APAE-30

REACTORS—POWER

UNITED STATES ATOMIC ENERGY COMMISSION

ARMY PACKAGE POWER REACTOR APPR-1 OPERATING MANUAL AND INSPECTION AND SERVICE MANUAL

February 1958

Alco Products, Inc.
Schenectady, New York

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APAE-30

OPERATING MANUAL

ARMY PACKAGE POWER REACTOR
APPR-1

This manual covers the basic operating instructions to assist the operator in handling the Army Package Power Reactor. This information is based on construction as of date material was compiled.

FEBRUARY 1958

ALCO PRODUCTS, INC.
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INTRODUCTION

The Army Package Power Reactor (APPR-1) is a prototype of an air-transportable power plant designed to meet the requirements and site conditions of a remote military base. Transportability, simplicity of maintenance and operation, assembly and logistics were among the principal factors considered in the design; however, due to the conditions at the site of this first installation (Fort Belvoir, Virginia), many design features applicable to remote locations were not incorporated.

From the operation of the APPR-1 prototype as an experimental unit it is expected that a great deal of data will be developed which will be directly applied to the truly remote location design. The prototype will also be used to train crews of operators and, accordingly, is equipped with space and facilities for training.

Subsequent APPR-1 type power plants will be of even simpler design. Therefore, an understanding of the operation of the APPR-1 prototype, as set forth in this manual, should enable the operator to readily undertake the operation of these subsequent APPR-1 type power plants.

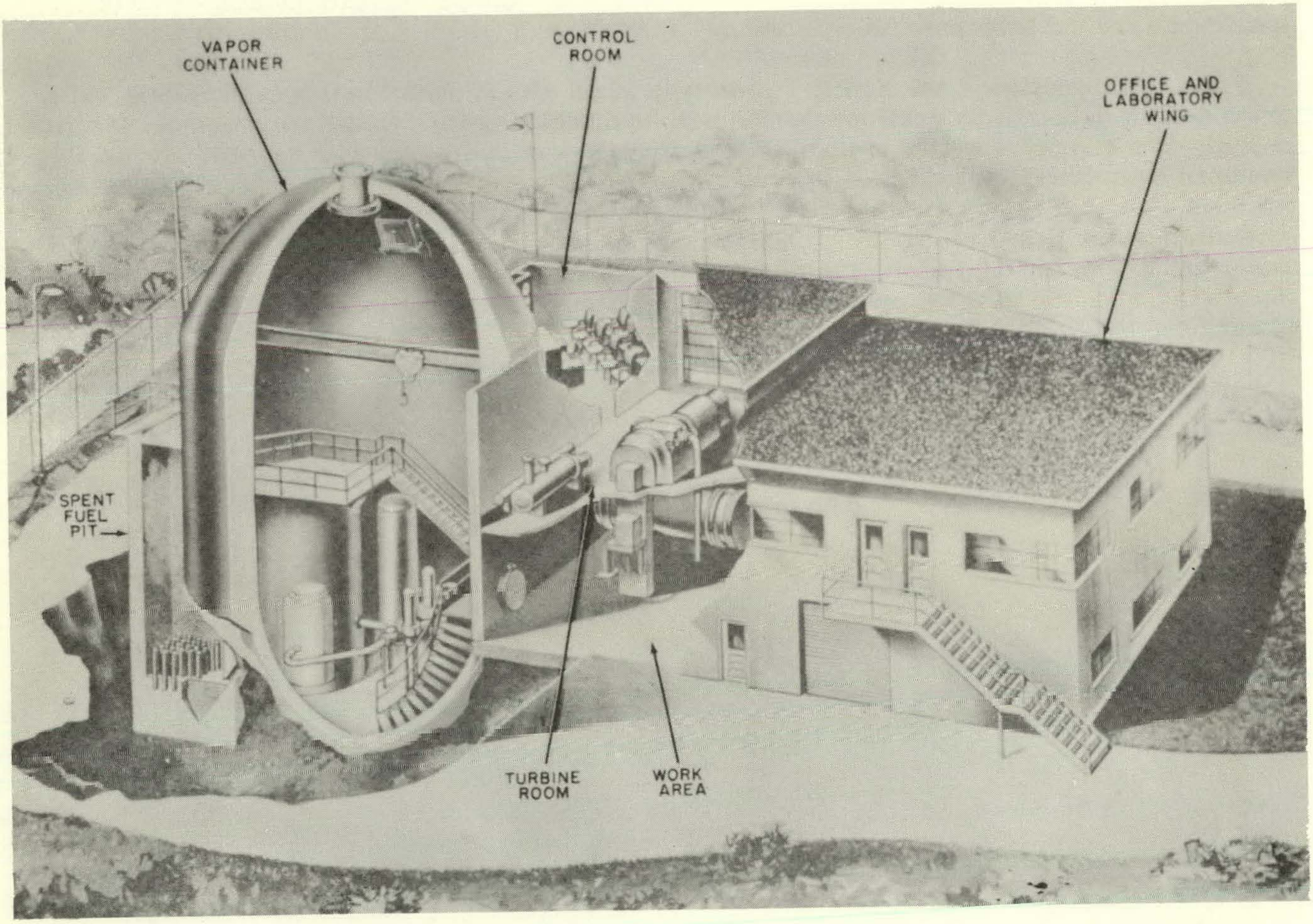


Figure 1-1. Army Package Power Reactor, APPR-1, Cutaway View

SECTION 1

GENERAL DESCRIPTION

The Army Package Power Reactor (APPR-1) is a nuclear power plant capable of producing 1855 to 1975 net kilowatts of electricity. Essentially, it consists of a pressurized water-cooled reactor system (primary system) and a conventional steam turbine system (secondary system). The primary system produces low-pressure steam for the operation of a 2000-kw. turbo-generator. See figure 1-1.

The primary and secondary systems are both closed loops. High pressure water circulating through the primary system is used to cool and extract heat from a solid fuel uranium reactor. The heated primary water flows through a steam generator, where, in a nonmixing heat exchanger, the secondary system water is converted to superheated steam for the operation of the turbine-generator. The turbine-generator output is fed into one end of a 4160-volt loop bus. Each leg of the bus is tapped for station service. The other end of the loop bus is connected to a pole line leading through a service transmission transformer where voltage is stepped down to 2400 volts and fed into ERDL feeder lines.

The plant's primary system, because of its radio activity, is enclosed within shielding and is isolated during plant operation. Access to the rest of the plant's equipment can be had at all times.

In addition to incorporating services, such as fire protection, heating and ventilation, etc, the APPR-1 provides space and facilities for training. The control room contains all the instruments and controls needed for operation and also provides space for observers to follow and learn the operator's techniques. A graphic panel permits operators and observers to know, at all times, the exact conditions existing in all of the plant's operating circuits. The plant also contains a classroom, an instrument room and a laboratory.

PRIMARY SYSTEM

The primary system will be sub-divided, for descriptive purposes, into the primary coolant loop, the vapor container, the concrete shielding, the seal leakage system, demineralizer system, waste disposal system, and 12 pt radiation monitoring equipment. It should be noted that all data given in this section is for design conditions at full load.

Primary Coolant Loop

The primary coolant loop is a closed loop through which the pressurized primary system water (the coolant) is circulated. The principal components of the primary loop are shown in figure 1-2.

When the power plant is operating, the coolant is circulated through the primary system by a primary coolant pump at a constant rate of 4000 gpm (1,660,000 lb/hr). The temperature oi the coolant, at full power design condition, will be 431.6° F when it enters the pressure vessel. It extracts heat from a reactor within at a rate of 34,100,000 BTU/hr (20.55 BTU/lb of fluid

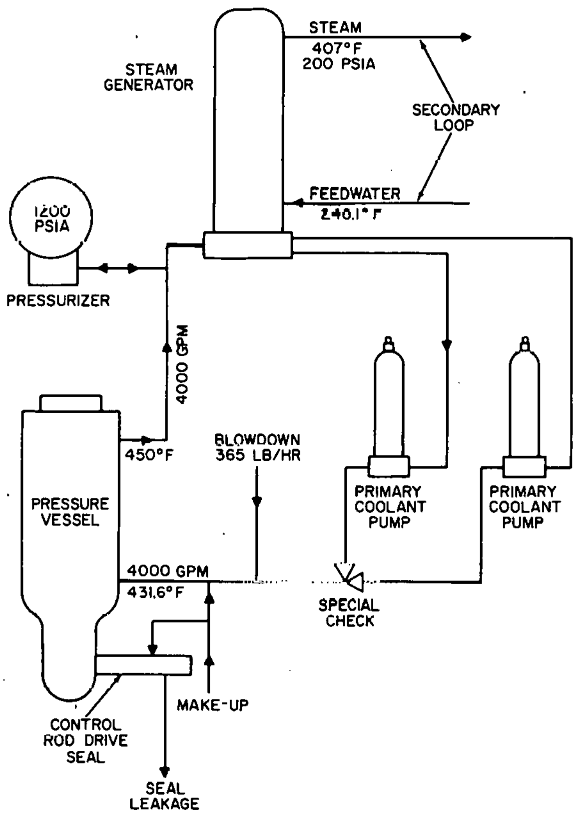


Figure 1-2. Primary Loop, Schematic Flow Diagram

flowing), so that its temperature is raised to 450° F. The coolant then passes to the steam generator, where it flows in parallel through tubing in a superheat region and steam generating region of the unit, giving up heat by conduction through the tube walls to the secondary system fluid. Upon leaving the steam generator the temperature of the primary coolant is 431.6° F. The coolant is then drawn through one of the primary coolant pumps and returned to the pressure vessel inlet.

A portion of the primary coolant is recirculated through the inactive pump leg in order to prevent the coolant temperature difference between the active and inactive pump legs from exceeding 10° F. This arrangement will prevent the possibility of relatively cold water entering the pressure vessel when the need for switching pumps arises; otherwise, the entrance of cold water into the reactor would contribute to a runaway reaction.

Some of the primary coolant is held in the pressurizer, where it is electrically heated to produce steam within the unit's dome to exert a pressure of 1200 psia on the primary coolant. This pressure is transmitted to the entire system through the pressurizer connecting leg between the pressure vessel and steam generator. By keeping the coolant under pressure, boiling, which could cause excessively hot spots in the reactor, is prevented. Since the fuel surface temperature may reach 567° F at full load, a pressure of 1200 psia is maintained to prevent boiling in the hot channels during temperature and pressure transients as well as during normal operation.

The primary coolant is continually blown down from a point just downstream of the steam generator at a full load design rate of 365 lb/hr rate. This blowdown maintains the purity of the coolant by keeping the amount of solids suspended in the coolant from rising above 2 parts per million. Control of coolant solids is critical since they are susceptible to becoming radioactive when flowing through the reactor and because they have a corrosive effect on the system's components and piping. The blowdown is cooled and treated for eventual reuse. Makeup water is introduced at a point just downstream of the primary coolant pump to maintain the pressurizer water level.

Vapor Container (Figure 1-1)

The vapor container is an enclosure of concrete and steel construction in which the entire primary system is housed. It consists of a cylindrical steel outer shell, with spherical ends, and a steel inner lining. The space between the inner lining and outer shell is filled with concrete. Outside the vapor container is a secondary concrete shield which surrounds all but the top dome of the unit.

The enclosure is capable of containing the pressure which would be developed by the flashing into steam of the entire volume of primary and secondary system water within its confines and shields the surrounding area from direct radiation. In the event of a failure of any part of the high-pressure primary system, it will contain the resulting airborne radioactivity and missiles.

Piping and conduit penetrating the vapor container wall is all offset to preclude radiation streaming. Pipes carrying incoming fluids are fitted with check valves located outside the vapor container wall to prevent the escape of radioactive fluid. Pipes carrying outgoing fluids are fitted with pneumatically operated trip valves outside the vapor container which will close in the event that pressure in the vapor container rises to 5 psi above atmospheric pressure. The vapor container wall is also penetrated by a tubular steel chute for transfer of spent fuel elements from the reactor within the pressure vessel to a spent fuel pit outside the vapor container. This tube is fitted with a plug valve physically located in a portion of the tube outside the vapor container in order to ensure pressure integrity of the container in case of damage to the tube inside the container.

Air connections from a ventilating system also penetrate the vapor container wall and consist of steel piping equipped with gate valves and flanges with blank inserts. This prevents the spread of airborne radioactivity outside the vapor container under any conditions.

Access to the vapor container can be had through a double door access opening at the lower plant floor level. When the reactor is in operation, the doors are bolted closed and the space between filled with water, thereby providing adequate shield protection against radiation streaming.

A space cooler supplied by the blowdown cooling water pumps keeps the temperature of the atmosphere in the vapor container at 125° F or less. Two spray heads are installed inside the top of the vapor container. In the event the primary system ruptures, water containing boron may be introduced through these spray heads by means of the primary fill pump.

Seal Leakage System (Figure 1-3)

The reactor pressure vessel is penetrated at seven points through which reactor control rod drive shafts operate. The seal leakage system functions to prevent the radioactive coolant in the pressure vessel from escaping at any of these seven points.

High-pressure water from the primary coolant make-up line is directed to seal assemblies at each of the seven pressure vessel penetrations. Since the pressure of the water flowing through the seal assemblies is greater than that of the water in the pressure vessel, flow is into rather than out of the pressure vessel. Some of the seal water therefore enters the primary system and serves as make-up water. The rest of the seal water flows to a seal leak-off collecting tank from which it is periodically pumped into the primary coolant blowdown line for eventual reuse.

Demineralizer System

Two mixed-bed demineralizers with cartridge-type resin beds are provided in the plant for the removal of impurities from primary system blowdown. The demineralizers are in parallel and only one is used at a time, the other serving as a spare. In operation, radioactive nuclides removed from the blowdown will cause the demineralizer in use to become radioactive; therefore, they are individually shielded. When a demineralizer becomes exhausted, it is removed and placed in a lead-lined cask for shipment to a processing plant for disposal and a new unit is installed in its place.

