes the in-service demineralizer.

When the operator decides to dispose of the contents of a recycle hold-up tank, the alternate flow path is valved into service. The contents are then recycled back to the tank to obtain a representative tank sample. The results of the sample analysis determine the disposition of the tank contents based on the criteria listed below:

1. If the radioactivity level is acceptable, the liquid is directed to the recycle evaporator for boron recovery.

2. If the radioactivity level is unacceptable, the liquid is recycled through the alternate evaporator feed demineralizer and filter train.

3. If the radioactivity level remains unacceptable after operation 2, the liquid is directed to the Waste Treatment System.

4. If the radioactivity levels and boron concentration permit, the liquid may be returned to the Reactor Coolant System.

Most of the evaporator operation is automatic. A level control in the feed tank-evaporator controls the feed flow. Distillate is continuously pumped from the evaporator. However, a sample analysis is required to determine the disposition of the concentrates. If the radioactivity level and the chemical quality are acceptable, the solution is concentrated to 4% by weight. An evaporator concentrates pump is then started and the concentrates are transferred to the Chemical and Volume Control System boric acid tanks. If the concentrates are unacceptable for reuse, they may be concentrated to 12% by weight for drumming. They are then pumped either to the Liquid Waste Treatment System concentrates tank or directly to the drumming station.

The evaporator has redundant pumps for both the distillate and the concentrate. The redundant pumps are interlocked so that two cannot be started or running at the same time. Either pump must be started manually.

Distillate flow is continuous through the recycle evaporator distillate demineralizer and filter to the recycle evaporator distillate tank. If radiation is detected in the distillate stream, a three way valve directs the flow to the Boron Recycle System influent header.

The distillate train has various interconnections with the parallel Liquid Waste Treatment evaporator distillate train. These connections allow the use of the waste evaporator distillate demineralizer or the waste evaporator distillate tank as standby.

When sufficient volume has accumulated in the recycle evaporator distillate tank, distillate flow is terminated. The tank contents are recirculated to obtain a representative sample. If the sample analysis meets reactor grade water quality requirements, the liquid is pumped to the Chemical and Volume Control System reactor makeup water storage tanks. If the water is unacceptable, it is returned to the Boron Recycle System influent header for reprocessing.

9.3.5.3 Design Evaluation

The Boron Recycle System does not perform any safety functions. Parts of the system which could release radioactive gases are safety class 3. These piping and components are designed, fabricated, and inspected according to applicable code requirements. Welded piping connections and diaphragm valves are used to minimize leaks.

The system is designed to operate so that a single malfunction will not shut it down. Parallel flow paths, equipment, and valving allow a standby train to operate while the first train is being maintained. Part of the backup equipment is included in the Liquid Waste Treatment System.

All operations are remote so that the operator is not exposed to the system. Each equipment cubicle and all pipe chases will handle any leakage either by containing them or routing them to a drain tank.

9.3.5.4 Tests and Inspections

The Boron Recycle System design and operation allow normal industry practice of inspection and preventative maintenance. Both the parallel train of equipment design together with the intermittent operation of the system allow frequent access to system components.

9.3.5.5 Instrumentation

The Boron Recycle System instrumentation is listed below by function. A common alarm on the Main Control Board in the control room indicates any alarms on the local Boron Recycle System panel.

Temperature

Temperature indicator is located in the system influent header. A high temperature signal initiates an alarm and controls a three-way valve to bypass the demineralizers.

Pressure

Pressure indicators are located as listed below:

1. Recycle evaporator feed demineralizer pressure differential. A

high pressure signal initiates an alarm and controls a three-way valve to divert flow directly to a recycle holdup tank.

2. Local pressure indicators are located to measure each demineralizer and filter pressure differential, each pump discharge pressure, and the recycle holdup tanks vent line pressure.

Flow

Local flow indicators are located in the recycle holdup tank vent line and in the recycle evaporator feed line.

Level

Water level indicators are provided for each of the recycle holdup tanks. Both high and low alarms indicate locally. The high level alarm is also indicated on the Main Control Board in the control room. A local level indicator is provided for the recycle evaporator distillate tank.

Radiation

A radiation detector is located in the recycle evaporator distillate line. Radiation level and high radiation alarm are provided both locally and on the Main Control Board in the control room. A high radiation signal also actuates a three-way valve to divert flow to the Boron Recycle System influent header.

TABLE 9.3.5-1

PRINCIPAL COMPONENT DATA SUMMARY

Recycle Evaporator Feed Pump

Number	2
Type	Canned horizontal cent.
Design flow, operating/runout	35 gpm/100 gpm
Design head	250 /200 ft
Design temperature	$200^{o}F$
Design pressure	150 psig
Material	Stainless Steel

Recycle Evaporator Distillate Tank Pump

Number	1
Type	Canned horizontal cent.
Design Flow, operating/runout	35 gpm/100gpm
Design head	250/200 ft.
Design temperature	$200^{o}F$
Design pressure	150 psig
Material	Stainless steel

TABLE 9.3.5-1 (CONT)

Recycle Holdup Tank*	
Number	2
Type	Vertical
Usable volume per tank	56,000 gal.
Design pressure	Atmospheric
Design temperature	$200^{o}F$
Material	Stainless steel
Recycle Evaporator Distillate Tank*	
Number	1
Usable volume	5000 gal.
Design pressure	Atmospheric
Design temperature	$200^{o}F$
Material	Stainless steel
Recycle Evaporator Reagent Tank	
Number	1
Usable volume	5 gal.
Design pressure	150 psig
Design temperature	$200^{o}F$
Material	Stainless steel

* Diaphragm required

TABLE 9.3.5-1 (CONT)

Recycle Evaporator Feed Demineralizer

Number	2
Type	Flushable
Design pressure	150 psig
Design temperature	200^{O}F
Design flow	120 gpm
Resin volume	30 cu. ft.
Material	Stainless Steel
Resin type	IRN-150*

Recycle Evaporator Distillate Demineralizer

Number	1
Type	Flushable
Design pressure	150 psig
Design temperature	200^{O}F
Design flow	35 gpm
Resin volume	20 cu. ft.
Material	Stainless Steel
Resin type	IRN-78*

* Rohm and Haas amberlite or equivalent

TABLE 9.3.5-1 (CONT)

Recycle Evaporator Concentrates Filter

Number	1
Type	Disposable cartridge
Design pressure	150 psig
Design temperature	$200^{o}F$
Design flow	35 gpm
ΔP at design flow	5 psi
Retention of 25u particles	98%
Material	Stainless steel

Recycle Evaporator Distillate Filter

Number	1
Type	Disposable cartridge
Design pressure	150 psig
Design temperature	$200^{o}F$
Design flow	35 gpm
ΔP at design flow	5 psi
Retention of 25u particles	98%
Material	Stainless steel

TABLE 9.3.5-1 (CONT)

Recycle Evaporator Feed Filter

Number	2
Type	Disposable cartridge
Design pressure	150 psig
Design temperature	$200^{o}F$
Design flow	150 gpm
ΔP at design flow	5 psi
Retention of 5u particles	98%
Material	Stainless steel

Recycle Evaporator

Number	1
Steam design pressure	50 psig
Design flow rate	15 gpm
Feed concentration	10-2500 ppm boron
Discharge concentration (concentrate)	7000-21,000 ppm boron
Discharge concentration (distillate)	10 ppm boron as H_3BO_3
Material	Stainless steel

9.3.6 GAS SUPPLY SYSTEM

9.3.6.1 Design Basis

The Gas Supply System (GSS) stores hydrogen, oxygen, and nitrogen and distributes these gases to locations for use throughout the plant. Hydrogen and oxygen are generated on board using electrolytic cells. Low pressure nitrogen are stored as liquid. The high pressure nitrogen is stored as gas. The system design requirements are shown on Table 9.3.6-1.

9.3.6.2 System Description

The gas supply system is shown on Figure 9.3-13, sheets, 1 and 2. The system comprises the hydrogen-oxygen generating unit; hydrogen dryer, purifier, low pressure compressors, and high pressure compressor; oxygen dryer, L.P. and H.P. compressors; hydrogen, oxygen and nitrogen gas cylinders; nitrogen liquid storage units; and the assocaited piping, valves and instrumentation. All the GSS components are located outside the containment.

The H_2-O_2 generating unit produces hydrogen and oxygen by electrolysis of demineralized water. The generating unit produces 150 SCF of hydrogen and 75 SCF of oxygen per hour. These gases are dehumidified and compressed to 100 psig for direct supply to the users. One high pressure compressor is provided for each gas to refill the corresponding reserve storage cylinders to 2400 psig. Nine high pressure storage cylinders are provided for hydrogen and one is provided for oxygen. Each cylinder contains 7600 SCF at 2400 psig. The high pressure header for each gas has a pressure regulator which maintains the downstream pressure at 100 psig.

High pressure nitrogen is stored in six cylinders, each containing 7600 SCF at 2400 psig. A pressure regulator is installed to regulate the downstream pressure to 750 psig.

Low pressure nitrogen is stored as liquid in two insulated tanks, each having a capacity of 522 gallons and operating at 245 psig. Each tank has a built-in vaporizer. A pressure regulator maintains the downstream pressure at 100 psig. The gas is then distributed to various users through the nitrogen manifold.

The storage vessels for all three gases are provided with lines to fill them from an external bulk supply. However, hydrogen and oxygen reserve storage cylinders are normally filled from the generating unit.

9.3.6.3 Design Evaluation

The gas supply system is designed for safe operation and reliable supply of hydrogen, oxygen, and nitrogen gases. The GSS is not an engineered safeguard system. Its components are not classified under ANS safety classifications. However the system meets other applicable codes as listed in Table 3.2-1.

The on-board generation of hydrogen and oxygen ensures a continuous and reliable supply of these gases, and eliminates the hazards of handling high pressure hydrogen cylinders.

The storage vessels of the GSS are designed to withstand a wide range of temperatures and pressures. Safety valves are provided to relieve gas in case of excessive pressure build-up.

Conventional tests and inspections of the GSS components are carried out to check gas impurities and leakage.

Necessary instrumentation is provided including pressure regulators and alarms.

TABLE 9.3.6-1

GAS SUPPLY SYSTEM DESIGN REQUIREMENTS

Gases	Users	Consumption	Storage Volume	Header Supply Pressure	Purity %
Hydrogen	Turbine-generator Volume control tank Catalytic H_2 recombiner	1500 SCFD 40000 SCF to fill generator to 75 psig	68400 SCF @ 2400 psig	100 psig	99.95
Oxygen	Catalytic hydrogen recombiner	500 SCFD	7600 SCF @ 2400 psig	100 psig	99.5
High Pressure Nitrogen	Accumulators	22650 SCF per accumulator	45600 SCF @ 2400 psig	750 psig	99.9
Low Pressure Nitrogen	Pressurizer relief tank Reactor coolant drain tank Spent resin storage tanks Gas decay tanks Catalytic H_2 recombiner Condensate storage tank Volume control tank	1500 SCFD*	1044 gallons* @ 245 psig	100 psig	99.9

* Includes average evaporation loss.

9.3.7 BULK CHEMICAL HANDLING SYSTEM

9.3.7.1 Design Bases

A five week supply of chemicals is provided by appropriatly sized tanks and storage areas. The treatment of the sea water used for cooling is provided by an onboard sodium hypochlorite generation system. The use of the sodium hypochlorite generator eliminates the need to store sodium hypochlorite on the platform.

Storage facilities are provided based on the following requirements:

Sulfuric acid		6000 gallons
Sodium hydroxide		250 gallons
Morpholine		420 gallons
Hydrazine		110 gallons
Phosphates	Trisodium	2000 lbs.
	Disodium	3400 lbs.
	Monosodium	1000 lbs.

TABLE 9.3.7-1

BULK CHEMICAL HANDLING SYSTEM

EQUIPMENT DESIGN PARAMETERS

Sulfuric acid tank		Vol. 6000 gallons 9 ft. dia. 12½ ft. length Material of construction carbon steel lined with baked on phenolic resin (Heresite) or equivalent 4 to 6 mils thick.
Sodium hydroxide tank		Vol. 250 gallons 3 ft. dia. 5 ft. length material of construction-carbon steel
Morpholine		420 gallons stored in 55 gal. drums
Hydrazine		110 gallons in 55 gal. drums
Phosphates	Trisodium	2000 lbs. stored in suitable bulk containers.
	Disodium	3400 lbs.
	Monosodium	1000 lbs.

The sodium hypochlorite is piped to the raw water intakes in sufficient concentration to provide 1 ppm of free chlorine continuously. The residual free chlorine at the plant outlet (seawater) will be controlled not to exceed .01 ppm. System equipment design information is shown on Table 9.3.7-1.

9.3.7.2 System Description and Design Evaluation

The System consists of two basic types of supplies, i.e., solids and liquids. Solids are stored as bulk and manually distributed to the proper mixing facility. The liquids are stored in two ways: Morpholine and hydrazine are contained in 55 gallon drums which are distributed to the mixing tanks manually; sulfuric acid and sodium hydroxide are distributed to the chemical feed tanks using pipes and associated controls. Sodium hypochlorite is continuously fed to the raw water system by the piping provided.

The system has no ANS Safety Classification. All piping valves and tanks are designed in accordance with accepted safe practices and ASME codes where applicable.

9.4 AIR CONDITIONING, HEATING, COOLING AND VENTILATION SYSTEMS

9.4.1 CONTROL AREA VENTILATION

9.4.1.1 Design Bases

The Control Area Ventilation is designed to maintain the control room, process rack room, and rod control room environments within acceptable limits for the operation of plant controls, for maintenance and testing of these controls, and for the uninterrupted safe occupancy of the control room during accident and post-accident recovery conditions. The control room systems are ANS Safety Class 3.

The Control Building Ventilation Systems are designed to:

1. Maintain the space temperature in each area within the range of 72 - 75°F and the relative humidity at a maximum of 50 per cent.

2. Provide sufficient air changes to satisfy occupancy requirements.

3. Provide slight pressurization of each area to prevent entry of airborne matter originating outside the areas during normal operation.

4. Prevent the entry of airborne fission products via the outside air intakes during post-accident shutdown.

5. Maintain design temperature and humidity conditions during post-accident shutdown.

6. Provide redundant equipment for the control room.

7. Conform with applicable requirements of General Design Criteria 19 as specified in 10 CFR 50.

9.4.1.2 System Description

Control Area Ventilation Equipment data are presented in Table 9.4.1-1, and materials of construction in Table 9.4.1-2. The Ventilation Flow Diagram is shown in Figure 9.4-1 and includes the following:

1. Control room air conditioning system including auxiliary charcoal filtration.

2. Process rack and rod control room air conditioning system.

3. Control room and process rack refrigeration condensing machines.

The Control Area Ventilation equipment is located at elevation 94 feet. Air is ducted from this area to the Control room on elevation 94 and the process rack and rod control rooms on elevation 76. All air intakes and exhausts are located above the 94 foot level.

TABLE 9.4.1-1

CONTROL AREA AIR CONDITIONING SYSTEM PERFORMANCE DATA

SUBSYSTEM	UNITS	FAN scfm, each	FILTERING P	FILTERING A	FILTERING C	REDUNDANCY RUNNING	REDUNDANCY STANDBY
Control Room Supply*	2	10,500	1	-	-	1	1
Control Room Return Air	1	9,700	-	-	-	1	-
Toilet Exhaust	1	800	-	-	-	-	-
Auxiliary Filtration	2	4,000	1	1	1	1 or 2 as required	-
Process Rack and Rod Control Room**	1	18,500	1	-	-	1	-
Process Rack and Rod Control Return Air	1	18,500	-	-	-	1	-
Control Room and Process Rack Condensing Unit	2	--	-	-	-	1	1
Emergency Supply Fan	1	5,000	-	-	-	1 as required	-

LEGEND:

P Prefilter or filter, efficiency 50%, NBS Dust Spot Test.

A Absolute or high efficiency particulate air filter, efficiency 99.97% on 0.3 micron DOP aerosol

C Activated charcoal filter, Type BC 727, efficiency 95% and 99% for methyl iodine and iodine, 70% RH, 45 FPM.

* Design conditions: Room at 75°F/50% RH; outside 95°F Summer, 0°F Winter. Outside air 15% of supply, minimum.

**45°F refrigeration suction temperature.

TABLE 9.4.1-2

CONTROL BUILDING AIR CONDITIONING SYSTEMS

Materials of Construction:

Air Intake Louvers	Aluminum
Ductwork	Galvanized Sheetmetal
Dampers	Galvanized Steel, Neoprene edges
Prefilters and Filters	50% NBS, Dual media with throwaway face mat followed by plated section of glass medium, aluminum separators and fire retardant scalant.
Filter Frames	Epoxy on steel
Coating Coils	Copper tubing, aluminum fins bonded to tubing
Heating Coils	Copper tubing, aluminum fins
Fan-Coil Assemblies	Steel construction, fiberglass insulation
Absolute Filters	Same as Table 9.4.2-2
Charcoal Filters	Same as Table 9.4.2-2
Fans	Steel construction throughout
Air Diffusers	Aluminum, lacquer finish
Registers	Aluminum, lacquer finish
Reheat Coils	Electric, alloy sheath and fins, step control
Supply Duct Insulation (Air Conditioning Supply)	Fiberglass
Condensing Units Condenser	Steel envelope - integral fin copper tubes
Refrigerant Compressors	Direct dew flexible coupling, constant speed unloaded starting, and multi-step capacity control
Refrigerant Piping and Specialties	Copper

The Control Area Ventilation Systems include all the components in each of the air conditioning equipment trains consisting of air filters, cooling coils, heating coils, charcoal filter trains, related fans and refrigeration condensing systems. An emergency supply fan is provided to supply control room ventilation in the event a tornado causes loss of the normal equipment. System performance data are shown in Table 9.4.1-1.

9.4.1.3 Design Evaluation

The Control Area Ventilation Systems provide adequate capacity to assure that design environmental conditions are maintained in the respective control areas under operating and shutdown conditions. One hundred percent active equipment redundancy is provided in the control room to assure reliable operation with one active component out of service.

Temperature, humidity, pressure, and radioactivity levels are constantly monitored. The control room system is equipped with auxiliary charcoal filters for air recirculation to remove odors and radioactive iodine vapors during post-accident shutdown. Control room equipment is manually switched to emergency power and essential service water supply following loss of off-site power.

Primary heating for the control area ventilation system is by means of steam. Zone reheating is accomplished by means of electricity.

During normal operation, a fixed proportion of room air and outside air is supplied to the rooms through filters, cooling coils, and heating coils.

The rooms are maintained at a slight positive pressure with respect to other adjoining areas.

All system's outside air intakes and exhausts, including toilet exhaust, close automatically upon containment isolation and safety injection initiation and the ventilation systems then operate on a 100 percent air recirculation basis. Such operation is continued while maintaining temperature requirements within the control areas. Manual control switches are located in the control room for remotely directing air through the absolute and charcoal filters during the air recirculation process for odor and iodine vapor removal and for gradually opening the outside air intake, also via the charcoal filters, once the outside radiation decreases to a level of 2×10^{-9} μCiI/cc air.

If smoke is detected within the rooms, air can be manually diverted through the high-efficiency filter train or expelled via exhaust air openings to atmosphere on a 100 percent capacity once-through basis.

Adjoining nonrelated areas are served by separate ventilation systems entirely independent of the Control Area Systems.

9.4.1.4 Tests and Inspections

Tests and inspections will be performed by the manufacturer to demonstrate the capability of components and systems to operate satisfactorily.

9.4.1.4.1 Manufacturer Shop Testing

The respective manufacturers will be required to demonstrate by appropriate tests the standards of performance which each of the following componets must satisfy:

1. Charcoal filter efficiency for removal of molecular iodine 131 and methyl iodide 131.

2. Charcoal filter capacity for retention of elemental iodine and methyl iodine.

3. Charcoal filter resistance to air flow.

4. HEPA filter efficiency and resistance test to meet UL label requirements.

5. Fan performance characteristics tested according to AMCA test procedures.

9.4.1.4.2 System Testing and Inspection

Operational tests will be performed in accordance with Section 14.1 prior to initial startup to demonstrate proper functioning of the systems. Tests will include the following:

1. System performance so as to meet design conditions.

2. Mechanical tests to ascertain presence of mechanical defects or deficiencies.

The operability of the activated charcoal filter can be assured by placing representative test samples of charcoal in the filter housing in locations which expose the samples to the same air flows as the charcoal bed, and by testing these for efficiency on a periodic basis.

9.4.1.5 Instrumentation and Application

The following instrumentation is utilized.

1. Air Flow Alarm. Located in control room.

2. Filter pressure differential. Located in control room.

3. Fire Detection Alarm. Located in control room locally.

4. "S" Signal Response. Closes outside air intake dampers automatically with provision for manual override in the control room.

9.4.2 AUXILIARY AREA VENTILATION SYSTEMS

9.4.2.1 Design Bases

The Auxiliary Area Ventilation Systems are designed to:

1. Maintain the space temperature and humidity at the design conditions outlined.

2. Maintain areas that are not potentially contaminated at a positive pressure to minimize inleakage.

3. Maintain areas that are potentially contaminated under a negative pressure to minimize outleakage.

4. Provide for purging of plant areas to the plant vent. Air exhausted to the plant vent is filtered, monitored and diluted.

5. Provide ANS Class 3 ventilation and cooling services essential to the operation of safeguards equipment, containment pipe penetrations, diesel generators, and fuel handling area facilities.

6. Perform each intended safety function with loss of one active component.

9.4.2.2 System Description

The Auxiliary Area Ventilation Systems are shown in Figures 9.4-2 and 9.4-3. System equipment data are given in Tables 9.4.2-1, materials and construction in Table 9.4.2-2. The following systems are provided:

1. Supply system serving waste treatment, liquid, storage, sampling and pipe spaces at elevation 40 feet, 58 feet, and 76 feet.

2. Air conditioned supply for contaminated change room, hot laboratory, counting room, contaminated laundry, contaminated instrument and control shop at elevation 40 feet, 58 feet, and 76 feet.

3. Air conditioned supply for machine shops and maintenance offices at elevation 94 feet.

4. Supply and exhaust systems for battery rooms and diesel generator rooms at elevation 58 feet and 40 feet respectively.

5. Supply and exhaust serving safeguards equipment areas elevation 7 feet 6 inches, 21 feet 4 inches, 40 feet, and 58 feet.

6. Supply and exhaust for boiler room and bulk gas storage.

7. Supply and exhaust system for fuel handling area at elevation 94 feet.

8. Supply and exhaust for diesel generator compartments.

9. Exhaust system serving waste treatment, liquid storage, sampling, pipe spaces, contaminated change room, hot laboratory, counting room, contaminated laundry, contaminated instrument and control shop at elevations 40 feet, 58 feet, and 76 feet.

10. Exhaust for contaminated machine shop and maintenance office at elevation 94 feet.

11. Exhaust for clean machine shop and maintenance office at elevation 94 feet.

12. Unit coolers for safeguards equipment compartments at elevation 7 feet, 6 inches.

13. Charcoal air filtration units for safeguards equipment areas at elevation 7 feet, 6 inches.

14. Charcoal filter exhaust for counting room, and sampling hood in hot laboratory, both at elevation 58 feet.

Auxiliary Area Main Ventilation Supply Systems Items 1 and 5

Items 1 and 5 include two main supply air systems which during normal plant operation handle the bulk of the makeup air to the auxiliary area. Each supply system supplies air on a once-through design basis utilizing a 100 percent capacity fan at the rate of approximately five building air changes per hour. Each supply system is equipped with an air filter and steam heating coil, thermostatically controlled. Air flow is manually adjusted to satisfy the design requirements.

Air Conditioned Supply, Items 2 and 3

Items 2 and 3 systems supply conditioned air to some areas on a once-through basis utilizing 100 percent capacity equipment in each area. The systems are sized to provide design temperature and humidity conditions. Air is filtered, cooled and heated.

Supply and Exhaust Systems, Item 4

These systems serve the battery and diesel generator rooms on a once-through basis. Supplies are equipped with filters and heating coils. The supplies to the diesel generator rooms operate independently of the diesel generator room ventilation systems which are utilized only during Diesel Generator

Ventilation Systems which are utilized only during diesel generator operation. (See Item 8)

Auxiliary Area Miscellaneous Ventilation Systems, Items 6, 10, 11, 14

Miscellaneous ventilation systems supply and exhaust air to and from functionally isolated or dissimilar areas for the removal of heat, and/or airborne contamination. Figure 9.4-3 depicts the air flow and filter arrangement of the main system described and also typifies the miscellaneous systems which have similar components.

Fuel Handling Area Supply and Exhaust, Item 7

The Fuel Building Ventilation Systems (Figure 9.4-2) consist of a central supply and exhaust air system. The supply system includes two 50 percent filter, heating coil and fan component trains. The exhaust system includes two 50 percent prefilters, absolute filter, and charcoal filter trains. Three 50 percent capacity fans are utilized. The supply and exhaust fans can be manually switched from four building air changes per hour to eight per hour. The supply system makes use of one or two 50 percent fan-coil trains. Likewise one or two exhaust fans are placed on stream to match the supply.

Supply air is introduced into the building from ducts located at approximately the 112-foot level. All air is exhausted at the perimeter of the fuel pit via slot-type exhaust openings ducted to the exhaust system.

The exhaust air is directed through the prefilters and absolute filters and to the plant vent. Provision is also made for diverting the air through the charcoal filters during refueling operations.

Diesel Generator Ventilation, Item 8

The Diesel Generator Ventilation Systems perform a heat removal function during engine operation and consist of:

1. A 100 percent capacity supply fan, filter, and modulating dampers operating in response to a room thermostat and associated ductwork.

2. One 100 percent capacity exhaust fan, modulating discharge damper and ductwork.

Compartment heating is accomplished by means of the air supply units, Item 4, as conditions warrant.

Main Ventilation Exhaust Systems, Items 5 and 9

Items 5 and 9 include the main exhaust air systems. These systems operate simultaneously serving different areas within the auxiliary building. Each exhaust system makes the use of two 100 percent capacity exhaust fans; one is maintained on standby status. Each exhaust system is equipped with a prefilter and absolute filter. Exhaust air flow rate is controlled manually. The building is maintained at a negative pressure. Air is exhausted from each of the respective areas of the building with a duct system sized in such a manner as to cause the flow of building air from the zone of least potential contamination to the zones of increasing potential contamination.

Engineered Safeguards Fan-Coil Air Cooling Units, Item 12

Fan-coil air cooling units perform a heat removal for safeguards pump motors located in the safeguards compartments. Each unit consists of a fan-coil and ducting which supplies cooling air to the motors. Heat is transferred to essential service water. Power is supplied from the engineered safeguards buses.

The fan-coil units remove heat generated by the following motors:

1. Residual heat removal pump motors

2. Containment spray pump motors

3. Safety injection pump motors

4. High head safety injection pump motors

5. Auxiliary feedwater pump motors and steam driven pump

6. Essential raw water pump motors

7. Essential service water pump motors

During normal and shutdown operation and ventilation of the rooms and spaces housing containment penetrations and compartments housing the safeguards equipment pumps is supplied and exhausted by the main ventilation systems, Item 5.

Charcoal Air Filtration Units for Safeguards Compartments, Item 13

The charcoal air filtration units serve as airborne contamination removal and control function during operation of safeguards pumps and associated equipment within the safeguards pipe tunnels and compartments. Each filtration unit consists of a HEPA and charcoal filter train within a self-contained fan and housing.

9.4.2.3 Design Evaluation

The auxiliary building ventilation provides design temperatures and environmental conditions in the various areas of the building during normal operating and shutdown. Safety Class requirements are presented in Table 3.2-1.

Redundancy is included in the fuel handling area ventilation to assure operation of such systems with one active component out of service. Activated charcoal filters are in all cases completely isolated from the normal exhaust air stream to protect the adsorbers from exposure to moisture, hydracarbons, and other poisons and consequent loss of holding capacity for iodine and methyl iodine.

Under normal operating conditions, the balance between supply and exhaust in potentially contaminated areas is controlled manually to maintain a negative pressure in the area corresponding to a capture velocity of not less than 80 fpm with respect to the atmosphere and/or adjoining areas. All vents from potentially contaminated areas are directed through absolute filters and to the plant vent which is continuously monitored for particulate and gas radioactivity. Supply air is filtered. All systems are located for convenient access, control and monitoring.

Fuel Pit Ventilation

During the spent fuel handling operation, a fuel pit enclosure is utilized to capture the normal airborne emissions from the surface of the water. Air is uniformly drawn through the top of the enclosure and passed vertically downward against the surface of the water and thence to the fuel pit perimeter exhaust outlets. Air is exhausted at the rate of not less than eight building air changes per hour. Provision is made to maintain the pit enclosure at a negative pressure of approximately .50 inch water column (w.c.). At this time a draft of not less than 80 fpm is established at the fuel pit enclosure to containment interface opening in the direction of the fuel pit; the containment is also at a negative pressure of approximately .50 inch w.c. The fuel building pressure is maintained at a negative pressure with respect to the outside atmosphere as previously indicated for potentially contaminated areas.

During emergency operation, following accidental release from a fuel assembly being handled, the building supply system shutdown and all building openings are closed to establish a fuel building negative pressure of approximately .25 inch w.c. The pit enclosure and containment negative pressure of approximately .50 inch w.c. is maintained. The containment purge system isolation valves are closed and the purge fans are shutdown until normal conditions are restored.

The cask loading areas is ventilated by means of the same system which ventilates the fuel pit. This system exhausts air via HEPA and charcoal filters and to the plant vent. When not used for refueling, it exhausts to the plant vent after passing through the HEPA filter train.

Engineered Safeguards Compartment Ventilation

During normal plant operations when safety equipment is not in operation the safeguards compartments are ventilated by the systems listed under Items (4) and (5). In an accident condition, the item (5) system is shutdown, while the item (4) system remains in operation. The systems listed under items (12) and (13) are activated by the safety injection "S" signal.

9.4.2.4 Tests and Inspection

Tests and inspections will be performed by the manufacturer where required by the Applicant to demonstrate that a components meet specific requirements.

Manufacturer Shop Testing

Appropriate tests will demonstrate the following:

1. Carbon filter capabilities for removal of molecular iodine-131 and methyl iodide-131.

2. Carbon filter iodine collection capability.

3. Carbon filter cell leaktightness integrity.

4. Carbon filter flow resistance.

5. HEPA filter efficiency and resistance test to meet UL label requirements.

6. Fan performance characteristics tested according to AMCA test procedures.

System Testing and Inspection

Operational testing will be performed in accordance with Section 14.1 prior to initial startup to demonstrate proper functioning of the system.

Testing will include the following:

1. Leaktightness tests of components and systems

2. System functional test

For the purpose of periodically testing the retentive capability of the carbon filter, representative test carbon samples will be placed in the filter housing in locations which allow the samples to be subjected to the same air flows as the carbon bed. The samples will be periodically removed and tested.

9.4.2.5 Instrumentation and Application

The following instrumentation is utlizied:

1. Air Flow Alarm - Located in control room.

2. Exhaust Fan Pressure Differential - Located in control room.

3. Fire Detector Alarm - Located in control room and locally, detectors in duct systems with provisions for automactic shutdown of air supply systems.

4. High-Low Temperature Alarm - Located in control room.

5. Filter Pressure Differential - Indicated locally.

TABLE 9.4.2-1

AUXILIARY AREA VENTILATION SYSTEMS

Item	System	Units	Capacity (each) scfm	Filtering	Design Conditions				Other Conditions
					Building		Outside		
					Summer	Winter	Summer	Winter	
1	Controlled Access Waste Treatment, Processing, Recycle and Holdup tanks, Liquid Storage, Sampling and Piping Space Supply; Elevations 40,58 & 76	1	116,700	P*	-	$70^{o}F$	-	$0^{o}F$	Five air changes per hour
2	Contaminated Change Room, Hot lab Counting Room, Contaminated Laundry & Contaminated I&C Shop Supply; Elevations 58 & 76	1	8,500	P	$75^{o}F$ 50% RH* max.	$75^{o}F$ 50% RH* max.	$95^{o}F$ 78 wet bulb	$0^{o}F$	Chilled water is from service building Chiller
3	Clean & Contaminated Machine Shops & Maintenance Offices Supply Elevation 94	1	8,600	P	$75^{o}F$ 50% RH* Max.	$75^{o}F$ 50% RH* Max.	$95^{o}F$ 78 wet bulb	$0^{o}F$	
4.1	Battery & Sw.Gr. Rm Supply; Elevation 58	4	4,100	P	$110^{o}F$	$70^{o}F$	$95^{o}F$	$0^{o}F$	
4.2	Battery & Sw.Gr. Rm Exhaust; Elevation 58	4	4,100	-	--	--	--	--	
5.1	Safeguards Equipment Areas Supply; Elevations 7'6", 21'4", 40 & 58	1	68,600	P	-	$70^{o}F$		$0^{o}F$	Five air changes per hour.

*Symbols are identified at end of table

TABLE 9.4.2-1

AUXILIARY AREA VENTILATION SYSTEMS

Item	System	Units	Capacity (each) scfm	Filtering	Design Conditions: Building Summer	Design Conditions: Building Winter	Design Conditions: Outside Summer	Design Conditions: Outside Winter	Other Conditions
5.2	Safeguards Equipment Areas Exhaust; Elevations 7'6", 21'4", 40 & 58	1	68,600	P,A	-	-	-	-	Redundancy-one fan running, one 100% standby.
6.1	Boiler Room Supply Elevation 58	1	21,000	-	$115^{\circ}F$	$50^{\circ}F$	-	$0^{\circ}F$	Twenty air changes per hour
6.2	Bulk Gas Storage Exhaust; Elevation 58	1	7,000	-	Same as outside		-	-	Six air changes per hour
7.1	Fuel Area Supply	1	94,000	P	$110^{\circ}F$	$70^{\circ}F$	$95^{\circ}F$	$0^{\circ}F$	
7.2	Fuel Area Exhaust	1	94,000	P,A,C*	-	-	-	-	
8.1	Diesel Room Supply Elevation 40	4	32,000	P	$110^{\circ}F$	$50^{\circ}F$	$95^{\circ}F$	$0^{\circ}F$	Supply based on rate of heat rejection
8.2	Diesel Room Exhaust Elevation 40	4	32,000	-	-	-	-	-	
9	Item 1 Exhaust & Contaminated Change Room, Machine Shop, Hot Lab Counting Room, Contaminated Laundry & Contaminated I & C Shop Exhaust; Elevations 40, 58 & 76	1	128,700	P,A	-	-	-	-	Redundancy - one fan running, one 100% standby

*Charcoal filters are full flow capacity filters.

TABLE 9.4.2-1

AUXILIARY AREA VENTILATION SYSTEMS

Item	System	Units	Capacity (each) scfm	Filtering	Design Conditions				Other Conditions
					Building		Outside		
					Summer	Winter	Summer	Winter	
10	Transfer Fan, From Clean Machine Shop, Maintenance office to Mechanical Equipment Room, Elevation 94	1	3,900	-	-	-	-	-	
11	Mechanical Equipment Room & Day Tank Exhaust, Elevation 94	1	4,100	-	-	-	-	-	
12.1	A. Safeguards Pipe Tunnel & Compartment No. 1	1	15,000	-	120^{o}F *	120^{o}F *	-	-	Actuated on "S" signal or pump operation.
12.1	B. Safeguards Pump & Auxiliary Equipment Comp. No. 1	1	16,200	-	120^{o}F *	120^{o}F *	-	-	Actuated on "S" signal or pump operation.
12.2	A. Safeguards Pipe Tunnel & Compartment No. 2	1	15,000	-	120^{o}F *	120^{o}F *	-	-	Actuated on "S" signal or pump operation.
12.2	B. Safeguards Pump and Auxiliary Equipment Comp. No. 2	1	16,200	-	120^{o}F	120^{o}F	-	-	Actuated on "S" signal or pump operation.

*Room temperature; supply to motors at 100^{o}F

TABLE 9.4.2-1

AUXILIARY AREA VENTILATION SYSTEMS

Item	System	Units	Capacity (each) scfm	Filtering	Design Conditions Building Summer	Design Conditions Building Winter	Design Conditions Outside Summer	Design Conditions Outside Winter	Other Conditions
12.3	A. Safeguards Pipe Tunnel & Comp. No. 3	1	8,400	-	120°F *	120°F *	-	-	Actuated on "S" signal or pump operation.
12.3	B. Safeguards Pump and Auxiliary Equipment Comp. No. 3	1	16,200	-	120°F *	120°F *	-	-	Actuated on "S" signal or pump operation.
12.4	A. Safeguards Pipe Tunnel & Comp. No. 4	1	8,400	-	120°F *	120°F *	-	-	Actuated on "S" signal or pump operation.
12.4	B. Safeguards Pump and Auxiliary Equipment Comp. No. 4	1	10,800	-	120°F *	120°F *	-	-	Actuated on "S" signal or pump operation.
13	Charcoal Air Filtration Units for Safeguard Compartments	4	1,500	P.A.C.	-	-	-	-	Actuated on "S" signal or pump operation.
14	Sampling Room & Hot Lab Exhaust, Elevation 58	1	1,600	P.A.C.	-	-	-	-	Discharges through Item 9

*Room temperature; supply to motors at 100°F

TABLE 9.4.2-1 (NOTES)

AUXILIARY AREA VENTILATION SYSTEMS

P	Prefilter or filter; efficiency 50% NBS dust spot test
A	Absolute or high efficiency particulate air filter; efficiency 99.97% on a .3 micron DOP Aerosol.
C	Activated charcoal filter; type BC 727, bed thickness 2", efficiency 95% and 99% for methyl iodine and iodine, 80% RH 45 FPM
RH	Relative humidity

TABLE 9.4.2-2

AUXILIARY BUILDING VENTILATION SYSTEMS

Material of Construction	
Air Intake Louvers	Aluminum
Air Plenums	Galvanized sheetmetal or painted steel
Ductwork	Galvanized sheetmetal or painted steel
Duct Insulation (Air Conditioning Supply)	Fiberglass
Dampers	Galvanized steel, Neoprene edges
Air Intake Filter Mechanism	Epoxy on steel
Filter Frames	Epoxy on steel
Heating Coils	Copper tubes, aluminum fins
Fans	Steel Construction
Fan Inlet Dampers	Steel Construction
Absolute Filters-Efficiency 99.97% on .3 micron DOP particles	Water proof glass medium; Separators, none Frame, FR* particle board; flanges, none; sealant, FR foam.
Prefilters Efficiency 50% on the NBS** Dust Spot Test	Dual media;with throw away glass face mat, followed by pleated section of glass medium with aluminum separators, FR particle board frame and FR sealant

TABLE 9.4.2-2 (CONT)

Air supply Filter Efficiency 50% NBS	Automatic glass air mat followed by pleated filter cells, glass medium. Metal parts epoxy coated
Barnebey-Cheney Type 727 or equal charcoal filter, 2" bed thickness, efficiency not less than 95 and 99 percent for methyl iodine and iodine respectively @ 80 percent relative humidity and 45 FPM superficial air velocity and maximum filter loading of 10 mg I/gc.	Housing-structural steel or concrete, painted and galv. sheet steel adsorber, stainless steel perforated metal; charcoal impregnated with KI and iodine; source of charcoal, coconut shell; method of activating, high temperature steam; particle size distribution per MIL-C-17605B (ships) para. 4.6.3.
Air Diffusers	Aluminum, lacquer finish
Registers	Aluminum, lacquer finish

* Fire retardant

** National Bureau of Standards

9.4.3 ADMINISTRATION AND SERVICE BUILDING VENTILATION

9.4.3.1 Design Bases

The Administration and Service Area Ventilation is designed to maintain comfortable working, recreation, and sleeping conditions during normal plant operation, and in the emergency relocation area following a loss of coolant accident (LOCA).

The ventilation systems are designed to:

1. Maintain the space temperature in each area within 72 to 75°F on a year-round basis; humidity a maximum of 50 percent relative to saturation.

2. Provide adequate ventilation air for personnel occupancy.

3. Provide slight positive pressure with respect to adjoining areas and the atmosphere.

4. Maintain design temperature conditions in the emergency relocation area following LOCA.

9.4.3.2 System Description

System performance data are given in Table 9.4.3-1, and materials of construction in Table 9.4.3-2. The system flow diagrams are shown in

Figure 9.4-4 and include the following:

1. Relocation area, elevation 40 feet

2. Living quarters, elevation 76 feet

3. Living quarters, elevation 58 feet

4. Relocation area refrigeration condensing machines

5. Living quarters ventilation system water chillers.

Relocation area ventilation equipment, including refrigeration machines, are located within the relocation area. Other ventilation equipment and water chillers are located in ventilation machinery rooms outside the living quarters.

Air is distributed to the various areas at a constant rate with two 50 percent capacity systems in proportion to the heat gains from body heat, lights, and building transmission sources. Each supply system is subdivided into several zones with individual temperature controls in each.

The ventilation systems are equipped with standard filters, cooling coils and heating coils except the relocation area systems which are equipped with charcoal filter trains each consisting of prefilter, absolute filter, and charcoal filter for removing odors, and iodine vapors, plus particulates during occupancy following LOCA. The relocation area systems are maintained on the engineered safeguards buses and use service water supply. All systems have an emergency sequence feature following a LOCA in which all air intakes and exhaust openings are automatically closed; the emergency relocation systems remain in operation on 100 percent air recirculation while remaining systems are shut down.

Primary heating is by means of steam. Zone reheating is accomplished by means of electricity.

9.4.3.3 Design Evaluation

The emergency relocation area system is ANS Safety Class 3, as noted in Table 3.2-1. Other administration and service building systems are not classified as Nuclear Safety System.

During normal operation, a fixed proportion of outside air is supplied to the rooms through filters, cooling coils, and heating coils. The rooms are maintained at a slight positive pressure with respect to other areas and the outside atmosphere.

In the event of an emergency, all outside building openings are closed automatically in response to the "S" signal. A manual control switch is provided locally for diverting the air through the absolute and charcoal filters of the emergency relocation area systems while the systems remain in operation on a 100 percent air recirculation mode; all other systems are shut down. Relocation area outside air intakes are gradually re-opened by means of another local switch once atmospheric radioactivity has decreased to an acceptable level. Outside air can be introduced via the activated charcoal filter as in the case of the control room, sub-section 9.4.1.

9.4.3.4 Tests and Inspections

Tests and inspections will be performed by the manufacturer where required by the Applicant to demonstrate that components meet specific requirements.

9.4.3.4.1 Manufacturer's Shop Testing

Appropriate tests will demonstrate the standards of performance which each component must satisfy.

9.4.3.4.2 System Testing and Inspection

Operational tests will be performed in accordance with Section 14.1 prior to initial startup to demonstrate proper functioning of the systems. Tests will include:

1. System performance to meet design conditions.

2. Mechanical tests to ascertain presence of mechanical defects or deficiencies.

9.4.3.5 Instrumentation and Application

The following instrumentation is utilized:

1. Relocation Area Room Temperature Indicator. Located in control room.

2. Fire Detector Alarm. Alarms in Control room and locally, detectors in duct systems with provisions for automatic shutdown of air supply systems.

3. "S" Signal Fan Shutdown. Automatic with manual override in control room.

4. Filter Pressure Differential. Located in control room and locally for relocation area. all others locally.

5. Flow Alarm. Located in control room.

6. Temperature and Pressure Indicators. Local indication on chilled water systems.

TABLE 9.4.3-1
ADMINISTRATION AND SERVICE AREA VENTILATION SYSTEMS
DESIGN CONDITIONS AND PERFORMANCE DATA

	SUBSYSTEM						
	Supply Air Elevation 76-Item 1	Supply Air Elevation 58-Item 2	Return Air Fan Elevation 76-Item 3	Return Air Fan Elevation 58 Item 4	Relocation Area Supply Elevation 40-Item 5	Water Chiller Item 6	Relocation Area Condensing Unit Item 7
Number	1	1	1	1	2	2	2
Flow, each, scfm	27,000	16,000	24,000	12,800	5,300	-	-
Filtering	P	P	-	-	P,A,C,	-	-
Design Conditions:							
Inside, Summer, & Winter, °F	75, maximum; 50% relative humidity	75, maximum; 50% relative humidity	-		75 maximum 50% relative humidity	-	-
Outside, Summer °F	95	95	-	-	95	-	-
Wet Bulb, " °F	78	78	-	-	78	-	-
Outside, Winter °F	0	0	-	-	0	-	-
Redundancy:*							
Running	1	1	1	-	2	2	2
Other Conditions	Outside Air 25%	Outside Air 20%	-	-	Outside Air 20%	Water is supplied to Items 1&2 above & Items 2&3 of Sect. 9.4.2	45°F Refrigerator suction

*No standby units.

LEGEND:

P Prefilter or filter; efficiency 50% NBS, dust spot test except filters in normal air stream have filter efficiency of 65-80% according to Air Filter Institute Code (AFIC) weight method.

A Absolute filter; efficiency 99.97% on .3 micron DOP aerosol.

C Charcoal filter; Type BC 727, efficiency 95% and 99% for methyl iodine and iodine, 70% RH, 45 FPM.

TABLE 9.4.3-2

ADMINISTRATION AND SERVICE BUILDING

Materials of Construction:

Air Intake Louvers	Aluminum
Ductwork	Galvanized Sheetmetal
Dampers	Galvanized Steel Neoprene edges
Prefilters in Charcoal Filter Train	50% NBS. Dual media with throw away face mat followed by pleated section of glass medium, aluminum separators and fire retardant sealant
Absolute Filters Efficiency 99.97% on 0.3 micron DOP particles	Waterproof glass medium; separators none; frame, FR* particle board; flanges, none; sealant, FR foam. Dual media; with throw away glass face mat, followed by pleated section of glass medium with aliminum separators, FR particle board frame and FR sealant
Filters in Normal Air Stream, Efficiency 65-80% Filter Institute Code, Weight Method	Glass mat, replaceable
Filter Frames Fan-Coil Assemblies Cooling Coats	Epoxy on steel construction, fiberglass insulation, copper tubing, aluminum fine bonded to tubing.
Heating Coils	Copper tubing aluminum fine
Fans	Steel construction throughout paint finish
Air Diffusers	Aluminum, lacquer finish
Registers	Aluminum, lacquer finish
Reheat Coils	Electric alloy sheath and fins, step control
Dual Insulation (Air Conditioned Supply)	Fiberglass

TABLE 9.4.3-2 (cont'd)

Water Chillers	
Condensers	Steel envelope - integral fin copper tubes
Evaporators	Seamless copper tubes roller expanded into tube sheets, steel shell insulated with urethane foam and covered with steel jacket
Refrigerant Compressors	Direct dual flexible coupling, constant speed unloaded starting, and multi-step capacity control
Refrigerant Piping and Specialities	Copper
Chilled Water Piping	Copper
Chilled Water Pumps	Bronze Fitted
Condensing Units	Materials similar to water chilled materials

*Fire retardant
**National Bureau of Standards

9.4.4 TURBINE BUILDING VENTILATION SYSTEMS

The turbine building is served by two major ventilation systems each serving the following respective areas:

1. Turbine hall defined by floor levels at elevation 40, 64 and 94'.

2. Transformer room and switchgear room at elevation 40 and 71' respectively.

9.4.4.1 Design Bases

The turbine building ventilation systems are designed to provide the necessary ventilation and maintain the temperature within acceptable limits for personnel access. The systems also slightly pressurize the areas with respect to adjoining areas.

The systems are designed to:

1. Maintain a summer operating temperature not in excess of 115°F at the roof level of the turbine hall where the air leaves via roof ventilators and 110°F at the ceiling level in the transformer and switchgear rooms.

2. Maintain a winter operating temperature of approximately 70°F.

3. Provide a winter shutdown temperature of not less than 50°F.

4. Provide a change of air to satisfy normal ventilation requirements at all times.

5. Maintain a slight building positive pressure during normal operation.

6. Provide heat and smoke venting for the turbine hall.

9.4.4.2 System Description

The turbine building ventilation is shown in Figure 9.4- 5 Performance data are given in Table 9.4.4-1, materials of construction in Table 9.4.4-2.

The facility consists of three roof truss-mounted projection unit heaters, nine outside wall-mounted horizontal-type unit heaters installed on the 40-foot level, and ten vane-axial air supply fans. The fans draw the outside air through ducting from intakes above the 94-foot level and discharge it into the turbine hall at the 54-foot level. Fans are housed in plenums equipped with outside and return air modulating dampers. Air is supplied to the transformer and switchgear rooms with duct units at the two levels involved. Motorized roof ventilators are located in the turbine hall roof to remove spent air. Likewise air is mechanically exhausted from the transformer and switchgear rooms.

9.4.4.3 Design Evaluation

The Turbine Building Ventilation Systems provide the design temperatures indicated. The systems are reliable since a single component failure has a small effect on the overall performance in view of the number of fans and heaters utilized.

The building air circulation is directed into regions of high heat removal by selectively placed floor gratings and roof ventilators. A space thermostat modulates the outside and return air dampers to control the mixing proportion of outside and return air. Since adequate heat is transferred to the air by the equipment installed in the building, the inside and outside air mixture maintains the supply air temperature sufficiently high to prevent objectionable drafts during cold weather.

During shutdown periods, three roof truss-mounted, projection unit heaters blow heated air down to the 94-foot level, blanketing the cold outside walls as the air rises to return to the heaters. As a result, the temperature gradient between the floor and roof is minimized, and heat is routed to the exposed outside walls and roof. In addition to the roof-mounted heaters, nine outside wall-mounted horizontal-type unit heaters are installed on the 40-foot level.

Since the outside air intakes and exhaust ventilators are interlocked with the operation of the supply fans, they are automatically closed during shutdown periods. To provide natural ventilation, a remote-manual override allows proportional opening of the roof ventilator dampers and outside air intake dampers.

The exhaust fans can be operated on a once through air basis if desired for the purpose of purging the building area.

9.4.4.4 Tests and Inspections

Tests and inspections will be performed by the manufacturer where required by the applicant to demonstrate that components meet specified requirements.

9.4.4.4.1 Manufacturers Shop Testing

Appropriate tests will demonstrate the standards of performance, which each component must satisfy.

9.4.4.4.2 System Testing and Inspection

Operational tests will be performed in accordance with Section 14.1 prior to initial startup to demonstrate proper functioning of the systems. Tests will include:

1. System performance as to meet design conditions.

2. Mechanical test ascertain presence of any mechanical defects or deficiencies.

9.4.4.5 Instrumentation and Application

The following instrumentation is utilizied:

1. Room Temperature Indicator. Located in control room.

2. Room Pressure Indicator. Located in control room.

3. Fire Detector Alarm. Located in control room and locally. Detectors are in duct systems with provisions for automatic shutdown of air supply systems.

4. "S" Signal Fan Shutdown. Automatic with manual override in the control room.

TABLE 9.4.4-1

TURBINE AREA VENTILATION SYSTEM PERFORMANCE DATA

	SUBSYSTEMS			
	AIR SUPPLY	PROJECTION UNIT HEATERS	HORIZONTAL UNIT HEATERS	AUXILIARY ROOM EXHAUST
Number	10	3	9	1
Fan capacity, scfm each	100,000	25,000	4,300	7,500
Filtering	Filter	--	--	--
Design Conditions:				
Building, Summer, °F	115	50	50	--
Building, Winter, °F	70	--	--	--
Outside, Summer, °F	95	--	--	--
Outside, Winter, °F	0	0	0	--
Redundancy:				
Running	10	3	9	1
Standby	--	---	--	--
Other Conditions	Winter minimum outside air, 10% Summer minimum outside air, 100%	Run during shutdown	Run during shutdown	--

TABLE 9.4.4-2

TURBINE BUILDING VENTILATION

Materials of Construction:

Air Intake Louvers	Aluminum
Air Plenums	Epoxy on steel
Ductwork	Galvanized sheetmetal
Dampers	Galvanized steel, neoprene edges
Filter Frames	Epoxy on steel
Heating Coils	Copper tubes, aluminum fins
Centrifugal Fans	Steel construction
Fan Inlet Dampers	Steel construction
Filters	Fiberglass
Registers	Aluminum, lacquer finish
Propeller Fans	Aluminum
Roof Ventilators	Aluminum

9.4.5 CONTAINMENT VENTILATION

The Containment Ventilation includes the normal containment preaccess filtration and purge system described in terms of air clean-up under Section 6.2.3. This system provides make-up air for containment, thus influencing the containment temperature and pressure and is therefore also described under this section.

9.4.5.1 Design Bases

The Containment Ventilation systems are designed to maintain the temperatures in the various regions of the containment within acceptable limits during operation of the equipment and for personnel during inspection, maintenance, and testing. The systems can also purge the containment with outside air via the plant vent. The systems are not engineered safety systems and therefore are not required to operate under accident conditions.

The containment ventilation systems are designed to:

1. Purge the containment atmosphere to the plant vent at the rate of 1.5 changes in the containment air volume in one hour.

Air supplied as make-up air is introduced into the containment at a temperature no lower than 60^{o}F. Air exhausted to the plant vent is filtered, monitored, and diluted per Section 6.2.3.

2. Reduce the concentration of airborne fission products which may be introduced into the containment atmosphere via leakage from the Reactor Coolant System, Section 6.2.3.

3. Purge the in-core instrumentation room atmosphere to the plant vent during periods of personnel access to this room.

4. Maintain the containment upper compartment at a maximum of 110^{o}F during plant operation and a minimum of 60^{o}F during plant shutdown to permit personnel access as required.

5. Maintain a maximum temperature of 120^{o}F in the lower compartment (maximum 140^{o}F inside the primary concrete shield) during plant operation.

6. Maintain the in-core instrumentation room at a maximum of 90^{o}F during plant operation and a minimum of 60^{o}F during plant shutdown to allow personnel access as required.

7. Provide a reliable supply of cooling air to the control rod drives.

8. Provide cooling for the reactor vessel support structure and the concrete surrounding the reactor vessel to prevent the concrete temperature from exceeding 150°F.

9. Protect the containment against excessive negative pressures.

9.4.5.2 System Description

Performance data are given in Table 9.4.5-1, and materials of construction in Table 9.4.5-2. The Containment Ventilation Systems are shown in Figure 9.4-4 and include the following:

a. Purge supply and exhaust

b. Upper compartment ventilation

c. Lower compartment ventilation

d. In-core instrumentation room ventilation

e. Control rod drive mechanism ventilation

f. Reactor vessel support ventilation

g. Containment vacuum relief

TABLE 9.4.5-1

CONTAINMENT VENTILATION SYSTEM
EQUIPMENT DESIGN PARAMETERS

	SUBSYSTEM						
	Purge Supply (1)	Purge Exhaust (1)	Upper Compartment	Lower Compartment (2)	Containment Instrumentation (3)	Control Rod Drive Mechanism	Reactor Vessel Support
Number	2	2	2	4	2	4	2
Fan capacity, scfm, each	18,000	18,000	20,000	130,000	8,000	20,000	15,000
Filtering	P	P,A,C	P	P	P	-	-
Design Conditions:							
Source, Summer, °F	-	-	110	120	90	150	150
Source, Winter, °F	-	-	60	60	60		
Outside, Summer, °F	95	-	95	95	95	-	-
Outside, Winter, °F	0	-	0	0	0	-	-
Redundancy:							
Running	2 as req.	2 as req.	2	3	1	3	1
Standby	-	-	-	1	1	1	1

NOTES:
(1) Purge rate 1.5 air changes/hr. Charcoal filter capacity for each unit is 9000 cfm.
(2) 140°F inside primary shield
(3) Vents to purge system.

LEGEND:
P Prefilter or filter, efficiency 50%, NBS, Dust Spot Test.
A Absolute or high efficiency particulate air filter, efficiency 99.97% on .3 micron DOP aerosol
C Activated charcoal filter, Type BS727 efficiency 95% and 99% for methyl iodine and iodine, 70% RH 45 FPM

TABLE 9.4.5-2

CONTAINMENT VENTILATION SYSTEM

Materials of Construction:	
Air Intake Louvers	Stainless Steel
Air Plenums	Carbon Steel, protective finish
Ductwork	Carbon Steel, protective finish
Dampers	Carbon Steel, protective finish
Air Intake	
Filter Mechanism	Protective finish on steel
Filter Frames	Protective finish on steel
Heating Coils	Copper tubes, copper fins
Fans	All steel construction
Absolute Filters	Same as Table 9.4.2-2
Prefilters	Same as Table 9.4.2-2 *
Air Supply Filters	Same as Table 9.4.2-2
Charcoal Filters	Same as Table 9.4.2-2 **
Air Diffusers	Steel, protective finish
Registers	Steel, protective finish

* Except prefilter media separators are of asbestos.

** Except a compatible protective coating is used in place of galvanizing.

All of the ventilation systems with the exception of the purge supply and exhaust, which are located in the auxiliary building, are located within the containment structure.

The purge supply and exhaust is described in Section 6.2.3.2.1

Upper Compartment Ventilation is supplied by two 50 percent capacity, free-standing, recirculating, ventilating units, each with associated water cooling and steam heating coils.

Lower Compartment Ventilation is supplied by four 33-1/3 percent capacity recirculating ventilation units, with associated water cooling coils and ducting located in the annular concrete chambers around the periphery of the lower containment compartment.

In-Core Instrumentation Room Ventilation is provided by two 100 percent redundant free-standing air conditioning units. The in-core instrumentation room is a dead-ended part of the lower containment compartment.

Control Rod Drive Mechanism Ventilation is provided by four 33-1/3 percent capacity recirculating fans and associated ductwork located in the lower compartment outside the primary shield. The system maintains the required flow of cooling air through the control rod drive mechanism shroud.

Reactor Vessel Support Ventilation is supplied by two 100 percent redundant circulating fans, located in the lower compartment outside the primary shielding, and associated ductwork.

Containment Vacuum Relief is provided by four 33 1/3 percent capacity pneumatically actuated valves in the upper compartment. Valve controls sense the pressure differenital between the containment and annulus.

9.4.5.3 Design Evaluation

The Containment Ventilation Systems provide adequate capacity to assure that proper temperatures are maintained in all regions of the containment under operating and shutdown conditions. Redundancy is included to maintain full capacity or reduced capacity of each system with one active component out of service.

The Purge Supply and Exhaust Systems, initiated manually, serve the upper compartment, the lower compartment, and the instrumentation room. The upper compartment purge system ventilates the canal during the refueling process by drawing exhaust air from the surface of the canal. Exhaust air from the instrumentation room passes through charcoal filters in the purge exhaust system.

Approximately 1.5 air changes per hour can be provided. Venting capacity is controlled by operating one or two fans of the supply and exhaust systems and by regulating variable air inlet dampers.

The purge exhaust system can also operate on a recirculation basis to reduce airborne particulates and fission products in the containment atmosphere. During this operating mode the supply fans, supply filters, and heating coils are bypassed. The system operates with one exhaust fan at 50 percent of system capacity when the activated charcoal filters are on stream.

Upper Compartment Ventilation requires the simultaneous operating of both units.

Lower Compartment Ventilation is achieved using three of the four fans; the fourth is kept on standby.

In-Core Instrumentation Room

The two air conditioning units, one operating and one on standby, provide conditioned air to the in-core instrumentation room through a central air distribution system. Air is drawn through the room by the purge supply and exhaust system.

Control Rod Drive Mechanisms are ventilated by drawing cooling air from the lower compartment, passing it through the mechanism shroud, and returning it to the lower compartment. Three fans are normally operating, a fourth fan is on standby. The standby fan automatically starts when the temperature surrounding the control rod drive mechanism reaches a preset maximum level.

Reactor Vessel Support is cooled by drawing air from the region around the reactor vessel support and then returning it to the lower compartment.

Containment Vacuum Relief equalizes pressure, between the containment and the annulus between the containment and the shield building, to safeguard against malfunctioning of the Containment Spray System which could cause a reduced pressure in the containment. A pressure sensor opens the valves at a preset level. Valves close automatically as the pressure levels return to normal.

9.4.5.4 Test and Inspections

Tests and inspections will be performed by the manufacturer where required by the applicant to demonstrate that components meet specified requirements.

9.4.5.4.1 Manufacturers Shop Testing

Appropriate tests will demonstrate the following:

1. Carbon filter capabilities for removal of molecular iodine-131

and methyliodide-131.

2. Carbon filter iodine collection capability.

3. Carbon filter cell leaktightness integrity

4. Carbon filter flow resistance

5. HEPA filter efficiency and resistance test to meet UL label requirements.

6. Fan performance characteristics tested according to AMCA test procedures.

9.4.5.4.2 System Testing and Inspection

Operational testing will be performed in accordance with Section 14.1 prior to initial startup to demonstrate proper functioning of the system. Testing will include the following:

1. Leaktightness tests of components and systems.

2. System functional test.

For the purpose of periodically testing the retentive capability of the carbon filter, representative test carbon samples can be placed in the filter housing in locations which allow the samples to be subjected to the same air flows as the carbon bed. The samples can be periodically removed and tested for iodine removal capability.

9.4.5.5 Instrumentation and Application

The following instrumentation is utilized:

1. Air Flow Alarm. Located in control room.

2. Containment Pressure. Indicated in control room. Provision is made for manually regulating the air supply fan inlet air dampers.

3. Exhaust Fan Pressure Differential. Indicated in control room.

4. Fire Detector Alarm. Located in control room and locally, detectors in duct systems with provisions for automatic shutdown.

5. "S" Signal Fan Shutdown. Automatic with manual override in control room.

6. High-low Temperature Alarm. Located in control room.

7. Filter Pressure Differential. Indicated locally.

9.5 OTHER AUXILIARY SYSTEMS

9.5.1 FIRE PROTECTION SYSTEM

9.5.1.1 Design Basis

The Fire Protection System (FPR) is designed to prevent, detect, extinguish, limit or control fire and its hazards and damaging effects, both inside the floating nuclear plant and inside the breakwater basin. The design of the FPR system incorporates the criteria established by the Nuclear Energy Property Insurance Association's (NEPIA) document, Basic Fire Protection for Nuclear Power Plants, March 1970; the National Fire Codes 1971-1972, published by the National Fire Protection Association; and the Code of Federal Regulations - Title 46, Chapter 1.

Portions of the FPR system used to protect Category I equipment are designed to meet seismic Category I requirements.

9.5.1.2 System Description

The FPR system is shown on Figure 9.5-1 and consists of a closed loop firemain which supplies the various water and foam subsystems. Water is supplied to the firemain by three electric motor-driven, horizontal, centrifugal pumps. The fire pumps are located in the plant safeguard areas at elevation 7'6". Two of the three fire pumps are capable of supplying the system demand. The third pump is redundant and serves as a standby adding reliability to the system. Each pump is equipped with a control panel to provide for manual and automatic operation. The FPR system design parameters are listed in Table 9.5.1-1.

A pressure of 115 to 125 psig is maintained on the firemain by use of a 1000 gallon head tank and a 50 gpm jockey pump. The jockey pump automatically starts at 115 psig and shuts off at 125 psig. The head tank is located beneath the turbine hall roof with the water level at approximately the 170 foot elevation. A pressure detector located on the firemain loop monitors the system pressure and controls the jockey pump and fire pump operation. If a water demand on the fire system reduces the firemain pressure to 110 psig, one fire pump will start automatically. If one pump is unable to maintain pressure, the second pump will start at 100 psig. The third pump starts if system pressure drops to 90 psig. All fire pumps run, once they have started, until manually shut off.

Water for the FPR system is provided to the fire pumps by the floating nuclear plant's four fresh water filled trim tanks. The four trim tanks hold a total of 7500 short tons of water at 50 percent capacity.

Fifteen hundred tons of fresh water could be removed from any two adjacent trim tanks without causing a significant change in draft or trim. At full pumping capacity of two fire pumps, this 1500 tons will allow approximately

1.3 hours of operation with fresh water. Operation with fresh water can be maintained for a longer period when suction is taken on all four trim tanks. In the event of initial fresh water shortage or prolonged use of the fire system which depletes the fresh water supply, the operator can remotely realign the fire pump suction from the trim tanks to a sea chest. Two sea chest suctions are provided to assure a supply of seawater if required. Level detectors installed on each trim tank provide indication and an alarm in the control room if a low level develops in a trim tank during fire system operation. A lo-lo level alarm automatically shuts a valve to isolate the affected trim tank from the fire pump suction piping. Automatic isolation of a trim tank is provided to prevent a fire pump from taking suction from an empty tank and air binding the pump.

The fire pumps discharge to a closed loop firemain which rings the plant. The firemain supplies water to all the fixed fire protection water systems, the foam proportioners, and to the standpipe system. The firemain is equipped with isolation valves for damage control and maintenance purposes. Standpipes are located throughout the plant. Valved connections with hose, hose reels, nozzles, tools, and emergency lights are provided on these standpipes at various levels so that all parts of the plant are within reach of two hose streams.

The types of water protection systems provided and the areas protected by each type system are as follows:

1. Automatic Wet Pipe Sprinkler Systems protect the following equipment or areas:

   a. Area under the Turbine Building operating floors.

   b. Turbine Generator lubricating oil storage tank.

   c. Turbine Generator lubricating oil reservoir, coolers, and conditioners.

   d. Boiler room and boiler oil tank room.

   e. Receiving and general stores area.

   f. Machine shop and machine shop stores.

   g. Bulk oxygen, bulk nitrogen, and HVAC filter storage area.

   h. Service area.

   i. Combustible storage area.

   j. Paint storage area.

   k. Radwaste baler area.

l. New fuel handling area.

m. Diesel oil storage tanks.

2. Automatic Water Spray Deluge Systems protect the following equipment or areas:

   a. Main and station transformers.

   b. Turbine Generator bearing housing.

   c. Hydrogen Seal Oil unit.

   d. Hydrogen manifold and bulk storage tanks.

   e. Charcoal filters.

All water subsystems (sprinkler and spray) are provided with alarms which annunciate in the control room any time the system operates.

A low pressure carbon dioxide system, located adjacent to the control room at elevation 94 feet, is provided for the automatic and/or manual protection of various areas listed below. The system contains a low pressure storage tank sized to furnish two full charges to the area requiring the largest quantity of CO_2 plus a reserve of CO_2 for use in purging the turbine generator. The CO_2 is stored in an insulated pressure vessel having an automatically operated refrigeration system.

Electrically operated rate-of-rise thermostats are used to actuate the total flooding carbon dioxide system and to secure ventilation in the diesel generator spaces. A pre-emission alarm and an override of the automatic release with a manually actuated release is provided in each space for the protection of personnel.

Carbon dioxide from the low pressure storage tank is also supplied to manually actuate fixed systems protecting the Process Rack Room and the electrical penetration area. Hand held, manually operated CO_2 hose reels are provided for the Control Room and Rod Control Equipment Room. These CO_2 hose reels are provided in addition to portable extinguishers. Ionization type detectors monitor the above areas and alarm in the Control Room, but do not operate the CO_2 system automatically.

A fixed mechanical foam system is provided for flooding the portion of the basin around the floating nuclear plant bounded by the breakwater and an oil boom. The oil boom is located to prevent any oil spilled external to the breakwater entrances from getting close to the floating nuclear plant. A foam monitor station is provided near the helicopter landing pad. The mechanical foam generators are supplied directly from the firemain.

A fast-acting flame extinguishing system utilizing Halon 1301 is provided for the ventilation system air intakes to prevent ignition of any fuel-air mixture which may enter the plenums. A description of the intakes and the detection system used to initiate the extinguishing system is contained in Section 12.2.2.

Portable CO_2 and dry chemical extinguishers are provided throughout the plant, as appropriate for the type of fire hazard in specific areas.

9.5.1.3 Design Evaluation

The supply of fresh water available in the platform trim tanks for fire fighting exceeds the supply provided for most land based plants. In addition, seawater is available if required.

The three fire pumps are widely separated from each other so that it is highly unlikely that more than one pump could be lost due to a single accident. The fire pumps are sized so that any two pumps can supply the system water demand. The fire pump motors are capable of receiving electrical power from both normal station power and the diesel generators.

The design water demand and pump capacity of the FPR system is based on supplying water from the firemain to the foam system for fighting an oil fire in the basin, while simultaneously supplying water to four, 250 gpm fire hydrants in the plant.

To comply with the above regulation, a water rate of .016 gpm for each square foot of basin area protected is provided to foam production equipment.

Foam concentrate is mixed in the proportion of 3 percent by volume with 97 percent water. Sufficient foam concentrate is provided for two 15 minute periods of foam application.

The firemain is sectionalized by valves for isolation in the event of damage to any section of the line.

Fire and smoke detection devices are provided in conjunction with the fire protection systems and in areas where no automatic protection is provided. The types of detectors provided are ionization smoke detectors, fixed temperature detectors, rate-of-rise detectors, and capillary detectors. Manual fire alarm stations are provided throughout the building. All detectors alarm in the Control Room to alert the operator in case of a fire, fire system operation, or fire system malfunction. Pressure gauges in the Control Room also tell the operator the pressure conditions in the firemain header. Further information concerning fire detection and alarms is presented in Section 7.8.

Many interior building walls of the plant are of 2-3 hour fire resistant construction to prevent entrance of fire from an adjoining area. These fire resistant walls are also located around exceptionally hazardous areas such as the diesel generator rooms, fuel oil storage areas, and lubricating oil storage areas. The floors of all sprinkler-protected areas will be pitched to facilitate drainage and collection of water.

9.5.1.4 Tests and Inspections

All fire pumps, alarms, and automatic extinguishing systems are periodically tested in accordance with plant operating procedures to insure proper performance when required. In addition all portable equipment is checked in accordance with plant operating procedures to insure it is properly charged and in good working condition.