The blowdown is cooled to a temperature of 140° F or less before it is passed through the demineralizer to prevent the demineralizer resins from being damaged. Blowdown leaving the demineralizer is discharged to the primary coolant make-up tank; however, if the blowdown is excessively radioactive (7.5 mr/hr at the monitor), its flow is automatically diverted to the contaminated waste storage tank instead of through the demineralizer. Under these conditions condensate is fed through the demineralizer to provide enough make-up water to maintain the level in the make-up tank. Normally, however, only enough condensate is drawn

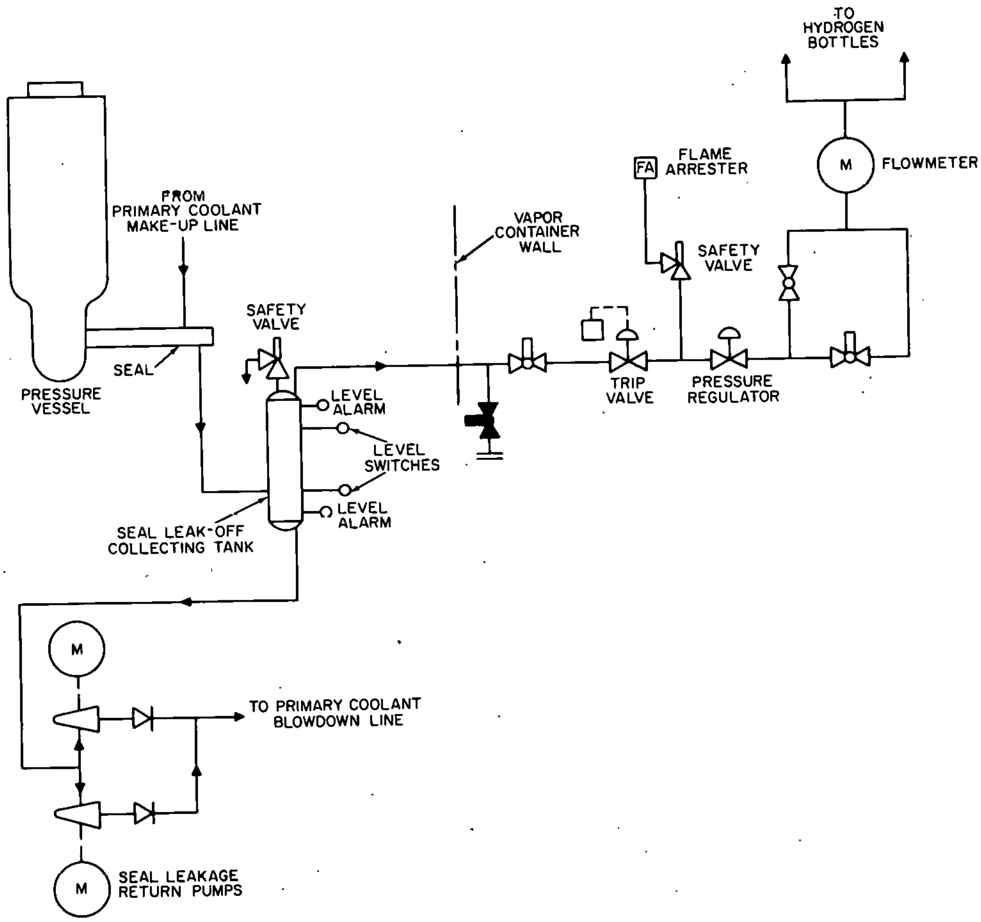


Figure 1-3. Seal Leakage System, Schematic Flow Diagram

into the system to compensate for losses that may occur in the system. A micrometallic filter is located downstream from the demineralizers to collect any resins which might leak out of the demineralizer. Block valves and a bypass are provided to facilitate filter replacement.

Waste Disposal System (Figure 1-4)

An underground, concrete shielded, contaminated waste storage tank, located outside the power plant, is provided to receive all significantly radioactive fluids. Blowdown cooling water from the blowdown cooler and the space cooler is normally discharged to the seal pit; however, should it become radioactive, it is considered contaminated waste. The water is continuously monitored and, if its radioactivity becomes so great as to make discharge to the seal pit unsafe (1×10^{-7} uc/cc), the radiation monitor automatically operates a three-way control valve to divert the water to the contaminated waste storage tank. Primary coolant blowdown and seal leakage is considered waste if its radioactivity is too high to safely permit its passage through the unshielded primary coolant make-up tanks, pumps, and lines. Under these circumstances, a radiation monitor automatically operates a three-way control valve to divert the water to the contaminated waste storage tank. The secondary system steam generator blowdown can be diverted to the tank if it becomes radioactive.

Radioactive waste is held up in the tank until its radioactivity decays sufficiently (1×10^{-7} uc/cc) and/or is recirculated through demineralizers by way of temporary connections to permit safe discharge. The waste is then pumped through a temporary connection to the station waste line leading to the seal pit. Provision is made for installing temporary connections to circulate the waste through the demineralizer before discharge to the seal pit. It is also possible, through temporary connections, to return the waste from the demineralizer to the tank for subsequent recirculation through the demineralizer. If the quantity of contaminated solids in the waste is not too great, it is possible, following sufficient demineralization, to return the water to the primary coolant make-up tank for reuse.

A vent from the hot waste tank to the stack allows the escape of gases. This flow is continuously monitored for radioactivity and a control valve, manually operated from the control room, permits closing the vent should the gases contain an unsafe amount of activity.

Caustic soda can be fed into the tank to neutralize the corrosive effects of the waste.

Radiation Monitoring

The power plant incorporates five area monitoring and six operational monitoring stations. All area monitoring is recorded at the radiation section of the control panel; operational monitoring stations on the seal pit, stack, and secondary blowdown are recorded.

Both area and operational monitors will actuate alarms when the radiation level at the monitored station or point becomes excessive. Area monitoring stations are as follows:

Control Room. Located in control room on vapor container wall four feet above floor. Sensitive to gamma and thermal neutron radiation.

Vapor Container. Located inside vapor container about three feet above the floor grating near the access opening in full view of all major equipment. Sensitive to gamma and thermal neutron radiation.

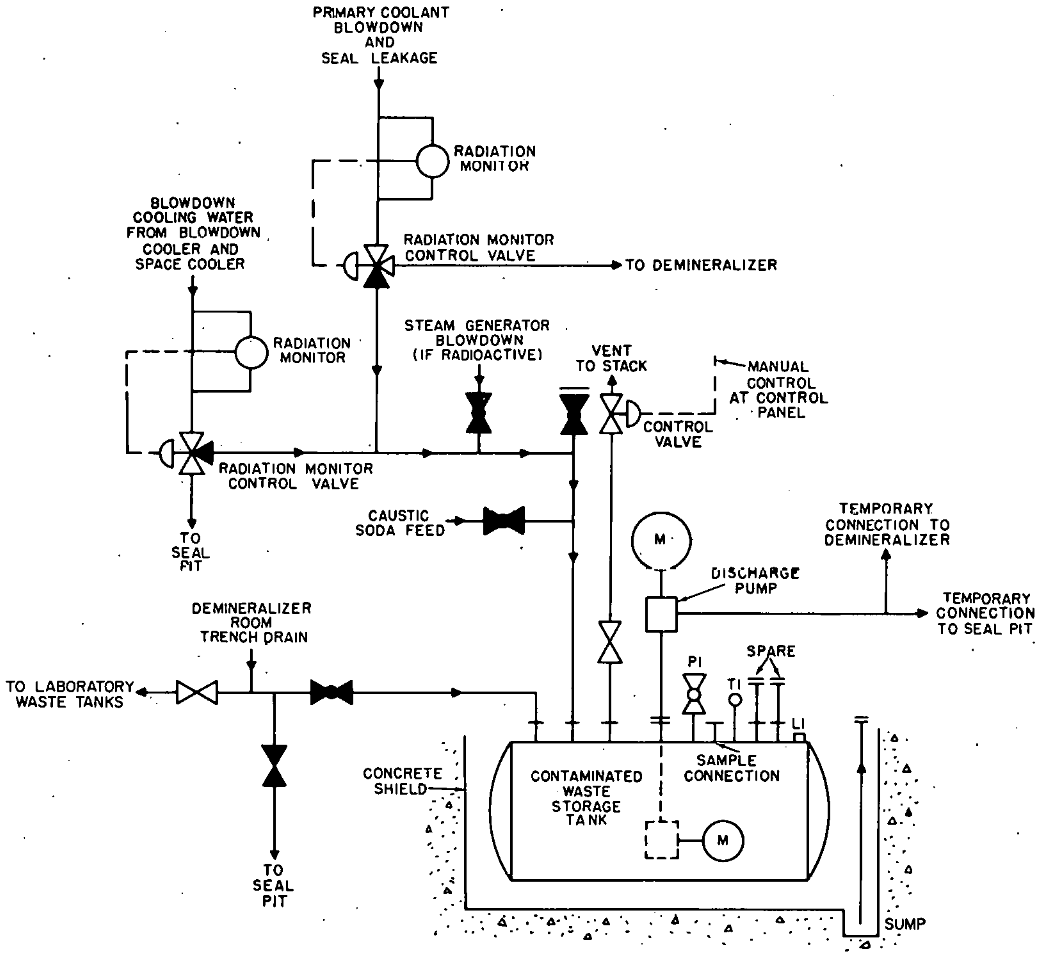


Figure 1-4. Contaminated Waste Disposal System, Schematic Flow Diagram

Vapor Container Entrance. Located outside of the outer vapor container door even with the uppermost portion of the passageway. This monitor will detect radiation streaming through the vapor container passageway accompanying loss of water on the lock. It is sensitive to gamma and thermal neutron radiation.

Spent Fuel Pit. Located on the exterior of the vapor container at its nominal westernmost point under the fuel pit cover plate. Sensitive to gamma radiation only.

Demineralizer Room. Located inside demineralizing equipment room on the south wall. Sensitive to gamma radiation only.

Operational monitoring points in the primary system are as follows:

Primary Blowdown. A partially immersed chamber located in the primary blowdown line and sensitive to beta-gamma radiation. A meter relay actuates an alarm and control valve. The latter diverts flow of blowdown to the contaminated waste storage tank.

Blowdown Coolant. A partially immersed chamber located in the blowdown cooling water line and beta-gamma sensitive. A meter relay actuates an alarm and control valve. The latter diverts flow of cooling water to the contaminated waste storage tank.

SECONDARY SYSTEM

For general description the secondary system will be sub-divided into the steam system, the condenser water and cooling water systems, make-up water system, and radiation monitoring.

Steam System

The steam system is a conventional steam plant loop. The principal components of the secondary loop are shown in figure 1-5.

When the power plant is operating at full load design conditions, feedwater is drawn from the condenser hot well at a temperature of 108.7°F by one of the boiler feed pumps, and circulated through the air ejector condensers where the temperature rises to 116.2°F from the heat released by the condensing ejected vapor. It then passes through the tubes of the feedwater heater where steam bled from the turbine plus vapor and condensate from the evaporator enter the heater shell, raising the temperature of the feedwater to 246.1°F. The feedwater then enters the steam generator, at a full load rate of 34,270 lb/hr.

The volume of feedwater in the shell of the steam generator is heated by primary coolant flowing through the steam generator tubes and is continuously converted to vapor which passes through an external moisture separator reaching 99.7% quality at a temperature of 381.8°F. The vapor then passes to the superheating section of the steam generator where it is superheated to a temperature of 497°F at 200 psia. Steam leaves the steam generator at a full load rate of 34,070 lb/hr. 200 lb/hr is lost in blowdown to remove solids and reduce the chloride content of the system.

From the main steam line, 1640 lb/hr of steam is bled off to be used by auxiliary equipment. There will also be an additional loss of 220 lb/hr maximum from the secondary system.

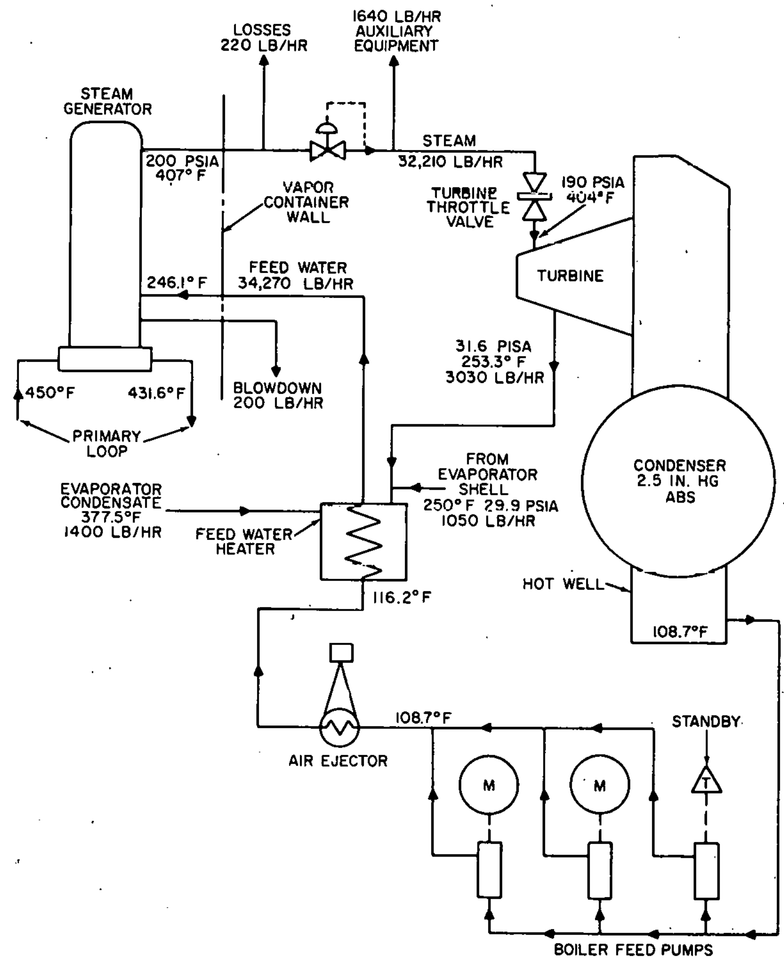


Figure 1-5. Steam Cycle, Schematic Flow Diagram

Thus, 32,210 lb/hr of steam arrives at the turbine. Due to line losses, the steam pressure drops to 190 psia and the temperature drops to 404° F.