TABLE 9.5.1-1

FIRE PROTECTION SYSTEM COMPONENTS DESIGN DATA

Fire Pumps

Number	3
Type	Centrifugal, motor driven
Capacity, gpm	2500
Heat, ft	350
Motor, hp	300

System Materials

Piping	Carbon Steel
Valves	Cast steel

9.5.2 COMMUNICATION SYSTEMS

9.5.2.1 Design Basis

Internal plant communications are designed to provide convenient, effective means to facilitate operator action between various plant locations during all design basis conditions. The internal communication system is supplemented by plant-to-shore systems provided by the owner.

9.5.2.2 System Description

The basic plant communication system consists of a page/party system with handsets and loudspeakers distributed throughout the plant.

The owner will provide equipment for communication with the system dispatcher and with others. The applicant is providing the Emergency Alarm, Page/Party System and a battery powered telephone used for calibration and installed in specific plant locations.

9.5.2.3 Design Evaluation

The plant paging system and the plant-to-shore communications systems are independent. A failure of any one system will not eliminate either interplant or plant-to-shore communications.

9.5.2.4 Inspection and Testing

All communication systems with the exception of the battery powered telephone and emergency alarm portion of the page/party systems are in operation daily; this allows for testing to ensure the system is operable. The battery powered system and emergency alarm may be tested periodically to ensure that they remain operable.

9.5.3 LIGHTING SYSTEM

The lighting system provides necessary illumination for plant operation under normal and emergency conditions. The lighting installation conforms with latest Central Station Practices, and foot candle levels conform to the recommendations of the Illuminating Engineering Society.

Power for lighting of all areas comes from the main generator during normal operation. If generator power is lost, lighting will be supplied through the shore cables. On loss of both normal sources, emergency lighting panels are transferred automatically from the normal ac source to a dc battery system, which provides enough emergency illumination to permit movement throughout critical areas of the plant.

The plant operator can manually transfer normal lighting to the diesel generators if all offsite power is lost.

Each specific area of the Floating Nuclear Plant is served by separate buses and transformers. The turbine area lighting is served by transformers, distribution panels, and several lighting panels. The panel for the emergency lighting is normally connected to the ac supply, with automatic transfer to the battery system upon loss of ac sources. Fluorescent and incandescent lighting is used in the low-bay, with mercury vapor in hi-bay areas.

The safeguards areas are served by transformers from the engineered safeguards ac bus. The diesel generator supplies power if all outside ac sources fail. Emergency lighting, connected to ac with automatic transfer to dc, provides limited illumination during transition from normal to diesel generator supply. Lighting fixtures are the same as in the turbine area.

The remainder of the plant is served by two separate buses and transformers with a secondary tie breaker for automatic transfer upon loss of one of the supply buses or transformers. This system serves the containment building, control and electrical area, primary auxiliary area, and services and facilities areas. One-half the lighting load in each of these areas is served by each supply bus to assure sufficient lighting if one-half of the components should fail. Emergency lighting, normally supplied by ac with automatic transfer to dc, provides minimal lighting if all ac sources are lost. Lighting fixtures in these areas are the same as in the turbine and safeguards areas. Lighting in the containment and other potentially radioactive areas will exclude the use of lamps containing mercury. The breakwater and obstruction lighting is fed by a separate 3-phase service with alternate sources.

9.5.4 DIESEL GENERATOR FUEL OIL SYSTEM

9.5.4.1 Design Bases

This system ensures an onboard supply of No. 2 fuel oil to the four emergency diesel generators for a period of seven days, with the diesels operating at their continuous rating as given in Section 8.3.

Each fuel oil day tank provides storage for one hour operation of its respective diesel at its continuous rating.

Each fuel oil transfer pump has a capacity approximately three times the rate of consumption of each diesel operating at its continuous rating.

The storage tanks are designed to the requirements of the ABS Rules for Building and Classing Steel Vessels. For corrosion protection, the tanks interiors are coated.

The piping, valves, and fittings on the oil filling line to all the diesel storage tanks, up to and including the motor operated isolation valves, are designed to ANSI standards. The downstream side of the filling line isolation valves to the day tanks meet ANS safety class requirements. Table 3.2-1 lists the design criteria for all of the components of this system.

9.5.4.2 System Description

The diesel generator fuel oil system is shown in Figure 9.5-2.

Each diesel generator set is provided with a complete and independent fuel oil storage and supply system. Each system consists of one storage tank, one transfer pump, and one day tank. Each storage tank is built into the hull structure under its respective diesel.

During operation, oil from the storage tank is pumped by the transfer pump to the day tank. The diesel is supplied from the day tank, through filters, by the engine driven pump. Excess oil returns to the day tank through the pressure regulator. A level controller installed on each day tank starts the transfer pump on low oil level and stops the pump on high level. A local level indicator is provided on each tank. High and low level annunciators inform the operators of the fuel quantity.

A common filling line leads to each oil storage tank. During oil transfer operation, one tank is filled at a time. When the oil reaches the desired level, a level switch closes the isolation valve. If the valve malfunctions the level rises and the high level alarm is sounded. The operator on the platform can then close the emergency shut-off valve located on the common filling line. In case this valve fails, or in case any other emergency condition arises the operator on the platform can communicate with the operator on the loading barge to have the filling pump stopped. Open and closed positions of all the motor operated valves are indicated in the local transfer station.

A flanged connection is provided on each transfer pump discharge line and on each filling line to be used when emptying the storage tanks. A permanent interconnection between the boiler oil storage tanks and the diesel generator oil storage tanks is also provided.

9.5.4.3 Design Evaluation

Onboard fuel storage, adequate for one week operation at continuous rating, is provided with appropriate allowance for periodic testing. Additional operating time at a reduced load is available.

The diesel generator oil storage tanks have double bottoms and double sides where tank failure could result in oil spillage into the safeguards area or into the sea. The tank interiors are coated for protection against corrosion. A gauge glass is installed on one side of each tank to show the level of water, if any, inside the tank. Water can be removed through a drain connection at the bottom of each tank. The gauge glasses are removable to permit cleaning or replacement.

Each day tank is sized to store one hour supply of fuel to its diesel operating at continuous rating. This serves as a dependable initial source of oil during starting.

In the event any single component in any of the four independent fuel oil systems fails and renders the associated diesel inoperative, the three remaining diesel trains will handle the load required for minimum engineered safeguards.

Operation of the emergency diesel generators is discussed in Section 8.3.

9.5.5 WEATHER DECK DRAIN SYSTEM

9.5.5.1 Design Bases

The Weather Deck Drain System is designed to achieve the following:

1. To drain water due to spray and precipitation from all roof areas of the plant.

2. To remove water at a rate equivalent to 7 inches of rainfall per hour. This is to comply with the recommendations of U. S. Department of Commerce Publication BMS66, "Building Materials and Structures".

9.5.5.2 System Description

The weather deck drains consist of gutters, or waterways, and gravity drain pipes for each exposed surface (see Figure 9.5-3). Where feasible, the water from each roof is drained directly overboard. In some cases the water from one roof is drained on to an adjacent roof at a lower elevation and then drained overboard.

9.5.5.3 Design Evaluation

The system is designed to provide a simple and reliable means for draining all water from the plant roof areas. Sufficient roof slope and/or camber will be provided in the roof design to assure drainage during plant design pitch and roll conditions. Drain pipes are sized to remove water at the designated rate.

9.5.6 DOMESTIC WATER AND SANITARY SYSTEMS

The Domestic Water System supplies fresh water to drinking fountains, showers, lavatories, sinks and any other facilities requiring potable water.

The design complies with U.S. Public Health Service Publication No. 393.

The Sanitary System is used to dispose of all non-contaminated waste produced by the crew, i.e., sewage, domestic trash and garbage.

The system design complies with U.S. Public Health Service Publication No. 393.

Effluent water standards as proposed by the Environmental Protection Agency are satisfied for coliform bacteria, B.O.D., and suspended solids.

These are:

Coliform bacteria.	240 or less per 100 ml.
Proclumical oxygen demand (B.O.D.)	100 mg/liter
Suspended solids	150 mg/liter

9.6 PLATFORM SYSTEMS

9.6.1 PLATFORM DRAIN SYSTEM

9.6.1.1 Design Bases

The Platform Drain System is designed to achieve the following:

1. Drain all deep tanks and innerbottom areas (below 7 foot 6 inch level), with the exception of those compartments which serve as the platform trim tanks.

2. Separate and retain onboard all grades of oil mixed with the drain water.

9.6.1.2 System Description

The Platform Drain System is a fixed pumping system consisting of separate branch suction lines for each compartment connected by manifold valves to a common drain suction main which is served by three drain pumps (See Figure 9.6-1). One independent branch suction line is provided for each of the watertight compartments served.

The through runs of piping are schedule 80 with a welded pipe sleeve at each watertight bulkhead penetration. Each suction line is fitted with a non-return or foot valve.

The three platform drain pumps are of the centrifugal motor-driven type. The drain pumps discharge overboard through oily water separators.

All system components are located in spaces provided within the platform. The components are arranged so that two drain pumps and approximately one-half of the suction valves are in one compartment, while the third drain pump and remaining suction valves are located in a separate watertight compartment. One oily water separator and one priming system are located in each space. The drain pumps are mounted on the 7-foot, 6-inch level. One drain pump is a submersible type and is operated from a local control station above the 40-foot level.

The oily water separators are each rated to handle the discharge flow from one drain pump, and to remove from the overboard discharge all grades of oil which may have accumulated. Oil removed by each separator is collected in a tank which is drained at periodic intervals into containers suitable for shipment ashore.

The vacuum priming systems are packaged units consisting of automatic priming valves and a suction pump with associated components. When a drain pump is started, the associated priming system operates automatically to produce between 10 and 15 inches of Hg vacuum at the pump suction.

The presence of water in the compartments is automatically detected and alarmed in the control room by the Hull Leakage Surveillance System (Section 7.8). The drain pumps and valves are manually operated upon receipt of a signal indicating water in a compartment.

The Platform Drain System components are listed in Table 9.6.1-1.

9.6.1.3 Design Evaluation

The Platform Drain System is designed to provide a reliable and readily available means for removing water from the platform compartments. The system is designed to be equivalent to the bilge system for an ocean going nuclear passenger vessel. Sufficient local instrumentation is provided to monitor operation of the system.

TABLE 9.6.1-1

PLATFORM DRAIN SYSTEM COMPONENTS

Drain Pumps	
Number	3
Type	Centrifugal
Capacity, gpm	1650
Head, ft.	92
Motor, hp	60
Priming Pumps	
Number	2
Type	Liquid Seal Ring
Capacity, cfm	30
Head, in., Hg	15
Motor, hp	2
Oily Water Separators	
Number	2
Capacity, tons/hr. input	500
Oil Collection Tank	
Number	2
Capacity, gallons	1000
System Materials	
Piping	Seamless drawn 90-10 copper-nickel
Valves:	
Single body	Bronze
Manifold	Cast copper-nickel

9.6.2 PLATFORM TRIM SYSTEM

9.6.2.1 Design Bases

The Platform Trim System (PTS) controls platform list and trim due to expected major weight changes associated with infrequent operations. An example of such a weight change would be de-watering portions of the Main Circulating Water System for maintenance during plant shutdown. The PTS is not designed to overcome or compensate for roll and/or pitch motions caused by temporary wind loads or wave action. The PTS corrects platform list and/or trim by transferring water between trim tanks, located at each corner of the platform. The PTS is capable of compensating for platform list and/or trim conditions to maintain an even keel during refueling operations. Platform attitudes are discussed in Section 3.7.1.

9.6.2.2 System Description

The Platform Trim System (figure 9.6- 2) consists of four trim tanks located one at each corner of the platform and connected by fixed piping through a manifold to the trim pump. The piping arrangement is such that the trim pump may take suction from or discharge to any combination of tanks, as well as discharge overboard.

The trim tanks are located in the platform hull section below elevation

40 feet. Each trim tank is approximately 80 feet by 38 feet by 40 feet deep and has an average maximum capacity of 3700 short tons. The trim tanks have the secondary function of providing a source of water for the Fire Protection System (Section 9.5.1). Piping connections, separate from the trim system connections, are provided from each trim tank to the suctions of the fire pumps. Fresh water, in lieu of seawater, is maintained in the trim system to prevent excessive corrosion and scale formation in the tanks, and for fire fighting service. Make-up water, if required, is provided to the PTS from the Make-Up Water System (Section 9.2.3).

The trim pump is a centrifugal, motor-driven type. The pump capacity is adequate to compensate for the expected weight distribution changes due to on-loading, off-loading, or transferring of liquids and/or stores aboard the platform. The trim pump is located at elevation 7' 6" between bulkheads 5-6 and B-C. A connection is provided at the suction of the trim pump from the Platform Drain System (Section 9.6.1) vacuum priming system. This priming connection assures that the trim pump can maintain suction on low trim tank water levels. A manual eight valve manifold is installed in the trim system adjacent to the trim pump which permits alignment of the trim pump suction and discharge to the proper trim tanks. The trim system overboard discharge line permits pumping water from the trim tanks overboard, if required. The overboard discharge line contains a stop check valve and terminates above the platform water line to assure that seawater does not enter the trim system.

Inclinometers, installed parallel to the longitudinal and transverse axes of the platform, are provided in the control room to indicate the list and trim of the platform. Inclinometers are also installed in the area of the manipulator crane to indicate list and trim conditions during refueling operations.

If compensation for platform list or trim is required, operation of the trim pump and the manifold valves is performed manually at the trim pump station located at elevation 7'6". A test connection between the Platform Trim System and the Fire Protection System provides the capability to transfer water between trim tanks using any fire pump in the event the trim pump is incapacitated.

Table 9.6.2-1 lists the PTS materials of construction and equipment data.

9.6.2.3 Design Evaluation

The Platform Trim System provides a reliable means for transferring water internally to maintain the platform on an even keel. The system is capable of adjusting platform draft over a limited range as well as correcting for weight distribution changes. Once the platform is moored in the breakwater and initially trimmed (no list or trim), it is not anticipated that PTS operation would be required except during major weight redistribution during plant shutdown and maintenance.

In the event the trim pump is incapacitated for some reason and the platform trim must be adjusted, one of the three fire pumps can be used to transfer trim tank water via the testing cross-connect between the Platform Trim System and the Fire Protection System.

To reduce the possibility of leakage from the PTS, welded construction is used wherever possible. Typical exceptions to the welded construction are at connections to equipment, such as pumps, which could require removal for maintenance. Indication of a leak in the PTS System is provided by the Hull Leakage Surveillance System (Section 7.9) and by the trim tank level indicators. To prevent leakage from the trim tanks in the event of a leak in the PTS, isolation valves are provided adjacent to each PTS piping connection to the trim tanks. These isolation valves are provided with extension handles for remote operation from the 40 foot elevation.

Since the platform is inherently stable, a rupture of a trim tank or misuse of the PTS will not create a list or trim condition which prevents safe operation of the reactor. The water transfer rate of 500 gpm is relatively slow and the operator in the control room can detect unexpected changes in list or trim with the installed inclinometers and stop pumping operations.

The worst failure or misuse of the PTS would be less severe than a condition in which the water from two full trim tanks on one side was pumped into two empty tanks on the opposite side. This would transfer 7400 tons of water a distance of 340 feet causing a change in attitude of 3^o. The operating bases attitude is 1^o, the design basis is 6^o as described in Section 3.7.1.

Platform free-surface effects are discussed in Section 3.1.2.7.

9.6.2.4 Testing and Inspections

Following installation the system will be functionally tested to demonstrate proper operation. Periodic system operation will allow for continued surveillance.

9.6.2.5 Instrumentation and Application

Instrumentation is provided to monitor and insure proper system operation.

The following specific instrumentation is provided.

1. Local pressure indicator at trim pump discharge.

2. Local vacuum-pressure indicator at trim pump suction.

3. Local flow indicator and flow totalizer at trim pump discharge.

4. Four remote reading liquid level indicators. One for each trim tank to read out in the control room.

5. Two control room mounted inclinometers to indicate platform list and trim.

6. Two inclinometers in the refueling area to indicate platform list and trim during refueling.

7. A trim pump running light is installed in the control room to provide the operator indication that trimming operations are in progress.

Each trim tank liquid level indicator performs two alarm functions and one control function. The alarm and control functions are provided for operation of the Fire Protection System and are discussed fully in Section 9.5.1.

TABLE 9.6.2-1

PLATFORM TRIM SYSTEM COMPONENTS

Trim Pump	
Number	1
Type	Centrifugal
Capacity, GPM	500
Head, ft.	150
Horsepower, HP	30
Inclinometers	
Number	4
Range, degrees	0-10° either side of vertical.
Increments	.1°
System Materials	
Piping	Carbon Steel
Valves	Carbon Steel

9.6.3 CATHODIC PROTECTION - HULL

9.6.3.1 Design Basis

The Cathodic Protection System for the hull is designed to provide protection of the submerged portion of the hull from electrochemical corrosion. To provide this protection a potential of +0.85 ± .05 volts, as compared to a Silver - Silver Chloride reference cell, is maintained the outer surface of the hull. The system is capable of delivering a current density of 10 mAmps dc per square foot on the hull; however, the system is controlled to provide only the current needed to maintain a 0.85 volt hull potential. The system is also designed to eliminate hydrogen evolution by keeping the hull potential within the correct limits (+0.85 ± .05V), which will preclude any electrochemical corrosion.

9.6.3.2 System Description

An impressed current system was chosen to provide the necessary protection. The system includes a dc rectifier, distribution cables, reference cells, controls, and anodes with the submerged portion of the hull serving as the cathode. Metals in contact with seawater are electrically connected to the hull to ensure no stray current corrosion.

9.6.3.2.1 Anodes

The anodes are made of a material with an expected usable life of 20 years. The voltages used will be below that of the physical-chemical breakdown voltage of the anodes. The anodes operate at 2 - 20 amps as dictated by the requirements to maintain polarization. The anodes are mounted to the hull by means of a sealed gland, gate valve, arrangement to provide leak-proof removal from inside the platform. In their operating mode the active portion of the anodes is remote from the hull to provide good current distribution and an even current density on the hull. All electrical connections are made inside the hull with current flow through the anode to the active outer portion.

9.6.3.2.2 Power Supply and Distribution

The necessary dc power is supplied by simple rectifiers, arranged on the platform to optimize anode cable length. These units are simple unfiltered selenium air-cooled rectifiers with taps on the secondary windings to provide variable current output. A tap-fuse for each anode ensures that the failure of one anode will not influence the performance of others. The power to the unit is 430V - 3 phase. The distribution lines from the rectifiers to the units will be fused to prevent overload.

Periodic checks of the current and voltage outputs from the rectifiers ensure correct operation. The rectifiers are standard units, therefore replacement or repair can readily be made.

9.6.3.2.3 Controls

Control is provided through the use of reference electrodes in coordination with the current to each anode. The locations of the reference cells provide a reliable measurement of the hull potential, the optimum potential being 0.85 volts as opposed to a Silver- Silver chloride reference cell.

This potential will then be used as the basis for adjusting the current requirements at each anode, independent of the current requirement at any other anode. Care will be taken to ensure that enough current is used to polarize the hull, but not so much as to cause hydrogen evolution. The driving voltage may also change, if only slightly, as the film resistance at the hull increases as calcareous deposits are formed. At each rectifier the ability to measure the voltage and current to each anode is available to provide periodic monitoring.

9.6.3.3 Design Evaluation

This system's design is optimized with respect to hull protection, ease of operation, maintainability, personnel safety, and reliability based on the present technology available. Several of the leading manufacturers of cathodic protection equipment have successfully employed similar systems with a high degree of reliability. These systems have been used in a variety of environments with satisfactory performance. Oil drilling platforms in the Gulf of Mexico have been cathodically protected with impressed current systems for the last 20 years. The U.S. Navy's reserve fleet has also been protected with impressed currents since 1953.

An impressed current system is preferred when a relatively high degree of system stability is possible as will be the case inside a breakwater. Once the system's stable current has been established, there is no reason that any great current fluctuation will be encountered for the life of the plant.

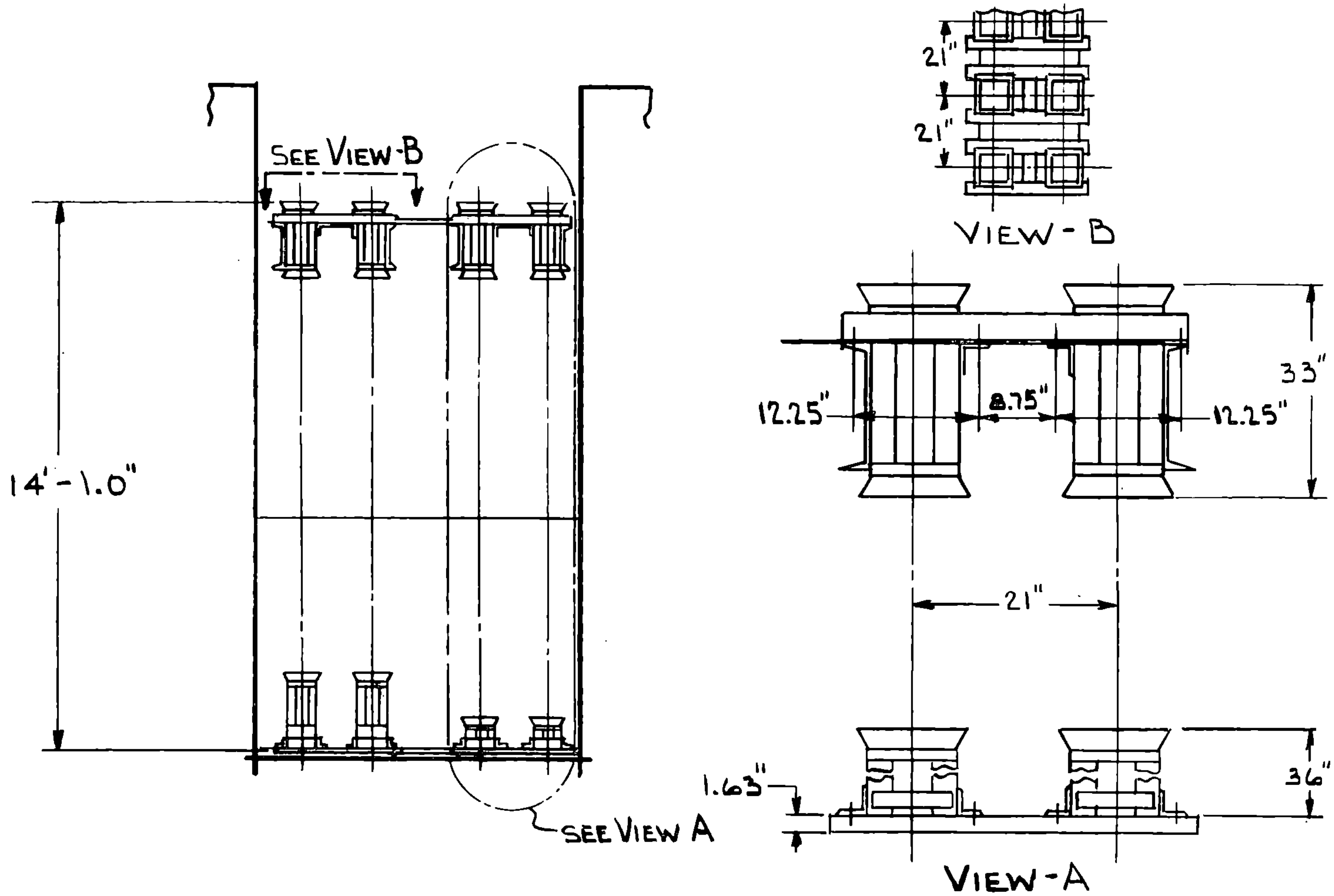
9.6.3.4 Testing and Inspection

Subsequent to platform flotation, the rectifiers and reference cells will be checked for correct operating characteristics.

After the plant has been delivered, all components of the Cathodic Protection System will be activated, adjusted, and tested.

This includes testing reference cells to insure correct potential, visual inspection, and output monitoring of the rectifiers to ensure correct operation, visual inspection of all cables in the system, establishment of the correct current requirements to each anode, and ensurance that all anodes are operational. At approximately monthly intervals the system will be rechecked until a stable polarizing current is established. Once a stable current has been established, periodic checks of system components will be performed.

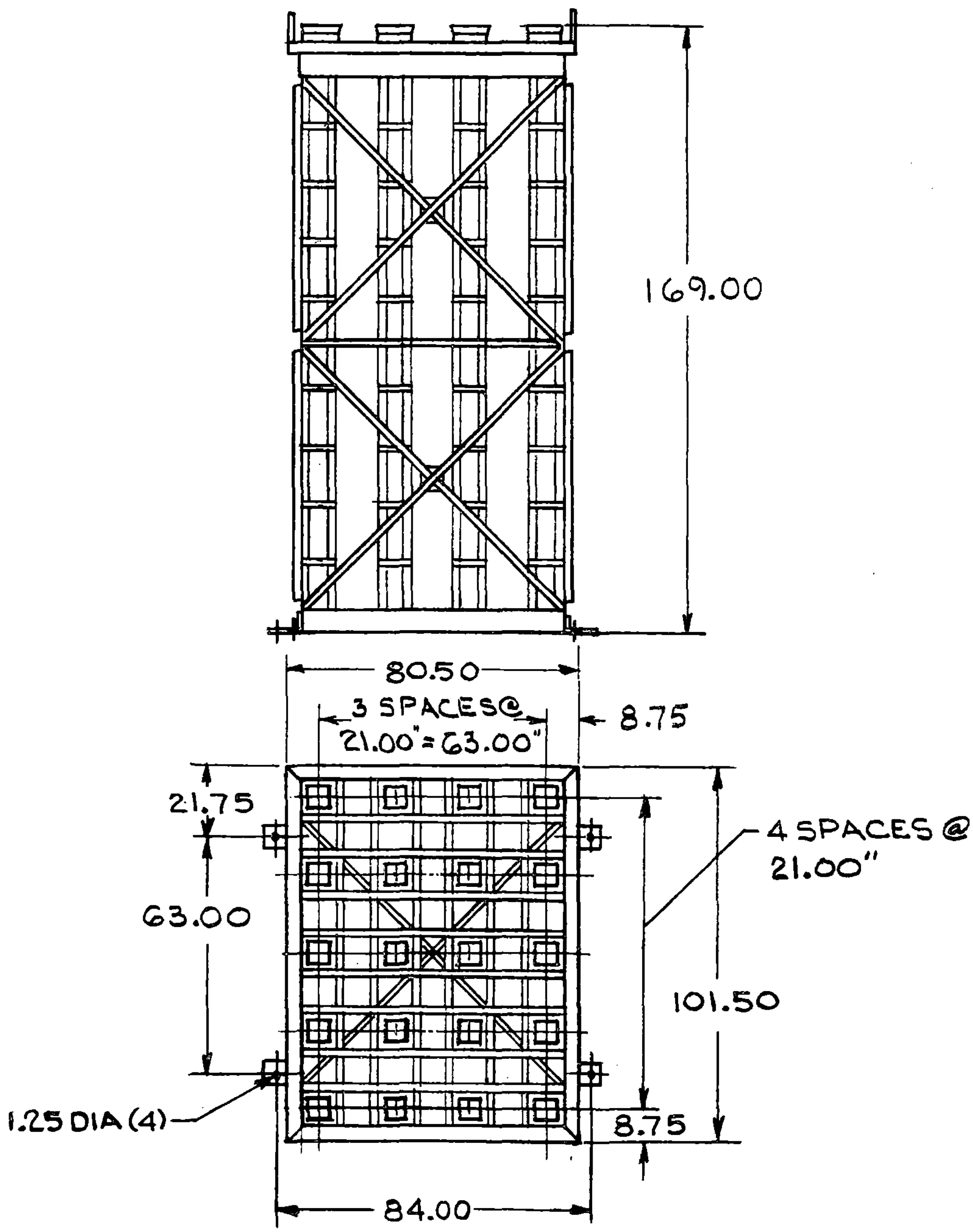
Operating personnel will periodically check and inspect system components to ensure proper operation. This includes monitoring of hull potential and current flow and voltage drop through each anode.



NEW FUEL STORAGE RACKS

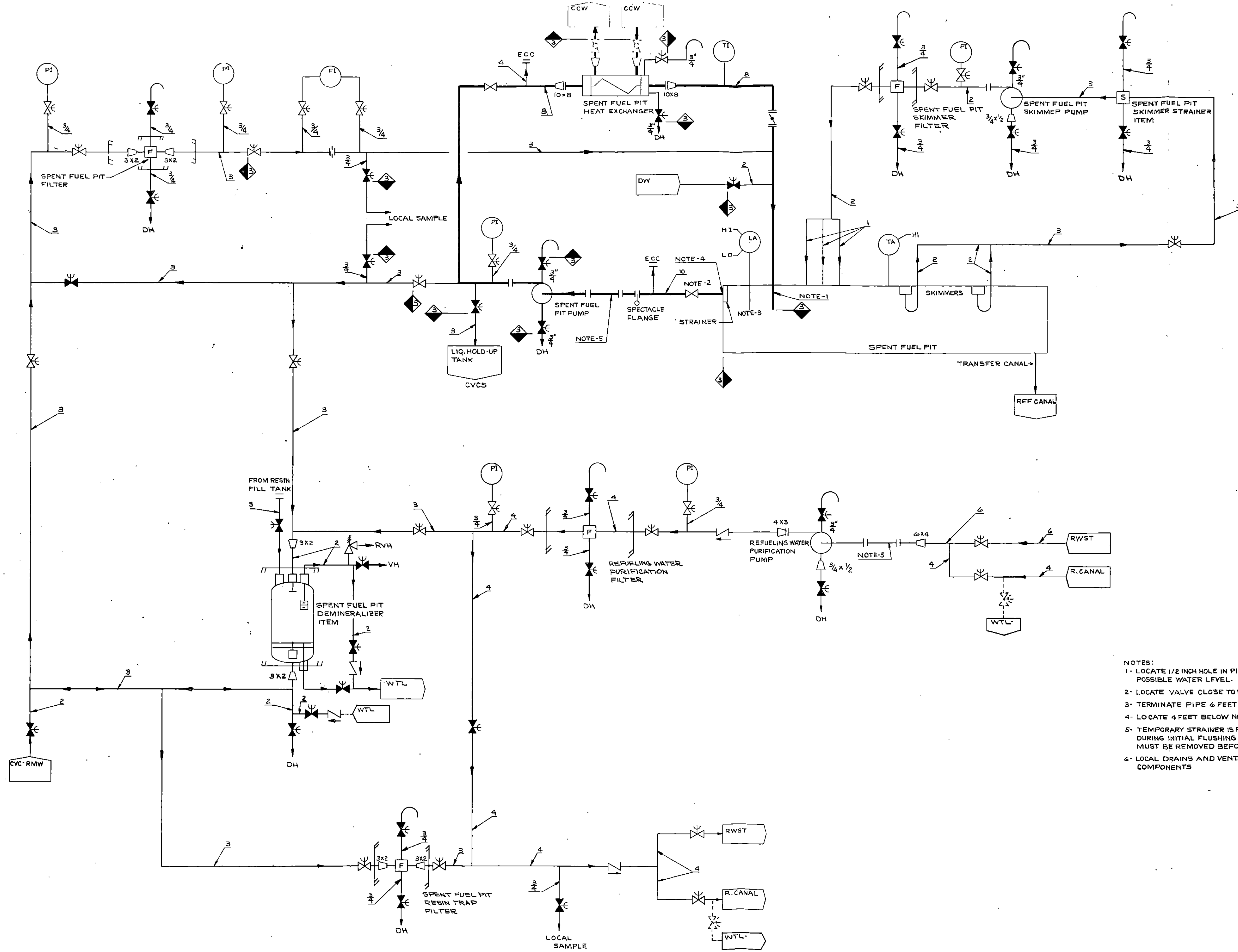
11/1/72

Figure 9.1-1



SPENT FUEL STORAGE RACKS

11/1/72 Figure 9.1-2

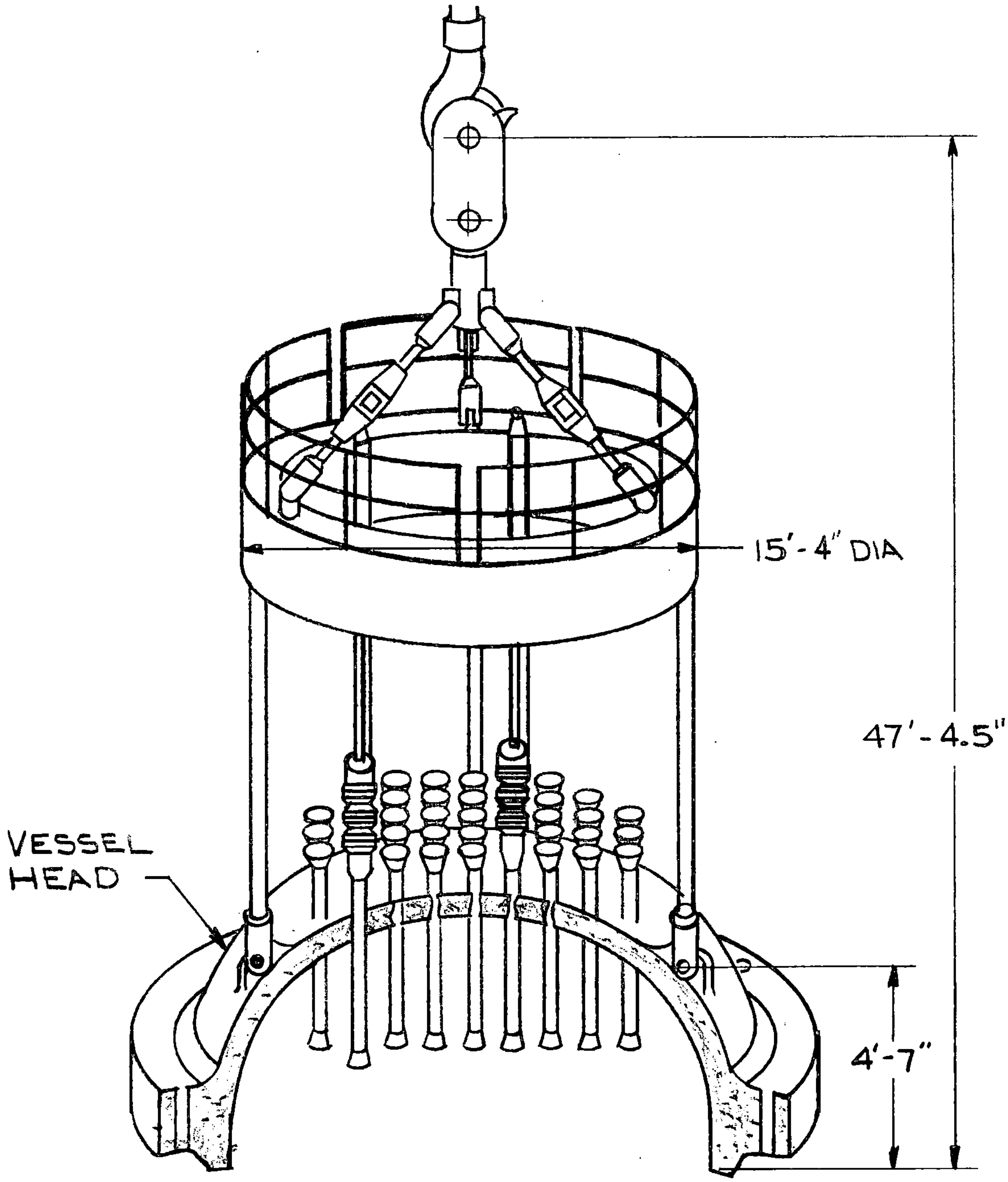


NOTES:
1- LOCATE 1/2 INCH HOLE IN PIPE 1 INCH BELOW LOWEST POSSIBLE WATER LEVEL.
2- LOCATE VALVE CLOSE TO SPENT FUEL PIT WALL.
3- TERMINATE PIPE 6 FEET ABOVE FUEL ASSEMBLIES.
4- LOCATE 4 FEET BELOW NORMAL WATER LEVEL.
5- TEMPORARY STRAINER IS PLACED IN THE SPOOL PIECE DURING INITIAL FLUSHING OPERATIONS. STRAINER MUST BE REMOVED BEFORE PLANT START-UP.
6- LOCAL DRAINS AND VENTS PROVIDED FOR SMALL COMPONENTS

OFFSHORE POWER SYSTEMS

Title: SPENT FUEL PIT COOLING AND CLEANUP SYSTEM

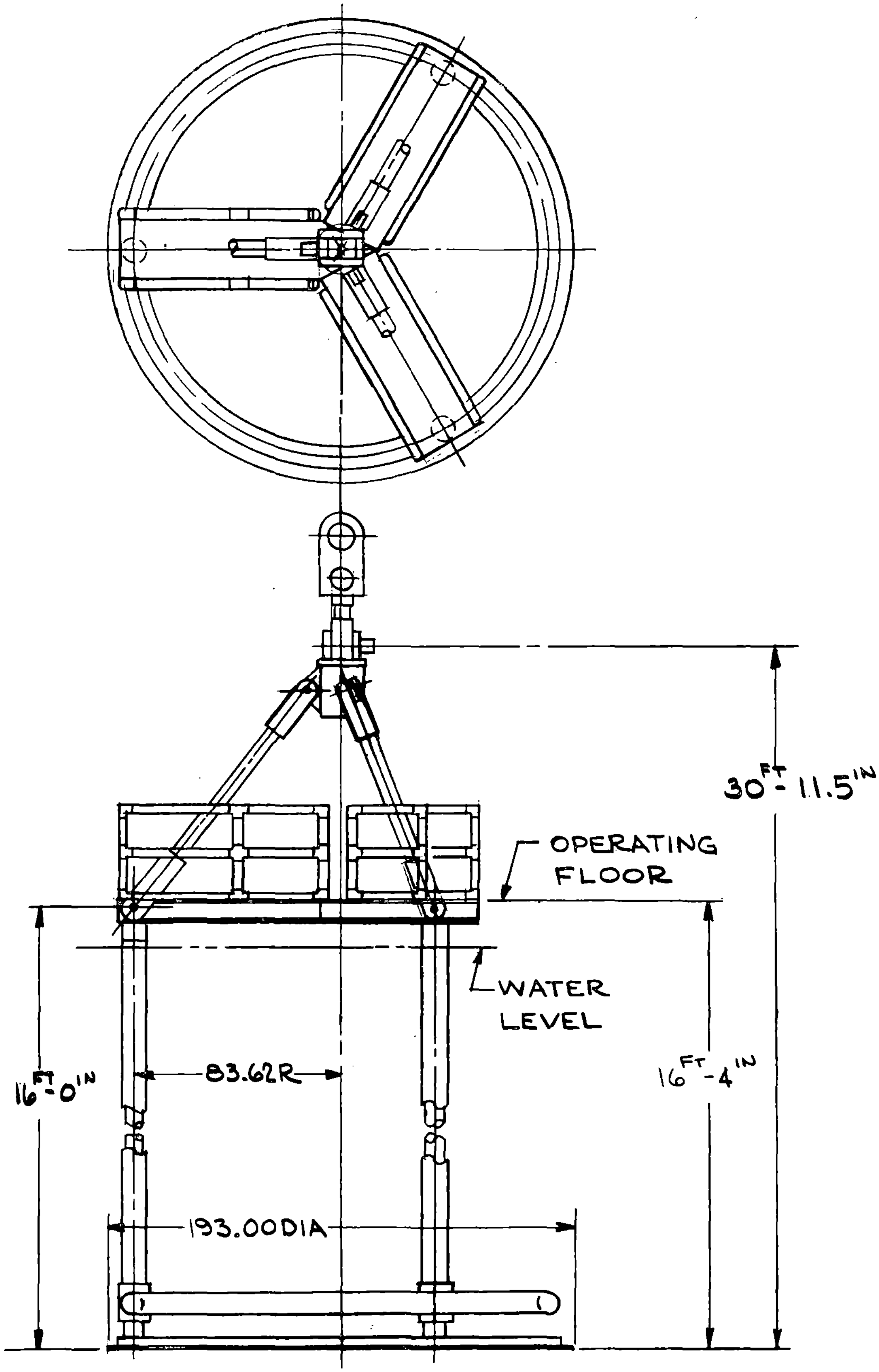
11/1/72 Figure: 9.1-3



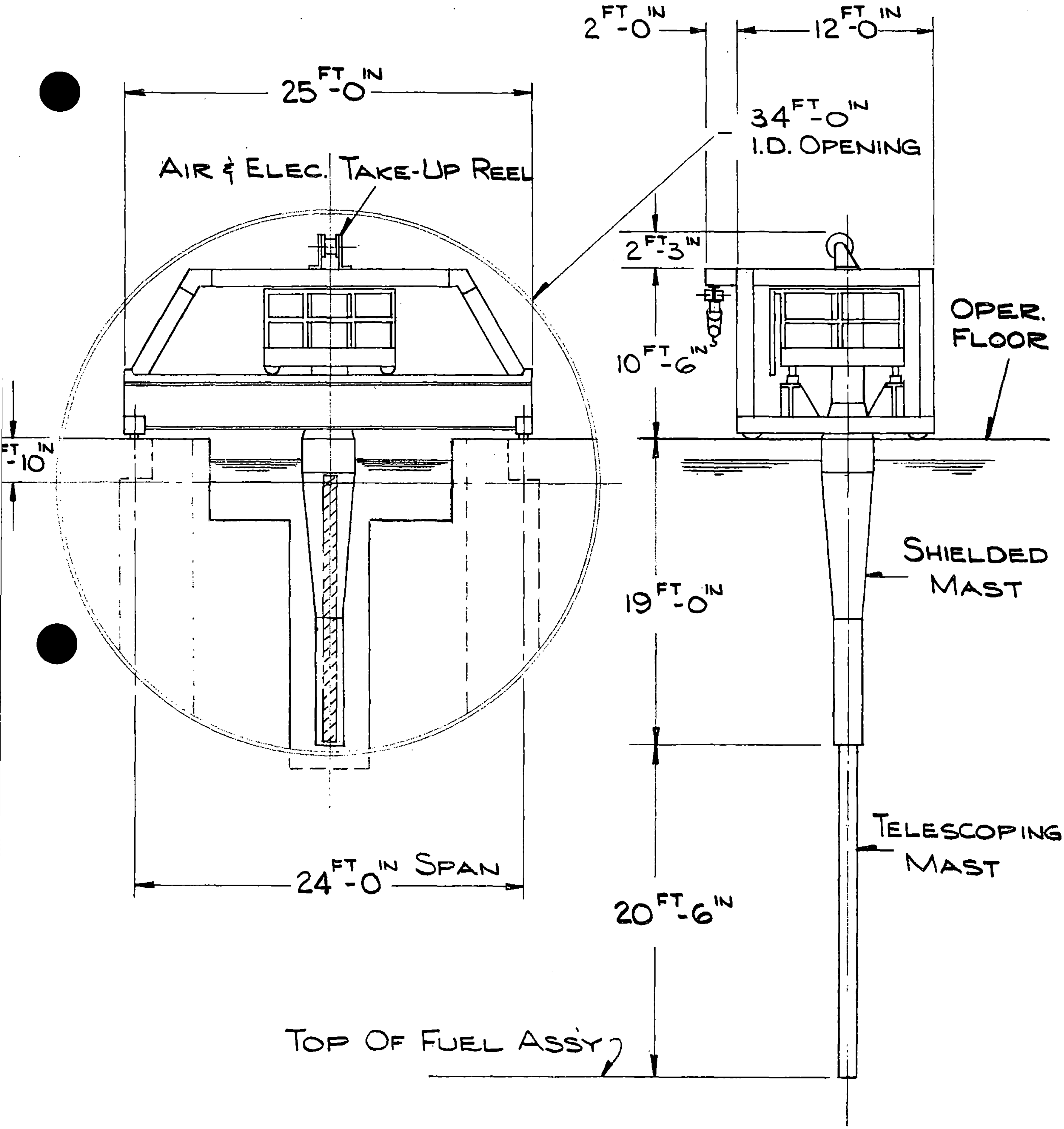
REACTOR VESSEL HEAD LIFTING DEVICE

11/1/72

Fig. 9.1-4

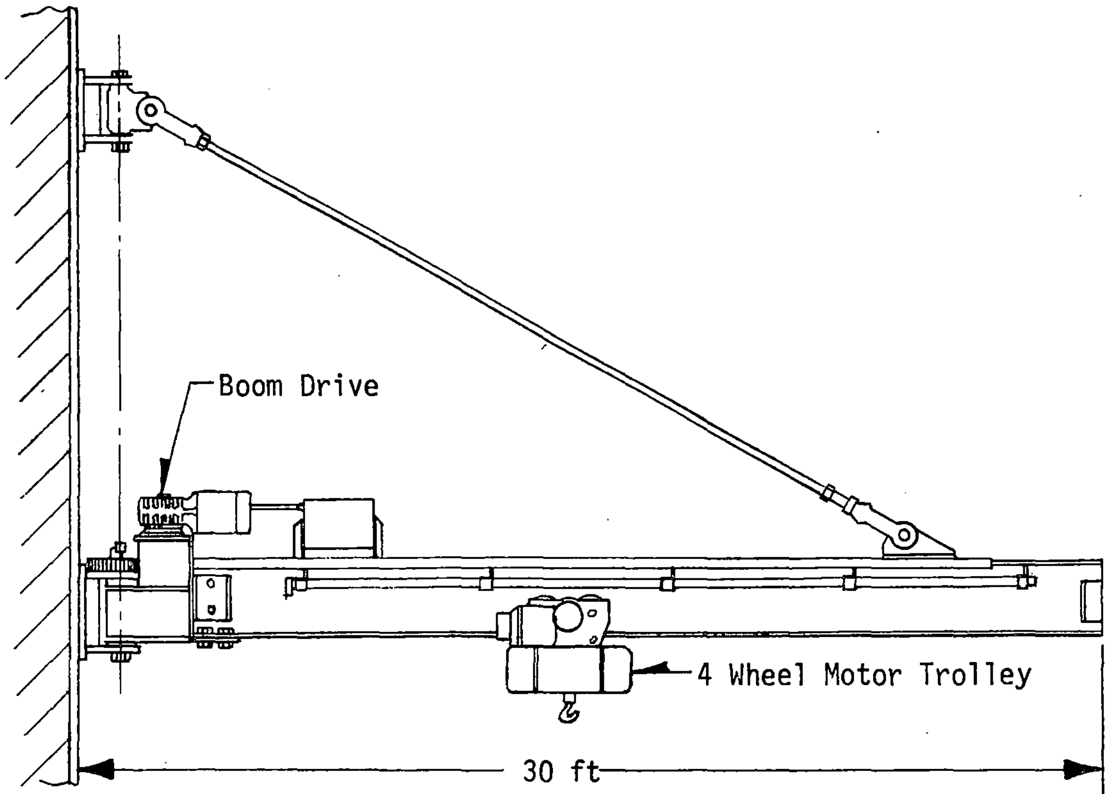


REACTOR INTERNALS LIFTING RIG
11/1/72 Fig. 9.1-5



MANIPULATOR CRANE

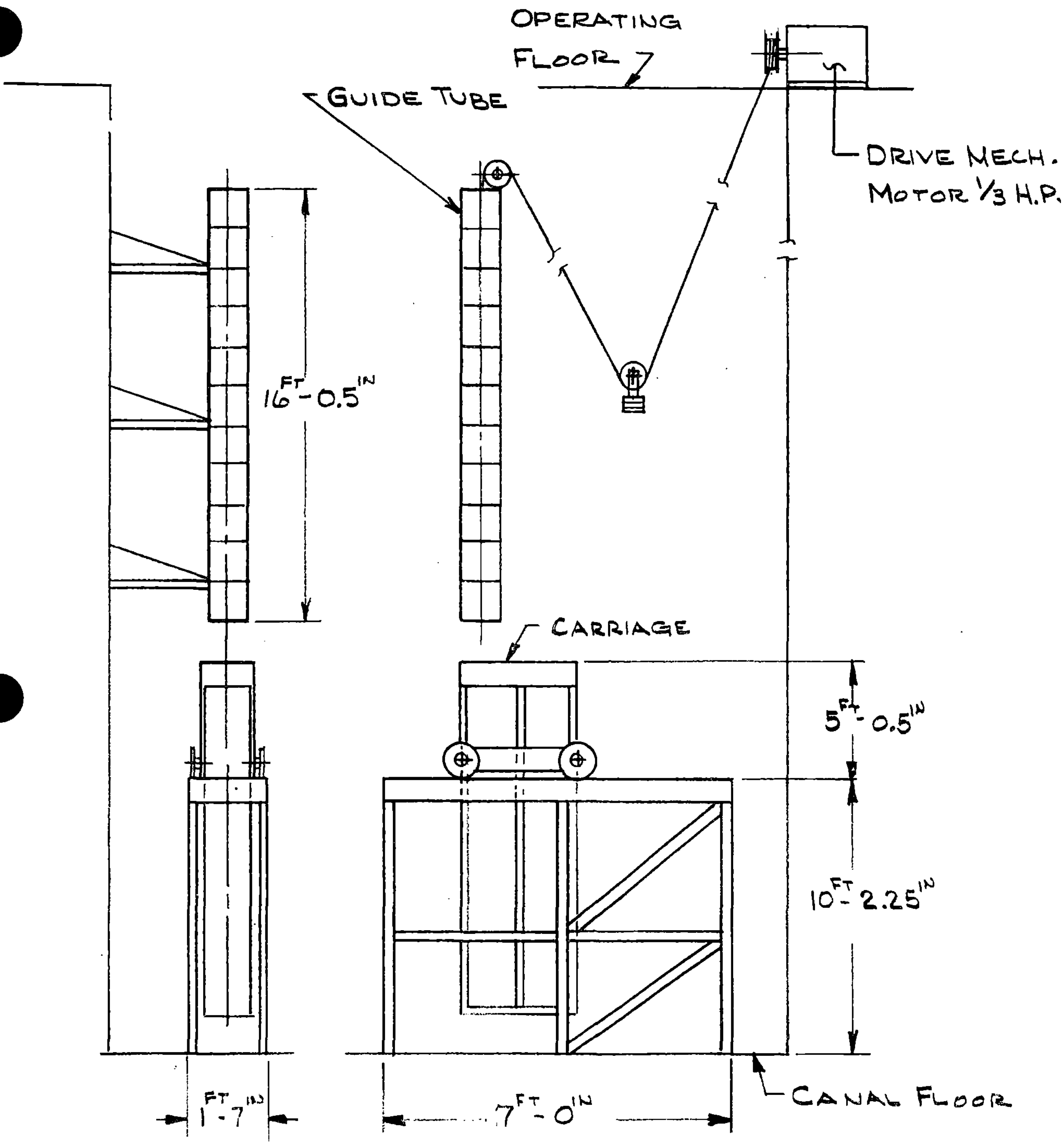
11/1/72 Fig. 9.1-6



CONTAINMENT JIB CRANE

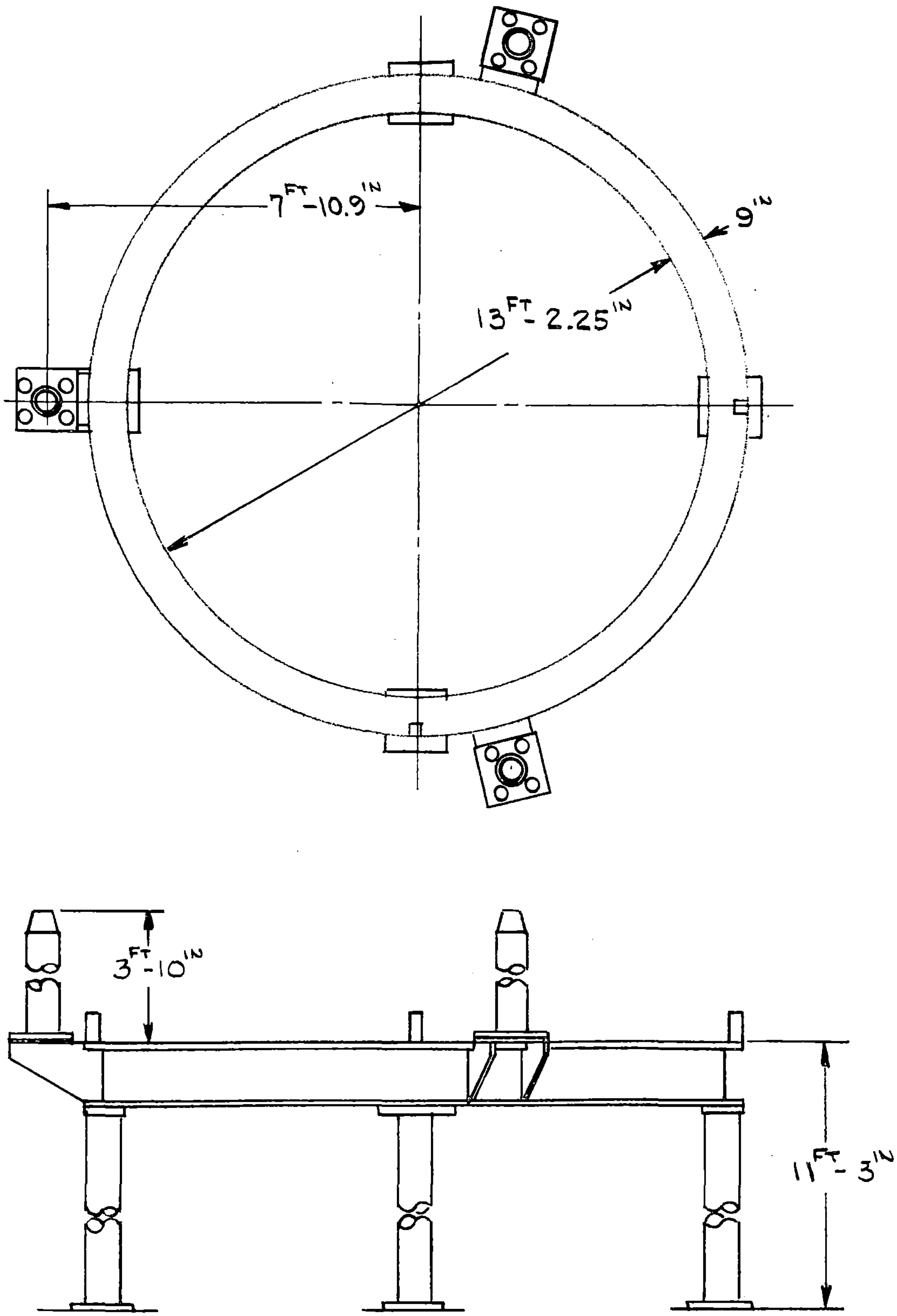
11/1/72

Fig. 9.1-7



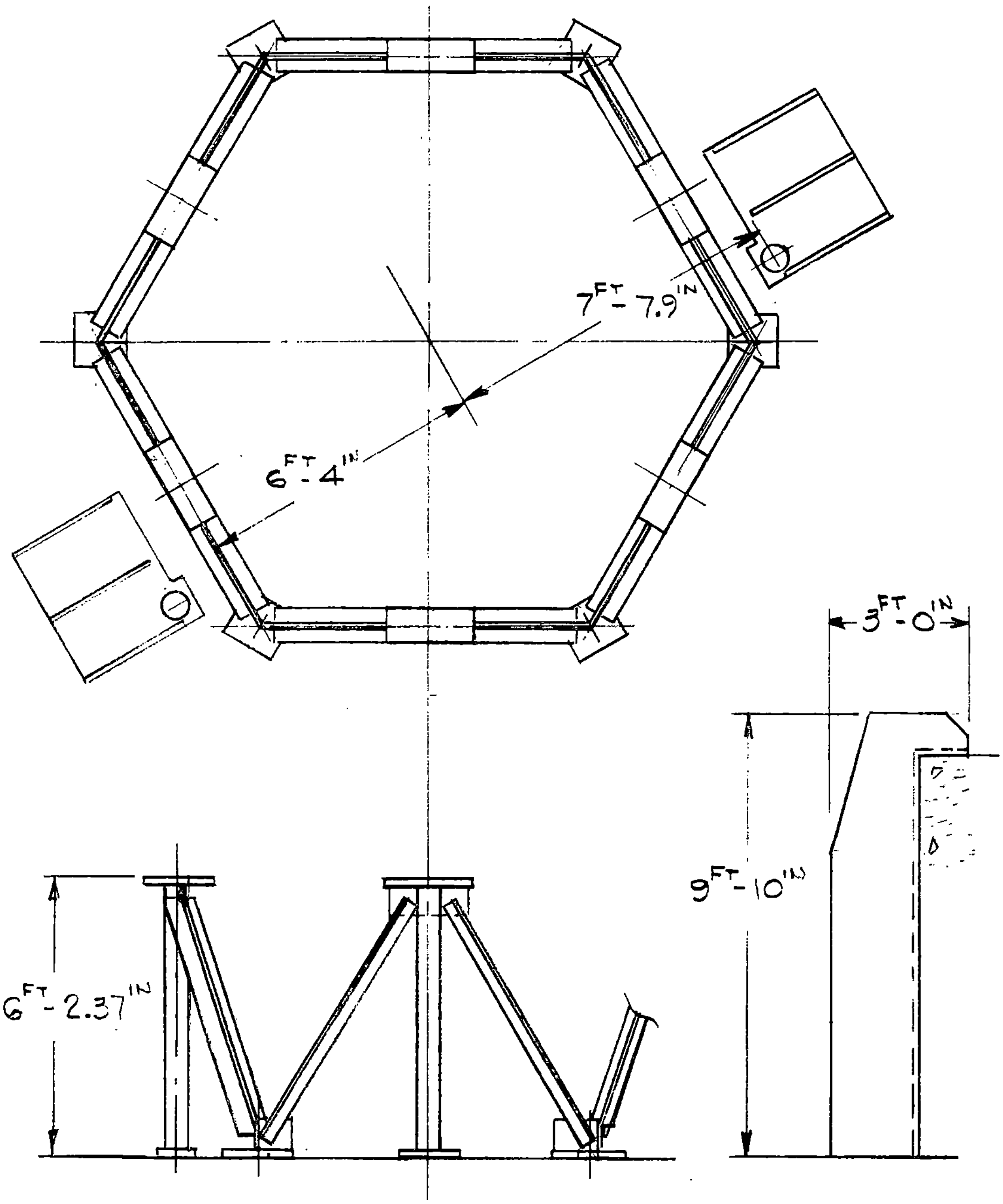
ROD CLUSTER CONTROL CHANGING FIXTURE

11/1/72 Fig. 9.1-8



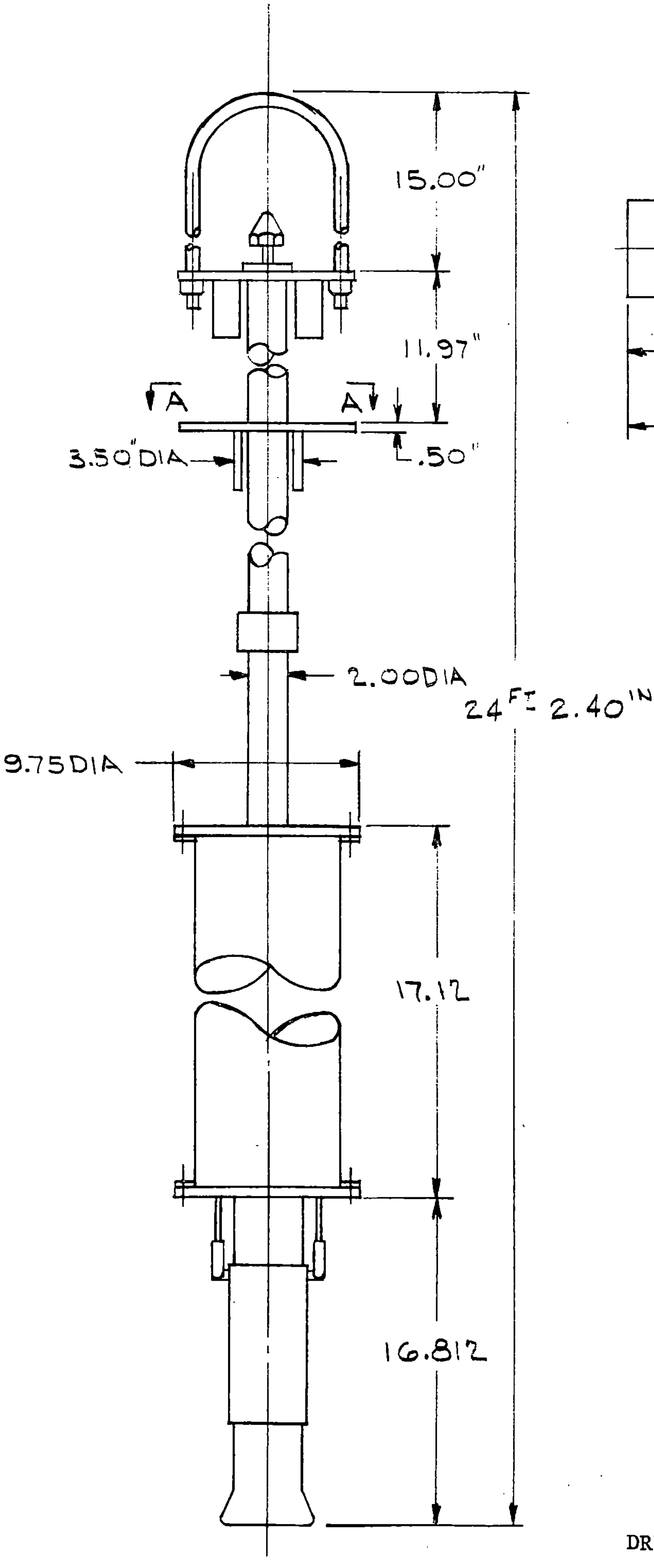
UPPER INTERNALS STORAGE STAND

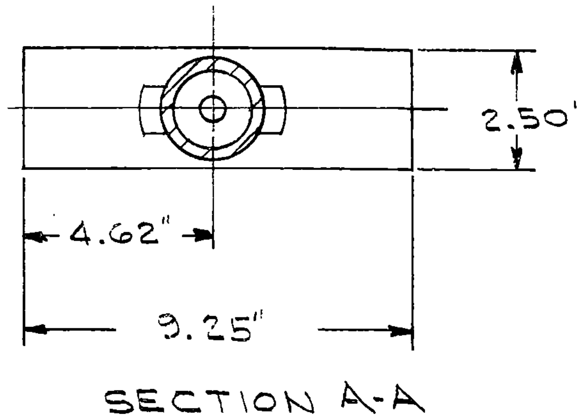
11/1/72 Fig. 9.1-9



LOWER INTERNALS STORAGE STAND

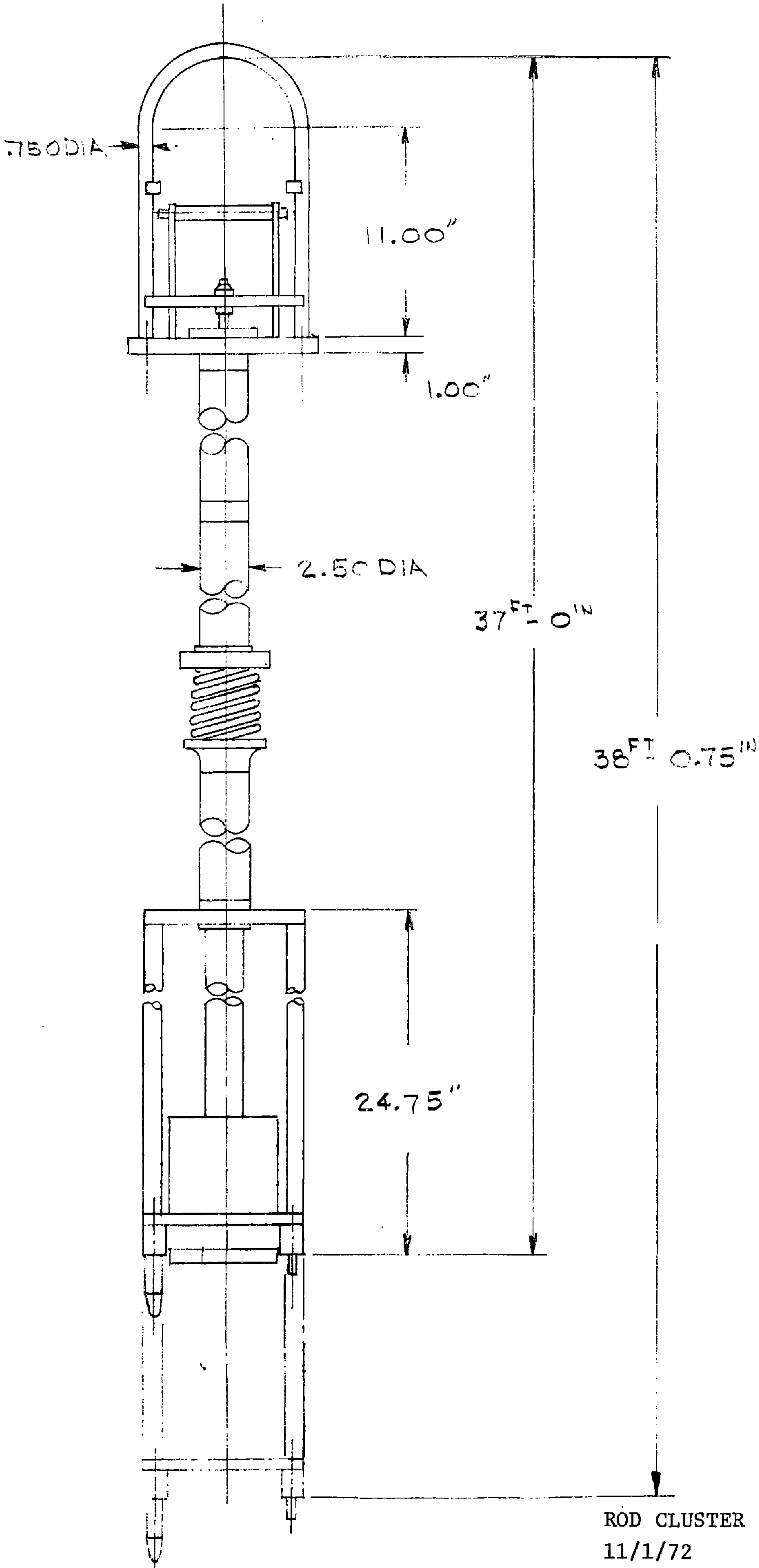
11/1/72 Fig. 9.1-10





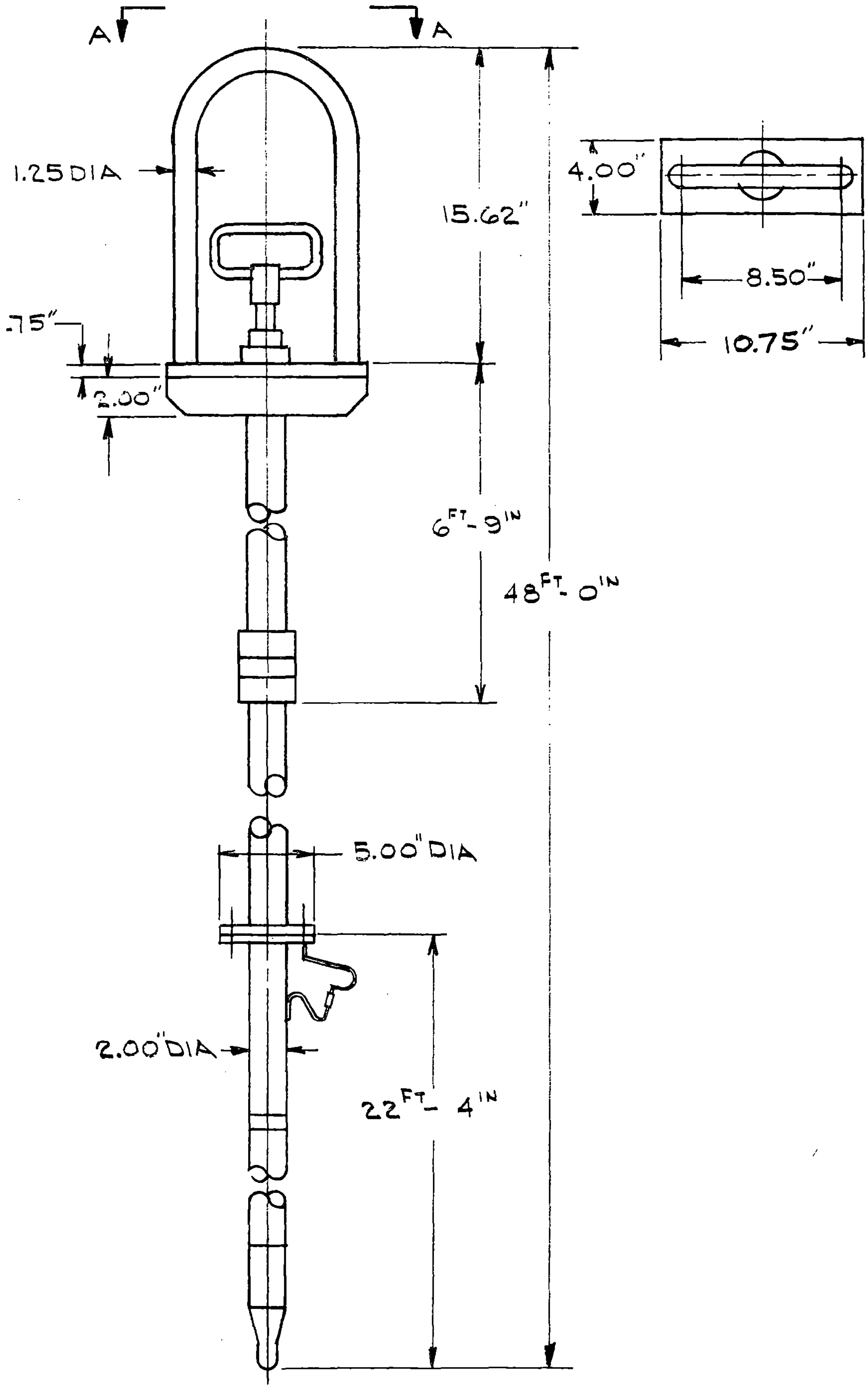
DRIVE SHAFT UNLATCHING TOOL

11/1/72 Fig. 9.1-11



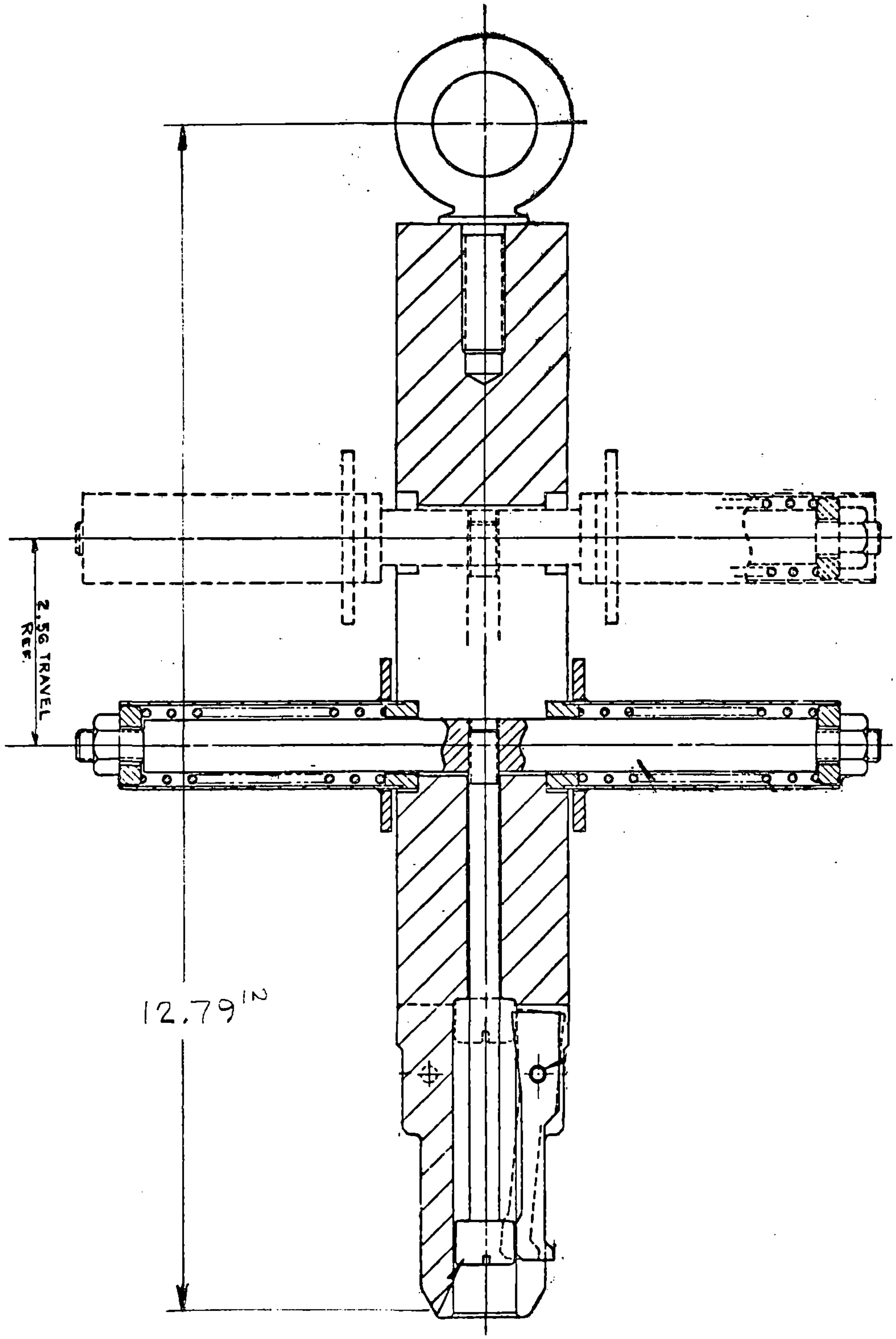
ROD CLUSTER CONTROL THIMBLE PLUG TOOL

11/1/72 Fig. 9.1-12



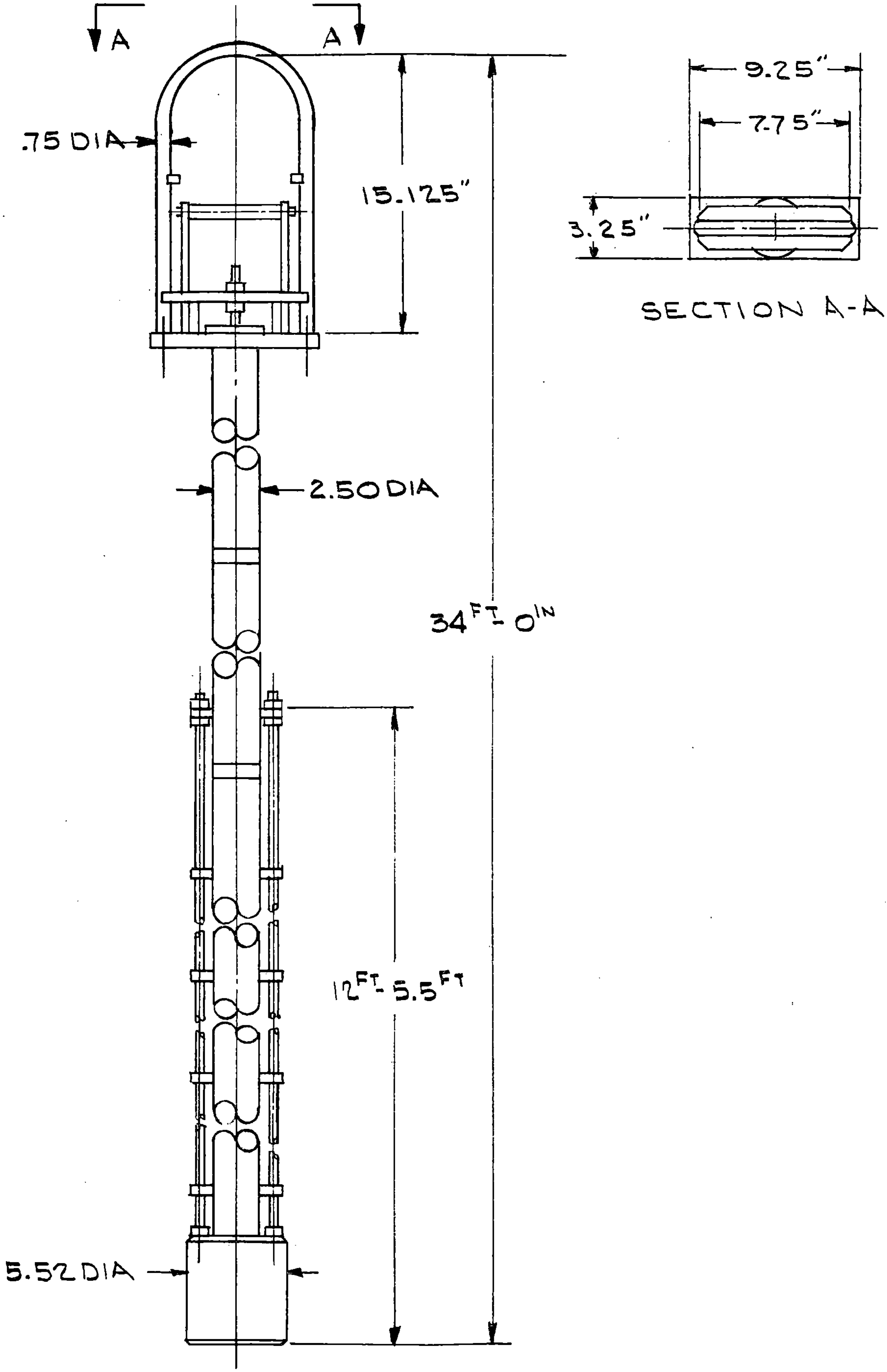
IRRADIATION SAMPLE HANDLING TOOL

11/1/72 Fig. 9.1-13



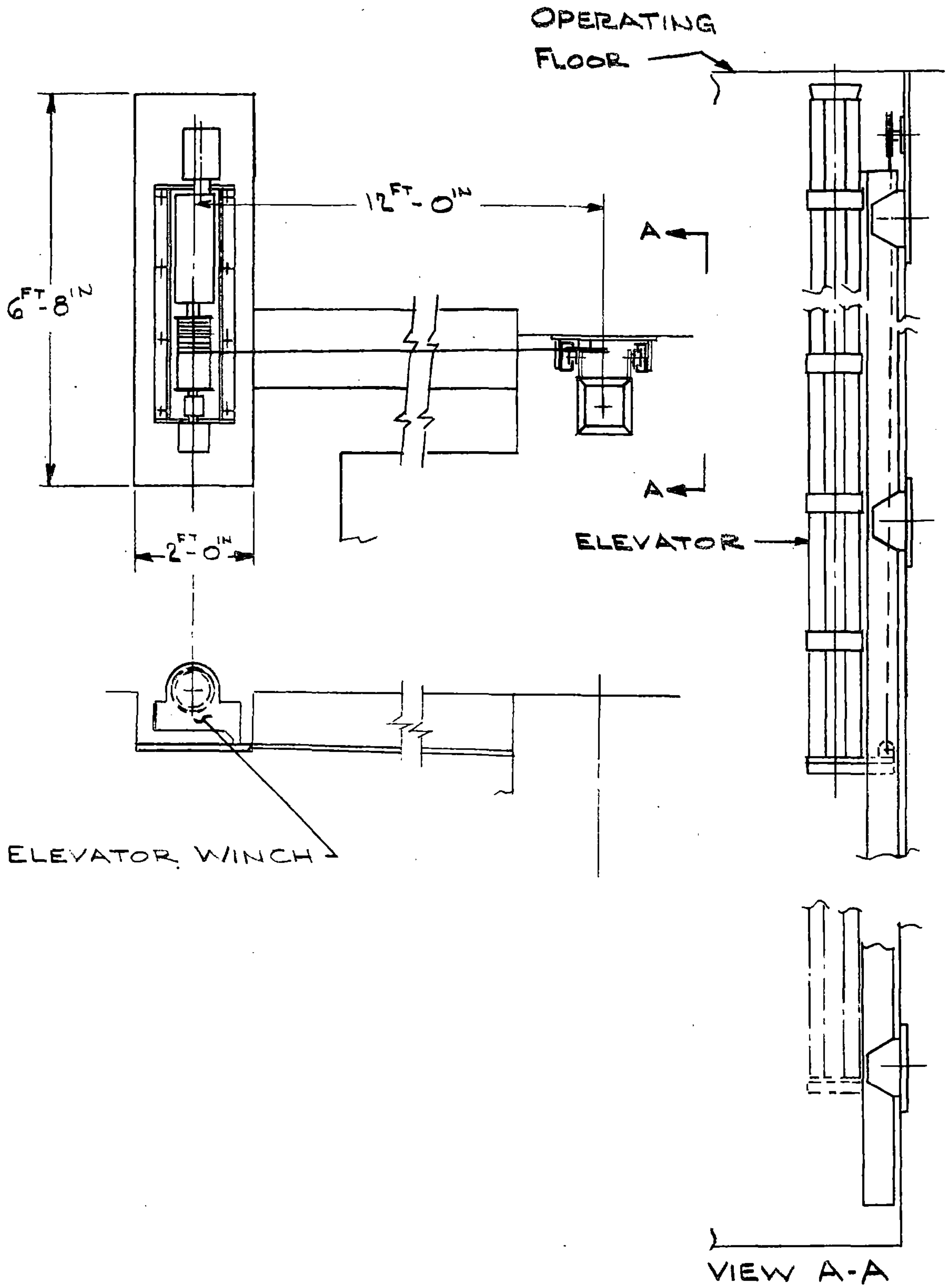
NEW CONTROL ROD CLUSTER HANDLING TOOL

11/1/72 Fig. 9.1-14



GUIDE TUBE COVER HANDLING TOOL

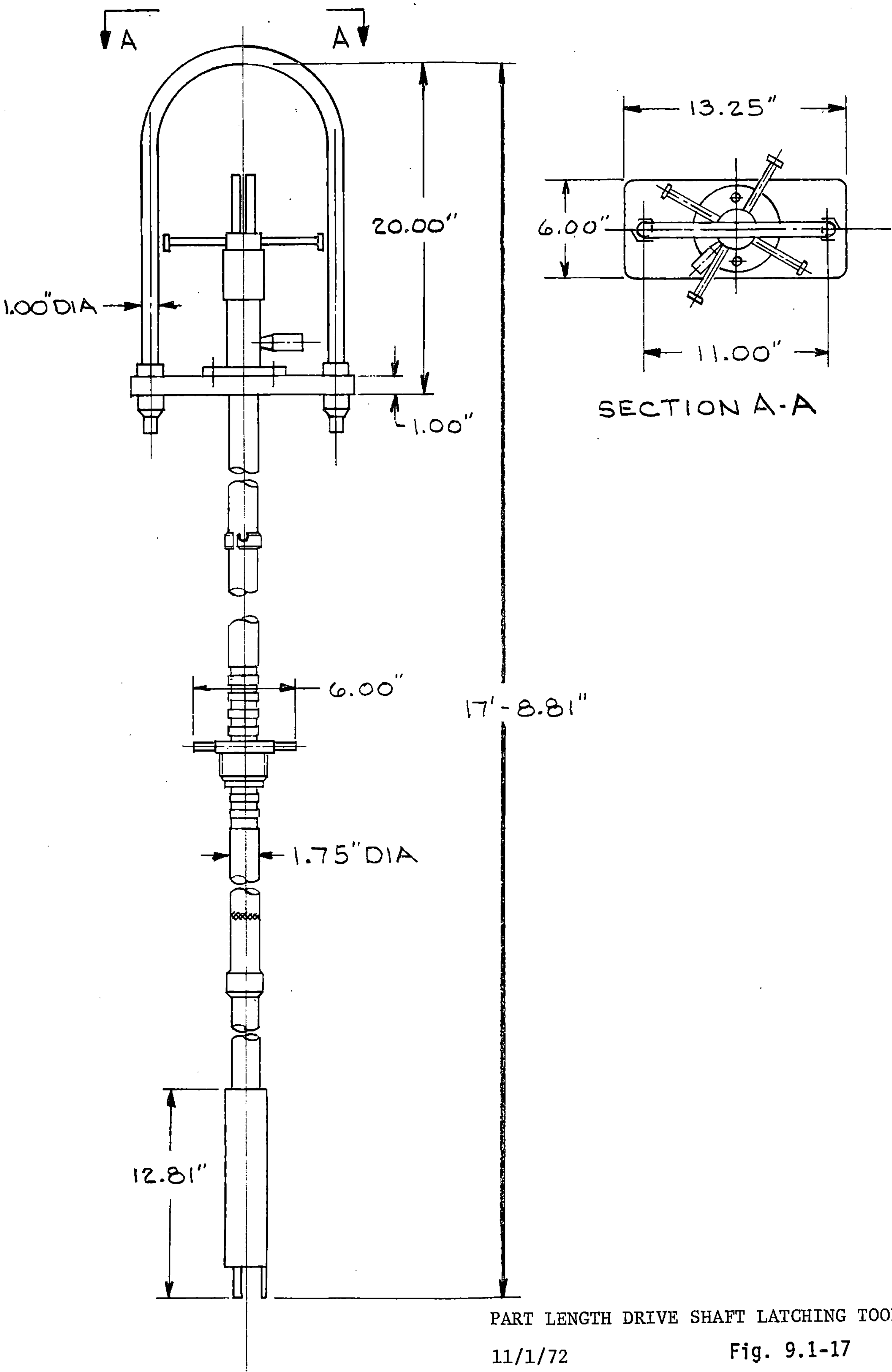
11/1/72 Fig. 9.1-15



NEW FUEL ELEVATOR

11/1/72

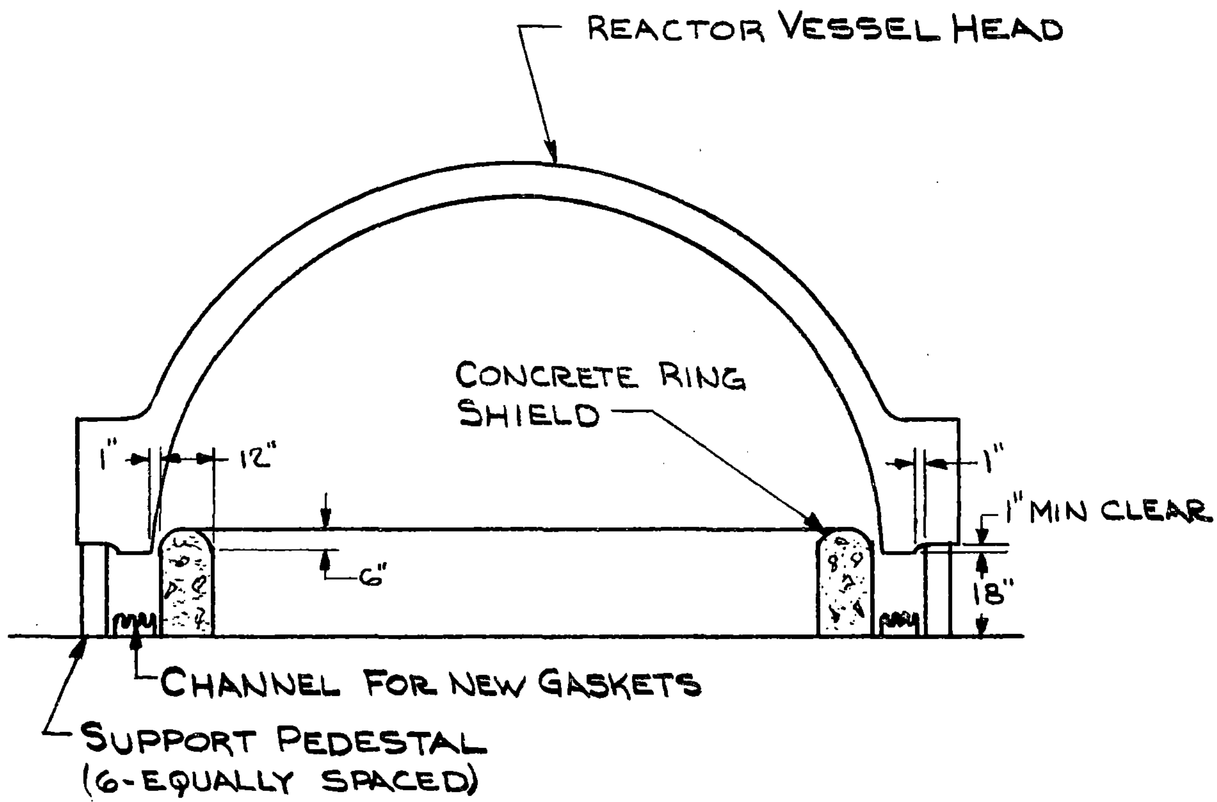
Fig. 9.1-16



PART LENGTH DRIVE SHAFT LATCHING TOOL

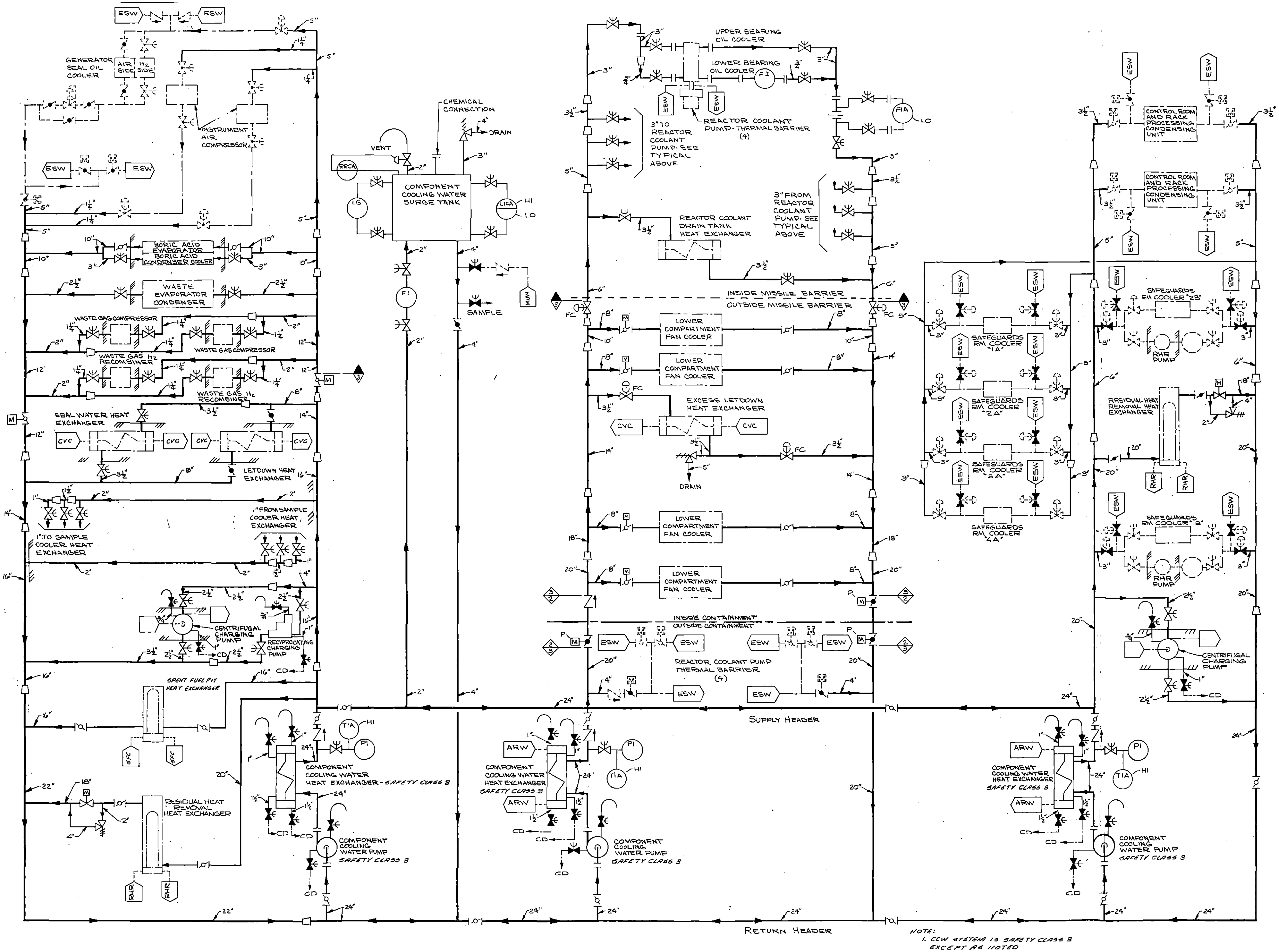
11/1/72

Fig. 9.1-17



REACTOR VESSEL HEAD STORAGE STAND

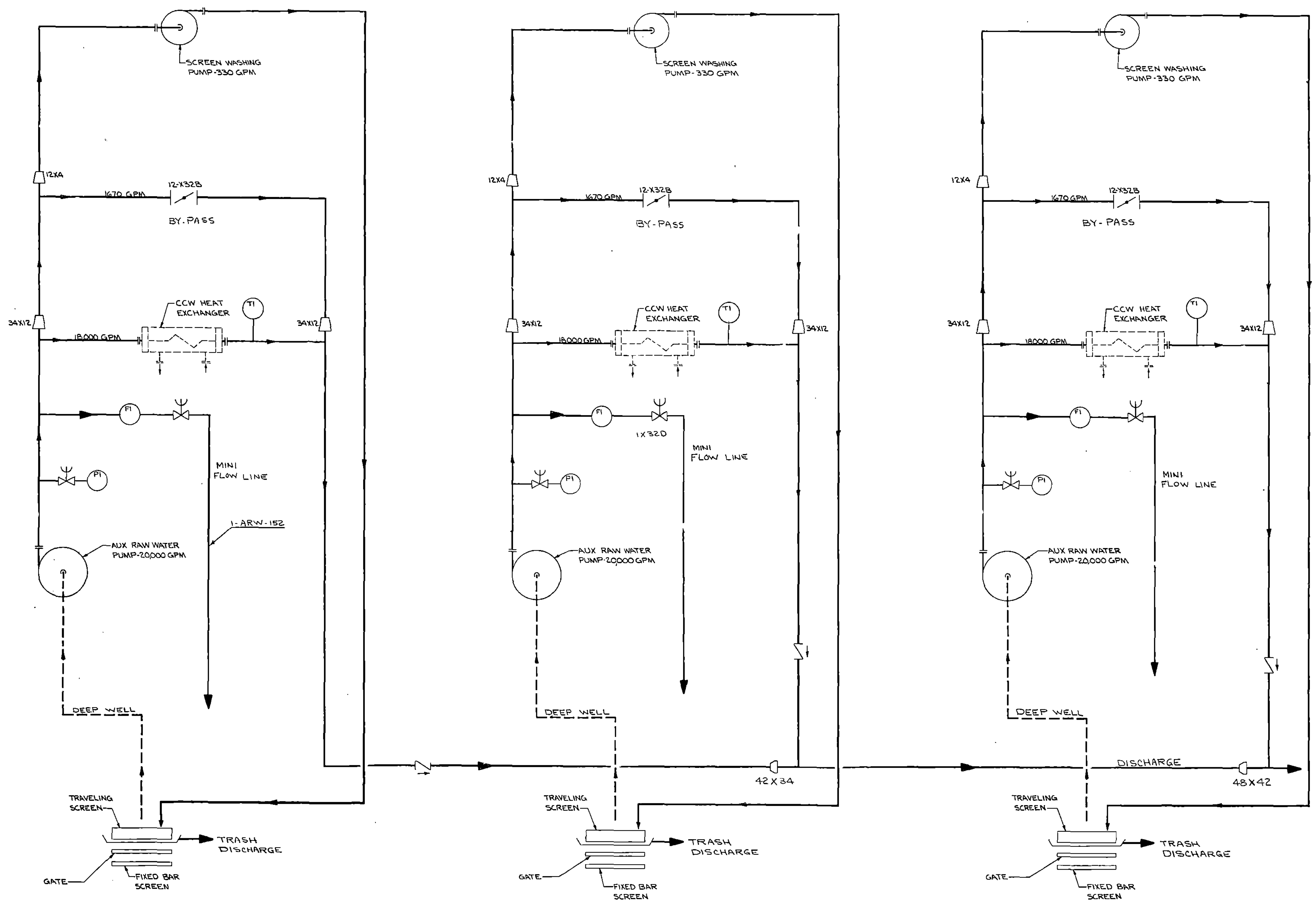
11/1/72 Fig. 9.1-18



OFFSHORE POWER SYSTEMS

Title: COMPONENT COOLING WATER SYSTEM FLOW DIAGRAM

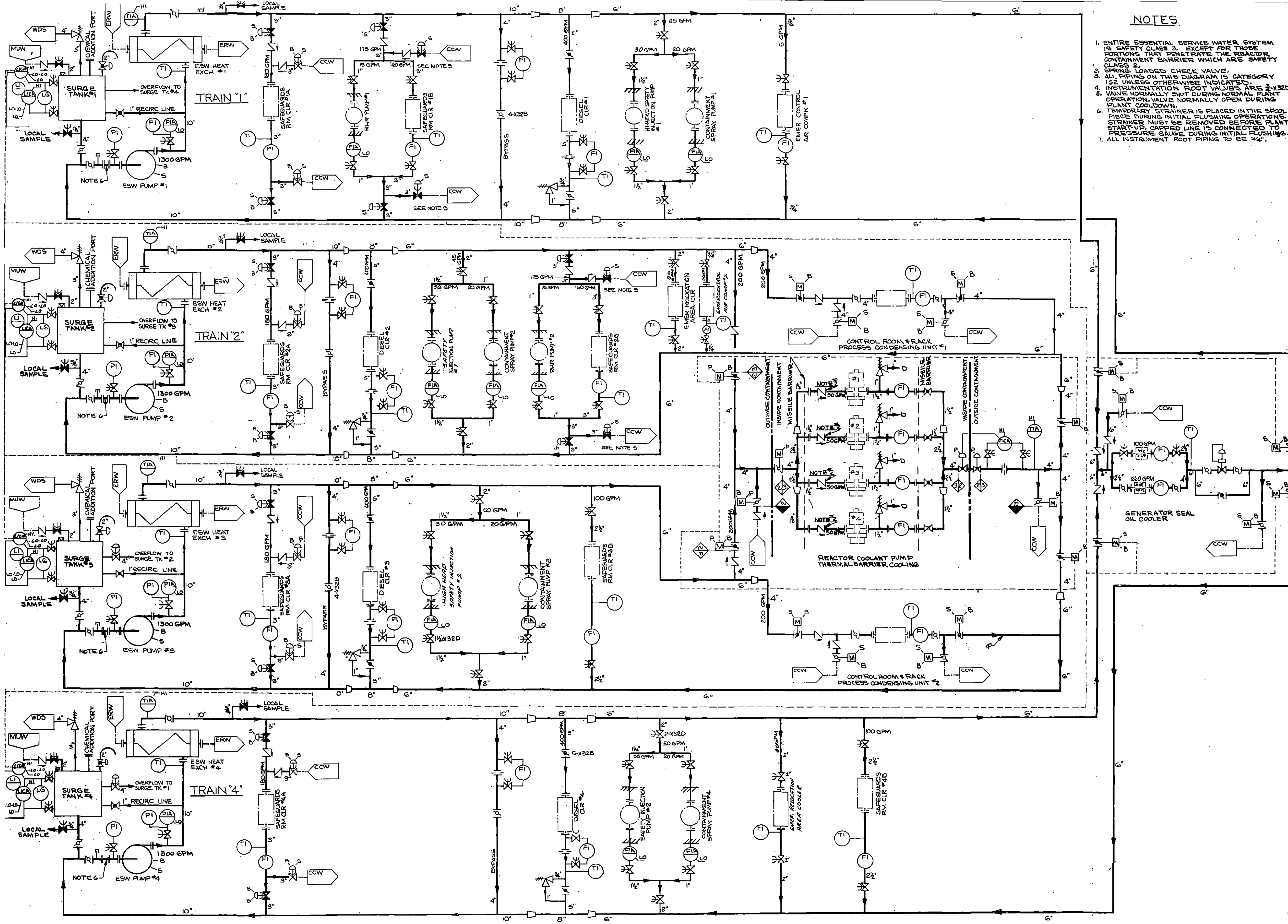
11/1/72 Figure 9.2-1



OFFSHORE POWER SYSTEMS

Title: AUXILIARY RAW WATER SYSTEM-FLOW DIAGRAM

11/1/72 Figure: 9.2-2



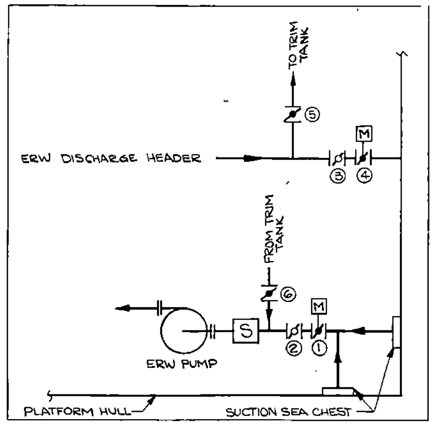
NOTES

1. ENTIRE ESSENTIAL SERVICE WATER SYSTEM IS SAFETY CLASS 3. EXCEPT FOR THOSE PORTIONS THAT PENETRATE THE REACTOR CONTAINMENT BARRIER WHICH ARE SAFETY CLASS 2.
2. SPRING LOADED CHECK VALVE.
3. ALL PIPING ON THIS DIAGRAM IS CATEGORY 152 UNLESS OTHERWISE INDICATED.
4. INSTRUMENTATION ROOT VALVES ARE ¾-X32D.
5. VALVE NORMALLY SHUT DURING NORMAL PLANT OPERATION. VALVE NORMALLY OPEN DURING PLANT COOLDOWN.
6. TEMPORARY STRAINER IS PLACED IN THE SPOOL PIECE DURING INITIAL FLUSHING OPERATIONS. STRAINER MUST BE REMOVED BEFORE PLANT START-UP. CAPPED LINE IS CONNECTED TO PRESSURE GAUGE DURING INITIAL FLUSHING.
7. ALL INSTRUMENT ROOT PIPING TO BE ¾".

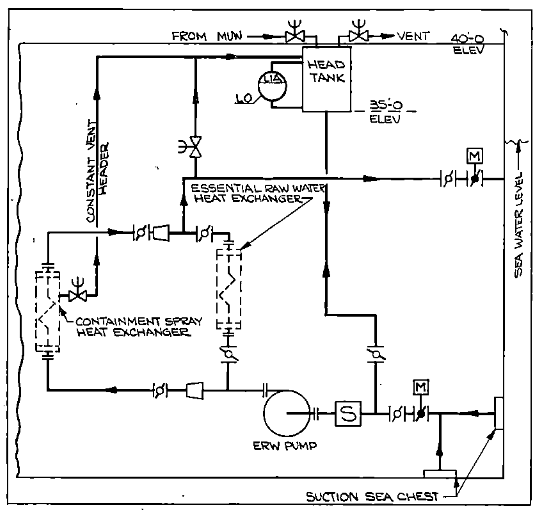
OFFSHORE POWER SYSTEMS

Title: ESSENTIAL SERVICE WATER SYSTEM FLOW DIAGRAM

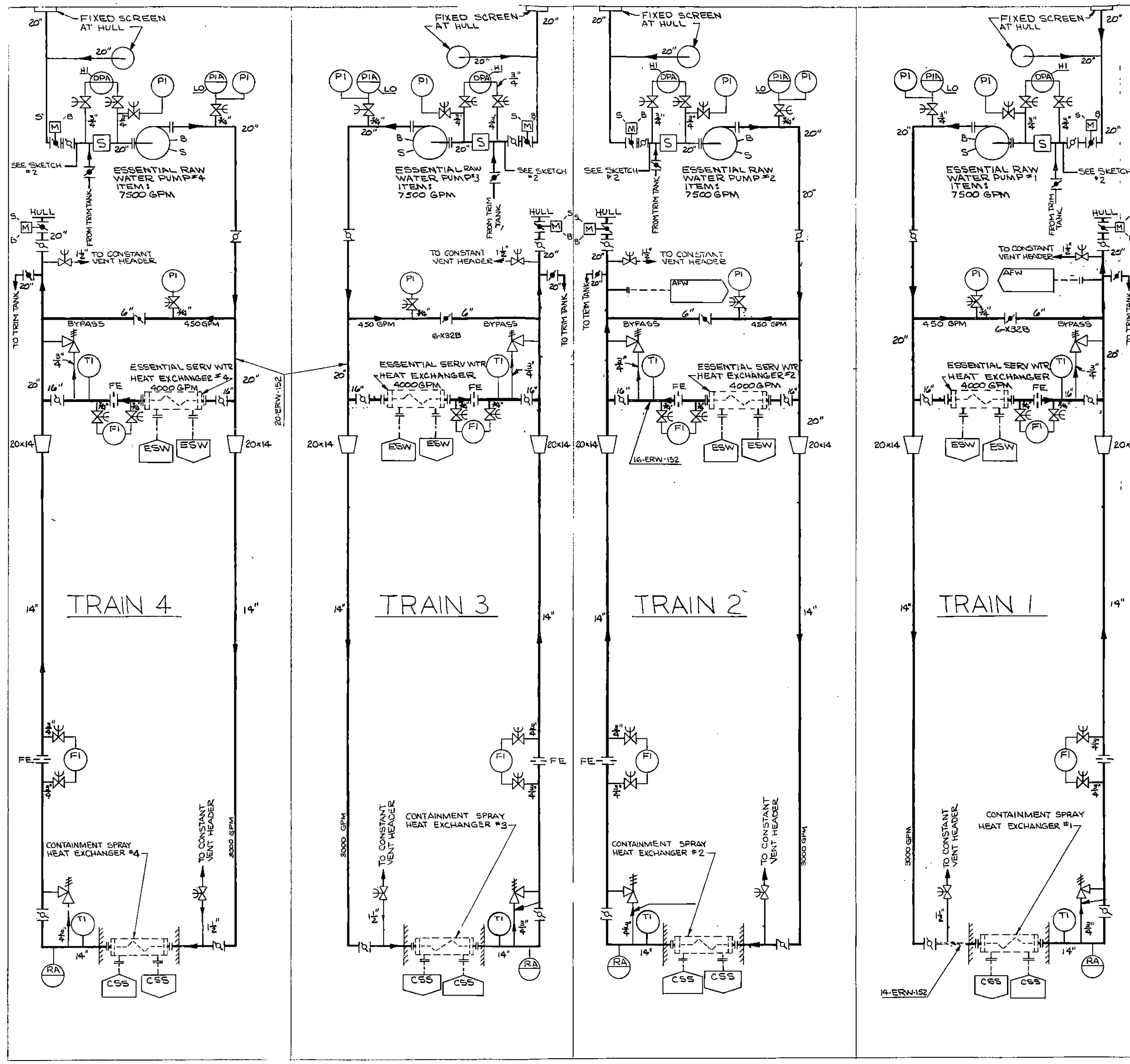
1/1/73 Figure: 9.2-3



SKETCH #1
PIPING AND VALVE ARRANGEMENT FOR TESTING ERW SYSTEM



SKETCH #2
HEAD TANK AND CONSTANT VENT PIPING ARRANGEMENT



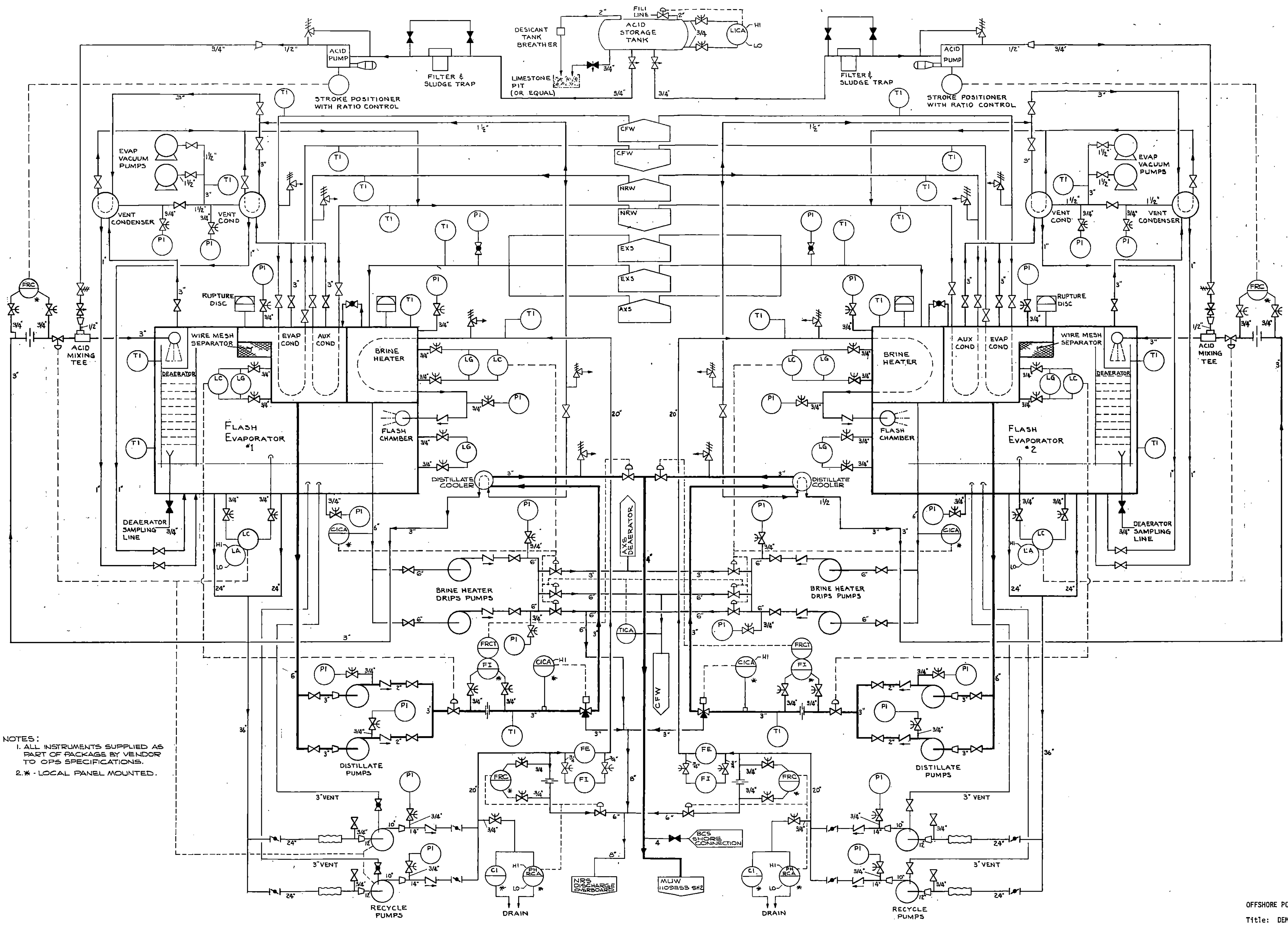
NOTES:
1. THE ENTIRE ESSENTIAL RAW WATER SYSTEM IS SAFETY CLASS 3.
2. PIPING BETWEEN HULL AND MOTOR OPERATED ISOLATION VALVES IS 90:10 CU-NI.

OFFSHORE POWER SYSTEMS

Title: ESSENTIAL RAW WATER SYSTEM - FLOW DIAGRAM

11/1/72

Figure: 9.2-4



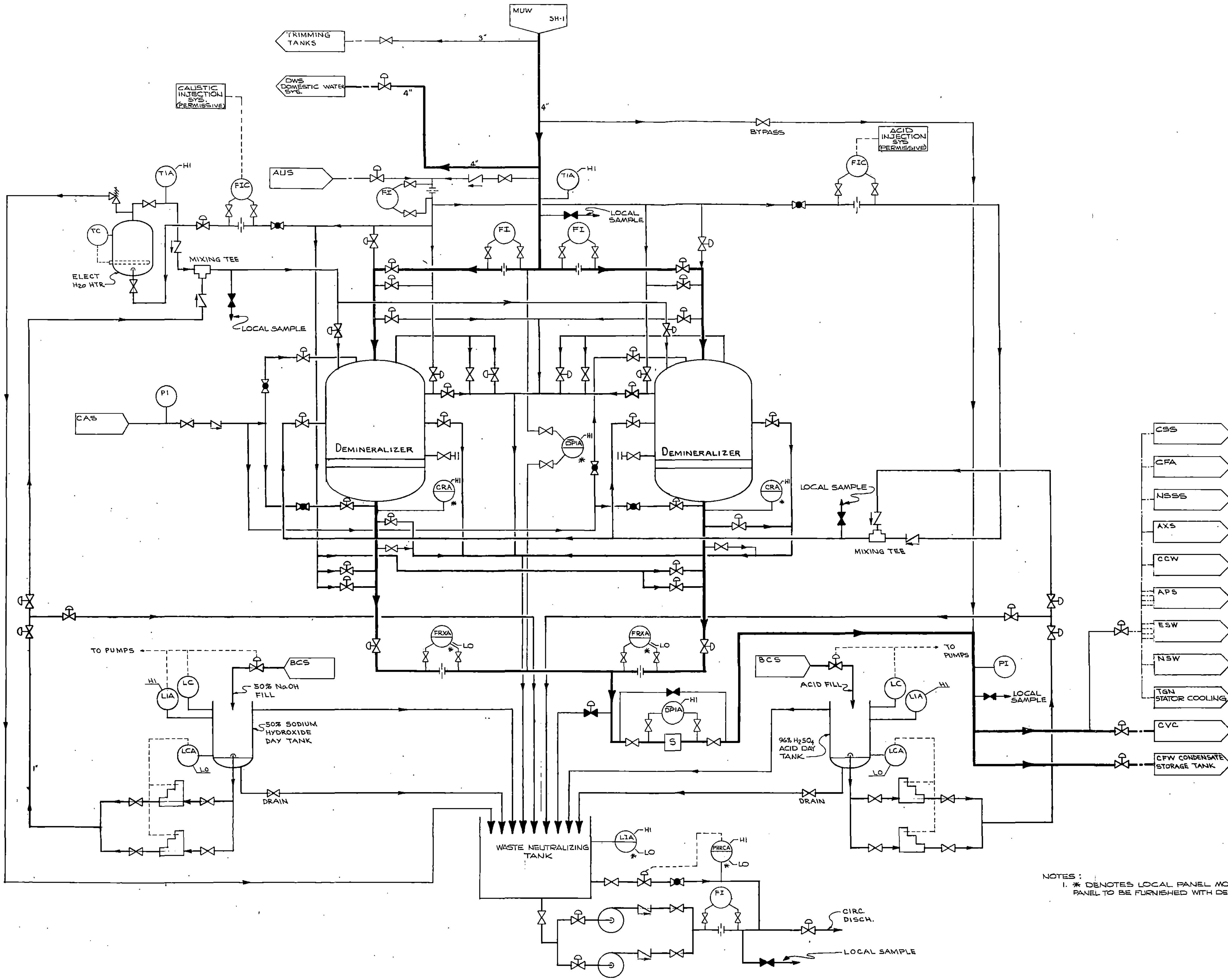
NOTES:
1. ALL INSTRUMENTS SUPPLIED AS PART OF PACKAGE BY VENDOR TO OPS SPECIFICATIONS.
2. * - LOCAL PANEL MOUNTED.

OFFSHORE POWER SYSTEMS

Title: DEMINERALIZED WATER MAKE-UP SYSTEM-FLOW DIAGRAM

11/1/72

Figure: 9.2-5
Sheet 1



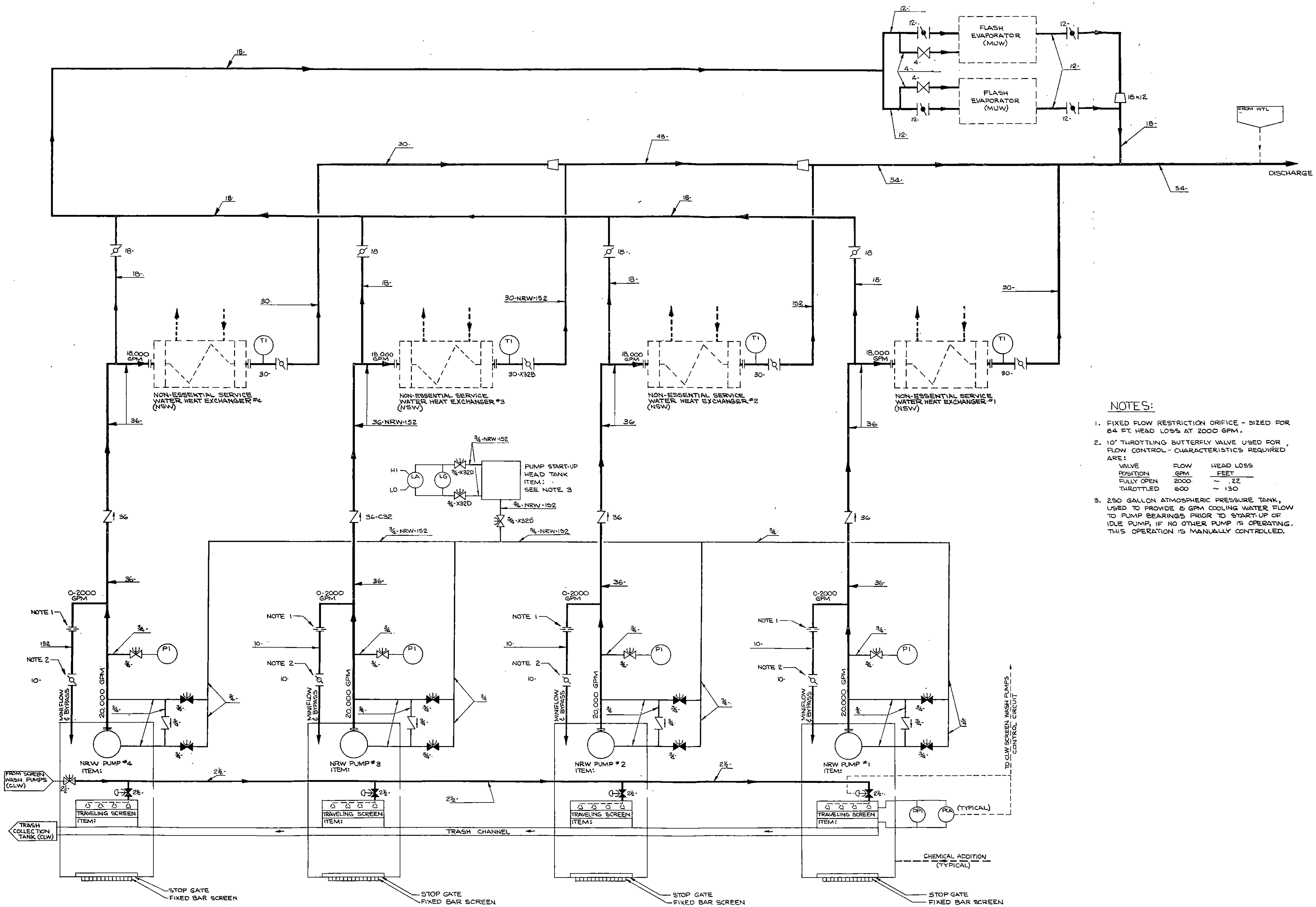
NOTES :
1. * DENOTES LOCAL PANEL MOUNTED INSTRUMENT. PANEL TO BE FURNISHED WITH DEMINERALIZER EQUIP.

OFFSHORE POWER SYSTEMS

Title: DEMINERALIZED WATER MAKE-UP SYSTEM FLOW DIAGRAM

11/1/72

Figure: 9.2-5 Sheet 2



NOTES:

1. FIXED FLOW RESTRICTION ORIFICE - SIZED FOR 84 FT. HEAD LOSS AT 2000 GPM.
2. 10" THROTTLING BUTTERFLY VALVE USED FOR FLOW CONTROL - CHARACTERISTICS REQUIRED ARE:

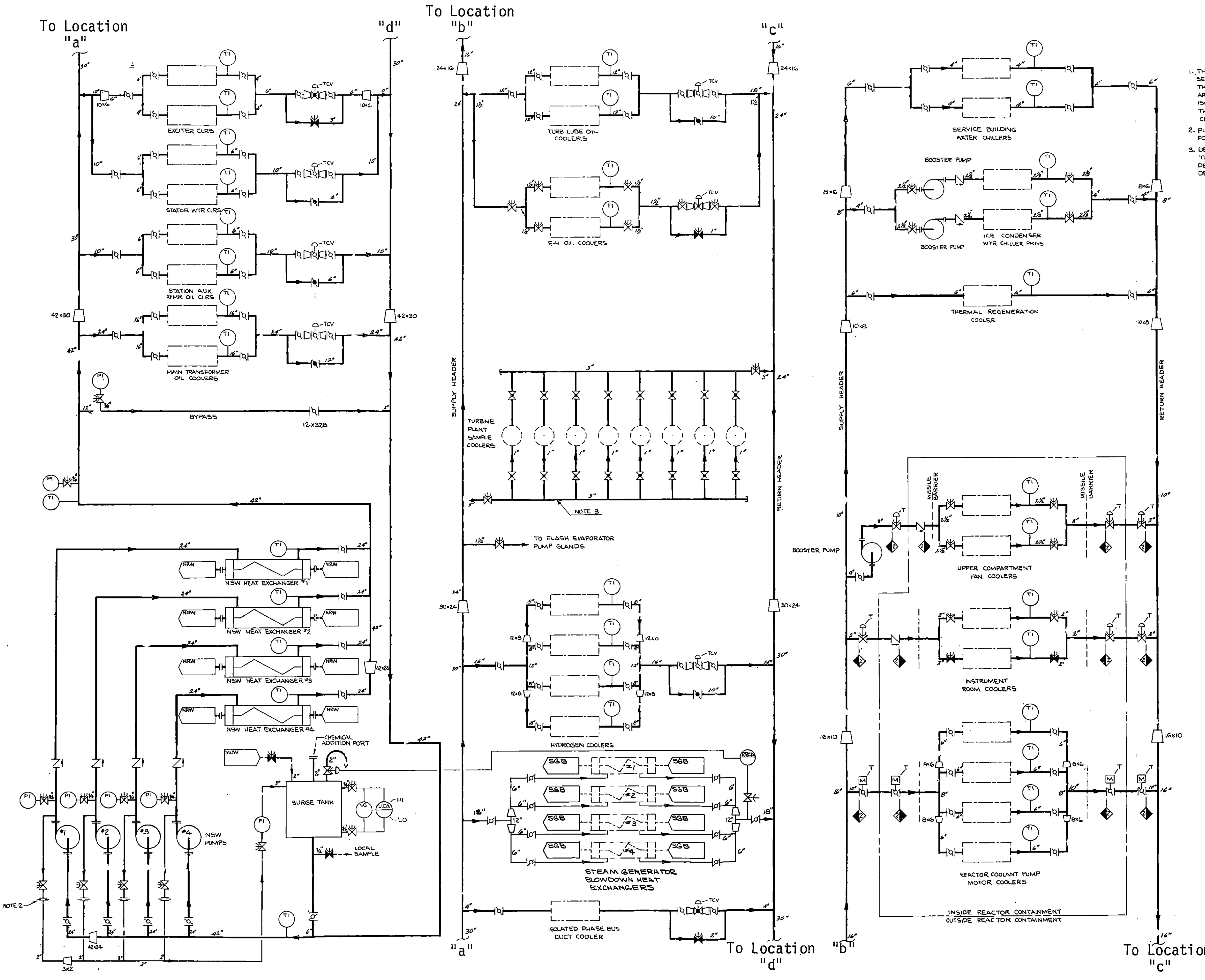
VALVE POSITION	FLOW GPM	HEAD LOSS FEET
FULLY OPEN	2000	~ .22
THROTTLED	600	~ 130

3. 250 GALLON ATMOSPHERIC PRESSURE TANK, USED TO PROVIDE 8 GPM COOLING WATER FLOW TO PUMP BEARINGS PRIOR TO START-UP OF IDLE PUMP, IF NO OTHER PUMP IS OPERATING. THIS OPERATION IS MANUALLY CONTROLLED.

OFFSHORE POWER SYSTEMS

Title: NON-ESSENTIAL RAW WATER SYSTEM FLOW DIAGRAM

11/1/72 Figure: 9.2-7



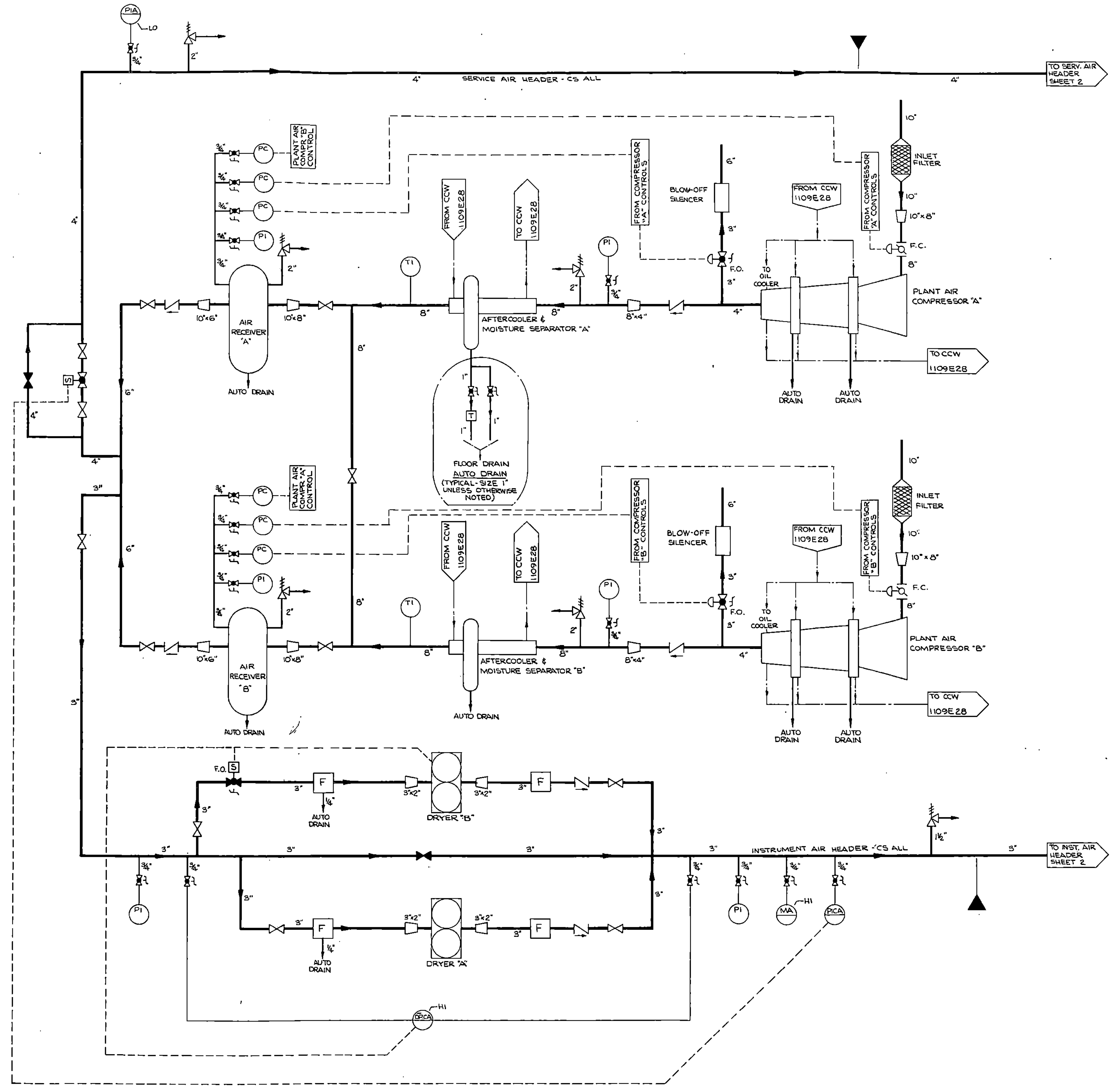
NOTES:

1. THOSE PORTIONS OF THE NON-ESSENTIAL SERVICE WATER SYSTEM THAT PENETRATE THE REACTOR CONTAINMENT BOUNDARY ARE SAFETY CLASS 2 BETWEEN ISOLATION VALVES. THE REMAINDER OF THE SYSTEM IS NOT COVERED BY SAFETY CLASSES.
2. PUMP MINIFLOW FIXED ORIFICES SIZED FOR 112 FT. HEAD LOSS AT 60 GPM FLOW.
3. DETAILS OF COOLING WATER CIRCUIT FOR TURBINE PLANT SAMPLE COOLERS TO BE DEVELOPED AFTER SAMPLING SYSTEM DESIGN IS FIRM.

OFFSHORE POWER SYSTEMS

Title: NON-ESSENTIAL SERVICE WATER SYSTEM FLOW DIAGRAM

11/1/72 Figure: 9.2-6

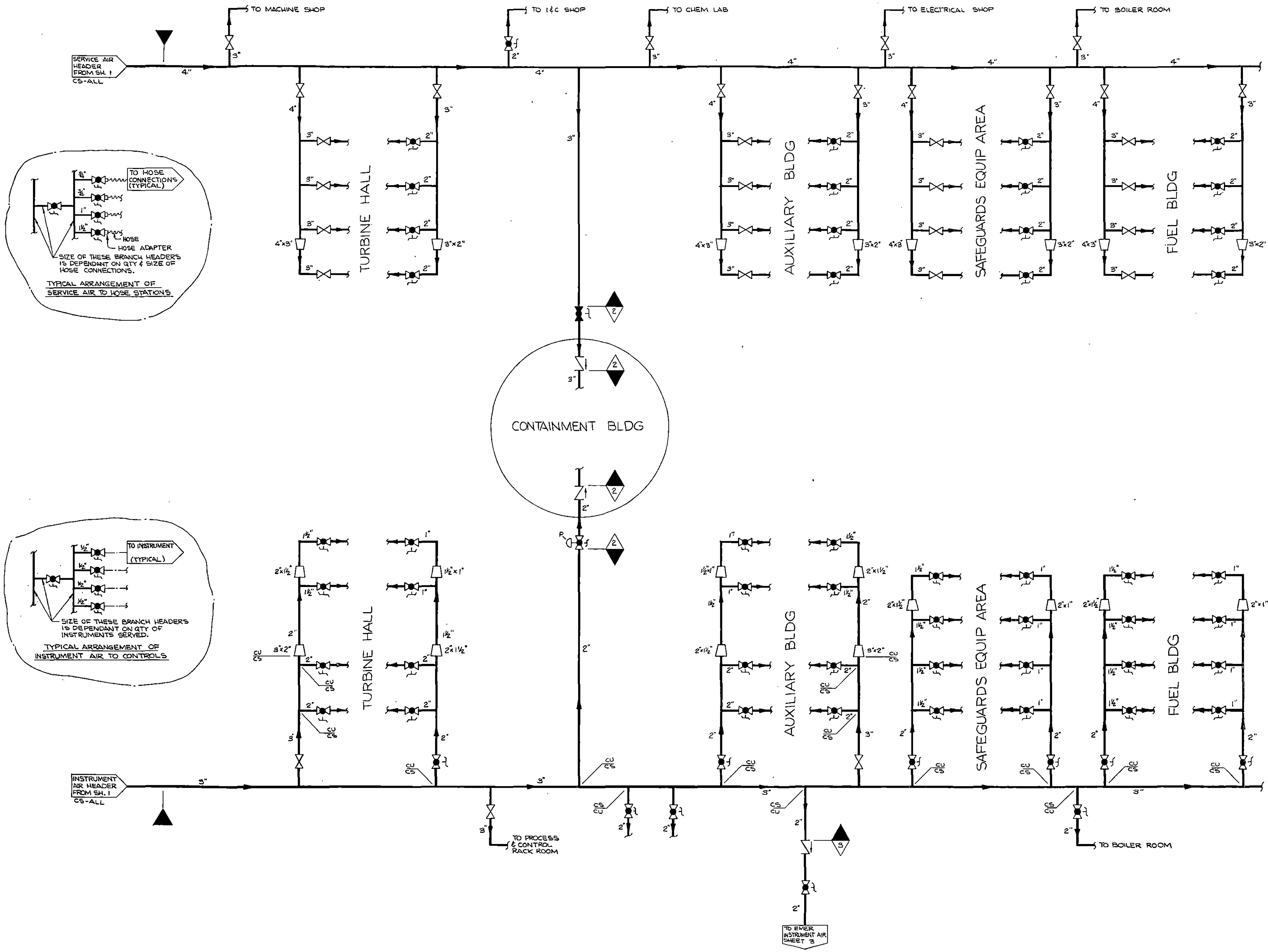


OFFSHORE POWER SYSTEMS

Title: COMPRESSED AIR SYSTEMS - FLOW DIAGRAM

11/1/72

Figure: 9.3-1
Sheet 1

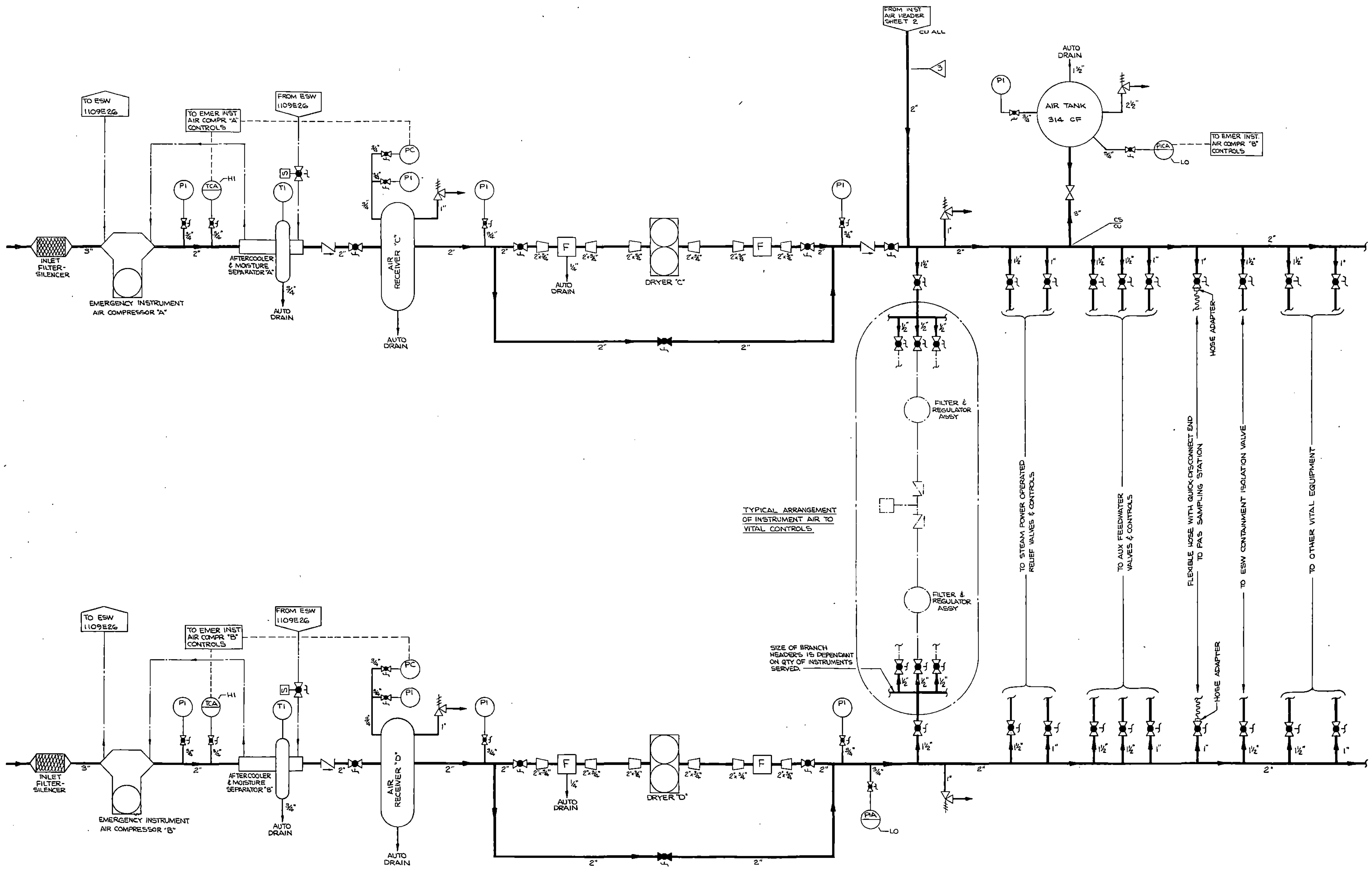


OFFSHORE POWER SYSTEMS

Title: COMPRESSED AIR SYSTEMS - FLOW DIAGRAM

11/1/72

Figure: 9.3-1
Sheet 2

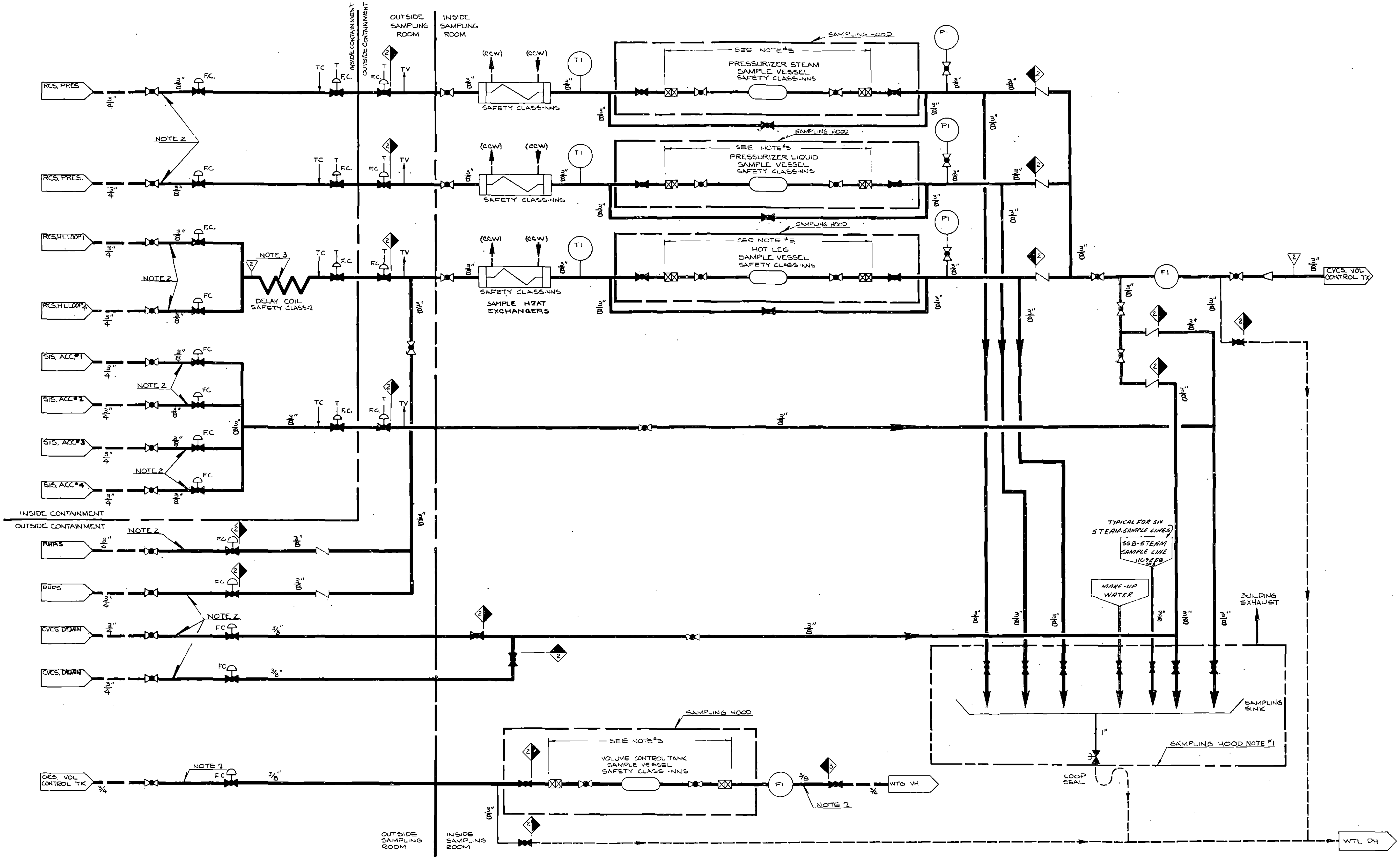


OFFSHORE POWER SYSTEMS

Title: COMPRESSED AIR SYSTEMS-FLOW DIAGRAM

11/1/72

Figure: 9.3-1
Sheet 3

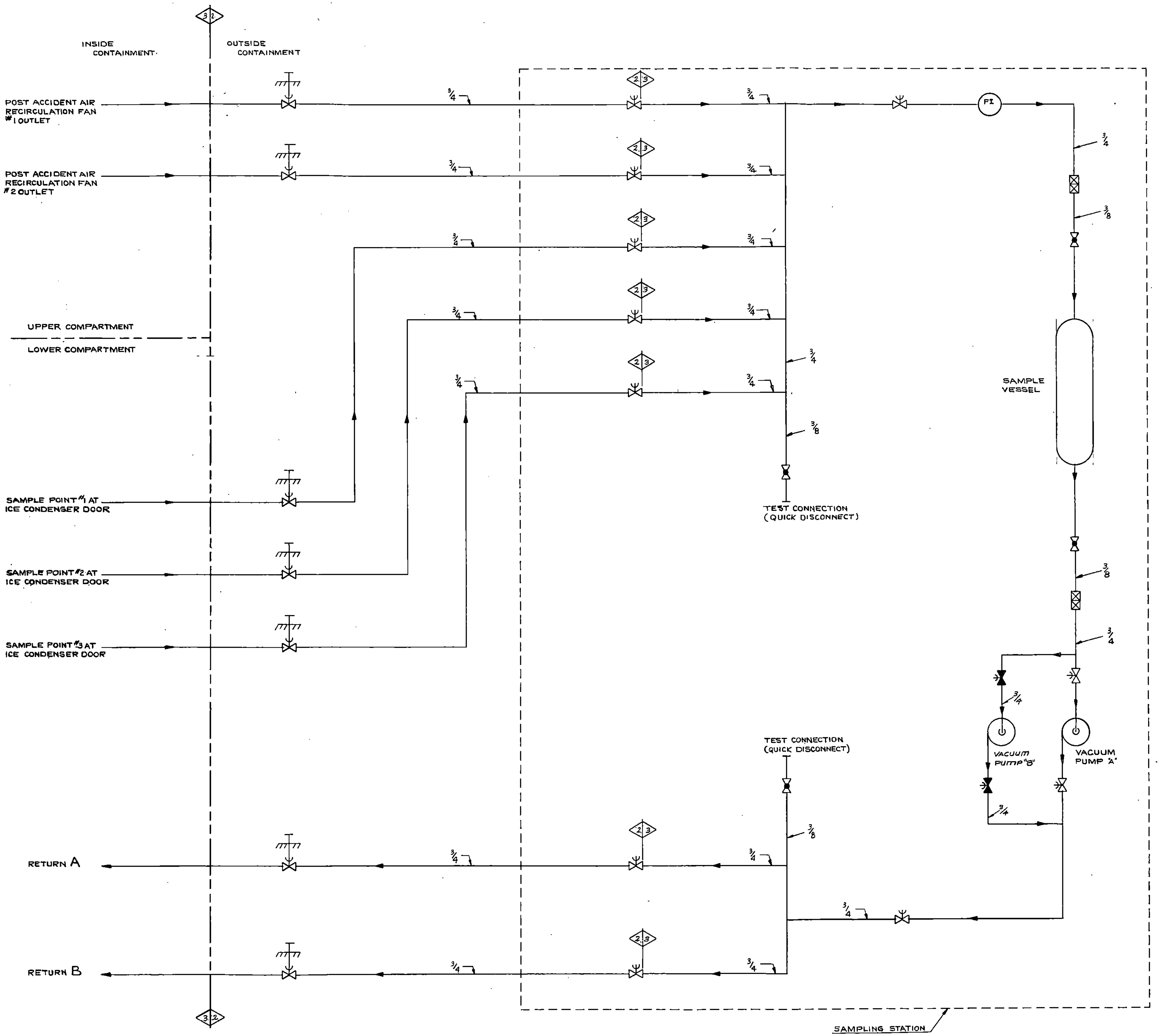


NOTES:
1. SAMPLE SINK AND HOOD ASSEMBLY SUPPLIED AS PACKAGE.
2. 3/8 TUBING INSERTED IN 3/4" NOMINAL PIPE AT VALVE.
3. ALL TUBING AND VALVES ARE 3/8" O D EXCEPT AS DETAILED.
4. SYSTEM DESIGNATION FOR NSSS SAMPLING SYSTEM IS SSR.
5. QUICK DISCONNECT COUPLINGS AND ANGLE VALVES ON BOTH SIDES OF SAMPLE VESSELS ARE INTEGRAL WITH VESSELS.
6. PIPE DESIGNATION FOR ALL LINES IS SS-250SR, EXCEPT WHERE INDICATED OTHERWISE.