The turbine converts the heat energy of the steam to mechanical energy which is transmitted to the generator for the production of electrical power. 3030 lb/hr of 31.6 psia steam is bled from the third stage of the turbine to service the feedwater heater.

Exhaust steam from the turbine passes to the condenser shell, where it condenses at a pressure of 2.5 in. Hg absolute (27.42 in. Hg vacuum) and collects in the hot well.

Cooling Systems Serving the Primary System (Figure 1-6)

There are two cooling systems serving the primary system equipment. One utilizes secondary system condensate and the other utilizes river water for cooling.

The primary coolant pumps and pressure vessel are cooled by condensate taken from the condenser hot well by one of the two condensate recirculating cooling pumps. The cooling water is directed to the primary system components through two parallel loops. One loop supplies water to the cooling water jackets of the primary coolant pump motors. The condensate flows in series from one pump motor jacket to the other pump motor jacket and then returns to the condenser hot well. The second loop supplies condensate cooling water through the cooling coils, around the bottom of the pressure vessel, and then through the shield water cooling coils, located in the water shield surrounding the pressure vessel, and then returns to the condenser hot well. The shield water layer tends to become heated because of its proximity to the reactor; therefore, it is cooled to prevent it from vaporizing, which would reduce the effectiveness of the primary shield. The bottom of the pressure vessel is close to the concrete floor of the vapor container; therefore, the space between the bottom of the pressure vessel and the floor of the vapor container is cooled to prevent excessive thermal stresses in the concrete.

River water is used as coolant in the primary coolant blowdown cooler and vapor container space cooler. The river water is supplied by the blowdown cooling water pumps, which take a suction from the circulating water lines, and directed through two parallel paths, one leading through the tube side of the blowdown cooler and the other through coils in the space cooler. After use, the river water is normally discharged to a seal pit; however, should a leak occur in the blowdown cooler and a significant amount of radioactive primary system coolant become mixed with the river water to give an activity level of 1 X 10^{-8} beta-gamma, discharge will be be automatically diverted to a contaminated waste storage tank.

This system also supplies cooling water to the main air compressor, the secondary blowdown cooler, the spent fuel pit cooler, and the sample coolers.

Condenser Water and Cooling Water System (Figure 1-7)

One of the circulating water pumps situated in Gunston Cove draws river water through screens at the rate of 4500 gpm (2,241,006 lb/hr) to provide cooling water for the condenser, the booster water pump system, the chlorinator, and the blowdown cooling water system. Chlorine is periodically injected into the feed line to control algae growth.

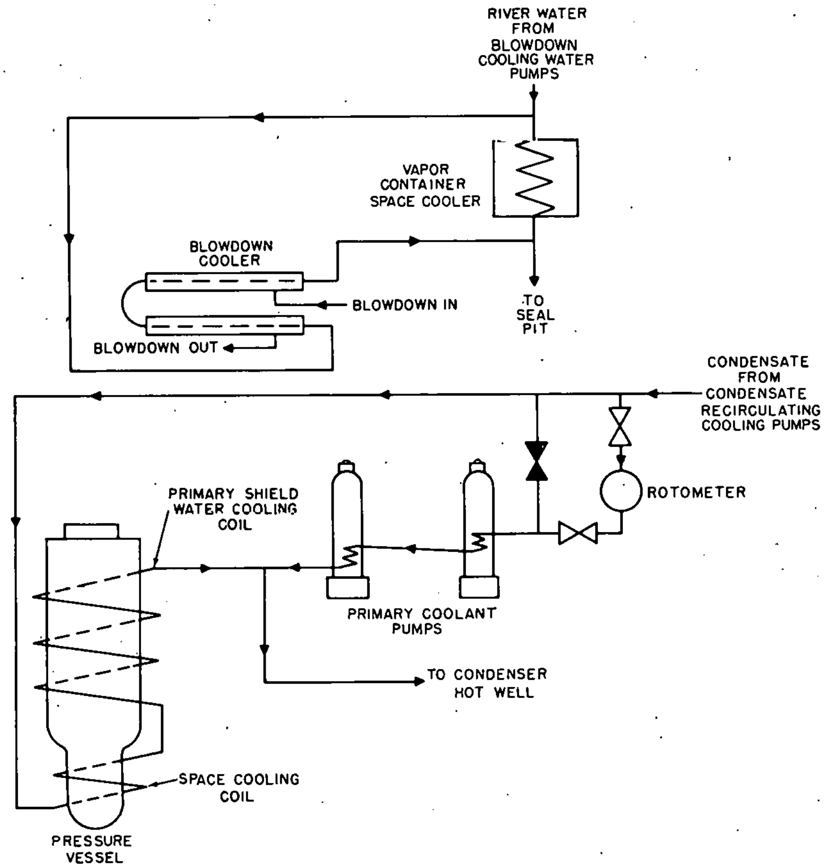


Figure 1-6. Primary Cooling Systems, Schematic Flow Diagram

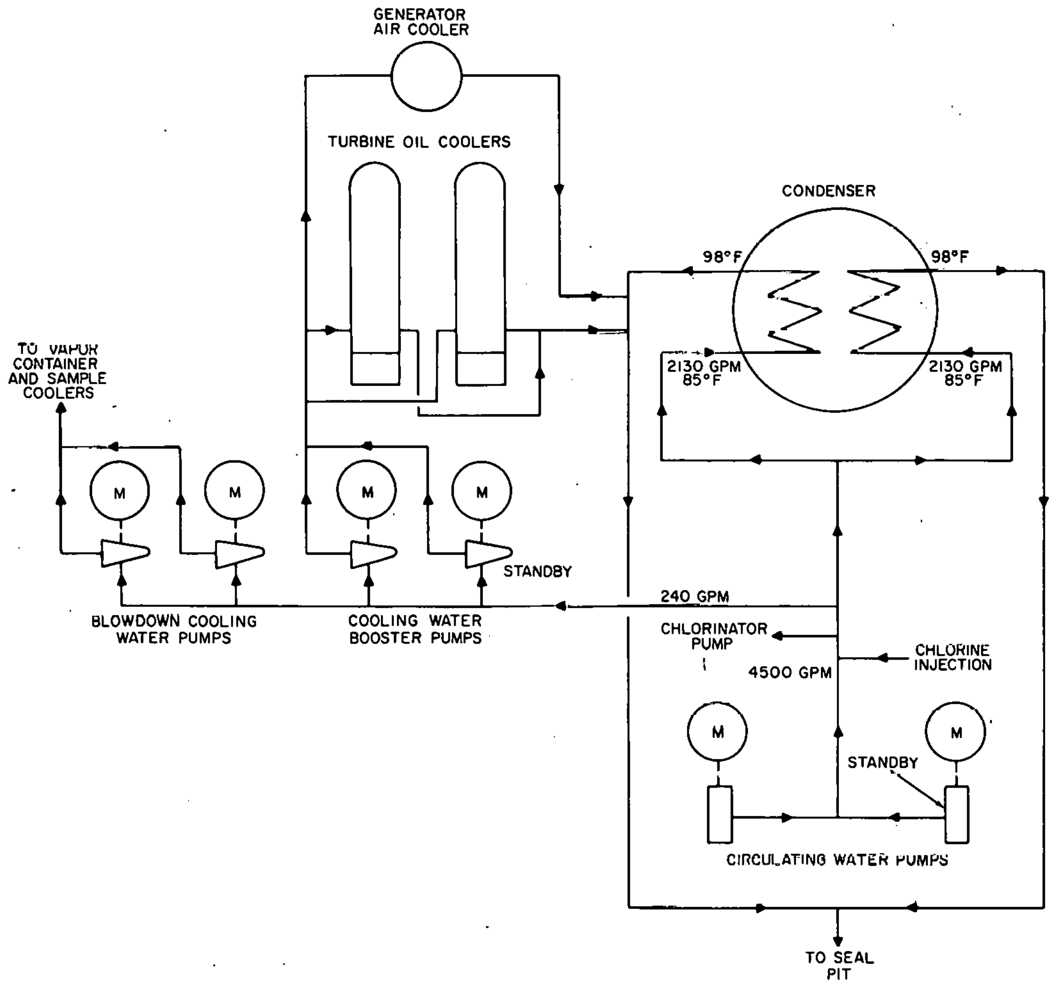


Figure 1-7. Condenser Water and Cooling Water Systems, Schematic Flow Diagram

Of the 4500 gpm of water supplied by the circulating water pumps, 4260 gpm goes to the condenser while the other 240 gpm goes to the auxiliary systems. There are two auxiliary cooling water systems involved. One is the cooling water booster pump system, which supplies cooling water to the oil coolers and generator air cooler. The other is the blowdown cooling water system. (See Cooling Systems Serving the Primary System, above.)

The condenser cooling water divides into two paths, each serving one bank of tubes in the divided flow condenser. This arrangement permits one side of the condenser to be shut down for cleaning or repair while the other side handles the exhaust steam cooling load.

The condenser is designed to receive circulating water at a nominal temperature of 85° F, the maximum likely to occur, under which circumstances the water is discharged at a temperature of 98° F. The inlet temperature, of course, will vary with weather and season changes. A drop in circulating water temperature will increase the cooling effect on the condensing steam and increase the condenser vacuum accordingly. This condition is not undesirable, as the steam cycle efficiency increases as condenser pressure drops.

The circulating water from the condenser and the coolers, used once, is discharged to the seal pit.

Make-Up Water System (Figure 1-8)

Assuming that the evaporator is operating and that the plant is under normal full load operating conditions, the steam system loses 200 lb/hr of fluid through steam generator blowdown, 220 lb/hr maximum from the secondary system from miscellaneous causes, and 100 lb/hr blowdown from the evaporator blowdown. In addition to these losses, 630 lb/hr will be stored in a 5000-gallon capacity distilled water tank to be used for make-up when the evaporator is not being used.

To maintain the fluid level in the system, 1150 lb/hr of water is drawn from the service water tank by the evaporator feed pump and introduced into the evaporator shell where it is distilled to remove solid impurities. Steam bled from the main steam line condenses in the evaporator tubes, providing heat to vaporize the make-up water. In vaporizing, the solid impurities separate from the make-up water and are removed by the 100 lb/hr evaporator blowdown. The purified vapor is conducted to the shell side of the feedwater heater where it condenses, aids in heating the feedwater, and is then carried to the condenser hot well for system use.

Since the evaporator must be shut down periodically to remove accumulated scale and occasionally for repairs, a certain amount of feedwater is diverted from the feedwater line to the distilled water tank to be held as a reserve supply. Feedwater enters the distilled water tank at the rate of 630 lb/hr (1.27 gpm) while the evaporator is in operation. During evaporator shutdown periods, water is drawn from the tank to make up system losses.

When the evaporator is shut down, the loss of make-up water from the evaporator causes the condenser hot well level to drop, automatically closing a valve to stop the flow of feedwater to the distilled water tank. Since no make-up water is being supplied to the system, the level in the hot well will drop further, automatically opening a valve to draw from the distilled water tank to compensate for the loss. In these circumstances, the water in the tank must make up the 200 lb/hr steam generator blowdown and the 220 lb/hr line losses, a net

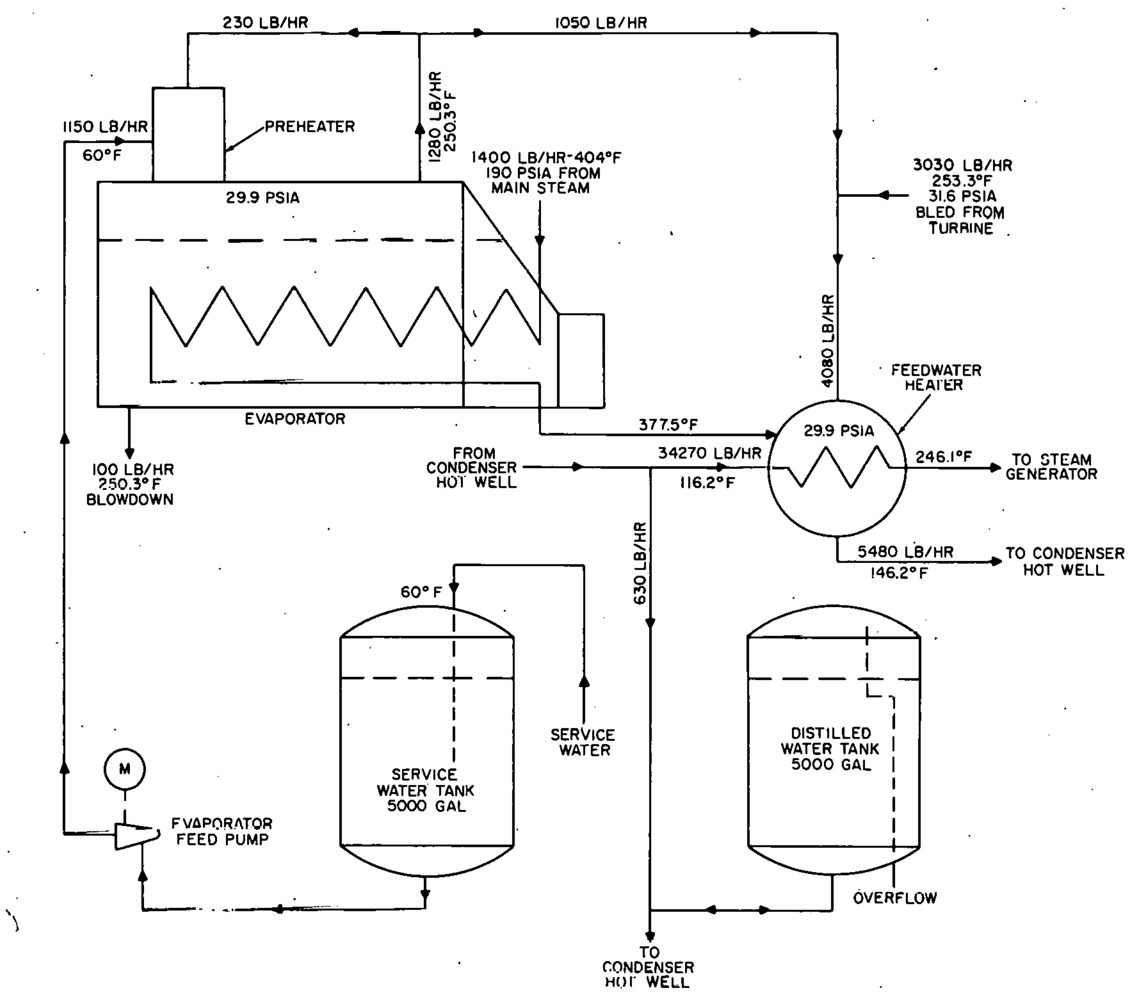


Figure 1-8. Secondary Make-Up Water System, Schematic Flow Diagram

total of 420 lb/hr (0.84 gpm). Thus, in view of the 5000-gallon capacity of the tank, nearly a 100-hour supply is available.