OFFSHORE POWER SYSTEMS

Title: NSSS SAMPLING SYSTEM FLOW DIAGRAM

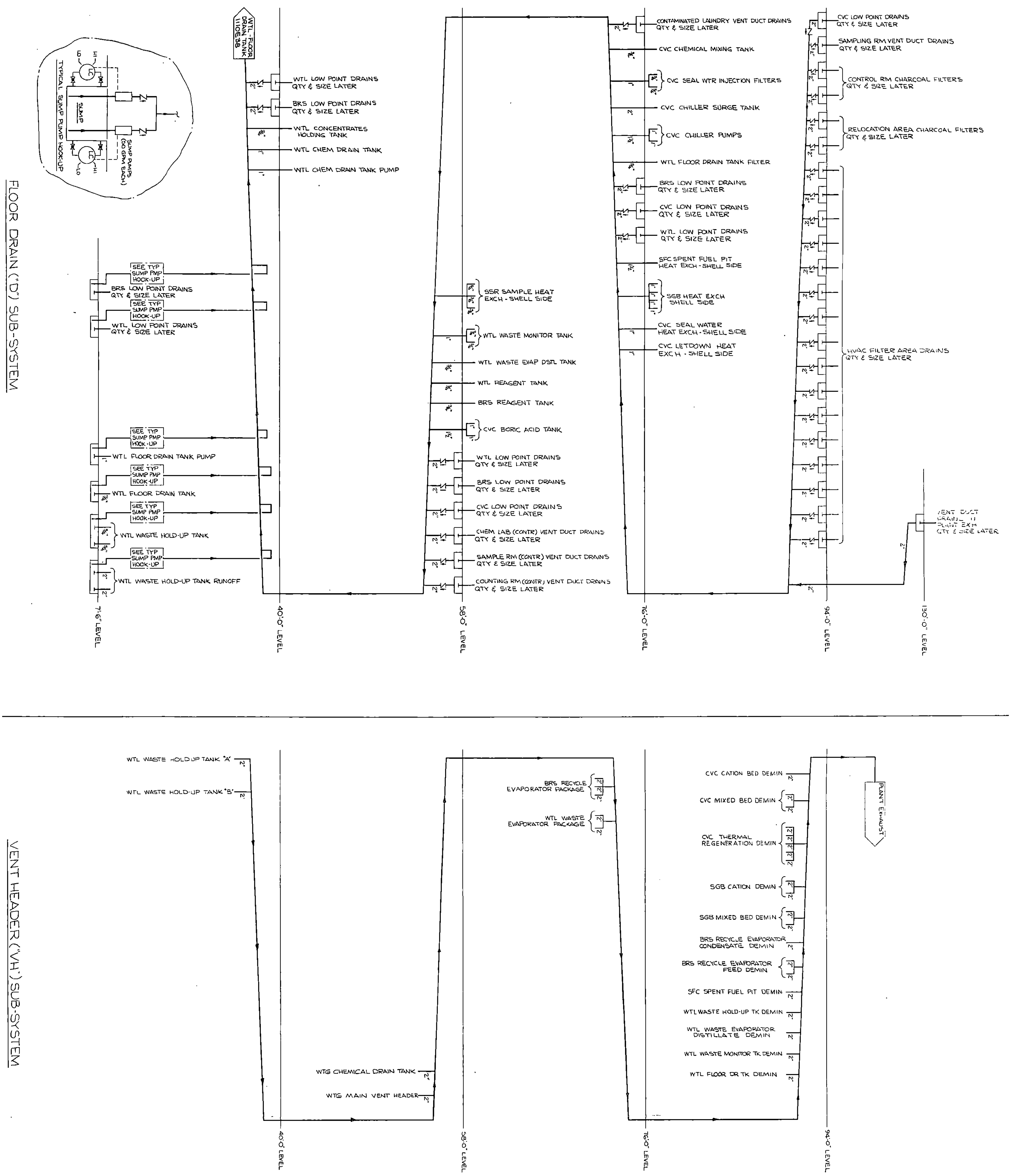
1/1/73 Figure: 9.3-2



OFFSHORE POWER SYSTEMS

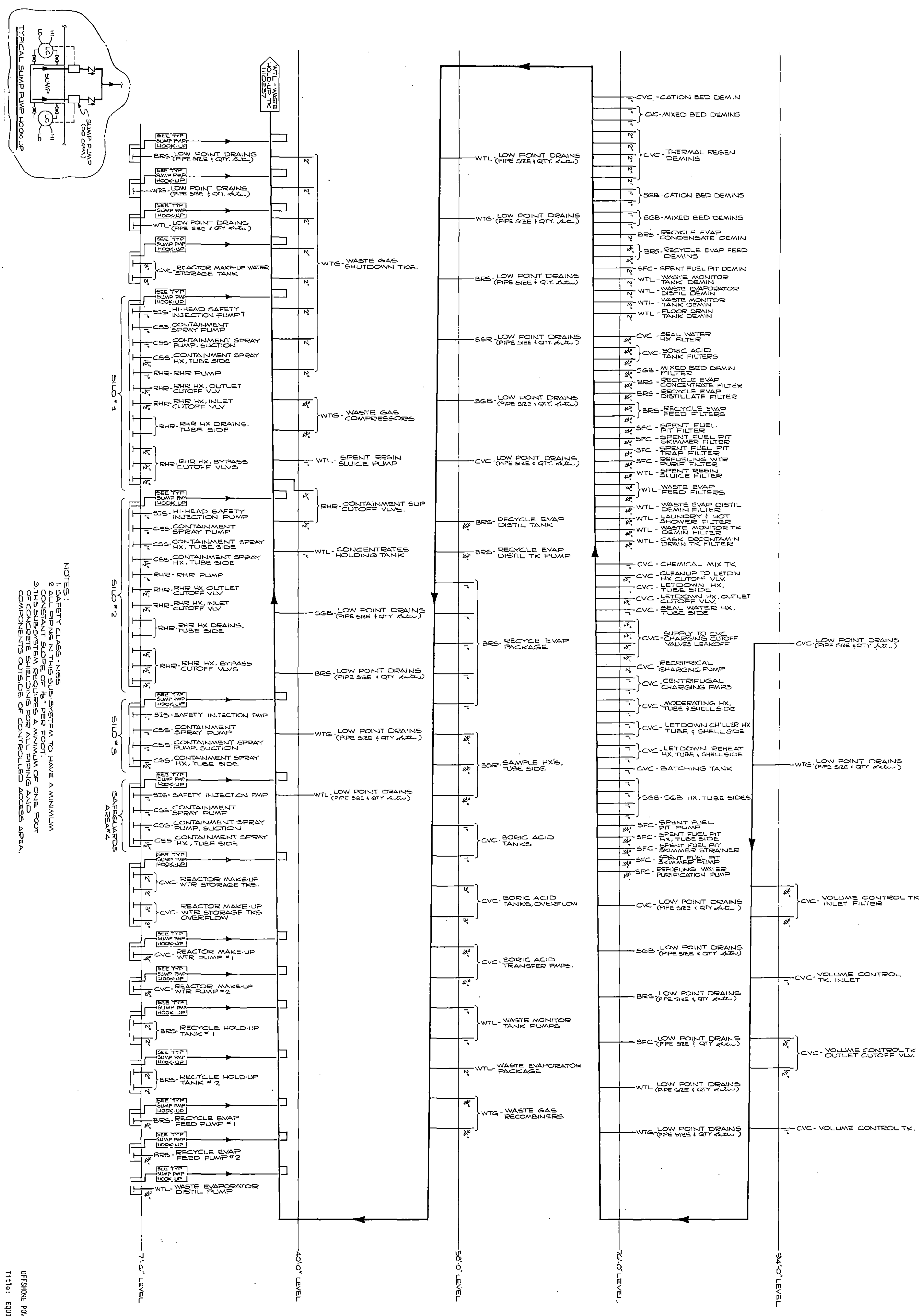
Title: CONTAINMENT POST-ACCIDENT SAMPLING SYSTEM FLOW DIAGRAM

11/1/72 Figure: 9.3-3



NOTES
(APPLICABLE TO BOTH "D" & "VH" SUB-SYSTEMS)
1. SAFETY CLASS - NNS.
2. ALL PIPING IN THESE SUB-SYSTEMS TO HAVE A MINIMUM CONSTANT SLOPE OF 1/8" PER FOOT.
3. THESE SUB-SYSTEMS REQUIRE A MINIMUM OF ONE FOOT OF CONCRETE SHIELDING FOR ALL PIPING AND COMPONENTS OUTSIDE OF CONTROLLED ACCESS AREAS.

OFFSHORE POWER SYSTEMS
Title: EQUIPMENT AND FLOOR DRAIN SYSTEM
FLOOR DRAINS AND VENT HEADER
11/1/72 Figure: 9.3-4



NOTES:
1. SAFETY CLASS - NSS
2. ALL PIPING IN THIS SUB-SYSTEM TO HAVE A MINIMUM CONSTANT SLOPE OF 1/8" PER FOOT.
3. THIS SUB-SYSTEM REQUIRES A MINIMUM OF ONE FOOT OF CONCRETE SHIELDING FOR ALL PIPING AND COMPONENTS OUTSIDE OF CONTROLLED ACCESS AREA.

OFFSHORE POWER SYSTEMS

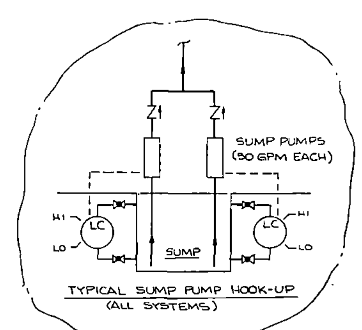
Title: EQUIPMENT AND FLOOR DRAIN SYSTEM DRAIN HEADER

11/1/72

Figure: 9.3-5

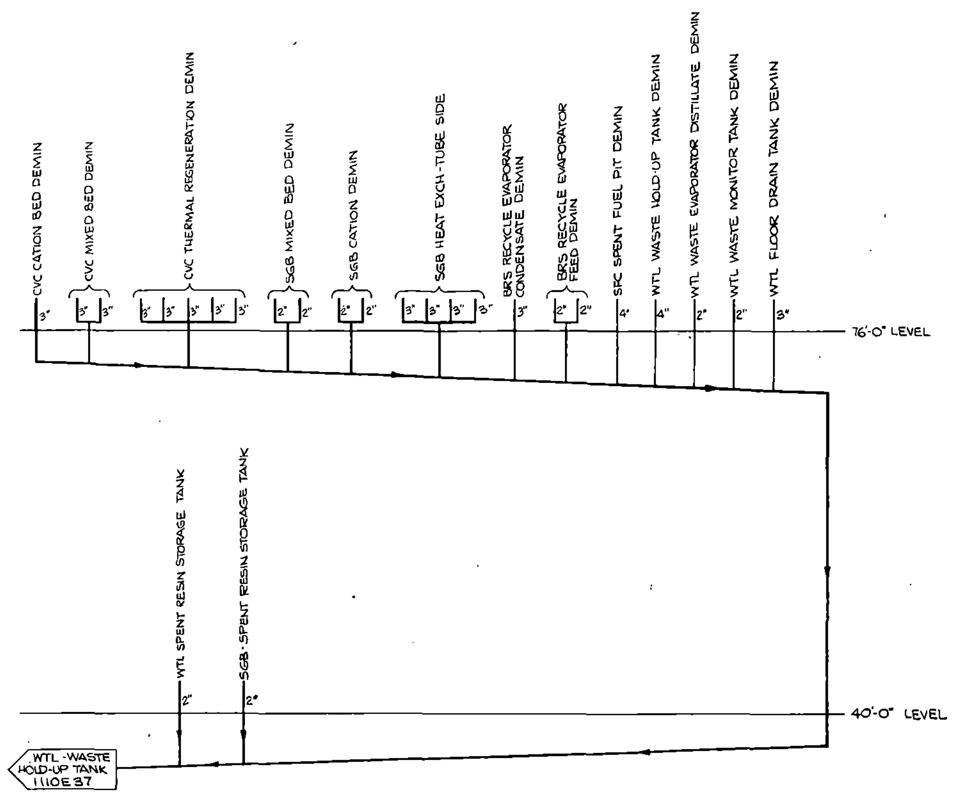
NOTES:

1. SAFETY CLASS-3.
2. ALL PIPING IN THIS SUB-SYSTEM TO HAVE A MINIMUM CONSTANT SLOPE OF 1/8" PER FOOT.
3. THIS SUB-SYSTEM REQUIRES A MINIMUM OF ONE FOOT OF CONCRETE SHIELDING FOR ALL PIPING AND COMPONENTS OUTSIDE OF CONTROLLED ACCESS AREAS.

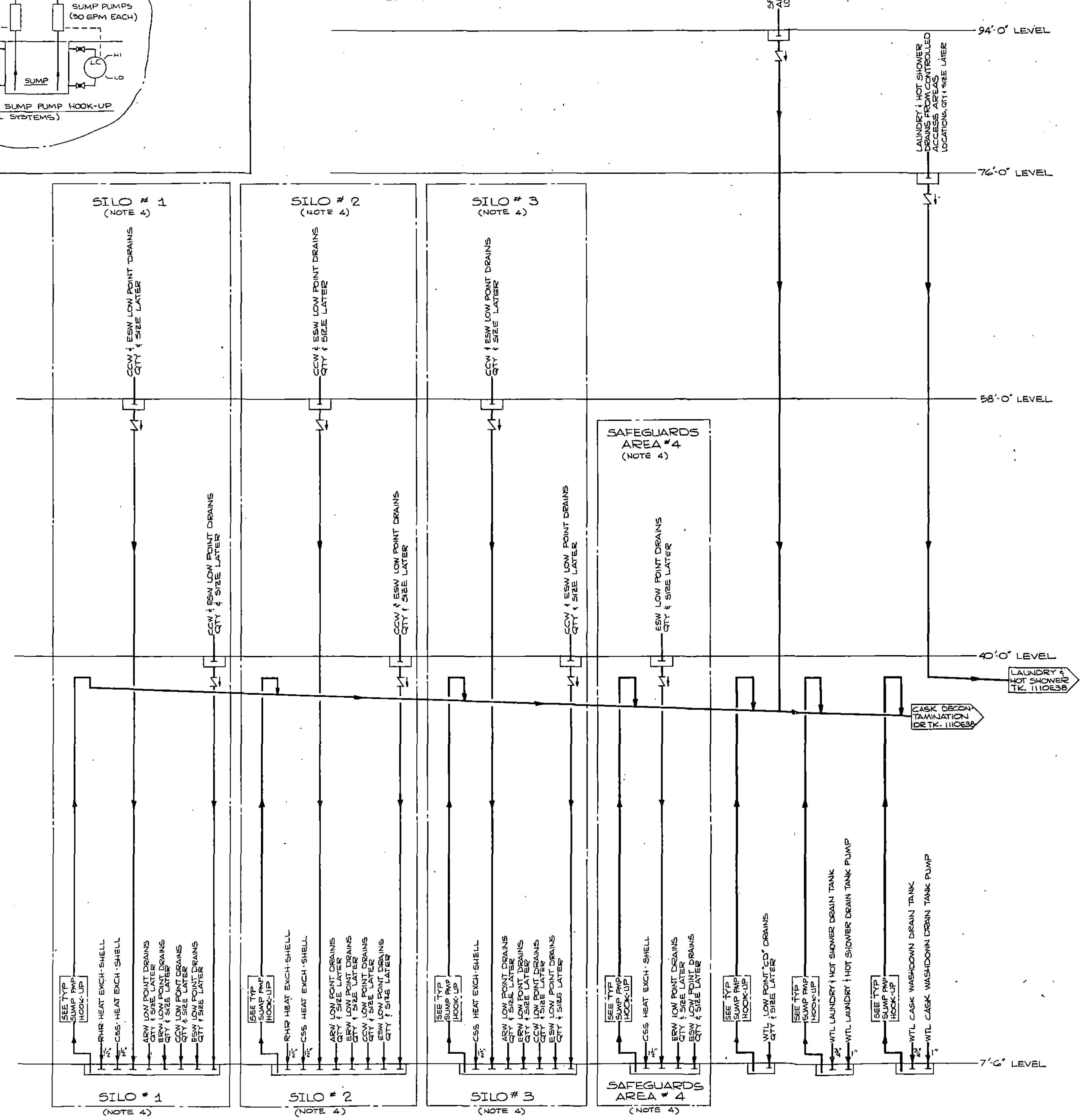


NOTES:

1. SAFETY CLASS-NNS.
2. ALL PIPING IN THIS SUB-SYSTEM TO HAVE A MINIMUM CONSTANT SLOPE OF 1/8" PER FOOT.
3. THIS SUB-SYSTEM REQUIRES A MINIMUM OF ONE FOOT OF CONCRETE SHIELDING FOR ALL PIPING AND COMPONENTS OUTSIDE OF CONTROLLED ACCESS AREAS.
4. ALL "CD" DRAINS LOCATED IN SHIELDED SAFEGUARDS AREAS TO BE DRAINED TO A SUMP LOCATED OUTSIDE THE SHIELDED AREA.



RELIEF VALVE HEADER ("RVH") SUB-SYSTEM



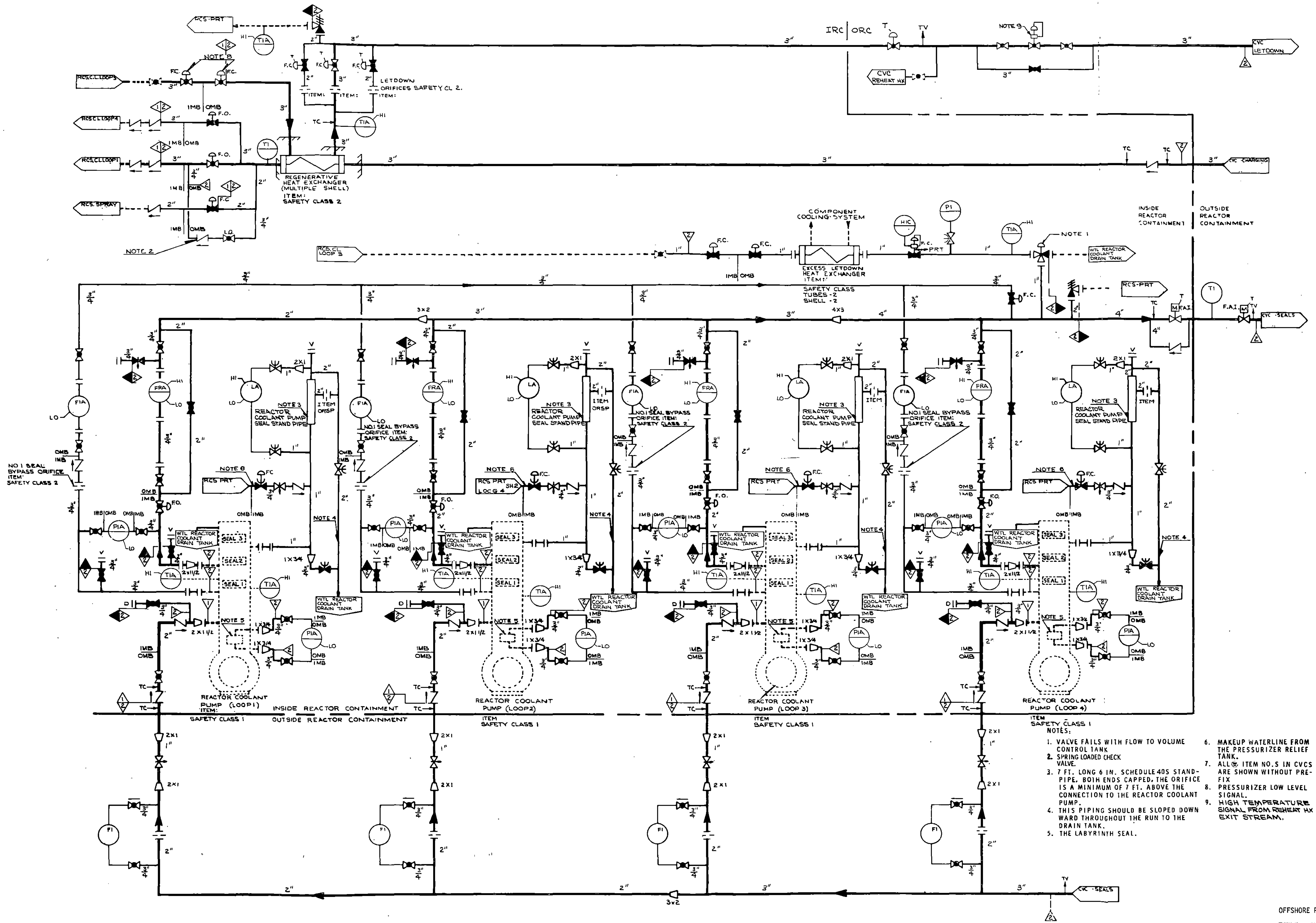
CHLORIDE DRAIN ("CD") SUB-SYSTEM

OFFSHORE POWER SYSTEMS

Title: EQUIPMENT AND FLOOR DRAIN SYSTEM

CHLORIDE DRAINS AND RELIEF VALVE HEADER

11/1/72 Figure: 9.3-6

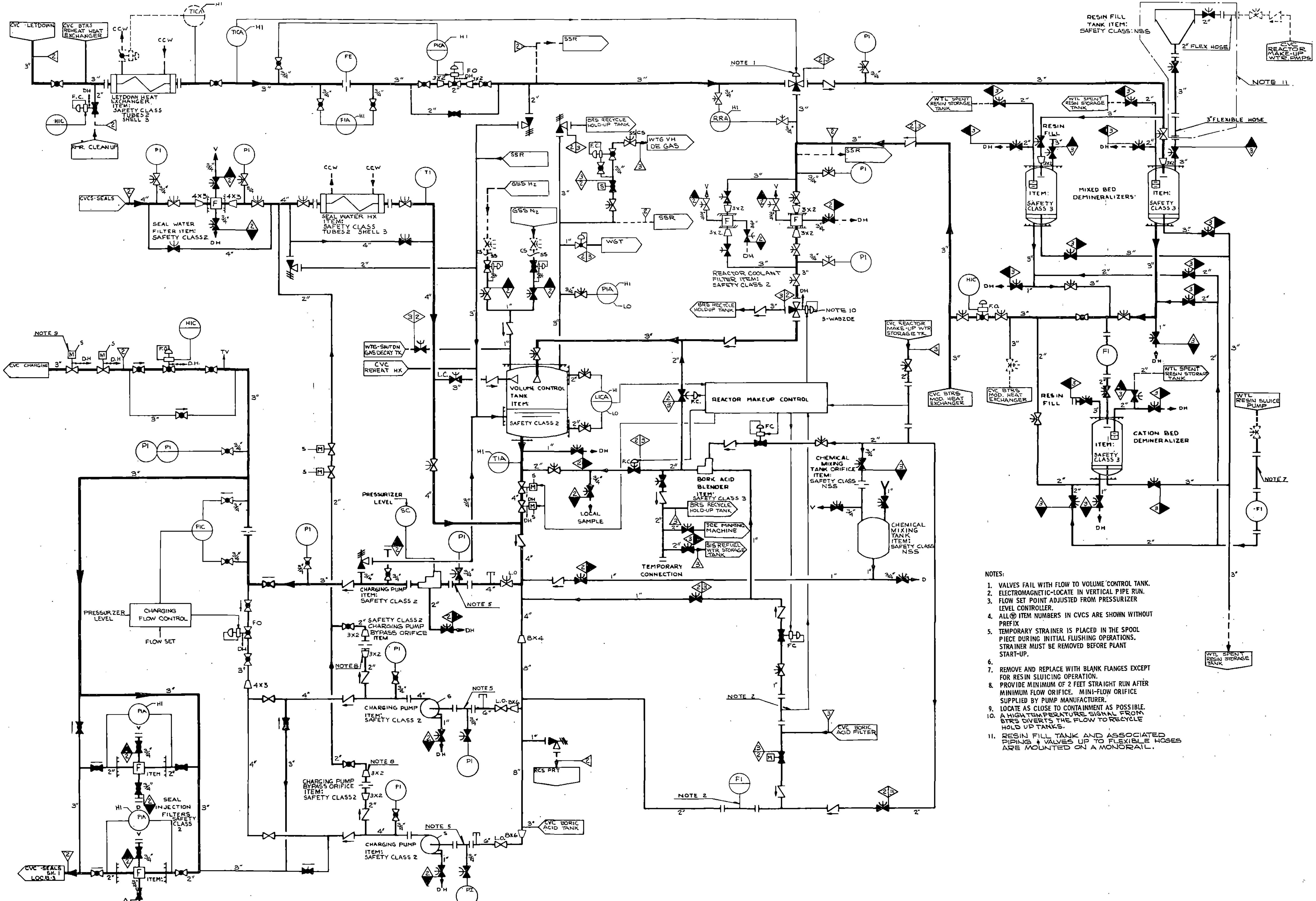


OFFSHORE POWER SYSTEMS

TITLE: CHEMICAL AND VOLUME CONTROL SYSTEM

REACTOR COOLANT PUMP-SEAL SYSTEM

11/1/72 Figure: 9.3-7



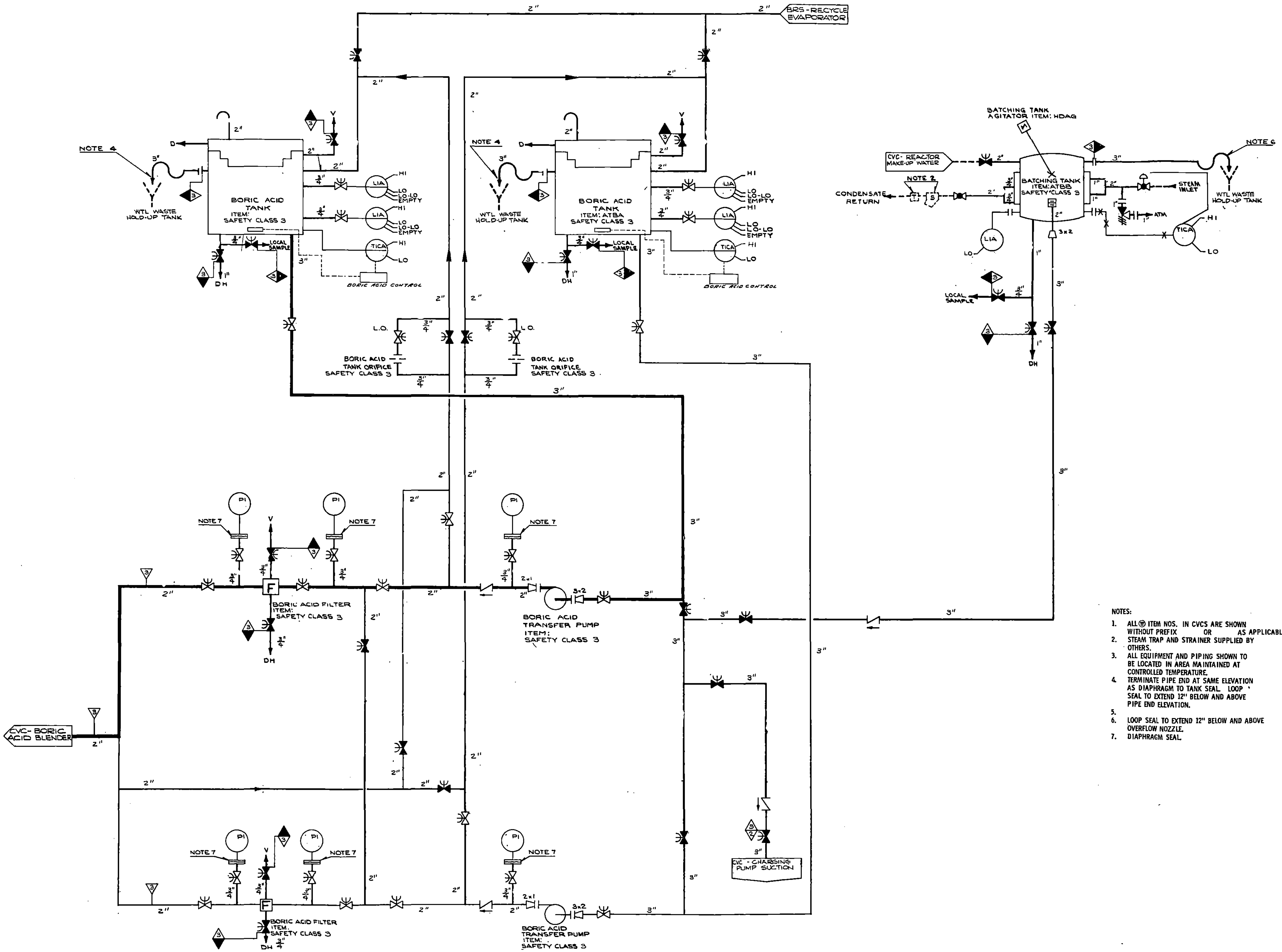
NOTES:

1. VALVES FAIL WITH FLOW TO VOLUME CONTROL TANK.
2. ELECTROMAGNETIC-LOCATE IN VERTICAL PIPE RUN.
3. FLOW SET POINT ADJUSTED FROM PRESSURIZER LEVEL CONTROLLER.
4. ALL Ⓡ ITEM NUMBERS IN CVCS ARE SHOWN WITHOUT PREFIX
5. TEMPORARY STRAINER IS PLACED IN THE SPOOL PIECE DURING INITIAL FLUSHING OPERATIONS. STRAINER MUST BE REMOVED BEFORE PLANT START-UP.
6.
7. REMOVE AND REPLACE WITH BLANK FLANGES EXCEPT FOR RESIN SLUICING OPERATION.
8. PROVIDE MINIMUM OF 2 FEET STRAIGHT RUN AFTER MINIMUM FLOW ORIFICE. MINI-FLOW ORIFICE SUPPLIED BY PUMP MANUFACTURER.
9. LOCATE AS CLOSE TO CONTAINMENT AS POSSIBLE.
10. A HIGH TEMPERATURE SIGNAL FROM BTRS DIVERTS THE FLOW TO RECYCLE HOLD UP TANKS.
11. RESIN FILL TANK AND ASSOCIATED PIPING & VALVES UP TO FLEXIBLE HOSES ARE MOUNTED ON A MONORAIL.

OFFSHORE POWER SYSTEMS

Title: CHEMICAL AND VOLUME CONTROL SYSTEM LETDOWN SYSTEM

11/1/72 Figure: 9.3-8



NOTES:

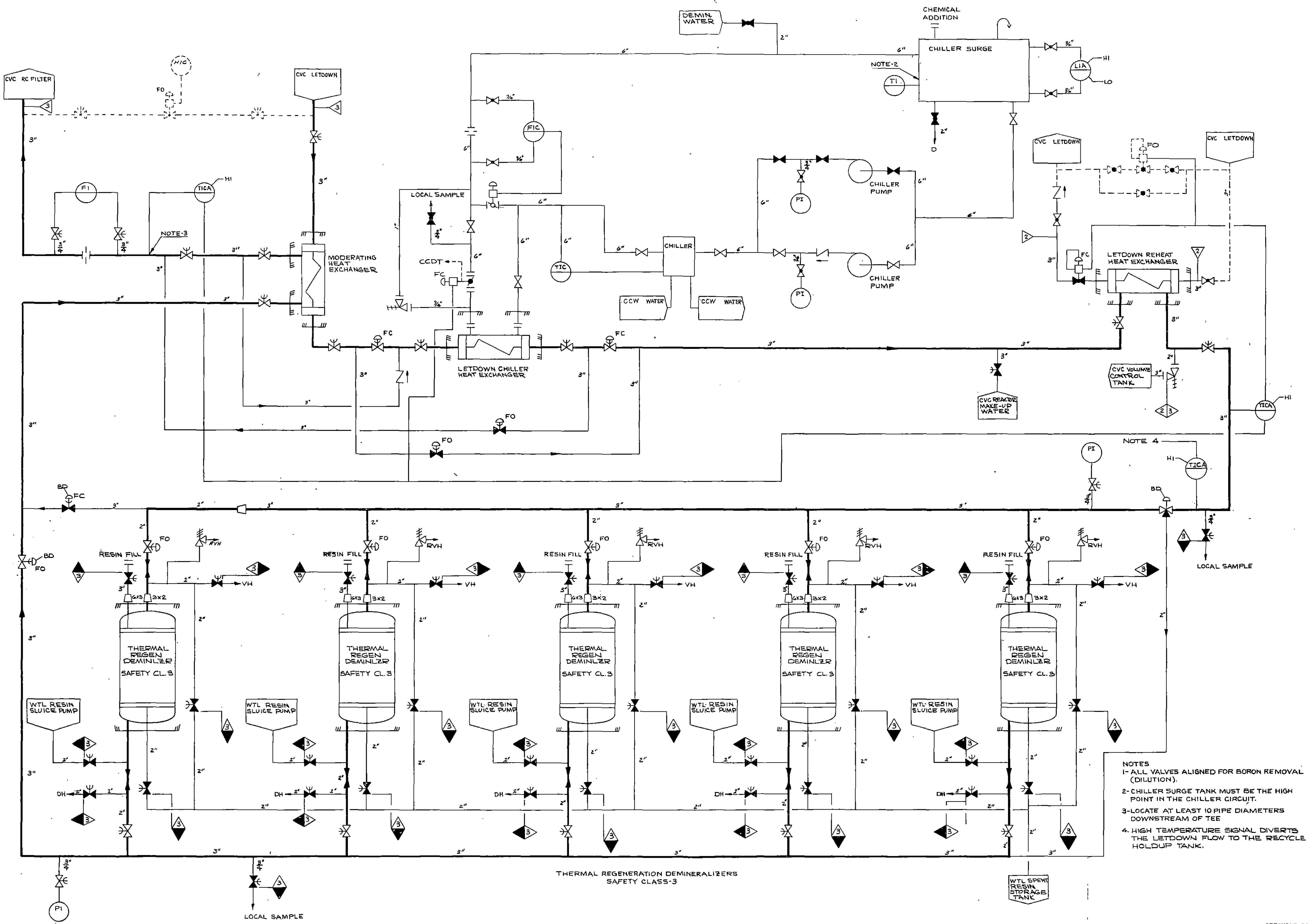
1. ALL ⓦ ITEM NOS. IN CVCS ARE SHOWN WITHOUT PREFIX OR AS APPLICABLE.
2. STEAM TRAP AND STRAINER SUPPLIED BY OTHERS.
3. ALL EQUIPMENT AND PIPING SHOWN TO BE LOCATED IN AREA MAINTAINED AT CONTROLLED TEMPERATURE.
4. TERMINATE PIPE END AT SAME ELEVATION AS DIAPHRAGM TO TANK SEAL. LOOP SEAL TO EXTEND 12" BELOW AND ABOVE PIPE END ELEVATION.
5.
6. LOOP SEAL TO EXTEND 12" BELOW AND ABOVE OVERFLOW NOZZLE.
7. DIAPHRAGM SEAL.

OFFSHORE POWER SYSTEMS

Title: CHEMICAL AND VOLUME CONTROL SYSTEM

BORIC ACID TRANSFER SYSTEM

11/1/72 Figure: 9.3-9

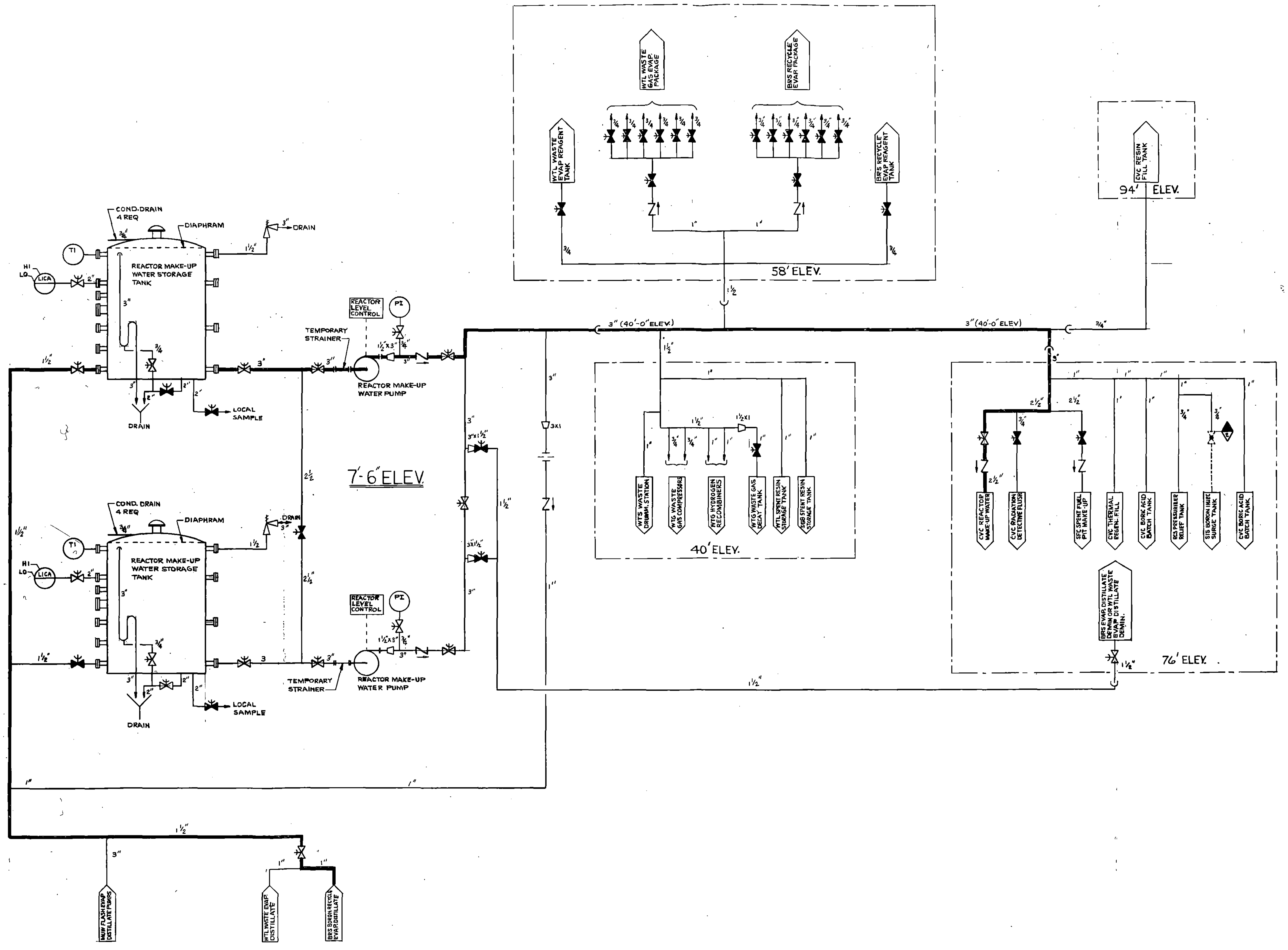


NOTES
1- ALL VALVES ALIGNED FOR BORON REMOVAL (DILUTION).
2- CHILLER SURGE TANK MUST BE THE HIGH POINT IN THE CHILLER CIRCUIT.
3- LOCATE AT LEAST 10 PIPE DIAMETERS DOWNSTREAM OF TEE
4- HIGH TEMPERATURE SIGNAL DIVERTS THE LETDOWN FLOW TO THE RECYCLE HOLDUP TANK.

OFFSHORE POWER SYSTEMS

Title: CHEMICAL AND VOLUME CONTROL SYSTEM
BORON THERMAL REGENERATION SYSTEM

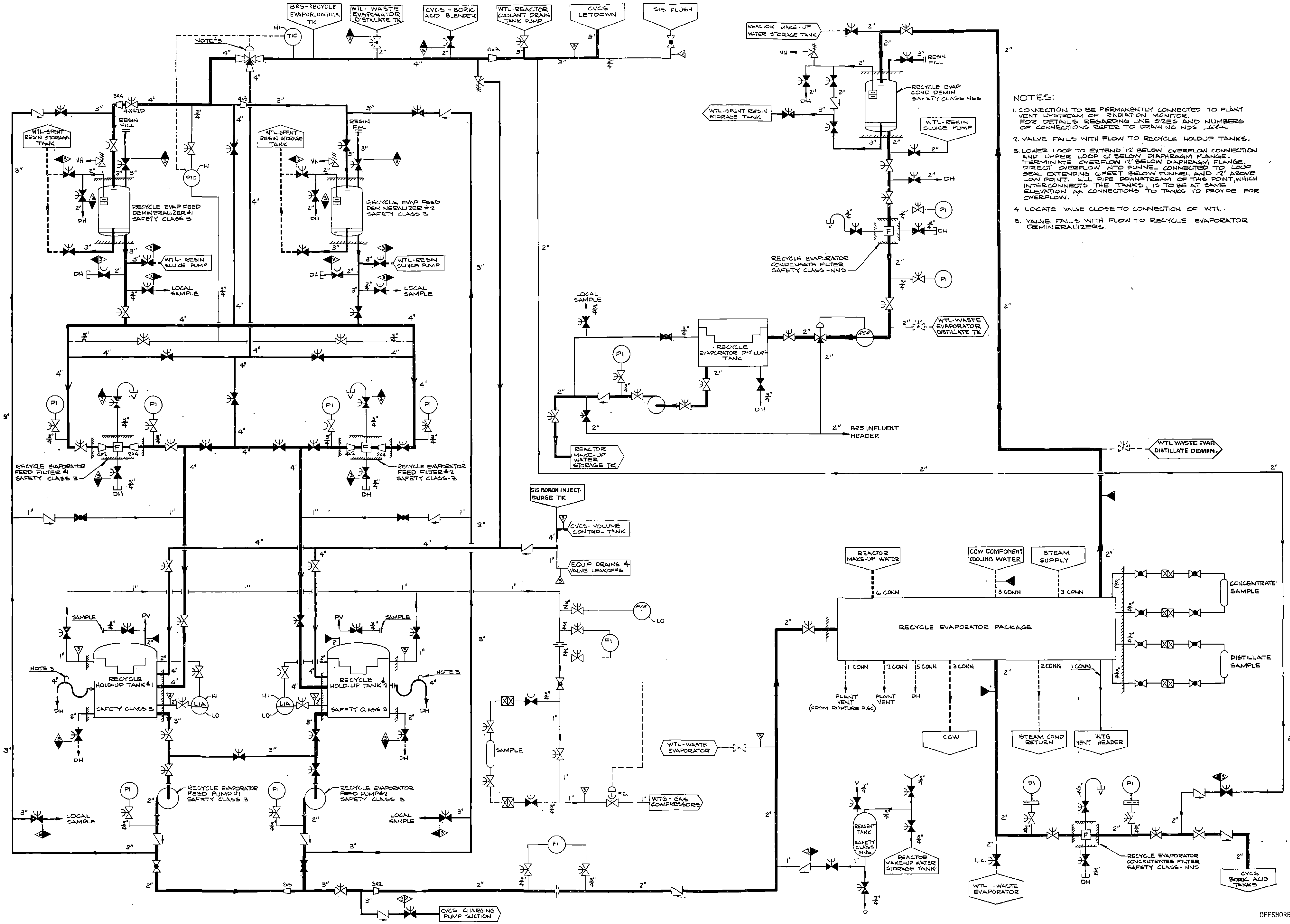
11/1/72 Figure: 9.3-10



OFFSHORE POWER SYSTEMS

Title: CHEMICAL AND VOLUME CONTROL SYSTEM
REACTOR MAKE-UP WATER

11/1/72 Figure: 9.3-11



NOTES:

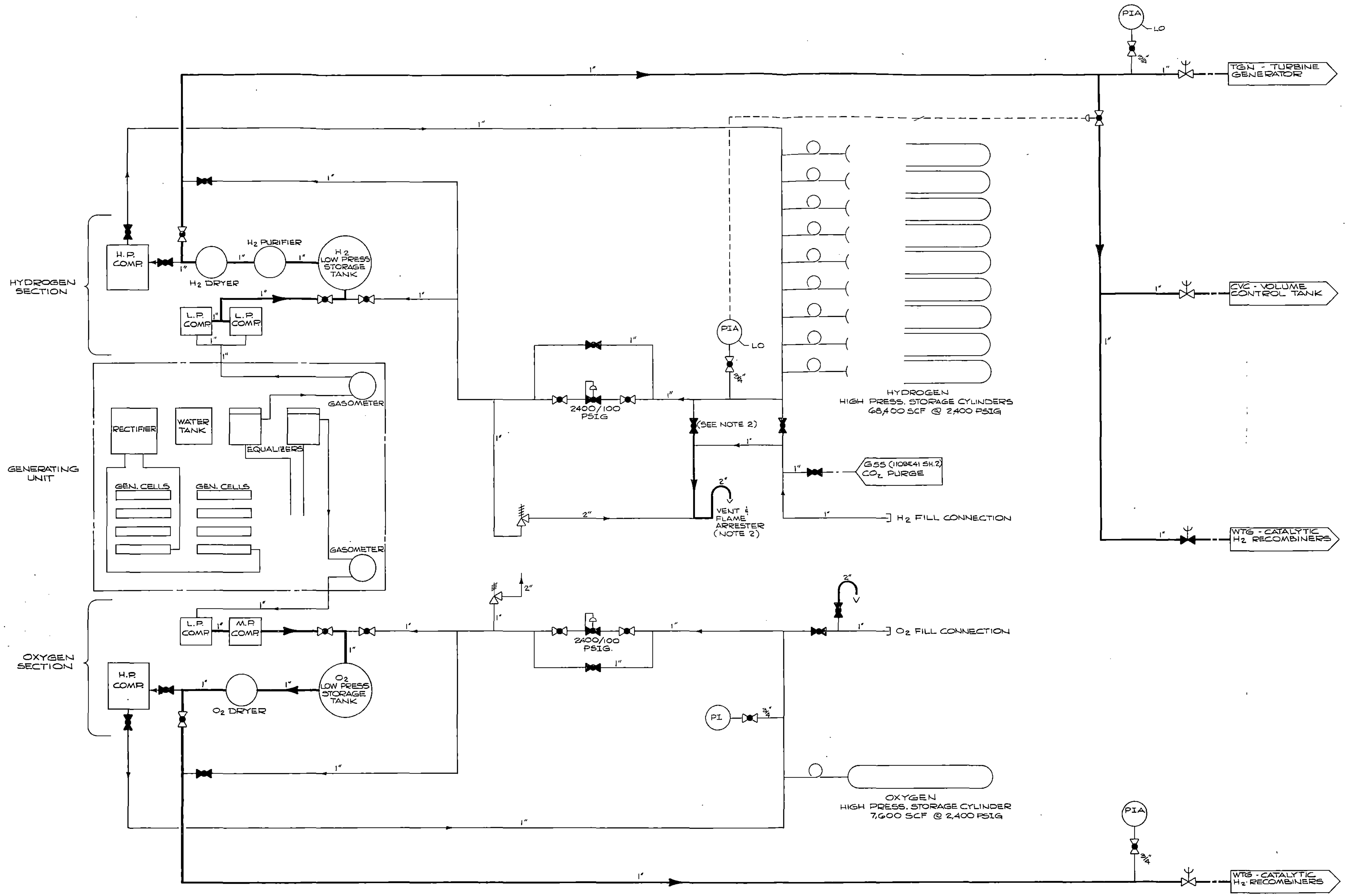
1. CONNECTION TO BE PERMANENTLY CONNECTED TO PLANT VENT UPSTREAM OF RADIATION MONITOR. FOR DETAILS REGARDING LINE SIZES AND NUMBERS OF CONNECTIONS REFER TO DRAWING NOS.
2. VALVE FAILS WITH FLOW TO RECYCLE HOLDUP TANKS.
3. LOWER LOOP TO EXTEND 12" BELOW OVERFLOW CONNECTION AND UPPER LOOP 6" BELOW DIAPHRAGM FLANGE. TERMINATE OVERFLOW 12" BELOW DIAPHRAGM FLANGE. DIRECT OVERFLOW INTO FUNNEL CONNECTED TO LOOP SEAL EXTENDING 6 FEET BELOW FUNNEL AND 12" ABOVE LOW POINT. ALL PIPE DOWNSTREAM OF THIS POINT, WHICH INTERCONNECTS THE TANKS, IS TO BE AT SAME ELEVATION AS CONNECTIONS TO TANKS TO PROVIDE FOR OVERFLOW.
4. LOCATE VALVE CLOSE TO CONNECTION OF WTL.
5. VALVE FAILS WITH FLOW TO RECYCLE EVAPORATOR DEMINERALIZERS.

OFFSHORE POWER SYSTEMS

Title: BORON RECYCLE SYSTEM-FLOW DIAGRAM

11/1/72

Figure: 9.3-12



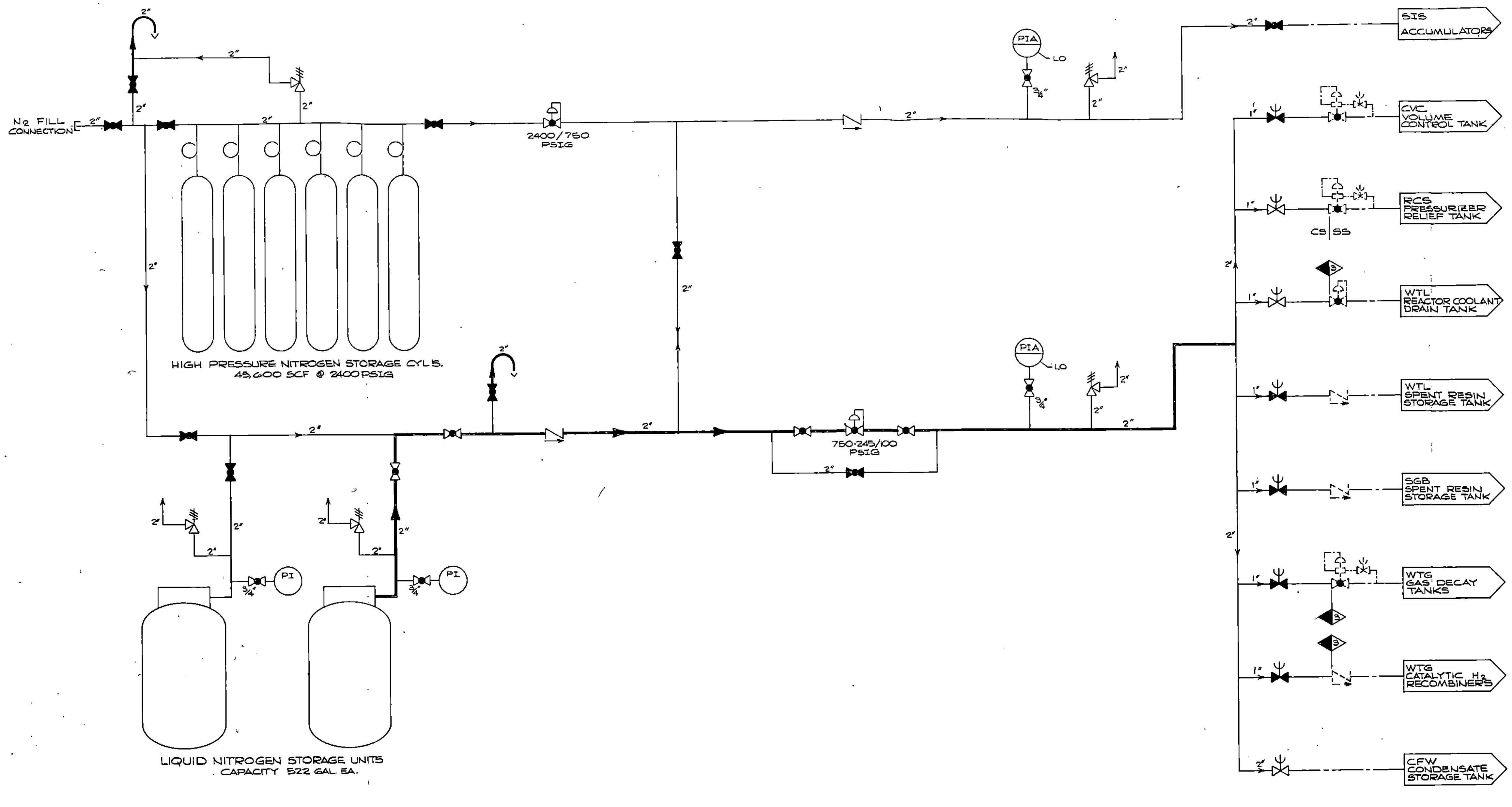
NOTES:
1. THE SYSTEM DESIGNATION FOR GAS SUPPLY SYSTEM IS GSS.
2. LOCATE THE VENT VALVE CLOSE TO STORAGE CYLINDERS AND EXTEND THE VENT LINE FOR RELEASING GAS TO OPEN SPACE.

OFFSHORE POWER SYSTEMS

Title: GAS SUPPLY SYSTEM - FLOW DIAGRAM

11/1/72

Figure: 9.3-13
Sheet 1



NOTES:

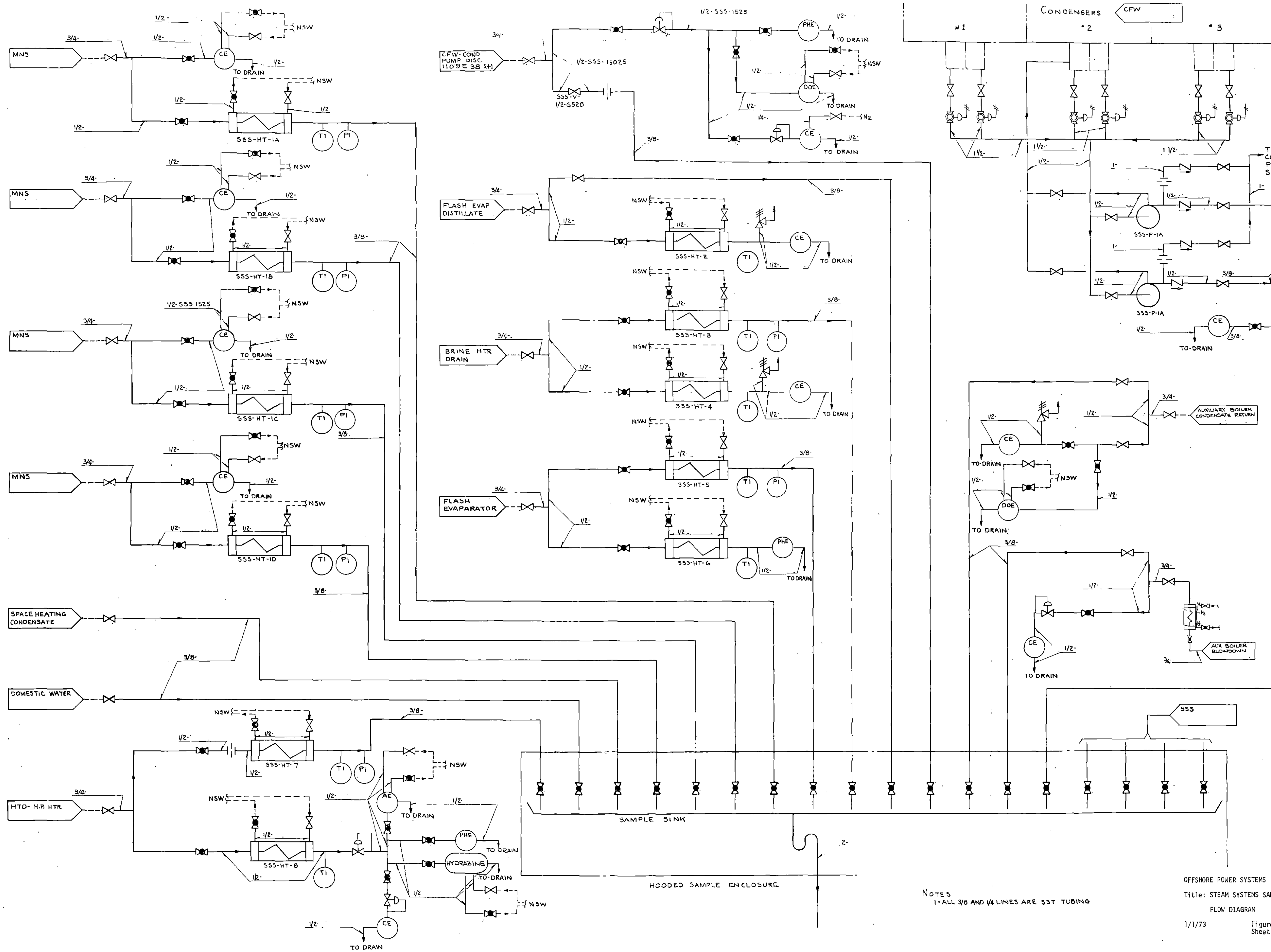
1. THE SYSTEM DESIGNATION FOR THE GAS SUPPLY SYSTEM IS GSS.