Radiation Monitoring

The secondary system incorporates operational monitoring stations as follows:

Steam Generator Condensate. A partially immersed station in the sample line from the blowdown line which is beta-gamma sensitive. A meter relay actuates an alarm.

Condenser Hot Well. A partially immersed station in the condensate recirculating pump slip stream to the condenser which is beta-gamma sensitive. A meter relay actuates an alarm.

Seal Pit. Water sampling monitor, gamma sensitive.

Vent Stack. Air sampling monitor, beta-gamma sensitive.

ELECTRICAL SYSTEMS

Ring Bus System (Figure 1-9)

A loop bus, connected to the APPR-1 generator at one end and through the ERDL busses to the VEPCO power system at the other, is the principal electrical power transfer system of the plant. It is a three-phase, three-wire system, supplied by a Y-connected alternator rated at 2500 kva at 0.8 power factor and 4160 volts. The generator field is supplied by a 15-kw, 125-volt d-c exciter. Output power leaves the ring bus through a 4160-volt overhead transmission line to the ERDL Substation, H-327, at which point a 2500-kva, Y-delta transformer steps down the line voltage to 2400 volts, and power is fed into the Fort Belvoir system through a 600-ampere, 2400-volt breaker. The system is protected from overloading by relay-tripped air circuit breakers.

At two points on the ring bus, taps for station service power are made in such a manner that each tap, if necessary, is capable of meeting all station service needs. One tap is made from bus A, the other from bus B. These feeders draw power through the ring from VEPCO for plant start up. When steam is available to the turbine, the generator is brought up to speed at no load, synchronized with the VEPCO system, and brought on the line. Thereafter, station service power is supplied by the APPR-1 generator.

In the event of a short circuit in either 4160-volt bus, breakers are tripped to isolate the bus from the rest of the system and the other bus carries the entire load. It is this provision of duplicate busses that gives rise to the "ring" construction.

Station Service (Figure 1-9)

The two feeders from the 4160-volt ring bus feed power to two 300-kva, delta-Y transformers which step down the voltage to 480 volts for use by station service equipment. Two 460-volt busses (there is a 20-volt drop in the line) supply such plant equipment as primary and secondary system feedwater and circulating water pump motors, pressurizer heaters, control rod drive motors, ventilation and space cooler fan motors, a d-c rectifier, a d-c battery-charging motor-generator set, control power supply, air supply compressor motors, and station lighting.

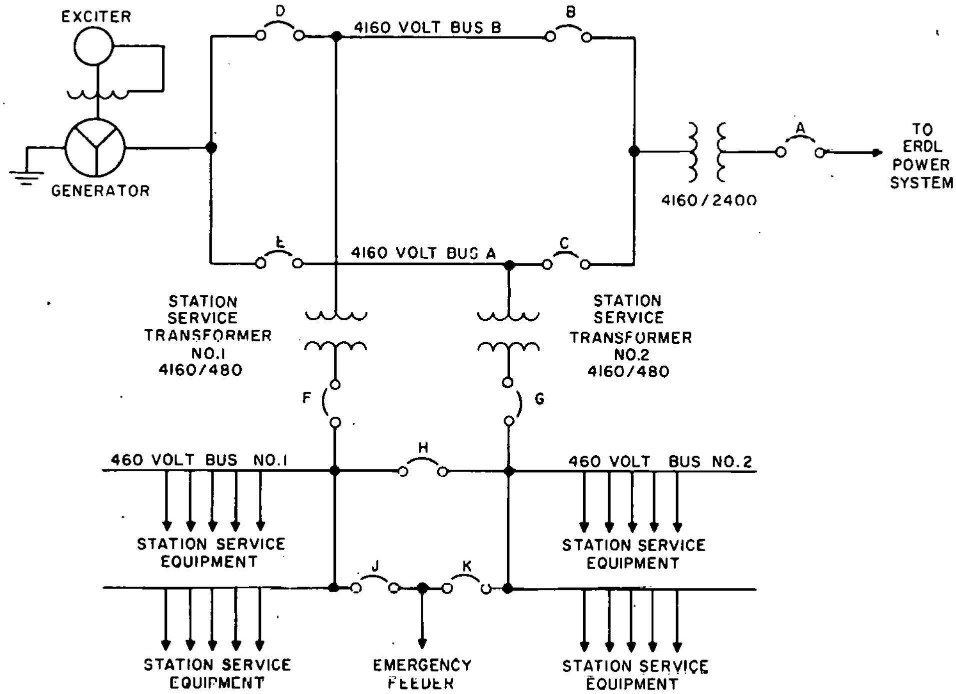


Figure 1-9. Electrical System, Simplified One-Line Diagram

The system is protected from overloading and loss of power by relay-actuated air circuit breakers. If, for any reason, one of the station service feeders goes out, the other 460-volt bus is automatically connected so as to supply both 460-volt busses. In most cases, station service equipment is provided in duplicate, one of each 460-volt bus to further safeguard continuous operation. Each station service component is protected by an individual air circuit breaker.

D-C Systems (Figure 1-10)

A 125-volt d-c distribution system supplies power to such equipment as switchgear relays, instruments and controls, annunciator, and emergency lights.

The system receives power from a rectifier charger or a motor-generator set or both. These units are powered from the No. 1 460-volt bus. A 125-volt d-c battery is connected in parallel with these sources to store energy for emergency use if a-c power fails.

The system is protected from overloads by air circuit breakers at each component.

PLANT SERVICES

Water

Water for plant use is drawn from the Fort Belvoir service water supply. This supply is used for fire protection and domestic service and evaporator make-up.

Heating and Ventilation

Four heat pumps are incorporated into a conventional air conditioning system for both heating and cooling of the plant. Unit heaters are provided to supplement the heat pumps and to heat portions at the plant that are not air conditioned.

Hoods, leading to air exhaust ducts, are placed over the laboratory sink and over the emergency d-c power supply batteries to remove noxious fumes.

Fire Protection

Fire hoses, situated in the ground floor work area and in the turbine room, provide interior fire protection. Two hydrants are provided for exterior protection.

Manually operated fire alarm boxes are distributed throughout the building. Any alarm sounded in the plant is transmitted to the Fort Belvoir fire department.

Air System

Plant controls and process indicators are pneumatically operated. A single stage 6" x 5", double-acting reciprocating air compressor supplies air for this purpose. A two-stage, single acting compressor is provided for standby service. Compressed air is stored in an air receiver for distribution to all pneumatic instruments.

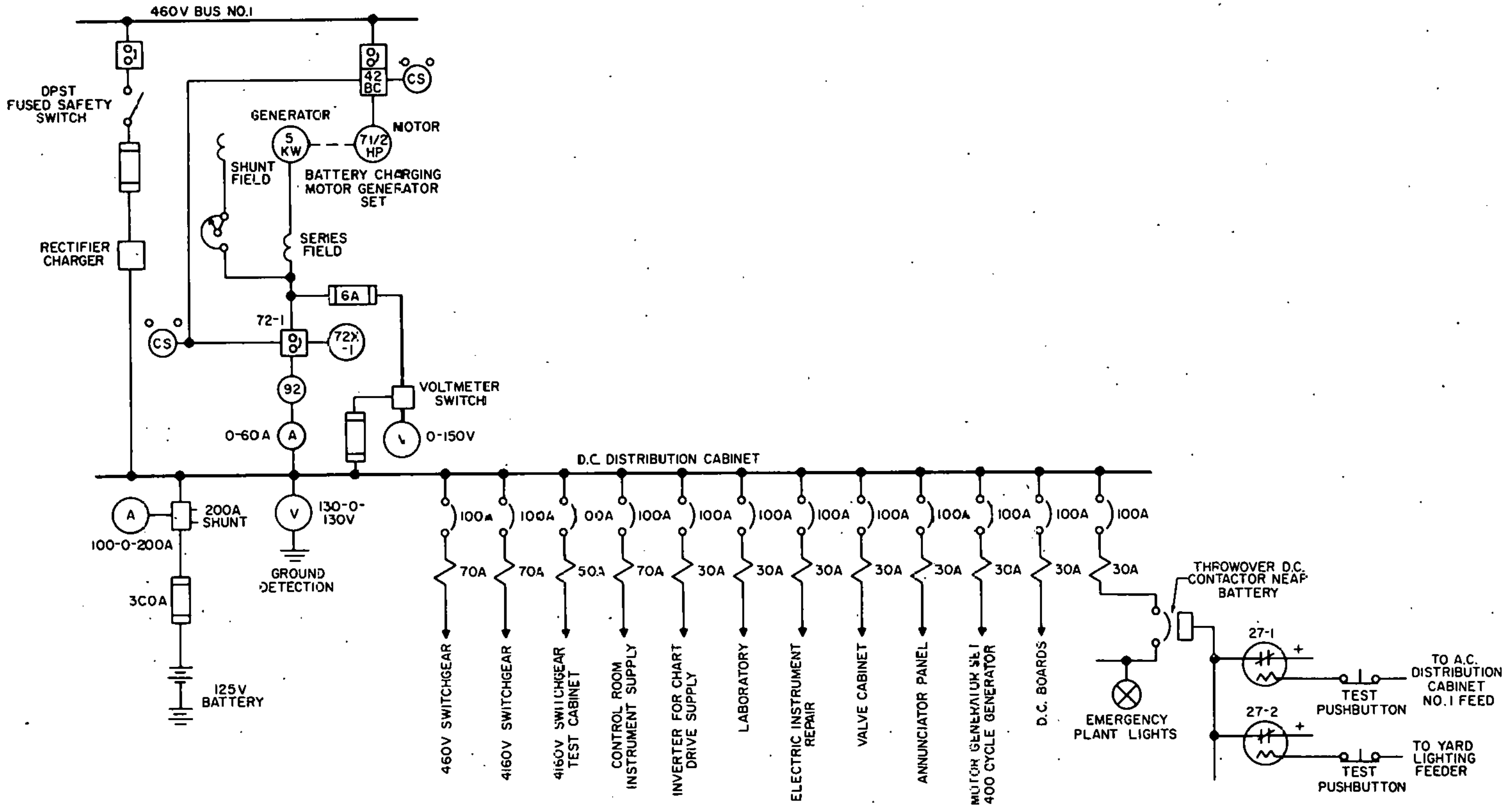


Figure 1-10. DC Distribution System, One-Line Diagram

Laboratory Facilities

A laboratory for the analysis of process water samples is located on the ground floor level. Its equipment includes a hood-enclosed sink as well as other conventional laboratory equipment. Hot and cold water, electrical outlets, and health physics equipment is provided.

Maintenance Facilities

An instrument shop for the repair and calibration of instruments is situated on the operating floor level.

Shelves for storage of spare parts as well as operating and maintenance tools are located in the ground floor work area. Space for the installation of a work bench is provided in the same area.

Sewage System

Plant waste, leakage, and the circulating water discharge is piped to a partially underground, concrete seal pit located about 200 feet south of the plant building. Overflow from the pit is discharged to Gunston Cove at a point over 600 feet downstream from the condenser circulating water intake point.

Sanitary sewage is piped underground out of the plant, to a 2000-gallon septic tank located about 80 feet south of the plant building. Overflow from the septic tank is drawn through a siphon chamber to a sand bed.

Contaminated Waste Disposal System

An underground, concrete-shielded, 5000-gallon stainless steel tank safely holds all radioactive plant process waste. Contents of the tank may be discharged, after decontamination, to the seal pit.

Two 250-gallon underground tanks are provided to collect active waste from the laboratory.

PLANT OPERATION

Overall operating procedures for the plant are described in detail in Section 4, PLANT OPERATION. Detailed operating procedures for each plant component are described in Section 2, COMPONENT DESCRIPTION AND OPERATION.

Briefly, the APPR-1 is started up by drawing power from VEPCO through the ring bus for station service equipment. Primary and secondary water is circulated through the system. The reactor is made critical and brought up to power. As steam is produced in the steam generator, the steam main to the turbine is gradually warmed up until full load steam conditions are reached. Steam is then delivered to the turbine and a vacuum is established in the condenser. The turbine is brought up to speed at no load. The generator voltage is raised to normal and frequency is synchronized with VEPCO and is brought on the line by closing the breakers and gradually adding load. The generator load will normally be controlled by the load limiting device. This will cause VEPCO to take all power swings and prevent APPR-1 from being overloaded.

SECTION 2

COMPONENT DESCRIPTION AND OPERATION

PRIMARY SYSTEM

The primary system of the APPR-1 power plant comprises a reactor, pressurizer and heater, primary coolant pumps, and steam generator, together with seal leakage system, blowdown, demineralizer and filter, and make-up systems, spent fuel pit, hot waste systems, trip valves and piping, all of which function together to provide a controllable source of heat energy which is used to operate the power plant's secondary system. Excluding certain portions of the water purification and make-up equipment, spent fuel pit, and portions of the contaminated waste system, all of the major components of the primary system are located within the vapor container.

Reactor

General Description (Figure 2-1). The APPR-1 reactor comprises a core of fuel elements through which primary system water flows to be heated. Because of the high primary system water pressure, the reactor core is housed in a steel pressure vessel which is surrounded by shielding. Control rods operate through voids in the reactor core and are driven and positioned by a control rod drive system which operates through special seals near the bottom of the pressure vessel. The amount of effective fuel in the reactor and therefore the mean temperature of the reactor (period at low temperatures) is controlled by regulating the control rods.

The condensate recirculating pumps supply water to coils surrounding the bottom of the reactor vessel and coils in the inner and outer shielding tanks. This cooling system prevents boiling in the shield tanks and aids in cooling the system at shutdown. The reactor control system enables the operator to closely regulate all phases of reactor operation and includes numerous automatic devices which contribute to the safe operation of the reactor.

Fuel Elements (Figure 2-2). The reactor core is an assemblage of fuel elements supported at top and bottom by stainless steel grids in a seven by seven square array with the corners missing. Seven of the positions in this array contain control rods consisting of a fuel element and an absorber element. A 0.0625-inch thick stainless steel skirt connects the two supporting grids, surrounds the fuel elements or core, and aids in directing the flow of primary water through the core.

The core comprises 38 fuel elements of rectangular plate construction. Each element consists of 18 plates. Each plate consists of U235-enriched uranium dioxide uniformly distributed and imbedded in a stainless steel matrix and stainless steel clad. A small amount of boron carbide is dispersed throughout each plate and acts as a "burn-out poison" (neutron absorber) to limit the chain reaction and thereby increase the life of the reactor. Each plate is 2.76 inches wide, 0.030 inch thick, and 23 inches long. The assembled plates form a fuel element, with a gap of 0.133 inch between adjacent plates for the flow of primary water. Stainless steel end boxes on the top and bottom of each element are used to position the element in the core and

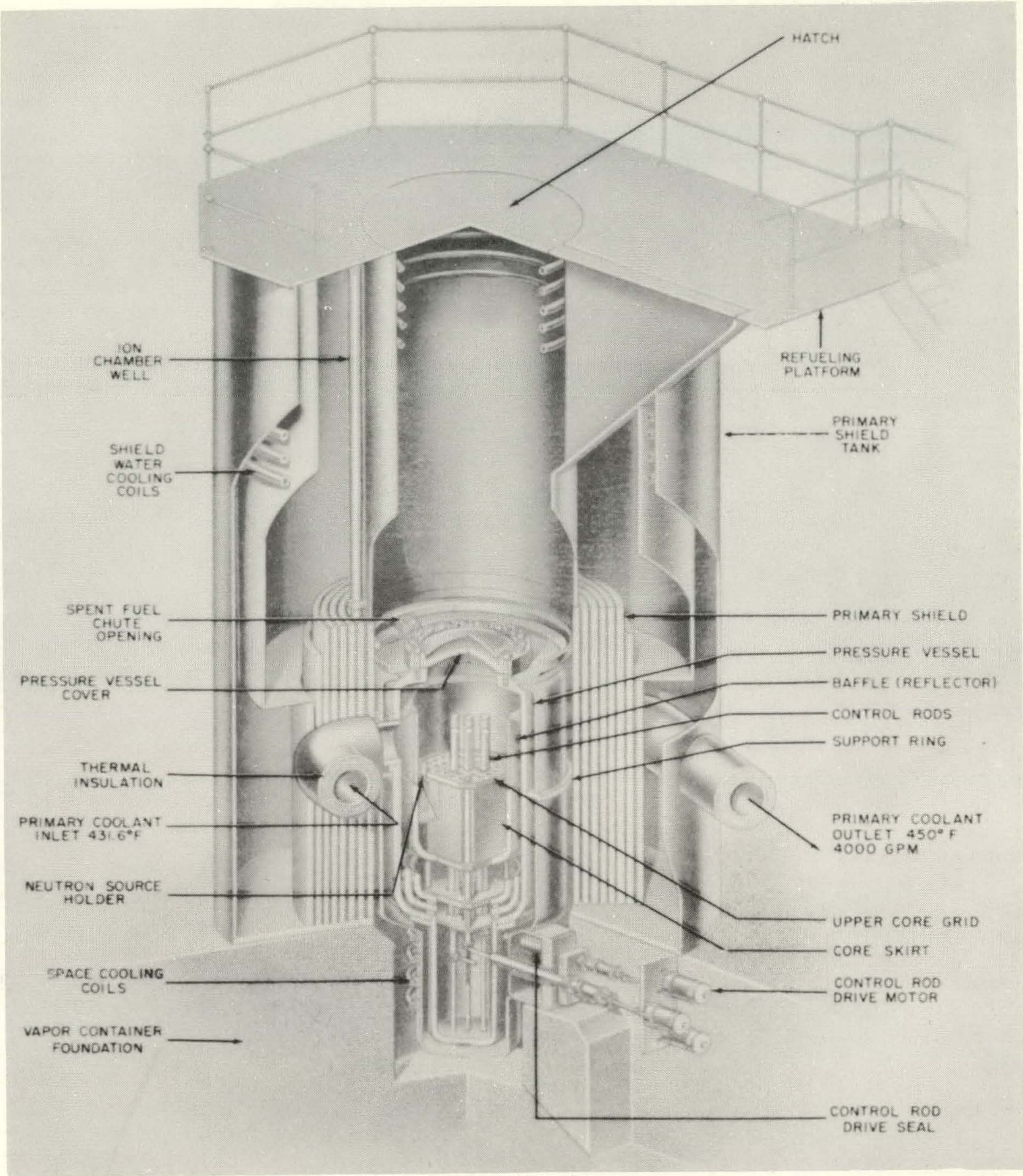


Figure 2-1. Reactor and Primary Shield

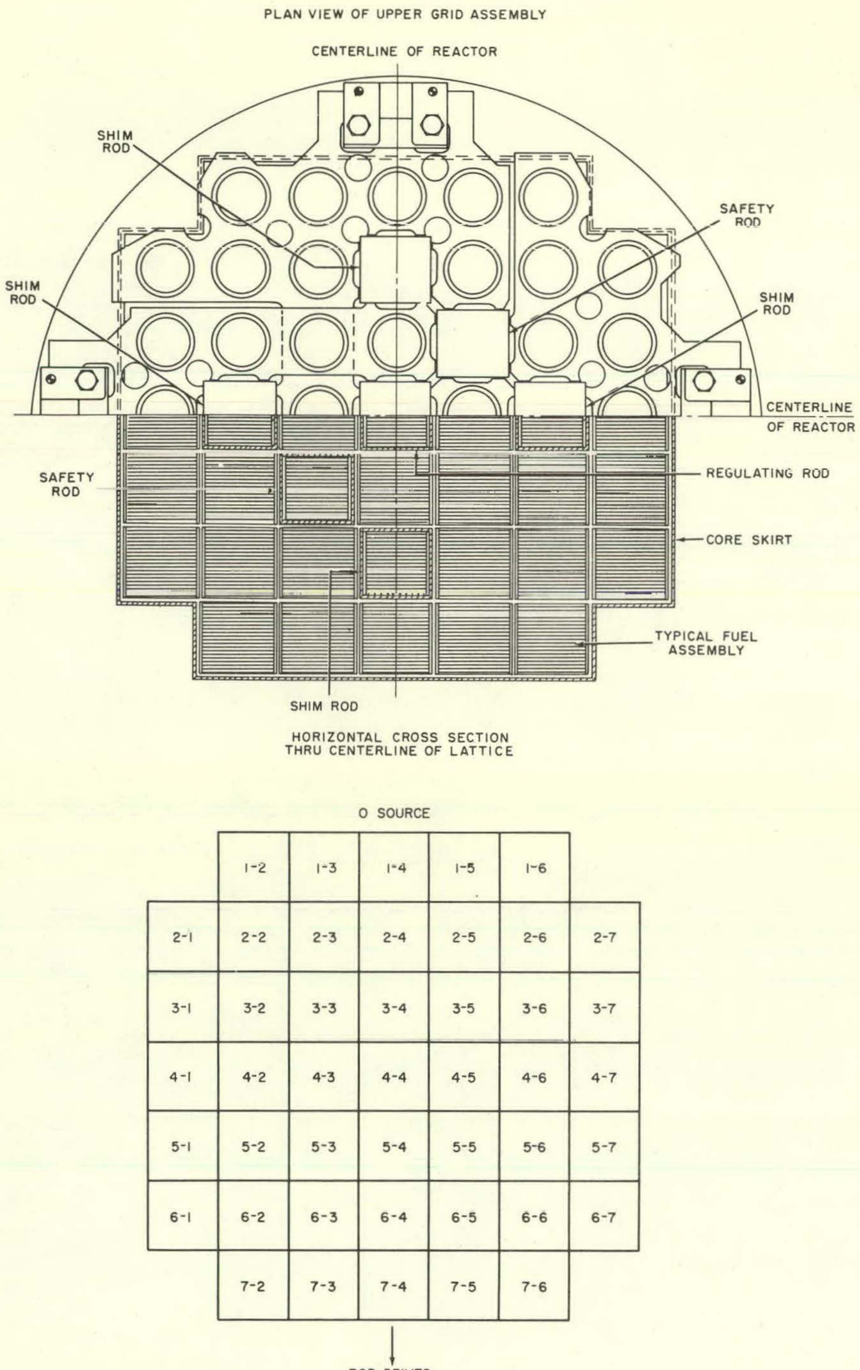


Figure 2-2. Reactor Core, Cross Section

direct the coolant flow. Slotted stainless steel plates, 0.050 inch thick, space the fuel plates and form two sides of the fuel elements.

Pressure Vessel (Figure 2-1). The reactor core is contained within a cylindrical steel pressure vessel that has a 48-inch inside diameter, is 2-3/4 inches thick, and 64-1/8 inches long. A standard ellipsoidal head is provided at the bottom of the cylinder. A ring forging to support the vessel cover is provided at the top. All joints are welded and stress relieved. Inside surfaces in contact with primary water are clad or overlaid with 0.25-inch-thick stainless steel.

A flanged cover is attached by 18 alloy steel studs threaded to a reinforcing ring welded into a circular opening in the upper head. The cover seals the vessel during reactor operation, while providing a means of access to replace spent fuel elements. A 22-1/2-inch inside diameter by 1-1/2-inch-thick by 55-5/8-inch-long enclosure is welded into a reinforced circular opening in the bottom of the vessel to contain the control rod drive mechanisms. The wall of the enclosure is penetrated at seven points by water-sealed control rod drive shafts.

Four inches of thermal insulation and a waterproof stainless steel jacket surround the entire vessel.

Inlet and outlet pipes, of 12-inch nominal diameter, are welded to the vessel at opposite ends of a diameter of the cylindrical shell near the top head.

The vessel is supported by a steel ring welded to it just below the inlet and outlet pipes. External support is provided by the inner shield ring surrounding the vessel.

Inside the outer shell, and concentric with it, a steel baffle encloses the core. In addition to acting as a baffle to direct the flow of primary water through the core, it serves as a gamma radiation shield to reduce the heating effect of this radiation on the pressure vessel wall. This barrier also provides additional shielding of the surroundings from radiation.

Primary Shield (Figure 2-1). The primary shield is a water-filled steel structure which surrounds the pressure vessel. The shield is 46 inches thick and consists of alternate layers of 2 inches of steel and 1 inch of water. The inner wall of the shield is a 2-inch thick steel cylinder. Above the vessel, mounted on the inner shield ring, is a 12-foot-deep tank which is kept filled with water. Mounted on the inlet and outlet pipes are 7-inch-thick steel rings to prevent radiation streaming through the pipe penetrations of the shield.

Surrounding this shield is a 13-foot, 5-inch-diameter tank filled with water to a height 12 feet above the top of the pressure vessel. The total effect of this steel and water shielding is to reduce the radiation exposure in the vicinity to a point where occupancy of the vapor container is permissible when the reactor is shut down and to reduce the size requirements for the concrete secondary shielding.

Control Rods (Figure 2-3). Seven control rods, identical in construction, provide the means of controlling the reactor power level. Each rod consists of two sections mounted in a hollow, square member. The top sections of the rods contain boron enriched in the B_{10} isotope, imbedded in an electrolytic iron matrix. This material is an effective neutron absorber which, when positioned in the reactor core, controls the fission rate by absorbing excess neutrons. The lower section of each rod contains a fuel element having 16 fuel plates similar in construction to those used in the stationary fuel elements.