OFFSHORE POWER SYSTEMS

Title: GAS SUPPLY SYSTEM - FLOW DIAGRAM

11/1/72

Figure: 9.3-13
Sheet 2



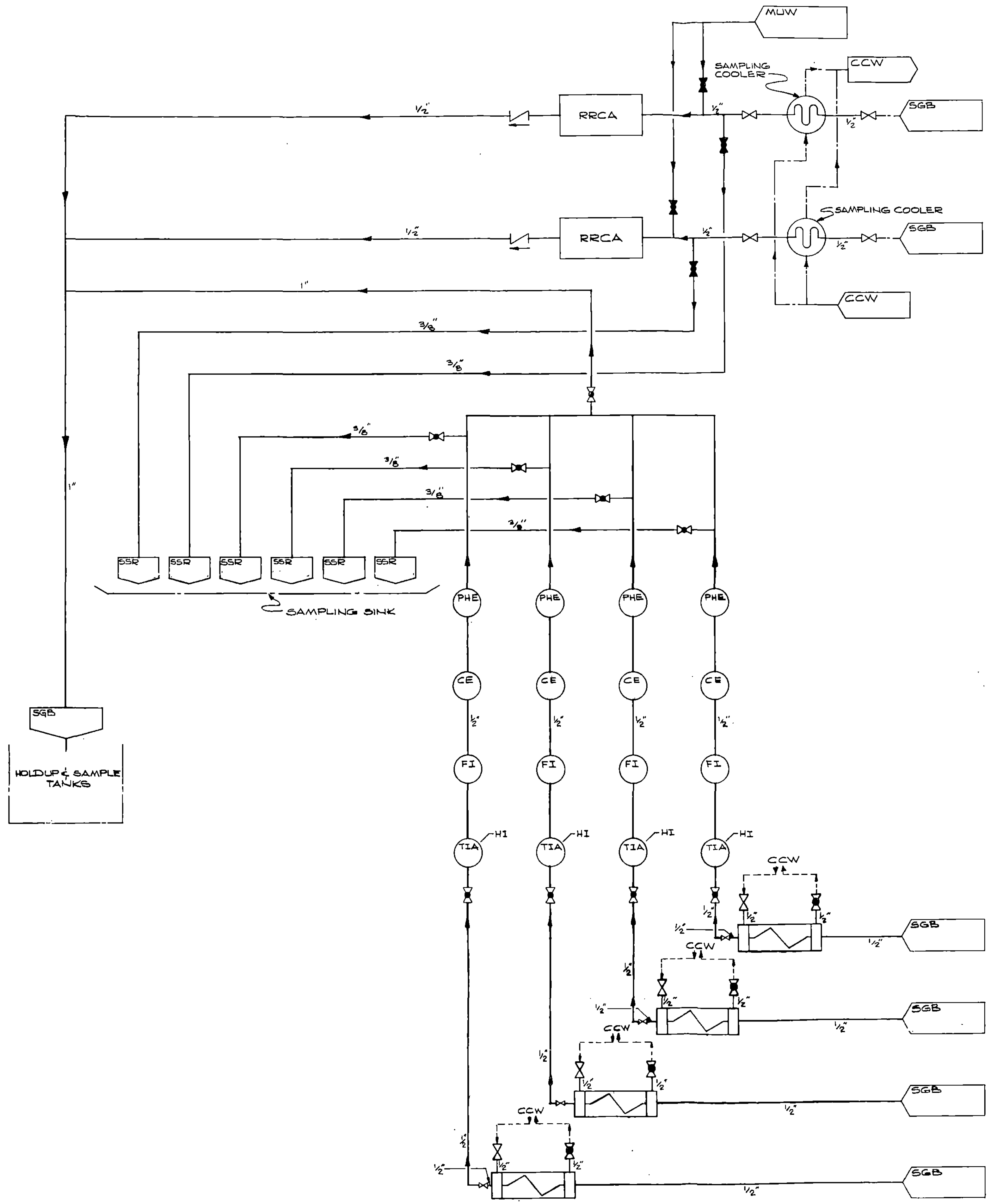
NOTES
1- ALL 3/8 AND 1/4 LINES ARE SST TUBING

OFFSHORE POWER SYSTEMS

Title: STEAM SYSTEMS SAMPLING SYSTEM FLOW DIAGRAM

1/1/73

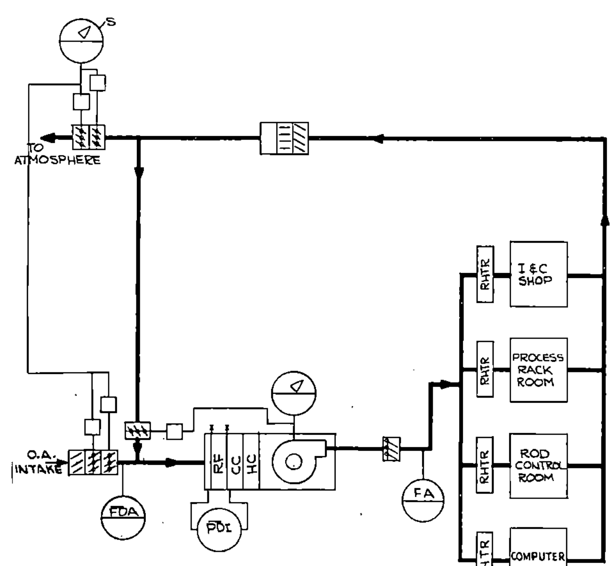
Figure 9.3-14, Sheet 1



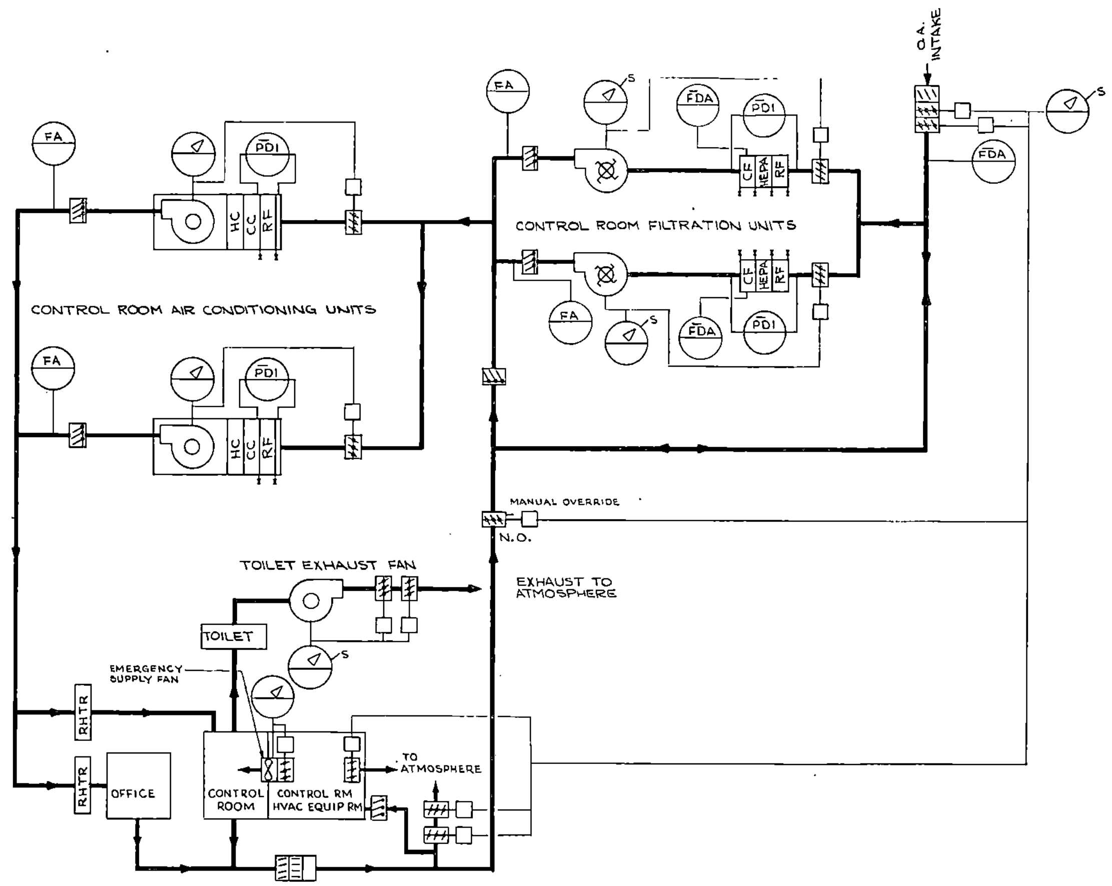
OFFSHORE POWER SYSTEMS

Title: STEAM SYSTEMS SAMPLING SYSTEM FLOW DIAGRAM

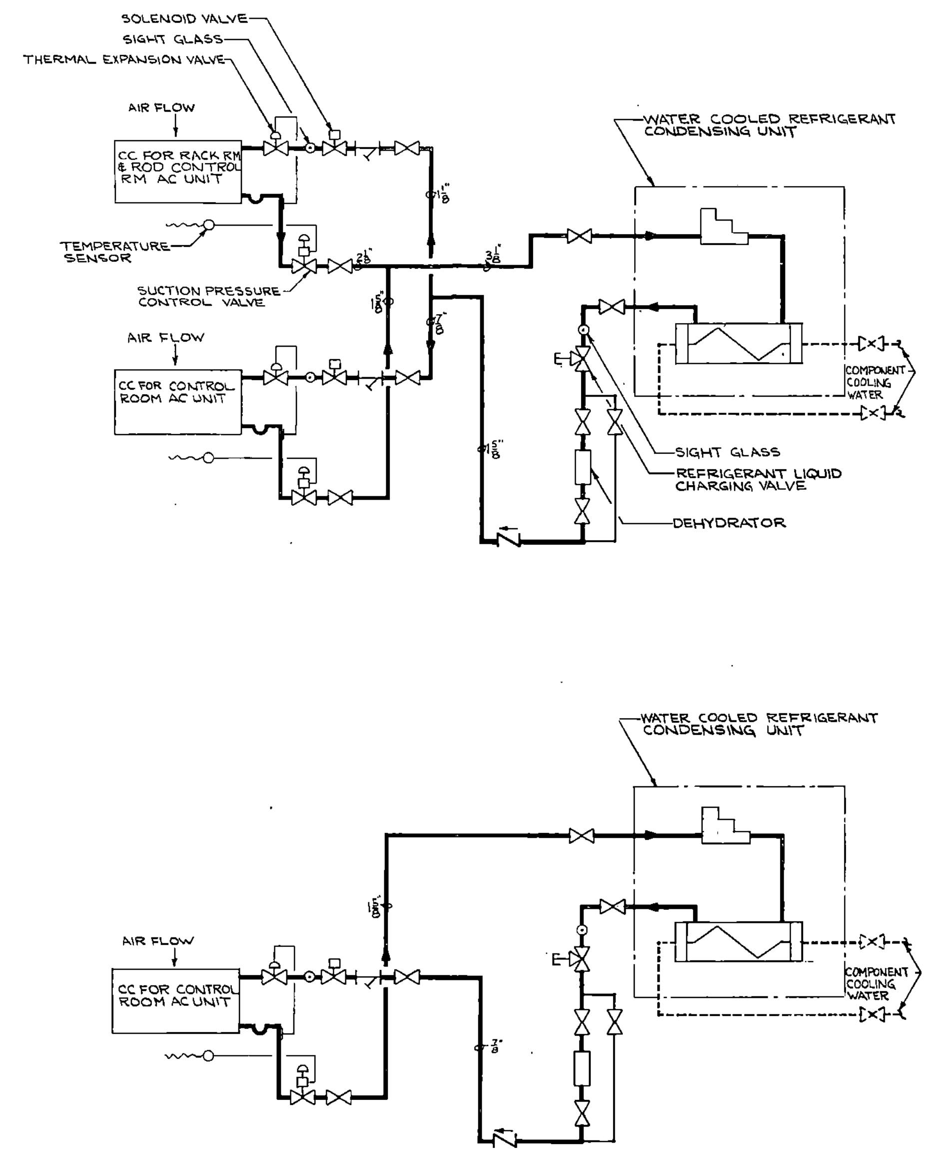
1/1/73 Figure 9.3-14, Sheet 2



PROCESS RACK ROOM & ROD CONTROL ROOM AIR CONDITIONING SYSTEM



CONTROL ROOM AIR CONDITIONING SYSTEM

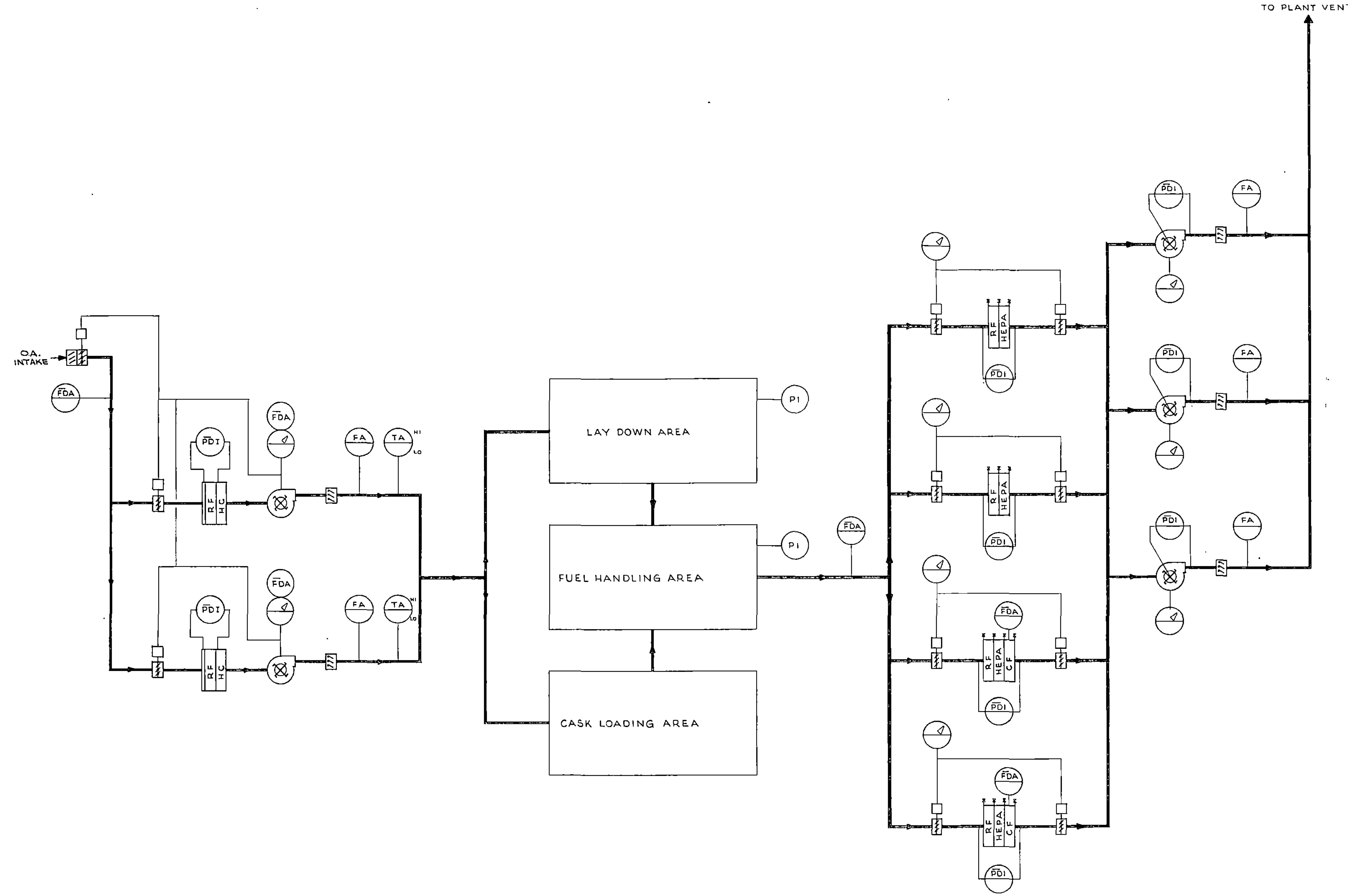


CONTROL ROOM, PROCESS RACK ROOM, & ROD CONTROL ROOM AIR CONDITIONING UNIT REFRIGERANT SYSTEM

OFFSHORE POWER SYSTEMS

Title: CONTROL AREA VENTILATION FLOW DIAGRAM

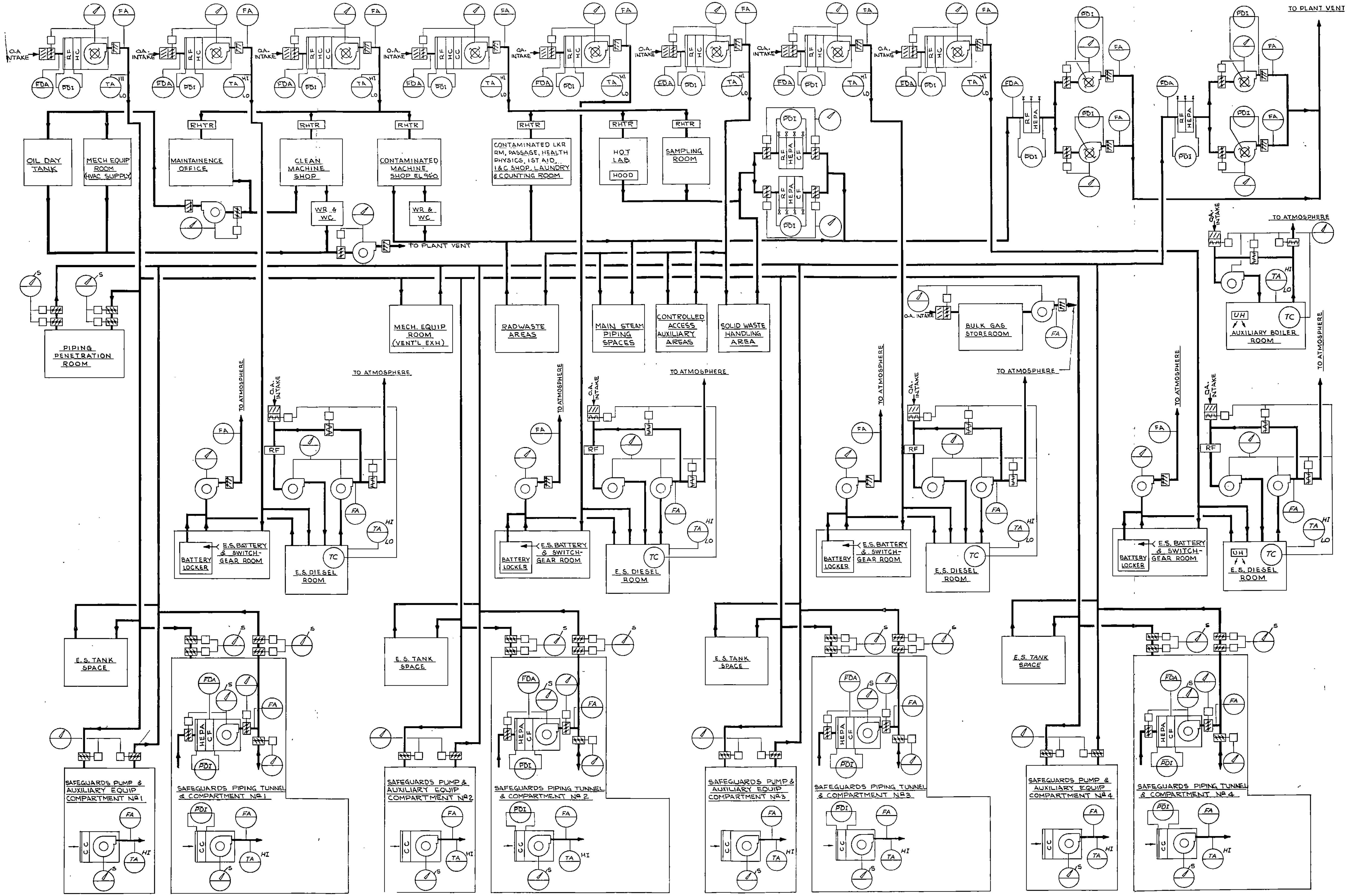
11/1/72 Figure: 9.4-1



OFFSHORE POWER SYSTEMS

Title: FUEL HANDLING AREA SUPPLY AND EXHAUST VENTILATION

11/1/72 Figure: 9.4-2

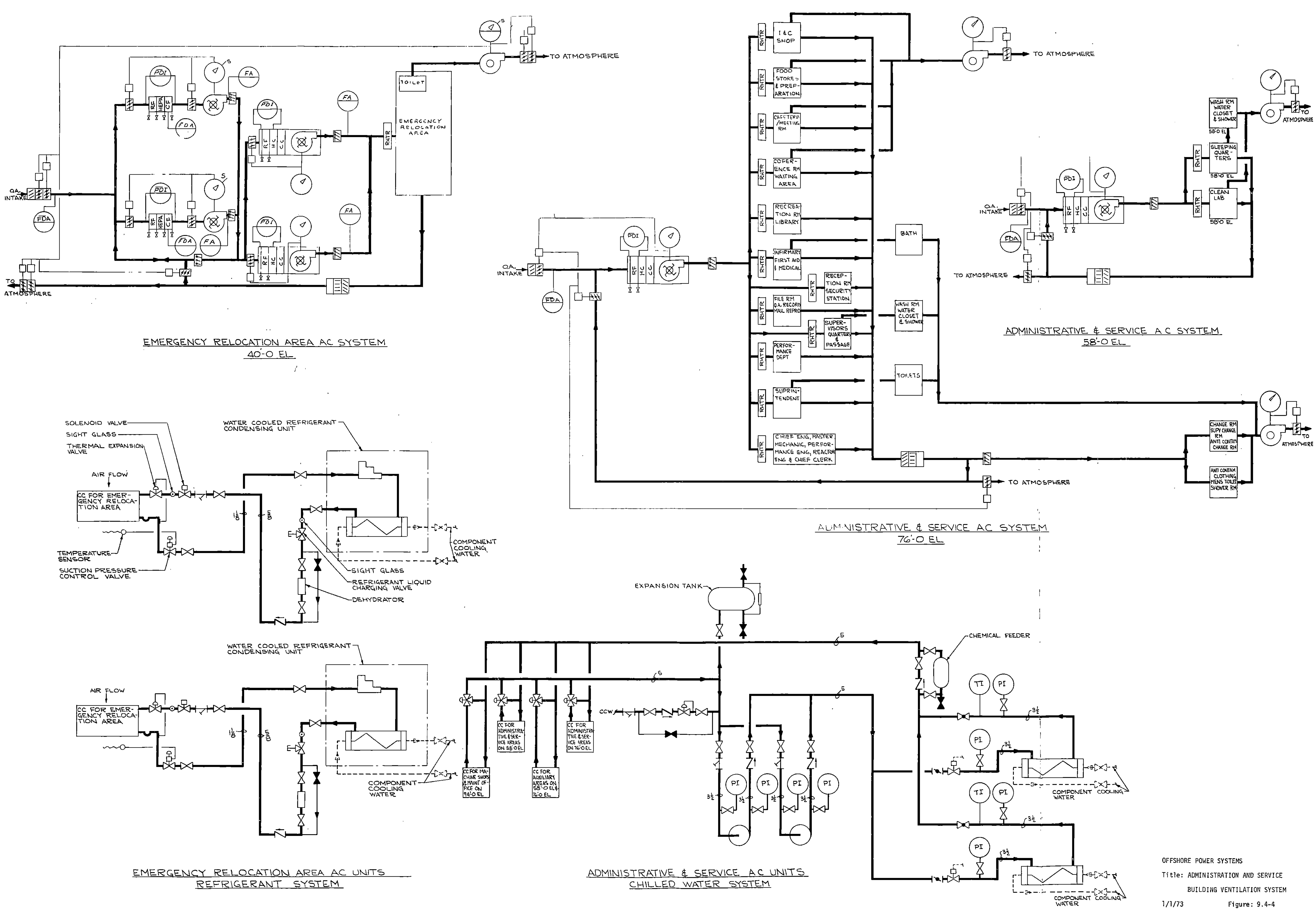


OFFSHORE POWER SYSTEMS

Title: AUXILIARY AREA VENTILATION

11/1/72

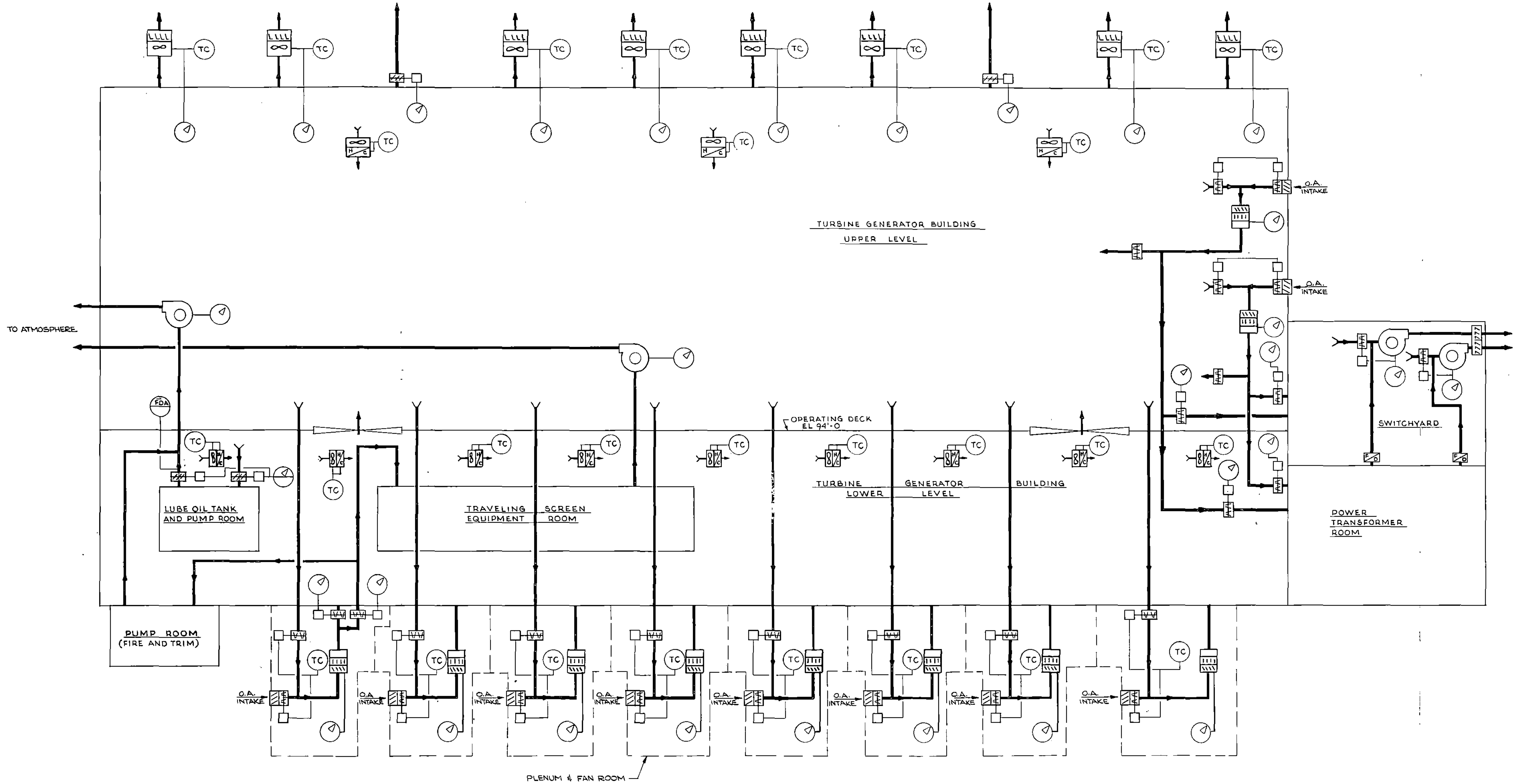
Figure: 9.4-3



OFFSHORE POWER SYSTEMS

Title: ADMINISTRATION AND SERVICE BUILDING VENTILATION SYSTEM

1/1/73 Figure: 9.4-4

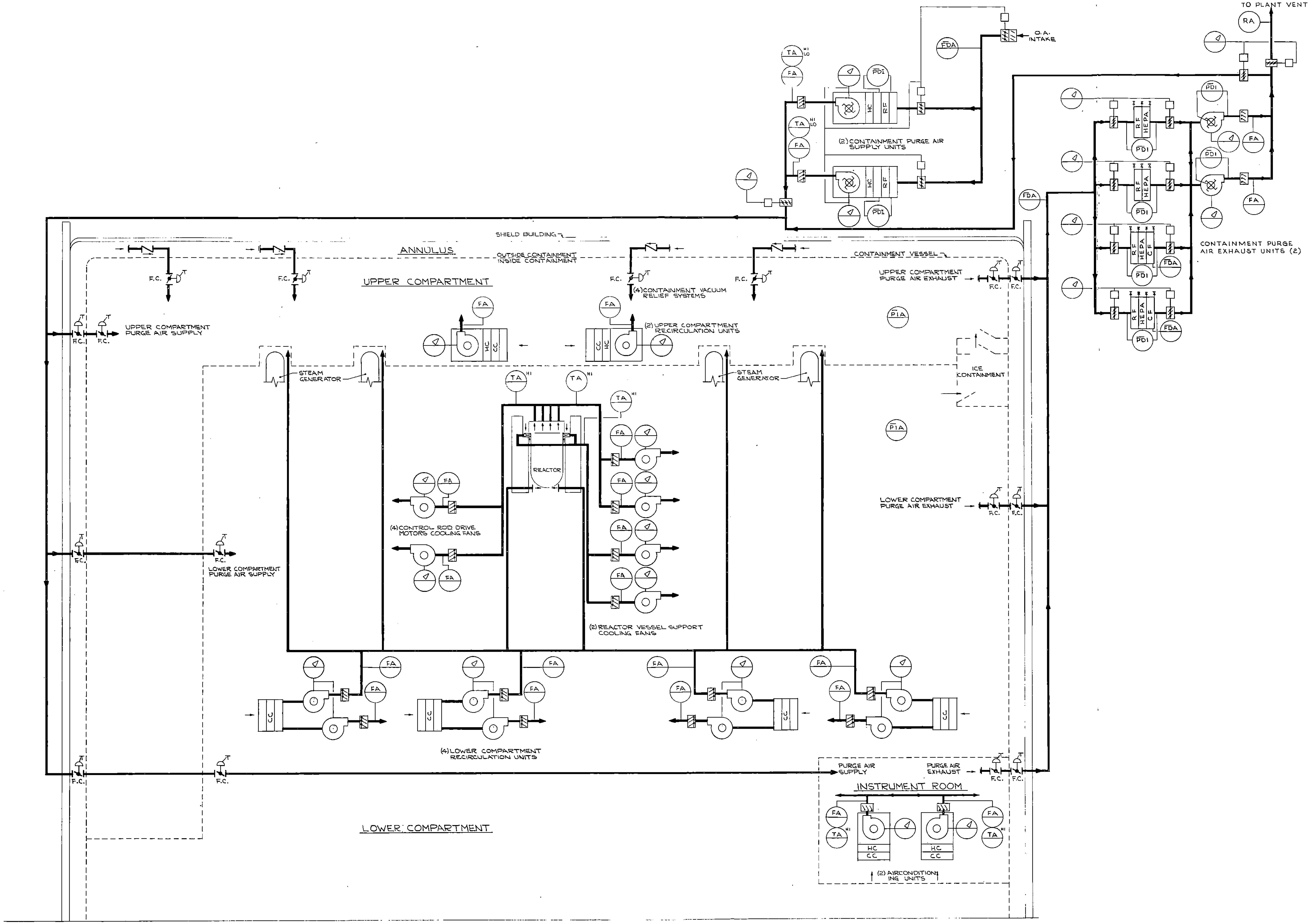


OFFSHORE POWER SYSTEMS

Title: TURBINE BUILDING VENTILATION

11/1/72

Figure: 9.4-5

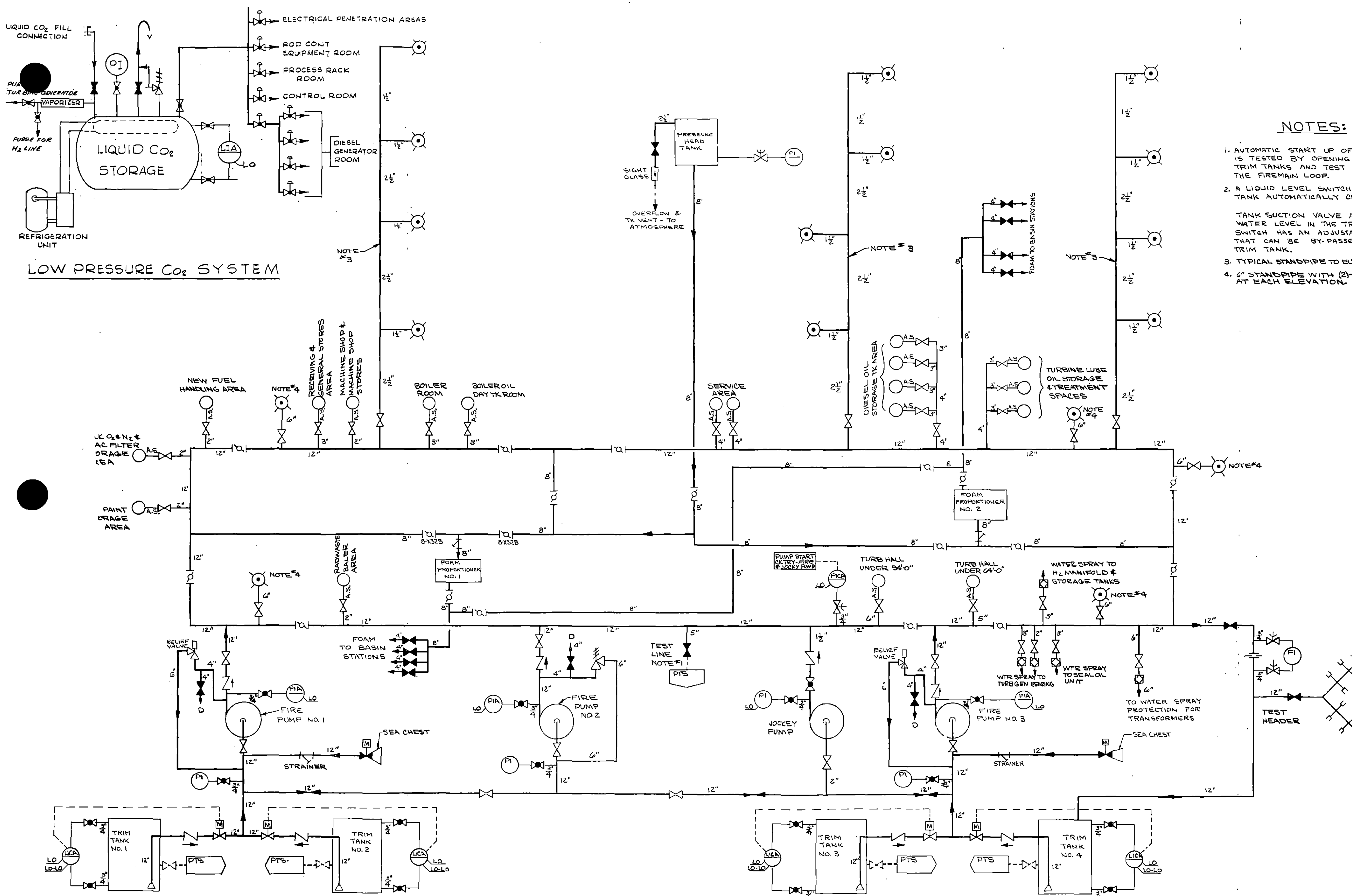


OFFSHORE POWER SYSTEMS

Title: CONTAINMENT VENTILATION

11/1/72

Figure: 9.4-6



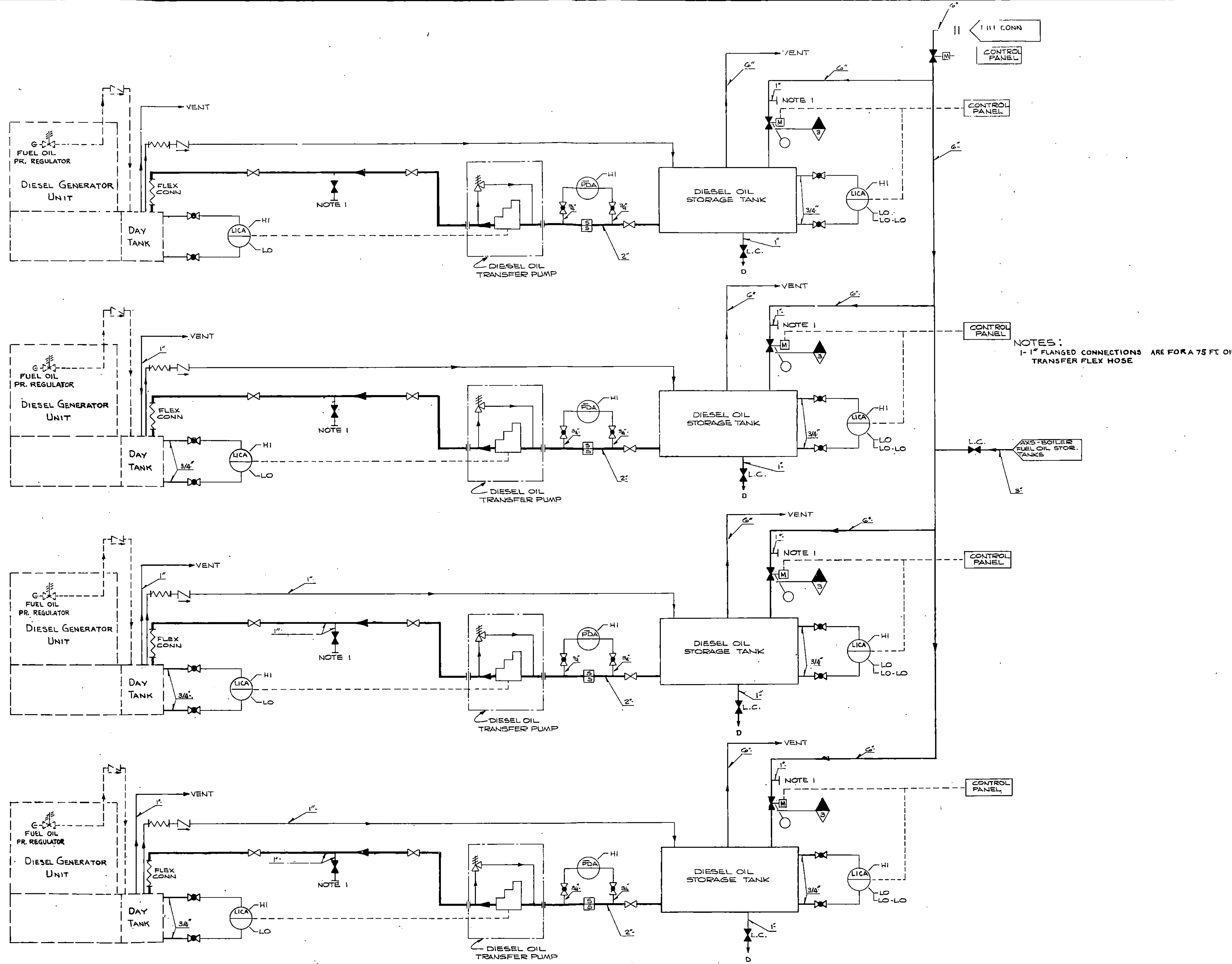
NOTES:

1. AUTOMATIC START UP OF THE FIRE PUMPS IS TESTED BY OPENING MANIFOLD VALVES TO TRIM TANKS AND TEST LINE VALVE FROM THE FIREMAIN LOOP.
2. A LIQUID LEVEL SWITCH ON EACH TRIM TANK AUTOMATICALLY CLOSES THE TRIM TANK SUCTION VALVE AT A PREDETERMINED WATER LEVEL IN THE TRIM TANK. EACH SWITCH HAS AN ADJUSTABLE SET POINT THAT CAN BE BY-PASSED FOR EITHER TRIM TANK.
3. TYPICAL STANDPIPE TO ELEVATIONS ABOVE 40 FEET.
4. 6" STANDPIPE WITH (2)-2½" HOSE CONNECTIONS AT EACH ELEVATION.

OFFSHORE POWER SYSTEMS

Title: FIRE PROTECTION SYSTEM FLOW DIAGRAM

1/1/73 Figure: 9.5-1

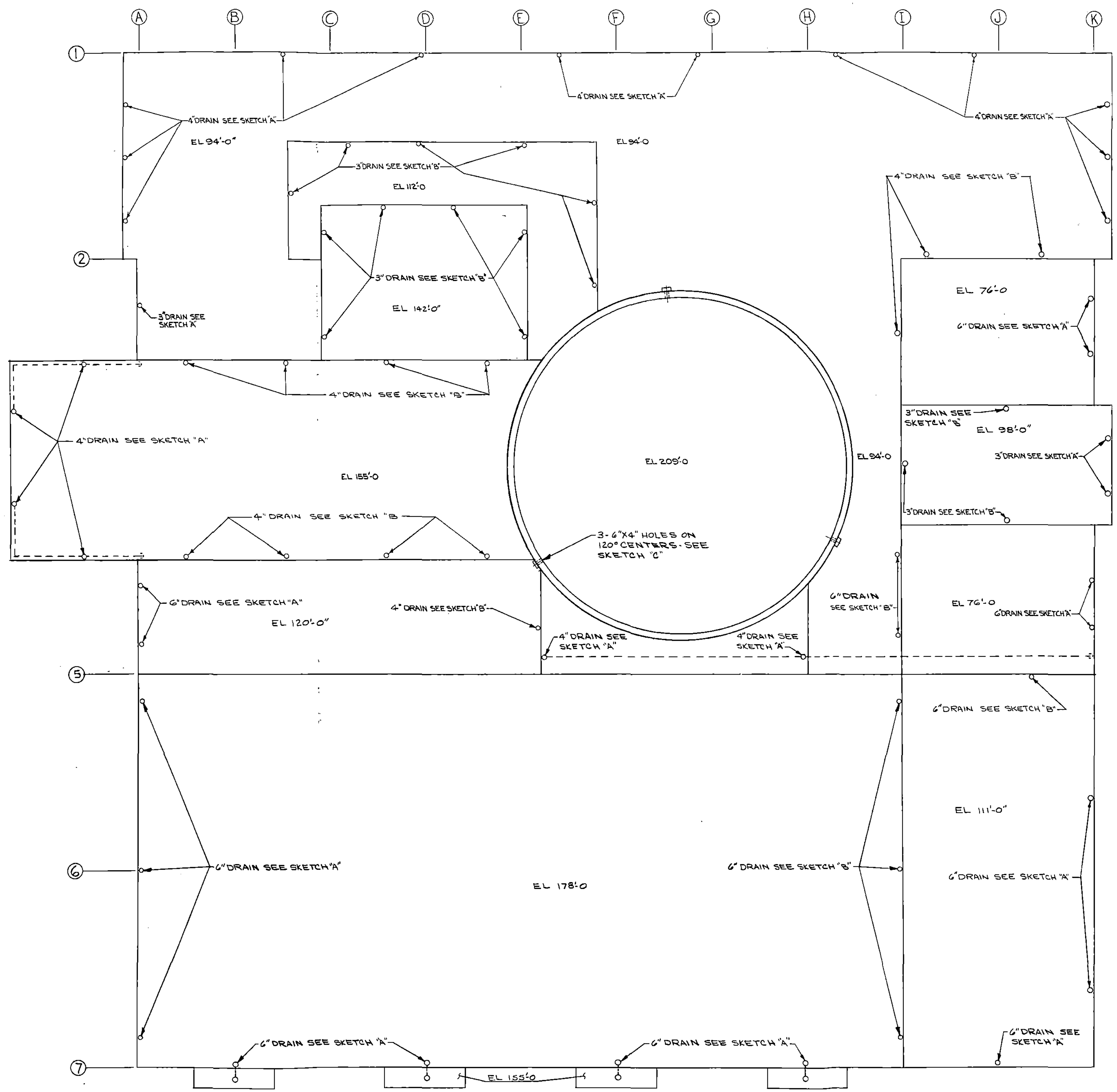


OFFSHORE POWER SYSTEMS

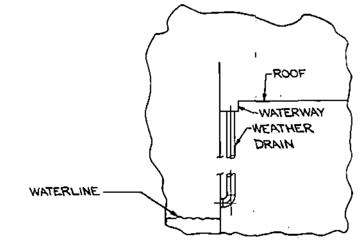
Title: DIESEL GENERATOR FUEL OIL SUPPLY SYSTEM

11/1/72

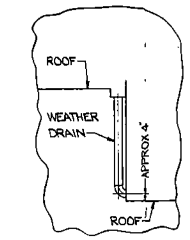
Figure: 9.5-2



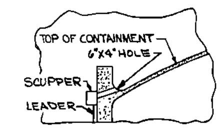
PLAN VIEW-EL 210'-0



SKETCH "A"
SHOWING TYPICAL RUN OF WEATHER DRAIN THAT GOES OVERBOARD FROM ROOF AREA



SKETCH "B"
SHOWING TYPICAL WEATHER DRAIN THAT SPILLS ON ROOF BELOW



SKETCH "C"
TYPICAL SECTION VIEW SHOWING DRAINAGE FOR CONTAINMENT BUILDING

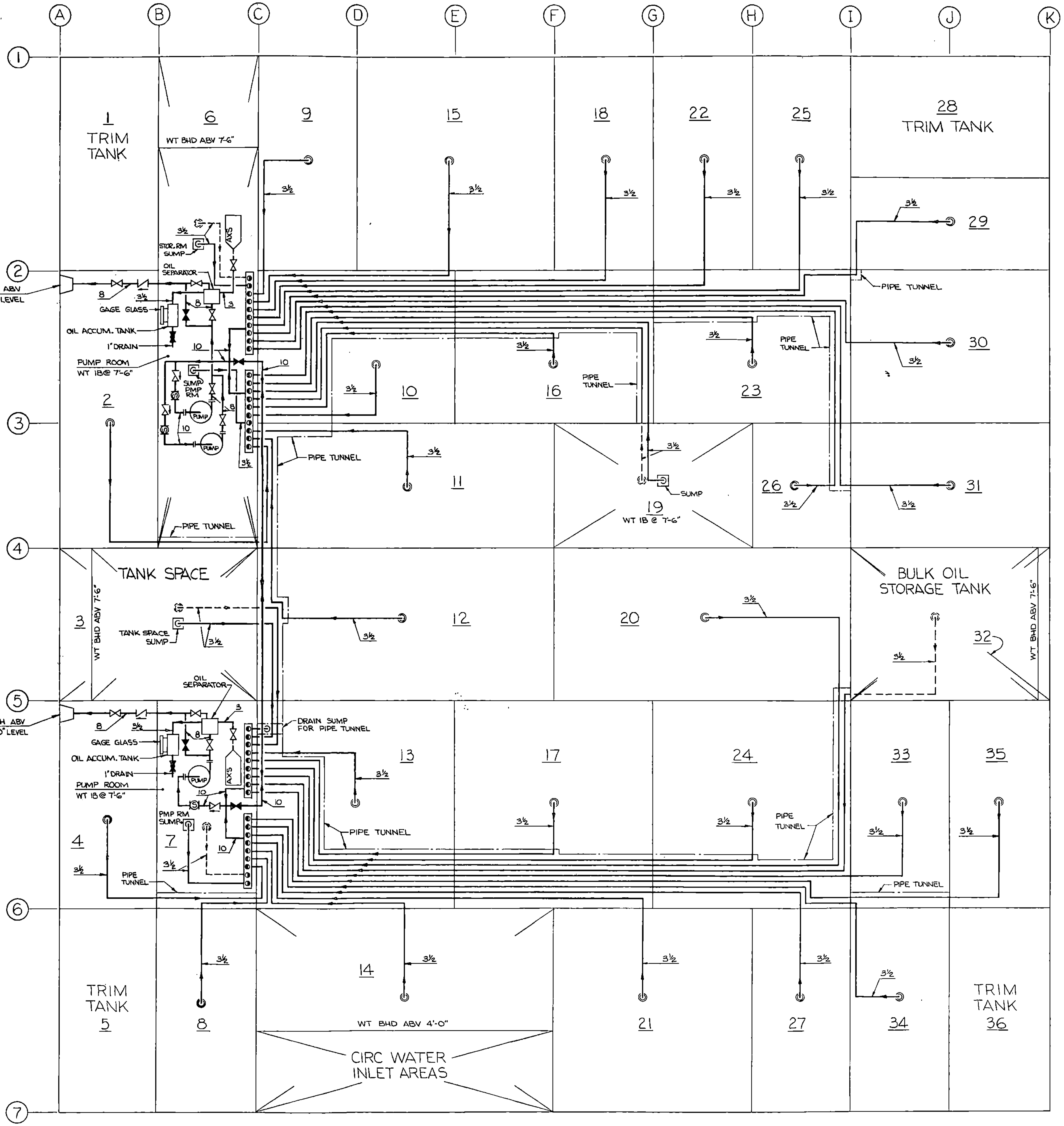
NOTES:

1. WEATHER DRAINS ARE TO BE GALVANIZED CARBON STEEL-ASTM-A106 GRADE A OR B.
2. WELDS AND DAMAGED AREAS ON PIPES ARE TO BE PAINTED WITH AN INORGANIC ZINC COMPOUND AFTER INSTALLATION IS COMPLETED.
3. THIS SYSTEM IS NOT COVERED BY ANY SAFETY CLASS.
4. DRAIN SPOUTS AT TOP OF CONTAINMENT ARE TO BE GALVANIZED CARBON STEEL.
5. ALL ROOF LEVEL DIMENSIONS SHOWN ON PLAN ARE TOP OF STEEL PLATE. TO TOP OF ROOFING MATERIAL ADD 4" TO 6".

OFFSHORE POWER SYSTEMS

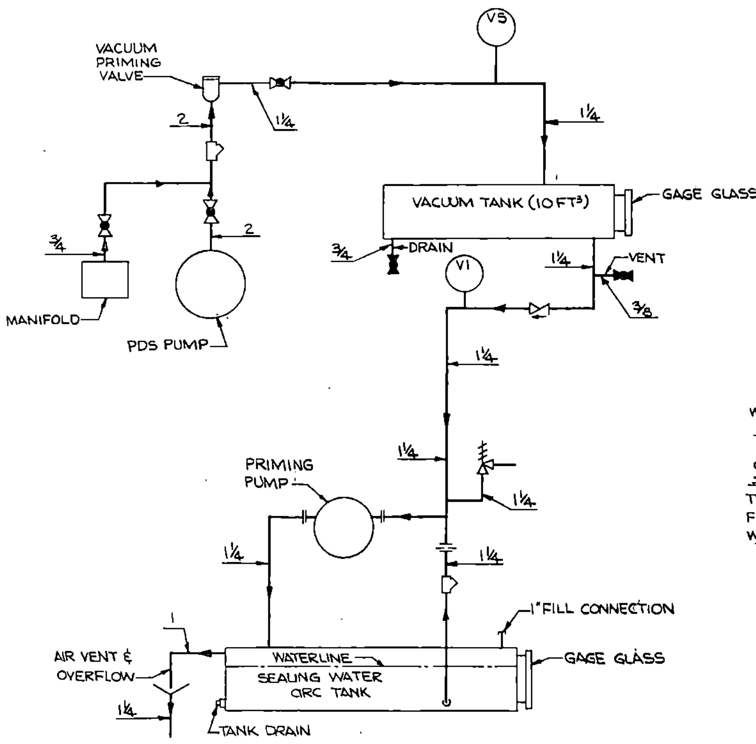
Title: WEATHER DECK DRAIN SYSTEM

11/1/72 Figure: 9.5-3



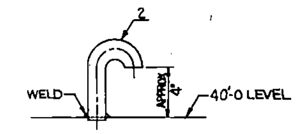
PLAN VIEW

SHOWING DRAINAGE OF COMPARTMENTS BELOW 40'-0" LEVEL.



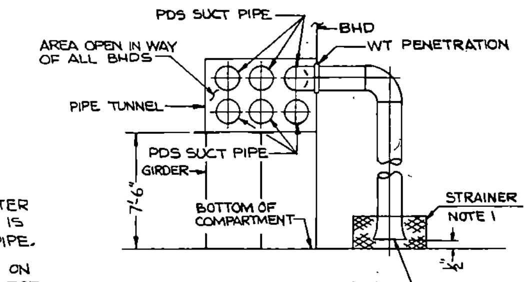
PRIMING SYSTEM

ONE IN EACH SPACE WHERE PUMPS ARE LOCATED



SKETCH "A"

TYPICAL AIR ESCAPE FROM COMPARTMENTS WITHOUT VENTILATION



SKETCH "B"

SHOWING TYPICAL SECTION OF PIPE TUNNEL & PDS SUCTION TAILPIPE

NOTES

1. STRAINERS ARE TO BE PERFORATED STEEL (ZINC COATED AFTER FABRICATION). THE NET CLEAR AREA OF THE PERFORATIONS IS TO BE AT LEAST THREE TIMES THE AREA OF THE SUCTION PIPE.
2. EACH DRAIN PUMP SHALL BE FITTED WITH A VACUUM GAGE ON THE SUCTION SIDE AND A PRESSURE GAGE ON THE DISCHARGE SIDE.
3. ALL VALVES 3" & ABOVE SHALL HAVE FLANGED CONNECTIONS.
4. SUCTION TAILPIPES (BELLMOUTHS) ARE TO HAVE AN OPEN SUCTION AREA OF 1½ TIMES THE AREA OF THE SUCTION TAILPIPE.
5. ONE DRAIN PUMP SHALL BE OF THE SUBMERSIBLE TYPE WITH MEANS FOR REMOTE OPERATION OF PUMP AND VALVES WHICH ARE NECESSARY FOR DRAINING THE SPACE WHERE PUMPS ARE LOCATED.
6. AIR ESCAPES SHALL NOT TERMINATE IN FOOD HANDLING AREAS OR CREW LIVING SPACES.
7. THIS SYSTEM IS NOT COVERED BY ANY SAFETY CLASS.
8. WATER TIGHT PENETRATION FITTINGS SHALL BE PROVIDED WHERE PIPES PENETRATE PUMP ROOM BULKHEADS.
9. DRAINS REFERRING TO THIS NOTE LEAVE SUMP AND ENTER NEAREST PIPE TUNNEL THEN RUN TO PUMP ROOM AS SHOWN IN SKETCH "D".

LEGEND OF SYMBOLS

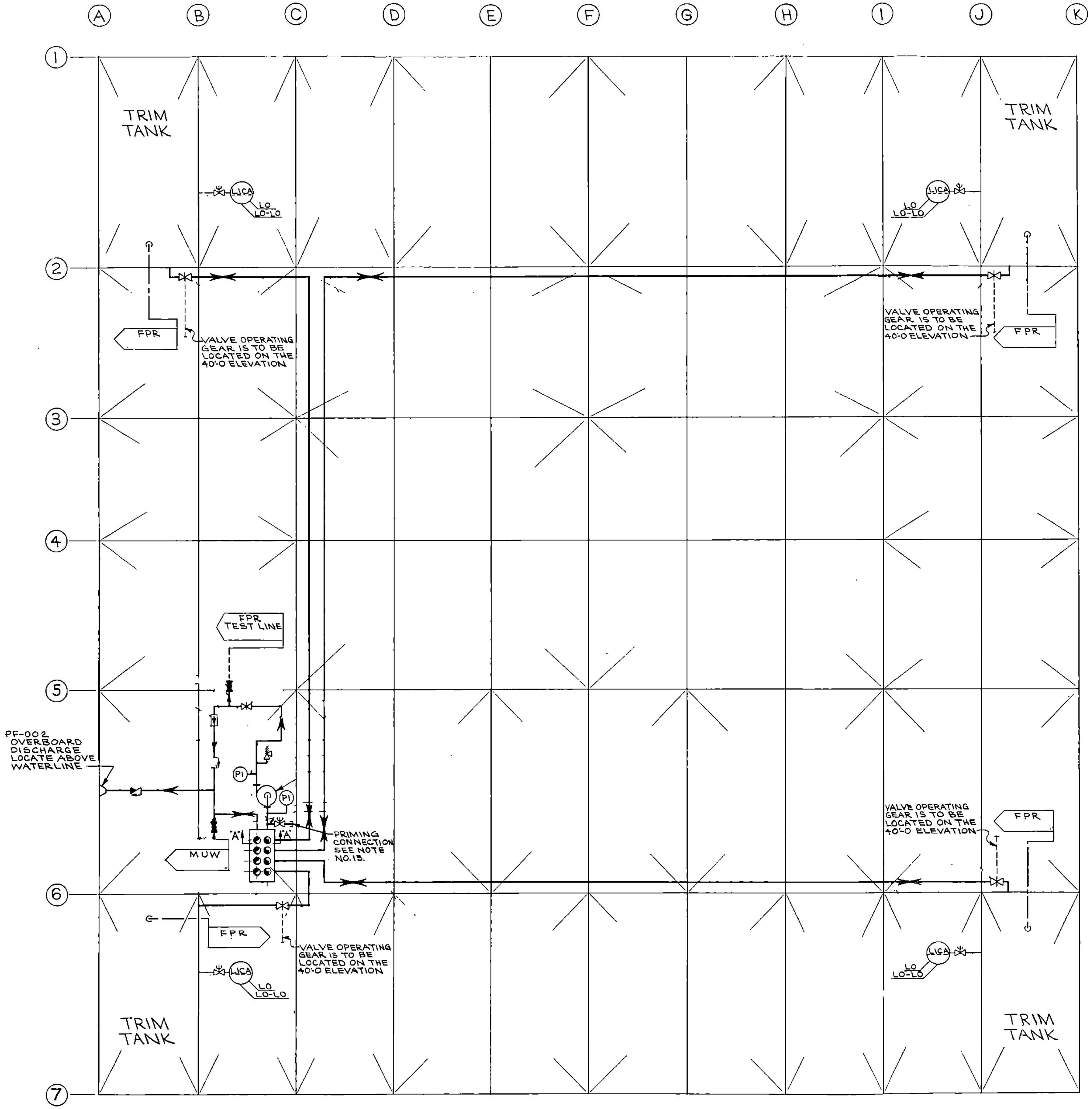
(S) MACOMB STRAINER

MANIFOLD - STOP CHECK VALVE

OFFSHORE POWER SYSTEMS

Title: PLATFORM DRAIN SYSTEM

11/1/72 Figure 9.6-1



OFFSHORE POWER SYSTEMS

Title: PLATFORM TRIM SYSTEM FLOW DIAGRAM

1/1/73 Figure: 9.6-2

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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 includes a tandem-compound, six-flow exhaust turbine and a direct coupled generator. Steam from the outlet of the four steam generators is supplied to drive the main turbine-generator.

Moisture separation with two stage reheat is provided between the high-pressure and low-pressure turbines for all steam entering the low-pressure turbines. Steam from the low-pressure turbines is condensed in three surface type single pass condensers of divided water box design. Condensate is collected in the condenser hotwells sized for 5-minute storage at the maximum calculated flow rating.

The condensate and feedwater system return feedwater to the steam generators through six stages of extraction feedwater heating. Circulating water is pumped from the sea through the main condensers and returned to the sea.

The heat balance at maximum guaranteed rating is shown in Figure 10.1-1. Key parameters are shown in Table 10.1-1.

TABLE 10.1-1

MAJOR STEAM AND POWER CONVERSION EQUIPMENT*

SUMMARY DESCRIPTION

TURBINE GENERATOR

Maximum Guaranteed Rating (3425 MWt)

Throttle pressure, psia	980
Temperature, F	542.1
Steam Moisture, %	0.36
Back pressure, in HgA	1.75
Steam flow (Total NSSS steam flow),lb/hr	15,143,128
Throttle flow, lb/hr	14,344,978
Output, KW	1,211,469
Power factor, P.F.	0.90
H_2 Pressure, psig	75

Maximum Calculated Rating (3522 MWt)

Throttle pressure, psia	980
Temperature, F	542.1
Steam Moisture, %	0.36
Back pressure, in HgA	1.75
Steam flow (Total NSSS steam flow) lb/hr	15,900,285
Throttle flow, lb/hr	15,099,646

TABLE 10.1-1 (Continued)

Output, KW	1,261,780
Power factor, P.F.	0.90
H_2 Pressure, psig	75

*Note: These ratings are calculated for a specific location and will vary with different off-shore sites as the design circulating water temperature changes.

10.2 TURBINE-GENERATOR

10.2.1 DESIGN BASES

The turbine generator converts the thermal energy to electric energy. Guaranteed ratings are specified in Table 10.1-1.

The functional limitation on the turbine imposed by the nuclear steam supply system (NSSS) is that the NSSS accepts step load changes of ± 10 percent and ramp load changes of ± 5 percent per minute not exceeding 100 percent. A step load decrease up to 95 percent of rated load is accommodated without reactor or turbine trip. Complete load loss will cause reactor and turbine trip.

10.2.2 DESCRIPTION OF TURBINE-GENERATOR EQUIPMENT

10.2.2.1 Turbine

The turbine is a four casing, tandem-compound, six-flow bottom exhaust, 1800 rpm unit with 44 inch last stage blades. Directly connected to the turbine shaft is an ac generator. Coupled to the generator is a brushless excitation system.

Moisture separation and two stage reheating of the steam are provided between the high-pressure and low-pressure elements. Two shells, each of which contain combined moisture separator-reheater assemblies are located on each side of the turbine parallel to the turbine shaft. During normal operation turbine-generator bearings are lubricated by a conventional pressurized oil system, with the main lubricating oil pump integral with the turbine shaft. During startup or shutdown, ac motor-driven pumps supply bearing oil and seal oil to the turbine-generator. A dc motor-driven backup pump is provided in case of loss of ac power.

Steam from the four steam generators enters the high-pressure turbine through four stop valves and four governing control valves. Two stop valves and two control valves form a single assembly on each side of the turbine. After expanding through the high-pressure turbine, steam flows through the moisture separators and reheaters to three low-pressure turbines. Reheated steam flows from the moisture separator-reheater vessels through an intermediate stop and an intercept valve in each of six reheat steam lines leading to the low-pressure turbines.

Steam from each low-pressure turbine is exhausted into a condenser, one for each low-pressure turbine.

10.2.2.2 Steam Extraction Connections

Turbine steam extraction connections are provided for six stages of feed-water heating. Steam from the first extraction point of the high-pressure turbine is supplied to high-pressure feedwater heater number 1 and to the first stage reheater tube bundles. Steam is taken from the high-pressure turbine exhaust piping to feedwater heater number 2. Main steam from the steam generators is supplied to the second stage reheater tube bundles. First, second, third, and fourth extraction steam points from the low-pressure turbines are supplied to heaters 3, 4, 5, and 6, respectively. The extraction steam system is shown in Figure 10.2-1, Sheets 1 and 2.

10.2.2.3 Generator

The generator is sized to accept the output of the turbine at rated steam conditions. It is a direct coupled, 60 Hz, 3-phase, 25,000 volt unit rated at max. calc. 1,402,000 kVA at 0.90 power factor when using 75 psig H_2 gas pressure, and has a short circuit ratio of 0.50. Both ends of the generator shaft are oil sealed to prevent hydrogen leakage. Generator rating, temperature rise, and insulation class are in accordance with ANSI standards.

10.2.2.4 Automatic Controls

Automatic control actions, alarms, and trips are initiated by deviation of system variables from present values. The automatic control functions are programmed to protect the turbine generator and the reactor with appropriate corrective actions. The turbine-generator unit automatically is tripped if the reactor is tripped.

The turbine-generator is equipped with an electrohydraulic control system that combines the principles of solid-state electronics and high-pressure hydraulics to control steam flow through the turbine. The control system has three subsystems:

Speed control unit

Valve flow control unit

Load control unit

1. Speed Control Unit

The speed control unit compares actual turbine speed with a speed reference or actual acceleration with an acceleration reference and provides a speed error signal for the load control unit. The load control unit combines the speed error signal with the load reference signal, provides the proper bias, and determines desired steam flow signals for the governor valves, control valves, intermediate stop and intercept valves. The valve flow control units accurately position all the steam admission valves to obtain required steam flow through the turbine.

2. Valve Flow Control Units

The flow of the main steam entering the high-pressure turbine is controlled by four stop valves and four governing control valves. Each stop valve is controlled by an electrohydraulic servoactuator so that the stop valve is either fully open or fully closed. The function of the stop valves is to shut off the flow of steam to the turbine when required. The stop valves are closed within 0.25 seconds by actuation of the emergency trip device (see turbine protection trips, following), which is independent of the electronic flow control unit. During startup, all control valves are set wide open and initial throttling pressure drop occurs across the stop valve pilot valves, which allows the first stage nozzles and shells to heat uniformly. The turbine control valves are positioned by an electrohydraulic servoactuator in response to a signal from the flow control unit. The flow control unit signal positions the control valves for long range speed control through the normal turbine operating range and for load control after the turbine-generator unit is synchronized.

The valves located in the crossover lines are reheat stop and intercept valves and control steam flow to the low-pressure turbines. During normal operation of the turbine, the reheat stop and intercept valves will be wide open. The intercept valve flow control unit positions the valve during startup and normal operations and closes the valve rapidly on loss of turbine load. The reheat stop valves close completely on turbine overspeed trip.

3. Load Control Unit

The power-load unbalanced relay in the load control unit acts to prevent turbine-generator overspeed trip following a sudden loss of electrical load. If the load is lost and a power load unbalanced exceeding 30 percent exists, the power load unbalance relay resets the desired load to zero and starts running the load reference back toward zero load. As the turbine accelerates, the control and intercept valves are closed at the maximum rate by fast-acting solenoid valves actuated by the power load unbalance relay, to prevent the unit from reaching the overspeed trip setting. Closure of stop valves on either of two overspeed trips is the second line of turbine protection.

4. Turbine Protection Trips

Turbine protective trips are independent of the electronic control system, and when initiated, cause tripping of all turbine inlet valves:

a. Overspeed trip (mechanical)

b. Overspeed trip (electrical)

c. Low vacuum trip

d. Thrust bearing trip

e. Electrical solenoid trip actuated by:

    1. Reactor trip

    2. Generator electrical trips

    3. Manual trip from control room

f. Manual trip lever located at the turbine

g. Low bearing oil pressure trip

10.2.2.5 Other Protective Systems

In addition to the previously mentioned devices, other protective features of the turbine and steam system are:

1. Automatic load runback to approximately 23 percent of full load in case of loss of cooling water to generator stator.

2. Safety valves on the moisture separator-reheater to protect the high-pressure turbine cylinder crossover piping, and the MSR shell from overpressure in the event of a turbine trip.

3. Extraction line nonreturn valves to protect the turbine from overspeed due to reverse flow in case of a turbine trip.

4. Low-pressure turbine casing rupture diaphragms to protect the low-pressure turbine cylinders from overpressure in case of loss of condenser vacuum.

The extraction line nonreturn valves are closed through an air pilot valve, which is actuated by the loss of EHC hydraulic fluid pressure when the turbine-generator is tripped.

10.2.2.6 Instrumentation

Instrumentation is provided to continuously monitor and/or alarm such turbine-generator conditions as:

1. Shaft eccentricity
2. Shaft vibration at main bearings
3. Shell expansion
4. Differential expansion between shell and rotor
5. Turbine speed
6. Turbine metal temperature
7. Bearing temperatures
8. Generator hydrogen gas and stator cooling water temperatures.
9. Exhaust hood temperature
10. Condenser vacuum
11. Stator winding temperatures
12. Shaft eccentricity phase angle
13. Shaft vibration phase angle

10.2.3 DESIGN EVALUATION OF TURBINE-GENERATOR AND RELATED STEAM HANDLING EQUIPMENT

The pressurized water reactor system maintains an inherently low radioactivity level in steam handling systems, as has been demonstrated by operating experience. Radioactivity concentration during operation with assumed defective fuel and leaking steam generators are given in Section 12.4.

Activity levels in the turbine are expected to be low and some shielding is provided by the piping, turbine casing, and other components. Additional shielding will not be required to permit access to the turbine area.

10.3 MAIN STEAM SYSTEM

The main steam system is shown in Figures 10.3-1, Sheet 1 and 2.

10.3.1 FUNCTION

The main steam system conveys steam from the Nuclear Steam Supply System to all main steam users such as the turbine-generator, the turbine drives for main feed pumps and auxiliary feed pump, steam jet air ejectors and moisture seperator reheaters.

10.3.2 DESIGN BASIS

10.3.2.1 Performance Criteria

1. At the maximum guaranteed steam flow the line pressure loss will not exceed 20 psi between the steam generator outlet and the turbine generator valves.

2. Under all normal plant operating conditions and on-line testing, the heat load on the four steam generators is evenly balanced. The temperature difference at the turbine valves is maintained within that specified by the turbine-generator manufacturer.

3. The safety function of heat removal from the reactor is controlled during all plant conditions.

4. In the event of a single active failure of a component in the main steam system, the plant is capable of being controlled and brought subcritical.

5. In the event of a steam pipe break inside the containment, the containment design pressure is not exceeded.

6. In the event of a steam pipe break outside the containment, the cooldown rate is automatically controlled in such a way that the radioactive release to the environment can be shown to remain within 10 CFR 100 limits assuming the plant was operating with steam generator leaks.

7. The main steam system shall perform its safety related functions, during and after a pipe break incident, while sustaining a single active failure of a component.

8. A main steam line incident will not impair the functions of any other plant safety system below the minimum required for safe shutdown of the reactor.

9. A main steam line incident will not precipitate a loss of coolant accident (LOCA).

10. Under all plant normal operating and testing conditions, all component stresses remain within the allowable range. Under abnormal conditions, stresses may approach yield level as described in Section 3.9. The main steam piping shall be designed for limiting environmental conditions as provided in design codes specified in Section 10.3.4.2.

11. The main steam system provides the means to limit radioactive release to the atmosphere and isolate a steam generator in the event of a steam generator tube rupture accident.

12. Crossflow is prevented between the plant ventilation systems and the atmospheric steam release points.

13. The safety functions of the main steam system are assured by protecting against missile and pipewhip damage.

14. Access and maintenance provisions are made to facilitate testing and repairs to the ASME Code safety valves, power operated relief valves, atmospheric dump valves and main steam stop valves.

15. The vent pipe arrangement on all steam pressure relieving devices is such that the steam is freely vented outside the buildings.

10.3.2.2 Design Codes

1. Those sections of the main steam system classified by the ANS in "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants," N-18.2, January 1972 and shown on flow diagrams Figures 10.3-1, Sheets 1 and 2, comply with "ASME Boiler and Pressure Vessel Code - 1971, Section III "Nuclear Power Plant Components, Summer 1972 Addenda".

2. All other sections of the main steam system comply with ANSI B31.1. -- 1967, "Power Piping".

10.3.2.3 Environmental Design Criteria

During all modes of the plant operation, the radioactive release to the atmosphere through the main steam system can be maintained within the limits specified in 10 CFR 20 and/or 10 CFR 100.

10.3.3 SYSTEM DESCRIPTION

The main steam system parameters are given in Table 10.3-1.

TABLE 10.3-1

SYSTEM PARAMETERS

Design Conditions	1300 psia, $600^{o}F$
Operating Conditions	1000 psia, $544^{o}F$ with maximum inlet moisture content of 0.25%
Maximum Guarantee Flow	15,143,128 lbs/hr
Maximum Calculated Flow	15,900,285 lbs/hr
Maximum Pressure Drop at maximum guaranteed flow	20 psi

Steam from the steam generators of the Nuclear Steam Supply System is conveyed by the main steam system to the main turbine generator and its auxiliary steam systems, the turbine drives for the main feed pumps, an auxiliary feed pump, and the air ejectors.

The steam generators are located inside the containment. The steam generators are contained within the lower compartment.

The steam outlet pipe is welded to the nozzle located on the top of each steam generator. The individual pipes are routed vertically alongside their associated steam generators. A flow restrictor is located in the horizontal run between the steam generator nozzle and the vertical run. The individual pipes are routed horizontally below the ice condenser to the containment wall. Between the crane wall within the containment and the concrete shield building the individual pipes are routed through steel tubes. Each tube connects the penetration in the outer shield building to the free space of the lower containment compartment inside the concrete cranewall. At the shield building the individual steam generator pipes are enclosed in a high temperature penetration and anchored to the reinforced concrete wall. This penetration is described in Section 3.8.2.7.

Outside the containment each of the steam generator pipes has branches connecting to the ASME Code safety valves and power operated relief valves.

Each steam line is equipped with a main steam stop valve (swing disc) held open by an air piston. This valve forms the boundary of the ANS safety classification of the main steam system. Within this boundary two of the main steam lines have branches which supply the turbine driven auxiliary feed pump. A 3" bypass globe valve with a power operator is provided across the main steam stop valve.

Close to and downstream of the stop valve, each steam line is equipped with a swing disc check valve. The four steam lines are paired into two headers. One of these headers conveys steam from two steam generators located furthest from the turbine generator. This header is routed around the outside of the containment into the turbine building. The other header conveys the steam from the remaining steam generators into the turbine building.

Inside the turbine building these two headers are joined to form a common header for all steam generators. Steam supplies are taken during normal and/or emergency conditions from this single header to: the individual main valves of the turbine generator, the turbine auxiliary steam system, atmospheric and condenser sections of the steam dump system, the main feed pump turbines and the air removal systems.

10.3.3.1 Valve Description

All valves are carbon steel body with 900 # ANSI pressure rating. Brief parameters of all the valves are shown in Table 10.3-2.

10.3.3.1.1 Safety Valves

Six safety valves are provided on each steam line upstream of the main steam stop valve outside the containment. The valves are single-seated and have external spring loading of the disc. The steam passes through a stuffing box, preventing the escape of steam from the downstream side of the valve. Each valve has a stellited disc. Data for the six safety valves are shown in Table 10.3-3.

Layout of the separately mounted vent piping surrounding the exit nozzle of the safety valve allows for vertical and horizontal displacement of the main steam piping caused by operational transit.

TABLE 10.3-2

VALVE DATA

Valve	No. Required on Each S.G. Line	Total	Size	Rating	Type
Safety	6	24	6" x 10"	895,000 lbs/hr at 1200 psia	Spring-loaded
Relief	1	4	8" x 10"	397,500 lbs/hr @ 1100 psia	Modulating Type
Stop	1	4	32"	3,975,000 lbs/hr	Swing disc
Check	1	4	32"	3,975,000 lbs/hr	
Bypass	1	4	3"	12,500 lbs/hr	Globe

TABLE 10.3-3

MAIN STEAM SAFETY VALVES

Set Pressure (psia)	Reseat Pressure (psia)	Outlet Reaction Force (lbs)	Orifice Area (in.)	Inlet/ Outlet Sizes (in)	Relieving Capacity lbs/hr
1192	1152	23,750	16	6/10	886,333
1204	1164	23,750	16	6/10	895,261
1216	1176	23,750	16	6/10	904,189
1228	1188	23,750	16	6/10	913,117
1240	1200	23,750	16	6/10	922,045
1252	1212	23,750	16	6/10	930,973

10.3.3.1.2 Atmospheric Power Relief Valves

One valve on each steam line downstream of the safety valves and upstream of the stop valves is provided. These valves are set to open at 50 psi below the lowest setting of safety valves, thus providing pressure relief on minor transients and avoiding lifting of the safety valves. The valves also provide 10 percent steam dump capacity as described in Section 10.4.4.

The valves are a modulating type with 0 - 100 percent flow control capability between the pressure range of 125 psia to 1200 psia. The control is automatic by the steam line pressure with provision for remote manual control by adjustment of the pressure set point from the control room. Local manual operators are provided for the event of complete loss of control air and also for control room evacuation. An isolation valve is provided upstream for removal of the valve for maintenance.

10.3.3.1.3 Main Steam Valves

The valving arrangement as shown in Figure 10.3-1 consists of a main steam stop valve (swing disc valve held open by an air piston) installed in series with a check valve. Air is exhausted from the cylinder on receipt of a trip signal. Each cylinder has an air reservoir. Redundancy is provided in air supply by providing double solenoid valves and non-return valves.

Separate air cylinder vent lines assure venting of air from the air cylinder which holds the valve open. During the time when the cylinder is venting, the air supply to the reservoir and the air cylinder is shut-off.