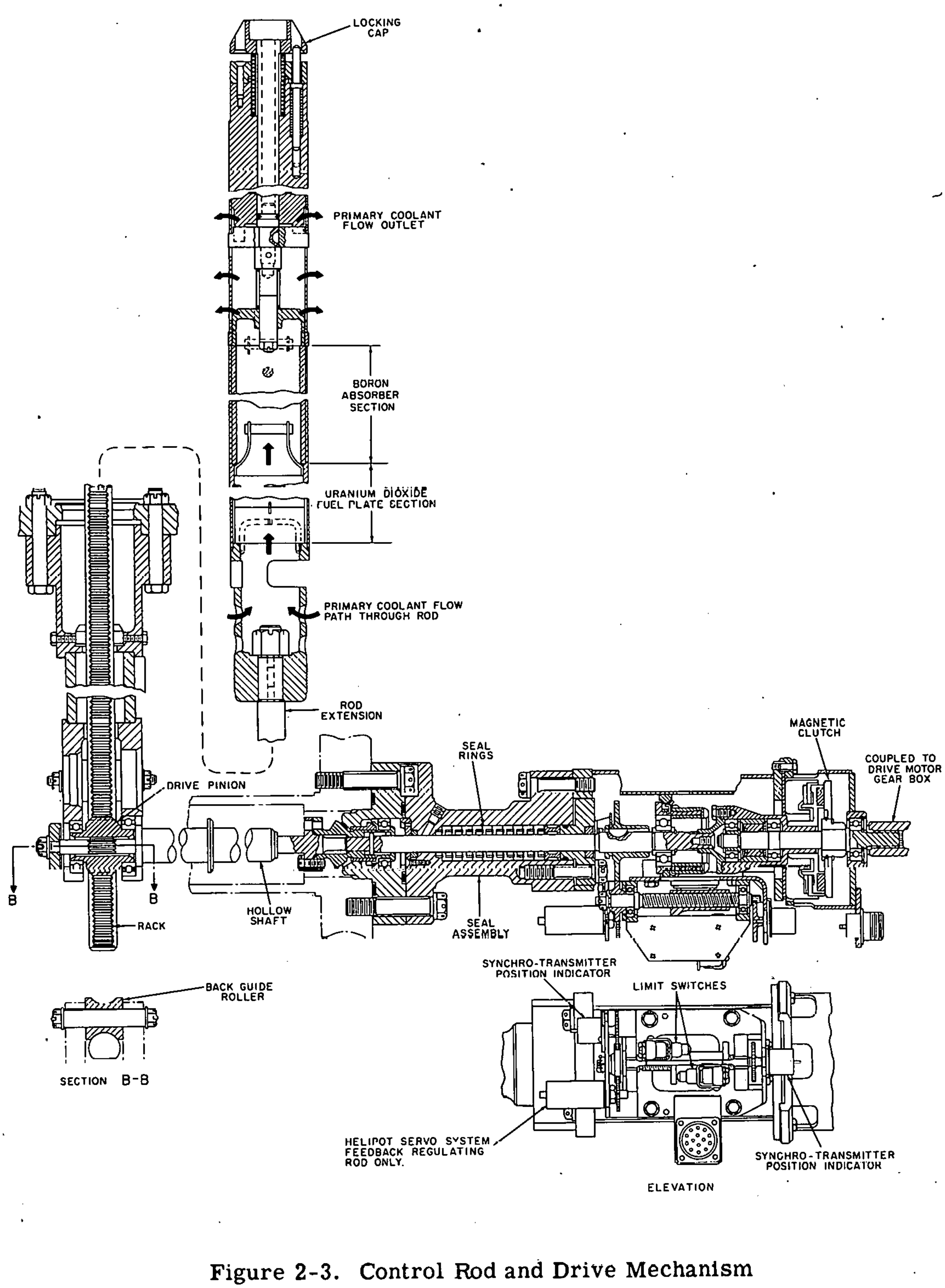


Figure 2-3. Control Rod and Drive Mechanism

For low-temperature operation the rods are raised to bring the reactor to a desired power level. Raising a rod introduces more fuel into the core and removes absorbing material. This creates a power level rise. When the desired power level is reached, the rods are inserted to a point where the fission rate and power level remain constant. This is known as the cricical position. To lower power, the rods are inserted to a point below the critical position. This produces a drop in power level. When the new power level is reached, the rods are returned to the critical position to maintain the level. The rate of power change depends on the displacement of the rods from the critical position; the greater the displacement, the faster the power will change.

As the temperature of the primary coolant is increased, a thermal property of the reactor known as the negative temperature coefficient begins to have effect and becomes increasingly significant as the temperature rises. This property is caused primarily by changes in water density with temperature rises. Consequently, a reactor, critical at a low temperature, becomes subcritical at a higher temperature, and it is necessary to raise the rods to overcome this effect. As the coolant temperature rises toward its rated value, the effect of the negative temperature coefficient becomes dominant and controls the power level of the reactor. Under these conditions, the control rods control the mean temperature of the reactor.

Five of the rods are used for control purposes, their vertical position being changed for the gradual decrease in reactivity of the reactor as fuel is consumed and to compensate for reactor fission product poisons. The other two rods are inserted 20.0 inches (fuel section in the core) and may be dropped in emergencies with the other five rods to shut down the reactor. (See figure 2-2 for position of safety rods.) In the event of an emergency, all of the control rods are released from their drive mechanisms by de-energizing the magnetic clutches, and are dropped to introduce their neutron absorber sections into the core. This procedure is known as "scramming" the reactor. When this is done the power level of the reactor drops very rapidly.

Each rod is guided at the top by guiding pads on the upper grid members and at the bottom by a drive pinion and a back-up roller. The absorber sections of the rod are hollow, and the bottom of the rod contains suitable openings to permit flow of the primary water through the rods at the same rate it flows through the fuel elements. A dash-pot shock absorber at the bottom of each rod prevents damage to the rod when dropped for a scram. Attached to the bottom of each rod is a stainless steel extension with a rack that meshes with the drive pinion of the control rod drive mechanism.

<u>Control Rod Drive System and Seals</u> (Figure 2-3). Inside the pressure vessel, each rod extension rack meshes with a drive pinion which is splined to a hollow shaft running to the outside wall of the vessel. A water seal, bolted to the outside face of the vessel, surrounds a shaft connecting the internal hollow shaft to the drive shaft of a reduction-geared motor. The connecting shaft is coupled to the motor drive shaft through a magnetic clutch. De-energizing the clutch coil releases the clutch and permits the rod to drop freely of its own weight to scram the reactor.

Each rod drive motor is a 1/8-hp, 440-volt, 3-phase induction motor. Switch-actuated relays interchange the phase connections of the motor field winding to reverse the direction of rotation. The motor is equipped with an integral brake to aid in positioning the rods accurately.

Geared to each connecting shaft are two synchro-transmitters electrically connected to control console meters to indicate rod position. Limit switches on each shaft prevent overtravel of the rod in either direction. Accuracy of rod positioning and indication is plus or minus 0.062 inch.

The connecting shaft seal consists of 12 encased metallic floating rings with a close clearance around the shaft. Water, drawn from the primary system make-up line, is introduced at the high-pressure end of the seal. This arrangement prevents the escape of radioactive primary water through the shaft penetrations of the pressure vessel wall. Each seal unit can be replaced without draining or depressurizing the primary system.

Cooling System. Water, drawn from the condenser hot well, is circulated in a cooling coil around the pressure vessel to prevent boiling of the water in the first water layer of the primary shield and to cool the space around the bottom of the vessel to prevent damage to the adjacent concrete. For further information, refer to Section 1, PRIMARY SYSTEM, Cooling Systems.

Control System (Figures 2-4 and 2-5). The reactor control system consists of six basic parts. These are the log N and period measurement system, the linear power measurement system, the reactor safety system, and the control rod drive control system. In addition, a tank is provided in which a boron salt solution can be placed for introduction by the primary coolant make-up pumps into the core if it is needed to drive the reactor sub-critical at low reactor temperatures at shutdown.

The log N and period measurement system provides the operator with a continuous record at the control panel of the neutron flux level, in percent of full load power, and of the reactor period, in seconds. The sensing element is an ion chamber located near the reactor vessel. It is sensitive to neutrons, and its output is electronically amplified and delivered to the recorders. Relays in the system sound an alarm if the period drops to 10 seconds and stops rod withdrawal. If the period drops to 3 seconds, the relays scram the reactor.

The linear power system measures the reactor power level. The output of an ion chamber similar to the one noted above is amplified and fed to a recorder on the control panel which is calibrated in percent of selector range setting. The system is equipped with an 18-position range selector switch to assure accuracy over a wide range of power levels.

There are two log count rate measurement systems. One system uses a Bf_3 chamber, the other a fission chamber. The outputs of these units are amplified and fed to two recorders on the control panel which are calibrated in counts per second. The purpose of these systems is to provide an indication of reactor operation at a very low power level (at startup, for example). Both the Bf_3 and Fission Chamber Log Count Rate Meters are needed to cover the entire low-power level range. The Bf_3 meter is most sensitive and covers the lowest range. At a higher level and before the Bf_3 meter goes off scale, the Fission Chamber Log Count Rate meter takes over and indicates levels well into the range of other channels. At these low levels, the current outputs of the other channels are too small to measure, because of the low neutron flux. The log count rate channels are set up to measure the neutron count rate as pulses until the power level and neutron flux become so high that individual counts can no longer be detected. The recorder is equipped with two backset switch interlocks. One is set at two counts/second and prevents upward control rod motion below this value. This assures that source neutrons are present and that sub-critical multiplication can be observed. The other is set at 10,000 counts/second and establishes the maximum end point for the recorder. The system is bypassed at this value.

The safety system automatically actuates a reactor scram when necessary. The system contains two safety amplifiers. The amplifiers are fed by three ion chambers and a process scram circuit. Of the eight outputs of the amplifiers, seven supply current to the control rod drive magnetic clutches; the eighth holds in a relay which, when released, sounds a scram alarm, trips the generator circuit breakers and the turbine throttle valve, and actuates the rod drives downward.

In the event two out of the three ion chambers sense excessively high neutron flux, the amplifiers act to cut off current to the control rod magnetic clutches to scram the reactor. In addition, certain dangerous thermal conditions in the plant will cause a process scram circuit to actuate a scram through the amplifiers.

A meter and selector switch on each amplifier permits the operator to check magnetic clutch current supply, magnetic clutch voltage supply, or amplifier power supply voltage.

The seven reactor control rods, while identical in construction, serve different control functions and, consequently, are not all operated in the same manner. (See figure 2-2 for rod configuration.)

Four of the control rods are called shim rods and, when moved simultaneously by operation of the gang switch, are used for coarse control of the reactor. Throughout this manual reference is made to five-rod gang operation. The five rods (four shim rods and one regulating rod) are a gang. In gang operation the rods may be moved individually or by means of the gang switch. In either case the rods will be moved in such a fashion that the distance between the rod withdrawn farthest and the rod inserted farthest shall be no more than two inches.

During the start up, the gang switch may be used to withdraw the five rods together within the following limitation. At any stage during its lifetime the core is in its most reactive condition at room temperature (68° F) and without xenon poisoning. In this most reactive condition, the reactor can become critical at a certain withdrawal position of the five-rod gang. The gang switch may be used to withdraw the rods together to not less than two inches distance from this critical position. Since the critical withdrawal position varies slowly throughout the core lifetime, it is not specified in this manual. Before any start up using the gang switch, the critical withdrawal position will be specified to the reactor operator by the shift supervisor. Two of the control rods are called safety rods and are normally inserted 20.0 inches (fuel plate section in the reactor core). The safety rods serve as standby control rods, should any of the other control rods fail to operate. The seventh control rod is called the regulating rod. It is situated in the center of the core and is used for fine control of the reactor. Each rod is motor-driven through magnetic clutch drives. All controls for the operation of the control rods are located on the control console.

Three-position selector switches for each rod permit the operator to position each one up or down in the core. An OFF position on these switches is provided for maintaining stationary control rod position. Indicating dials show each control rod's position at all times. Red signal lights indicate that rods have reached limit of upward travel and green signal lights indicate that rods have reached limit of downward travel.

The four shim rods and the regulating rod may be operated simultaneously by a single selector switch. The same may be done with the two safety rods.

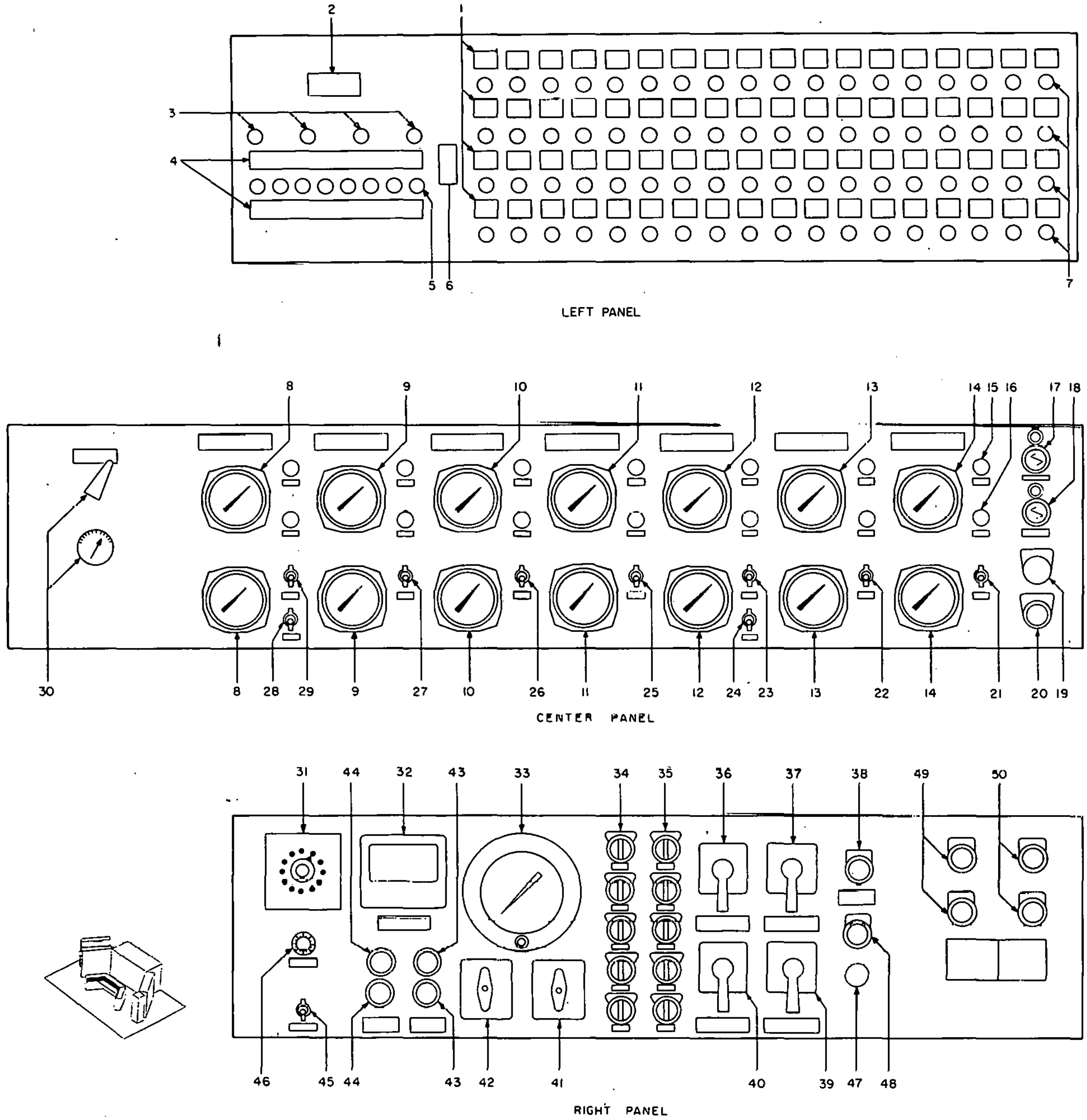


Figure 2-4. Control Console

Limit switches are situated on the rod drive to prevent overtravel of each rod in the upward or downward direction.

A transfer lock switch permits the operator to arrange the control circuits for routine-power operation or zero-power operation. For routine operation, the switch prevents raising any control rod until one of the primary coolant pumps has been started. In addition, the power level may be raised above a 200-w zero-power safety limit without causing a scram. For zero-power operation, control rod motion is permitted with inactive primary coolant pumps, no scram will occur because of lack of primary coolant flow and/or inoperative primary coolant pumps, and a scram will occur if the power level accidentally reaches 200 watts.

Refer to table 2-15 for a complete list of scrams and alarms.

LEGEND FOR FIGURE 2-4

1. Annunciated point nameplate over indicator lights
2. Common alarm signal light -- red
3. Test indicator lights
4. Test panel name plates
5. Test buttons
6. Annunciator panel switch
7. Acknowledge switches
8. Safety rod A position indicators
9. Safety rod B position indicators
10. Regulating rod position indicators
11. Shim rod No. 1 position indicators
12. Shim rod No. 2 position indicators
13. Shim rod No. 3 position indicators
14. Shim rod No. 4 position indicators
15. Rod position upper limit light -- red
16. Rod position lower limit light -- green
17. Reactor ON-OFF switch
18. Power ON-OFF switch
19. Scram pushbutton
20. Scram circuit reset pushbutton
21. Shim rod No. 4 individual drive control switch
22. Shim rod No. 3 individual drive control switch
23. Shim rod No. 2 individual drive control switch
24. Shim rod gang drive control switch
25. Shim rod No. 1 individual drive control switch
26. Regulating rod drive control switch
27. Safety rod B individual drive control switch
28. Safety rod gang drive control switch
29. Safety rod A individual drive control switch
30. Intercommunication system controls
31. Range selector switch-linear power channel
32. Regulating rod servo-control set point deviation
33. Pressure gauge (Remote parameters indicator)
34. Pressurizer heater individual control switches
35. Pressurizer heater individual control switches
36. Primary blowdown valve control switch
37. Transfer lock switch
38. Motorized steam valve close button
39. Primary coolant pump No. 2 control switch
40. Primary coolant pump No. 1 control switch
41. Parameter selector switch
42. Parameter selector switch
43. Heater gross control pushbuttons
44. Heater fine control pushbuttons
45. Regulating rod AUTO-MANUAL selector switch
46. Regulating rod servo-control set point adjustment
47. Signal light test button
48. Motorized steam valve position light
49. P.C. blowdown trip valve controls
50. Secondary blowdown trip valve controls

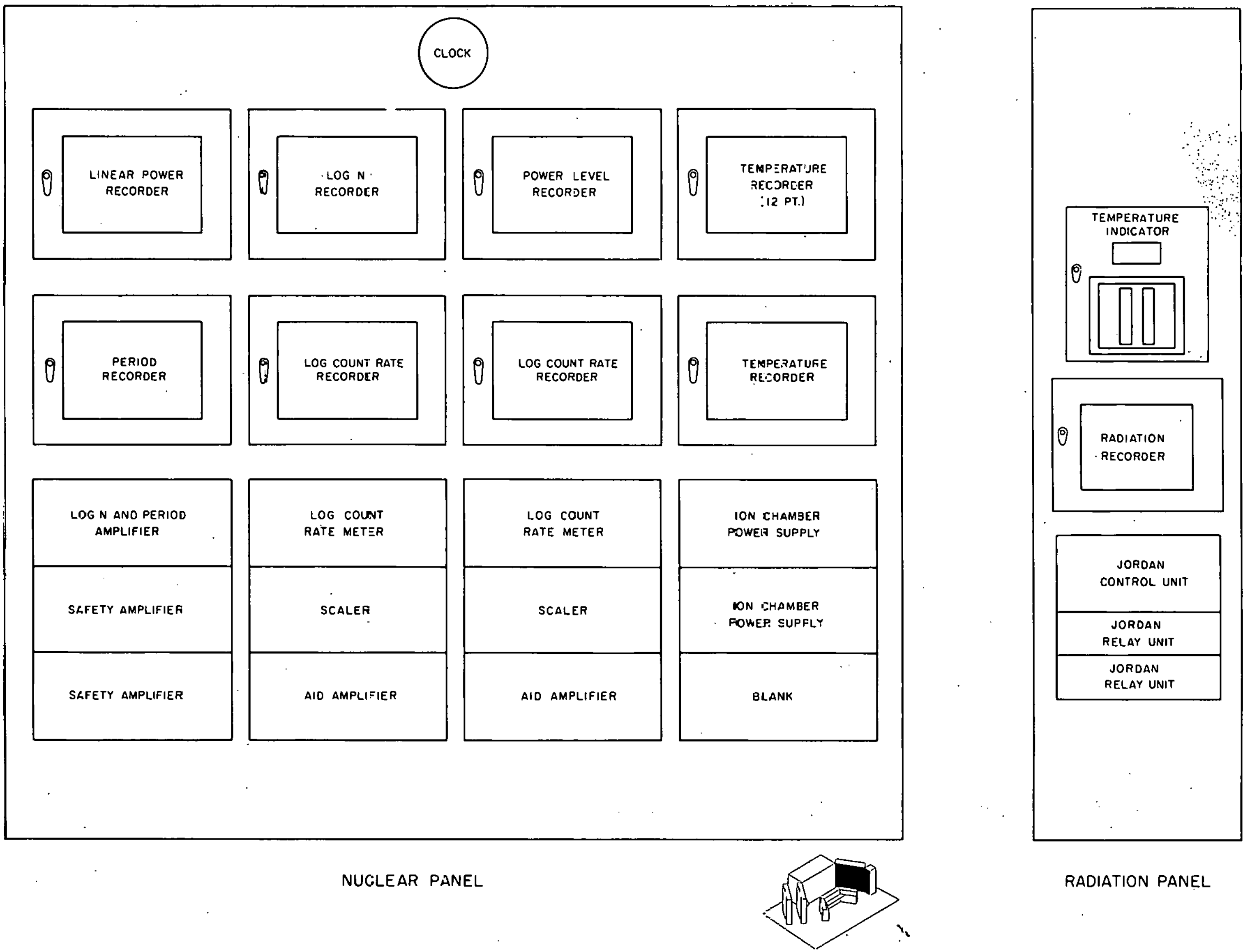


Figure 2-5. Nuclear and Radiation Sections Control Panel

Performance Data. Pertinent design and operating data for the reactor are tabulated below:

Core life before refueling, megawatt-yr	15
Neutron flux, average, thermal, at end of 15 mw-yr cycle, n/cm^2-sec	2.7×10^{13}
Operating pressure in reactor, full load, psia	1200
Coolant inlet temperature at reactor, full load, °F	431.6
Coolant outlet temperature at reactor, full load, °F	450.0
Maximum bulk water temperature, hottest channel, full load, °F	487.6
Coolant flow through core, full load, gpm	4000
lb/hr	1.66×10^6
Design heat output, full load, BTU/hr	34.1×10^6
Pressure vessel design maximum temperature, °F	650
Pressure vessel design maximum pressure, psig	1600

Operating Hazards. The radiation dose rate through the primary shield, at full-power operation of the reactor, is about 8000 times tolerance in a radial direction and 6000 times tolerance in a vertical direction. PERSONNEL MUST NEVER ENTER THE VAPOR CONTAINER WHILE THE REACTOR IS RUNNING AT POWERS ABOVE 200 KW.

After normal shutdown, the vapor container may be entered. However, personnel must check the dose rate before entering and at all times during occupancy.

Reactor Start Up.

1. The reactor may be brought critical under the following conditions if all other relevant conditions are normal.
   a. The transfer lock switch is in the zero-power position.
   b. The transfer lock switch is in the routine position, a primary coolant pump is running, and the low-pressure scram bypass switch is in the bypass position.
   c. The primary system is hot with the pressure above 1100 psi, the transfer lock switch is in the routine position, and a primary coolant pump is running.
2. By means of the safety gang switch and the shim gang switch, withdraw all seven rods to 1-1/2 inches. This cocks all rods, so that in the event of a scram in any subsequent operation, negative reactivity will be introduced by each of the seven rods.
3. By means of the safety rod gang switch, pull the two safety rods up 19.0 inches. Watch carefully for a rapid increase in multiplication. Some multiplication should be noticed on the log count rate recorders, but the reactor should not go critical.
4. By means of the shim rod gang switch, withdraw the five-rod bank (regulating rod and four shim rods) to not less than two inches from the most critical position. The most critical

position of the five-rod bank is defined as that position where the reactor would be critical with the two safety rods completely withdrawn, with the reactor at room temperature (68° F), and with no xenon poisoning. This position of the five-rod bank at beginning of core life is 3.7 inches. Accordingly, this step is omitted during the first few months of the core life. The reactor operator will always check with the shift supervisor for any change in the most critical position before this step in the procedures is followed.

5. Withdraw the five rods, one at a time, in small increments until the reactor becomes critical.

WARNING

At no time during the core life time should the distance between the rod withdrawn farthest and the rod inserted farthest of the five-rod bank be more than two inches and will normally be on the order of 0.1 inch.

6. Using the rods in the five-rod bank, withdraw the rods slightly one at a time and place the reactor on a positive period until the desired power level is reached. The positive period should be kept large enough (slow reactor power change) so that the reactor can be easily controlled. For routine low-power operation, any period longer than 30 seconds is considered safe.
7. If the primary system is to be heated, allow the reactor power level to rise to 500 kilowatts and return the reactor to just critical. Observe the Δt across the wye valve. Adjust the power level such that this Δt does not exceed 45° F. As the primary temperature rises, the reactor will tend to go sub-critical because of the negative temperature coefficient. Withdraw the rods one at a time so as to maintain the desired power level.

Pressurizer

Description (Figure 2-6). The pressurizer maintains the necessary primary system pressure to prevent boiling in the reactor. It is located inside the vapor container, and consists of a 25-cubic-foot-capacity, carbon-steel spherical steam dome welded atop a 16-inch-inside-diameter, carbon-steel vertical cylinder. The inside diameter of the dome is 45 inches and its wall thickness is 1-3/8 inches. The bottom of the cylinder is closed off by a 1-inch-thick stainless steel disc backed by a 4-1/8-inch carbon steel flange. The joint is sealed by an octagonal cross section, stainless steel ring gasket. Mounted on the disc are 30 electrical heaters, each rated at 3-1/3 kw. The elements are wired in parallel in groups of three, each group having a rating of 10 kw. The heaters are surrounded by a stainless steel baffle. The heater units, as well as the inside surfaces of the pressurizer, are clad with stainless steel.

A 4-inch nominal diameter pipe interconnects the pressurizer and the primary coolant line. The connecting pipe penetrates the pressurizer near the bottom of its cylindrical section. Pressure produced in the steam dome of the pressurizer is exerted on the primary system through the connecting pipe.

Two steel rings welded to the cylindrical section support the unit. The entire unit and the connecting pipe are surrounded by 4 inches of thermal insulation. A pressure relief valve, mounted on top of the dome, opens at 1500 psia to the inside of the vapor container to protect the system from overpressure.

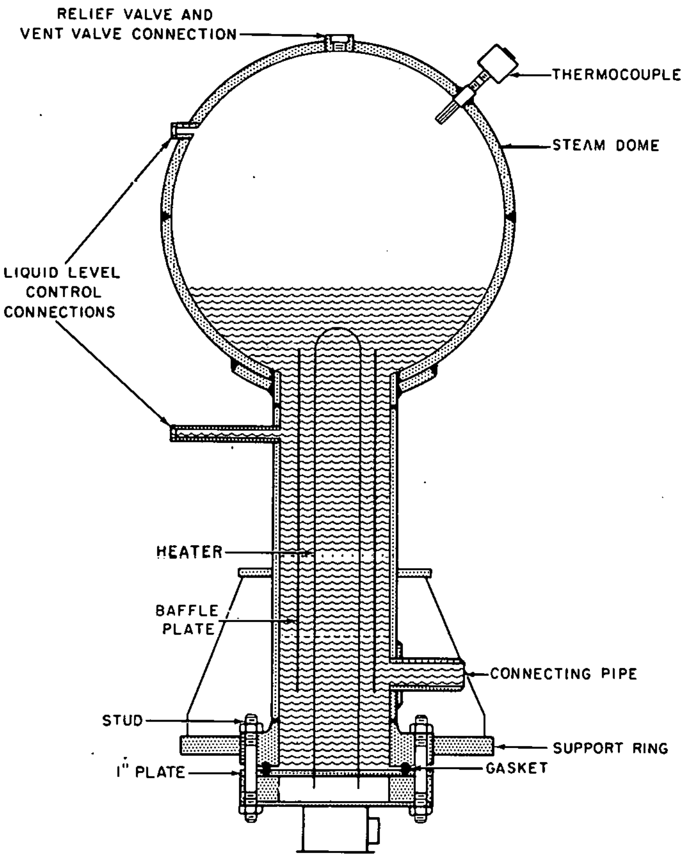


Figure 2-6. Pressurizer

During full-load operation, the heater control system responds to pressure changes to restore the rated pressure. At rated pressure conditions, a water temperature of 567.2°F will exist within the pressurizer, in equilibrium with the steam at the rated pressure of 1200 psia.

A drop in primary coolant temperature because of an increase in system load causes a contraction in volume of the water in the system, which lowers the level in the pressurizer. The steam pressure in the dome will drop and some of the water will flash into steam. The pressurizer heaters will automatically come on and evaporate additional water to restore normal operating pressure. The primary make-up system will automatically restore the normal water level. An increase in primary coolant temperature caused by a decrease in system load expands the volume of the water in the system, compressing the steam in the dome and raising its pressure.

Control System (Figures 2-4 and 2-7). Power for the operation of the heaters is taken from the 460-volt station service busses. Half of the heaters are powered from bus No. 1, the other half by bus No. 2. This arrangement ensures continuous heater operation in the event one of the busses fails.