A check valve in series with the main steam stop valve prevents back flow in the event of a pipebreak (upsteam of the stop valve). A 3" bypass globe valve with a power operator is provided across the main steam valve. The valve is used to equalize steam pressure on both sides before opening the main steam stop valve. The bypass line is also used for supplying the steam to the main feed pump turbine and air ejectors during startup operations.

10.3.4 EVALUATION OF DESIGN

10.3.4.1. Performance Evaluation

1. The fluid velocities and components selected limit frictional resistance at maximum guaranteed steam flow to 20 psi between the steam generator outlet nozzle and main turbine valves. The steam velocity is kept below 150 ft/sec.

2. During normal plant operation, the Nuclear Steam Supply System recommended maximum out-of-balance pressure between any two steam generators is 10 psi. As required by the turbine-generator manufacturer the steam delivered through any turbine main inlet valve must be within 25°F of the steam delivered simultaneously through any other main inlet valve. For short periods of time (a few minutes) the temperature difference may approach 50°F maximum. The arrangement of piping between the individual steam generators and the common header in the turbine building ensures approximately equal resistance to flow under all normal operating and on-load testing conditions. This assures any uneven heat load between the individual steam generators is within the above limit for the following specific conditions:

   a. During startup, load changes requiring up to 85% steam dump, shutdown and reactor physics testing.

   b. During multi and single valve operation of the turbine-generator and on-load testing of the turbine-generator valves, even heat load on all the steam generators is maintained.

   c. During operation with one reactor coolant pump shut-off, the arrangement of the steam system allows operation of the plant without exceeding the above turbine generator temperature out-of-balance limits.

3. The steam generator safety valves are spring-loaded and self-actuating type. There are no isolation valves between the safety valves and steam generator. Thus, the safety valves are available for overpressure protection at all times under all plant operating conditions. Power operated relief valves are available for plant cooldown at all times.

4. Mechanical failure of a control valve such as steam dump or power operated relief results in an uncontrolled steam release. The analysis for single spurious opening of a valve in the main steam system is presented in Section 15.2.13 of RESAR 3, Vol. VI, which shows that there would be no return to criticality. The maximum flow through any one of the ASME Code safety valves, power operated relief valves, atmospheric dump and condenser dump valves is specified not to exceed 970,000 lbs/hr at 1200 psia.

5. To prevent the containment pressure exceeding the design pressure in the event of a main steam pipe break inside the containment, following actions must be ensured:

   a. No more than one steam generator is allowed to completely blowdown.

   b. The steam released into the containment from the remaining steam generators is terminated within 10 seconds of the initiation of the break.

c. All the steam released into the containment must be directed into the lower compartment of the inner containment.

The steam pipe break incident actuates the main steam stop valves to close as described in "Engineered Safety Features Actuation System," Section 7.3 of RESAR 3.

Shutting the stop valves cuts off the individual steam generators from the pipe break. This action ensures that only the steam generator with the broken line blows down completely.

For analysis of single active failure see Section 10.3.4.1.7.

During the period when the steam break protection is being activated all the steam generators and piping contents continue blowdown into the containment. The closure time of the stop valves is 5 seconds allowing 5 seconds for activation which ensures shut-off in 10 seconds as assumed in pipe break analysis.

The arrangement of steam piping inside the containment ensures any break has only free flow access to the lower compartment of the containment. The enclosures around the steam generators ensures steam flow into the lower compartment. Steam from a break between the containment and the shield building is directed into the containment by the surrounding tube which has one free end in the lower compartment of the containment.

6. Detailed analysis of a main steam pipe break is presented in Section 15.4.2 of RESAR 3, Volume VII.

   A rupture of a main steam pipe would result in increased steam flow. The energy removal from the Reactor Coolant System causes a reduction of coolant temperature and pressure. In the presence of a negative moderator temperature coefficient, the core could return to power following a steam line break. To reduce the rate of reactor cooldown, the following provsions are made:

   a. A 16" flow restrictor is provided in the main steam piping close to the steam generator. The steam flow through the restrictor in case of a pipe break is only 1/4 of what it would be through the pipe with no restrictor.

   b. The fast closing main steam stop valves are provided. The valves close in 5 seconds or less of the receipt of signal to close. This provides that after the closure of valves the blowdown rate and mass released is dependent on only one steam generator.

The analysis presented in Section 15.4.2 shows that the dose rate values at the exclusion distance will not exceed the limits specified in 10 CFR 100.

7. The main steam system has the capability of performing all its safety related functions while sustaining a single active failure of a component. Each line has a fast closing stop valve with downstream check valve. Sufficient redundancy is provided in the stop valve controls as described in Section 10.3.3.1. These valves prevent blowdown of more than one steam generator for any break location even if one valve fails to close. For example, in the case of a break upstream of the stop valve in one line, either the check valve in that line or the stop valves in the other three lines will prevent blowdown of more than one steam generator inside the containment and thus prevents structural damage to the containment.

   In the event of a pipe break downstream of the valves with failure of one main steam stop valve to close, the steam flow through the break would continue from all the steam generators for no more than 10 seconds. However, after this period, the steam blowdown will continue only from the steam generator associated with the main steam stop valve which was assumed to fail. The other three steam generator lines will be used to shutdown the plant.

8. A main steam pipe in one line will not damage the steam and feed piping sections designated with a safety classification in the other 3 lines. The steam pipe break must also not cause damage to the auxiliary feed system, containment and asociated systems, systems required for safe shutdown of the plant (listed in Section 7.4 of RESAR 3). The damage as a result of a main steam pipe break in any pipe section is not allowed to affect the operability of other lines by a careful arrangement of equipment, missile shields, pipe whip restraints, hangers and supports.

9. A main steam line incident will not precipitate a loss of coolant accident (LOCA). A steam pipe break will not result in a steam generator tube rupture accident. Careful separation of the two systems and adequate design of missile barriers, pipe whip restraints, hangers and supports prevent steam line incidents from causing reactor coolant systems leakage.

10. The stresses imposed by the main steam piping upon main components such as steam generators, containment, and turbine generator remain within range as specified in Section 3.9 for normal plant operation and accident conditions.

This is achieved by a combination of piping layout, location and type of supports and anchors and cold springing if required. Safety valves, relief valves, and dump valve supports are designed for maximum dynamic loading caused by sudden opening of the valve.

11. In the event of a steam generator tube rupture accident, operator action is required as detailed in Section 15.4.3 of RESAR, Rev. 3.

12. The layout of the plant ventilation air intakes and the location of the steam release points are such that there is no possibility of drawing the steam into the building. In the turbine building, the atmospheric dump valves exhaust outside column A-A but the air intakes are provided on side 7-7. The safety and power operated relief valves exhaust in sections 23FG and 45FG. Air intakes are provided on Column 1-1.

13. For safety functions of the main steam system, the section from the steam generators to the main steam stop valves only is required. This section is protected from missiles from within the plant or from outside by missile barriers. Missile protection capability of the plant is analyzed in Section 3.5. Pipe whip damage from any other system piping such as feed pipes is minimized by adequate design of pipe whip restraints and physical separation in the layout.

14. Access for maintenance is provided for the safety valves, relief valves, dump valves and main steam stop valves.

15. Steam released due to sudden opening of the safety valves, relief valves and atmospheric dump valves is freely vented outside the buildings. The valve nozzles and vent pipes are designed to accommodate the thermal and reaction movements associated with the plant operation. The vents are adequately sized to prevent back pressure forcing steam into the building housing the valves. Ventilation is provided in buildings to prevent accumulation of steam inside the buildings from valve glands and leakage through valve seat.

10.3.4.2 Design Code Evaluation

The sections of the main steam system which have safety functions are classified according to the guidelines of ANS.

The section from the steam generator nozzle up to and including the main steam stop valve is in accordance with ANS Safety Class 2 ASME Boiler and Pressure Vessel Code, Section III, Code Class 2. Steam supply lines to auxiliary feed pump turbine up to the first valve on the line, have same classification as above.

Downstream of the first valve on the steam supply line to the auxiliary feed pump turbine and the exhaust from turbine to the atmosphere is in accordance with ANS Safety Class 3 and ASME Boiler and Pressure Vessel Code, Section III, Code Class 3.

Drain lines, vent lines, control air lines, up to the first isolation valve, shall be the same classification as the component.

The main steam piping downstream of the stop valves and up to the main valves on the turbine generator and various branch lines supplying the other auxiliaries have no safety function and therefore are designed in accordance with ANSI B31.1 - 1967 "Power Piping."

10.3.4.3 Environmental Design Evaluation

The doses resulting from environmental releases can be maintained within the limits specified under 10 CFR 20 and 10 CFR 100 requirements as applicable. Detailed analysis is presented in Sections 12.4 and 15.4.2.

The possible course for radioactive release to the atmosphere is through steam generator tube leakage. To limit the radioactivity in the main steam system, limits for reactor coolant leakage and activity level are specified for continued operation of the plant.

10.3.5 INSPECTION AND TESTING

Inspection and tesing during manufacturing are in accordance with the applicable ASME Codes and other regulatory bodies' requirements. Detailed requirements will be specified in component specifications. Specifically, the inspection and tesing requirements during manufacturing for main steam stop valves, power operated relief valves and safety valves are in accordance with ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Power Plant Components."

Visual inservice inspection of the system will be performed by the plant operating personnel. Inservice leakage test are not required by ASME Code.

Safety valves opening and closing set pressures will be tested by an air operated lifting mechanism. An outline of the test procedure is given in the Technical Specifications. The actual opening/closure pressure will be checked to be consistent with pressures given in Table 10.3.3. The operability of the relief valves is periodically checked by the plant operating personnel. The closing time of the main steam stop valves is checked at every refueling period.

10.4 OTHER FEATURES OF STEAM AND POWER CONVERSION SYSTEM

10.4.1 MAIN CONDENSERS

10.4.1.1 Description

The condenser is three shell, single pass and floor supported. The condenser is connected to the exhaust opening of each low pressure turbine by an expansion joint. Equalizing ducts between the shells of the three condensers limits the exhaust pressure differential to 2" HgA, with any shell out of service. The design parameters of the main condensers are shown on Table 10.4.1-1. Following a large load rejection, the three condensers accept bypass steam corresponding to 40% of steam flow at maximum calculated load.

The three condenser hotwells provide a total condensate storage, equivalent to that required for five minutes operation at maximum calculated load conditions.

10.4.1.2 Radioactivity Considerations

The radioactivity released to the turbine area is a function of the percentage of defective fuel clad, the escape rate coefficients, reactor coolant to the steam system leak rate, the steam system flow rate, the blowdown rate, steam system leakage, and the steam generator and condenser partition factors. These values are presented in Chapter 12.

TABLE 10.4.1-1

DESIGN PARAMETERS OF MAIN CONDENSERS

Quantity	3
Vacuum in each condenser	1.75" HgA
Circulating water flow to each condenser	297,000 gpm
Circulating water inlet temperature	60°F
Circulating water outlet temperature	76.5°F
Heat load per condenser	2496×10^6 Btu/Hr

10.4.2 MAIN CONDENSER EVACUATION SYSTEM

The condenser air removal system flow diagram is shown on Figure 10.4-1. To establish condenser vacuum, each condenser is provided with a steam jet hogging ejector. For removing non-condensable gases, each condenser shell is provided with twin element two stage steam jet air ejectors, each element rated at 100% capacity. Main steam is the motive steam and the ejectors are designed to operate with motive steam from 1300 psia to 125 psia by utilizing an automatic pressure reducing valve. The design parameters of the hogging ejectors and air ejectors are shown on Table 10.4.2-1. The discharge from the air ejectors is released to the atmosphere via a radiation monitor. This monitor triggers an alarm in the control room in case of radioactivity in the gases above a set limit.

10.4.2.1 Calculations of Radioactivity

Radionuclide releases in the main condenser evacuation system are described in Chapter 12.

10.4.3 TURBINE GLAND SEALING SYSTEM

The annulus space where the turbine shaft extends beyond the casing to the atmosphere is sealed by steam supplied to labyrinth packings. Where the packing seals against vacuum, the sealing steam leaks outward to a vent annulus that is maintained at a slight vacuum. The vent annulus also

TABLE 10.4.2-1

DESIGN PARAMETERS OF AIR REMOVAL EQUIPMENT

Hogging Ejectors	
Quantity	3
Capacity (each)	1200 cfm
Suction Pressure	15" HgA
Suction Temperature	70°F
Main Air Ejectors	
Quantity	3
Capacity each element	20 SCFM
Suction Pressure	1" HgA
Suction Temperature	7.5°F subcooling

receives air leakage from the outside. The air-stream mixture is drawn to the gland condenser and maintained at a slight vacuum. Where the packing seals against positive pressure, the sealing steam connection acts as a leakoff.

The steam seal header is automatically regulated at 3 to 4 psig using main steam at lighter loads. At higher loads when leakoff from pressure packings is more than that required by vacuum packings, the excess is discharged to the gland condenser. The gland condenser returns seal leakoff to the condenser as condensate. Noncondensable gases are discharged to the atmosphere by the gland exhausters.

Design Evaluation

There is negligible radioactivity leakage to the environment in the event of malfunction. Radiological monitoring is not required.

10.4.4 STEAM DUMP SYSTEM (TURBINE BYPASS SYSTEM)

The steam dump system is shown along with the main steam system in Figure 10.3-1, Sheets 1 and 2.

10.4.4.1 Function

The steam dump system provides a heat sink for the excess steam produced by the nuclear steam supply system during electrical load changes greater than the NSSS designed 5 percent per minute or 10 percent step load changes.

10.4.4.2 Design Bases

10.4.4.2.1 Performance Requirements

1. The steam dump system prevents a reactor or turbine trip during electrical load transients up to and including a step change from full power to station auxiliaries.

2. Nuclear plant safety is assured under all conditions of plant operation.

3. Loss of condensate from the steam and power conversion system is minimized.

4. Electrical output is not affected because of any unscheduled maintenance on the steam dump valves.

5. To reduce the frequency of maintenance on the dump valves and to limit steam leakage under normal plant operation, the valves are specified with a high degree of leaktightness.

10.4.4.2.2 Requirements for Single Active Failure Criterion

In the event of the spurious opening of a single steam dump valve, the plant will be shut down and maintained subcritical after trip.

10.4.4.2.3 Design Codes

The steam dump system is designed to withstand the environmental phenomena as required in the codes listed below:

1. The power operated relief valves section of the steam dump system which is included in the scope of the main steam system (Section 10.3) is designed according to the requirements given in Section 10.3.2.2.

2. The atmospheric dump valves and condenser dump valves are designed according to ANSI B.16.0 "Face-Face and End-End Dimensions of Ferrous Valves." The piping is designed according to ANSI B 31.1 "Power Piping."

10.4.4.2.4 Environmental Design Criteria

During all modes of steam dump system operation, the dose rate at the exclusion distance, when considered in conjunction with other releases, can be maintained within 10 CFR 20, and 10 CFR 100 requirements as applicable.

10.4.4.3 Description

The steam dump system can be divided into 3 sections:

1. Power operated relief valves with 10 percent full load capacity.

2. Atmospheric dump valves with 35 percent full load capacity.

3. Condenser dump valves with 40 percent full load capacity.

One power operated relief valve is provided on each steam generator upstream of the main steam stop valve and downstream of the safety valves. Each valve is provided with a manual shut-off isolation valve.

Downstream of the non-return valves, nine similar atmospheric dump valves on the common header are provided. Each valve is provided with an isolation valve. Steam is vented outside the building though the vent pipe. The vent pipe design allows free motion due to thermal growth and reaction forces of the valve and its associated piping.

Steam dump to the condenser is provided by 12 control valves. Isolation valves are provided on both sides of the valves. Steam traps and local strainers are provided on each dump line. Inside the condensers the steam lines are provided with sparge pipes to reduce the steam velocity.

Both the atmospheric dump and the condenser dump valves have 900# ANSI pressure rating globe body, piston actuator and electronic-pneumatic transducer. All the dump valves are modulating type. The valve operators are capable of opening the valve completely within 3 seconds over the system pressure range of 930-1200 psia. The valves are capable of being positioned automatically, modulating to pass the required flow. Positioning response is 10 seconds or less.

10.4.4.4 Design Evaluation

10.4.4.4.1 Performance Evaluation

1. The Nuclear Steam Supply System is capable of taking load changes of 10 percent step from steady state conditions or of 5 percent per minute without reactor trip. The dump system is designed to accept a turbine load change from full power to station auxiliaries which are about 5 percent of full load. As the reactor is capable of taking an initial step load change of 10 percent, the steam dump system design capacity must be 85 percent of the full load.

   The 85 percent system design capacity is provided by 3 subsections as follows. The size of the condenser and the limitation on condenser vacuum limit steam dump to the condenser to 40 percent of full load. The power operated relief valves which are provided in the main steam system (Section 10.3) provide an additional 10 percent steam dump to the atmosphere. The remaining 35 percent steam dump capacity is provided by the nine atmospheric dump valves on the common header.

   Excess steam for turbine load reductions up to 50 percent of full load is dumped to the condenser. If the condenser is unavailable, steam is dumped to the atmosphere.

   All the dump system valves open for a 95 percent step load reduction on the turbine. The valves modulate to close as reactor power is reduced to match the turbine load. The closing sequence is arranged for the condenser dump valves to close last. Only the required number of dump valves open simultaneously for turbine step load changes between 10 percent and 95 percent.

For 100 percent step load reduction on the turbine (turbine trip), the reactor is tripped. Steam generated by the stored and residual heat is dumped to condenser and/or atmosphere depending upon the availability of the condensers.

2. Safety of the plant is maintained under all conditions of plant operation. The steam dump system is not essential to the safe operation of the plant; it is designed to give the plant operating flexibility. The power operated relief valves which provide 10 percent steam dump capacity do have a safety function. These valves assure controlled cooldown of the reactor when condenser and atmospheric dump valves cannot be used. In the event of a 95 percent load loss on turbine and the unavailability of steam dump system, the safety valves protect the steam generators from overpressurization.

3. Loss of condensate is minimized by arranging steam dump controls for preferential operation of the condenser dump valves.

For up to 50 percent step load changes, none of the atmospheric dump valves open. However, in the event of a step load change greater than 50 percent, required number of atmospheric dump valves open simultaneously with the condenser dump valves. However, they modulate to close first leaving the condenser dump valves to close last.

4. Electrical output of the plant is not affected because of any unexpected maintenance required on the dump valves. The valves are provided with isolation valves in case maintenance of the dump valves is required. Access provisions are made to reach conveniently every dump valve.

5. Steam leakage under normal plant operation is limited by specifying all the valves with a high degree of leaktightness. This reduces the radioactive releases within the plant when operating with some radioactivity in the steam system. Increased valve life and reduced maintenance also result from leaktight valves. The valves are required to be tested by the manufacturer for leaktightness according to MSS-SP.61, a publication of Manufacturers Standards Society of the Valve and Fittings Industry.

10.4.4.4.2 Single Active Failure Evaluation

All the valves are specified such that the maximum steam flow through the inadvertent opening of a steam dump system valve will not exceed 970,000 lbs/hr at 1200 psia. Section 15.2.13 of RESAR-3 shows that there will be no return to criticality after trip in the event of a spurious opening of any valve in the system.

10.4.4.4.3 Design Code Evaluation

The power operated relief valves are located upstream of the main steam stop valves. The code designation for the power operated relief valves and their associated piping is in accordance with the ANS "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants."

The atmospheric dump valves and condenser dump valves have no safety function and hence are designed according to the ANSI standards given in the criteria.

10.4.4.4.4 Evaluation of Environmental Design Criteria

During normal operation of the steam dump system, the radioactive release to the atmosphere is limited by the technical specifications on reactor coolant leakage, and reactor coolant activity level. The dose levels at the exclusion distance during plant operation with leaking steam generator tubes can be maintained below the limits specified in 10 CFR 20 as shown in Section 12.4. In the event of a steam dump system pipe break the limits of 10 CFR 100 can be met as shown in subsection 15.4.2.

10.4.4.5 Inspection and Testing

The steam dump system will be functionally tested during unit startup. Normal operating system performance monitoring will detect any deterioration in the performance of system components and will be corrected by appropriate means as necessary.

All steam dump system valves are tested for leakage according to MSS-SP-61 by the manufacturer. The system is hydrotested during unit startup.

10.4.5 CIRCULATING WATER SYSTEM

10.4.5.1 Design Bases

The circulating water system is a once-through system supplying cooling water from the sea to the condensers. The design parameters for this system are listed in Table 10.4.5-1, Circulating Water System Design Parameters.

10.4.5.2 System Description

The circulating water system consists of six independent parallel flow paths as shown on the system layout in Figure 10.4-2. Each flow path contains seawater intake equipment consisting of trash racks, screens, circulating water pump, piping and instrumentation. The design data for the system components are given in Table 10.4.5-2. The seawater enters the circulating water system pump chamber through fixed trash racks and motor operated traveling screens. The circulating water pump intakes the seawater from the pump chamber and discharges to the condenser water box. The condenser consists of three twin bank surface condensers, each bank being supplied by a single pump. In the event one of the flow paths is out of service, adequate heat removal from the condenser will be possible if the load generation is reduced. The seawater is discharged from the condensers through six separate parallel pipes. These lines conduct the seawater to six square cross-over conduits, which discharge into a common catchment basin located near to but separate from the platform.

Control of marine growth through the circulating water system will be accomplished by sodium hypochlorite generators which will discharge into the intake chambers (refer to subsection 9.3.7).

Water level and pressure sensors will be located in strategic areas for detection of a pipe failure in the circulating water system. These detection devices will automatically trip the pump associated with the pipe which has failed.

TABLE 10.4.5-1

CIRCULATING WATER SYSTEM DESIGN PARAMETERS

Flow	890,000 gpm
Waste Heat, BTU/hr @ 100% Load capacity	7.5×10^9 BTU/hr
Cooling Water Temperature Rise, F	16.5 F

The materials chosen for the circulating water system will be suitable for seawater application

TABLE 10.4.5-2

CIRCULATING WATER SYSTEM COMPONENTS

DESIGN DATA

Name	No	Design Flow GPM
Circulating water pumps (Vertical, Mixed Flow, Single-stage)	6	150,000
Screen washing pumps (Horizontal, Centrifugal, Single-stage)	2	1,200
Trash pumps (Centrifugal, Single-Stage)	2	1,300
Traveling Screens	6	150,000

10.4.6 MAIN CONDENSATE FEEDWATER SYSTEM

The main condensate feedwater system is shown on Figures 10.4-3 sheets 1 through 4. The feed heater drains and vents system is shown in Figures 10.4-4 sheets 1 and 2.

10.4.6.1 Function

The main condensate feedwater system returns the condensed steam from the main condensers and the drains from the regenerative feed heating cycle to the steam generators while maintaining the feedwater inventories throughout the cycle.

10.4.6.2 Design Bases

10.4.6.2.1 Performance Criteria

1. The main condensate feedwater system shall maintain the feedwater inventories throughout the cycle during steady state and normal design transient conditions including load rejections up to 95% and thus prevent reactor trip due to low level in the steam generator.

2. Uniform feedwater temperature to all four steam generators shall be maintained under normal plant operating conditions.

3. The main condensate and feedwater system shall provide sufficient storage capacity of feedwater to compensate for the loss of feedwater due to atmospheric steam dump, steam generator blowdown, and the shrinkage of feedwater inventory due to load changes.

4. The main condensate feedwater system shall perform its safety related functions.

5. The main feedwater piping shall be designed for limiting environmental conditions as provided in the design codes specified in Section 10.4.6.4.2.

10.4.6.2.2 Design Codes

1. Those sections of the main condensate feedwater system classified by the ANS in "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants," N-18.2, January 1972 and shown on flow diagram 10.4-3 sheet 4 comply with "ASME Boiler and Pressure Vessel Code - 1971, Section III, Nuclear Power Plant Components, Summer 1972 Addenda."

2. The balance of the components shown on flow diagrams 10.4-3 sheets 1 through 4 and 10.4-4 sheets 1 and 2 comply with "ASME Boiler and Pressure Vessel Code - 1971, Section VIII" and "ANSI B31.1 - 1967, Power Piping" as appropriate.

10.4.6.3 System Description

The condensate feedwater cycle is a closed system in which the condensate is deaerated in the main condensers. Condensate from the condenser hotwell is pumped by three 33-1/3 percent capacity motor driven pumps through the steam jet air ejector condensers, gland condenser, flash evaporators and five stages of low pressure feedwater heaters to the suction header of two 50 percent capacity steam-turbine driven main feedwater pumps. The feedwater is then pumped through one stage of high pressure feedwater heaters and into a collecting header. Feedwater enters the containment through the four lines penetrating the containment wall, one line feeding each steam generator. The penetration details are discussed in Section 3.6.2.7.

Steam from the first stage extraction points of the high pressure turbine is routed to the high pressure feedwater heater shells, designated as No. 1 H-P (High Pressure) heaters. The succeeding feedwater heaters are numbered in ascending order. The No. 5 and 6 L-P (Low Pressure) heaters are rated 33-1/3 percent capacity each and are arranged in three parallel strings. The remaining feedwater heaters 4, 3, 2 and 1 are arranged in two parallel strings. Automatic bypass and block valves are provided around each string of feedwater heaters.

Feed flow regulation to each steam generator is achieved by the combination of a variable speed drive for the main feed pump and a feed flow regulating valve. The control logic of the three element system and the control of speed of the main feed pump drive is presented in RESAR 3, Subsection 7.7.1.7.

Chemical Additives

Diluted solutions of morpholine or equivalent and hydrazine are added to the feedwater downstream of the condensate pumps to control the pH and dissolved oxygen content of the feedwater respectively. Phosphate solution is added to the feedwater at each feed inlet line to the steam generators, to control scale formation in the steam generator in the event of contamination due to circulating water system leakage into the condenser.

Routing of Feedwater Heater Drains

Drains from the second stage reheater tube bundles cascade to the No. 1 high-pressure (H-P) heaters. Drains from these heaters, the first stage reheater tube bundles and moisture separators cascade to the H-P drain tank. Flashed steam from the H-P drain tank is vented to No. 2 low pressure (L-P) heaters. Drains from No. 2 L-P heaters are led to the H-P drain tank, from which the condensate is pumped by two 50 percent capacity H-P drain pumps to the main feedwater pump suction header. Drains from the No. 3 L-P heater cascade to the L-P drain tank. Flashed steam from the L-P drain tank is vented to the No. 4 L-P heaters. Drains from the No. 4 L-P heaters are led to the L-P drain tanks, from which the condensate is pumped by two 50 percent capacity L-P drain pumps into the condensate feedwater system between No. 4 and No. 3 L-P heaters. Drains from the No. 5 L-P heaters cascade to the No. 6 L-P heaters. Drains from the No. 6 L-P heaters are led to the condenser. The heater numbers 1, 3, 5, 6 and H-P and L-P drain tanks drain to the condenser hotwell in case of high water levels.

10.4.6.4 Design Evaluation

10.4.6.4.1 Performance Evaluation

1. The Nuclear Steam Supply System is capable of accepting transients of 10 percent step load change or 5 percent per minute of ramp load change without reactor trip. In order to prevent flashing and tripping of H-P and L-P drain pumps under normal design transient conditions, cold water from the condensate pumps is injected continuously to the suction lines of the H-P and L-P drain pumps. During a transient condition of 95 percent load rejection, the condensate feedwater system loses the heater's drain flow from the H-P and L-P drain pumps. To prevent reactor trip, the condensate pumps are able to run out to provide feedwater corresponding to 96 percent of maximum calculated flow to the feed pump suction. The main feedwater pumps are designed to deliver the feedwater flow for the increased steam generator pressure of approximately 100 psi during this transient with the feed regulating valve fully open.

2. In order to ensure uniform feedwater temperature to all the four steam generators, the piping layout downstream of the No. 1 H-P feedwater heaters will be arranged in such a way to ensure mixing of the feedwater from the No. 1 H-P heaters and its bypass.

3. The three condenser hotwells provide a total capacity of 158,000 gallons of condensate to compensate for the loss of feedwater due to atmospheric steam dump. The steam dump system is presented in subsection 10.4.4 and the main condenser description is presented in subsection 10.4.1. The condensate storage tank provides the makeup to the condensate feedwater system to compensate for the loss of feedwater due to steam generator blowdown and the shrinkage of feedwater inventory due to load changes. The condensate storage facility is presented in subsection 9.2.5.

4. In the event of main steam line break incident, it is necessary to isolate the feedwater flow to all the four steam generators. The isolation of feedwater flow to the steam generators is achieved by the safety injection signal. The redundant safety sequence signals actuate the closure of all the main feed regulators, trips the main feed pumps and closes the main feed pump discharge valves, thus ensuring the isolation of feedwater supply to the steam generators. In the event of high water level in any one of the steam generators due to the malfunction of the main feed regulator, the high-high level signal in the steam generator will trip the main feed pumps and close the main feed pump discharge valves.

10.4.6.4.2 Design Code Evaluation

The sections of the main condensate feedwater system which have safety functions are classified according to guidelines of ANS.

The feedwater piping downstream from and including the check and stop valves up to the steam generator is designated ANS Safety Class 2 and complies with ASME Boiler and Pressure Vessel Code, Section III.

10.4.6.5 Environmental Design Evaluation

The maximum radioactivity on the secondary side of any steam generator is specified in the technical specifications.

10.4.6.6 Inspection and Testing

Inspection and testing during manufacturing are in accordance with the applicable ASME codes and other regulatory bodies' requirements. Detailed requirements will be specified in the component specifications. Specifically, the inspection and testing requirements during manufacturing for main feed check and stop valves are in accordance with ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Power Components."

No inservice inspection is required by the ASME Boiler and Pressure Vessel Code Section XI.

10.4.6.7 Auxiliary Feedwater System

The auxiliary feedwater system is shown on Figure 10.4-5.

10.4.6.7.1 Function

The auxiliary feedwater system provides feedwater to the steam generator to remove the residual heat and cool the reactor coolant system to 350°F, in case the main condensate feedwater system is not available. The system prevents water relief through the pressurizer safety valves in the event of a loss of main feedwater flow accident.

10.4.6.7.2 Design Bases

10.4.6.7.2.1 Performance Criteria

1. The auxiliary feedwater system shall ensure sufficient feedwater supply for residual heat removal from the reactor coolant during the following postulated incidents:

   a. Loss of normal feedwater supply from the main condensate feedwater system.

   b. Loss of offsite power to the station auxiliaries.

c. Malfunctions of the Condensate Feedwater System.

d. Main steam line break incident.

e. Steam generator tube rupture.

f. Small break incident in the Reactor Coolant System.

2. The auxiliary feedwater system shall perform its safety related function while sustaining a single active failure for short term operation, or a passive or active failure for long term operation.

10.4.6.7.2.2 Design Codes

The auxiliary feedwater system is designated ANS Safety Class 2 and 3 as shown on Figure No. 10.4-5 and is designed, constructed and tested to "ASME Boiler and Pressure Vessel Code, 1971, Section III" "Nuclear Power Plant Components" Summer 1972 Addenda.

The piping downstream of the recirculation orifices is designated non-nuclear safety class and is designed to "ANSI B31.1-1967-Power Piping."

10.4.6.7.3 Description

The system consists of two auxiliary feedwater storage tanks, four motor driven auxiliary feedwater pumps and one non-condensing steam turbine driven auxiliary feedwater pump located in the safeguards areas. Safeguards areas are designed to provide tornado missile protection from outside sources (ref. Sections 3.3 and 3.8). The component data are presented in Table 10.4.6.7-1.

The motor driven pumps and the steam turbine driven pump take suction from the auxiliary feedwater tanks. The suction piping to each pump is valved in such a way that the pumps can take suction from either of the two auxiliary feedwater tanks.

Each motor driven pump discharges to only one steam generator through a regulating valve. The turbine driven pump discharges to all four steam generators through regulating valves. Discharge from the two pumping systems join in a common header downstream of the last stop valves to each steam generator. A flow indicator is provided on the common header before it joins the main feed line downstream of the main feed stop valves. Remote and local instrumentation and controls are provided for local and control room operation. Alarms are provided in the control room. The motor driven pumps and their associated controls are completely separate and obtain electrical power from the engineered safeguards buses as discussed in Section 8.3.

TABLE 10.4.6.7-1

AUXILIARY FEEDWATER SYSTEM COMPONENT DATA

EQUIPMENT

Auxiliary Feedwater Tanks

Number	2
Type	Vertical, cylindrical
Capacity	200,000 Gallons each
Material of construction	Carbon Steel
Design Code	ASME Section III

Pumps

Number	4
Type	Centrifugal, multistage horizontal, splitcase
Flow rate	240 gpm
Total discharge head	3400 ft.
Drive	Electric motor 300 HP 4160 volts 3600 rpm
Material of construction	401 stainless steel
Number	1
Type	Centrigual, multistage horizontal, splitcase
Flow rate	800 gpm at 45000 rpm
Total discharge head	3400 ft
Drive	Steam turbine 1000 HP 600 psig Steam, 4500 rpm
Material of construction	401 stainless steel (pump)

Steam to the turbine drive is supplied from two of the four steam generators upstream of the main steam stop valves. The exhaust from the steam turbine is led to the atmosphere.

10.4.6.7.4 System Operation

The reactor residual heat is transferred to the steam generators by natural circulation of the reactor coolant when power is not available to the reactor coolant pumps.

The motor driven pumps automatically start on low-low level in any steam generator, loss of main feed pump, safety injection signal, or loss of off-site AC power. The turbine driven pump starts automatically on low-low level in any two steam generators or loss of offsite power. The above starting signals also close the steam generator blowdown valves. The control logic of the startup of pumps is presented in Section 7.2. Once operating, flow to the steam generator and the water level is maintained by the remote manual control valves. Flow indication at each control point enables the feed flow to be balanced.

The steam generated during the residual heat removal is discharged to the atmosphere by the atmospheric power relief valves.

10.4.6.7.5 Design Evaluation

1. The detailed analysis for the loss of normal feedwater is presented in Section 15.2.8 of RESAR 3.

   The detailed analysis for the loss of offsite power to the station auxiliaries is presented in Section 15.2.9 of RESAR 3.

   The detailed analysis for the excessive heat removal due to feedwater system malfunctions is presented in Section 15.2.10 of RESAR 3.

   The detailed analysis of main steam line incident is presented in Section 15.4.2 of RESAR 3.

   The detailed analysis of steam generator tube rupture is presented in Section 15.4.3 of RESAR 3.

   The detailed analysis of small break incident in the Reactor Coolant System is presented in Section 15.3.1 of RESAR 3.

2. Each motor driven auxiliary feedwater pump and its associated controls obtain the electrical power separately from the engineered safeguards electrical system. Any two out of the four motor driven auxiliary feedwater pumps or the steam driven auxiliary feedwater pump assures adequate feedwater supply to the steam generators for residual heat removal. An ample supply of steam to the steam driven auxiliary

feedwater pump is available from either of the redundant steam supply lines.

Instrumentation and controls are provided on the local auxiliary shutdown panel to ensure that the reactor may be brought to a safe status in the event of evacuation of the main control room.

Sufficient storage capacity is provided in the two auxiliary feedwater storage tanks to bring the reactor to a safe status during loss of normal feedwater supply. The details of the condensate storage facility are presented in Section 9.2.6.2.

10.4.6.7.6 Inspection and Testing

The components which are designated as ANS Safety Class will be inspected and tested during manufacturing in accordance with ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Power Components." Periodic testing of the auxiliary feedwater pumps is covered in the Technical Specifications.

10.4.6.7.7 Instrumentation Applications

Each auxiliary feedwater storage tank is provided with remote and local level indicators and high and low level are alarmed in the control room. Low suction pressure from each of the two suction headers is alarmed in the control room. Remote and local indication of the suction and discharge pressure of each pump is provided.

The auxiliary feedwater control valves are normally open and can be remote manually adjusted from either the main control board or the auxiliary shutdown panel to regulate the auxiliary feedwater flow to the steam generators. The valves are designed to fail open in the event of loss of actuating power. The individual flows to the steam generators are indicated in the control room and on the auxiliary shutdown panel.

10.4.7 STEAM GENERATOR BLOWDOWN SYSTEM

The purpose of the steam generator blowdown system is to provide plant operating capability should minor steam generator or condenser leakage cause contamination of the secondary side water.

10.4.7.1 Design Bases

The important operating variables that the steam generator blowdown system is intended to control are as follows:

1. Steam Generator Secondary Side Water Chemistry

   Restrictive water chemistry operating limits are specified when the plant is operating. For example, chlorides present in the secondary side water due to a condenser leak are limited to 75 ppm to minimize corrosion failures of susceptable materials. Control of chlorides is accomplished by continuously removing a small volume of the concentrated water from the steam generator by blowdown and compensating by fresh water makeup or by recovery of the blowdown.

2. Steam Generator Secondary Side Radioactivity

Leakage of primary water to the secondary side through a steam generator tube or tubes will result in activation products and, in the case of fuel cladding imperfections, fission products contaminating the secondary side water. Control of the activity concentration in the steam generator secondary water is accomplished by a process of ion exchange demineralization and by recycling of the treated effluent.

The design of the steam generator blowdown system assumes that contamination of the secondary side water may occur from either ocean water or primary water. The maximum inleakage contaminating flow rates at which the plant can continue to operate are as follows:

1. Ocean Water Leakage Only

   Up to 1.2 gpm from the main condensers.

2. Primary Water Leakage Only

   Up to 0.1 gpm from the main steam generator if the maximum activity concentration in the primary water does not exceed the equivalent of 1% defective fuel (see RESAR, Rev. 3, Table 11.1-2).

3. Ocean and Primary Water Leakage

A combination of leakage from the main condensers and steam generators where the ocean water leakage does not exceed 0.2 gpm and the primary water leakage does not exceed 0.1 gpm with activity concentrations equivalent of 1% defective fuel.

10.4.7.1.1 Performance Requirements

The major performance requirements are that liquid effluents will have a minimum effect on the environment when discharged to the ocean; safe working conditions are provided through minimum personnel exposure of contained radioactivity in the system; and continued plant operations are possible with trace contaminating inleakage to the secondary water.

10.4.7.1.2 Sampling Criteria

Sampling stations are provided in various locations in the blowdown system to determine operating conditions and the operating performance of component equipment. Operating conditions of interest are primarily the detection of radioactivity by sample analysis of gross beta and gamma or of specific isotopes. Operating performance is primarily concerned with determining the accuracy of instruments (radiation monitors) and performance of the demineralizer resin beds.

For obtaining information for operator decisions and for determining system operating conditions sample stations are required in the following blowdown locations:

Heat Exchangers (Downstream) - tube side process water activity
(Downstream) - shell side cooling water activity

Holdup and Sample Tanks - treated process water activity

Backwash Receiving Tanks - backwash water activity

For obtaining information on component demineralizer resin bed performance sample stations are required upstream (inlet header) and downstream for each resin bed.

10.4.7.1.3 Isolation Criteria

The blowdown system design provides for isolation at the containment boundary through automatic closure of valves. The following signals will automatically close the valves:

1. Containment Isolation Signal

2. Blowdown System control function failures

   Pressure Instrumentation (High Pressure)

   Temperature Instrumentation (High Temperature)

   Flow Instrumentation (High Flow)

   Radiation Monitors

3. Air Ejector Discharge Activity Indication (Initial Isolation Only)

4. Blowdown System Liquid High Activity after Demineralizer

10.4.7.1.4 Design Codes and Component Parameters

The codes and classifications for the steam generator blowdown system equipment components governing the mechanical design are indicated in Table 10.4.7-1. The major components parameters are indicated in Table 10.4.7-2.

10.4.7.1.5 Environmental Design Criteria

The operation and control of the steam generator blowdown system is designed to have a minimum influence on the environment when liquid effluents are routed to the circulating cooling water for dilution and discharge to the ocean. The blowdown system liquid effluents have two categories

TABLE 10.4.7-1

STEAM GENERATOR BLOWDOWN SYSTEM

CODES AND CLASSIFICATIONS

Component	Design Code	Safety Class
Steam Generator Blowdown Heat Exchangers	ASME VIII	NNS
Steam Generator Blowdown Holdup & Sample Tanks	AWWA D-100 or ASME III	NNS
Steam Generator Blowdown Backwash and Receiver Tank	AWWA D-100 or ASME III	NNS
Steam Generator Blowdown Cation Demineralizer Tanks	ASME VIII	NNS
Steam Generator Blowdown Mixed-Bed Demineralizer Tanks	ASME VIII	NNS
Steam Generator Blowdown Sample and Mixing Pumps	ASME III, Class 3	NNS
Steam Generator Blowdown Backwash and Receiving Discharge Pump	ASME III, Class 3	NNS

TABLE 10.4.7-2

STEAM GENERATOR BLOWDOWN SYSTEM

MAJOR COMPONENT PARAMETERS

Steam Generator Blowdown Sample & Mixing Pump		
Number		2
Design Pressure, psig		150
Design temperature, °F		140
Design flow, gpm		75
Steam Generator Blowdown Backwash & Receiving Discharge Pump		
Number		1
Design Pressure, psig		150
Design temperature, °F		140
Design flow, gpm		75
Steam Generator Blowdown Heat Exchanger		
Number		4
System heat load		51×10^6 BTU/Hr
System cooling water flow		4000 gpm
	Shell Side	Tube Side
Fluid	Cooling Water (NSW)	Blowdown Water
Material	Carbon Steel	Stainless

TABLE 10.4.7-2 (Continued)

Steam Generator Blowdown Holdup and Sampling Tank	
Number	2
Capacity, gal./tank	12000
Design Pressure	Atmospheric
Design temperature, °F	140
Steam Generator Blowdown Backwash & Receiving Tank	
Number	1
Capacity, gal.	3000
Design Pressure	Atmospheric
Design temperature, °F	140
Steam Generator Blowdown Cation Demineralizer	
Number	2
Design Pressure, psig	150
Design temperature, °F	140
Design flow, gpm	50
Resin volume, ft^3	50
Steam Generator Blowdown Mixed-Bed Demineralizer	
Number	2
Design Pressure, psig	150

TABLE 10.4.7-2 (Continued)

Design temperature, °F	140
Design flow, gpm	50
Resin volume, ft^3	84

of criteria for the control of discharged streams.

1. No Activity (less than 10^{-4} $\mu c/ml$ before dilution.

The environmental variables of concern in the blowdown stream are as follows:

Temperature - 200°F before dilution. This blowdown temperature will increase the circulating cooling water temperature by less than 0.1°F at a flow of 600,000 gpm cooling water.

Oxygen Depletion - The blowdown system will have essentially zero oxygen and a few ppm of hydrazine. Upon dilution the oxygen depletion will be less than 0.01 ppm in the circulating cooling water.

Phosphates - 0.01 ppm or less after dilution in the circulating cooling water.

Nitrates or Chromates - zero, no nitrates or chromates are used in the steam generator water.

For the system variables, temperature, oxygen depletion and phosphates, the indicated limits in the circulating cooling water are considered to have no influence on the environment.

2. Activity Present

The environmental variables of concern in the blowdown stream are as follows:

Temperature - $120^{\circ}F$ or less before dilution. After mixing with the blowdown water the circulating cooling water will experience a temperature rise due to this input of less than $0.1^{\circ}F$.

Oxygen Depletion - Upon dilution, the oxygen depletion of the cooling water will be less than 0.01 ppm. Hydrazine is reduced in blowdown stream by the demineralizers. Also some oxygen is absorbed from the air by water when the stream is diverted to the sampling tanks before discharging.

Phosphates - About zero. Phosphates are removed by the demineralizers before discharging and dilution.

Boron - <0.1 ppb in the blowdown stream after the demineralizers and dilution or about zero (not detectable in the circulating cooling water).

Activity - Normally 10^{-9} μc/ml or less after the demineralizers and dilution in the circulating cooling water.

For the system variables; temperature, oxygen, depletion, phosphates and boron; the indicated limits in the circulating cooling water are considered to have no environmental effect. The activity variable is less than present or proposed standards.

10.4.7.1.6 Primary to Secondary Leakage

Leakage is indicated in Section 10.4.7.1, Design Bases.

1. Radioactive Discharge Rates

The release of radioactivity in liquids from the blowdown system will be minimized by recycling and recovering the normally discharged waste stream. During normal operation of the blowdown demineralizers the treated liquid will have an expected activity concentration of less than 10^{-4} μc/ml which, if not returned to condensate storage, may be discharged to the ocean provided the circulating cooling water flow is a minimum of 600,000 gpm. If the blowdown demineralizer effluent activity exceeds 10^{-4} $\mu c/ml$ the liquid will automatically be diverted to a sample tank. The activity of the collected liquid will be analyzed and the release rate, based on the laboratory activity analysis, will be determined. The release rate, then will be limited so as not to exceed site boundary governing regulations.

The release of tritium is not included in any of the radioactivity concentrations mentioned above or in other paragraphs in this section. With recycle and recovery of the blowdown liquid the concentration of tritium at the site boundary will be controlled so that it is less than governing regulations.

2. System Performance - High Leakage

The blowdown system design is based on processing liquid from the steam generators where a primary to secondary leak of up to 0.1 gpm is possible and fission products are present from fuel defects of 1%. Exceeding the leakage rate of 0.1 gpm when the fuel defects are proportionally less than 1% is not considered an environmental or operational limiting situation. Processing the blowdown stream through the system's demineralizers during this condition will produce an effluent with an activity concentration of 10^{-4} μc/ml or less. The design assumes that the demineralizer resin beds will exhaust faster due to an increase of ionized solids in the blowdown stream requiring a more frequent resin replacement. The exhaustion rate of the demineralizer resin beds with a leak greater than 0.1 gpm depends on the fuel cycle and, therefore, the concentration of boron in the primary water. Toward the end of a fuel cycle the boron concentration will be low and the increase in ionized solids would have a negligible effect on the rate of resin exhaustion.

Should the increase of primary water leakage occur when fuel defects are about 1% and the leakage rate exceeds 0.1 gpm there will be an increase in secondary system activity proportional to the increase in primary water leak rate. Liquid activity in the treated blowdown from the demineralizers is not expected to increase appreciably due to the conservative design capacity of the resin beds. Exceeding 10^{-4} μc/ml after the demineralizers, though, will cause the flow to be diverted to sample tanks. Depending on the activity level of the sample tank water (based on laboratory analysis) and the circulating cooling water flow rate (greater than 600,000 gpm) the plant operation may or may not be influenced.

For example, should the activity in the sample tanks be exceptionally high due to malfunction of the demineralizers at the higher leak rate, the release rate of radioactive liquid from the plant would be reduced. The system blowdown rate would also have to be reduced for this operating mode, due to the sampling tank's maximum volume.

3. Steam Generator - Shell Side Activity

The radioactivity concentration on the shell side of a steam generator after shutdown of the system is not firmly predictable due to the number of variables affecting its determination. Some of the variables include:

Operation period or life of the core

Rate and length of time of primary water leakage

Fission and activation products in primary leakage

Plateout or incorporation of activity in metallic corrosion products

Activity absorbed in secondary water sludge

In lieu of a predictive technique or model to quantify the concentration of activity in the shell side of the steam generator after isolation the experience of operating plants is substituted. This experience indicates the shell side radioactivity concentration is equivalent to radiation level after isolation, of 5 to 100 mr/hr in operating areas.

10.4.7.2 System Description

The steam generator blowdown system flow diagram is shown in Figure 10.4-6. (The written section supersedes the flow diagram.)

Operation with No Appreciable Activity in Blowdown

The blowdown is routed to the system heater exchangers (tube side) and cooled to 200°F by cooling water on the shell side from the non-essential service water system. After cooling, the fluid pressure is reduced from approximately 1000 psig to less than 150 psig. The blowdown flow rate is determined and controlled by the concentration of chlorides in the steam generator if condenser leakage is present; or set at a minimum rate of about 5 gpm per steam generator (a maximum blowdown capability of 75 gpm is provided for each steam generator). The blowdown flow is monitored for activity, and if not detected, the flow is routed to the circulating cooling water for dilution and discharge to the ocean. If activity is present, the system will be isolated by a signal from the radiation monitors.

Operation with Measurable Activity

When activity is detected in either the blowdown fluid or the air ejector off-gas discharge the blowdown system will be isolated. The operator manually restarts the system to determine which steam generator (or generators) is leaking by processing and analyzing the flow from each steam generator separately. The system flow rate based on activity in the leaking steam generator(s) is reset and the blowdown stream processed, by routing it through two cation demineralizer resin beds in series and two mixed bed demineralizers in series. A DF of 100 is used for design of activity removal by the four beds in series. The activity of the treated effluent is determined by a radiation monitor and if it is less than 10^{-4} μc/ml the treated effluent can be routed to the circulating cooling water for dilution and discharge to the ocean. If, in addition, the conductivity of the treated effluent is less than one micromho/cm the stream can be routed to condensate storage for plant reuse. If the activity should exceed 10^{-4} μc/ml, the flow will automatically be routed to one of two holdup and sampling tanks. Further laboratory analysis of this liquid will provide information on whether the liquid can be returned to condensate storage or on the allowable release rate to the circulating cooling water for discharge to the ocean.

The two cation demineralizer resin beds when operating in series will also function as filters to remove particulate or insoluble materials. As such, the cation resin beds will require occasional backwashing. This waste stream is recovered in a backwash receiving tank where the solids are allowed to settle and the clarified water decanted for return to condensate storage by reprocessing or discharge to the circulating cooling water after sampling and laboratory analysis.

The demineralizer cation and mixed bed resins are not regenerated with acid and caustic, but are used on a once through exhaustion cycle. When the ion exchange capability is exhausted, the resin bed will be sluiced to the liquid waste treatment system for fixation, drumming and disposal. During this period of resin transfer it will be possible to operate the demineralizers as three beds in series. Additional flexibility is also provided in that the demineralizers can be operated as a two bed system of cation resin and mixed bed resin. New resins are then added as replacement to the empty demineralizer tank at which time the new resin bed becomes the second unit for series operation when the demineralizer is returned to service. The liquid waste treatment system will also receive the settled sludge from the backwash receiving tank for fixation and drumming.

10.4.7.3 Safety Evaluation (Design Evaluation)

The system components that could fail and cause a safety related situation outside of the containment are considered in the following groupings.

10.4.7.3.1 Instruments and Controls

1. Temperature control is maintained downstream of the blowdown heat exchangers by control of the cooling water flow from the non-essential service water system. Failure of the temperature controller would release $>500^{o}F$ water to the circulating cooling water system or to the blowdown system demineralizer resin beds. Containment of this failure is expected by the installation of a second temperature sensing element downstream of the primary element which will isolate the system when higher temperatures other than those of the set points on the primary instrument are sensed.

2. Pressure control is maintained downstream of the system temperature control instrumentation. Failure of the pressure controller will subject the downstream equipment designed for 150 psi to about 1000 psi pressure. Protection of the downstream equipment is provided by a relief valve which discharges to the main condenser hotwell. To minimize the contamination of condensate in the hotwell when the blowdown system is processing water with radio-

activity, a flow element is located downstream of the relief valve. When this flow element senses flow, it will cause the blowdown system to be isolated.

3. Flow control for the system is provided downstream of the pressure control instrumentation. Failure of the flow control instrumentation is not expected to impair the system due to self regulating components (orifice plate, control valve, etc.) which increase the system pressure losses as the maximum flow is approached. The maximum flow after a loss of one flow controller is about 200 gpm/steam generator which would increase the system's maximum blowdown rate to about 425 gpm if the system's blowdown rate was initially established at 300 gpm. When blowdown is routed to the circulating cooling water for discharge, the increase in flow from design, 300 gpm, to 425 gpm for a short time is not expected to influence the environment.

4. Radiation liquid process monitors are provided to detect activity in the blowdown stream that is either being routed to the circulating cooling water for discharge or being routed to the condensate storage for recovery.

   Should the monitor fail when the blowdown stream routed to the circulating cooling water, the monitor for air ejector off-gas provides a backup if there is an increase in activity. In practice the air ejector off-gas monitor will probably detect activity and changes in activity in the secondary side before the liquid monitor in the blowdown stream.

Should the monitor for the stream routed to condensate storage fail, low level activity will enter the condensate storage tank. This low level of activity will be detected in the daily sample of water when analyzed in the lab. The period of time for this operating condition to continue would, therefore, be about one day. It is expected that the activity of this return water to condensate storage will be about 10^{-4} μc/ml or less. Higher activities will probably result should the system's demineralizer beds be exhausted at this time. It is expected though that with exhausted resin beds there will also be an increase in conductivity which will stop the flow to the condensate storage tank by closing the return valve.

10.4.7.3.2 Blowdown Heat Exchangers

Failure of a tube or tubes in the system's heat exchangers would allow blowdown water with radioactivity (i.e. if a steam generator tube fails) to enter the closed loop non-essential service water systems. This leakage will be detected by the radiation monitor in the non-essential service water system or by the increased water level in the system's surge tank. The leaking heat exchanger can then be found based on the results of water samples obtained from the shell side of each heat exchanger.

10.4.7.3.3 Demineralizers

The demineralizer tanks have underdrain screens or strainers which support the ion exchange resin beds. Should a failure of the underdrain occur, resins with absorbed radioactivity would be discharged from the tank. Since the four demineralizer units operate in series it is only the last unit in the train that would discharge resins to downstream equipment. An underdrain failure in any of the first three units would discharge resins to the following unit. In this situation the blowdown system would be shutdown while the resins are discharged to the liquid waste system. For the occurrence of an underdrain failure in the fourth train unit a strainer is installed downstream to collect the resins. These resins can then be flushed from the strainer to the backwash receiving tank and eventually be sent to the liquid waste system for disposal.

10.4.7.4 Tests and Inspections

Shop tests and inspections will be performed by the manufacturer and witnessed by Quality Assurance. The shop tests are to assure and demonstrate code conformance and capability to perform required function(s).

After installation of the system, performance tests will be required with nonradioactive water to demonstrate that the system complies with or meets design and/or purchase specifications.

10.4.7.5 Instrument Application

Instrumentation for process control of the blowdown system is reviewed under the following functional control modes (refer to Figure 10.4-6).

Temperature

Each steam generator blowdown line will be monitored for temperature downstream of the blowdown heat exchangers. The temperature will be controlled to either of two operating requirements, 200°F or 120°F, depending on the contamination present in the blowdown water. For contamination only with ocean water (condenser leak) the set point temperature will be 200°F, whereas, with contamination due to radioactivity (steam generator tube leak) the control temperature will be 120°F.

The output signal from the temperature controller will be used to set a control valve in the non-essential service cooling water line to the exchanger. Exceeding the set point temperature will alarm in the main control room and isolate the steam generator blowdown lines.

Pressure

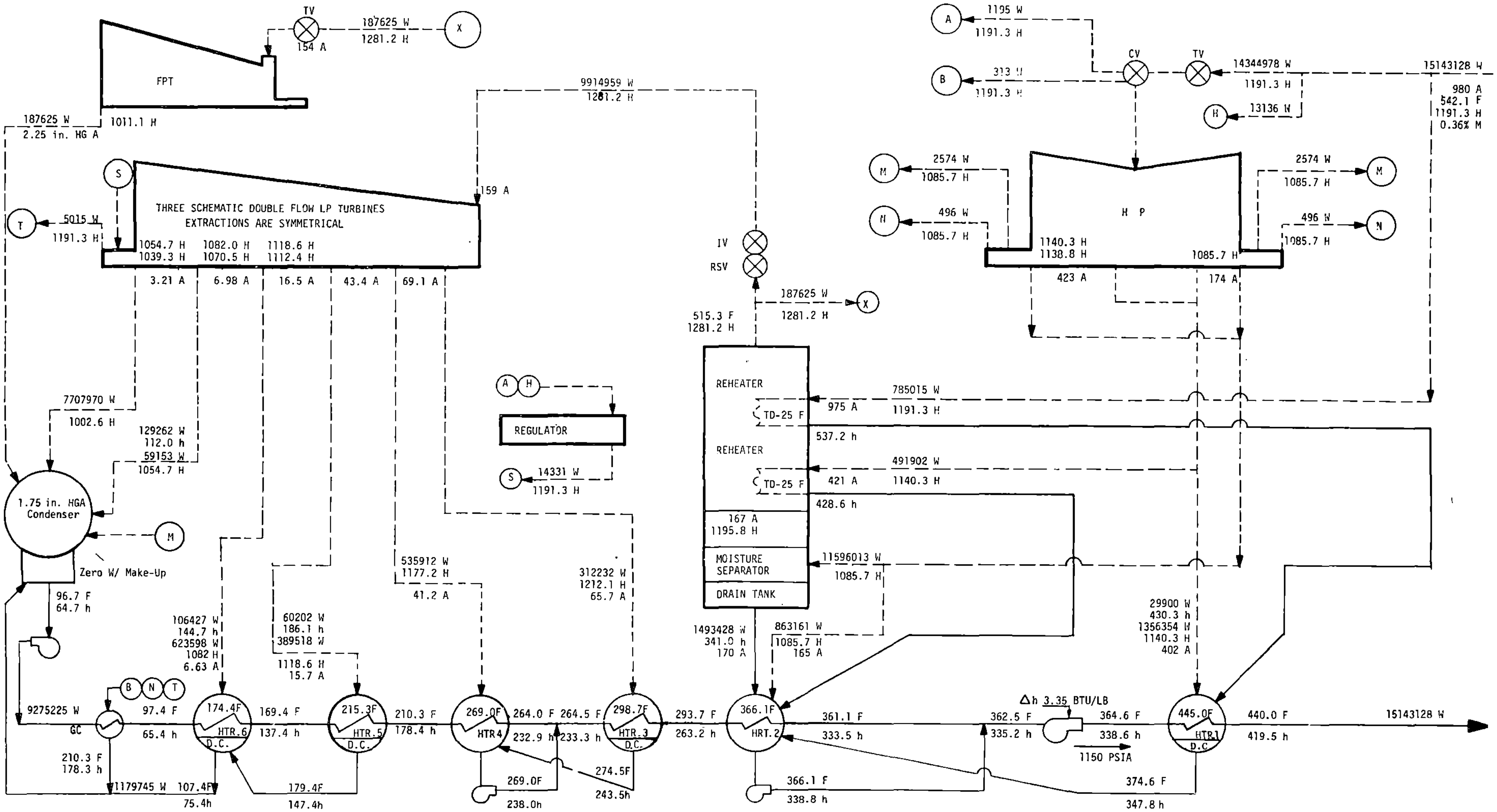
Downstream of the temperature control station the blowdown system pressure of 1000 psig will be reduced to less than 150 psig. Each steam generator blowdown line will have a pressure sensing element and controller, the output signal of which will control a pressure reducing valve.

Flow

Following the temperature and pressure control stations in each steam generator blowdown line, flow control is provided. The range of flow that requires control is from 5 to 75 gpm. Two flow elements, therefore, are provided one with a range of approximately 5 to 20 gpm, and a second with a range of approximately 20 to 80 gpm.

Radiation Monitors

Two process radiation monitors are required for the blowdown system (see Section 11.4 for the monitor details) for detecting radioactivity. One



NET HEAT RATE	$\frac{15143128\ (1191.3 - 419.5)}{1211469}$ = 9647 BTU/KWHR

(1) CALCULATIONS ARE BASED ON NO RADIATION LOSSES TO HEATERS OR EXTRACTION PIPING LOCATED IN THE CONDENSER NECK.
(2) CALCULATIONS ARE BASED ON 1967 ASME STEAM TABLES.
(3) PRIMARY VALVE AND ABOVE HEAT RATES ARE CALCULATED ON LOCUS OF VALVE POINTS.
(4) STM. GEN. FLOW AT MAX. GUAR. LOAD = 15143128 LB/HR.
STM. GEN. FLOW AT MAX. CALC. LOAD = 15900285 LB/HR.

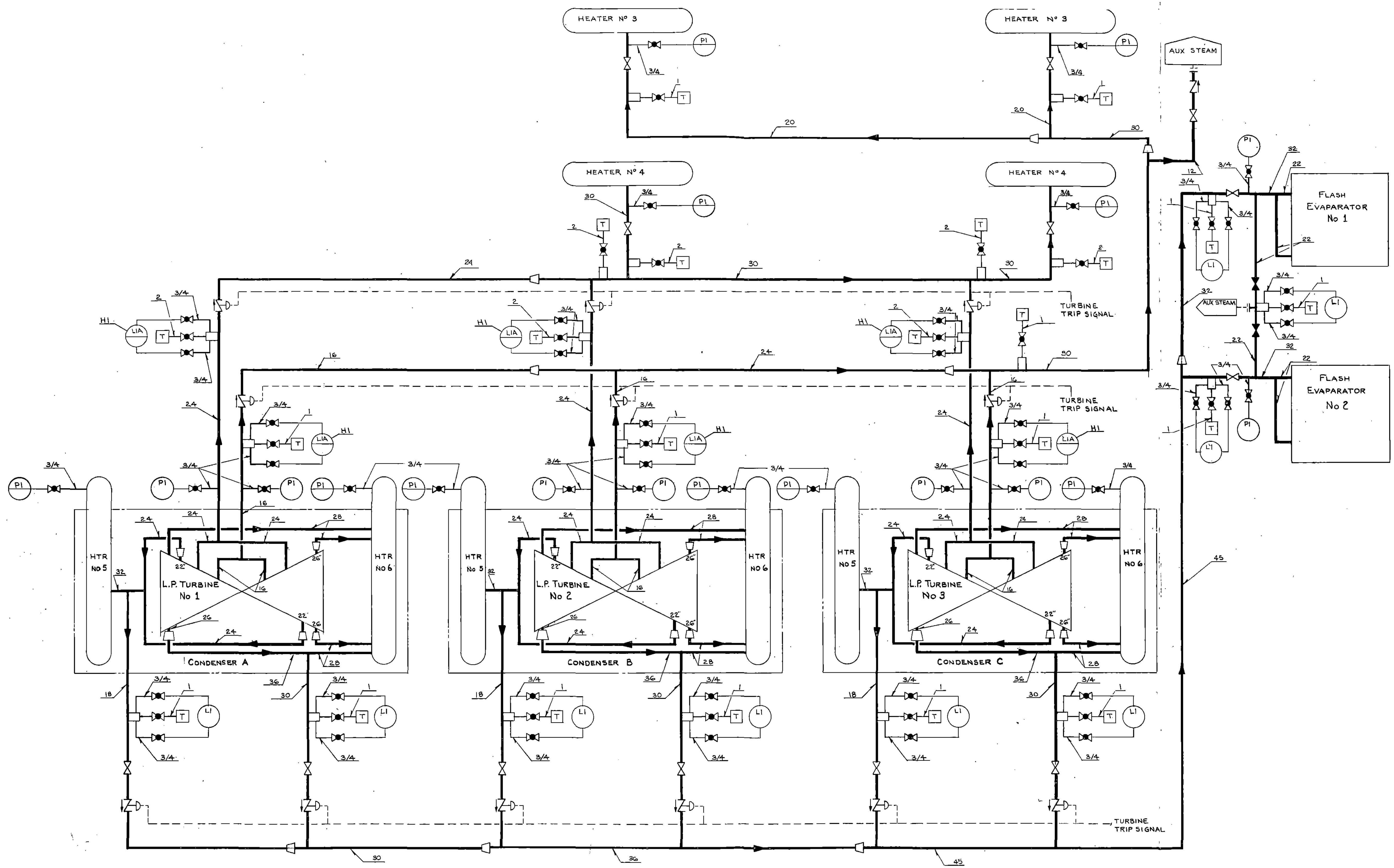
TEP	= 1002.4 BTU/LB
ELEP	= 987.8 BTU/LB
MECH. LOSS	= 4040 KW
ELECT. LOSS	= 14541 KW
	0.90 PF MIN H_2
FP POWER	= 14854 KW
FP EFF.	= 75%
TYPE	= TC6F-44

NAME PLATE RATING
1211469 KW TURBINE-GENERATOR UNIT
980 PSIA 542.1 F 1.75 IN. HG A
1402000 KVA 0.90 PF 25000 VOLTS 75# H_2

1211469 KW NET LOAD HEAT BALANCE
MAXIMUM GUARANTEED

REF: LTD. DWG. AB018 - 1094 A

OFFSHORE POWER SYSTEMS
Title: TURBINE-GENERATOR HEAT BALANCE
11/1/72
Figure: 10.1-1

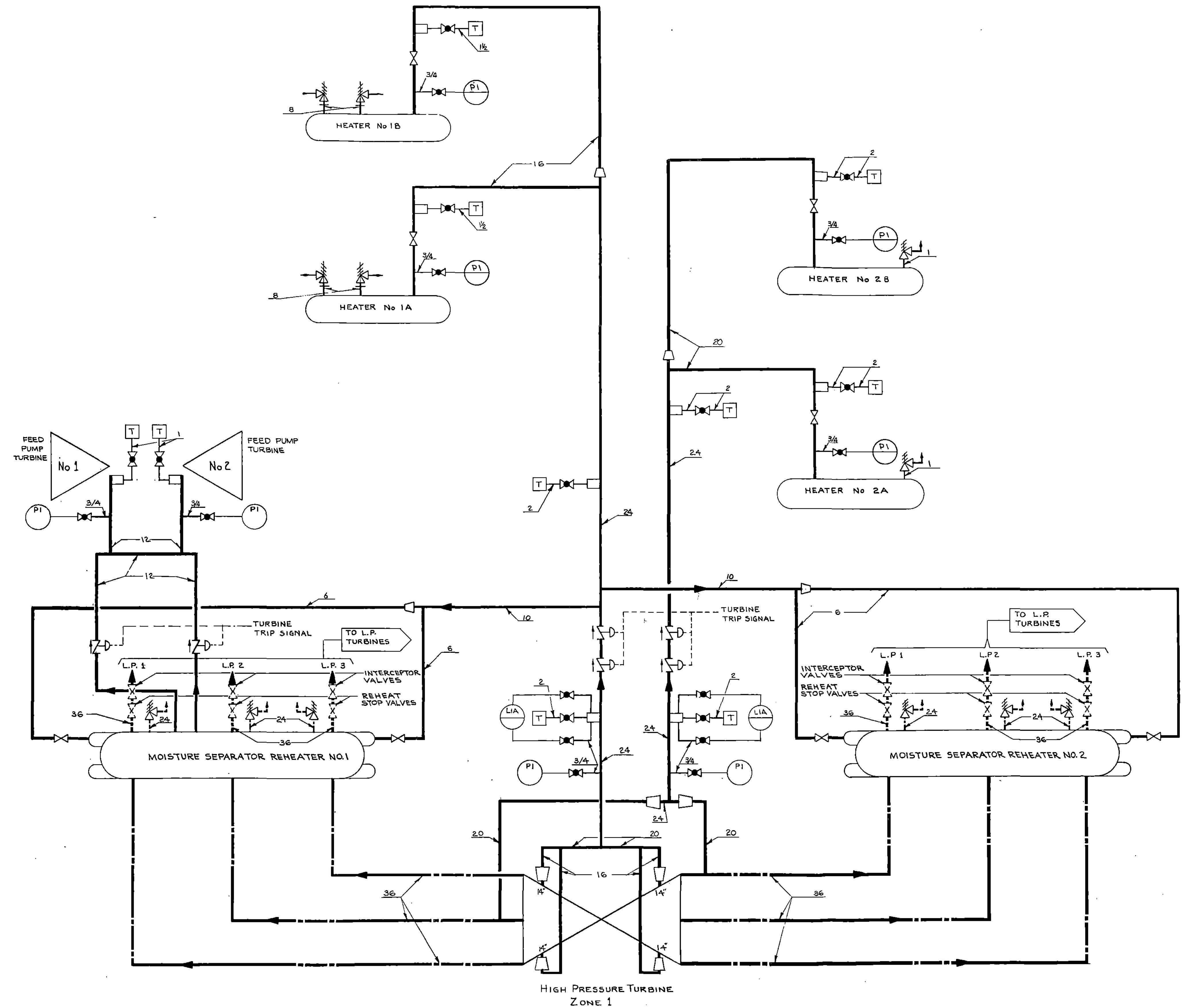


OFFSHORE POWER SYSTEMS

Title: EXTRACTION STEAM FLOW DIAGRAM

11/1/72

Figure: 10.2-1
Sheet 2

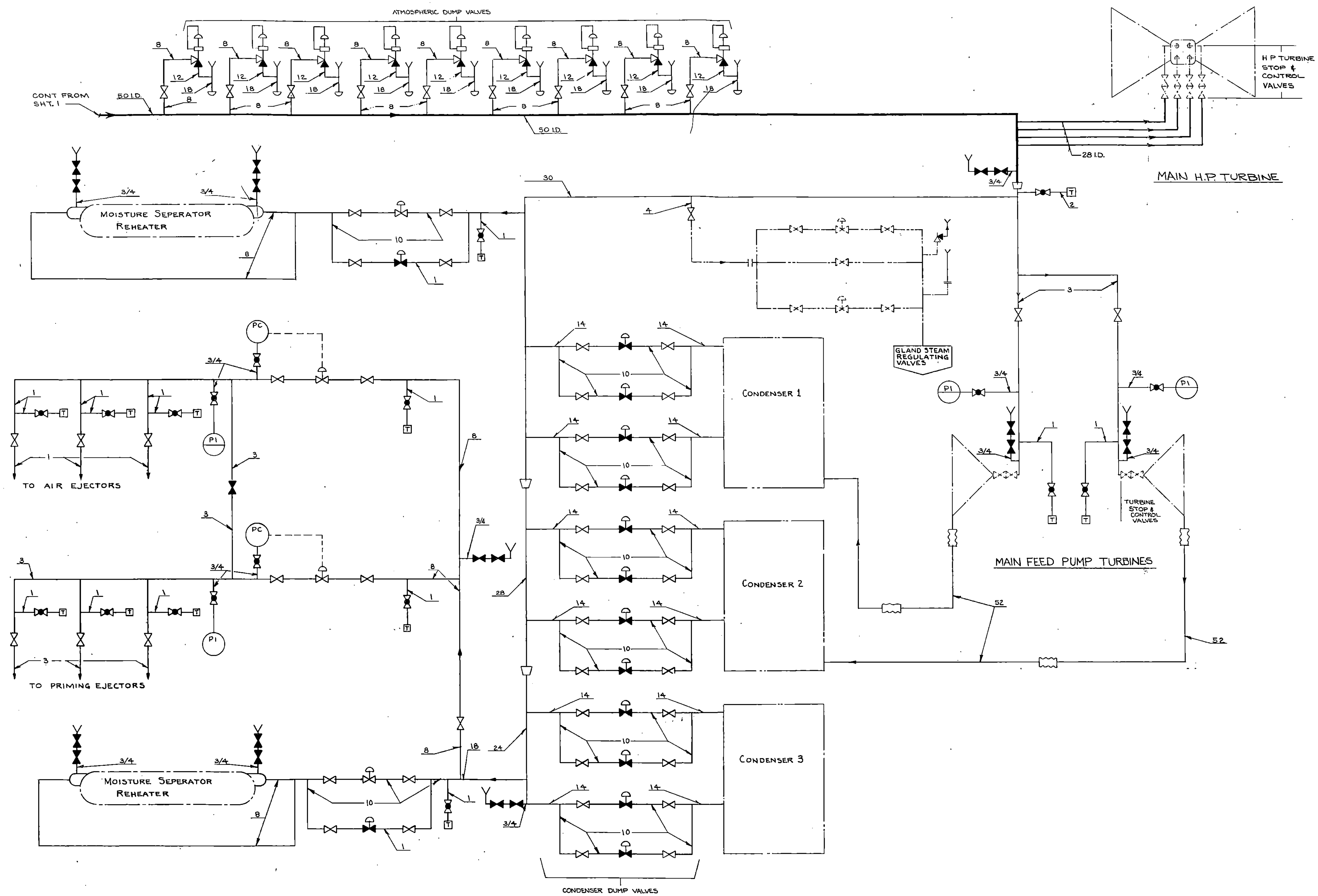


OFFSHORE POWER SYSTEMS

Title: EXTRACTION STEAM FLOW DIAGRAM

11/1/72

Figure: 10.2-1
Sheet 1

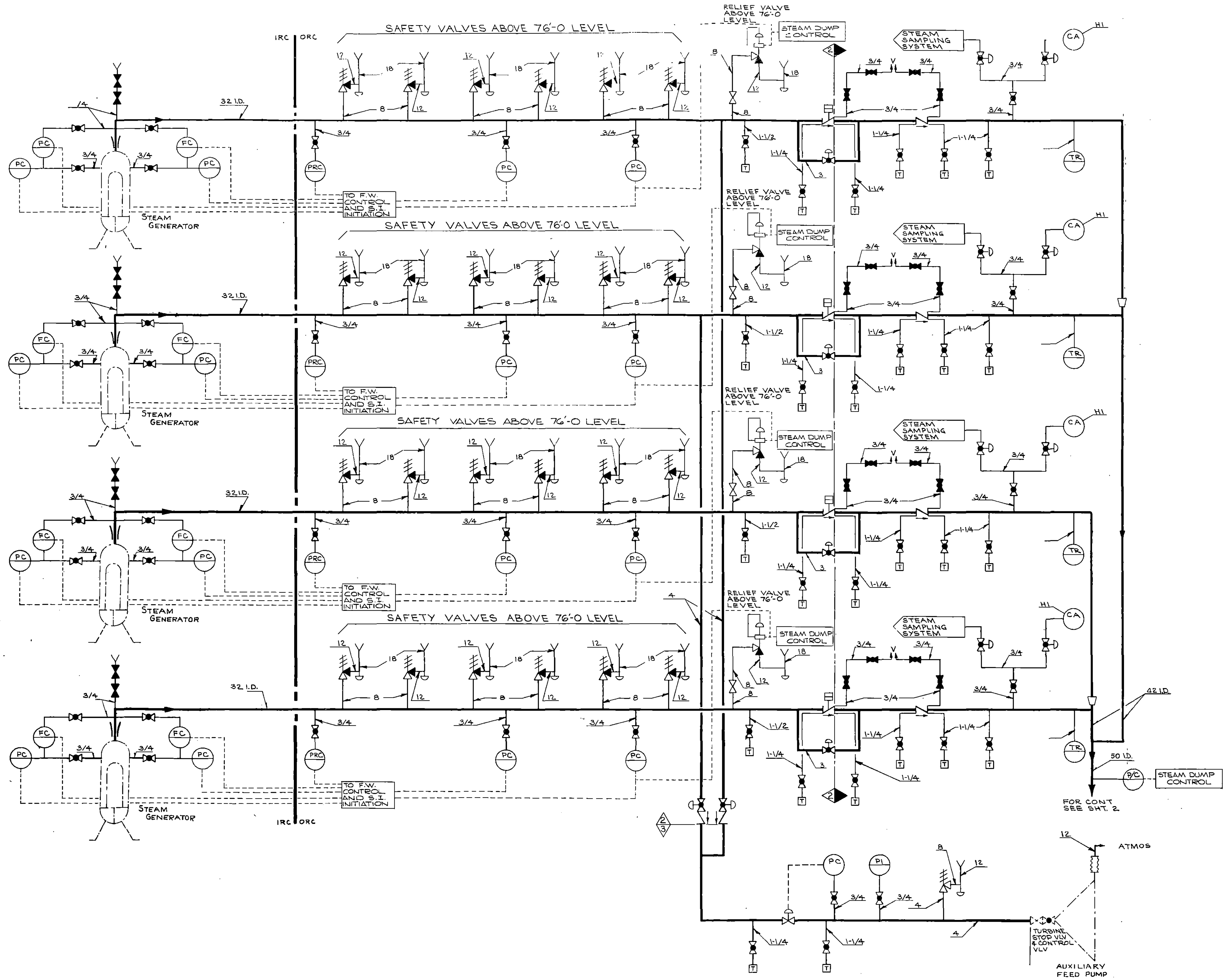


OFFSHORE POWER SYSTEMS

Title: MAIN STEAM FLOW DIAGRAM

11/1/72

Figure: 10.3-1
Sheet 2



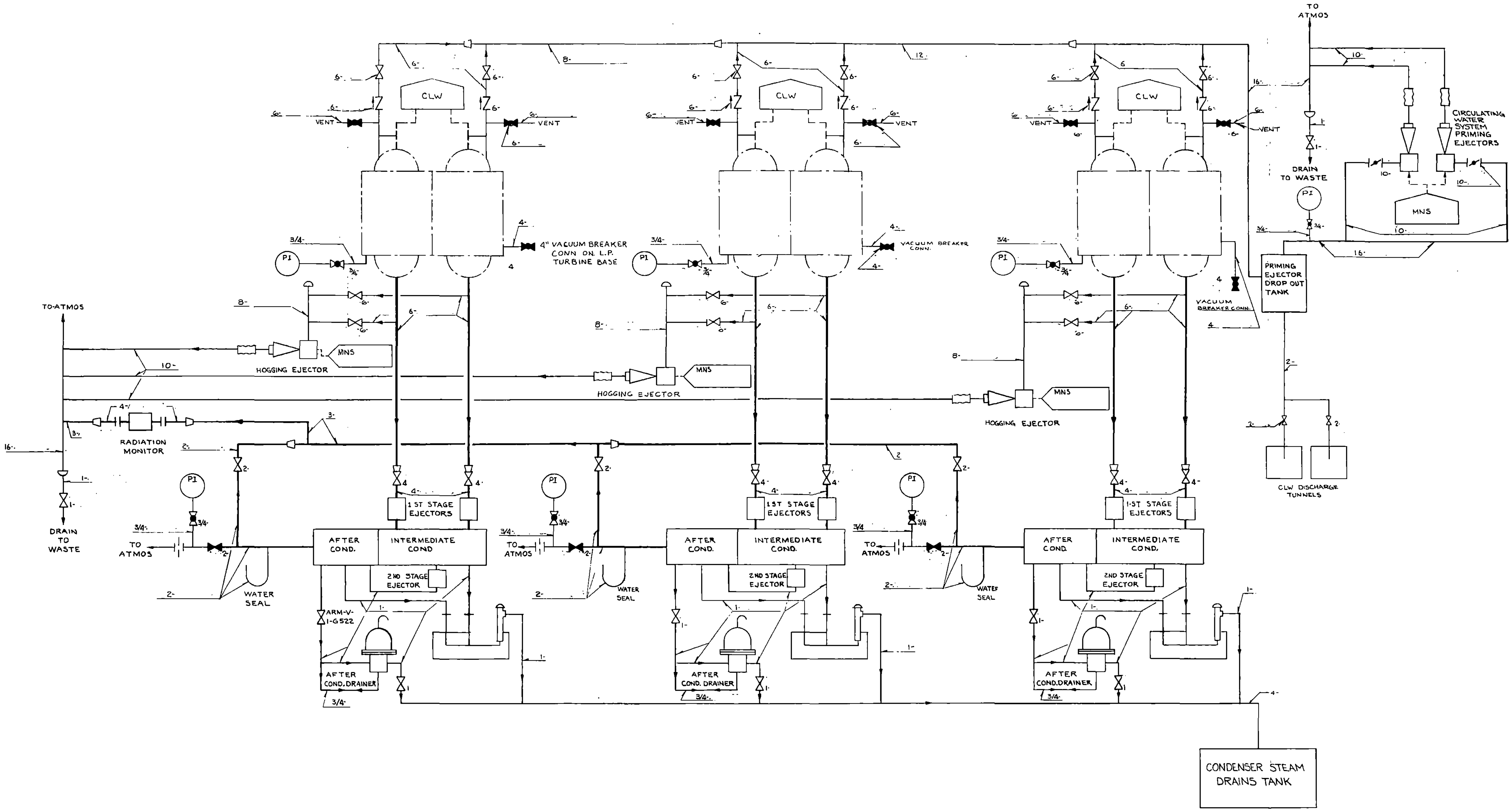
OFFSHORE POWER SYSTEMS

Title: MAIN STEAM SYSTEM

FLOW DIAGRAM

11/1/72

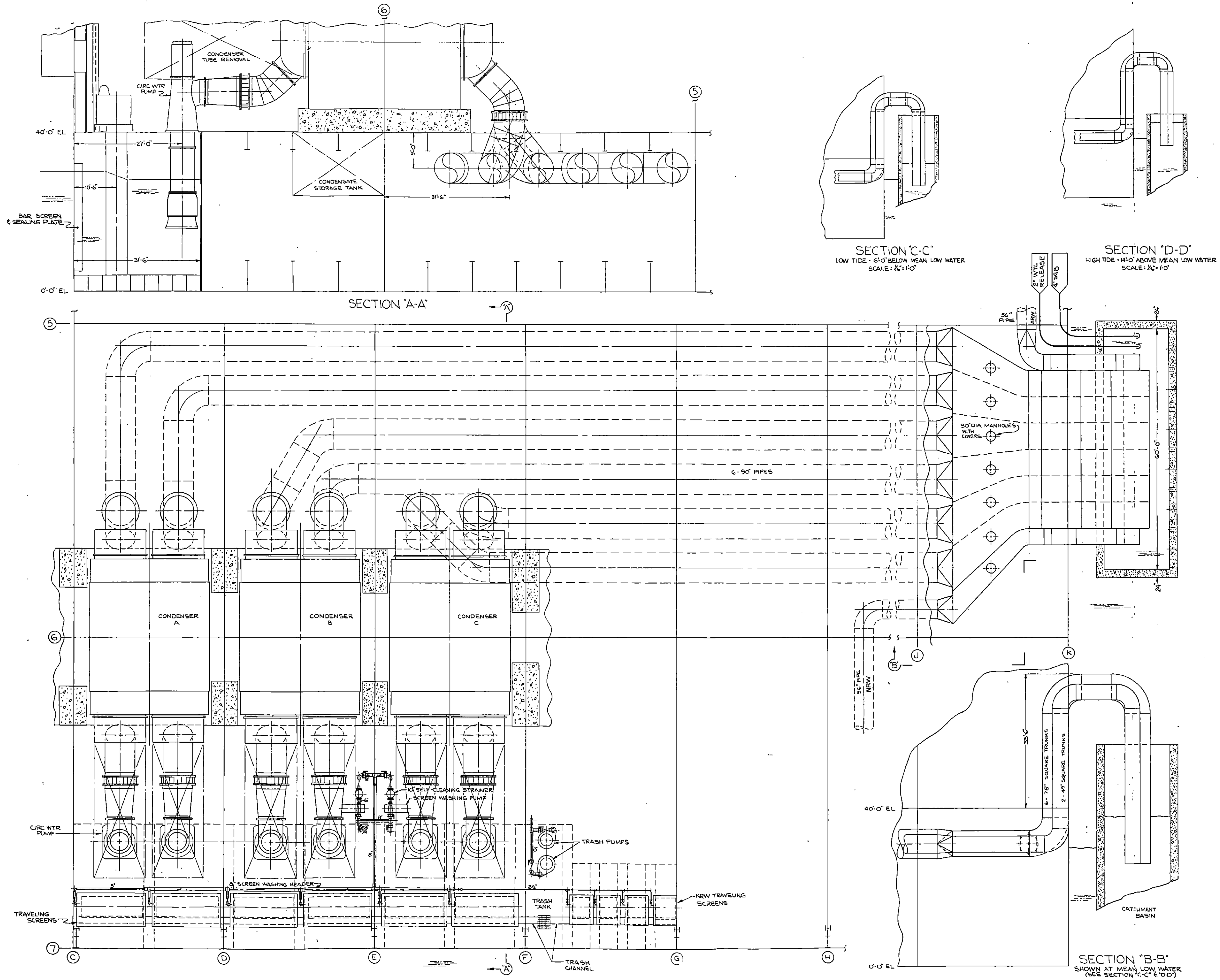
Figure 10.3-1
Sheet 1 of 2



OFFSHORE POWER SYSTEMS

Title: CONDENSER AIR REMOVAL SYSTEM

11/1/72 Figure: 10.4-1

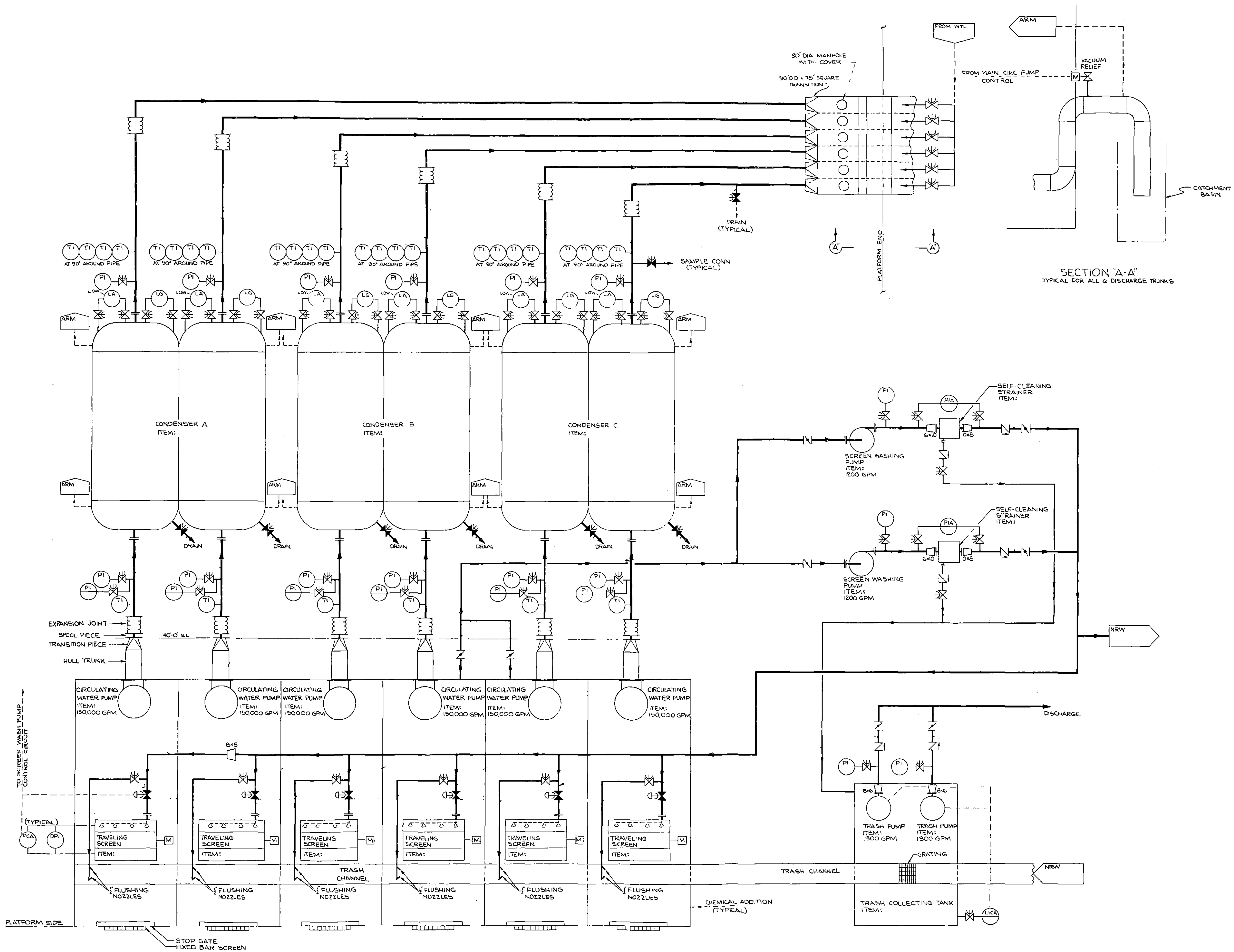


OFFSHORE POWER SYSTEMS

Title: CONDENSER CIRCULATING WATER SYSTEM LAYOUT

1/1/73

Figure: 10.4-2, Sheet 2

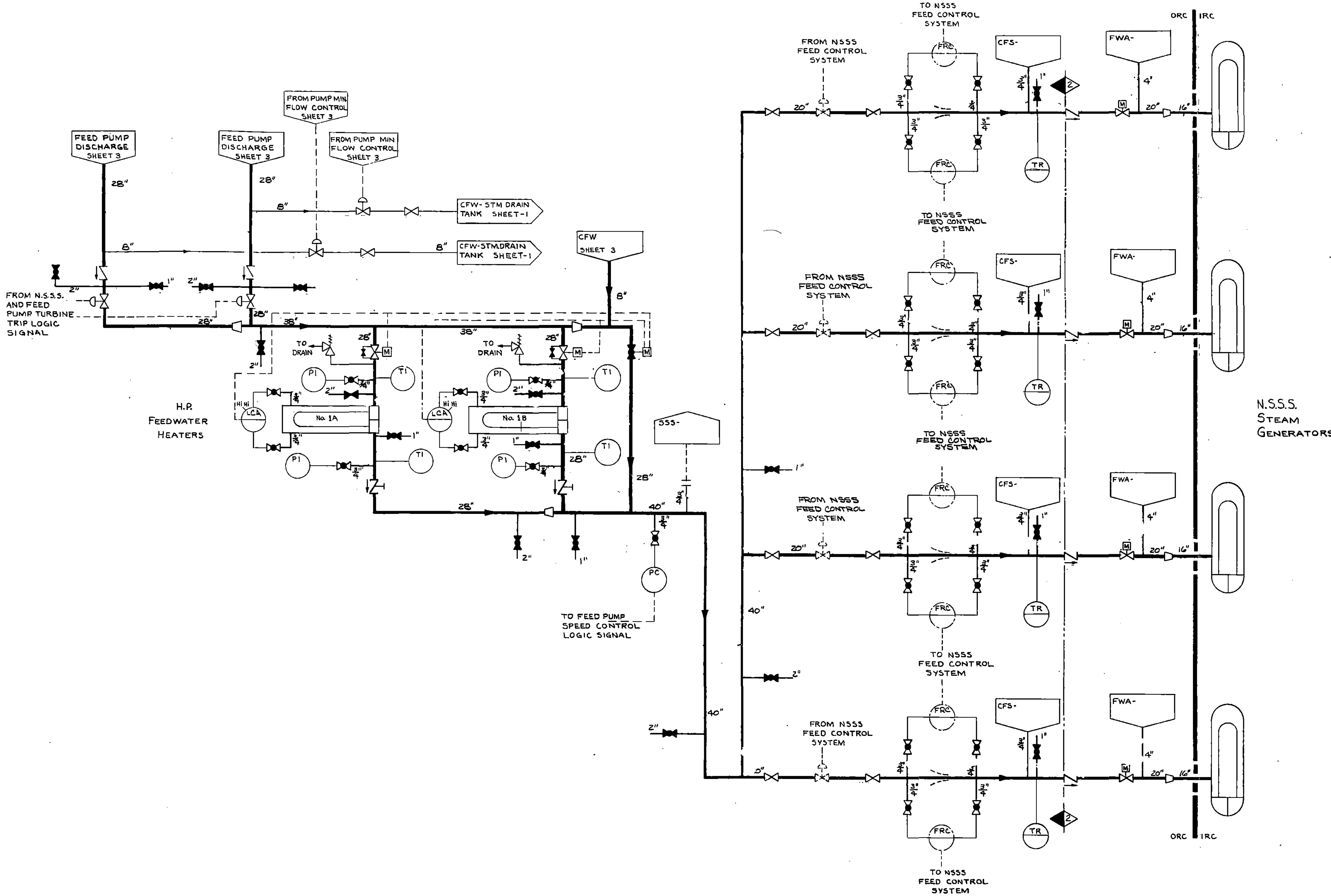


OFFSHORE POWER SYSTEMS

Title: CONDENSER CIRCULATING WATER SYSTEM FLOW DIAGRAM .

1/1/73

Figure: 10.4-2, Sheet 1

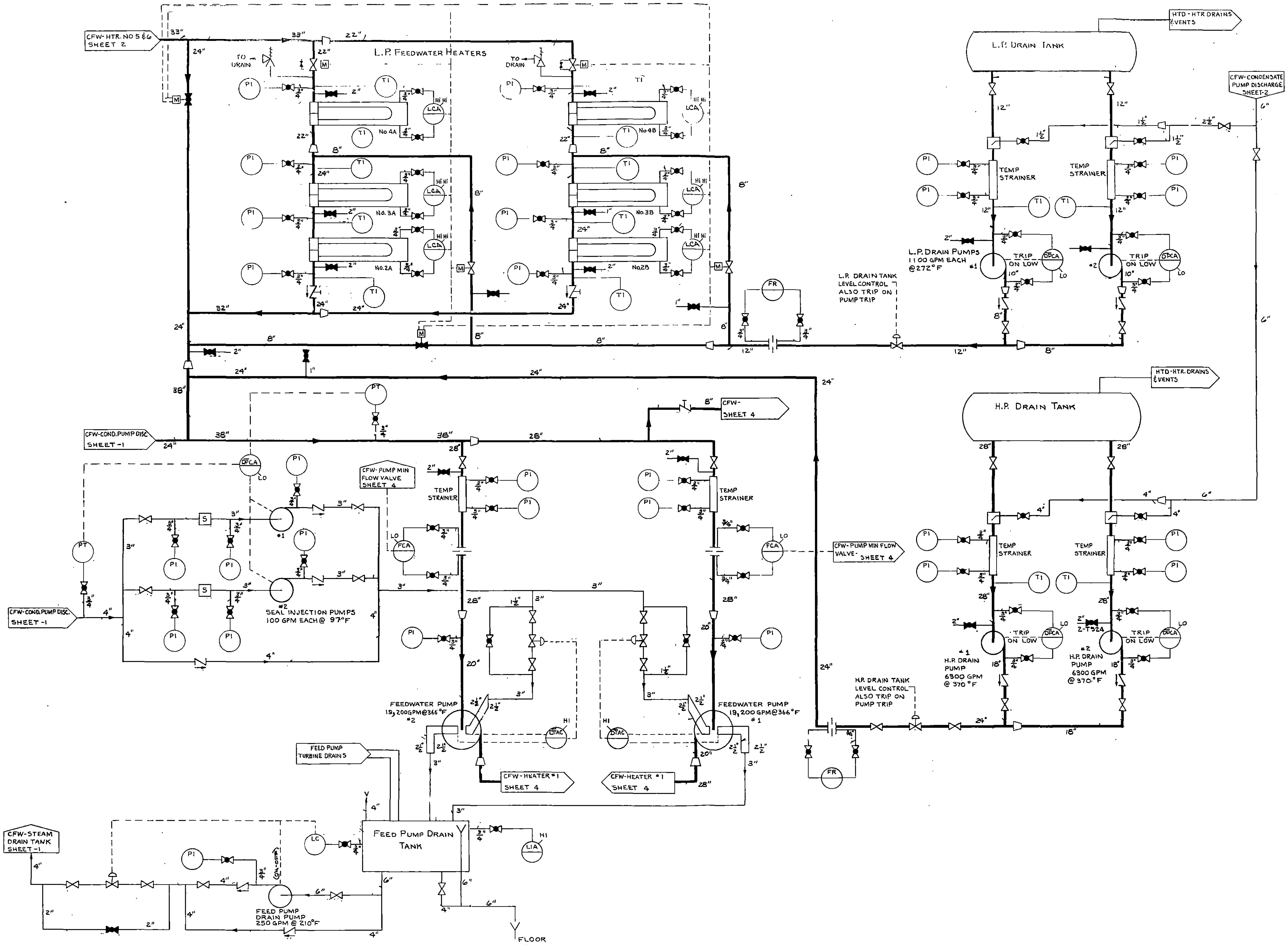


OFFSHORE POWER SYSTEMS

Title: CONDENSATE FEEDWATER SYSTEM

11/1/72

Figure: 10.4-3 Sheet 4

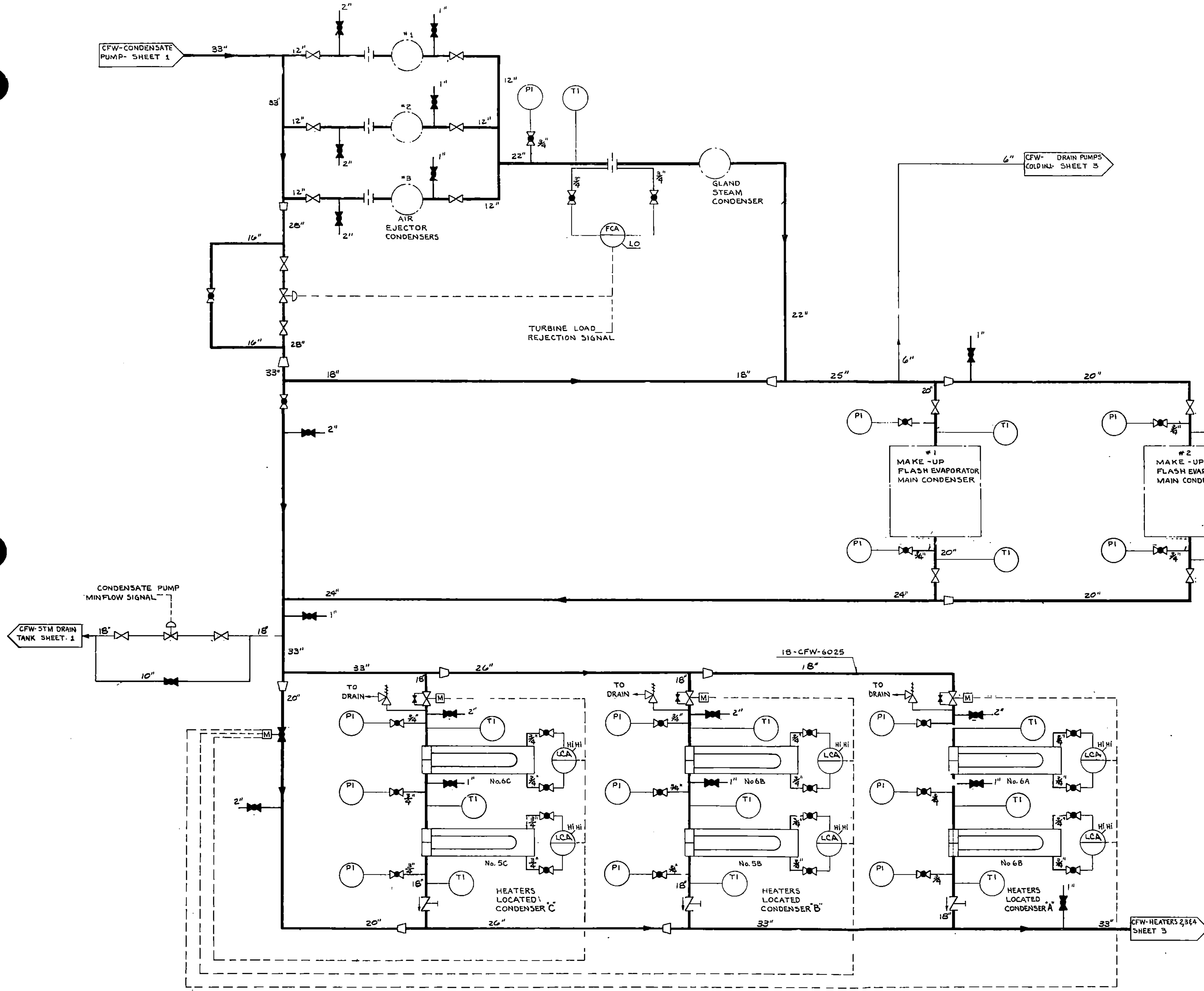


OFFSHORE POWER SYSTEM

Title: CONDENSATE FEEDWATER SYSTEM

11/1/72

Figure: 10.4-3 sheet 3

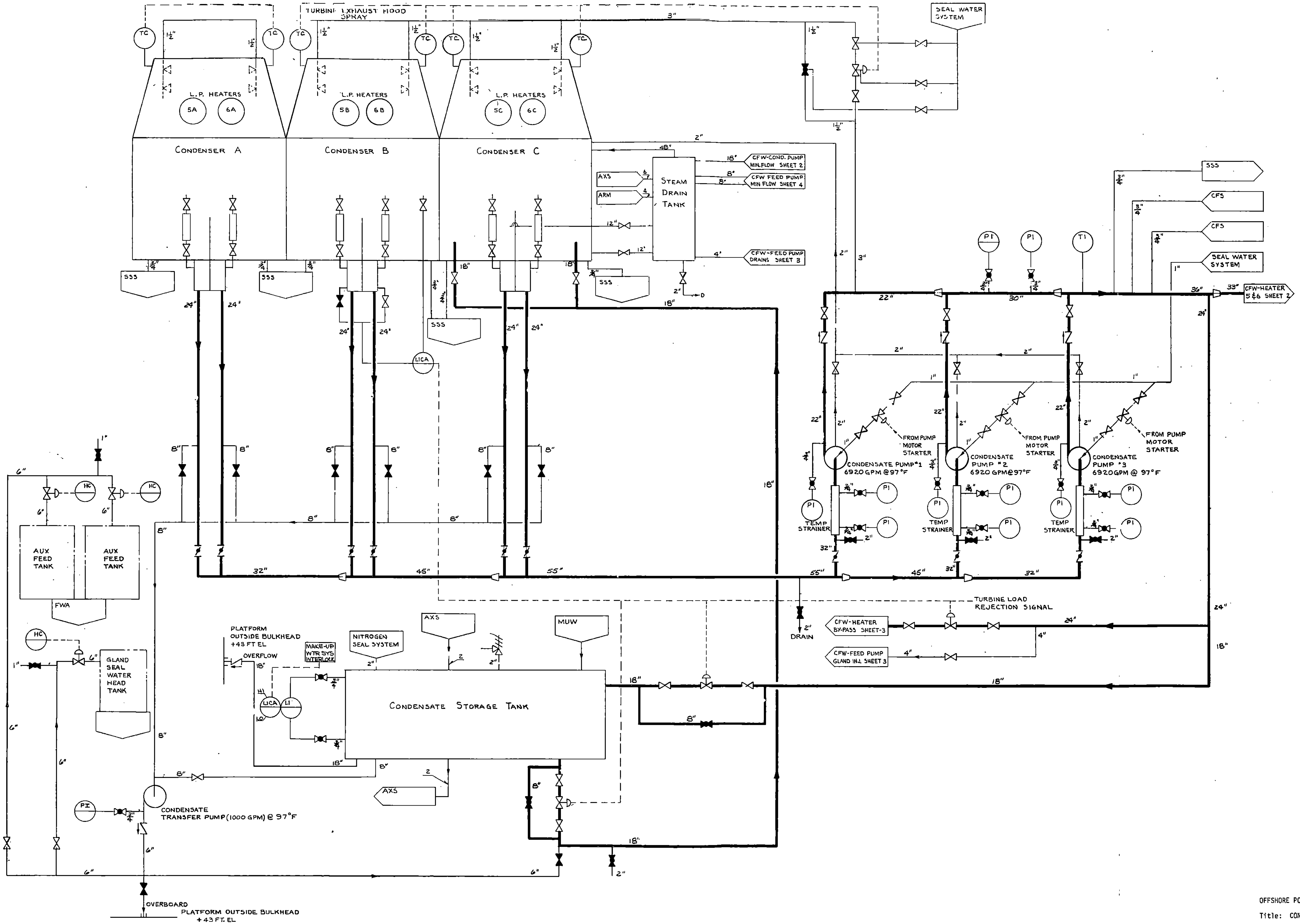


OFFSHORE POWER SYSTEMS

Title: CONDENSATE FEEDWATER SYSTEM

11/1/72

Figure: 10.4-3
Sheet 2

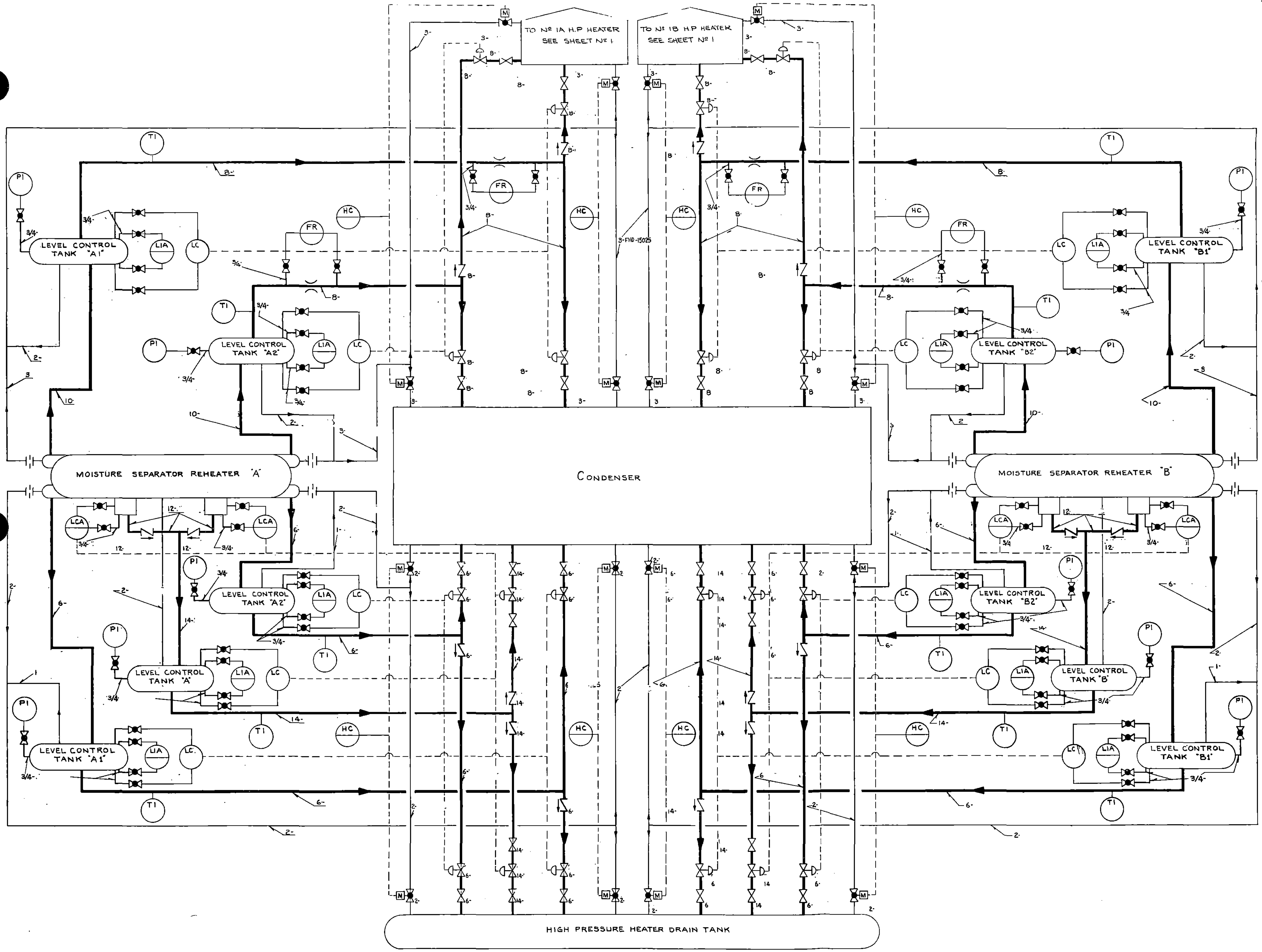


OFFSHORE POWER SYSTEMS

Title: CONDENSATE FEEDWATER SYSTEM

11/1/72

Figure: 10.4-3
Sheet 1



NOTES:

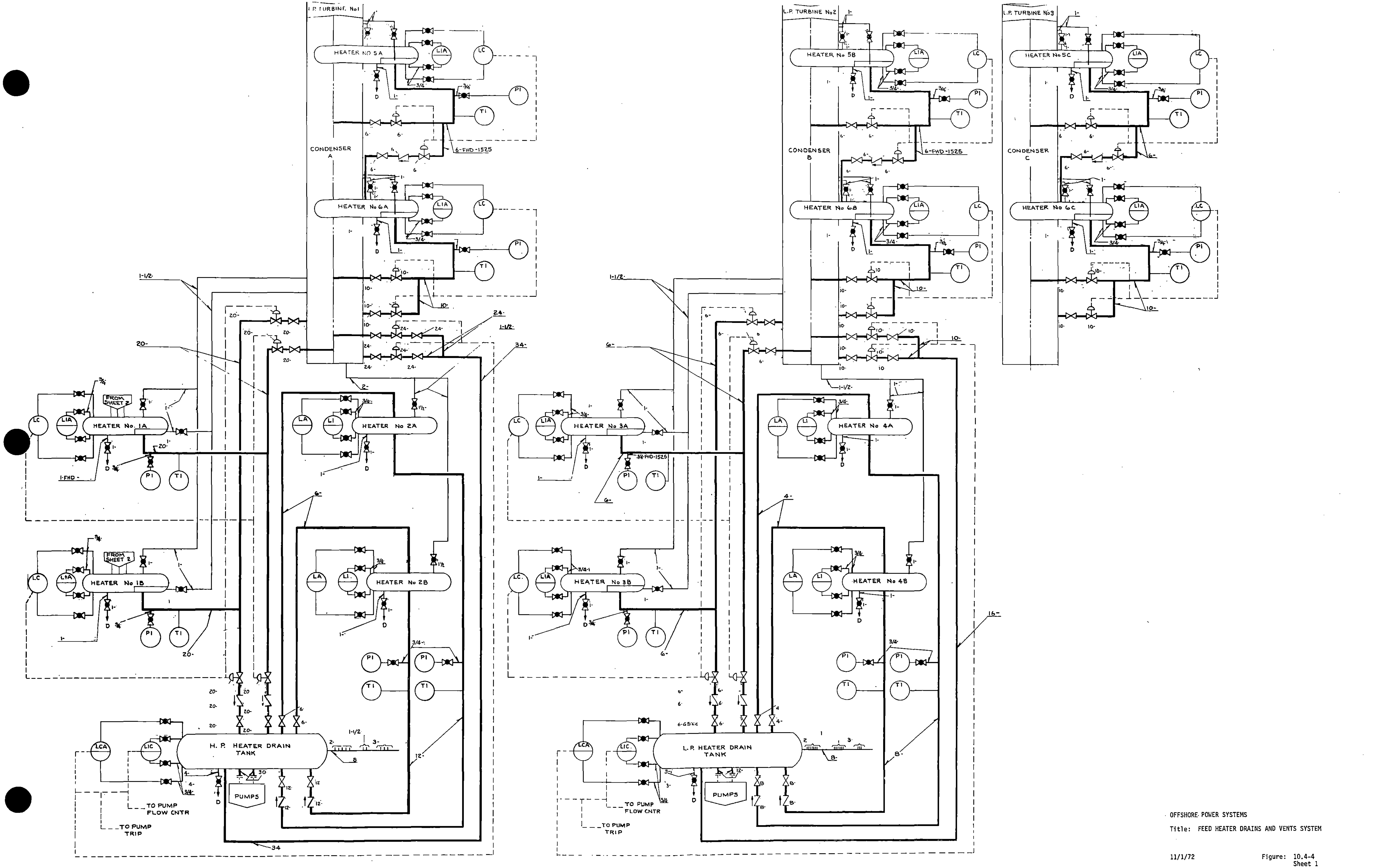
1- INSTRUMENTATION ROOT VALVES 66 TOTAL
(A) 28 1500PSIA (3/4-T)(HTD-V-)
(B) 20 600PSIA (3/4-T)(HTD-V-)
(C) 18 300PSIA (3/4-T)(HTD-V-)

OFFSHORE POWER SYSTEMS

Title: FEED HEATER DRAINS AND VENTS SYSTEM

11/1/72

Figure: 10.4-4
Sheet 2

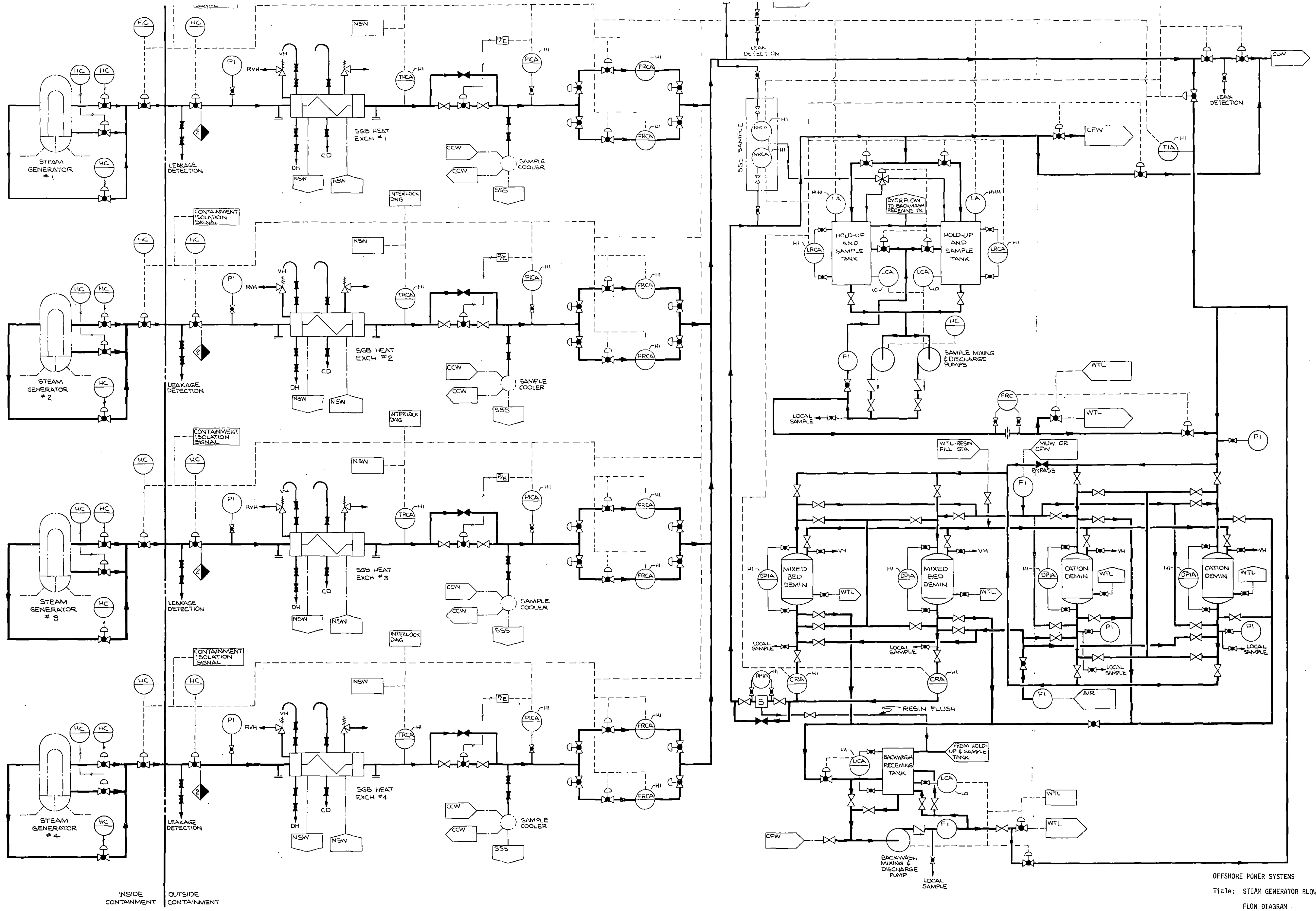


OFFSHORE POWER SYSTEMS

Title: FEED HEATER DRAINS AND VENTS SYSTEM

11/1/72

Figure: 10.4-4
Sheet 1

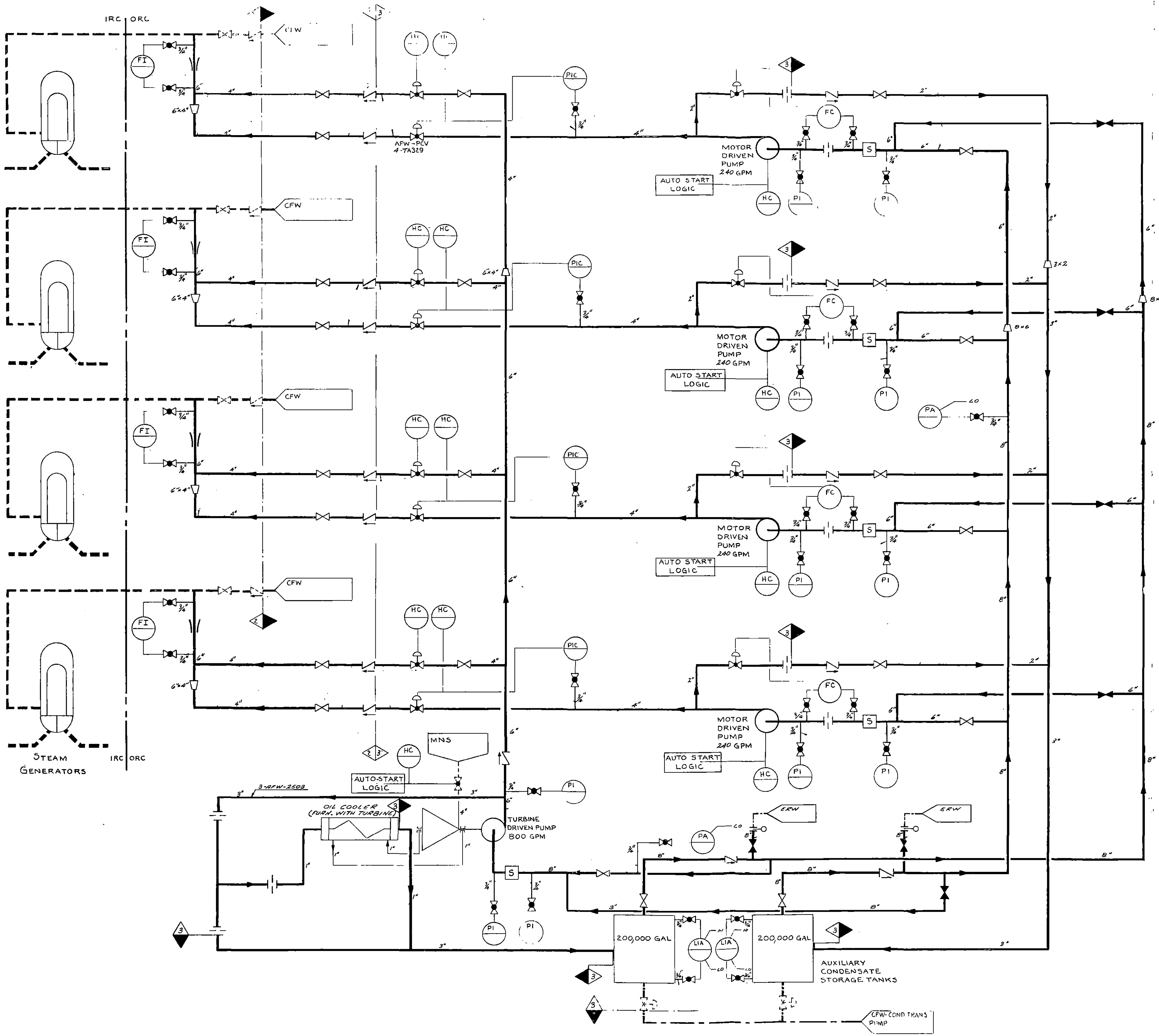


OFFSHORE POWER SYSTEMS

Title: STEAM GENERATOR BLOWDOWN SYSTEM FLOW DIAGRAM

1/1/73

Figure: 10.4-6



OFFSHORE POWER SYSTEMS

Title: AUXILIARY FEEDWATER SYSTEM FLOW DIAGRAM

1/1/73 Figure: 10.4-5

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CHAPTER 11

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CHAPTER 11

RADIOACTIVE WASTE TREATMENT MANAGEMENT

11.1 SOURCE TERMS

This Section is presented in RESAR-3, Section 11.1.

11.2 LIQUID WASTE TREATMENT SYSTEM

11.2.1 DESIGN OBJECTIVES

The Liquid Waste Treatment System is designed to collect, process and discharge liquid wastes. All liquids discharged to the environment can be shown to be below the maximum permissible concentration (MPC) radioactivity limits specified by 10 CFR 20. Furthermore, additional shielding, processing equipment and holdup capacity for decay are provided in the design to minimize personnel exposure and to assure that radioactive releases to the environment are kept to a minimum.

Table 11.2-1 shows the design basis for liquid volumes released. A break down of releases on an isotopic basis is given in Table 11.2-2. The releases are based on 1% cladding defects.

The radioactive releases from the plant coincident with equipment faults of moderate frequency can also be shown to be within 10 CFR 20 limits. Equipment faults of moderate frequency are listed below:

1. Malfunction in Liquid Waste Treatment System.

2. Excessive Reactor Coolant System leakage.

3. Excessive auxiliary system equipment leakage.

4. Steam generator tube leakage.

11.2.2 SYSTEM DESCRIPTION

11.2.2.1 System Design

The Liquid Waste Treatment System (WTL) handles all potentially radioactive liquid wastes except those associated with the Steam and Power Conversion Systems. The bulk of the radioactive liquids are processed by the Boron Recycle System and reused. Therefore, relatively small quantities of radioactive liquids enter the Liquid Waste Treatment System. In addition, the system is designed to recycle as much liquid as possible and thereby minimize releases to the environment.

Liquids are collected for batch processing. Based on a laboratory analysis of a representative sample, the liquids are processed or directly released. A permanent record of releases is maintained. Controls and instrumentation are located on local panels in shielded areas near the equipment.

The Liquid Waste Treatment System processing trains are segregated according to the location and the type of liquid handled.

These trains are 1) the recycle portion which handles reactor grade water; 2) Reactor containment portion which handles wastes from within containment; 3) Waste portion which handles all liquids that are ultimately released to the environment; and 4) Chemical and spent resin portion which handles wastes that are drummed for offsite shipment.

11.2.2.1.1 Recycle Portion (Tritiated and Aerated Water Sources)

The recycle portion of the Liquid Waste Treatment System is shown on Figure 11.2-1. The principle flow paths are shown by the heavy line. Two, 100 percent redundant flow paths and trains of processing equipment are provided. Normally, no liquids are released to the environment from this portion of the system.

Reactor grade water from controlled sources is collected in the waste holdup tanks. The major sources are a sample room sink and the drain header "DH". The waste holdup tank demineralizer is used to remove soluble radioisotopes. The evaporator strips any gases which may remain, removes boron and produces distillate (overhead) for reuse in the Reactor Coolant System. The evaporator concentrates (bottoms) are normally drummed. The distillate is directed through the waste evaporator distillate demineralizer to remove trace radioactivity and boron before it is collected in waste evaporator distillate tank. When sufficient volume has accumulated in the tank, it is normally transferred to Chemical and Volume Control System for reuse.

11.2.2.1.2 Reactor Containment Portion

The reactor containment portion of Liquid Waste Treatment System is shown on Figure 11.2-2. Deaerated tritiated water from sources such as valve leakoffs and reactor coolant pump seals flows into the reactor coolant drain tank. Normally, the liquid is directed to the Boron Recycle System. It may be routed to waste holdup tanks, In either case, the liquid is recycled and not released.

The containment sump collects the non-controlled leakages within containment. Normally, this liquid is directed to the floor drain tank. It may be directed to the waste holdup tanks. Normal sources include leakage from the fan coolers, service water systems, feedwater, etc. and hose water via the containment floor drains. This liquid is normally released via the waste portion of Liquid Waste Treatment System.

11.2.2.1.3 Waste Portion (Non-Reactor Grade Water Sources)

All liquid releases to the environment from the Liquid Waste Treatment System are handled by the waste portion of the system shown on Figure 11.2-3. Three drain tanks are provided to collect various types of liquids. The principal flow path for processing the liquid from each tank is shown by heavy lines. However, the flow paths are interconnected so that parallel flow paths and equipment may be used.

Each tank is handled on a batch basis. Normally, the sample analysis indicates the liquid is acceptable for release. Then it is routed to one of the waste monitor tanks. During this time the liquid normally directed to the tank flows to a standby tank. A detailed description of the drains normally entering each tank is included in Section 9.3.3.

The cask decontamination drain tank is used to collect the decontamination liquid, potential chloride and chemical drains. The laundry and hot shower tank is used to collect detergent liquids such as laundry and hot showers, soapy rinse water, etc. The floor drain tank is used to collect miscellaneous drains which are not routed to the other tanks. The containment sump contents are normally routed to this tank.

The floor drain tank, in particular, has a potential for receiving radioactive water from spills, leaks or equipment failures. For this reason, a flow path including part of the recycle portion of this system is available for processing. This flow path includes the floor drain tank demineralizer and the waste evaporator, if necessary, to remove radioactivity.

All the releases to the environment are via the waste monitor tanks on a batch basis and only after a sample analysis. A valve in the discharge line is interlocked with a process radiation monitor. The valve closes automatically when the radioactivity concentration in the liquid discharge exceeds the preset limit. Another valve in the discharge line is interlocked with a flow totalizer which monitors total plant cooling water discharge flow. This valve closes automatically when the total plant cooling water discharge flow falls below a preset limit. Liquid waste discharge, volume and radioactivity levels are recorded.

The estimated volumes of liquid entering each tank shown on Figure 11.2-1 are based on operating plant data.

11.2.2.1.4 Chemical and Spent Resin Portion

The chemical and spent resin portion of the Liquid Waste Treatment System is shown on Figure 11.2-4. All wastes from this portion of the system are drummed. The majority of waste consists of spent resins from various plant demineralizers.

Laboratory samples (spent and excess sample liquid) which are likely to be radioactive and/or which may contain chemicals required for analysis are discarded in a separate sink which drains to the chemical drain tank. Low activity drains from the laboratory, such as rinse water, are routed to the floor drain tank.

The normal flow paths are shown by heavy lines. However, several interconnections are provided for standby flow paths.

11.2.2.2 Component Design

The Liquid Waste Treatment System equipment design codes are listed in Section 3.2.2, Table 3.2-1. The design parameters are given in Table 11.2-3. The materials meet the system requirements and applicable codes. Piping and components parts in contact with liquid are stainless steel.

All parts of the system are located in controlled access area. Components have a potential surface radioactivity dose rate greater than 2.5 mr/hr are shielded.

11.2.2.2.1 Pumps

There are two standard size pumps used in the Liquid Waste Treatment System, as enumerated in Table 11.2-3.

All pumps have drain and vent connections. With the exception of the standby reactor coolant drain tank pump, they are started manually. A low suction level signal automatically shuts down each pump. The flow rate is controlled manually from a discharge throttle valve using a previously calibrated discharge pressure gauge.

11.2.2.2.2 Heat Exchangers

The reactor coolant drain tank heat exchanger is the only system heat exchanger. It is normally used to cool the contents from the reactor coolant drain tank. However, it is designed to cool the contents of the Reactor Coolant System pressurizer relief tank from 200°F to 120°F in less than eight hours. The heat exchanger is a U-tube type. The Component Cooling Water System provides cooling water to the shell side.

11.2.2.2.3 Tanks

The system tanks are listed in Table 11.2-3.

The reactor coolant drain tank collects leakoff type drains inside the containment. The tank provides surge and net positive suction head requirements for the reactor coolant drain tank pumps. A nitrogen blanket is maintained in the tank. Reactor coolant enters the tank from sources such as, the reactor vessel flange leakoff, valve leakoffs, reactor coolant pump seal leakoffs, and the Chemical and Volume Control System excess letdown heat exchanger.

A five gallon recycle evaporator reagent tank is provided for adding chemicals to the evaporator. Chemicals are manually added to the tank. Water from the reactor makeup water storage tanks can be used for mixing and providing a head for injection to the evaporator. Chemicals added are normally antifoaming agents but may also be for pH control or decontamination. The tank contains no radioactivity and is not shielded.

The remainder of the tanks serve as surge tanks so the system can be operated on a batch basis. The tanks are provided with level indicators and local alarms which initiate a common alarm in the control room. A low level signal shuts down the tank discharge pump.

11.2.2.2.4 Demineralizers

Four identical demineralizers are provided in the Liquid Waste Treatment System to remove soluble products. These are the waste evaporator distillate, waste monitor tank, floor drain tank, and waste holdup tank demineralizers. The demineralizers are not regenerated. When high pressure drop or effluent sampling indicates the need for resin replacement, the spent resin is sluiced to the spent resin storage tank. New resin is supplied from the Chemical and Volume Control System resin fill tank.

The resins are in the hydrogen-hydroxyl form. The design process decontamination factor is 100 based on operating experience cited in RESAR-3, Section 11.2.2.2.4. Table 11.2-4, repeated from RESAR-3, shows a range of decontamination factors for selected isotopes. These values were observed across mixed bed demineralizers containing cation resin in the lithium-7 form and anion resin in the borate form. Greater decontamination factors are expected for resin in hydrogen-hydroxyl form.

The minimum values in Table 11.2-4 were generally observed just prior to resin flushing and recharging while, during the operating life of the demineralizer, decontamination factors were consistently closer to the maximum values. Although specific operating contamination factors have not as yet been measured for other isotopes, their behavior in a mixed bed demineralizer may be inferred from these data. It anticipated, for example, that tellurium and bromine would have decontamination factors similar to those given for iodine and fluorine.

11.2.2.2.5 Evaporators

One 15 gpm waste evaporator package is provided in the Liquid Waste Treatment System. It is identical to the Boron Recycle System recycle evaporator package. The major components are listed below:

1. feed preheater

2. gas stripper

3. feed tank-evaporator

4. absorption tower

5. evaporator condenser

6. distillate cooler

7. vent condenser

8. concentrates pumps

9. distillate pumps

The influent liquid passes through the feed preheater and the gas stripper to the feed tank-evaporator. The gas stripper is a packed column. The stripping steam containing the entrained gases flows to the vent condenser. The condensed steam is returned to the gas stripper and the gases are displaced to the Gaseous Waste Treatment System.

The feed tank-evaporator boils off the liquid by steam coils. The vapors flow through the absorption tower where boron and other entrained impurities are removed and then flow back to the feed tank-evaporator. When boric acid concentration in the feed tank-evaporator reaches 12% by weight, the contents are pumped out. The purified vapors are condensed as distillate in the evaporator condenser. The distillate then flows through the distillate cooler and from the evaporator package.

11.2.2.2.6 Filters

Nine identical filters are provided as listed in Table 11.2-3. The filters are divided into two categories: one, those located downstream of demineralizers to catch resin fines; and two, those located to remove filterable particulates from fluid streams. Maximum radiation levels of the category one filters are based on a resin breakthrough. The floor drain tank filter is the only category two filter possibly having significant radiation. The maximum surface dose rate of these filters is 100 mr/hr.

11.2.2.2.7 Strainers

Table 11.2-3 lists the four identical strainers included in the system. The strainers are basket, in-line type and will trap only negligible radioactivity. They are regularly cleaned and placed back in service.

11.2.3 OPERATING PROCEDURES

Most of the Liquid Waste Treatment System is manually operated. It does not perform any engineered safety feature.

11.2.3.1 Recycle Portion

Most of the recycle portion influent flow is from the "DH" drain header system. One of the waste holdup tanks is valved to receive a continuous flow. When sufficient quantity has accumulated to warrant processing, the other waste holdup tank is valved into service. The tank contents are then recirculated to obtain a representative sample. The results of the sample analysis determine the disposition of the tank contents. Several alternatives are available such as:

Directing liquid through the waste holdup tank demineralizer to the waste evaporator.

Directing liquid through the floor drain tank demineralizer (if required to remove radioactivity to a waste monitor tank.

Recycling the liquid through a demineralizer or filter back to the tank and directing the contents to the floor drain tank.

Much of the evaporator operation is automatic. A level control in the feed tank-evaporator controls the feed flow. Distillate is continuously pumped from the evaporator package. However, a sample analysis is required to determine the disposition of the concentrates. Normally the bottoms are concentrated to 12% by weight boric acid for drumming. If the bottoms are acceptable for reuse, they may be concentrated to 4% by weight boric acid and transferred directly to the Chemical and Volume Control System boric acid tanks.

The distillate flow is continuous through the waste evaporator distillate demineralizer and filter to the waste evaporator distillate tank. If unacceptable conductivity is detected in the distillate stream, a three way valve directs the flow to a waste holdup tank.

When sufficient volume has accumulated in the waste evaporator distillate tank, distillate flow is terminated. The tank contents are recirculated to obtain a representative sample. If the sample analysis meets reactor grade water quality requirements, the liquid is pumped to the Chemical and Volume Control System reactor makeup water storage tanks. If the water is unacceptable for reuse the following alternatives are available:

The liquid may be recirculated for further processing.

The liquid may be transferred to the waste portion of the system for release.

11.2.3.2 Reactor Containment Portion

The part of the Liquid Waste Treatment System located within containment is fully automatic. The containment sump pumps normally direct liquid to the floor drain tank. An alternate connection is provided to the waste holdup tanks.

The reactor coolant drain tank collects tritiated, deaerated liquid from within the containment. A constant tank liquid level is maintained to minimize the amount of gas sent to Gaseous Waste Treatment System. Flow is continuously recirculated back to the tank through a reactor coolant drain tank pump and heat exchanger. A proportional control valve, operating on a signal from tank level, diverts the excess flow to the Boron Recycle System. An alternate connection is provided to the waste holdup tanks.

11.2.3.3 Waste Portion

The waste portion of Liquid Waste Treatment System is normally released to the environment. The floor drain tank collects "D" drains, the containment sump discharge, and liquids which cannot be recycled. The laundry and hot shower tank and the cask decontamination drain tank collect "CD" drains, laundry and hot shower drains, and spent fuel cask washdown drains.

Radioactivity levels are normally quite low. After holdup, the tank contents are circulated to obtain a representative sample. If the sample analysis indicates the liquid is acceptable for release, it is transferred to a waste monitor tank. The waste monitor tank liquid is again circulated, sampled, and analyzed before release. If this sample analysis indicates the liquid is unacceptable for release, the liquid is returned to the tank of origin.

Acceptable releases are directed by a waste monitor tank pump to the common plant cooling water discharge.

All liquids leaving the waste monitor tanks are continuously monitored for radiation prior to dilution. If the monitor closes the discharge valve the flow is diverted, normally to the floor drain tank.

If any samples indicate liquid is not acceptable for release, the operator has several process options available. These options include demineralization, filtration, evaporation, or drumming the liquid if necessary.

11.2.3.4 Chemical Drain and Spent Resin Portion

The chemical drains and spent resins of the Liquid Waste Treatment System are drummed for offsite shipment. The chemical drain tank receives liquids which neither can be recycled nor are acceptable for release because of their chemical content. When sufficient volume has accumulated it is pumped directly to the drumming station.

The spent resin storage tank receives spent resin from several system demineralizers. The tank provides holdup for decay and storage before the resins are drummed.

The sluicing of resins to the spent resin storage tank is a series of manual operations as listed below:

1. The demineralizer is valved out of its system and drained of liquid.

2. The flow path is valved for flow to recirculate from the spent resin sluice pump up through the demineralizer, through the spent resin storage tank, and back to the pump.
   (This operation loosens the bed for sluicing.)

3. The resins drain by gravity to the spent resin storage tank. Resins are never pumped through the spent resin sluice pump.

4. Operation 2 is repeated to remove any traces of resins. Only a negligible amount of resin is expected to remain in a demineralizer after flushing since the demineralizers are completely flushable.

5. The demineralizer is drained to spent resin storage tank.

After fresh resins have been added, operation 2 may be repeated to ascertain that the demineralizer is filled with water before valving it back into service. Excessive flow must be avoided to prevent resin classification.

When sufficient resins have accumulated, they are transferred to the drumming station. The spent resin storage tank is pressurized with nitrogen. The discharge valve is then opened and the resin forced to the drumming station. During this operation, the nitrogen is forced through the sparger in the tank bottom to maintain tank pressure. The nitrogen is vented to the plant vent header for depressurization.

The level indicating system in the spent resin storage tank is a conventional system, with a bellows to keep resin fines away from the instrument. The method of operation limits the resin to a maximum level and the water to a minimum level, the minimum water level being some distance above the resin level. The lower level tap is located in the area which contains water and no resin. This arrangement minimizes the possibility of plugging the level tap. Because the system indicated only total level and not the amount of resin and the amount of water, an inventory of spent resins in the tank is maintained.

11.2.3.5 Faults of Moderate Frequency

The system is designed to handle the occurrence of equipment faults of moderate frequency such as those listed below:

1. Malfunction in the Liquid Waste Treatment System

   The system has parallel equipment and flow paths for standby. Therefore, system operation is not altered during maintenance. In addition, considerable surge capacity is available. Valves and pumps have been standarized so that a spare can be used to replace most valves or pumps.

2. Excessive Leakage of Reactor Coolant Liquid

   This system is designed to handle a one gpm leak of reactor coolant in addition to the normal system influent flow. The leakage into the reactor coolant drain tank is automatically transferred to the Boron Recycle System. If the load is too great for that system it is transferred to the waste holdup tanks. Leakage of reactor coolant outside containment will also normally drain into the waste holdup tanks. It is expected that reactor coolant leakage into the other tanks is minimal.

3. Excessive Leakage in Auxiliary System Equipment

Inside containment, water from steam side leaks and fan coolers are collected in the containment sump. This liquid is normally directed to the floor drain tank. Other sources could be raw water system leaks which would flow into the cask decontamination drain tank or cooling water system leaks which would flow into the floor drain tanks.

4. Steam Generator Tube Leaks

These leaks are discussed in Section 10.4.7.

11.2.3.6 Operating Experience

Various Westinghouse PWR plant operating experiences are presented in RESAR-3, Section 11.2.3.3.

11.2.4 PERFORMANCE TESTS

Initial tests will be performed to verify the operability of the components, instrumentation and control equipment and applicable alarms and control setpoints.

The specific objectives are to demonstrate the following:

1. Pumps are capable of producing flow rate and head as required.

2. Waste filters are capable of passing required flow rate.

3. Waste evaporator is operable to specifications.

4. Waste evaporator mixing tank heaters are capable of maintaining the temperature of the fluid above the precipitation point.

5. Instrumentation, controllers and alarms operate satisfactorily to maintain levels, pressures and flow rates and indicate, record and alarm as required.

6. All sampling points are available for sampling.

During reactor operation the system is used at all times and hence is under continual surveillance.

11.2.5 ESTIMATED RELEASES

11.2.5.1 AEC Requirements

The following documents have been issued by the AEC to provide regulations and guidelines for release of radioactivety liquids.

1. 10 CFR 20, Standards for Protection Against Radiation.

2. 10 CFR 50, Licensing of Production and Utilization Facilities Against Radiation.

Radioactive liquid release limits are established by 10 CFR 20, and are summarized below:

1. The concentration limit on an unidentified instantaneous release basis as defined in Appendix B of 10 CFR 20 is 10^{-7} μc/cc.

2. The concentration limit on an identified basis is defined in Appendix B, Table 11, Column 2 of 10 CFR 20.

Concentration limits for the major isotopes are as follows:

Isotope	μc/cc
Mo-99	2xx 10^{-4}
I-131	3 x 10^{-7}
I-133	1 x 10^{-6}

Isotope	c/cc
Cs-134	9×10^{-6}
Cs-136	9×10^{-5}
Cs-137	2×10^{-5}

3. The maximum permissible concentration for tritium on an identified basis as given in Appendix B, Table II, Column 2 of 10 CFR 20 is 3×10^{-3} μ c/cc.

11.2.5.2 Design Releases

Liquid usage is dependent upon administrative control of decontamination, rinsing, floor scrubbing, and other water uses in controlled access areas. These administrative controls determine the volume rather than radioactivity released. Estimated quantities of liquids entering the system for potential ultimate release are presented in Table 11.2-1. The majority of radioactivity is contained in the assumed twenty gallons per day of reactor coolant which enters the floor drain tank. The amount of reactor coolant released is minimized by recycling and by using equipment with little, if any, leakage (for example, canned pumps and diaphragm valves).

11.2.6 RELEASE POINTS

There is a single release point from the Liquid Waste Treatment. This is a common line from the discharge of the two waste monitor tank pumps as shown on Figure 11.2-3. The line runs from the 58 foot level downward in the auxiliary area to the 7'-6" level. It runs beside the circulating water lines to the catchment basin in the breakwater. The flow is diluted in the plant cooling water and is discharged to the environment via the ocean discharge piping.

11.2.7 DILUTION FACTORS

Releases from the Liquid Waste Treatment System are diluted by the plant common discharge. The common discharge is the combined flow rates of the Circulating, Auxiliary Raw, and Non-essential Raw Water Systems. The maximum release flow rate from the Liquid Waste Treatment System is 100 gpm. Normally, it is 35 gpm. Table 11.2-5 lists the normal and minimum dilution factors for various plant operating conditions. Releases will be based on waste activity and existing dilution flow.

There is little, if any, recirculation of effluents from the plant common discharge to plant intakes. The discharge line runs outside the breakwater to the sea. The seawater intakes are inside the breakwater.

11.2.8 ESTIMATED DOSES

For continuity in the presentation of information pertaining to estimated doses, the applicant has included this information in Section 12.4, Summary of Normal Operation Doses.

TABLE 11.2-1

DESIGN ESTIMATES OF NORMAL ANNUAL LIQUID VOLUMES

Liquid Source	Volume (gallons per year)	Basis	Expected Annual Release (curies/year)
Laundry and Hot Shower Tank	120,000	Majority of Laundry & Hot Showers is During Refueling	0.45
Cask Decontamination Drain Tank	15,000	Majority of Liquid is From Decontamination of Spent Fuel Cask & Other Equipment Plus Floor Washdown Water	0.06
Floor Drain Tank	36,000	300 Gallons/Week Laboratory Rinses 40 Gallons/Day Non-Reactor Coolant Leakage 20 Gallons/Day Reactor Coolant Leakage	1.49
TOTAL	171,000		2.00

TABLE 11.2-2

ISOTOPIC LIQUID DISCHARGES

1. Corrosion and Non-Gaseous Fission Products

Isotope	Milli Curies/year	Isotope	Milli Curies/year
Cr-51	0.37	Nb-95	0.45
Mn-54	0.26	Zr-95	0.34
Mn-56	0.09	Mo-99	411.
Fe-55	0.38	I-131	501.
Fe-59	1.46	I-132	2.46
Co-58	12.21	I-133	97.50
Co-60	0.45	I-134	.61
Br-84	0.03	I-135	16.70
Rb-88	1.33	Te-132	23.10
Rb-89	0.03	Te-134	0.03
Sr-89	1.74	Cs-134	147.
Sr-90	0.08	Cs-136	46.50
Sr-91	0.02	Cs-137	730.
Sr-92	0.01	Cs-138	0.63
Y-90	0.01	Ba-140	1.19
Y-91	2.88	La-140	0.06
Y-92	0.01	Ce-141	0.28

TOTAL (Excluding H^3 and dissolved gases) = 2,000

TABLE 11.2-2 (CONT)

ISOTOPIC LIQUID DISCHARGES

2. Dissolved Noble Gases

Isotope	Milli Curies/year	Isotope	Milli Curies/year
Kr-85	10	Xe-133m	10
Xe-133	68	Others	NEGLIGIBLE

Total dissolved gases = 88

TABLE 11.2-3

EQUIPMENT PRINCIPAL DESIGN PARAMETERS

PUMPS

1. Reactor Coolant Drain Tank Pumps

Number	2	
Type	Canned	
Design pressure, psig	150	
Design temperature, °F	200	
Material	Stainless Steel	
	Operating Point #1	Operating Point #2
Design flow, gpm	100	140
Design head, ft.	300	250

2. Waste Holdup Tank Pumps

Number	2	
Type	Canned	
Design pressure psig	150	
Design temperature, °F	200	
Material	Stainless Steel	
	Operating Point #1	Operating Point #2
Design flow, gpm	35	100
Design head, ft	250	200

TABLE 11.2-3 (CONT)

3. Waste Evaporator Distillate Tank Pump

Number		1
Type		Canned
Design pressure, psig		150
Design temperature, ^{o}F		200
Material		Stainless Steel
	Operating Point #1	Operating Point #2
Design flow, gpm	35	100
Design head, ft.	250	200

4. Chemical Drain Tank Pump

Number		1
Type		Canned
Design pressure, psig		150
Design temperature, ^{o}F		200
Material		Stainless Steel
	Operating Point #1	Operating Point #2
Design flow, gpm	35	100
Design head, ft.	250	200

TABLE 11.2-3 (CONT)

5. Spent Resin Sluice Pump

Number		1
Type		Canned
Design pressure, psig		150
Design temperature, ^{o}F		200
Material		Stainless Steel
	Operating Point #1	Operating Point #2
Design flow, gpm	100	140
Design head, ft.	300	250

6. Laundry and Hot Shower Tank Pump

Number		1
Type		Canned
Design pressure, psig		150
Design temperature, ^{o}F		200
Material		Stainless Steel
	Operating Point #1	Operating Point #2
Design flow, gpm	35	100
Design head, ft.	250	200

TABLE 11.2-3 (CONT)

7. Floor Drain Tank Pump

Number		1
Type		Canned
Design pressure, psig		150
Design temperature, ^{o}F		200
Material		Stainless Steel
	Operating Point #1	Operating Point #2
Design flow, gpm	35	100
Design head, ft.	250	200

8. Waste Monitor Tank Pumps

Number		2
Type		Canned
Design pressure, psig		150
Design temperature, ^{o}F		200
Material		Stainless Steel
	Operating Point #1	Operating Point #2
Design flow, gpm	35	100
Design head, ft.	250	200

TABLE 11.2-3 (CONT)

9 Concentrate Holding Pump

Number		1
Type		Canned
Design pressure, psig		150
Design temperature, ^{o}F		200
Material		Stainless Steel
	Operating Point #1	Operating Point #2
Design flow, gpm	35	100
Design head, ft.	250	200

10. Cask Decontamination Drain Tank Pump

Number		1
Type		Canned
Design pressure, psig		150
Design temperature, ^{o}F		200
Material		Stainless Steel
	Operating Point #1	Operating Point #2
Design flow, gpm	35	100
Design head, ft.	250	200

TABLE 11.2-3 (CONT)

HEAT EXCHANGER

1. Reactor Coolant Drain Tank Heat Exchanger

Number	1	
Type	U-Tube	
Estimated UA, Btu/hr ^{o}F	70,000	

	Shell side	Tube side
Design pressure, psi	150	150
Design temperature, ^{o}F	250	250
Design flow, lb/hr.	112,000	44,600
Inlet temperature, ^{o}F	105	108
Outlet temperature, ^{o}F	125	130
Material	Carbon Steel	Stainless Steel

TANKS

1. Reactor Coolant Drain Tank

Number	1
Type	Horizontal
Usable volume, gallons	350
Design pressure, psig	100
Design temperature, ^{o}F	250
Material	Stainless Steel
Diaphragm	No

TABLE 11.2-3 (CONT)

TANKS (CONT)

2. Waste Holdup Tanks

Number	2
Type	Vertical
Usable volume, gallons	10,000
Design pressure, psig	Atmospheric
Design temperature, $^{\circ}F$	200
Material	Stainless Steel
Diaphragm	No

3. Waste Evaporator Distillate Tank

Number	1
Type	Vertical
Usable volume, gallons	5000
Design pressure, psig	Atmospheric
Design temperature, $^{\circ}F$	200
Material	Stainless Steel
Diaphragm	Yes

4. Chemical Drain Tank

Number	1
Type	Vertical
Usable volume, gallons	600

TABLE 11.2-3 (CONT)

TANKS (CONT)

Chemical Drain Tank (Cont)

Design pressure, psig	Atmospheric
Design temperature, ^{o}F	200
Material	Stainless Steel
Diaphragm	No

5. Spent Resin Storage Tank

Number	1
Type	Vertical
Usable volume, cu. ft.*	350
Design pressure, psig	100
Design temperature, ^{o}F	200
Material	Stainless Steel
Diaphragm	No

6. Laundry and Hot Shower Tank

Number	1
Type	Vertical
Usable volume, gallons	25,000
Design pressure, psig	Atmospheric
Design temperature, ^{o}F	200
Material	Stainless Steel
Diaphragm	No

* Total for resin and liquid

TABLE 11.2-3 (CONT)

TANKS (CONT)

7. Floor Drain Tank

Number	1
Type	Vertical
Usable volume, gallons	10,000
Design pressure, psig	Atmospheric
Design temperature, ^{o}F	200
Material	Stainless Steel
Diaphragm	No

8. Waste Monitor Tanks

Number	2
Type	Vertical
Usable volume, gallons	5000
Design pressure, psig	Atmospheric
Design temperature, ^{o}F	200
Material	Stainless Steel
Diaphragm	No

9. Waste Evaporator Reagent Tank

Number	1
Type	Vertical
Usable volume, gallons	5
Design pressure, psig	150

TABLE 11.2-3 (CONT)

TANKS (CONT)

9. Waste Evaporator Reagent Tank (Cont)

Design temperature, °F	200
Material	Stainless Steel
Diaphragm	No

10. Concentrates Holding Tank

Number	1
Type	Vertical
Usable volume, gallons	5000
Design pressure, psig	Atmospheric
Design temperature, °F	200
Material	Stainless Steel
Diaphragm	No

11. Cask Decontamination Drain Tank

Number	1
Type	Vertical
Usable volume, gallons	25,000
Design pressure, psig	Atmospheric
Design temperature, °F	200
Material	Stainless Steel
Diaphragm	No

TABLE 11.2-3 (CONT)

DEMINERALIZERS

1. Waste Evaporator Distillate Demineralizer

Number	1
Type	Flushable
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
Resin volume, cu. ft.	30
Material	Stainless Steel
Resin type	IRN-150*

2. Waste Monitor Tank Demineralizer

Number	1
Type	Flushable
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
Resin volume, cu. ft.	30
Material	Stainless Steel
Resin type	IRN-150*

* Rohm and Haas Amberlite or equivalent.

TABLE 11.2-3 (CONT)

DEMINERALIZERS (CONT)

3. Floor Drain Tank Demineralizer

Number	1
Type	Flushable
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
Resin volume, cu. ft.	30
Material	Stainless Steel
Resin type	IRN-150*

4. Waste Holdup Tank Demineralizer

Number	1
Type	Flushable
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
Resin volume, cu. ft.	30
Material	Stainless Steel
Resin type	IRN-150*

* Rohm and Haas Amberlite or equivalent.

TABLE 11.2-3 (CONT)

FILTERS

1. Waste Holdup Tank Demineralizer Filter

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
ΔP at design flow, psi	5
Size of particles, 98% retention	25 μ
Material	Stainless Steel

2. Waste Evaporator Distillate Filter

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
ΔP at design flow, psi	5
Size of particles, 98% retention	25 μ
Material	Stainless Steel

3. Spent Resin Sluice Filter

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200

TABLE 11.2-3 (CONT)

FILTERS (CONT)

3. Spent Resin Sluice Filter (Cont)

Design flow, gpm	150
ΔP at design flow, psi	5
Size of particles, 98% retention	25 μ
Material	Stainless Steel

4. Floor Drain Tank Filter

Number	1
Design pressure, psig	150
Design temperature, ^oF	200
Design flow, gpm	35
ΔP at design flow, psi	5
Size of particles, 98% retention	25 μ
Material	Stainless Steel

5. Waste Monitor Tank Demineralizer Filter

Number	1
Design pressure, psig	150
Design temperature, ^oF	200
Design flow, gpm	35
ΔP at design flow, psi	5
Size of particles, 98% retention	25 μ
Material	Stainless Steel

TABLE 11.2-3 (CONT)

FILTERS (CONT)

6. Laundry and Hot Shower Drain Tank Filter

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
ΔP at design flow, psi	5
Size of particles, 98% retention	25 μ
Material	Stainless Steel

7. Floor Drain Tank Demineralizer Filter

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
ΔP at design flow, psi	5
Size of particles, 98% retention	25 μ
Material	Stainless Steel

8. Cask Decontamination Drain Tank Filter

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200

TABLE 11.2-3 (CONT)

FILTERS (CONT)

8. Cask Decontamination Drain Tank Filter (Cont)

Design flow, gpm	35
ΔP at design flow, psi	5
Size of particles, 98% retention	25 μ
Material	Stainless Steel

9. Waste Holdup Tank Filters

Number	2
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
ΔP at design flow, psi	5
Size of particles, 98% retention	25 μ
Material	Stainless Steel

STRAINERS

1. Laundry and Hot Shower Drain Tank Strainer

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
ΔP at design flow, psi	Negligible
Mesh Number	40
Material	Stainless Steel

TABLE 11.2-3 (CONT)

STRAINERS (CONT)

2. Floor Drain Tank Strainer

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
ΔP at design flow, psi	Negligible
Mesh number	40
Material	Stainless Steel

3. Containment Sump Strainer

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200
Design flow, gpm	35
ΔP at design flow, psi	Negligible
Mesh number	40
Material	Stainless Steel

4. Cask Decontamination Drain Tank Strainer

Number	1
Design pressure, psig	150
Design temperature, ^{o}F	200

TABLE 11.2-3 (CONT)

STRAINERS (CONT)

4. Cask Decontamination Drain Tank Strainer (cont)

Design flow, gpm	35
ΔP at design flow, psi	Negligible
Mesh number	40
Material	Stainless Steel

EVAPORATORS

Waste Evaporator

Number	1
Steam design pressure, psig	50
Design flow, gpm	15
Feed concentration, ppm boron	10-2500
Bottoms concentration, ppm boron	7-21,000
Material	Stainless Steel
Design process decontamination factor	1000

TABLE 11.2-4

RANGE OF MEASURED DECONTAMINATION

FACTORS FOR SELECTED ISOTOPES

Isotope	Minimum	Maximum
I-131	1.1×10^1	1.6×10^4
I-133	1.1×10^1	1.8×10^4
I-135	1.4×10^1	2.0×10^4
Cs-137	2.4	1.3×10^3
F-18	1.73×10^1	1.5×10^3
Co-58	3.2×10^1	8.2×10^3
Mn-54	$> 2.5 \times 10^1$	$> 1.3 \times 10^2$

These values were observed across mixed bed demineralizers containing cation resin in the lithium-7 form and anion resin in the borated form.

TABLE 11.2-5

DILUTION FACTORS FOR RELEASE FROM LIQUID WASTE TREATMENT SYSTEM

DILUTION FLOW (GPM)

	Plant Operation		Plant Shutdown	
	Minimum	Normal	Minimum	Normal
1. Circulating Water System	600,000	900,000	----	-----
2. Auxiliary Raw Water System	18,000	36,000	18,000	36,000
3. Non-Essential Raw Water System	60,000	60,000	20,000	20,000
TOTAL FLOW	678,000	996,000	38,000	56,000
DILUTION FACTORS				
MINIMUM Dilution Factor (100 gpm release rate)	6780	9960	380	560
NORMAL Dilution Factor (35 gpm release rate)	19370	28457	1086	1600

11.3 GASEOUS WASTE TREATMENT SYSTEM

This section is presented in RESAR-3 Sections 11.3 through 11.3.6. RESAR-3 Sections 11.3.1, 2, 4, and 5 are incorporated here by reference. The Floating Nuclear Plant includes 8 gas decay tanks; 6 are used for normal power operation and 2 are used for shutdown. The system flow diagrams are shown on Figure 11.3-2, Sheets 1 and 2.

11.3.1 DESIGN BASES

The design bases are presented in RESAR-3, Section 11.3.1.

11.3.2 SYSTEM DESCRIPTION

The system description is presented in RESAR-3, Section 11.3.2

11.3.3 SYSTEM OPERATION

Initially the Gaseous Waste Treatment System is purged of air and blanketed with nitrogen. During normal power operation one gas decay tank is valved into the system. Nitrogen gas is continuously recirculated by one of the compressors through a recombiner and a gas decay tank to the compressor suction. Hydrogen mixed with the fission gases, which are stripped from the reactor coolant in the Chemical And Volume Control System volume control tank, joins the recirculating nitrogen at the compressor suction. The resulting hydrogen-nitrogen-fission gas mixture is pumped by a compressor to a recombiner.

Oxygen added at the recombiner reduces the hydrogen to a low residual level by oxidation to water vapor on a catalytic surface. After the water vapor is removed, the resulting gas stream (mainly a nitrogen-fission gas mixture) is recirculated through a gas decay tank to the compressor suction to complete the loop circuit.

The recirculation loop operates automatically. Hydrogen is continuously supplied at 0.7 SCFM at the volume control tank and oxygen at 0.35 SCFM at the recombiner. Valving is manual with extended stems through shield walls.

Waste Gas Treatment System is operated in such a way as to diminish the amount of radioactive gases which could be released as a consequence of any single failure. Only one waste gas decay tank at a time is in the circulating loop. The other waste gas decay tanks are isolated and separated by concrete enclosures. By alternating the operating waste gas decay tanks the radioactivity is distributed in nearly equal amounts in each storage tank. Therefore, any activity which would be potentially released from the system is minimized.

Pressure in the waste gas decay tanks will gradually increase during the life of the plant from the buildup of fission gases and nitrogen which is introduced with reactor coolant makeup.

The Gaseous Waste Treatment System operation remains the same even during cold shutdown until hydrogen addition to the volume control tank is terminated. Then, the waste gas decay tank is valved out of service and one of the two shutdown tanks is valved into service. The shutdown tank supplies nitrogen instead of hydrogen to purge the volume control tank. Since some hydrogen will continue to come out of solution, operation through the recombiners continues until no further hydrogen is being removed.

During the initial shutdown, fresh nitrogen is used. This nitrogen is stored in the shutdown tanks during normal power operation and is reused for subsequent shutdowns.

During shutdown, flow is from a shutdown tank to the volume control tank to the compressor suction to the shutdown tank to complete the loop. A side flow is recirculated from the shutdown tank through a recombiner to the compressor suction.

A survey has been performed of gaseous discharges from different Westinghouse PWR plants for one calendar year. The results are presented in RESAR-3, Table 11.3-4 and show that releases were only a small fraction of 10 CFR 20 limits. These plants have less capacity for containing gases than the floating nuclear plant, hence a greater need for releases to the environment.

11.3.4 PERFORMANCE TESTS

Performance tests are presented in RESAR-3, Section 11.3.4.

11.3.5 ESTIMATED RELEASES

Estimated releases are presented in RESAR-3, Section 11.3.5.

11.3.6 RELEASE POINTS

The only release point from the Gaseous Waste Treatment is through the vent header to the plant exhaust. However, the system is designed to contain all gases. Therefore, the only potential release is from leakage within the auxiliary area. RESAR-3, Table 11.3-1 presents a conservative estimate of these releases to be one hundred standard cubic feet per year. These releases are through the Auxiliary Area Ventilation Systems and the plant exhaust to the environment.

11.3.7 DILUTION FACTORS (Ref. 11.3.8)

11.3.8 ESTIMATED DOSES

For continuity in the presentation of information pertaining to dilution factors and estimated doses the applicant has included the information in Section 12.4, Summary of Normal Operation Offsite Doses.

11.4 PROCESS AND EFFLUENT RADIOLOGICAL MONITORING SYSTEMS

11.4.1 DESIGN OBJECTIVES

In order to handle, process, and/or release radioactivity in compliance with the AEC regulations or within the limiting conditions for operation, the radiological monitoring systems are designed to provide radiation measurements, records, alarms and/or automatic line isolations. They monitor process and effluent streams evolved by normal and anticipated plant operations wherever a potential release of radioactivity exists.

11.4.2 CONTINUOUS MONITORING

The functional performance requirements for the radiation monitoring systems are:

Warn operating personnel of high radiation levels.

Monitor amount of radioactivity released in effluents.

Perform some control functions when activity levels reach a preset limit.

Record and provide information concerning the amount of radioactivity released to effluent streams.

11.4.2.1 Design Bases

The components of the process and effluent radiation monitoring system are designed for the following conditions:

1. Temperature - An ambient temperature range of 40 to 120°F.

2. Humidity - 0 to 95 percent relative humidity.

3. Pressure - Components in the auxiliary building and control room are designed for normal atmospheric pressure.

4. Radiation - Process and effluent radiation monitors are of a non-saturating design so that no instrument or detector damage will occur even if exposed to radiation levels up to 100 times full scale indication.

5. Radiation monitoring equipment is designed and located such that radiation damage to electrical insulation and other materials will not affect their usefulness over the life of the plant.

6. Each radiation monitoring system is designed such that it may be checked on a daily basis, tested monthly, and recalibrated at re-fueling shutdown.

7. Access to the radiation monitoring system alarm setpoints in the control room is under administrative control.

8. All process and effluent radiation monitors are annunciated and indicated in the control room.

9. Process and effluent monitors continuously monitor radiation levels.

10. All process and effluent monitors provide instrument failure annunciation in the main control room.

11.4.2.2 System Description

Process and effluent radiological monitoring systems consist of channels which monitor radiation levels in various plant operating systems. The output from each channel detector is transmitted to the radiation monitoring system cabinets located in the control room where the radiation level is indicated by a meter and recorded by a multipoint recorder. High radiation level alarms are annunciated in the control room and indicated on the radiation monitoring system cabinets.

A tabulation of the process radiation monitoring channels is found in Table 11.4-1 for liquid and Table 11.4-2 for gas. The minimum sensitivity listed in the Table is based on a background level of 2 mr/hr.

Each channel contains a completely integrated modular assembly, which includes the following:

1. Log Level Amplifier

Accepts detector pulses, performs a log integration (converts total pulse rate to a logarithmic analog signal), and amplifies the resulting output for suitable indication and recording.

2. Power Supplies

Furnishes the positive and negative voltages for the transistor circuits, relays, and alarm lights and provides the high voltage for the detector.

3. Test-Calibration Circuitry

Provides a precalibrated pulse signal to test channel electronics, and a solenoid operated radiation check source to verify channel operation. An annunciator light in the control room indicates when the channel is in the test mode.

4. Radiation Level Meter

Provides a scale calibrated logarithmically over the range specified. The signal is also recorded by the recorder.

5. Indicating Lights

Indicates high-radiation alarms and circuit failures. A common annunciator in the control room is actuated on high radiation from any channel.

6. Bi-Stable Circuits

Two bi-stable circuits are provided, one to alarm on high radiation (actuation point may be set at any level over the range of the instruments), and one to alarm on loss of signal(circuit-failure).

7. Check Source

A remotely operated long half-life radiation check source is furnished in each channel. The energy emission ranges are similar to the radiation energy spectra being monitored. The source strength is sufficient to cause a noticeable upscale deflection.

8. Power Source

Each channel is supplied from a 120 volt ac vital instrument bus.

11.4.3 CALIBRATION AND MAINTENANCE

A primary calibration is performed on a one time basis, utilizing typical isotopes of interest to determine proper detector response. Further primary calibrations are not required since the geometry cannot be significantly altered within the sampler. Calibration of samplers is then performed based on a known correlation between the detector responses and a secondary standard.

Secondary standard calibrations are performed with a radiation source of known activity. This single point calibration confirms the channel sensitivity. The secondary standard calibration is performed by removing the detector and placing the check source on the sensitive area of the detector.

The radiation monitoring system channels can be checked daily and will be calibrated periodically.

Calibration of the indicated channels is recommended to be performed following any equipment maintenance which could result in reducing the accuracy of the instrument indication. Calibration is also recommended to be performed when the electric-pulse generator or the radioactive check source indicates instrument drift.

11.4.4 SAMPLING

In addition to the continuous monitors, local connections provide samples for radiological analyses. These samples provide periodic or batch information for processing requirements before transfer or release of radioactive fluids.

Table 11.4-3 lists these sample locations and provides the information regarding the type of sample, minimum frequency, purpose of analysis and the application of results.

These sampling connections are exclusive of the NSSS Sampling System (see Section 9.3.3) which may also furnish radiation information for guidance in the process operation.

TABLE 11.4-1

LIQUID PROCESS AND EFFLUENT MONITORS

Monitor	Type	Sensitivity Range (μc/cc)	Isotopes Monitored	Detector Energy Range	Control Function
Boron Recycle System	Scintillation	1.0×10^{-5} to 1.0×10^{-2}	I^{131} I^{133} CS^{134} CS^{132} CO^{58} CO^{60*}	Y-0.1 mev to Y-3 mev	On high activity diverts discharge to demineralizer clean up.
Component Cooling Water System Monitor	Scintillation	1.0×10^{-5} to 1.0×10^{-2}	Same as boron recycle system monitor	Y-0.1 mev to Y-3 mev	On high radiation signal initiates closure of the component cooling surge tank vent line.
Waste Processing Liquid Effluent Monitor	Scintillation	1.0×10^{-5} to 1.0×10^{-2}	Same as boron recycle system monitor	Y-0.1 mev to Y-3 mev	On high radiation signal, initiates valve closure in release line.

TABLE 11.4-1 (CONT)

Monitor	Type	Sensitivity Range ($\mu c/cc$)	Isotopes Monitored	Detector Energy Range	Control Function
Steam Generator Liquid Sample Monitor	Scintillation	1.0×10^{-5} to 1.0×10^{-2}	Same as boron recycle system monitor	Y-0.1 mev to Y-3 mev	On high activity alarm, stops direct steam generator blowdown to circulating water system. Permits blowdown flow to demineralizers.
Essential Service Water System Monitors (4 required)	Scintillation	1.0×10^{-5} to 1.0×10^{-2}	Same as boron recycle system monitor	Y-0.1 mev to Y-0.3 mev	On high activity alarm, closes surge tank vent valve.
Essential Raw Water (4 required)	Scintillation	1.0×10^{-5} to 1.0×10^{-2}	Same as boron recycle system monitor	Y-0.1 mev to Y-3 mev	Alarm only
Steam Generator Blowdown Liquid	Scintillation	1.0×10^{-5} to 1.0×10^{-2}	Same as boron recycle system monitor	Y-0.1 mev to Y-3 mev	On high activity, stops demineralized steam generator blowdown to the the circulating water system or condensate stg. tank. Permits discharge to sample tanks.

TABLE 11.4-1 (CONT)

Monitor	Type	Sensitivity Range (μc/cc)	Isotopes Monitored	Detector Energy Range	Control Function
Non-Essential Service Water	Scintillation	1.0×10^{-5} to 1.0×10^{-2}	Same as boron recycle system monitor	Y-0.1 mev to Y-3 mev	On high activity, closes surge tank vent valve
Failed Fuel Monitor	The failed fuel monitor is used to detect fuel failure by monitoring the gamma activity of the fission products released in the coolant and to alert the operator to take and analyze a coolant sample. Detector sensitivities and isotopes monitored are established on the evaluation of the consequences of a postulated rupture of a steam generator tube.				

* Sensitivity based on this isotope.

TABLE 11.4-2

GASEOUS PROCESS AND EFFLUENT MONITORS

Monitor	Type	Sensitivity Range μc/cc	Isotopes Monitored	Detector Energy Range	Control Function
Waste Gas Processing	Geiger-Mueller	10^{-6} to 10^{-3}	Kr 85, Ar 41 Xe 135, Xe 133	Y - 0.1 to 3.0 B - 0.2 to 3.0	Alarm only
Condenser Air Ejector	"	10^{-6} to 10^{-3}	" "	" "	Stops direct Steam generator blowdown to circulating water system. Permits blowdown flow to demineralizers.

11.5 SOLID WASTE SYSTEM

The Solid Waste Treatment System (WTS), shown in Figure 11.5-1, performs packaging of certain plant radwastes.

11.5.1 DESIGN OBJECTIVES

The design objectives of the Solid Waste Treatment System are:

1. Receive and render the following plant radwastes into a homogeneous solid product within a drum suitable for transportation and subsequent permanent burial:

    a. Evaporator concentrates

    b. Spent Resin

    c. Chemical drain liquid

    d. Solid Waste Treatment System flush liquid.

2. Receive and fix radioactive spent filter cartridges in a solidified matrix within a drum suitable for transportation and permanent burial.

3. Receive and compact compressible solid waste into a drum suitable for transportation and permanent burial.

4. Provide drum conveyance and handling.

5. Provide interim storage for drummed waste.

6. Perform drum filling, capping, decontamination and conveyance to storage remotely by a single operator behind shield walls.

7. Limit operator exposure during operation to 2.5 mr/hr.

8. Limit operator exposure during maintenance to 100 mr/hr.

9. Limit activity of filled drums to permit storage within shielding limits and shipment within a finite period.

10. Provide a reliable system incorporating automated features.

11.5.2 SYSTEM INPUTS

Radwastes drummed by the system consists of the following:

1. Spent resin

2. Evaporator concentrates

3. Spent filter cartridges

4. Chemical drain tank liquid

5. Compressible solid radwaste

6. Solid Waste System flush liquid.

Spent Resin

The volume of spent resin required to be drummed is a function of the volume and impurity level of the reactor plant and steam generator blowdown fluids processed by demineralizers. The expected annual radioactive spent resin volume is listed in Table 11.5-1.

Evaporator Concentrates

The volume of evaporator concentrates is dependent on the amount of recycle evaporator concentrates which are recycled and the amount of waste evaporator concentrates. The expected annual volume is listed in Table 11.5-1.

Spent Filter Cartridges

The number of spent filter cartridges required to be drummed is dependent on the volume and impurity level of reactor plant fluids processed by filters. The expected number of spent filter cartridges is listed in Table 11.5-1.

Chemical Drain Tank

Chemical drain tank liquid consists of spent radioactive samples and rinse liquid. The expected annual volume is listed in Table 11.5-1.

Compressible Solid Radwaste

Compressible solid radwaste consists of disposable clothing, rags, towels, floor covering, shoe covers, cloth smears, respirator filters, etc. The expected annual volume is listed in Table 11.5-1.

Solid Waste System Flush Liquid

Liquid utilized to flush the wet cement bearing surfaces of the system following batch drum filling operation is solidified. The expected annual volume is listed in Table 11.5-1.

The expected curie content of the above radwastes is listed in Table 11.5-1.

11.5.3 EQUIPMENT DESCRIPTION

11.5.3.1 System Description

The system consists primarily of a waste feed train, cement feed train, a waste-cement mixer/feeder, equipment to perform remote and automatic drum capping and decontamination, a baler to perform packaging of compressible solid waste, and a central control panel.

Waste Feed Train

The waste feed train consists of a waste process feed tank, waste dewatering pump, waste feeder and associated piping valves and instrumentation. Liquid and slurry wastes are received in the waste process feed tank where conditioning of the waste is performed depending on the type of waste. For resin slurry waste, dewatering is performed through redundant dewatering filters located inside the tank by a waste dewatering pump. The slurry level is determined by two redundant level detectors. Dewatering is performed to obtain the correct content of liquid such that when mixed with dry cement an acceptable solidified product is formed. For both evaporator concentrates and resin slurry wastes, agitation is performed in the tank to create a homogeneous solution and ensure a uniform waste feed mixture. Redundant radiation monitors are provided on the tank to indicate the activity level of the batched waste prior to drum filling. A radiation level indication is provided to minimize the possibility of exceeding the curie capacity of a drum. In addition, the tank design incorporates redundant electric heaters to maintain the desired temperature and a water spray header for decontamination. Following conditioning of the waste, the waste feeder conveys the waste feed through an in-line flow meter and flow totalizer into the waste-cement mixer/feeder. For drumming of filter cartridges, reactor makeup water or low activity waste liquid (which serves as the liquid of hydration for the cement) is substituted for the waste.

Cement Feed Train

The cement feed train consists of a cement bag dump station, cement elevator, cement dust collector, cement batch tank, cement feeders, and piping, valves and instrumentation. Dry cement is manually loaded into the elevator at the cement bag dump station for conveyance to the cement batch tank. The cement dust collector, consisting of a dust collection tank and associated blower and filter, maintains the area dust free. The cement batch tank consists of a static cylindrical storage upper section and vibrating lower section. The tank conditions the dry cement by vibration to a constant bulk density for uniform flow and metering of the cement feed. The dry cement is transferred from the tank to the waste-cement mixer/feeder by two feeders in series. The first feeder is a precision, controlled vibration screw feeder which regulates and adjusts the feed on demand from the control panel. The second feeder is a constant screw feeder equipped with a "gate switch" and vibrator. The function of the "gate switch" is to terminate waste feed if cement flow into the mixer/feeder is interrupted. The "gate switch" elininates the possibility of packaging any unsolidified wastes in a drum.

Mixer/Feeder

The waste and cement feeds are introduced simultaneously to the mixer/feeder. The mixer/feeder performs mixing of the waste and cement feeds and conveys the mixed product to the drum. The mixer/feeder consists of a rotating screw assembly (spiral and paddle type), flushing apparatus and drive motor assembly. The screw flight and paddle action of the mixer/feeder performs thorough mixing of the waste and cement feeds. A radiation monitor is provided at the drum filling location for indication of the curie content of the drum at time of filling.

Drum Capper

The drum capper performs remote drum capping from behind a shield wall. The capping operation begins with the capper arm fully extended in the control area. The operator then manually affixes a drum cover, complete with ring clamp and bolt, to the holding fingers. Remote capping sequence begins with the operator retracting the capper arm, followed by horizontally positioning the capper arm over the drum. Once over the drum the capper arm is extended until the cover comes in contact with the drum. The final step is to tighten the clamp bolt remotely with a pneumatic wrench.

Drum Decontamination Enclosure

After drum capping is performed, a decontamination spray is provided to remove any surface radioactive contamination from the drum. An enclosure, complete with spray nozzles, is lowered over the drum and fitted into a stationary bottom enclosure to completely enclose the drum. Hot water or steam is used as a spray to wash down all drum surfaces including the top and bottom. A steam drying cycle is used to remove remaining water droplets. The steam is condensed in the hood with condensate removed via a bottom drain connection and directed to the Liquid Waste Treatment System waste holdup tanks.

Baler

The baler compacts compressible solid waste into drums. The baler utilizes hydraulic pressure to force the baler ram into a drum. A baler ventilation shroud, connected to the auxiliary area ventilation system, is provided to collect dust or airborne particulate that may be emitted from the drum during waste compression.

Drum Conveyor

The drum conveyor, used to transfer drums at the drum filling station, consists of a motorized commercial type conveyance system.

Drum Storage Area Bridge Crane

The bridge crane performs drum handling in the drum storage area. The crane is a 10 ton capacity overhead monorail type. The unit is equipped with a dual motor drive to ensure operability. Visual monitors with remote indication are mounted on the unit to facilate drum handling and visual drum storage area inspection.

Component design data is presented in Table 11.5-2.

11.5.3.2 System Operation

Wastes are received by the system in the form of radioactive evaporator concentrates, spent resin slurries, spent filter cartridges and compressible solids. The modes of system operation for drumming the various types of wastes are described below.

Evaporator Concentrates

The waste process feed tank receives the evaporator concentrates in liquid form from the Liquid Waste Treatment System (WTL) concentrates holding tank or directly from the recycle or waste evaporators. Evaporator concentrates drumming is performed on a batch basis with the quantity of concentrates supplied to the tank determining the batch size. The maximum batch quantity is 750 gallons which fills approximately 25 drums. Indication of batch size is provided by redundant tank level detectors. The waste is agitated to obtain a homogeneous solution and ensure a uniform waste feed mixture. Electric heaters in the tank control the temperature of the concentrates sufficient to prevent crystallization. Indication of the radiation level is provided by the redundant radiation monitors. Following the conditioning of the waste in the waste feed process tank, subsequent drum filling operation is performed remotely from the system control panel.

Spent Resin Drumming

The waste process feed tank receives the spent resin in slurry form from the WTL spent resin storage tanks. Spent resin drumming is also performed on a batch basis with the batch size determined by the quantity of resin supplied to the tank. The level of settled solids (resin) and liquid is determined by either of two ultrasonic level detectors. Dewatering is then performed to obtain the desired liquid content to ensure that when mixed with dry cement an acceptable product is formed. Dewatering is accomplished through the dewatering filters, located inside the waste feed processing tank, by the waste dewatering pump. The filtrate is either pumped back to the spent resin storage tanks or to the waste holdup tanks for processing. The solution is then agitated to obtain a homogeneous solution and ensure a uniform waste feed mixture. Indication of the radiation level is provided by either of the two tank radiation monitors. Following the conditioning of the waste in the waste feed process tank, subsequent drum filling operation is performed remotely from the system control panel.

Spent Filter Cartridge Drumming

A spent filter cartridge is loaded into a drum at the location of cartridge removal from the filter vessel. A cartridge stand apparatus is placed inside the drum to support the cartridge. The drummed cartridge is transported to the drumming station inside the shielded filter cask. At the drumming station the bridge crane is used to lift and position the cask behind the shield wall on the drum conveyor at the filter cask removal location. The cask is then removed remotely from behind the shield wall. The drum, loaded with the cartridge, is then transferred to the drum filling position by the drum conveyor. Following positioning the drum is filled with cement.

The waste process feed tank is filled with clean or low activity waste water (acts as the waste feed) which serves as the moisture of hydration for the dry cement. The filling of the drum with cement is performed remotely from the system control panel.

Chemical Drain Tank Liquid

Drumming of chemical drain tank liquid is performed in the same manner as evaporator concentrates.

Solid Waste System Flush

Following batch drumming operation, the wet cement bearing components are flushed with reactor makeup water. The flush water is solidified in a drum pre-loaded with cement.

At the drum filling location, the drum is vibrated to settle the waste-cement mixture. Following drum filling, capping, and decontamination, drum conveyance to storage is performed by the drum storage area bridge crane.

11.5.4 EXPECTED VOLUMES

The expected radwaste volumes and the curie content are listed in Table 11.5-1.

The principal nuclides are the following:

Iodine - 131	Strontium - 89
Cesium - 134	Strontium - 90
Cesium - 137	Yttrium - 90
Cobalt - 58	Yttrium - 91
Cobalt - 60	Niobium - 95
Praseodymium - 144	Zirconium - 95
Cerium - 144	

11.5.5 PACKAGING

Department of Transportation (DOT) 17-H, 55 gallon drums are utilized for packaging. The drumming operation is performed with three limitations on the contained activity level:

1. Maximum radioactivity concentration must comply with radiological packaging requirements.

2. Activity level (with decay) must allow subsequent shipping of drum in a reasonable period of time.

3. Activity level must be within shielding limitations of the drum storage area.

The expected curie content of a filled drum for the various types of solid radwaste is presented in Table 11.5-1.

Packaging of the radwastes is performed in accordance with the following regulations and rules:

1. 10 CFR 71, Packaging of Radioactive Material for Transport.

2. 49 CFR 170-178, Department of Transportation-Hazardous Materials Regulations.

3. 49 CFR 146-149, Department of Transportation-Coast Guard Regulations.

11.5.6 STORAGE FACILITIES

The layout of the drum storage area is shown in Figure 1.2-3. The area consists of a main storage area and a hot drum storage area. High radiation level drums are stored in the hot drum area which is shielded by an additional foot of concrete.

The maximum drum storage capacity is 900 drums; main storage area - 710 drums; hot drum storage area - 190 drums. Three tier drum stacking can be utilized. The normal storage capacity of 700 drums utilizes two tier stacking. The maximum storage capacity (900 drums) utilizes three tier stacking.

Drum storage time is a variable, dependent on drumming rate requirements and the Owner's shipping schedule.

11.5.7 SHIPMENT

The means and scheduling of solid radwaste shipment from the plant are prescribed by the Owner and will be specified in the Owner's Application.

TABLE 11.5-1

EXPECTED ANNUAL SOLID RADWASTE VOLUMES AND CURIE CONTENT

RADWASTE	EXPECTED ANNUAL VOLUME	NO. OF DRUMS	EXPECTED ANNUAL TOTAL CURIES	EXPECTED CURIE CONTENT PER DRUM
Spent Resin	450 ft.^{3}	300	2,646[1]	8.82[1]
Evaporator Concentrates	3000 gals.	100	454[1]	4.54[1]
Spent Filter Cartridges	20 cartridges	20	Variable	Variable
Chemical Drain Tank Liquid	1000 gals.	33	15	0.45
Compacted Compressible Radwaste	825 ft.^{3}	120	Low	<1
Solid Waste System Flush Liquid	500 gals.	25	Low	<1

[1] Based on 0.2 percent fuel leakage as described in Section 12.4, and 30 day decay

TABLE 11.5-2

SOLID WASTE TREATMENT SYSTEM COMPONENT

DESIGN DATA

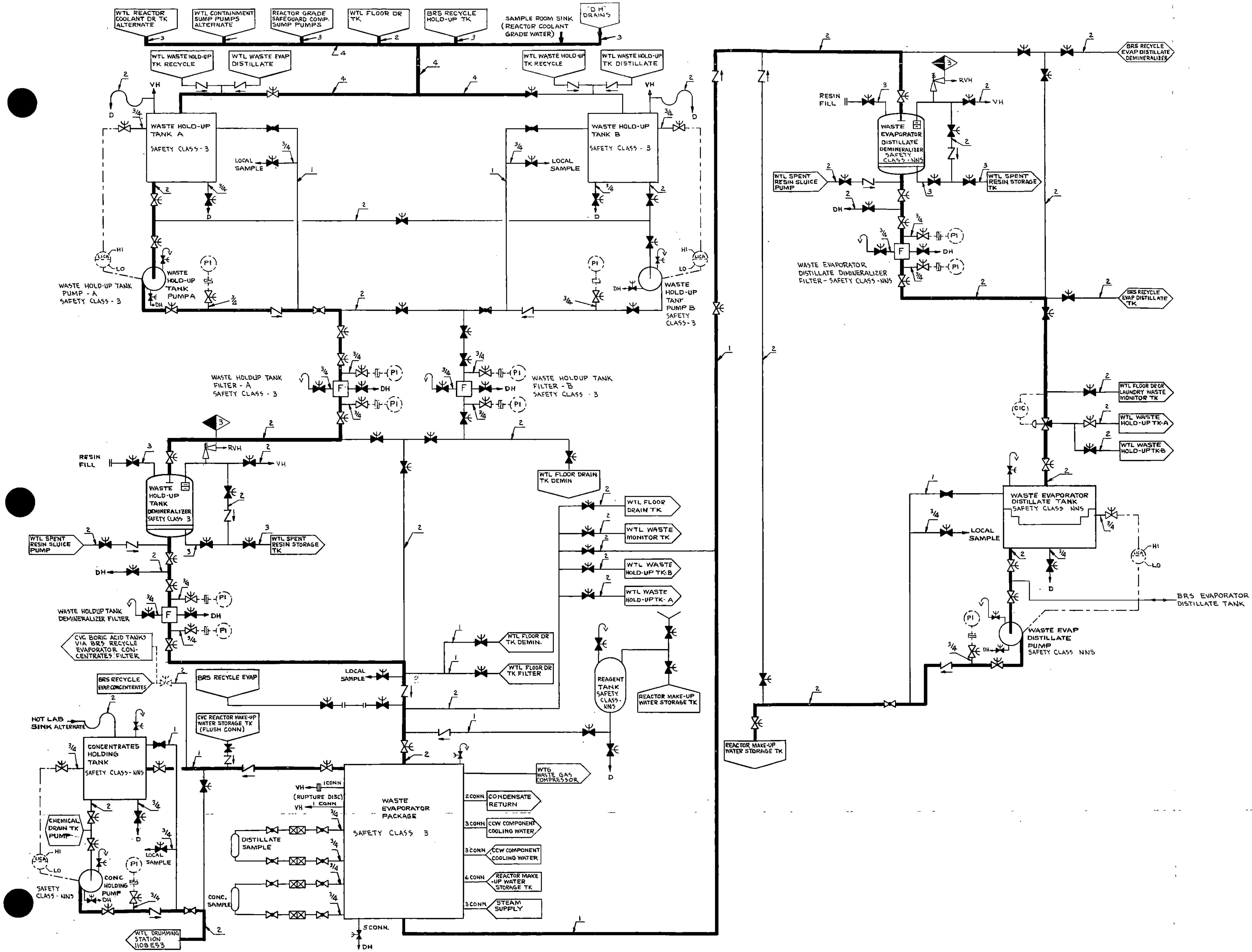
COMPONENT	
Waste Process Feed Tank	
Number/Plant	1
Design capacity (total), ft.^{3}	150
(useable), ft.^{3}	120
Design pressure, psig	10
Design temperature, $^\circ$F	200
Material	300 Stainless Steel
Code	ASME III, Class C
Safety Class	3
Waste Feeder	
Number/Plant	1
Type	Positive displacement
Speed control range, rpm	70-200
Motor rating, hp	2
Material	316 Stainless Steel
Code	ASME III, Class C
Cement Batch Tank	
Number/Plant	1
Design capacity (total), ft.^{3}	150
(useable), ft.^{3}	120
Type	Static cylindrical storage type with vibrating bottom section
Material	CS with corrosion resisting coating
Cement Dust Collector	
Number/Plant	1
Type	Commercial unit consisting of tank, 150 cfm blower and absolute filter

TABLE 11.5-2 (Continued)

SOLID WASTE TREATMENT SYSTEM COMPONENT

DESIGN DATA

COMPONENT	
Cement Feeder	
Number/Plant	1
Type	Vibrating trough and screw with a variable speed motor drive
Mixer/Feeder	
Number/Plant	1
Type	Stainless Steel stationary trough with rotating screw assembly, flush assembly and drive motor
Drum Capper	
Number/Plant	1
Type	Remote assembly
Drum Conveyor	
Number/Plant	1
Type	Motorized
Bridge Crane	
Number/Plant	1
Capacity, tons	10
Type	Monorail

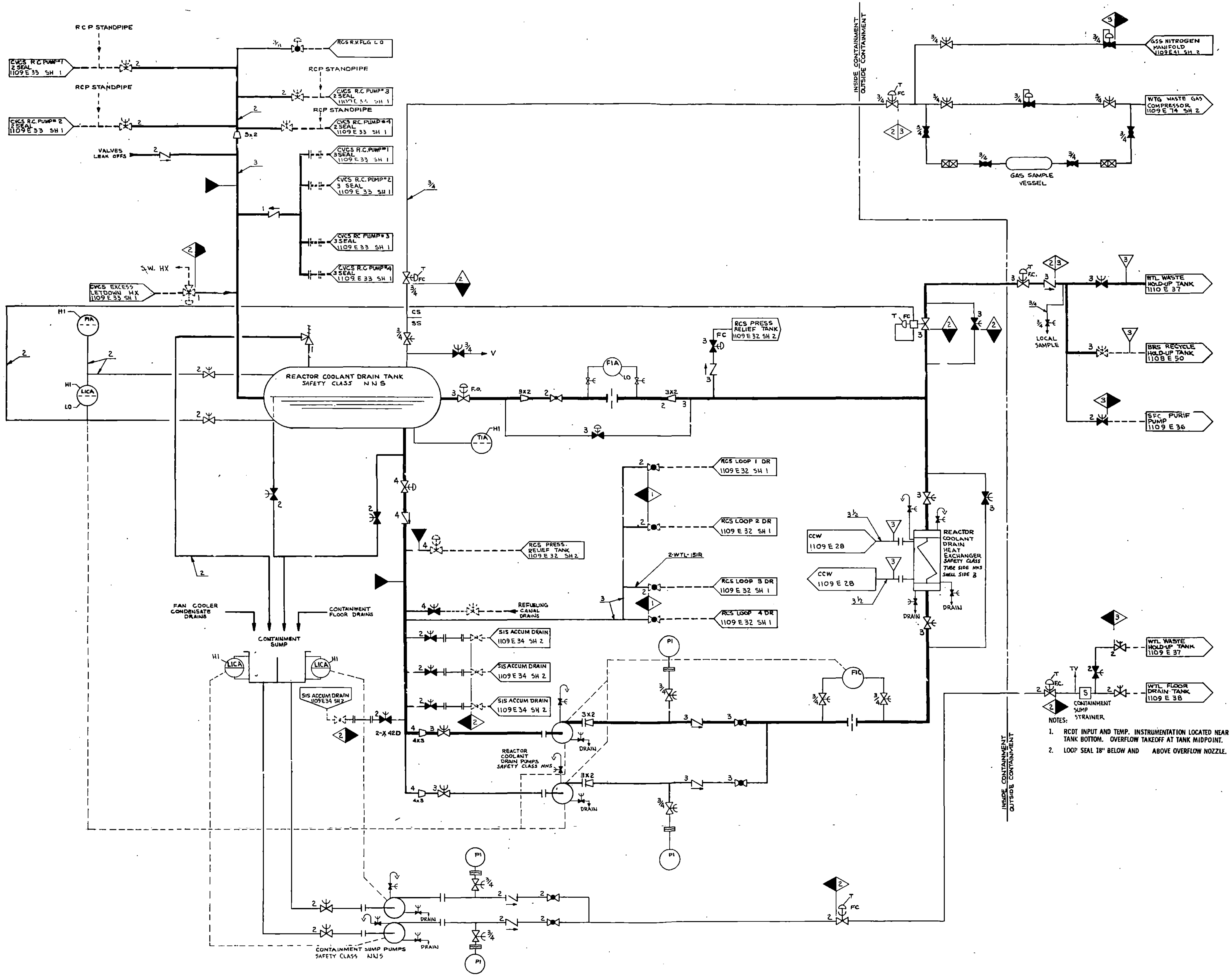


OFFSHORE POWER SYSTEMS

Title: LIQUID WASTE TREATMENT SYSTEM

REACTOR GRADE WATER

11/1/72 Figure: 11.2-1

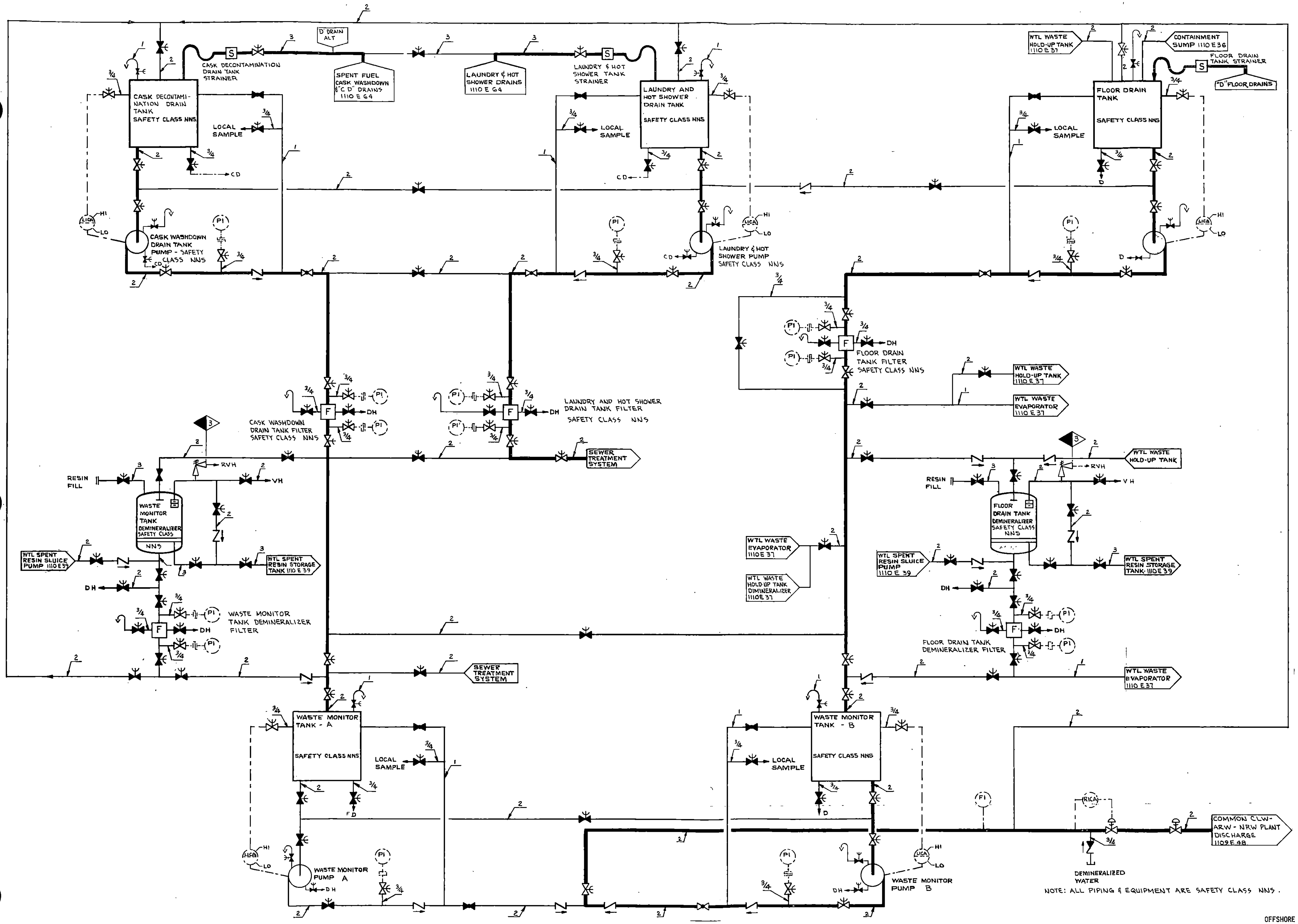


OFFSHORE POWER SYSTEMS

Title: LIQUID WASTE TREATMENT SYSTEM

REACTOR CONTAINMENT

11/1/72 Figure: 11.2-2

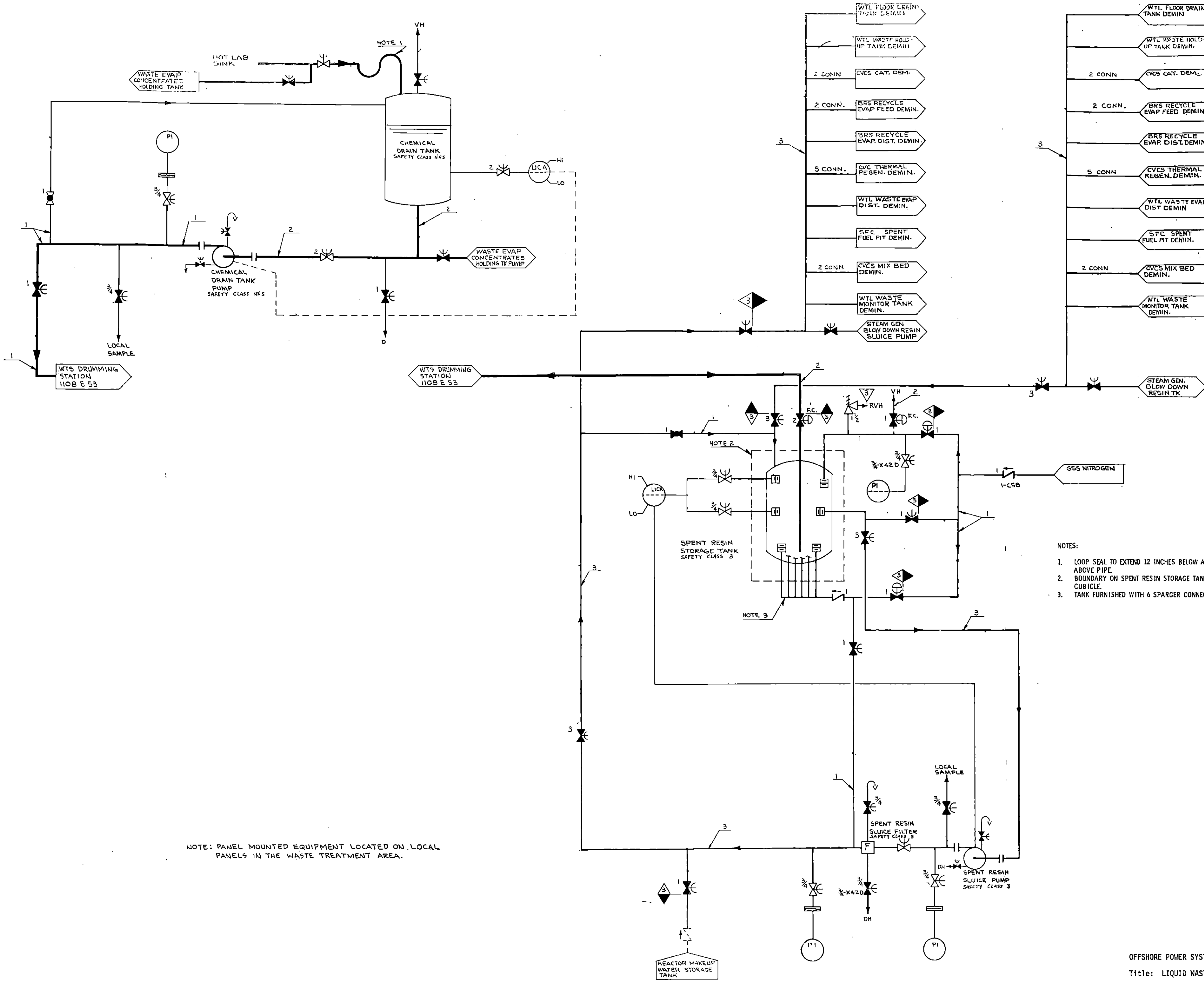


OFFSHORE POWER SYSTEMS

Title: LIQUID WASTE TREATMENT SYSTEM

NON-REACTOR GRADE WATER

11/1/72 Figure: 11.2-3



NOTES:

1. LOOP SEAL TO EXTEND 12 INCHES BELOW AND ABOVE PIPE.
2. BOUNDARY ON SPENT RESIN STORAGE TANK CUBICLE.
3. TANK FURNISHED WITH 6 SPARGER CONNECTIONS

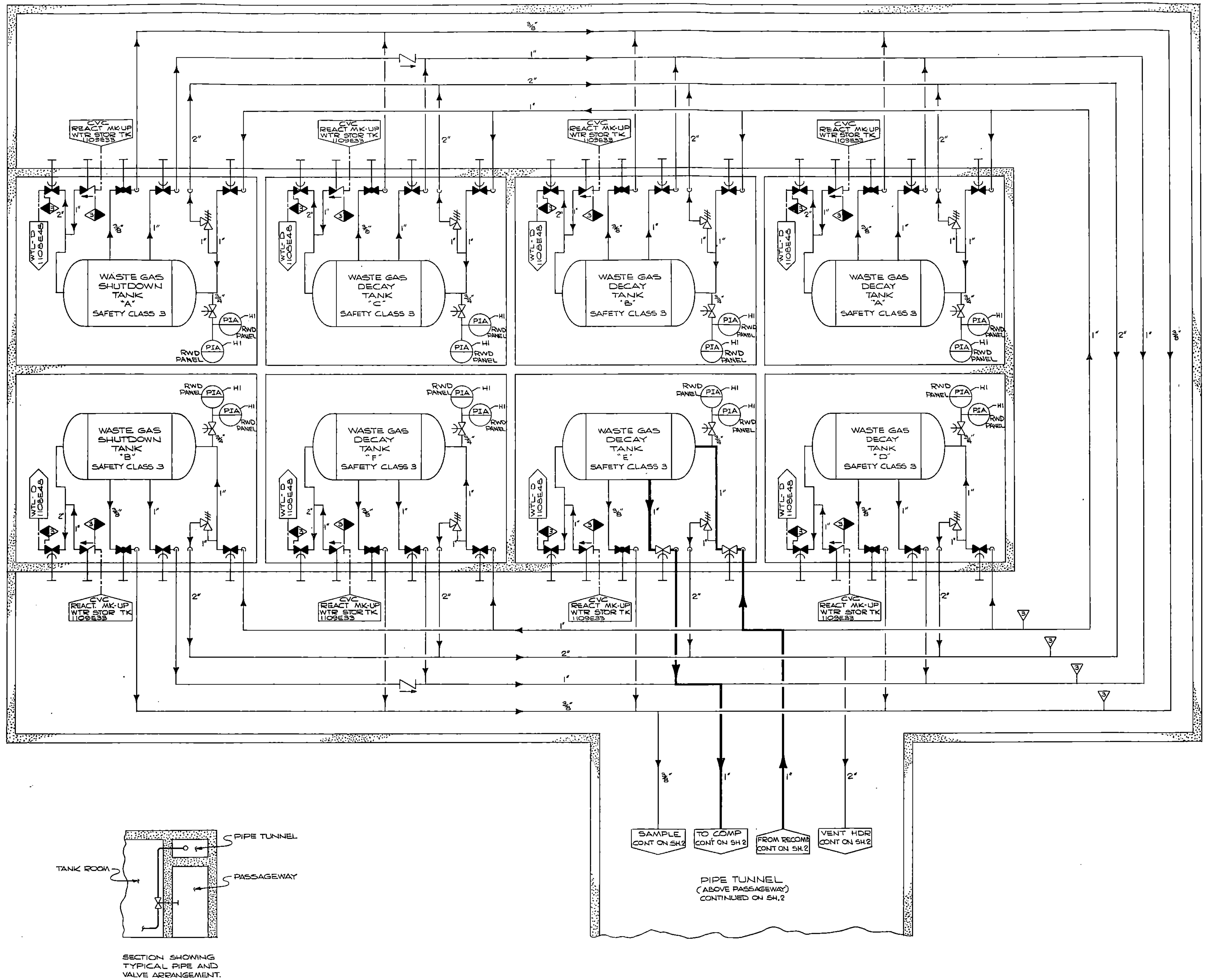
NOTE: PANEL MOUNTED EQUIPMENT LOCATED ON LOCAL PANELS IN THE WASTE TREATMENT AREA.

OFFSHORE POWER SYSTEMS

Title: LIQUID WASTE TREATMENT SYSTEM

CHEMICAL DRAIN AND SPENT RESIN

11/1/72 Figure: 11.2-4

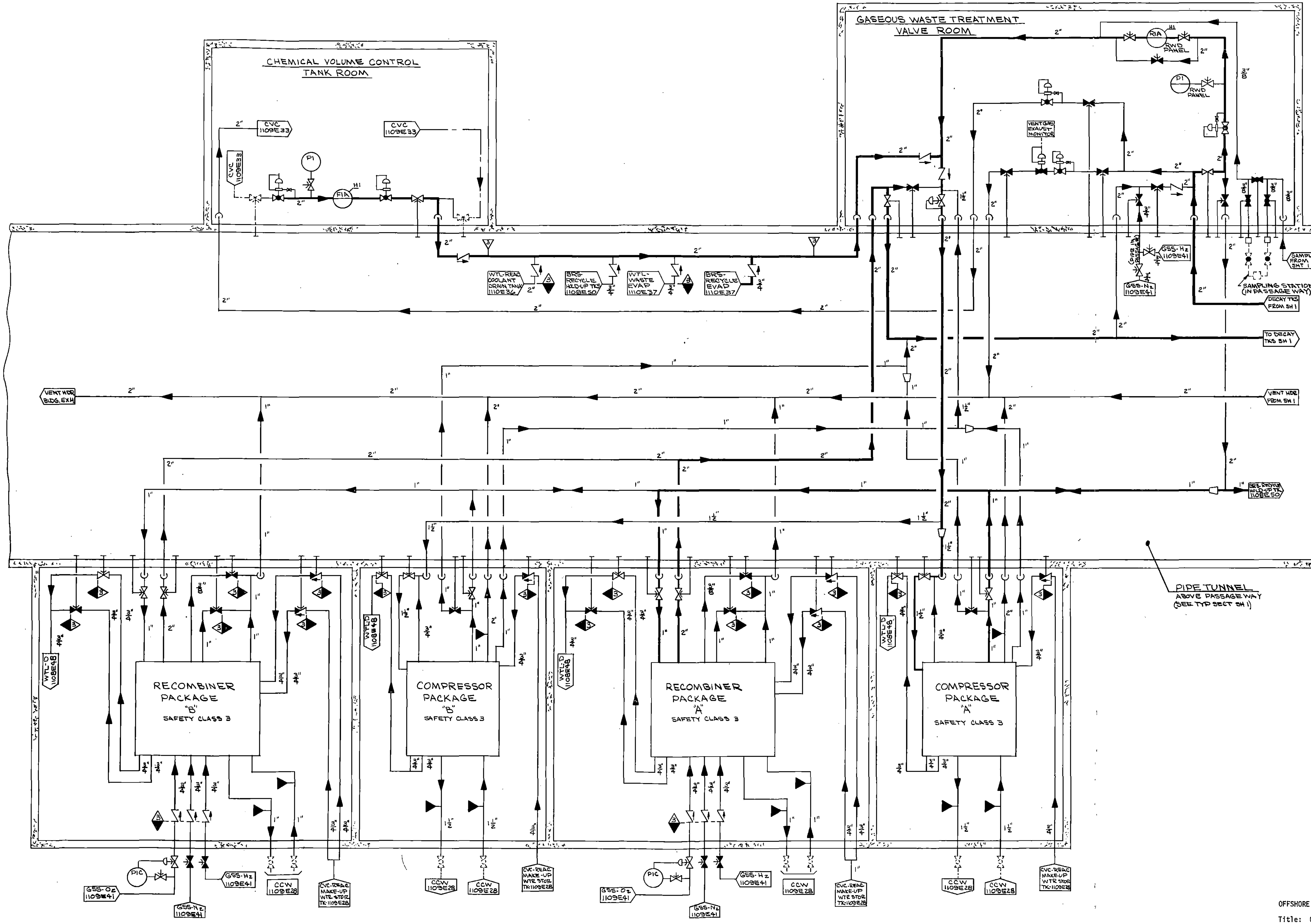


OFFSHORE POWER SYSTEMS

Title: GASEOUS WASTE TREATMENT SYSTEM

11/1/72

Figure 11.3-2
Sheet 1

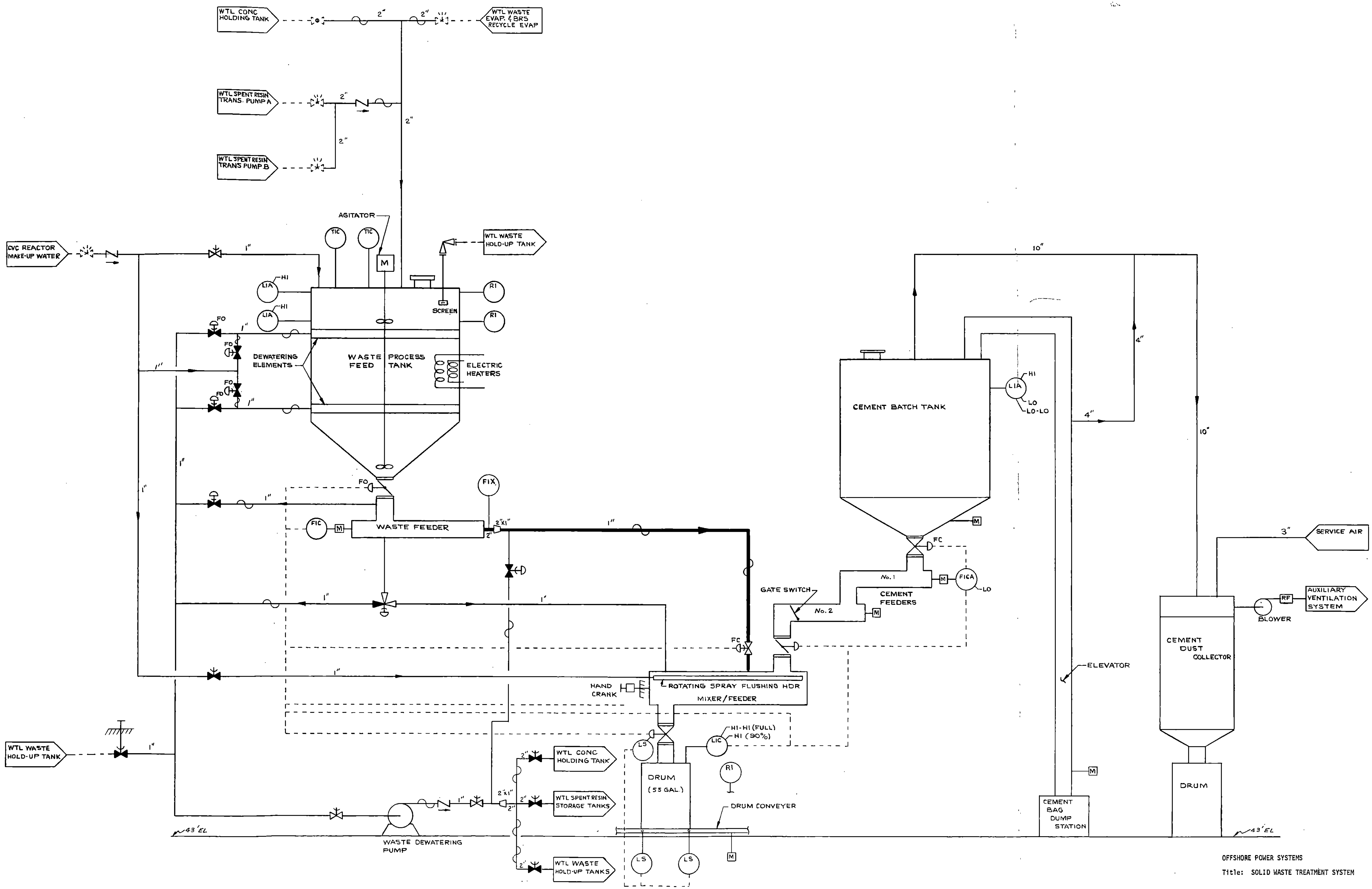


OFFSHORE POWER SYSTEMS

Title: GASEOUS WASTE TREATMENT SYSTEM

11/1/72

Figure: 11.3-2
Sheet 2



OFFSHORE POWER SYSTEMS

Title: SOLID WASTE TREATMENT SYSTEM

11/1/72 Figure 11.5-1