Three-position selector switches, located on the right-hand section of the console, enable each heater to be placed under fine control by the pressure recorder controller, under gross control by pressure actuated switches, or in the off position. The pressure controller will supply power to heaters if the pressure drops below 1200 psia. The pressure switches are not actuated unless the pressure drops to 1150 psia. During full-load operation, four of the heaters are placed under fine control and four under gross control. The circuit is so arranged that no power is supplied to any heater if the system pressure is 1200 psia or greater; power is supplied to those on the fine bus if the pressure falls below 1200 psia, but no lower than 1150 psia; power is supplied to fine and coarse buses if the pressure falls below 1150 psia. Pushbuttons enable the operator to bypass the pressure controlling devices and supply power to the heaters continuously during start up and in the event of control failure. The pressure is continuously recorded at the control panel.

The water level is automatically detected by a differential pressure cell which, through a control system, regulates the primary coolant make-up pump speed. As the level in the pressurizer varies, the amount of make-up water entering the system is varied to restore normal level. An alarm is sounded if the water level is either excessively high or low. Should the pressure become so low as to approach the boiling condition in the reactor or so high as to endanger primary system components, pressure switches initiate a reactor scram and sound an alarm.

A double-element iron-constantan thermocouple is mounted near the top of the dome and provides continuous measurement of the steam temperature.

Pressurizer Operation (Figures 2-4 and 2-7)

Startup

1. Check that pressurizer recorders and controllers are receiving power and functioning properly.

2. Check that the pressurizer is full of water.

3. Put two heaters on the fine bus and four on the coarse bus.

4. Put both heater buses on auto.

5. Add or remove heaters from the fine bus to maintain the desired heat-up rate. Do not exceed 50°F per hour temperature rise.

6. Blow down the primary system as necessary to limit the system pressure to 50 psig maximum until system temperature has been 200°F for 30 minutes.

7. When saturation temperature at 50 psig has been reached, increase blowdown and establish normal water level in the pressurizer while maintaining 50 psig.

8. Continue heating as the primary system temperature allows and observe system pressure rise. Check that gross heater bus is de-energized at 1185 psi.

9. Add heaters to fine bus to maintain heating rate.

10. Check that fine heater bus is de-energized at 1220 psi.

11. Set heater selector switches as follows for normal operation:

    a. One heater from each station service bus on fine control.

    b. Two heaters from each station service bus on coarse control.

    c. Both heater buses on auto.

Normal Operation

1. Periodically check system pressure.

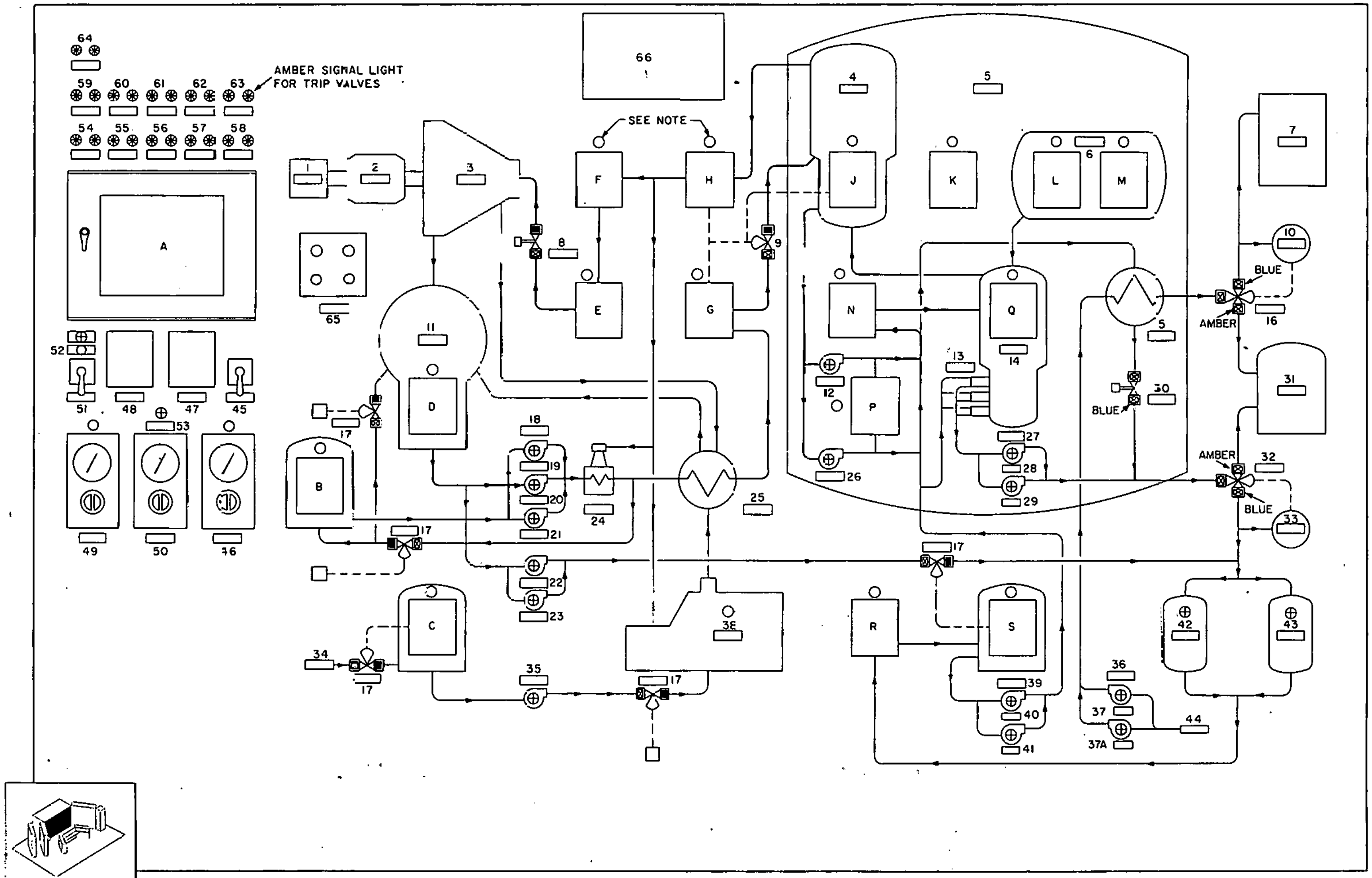
2. Periodically check pressurizer water level.

Shutdown. If the system pressure is to be maintained when the reactor is shut down, leave the pressurizer pressure and level controls on automatic. Note that the primary temperature must also be maintained above 200°F.

If the system is to be depressurized and cooled, adjust blowdown rate to raise and lower the pressurizer water level to cool the pressurizer. When system pressure approaches 0 psig, reduce the blowdown rate and completely fill the pressurizer.

Primary Coolant Pumps

Description (Figure 2-8). One of two "canned" motor pumps circulates the primary coolant through the primary system. They are hermetically sealed motor-pump units. The impeller mounted on the rotor shaft is of the mixed flow design. The rotor and stator of the pump are enclosed in leak-tight inconel jackets. When the primary system is filled, the pump



NOTE : WHITE LIGHT WITH NUMBER IN LENS INDICATES FUNCTION SELECTED ON GAGE AT CONSOLE.

KEY: ■ DENOTES GREEN LIGHT
⊠ DENOTES RED LIGHT

Figure 2-7. Graphic Section Control Panel

LEGEND FOR FIGURE 2-7

1. Exciter
2. Generator
3. Turbine
4. Steam Generator
5. Vapor Container
6. Pressurizer
7. Seal Pit
8. Turbine Throttle Trip Valve
9. Feedwater Control Valve
10. Radiation Monitor
11. Condenser
12. Primary Coolant Pump No. 1
13. Rod seals
14. Reactor Pressure Vessel
15. P.C. Blowdown Cooler
16. Three Way Valve
17. Level Control Valve
18. Boiler Feed Pumps
19. No. 1
20. No. 2
21. Emergency
22. Cond. Recirc. Cooling Pump No. 1
23. Cond. Recirc. Cooling Pump No. 2
24. Air Ejector
25. Feedwater Heater
26. Primary Coolant Pump No. 2
27. Seal Leakage Return Pumps
28. No. 1
29. No. 2
30. Primary Coolant Blowdown Valve
31. Hot Waste Storage
32. Three Way Valve
33. Radiation Monitor
34. Service Water Tank Supply
35. Evaporator Feed Pump
36. Blowdown Cooling Water Pumps
37. No. 1
37A. No. 2
38. Evaporator
39. Variable-Volume P.C. Make-Up Pumps
40. No. 1
41. No. 2
42. Demineralizer A
43. Demineralizer B
44. Supply from Circulating Water Pump Discharge
45. Primary Blowdown
46. Secondary Blowdown
47. Flow
48. Pressure
49. Air Loading Station
50. Hot Waste Tank Vent
51. Conductivity Selector
52. Evaporator Overhead Conductivity
53. Open to Stack
54. Trip Valve #2 Steam from Generator to Turbine
55. Trip Valve #1 Steam from Generator to Turbine
56. Trip Valve Drain from Steam Generator
57. Trip Valve Blowdown from Steam Generator
58. Trip Valve Cooling Water Return from Shield Tank
59. Trip Valve River H_2O from Blowdown Cooler
60. Trip Valve Primary Coolant Blowdown
61. Trip Valve Steam to Boiler Feed Turbine Pump and Condenser
62. Spare
63. Spare
64. Trip Valve from Seal Leakage Tank
65. Steam Generator Level Controller
66. Name Plate

A. Conductivity Recorder
B. Distilled H_2O Tank (Level Indicator)
C. Service H_2O Tank (Level Indicator)
D. Condenser Pressure (Recorder)
E. Steam Pressure (Recorder)
F. Steam Temperature (Recorder)
G. Feedwater Flow (Recorder)
H. Steam Flow (Recorder)
J. Steam Generator Level (Recorder)
K. Vapor Container Pressure (Recorder)
L. System Pressure (Recorder)
M. Pressurizer Level (Recorder)
N. P.C. Flow (Recorder)
P. ΔT P.C. Pump (Indicator)
Q. Temp. Differential across Reactor (Indicator)
R. P.C. Blowdown Flow (Recorder)
S. Primary Coolant Make-up Tank (level Indicator)

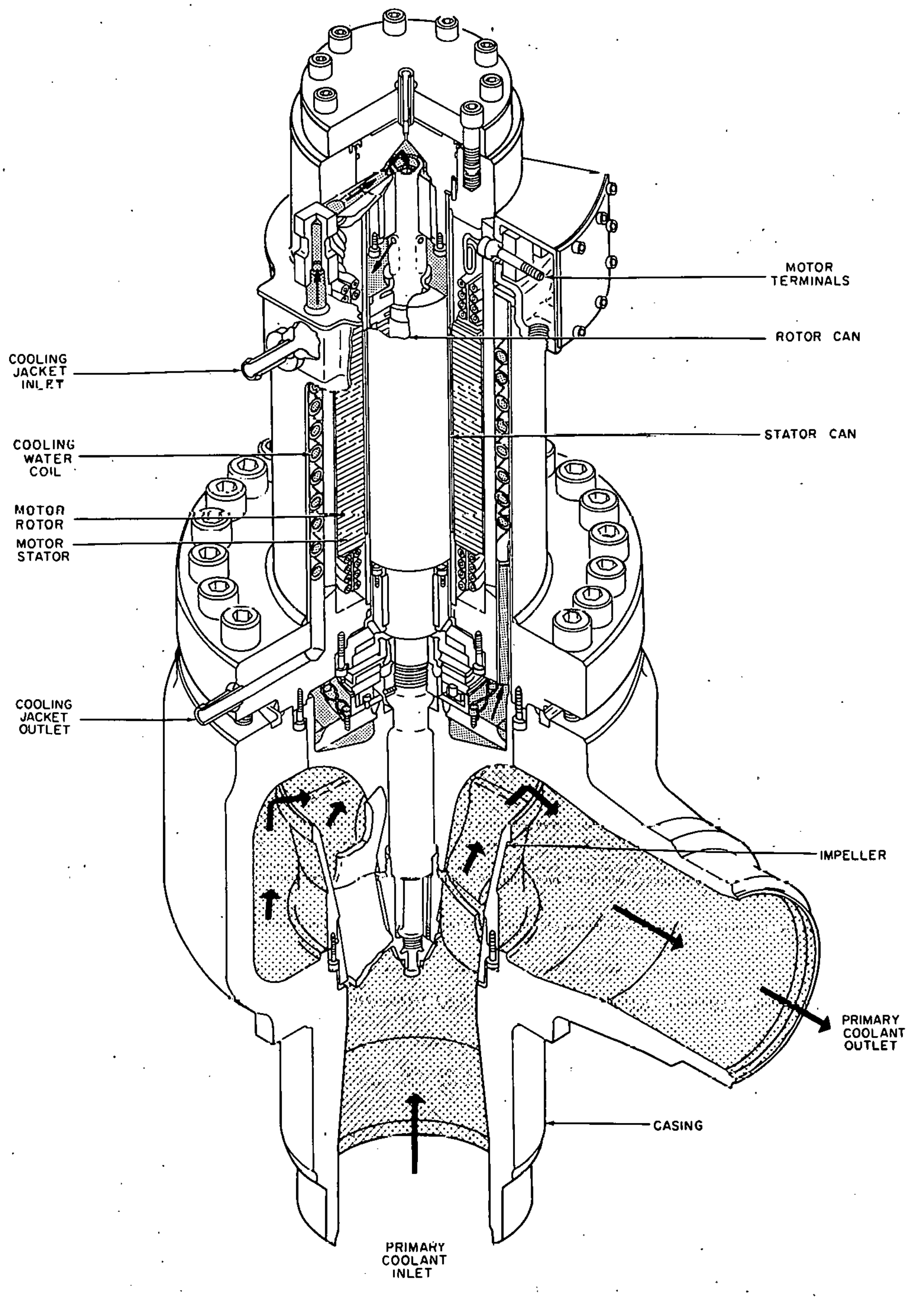


Figure 2-8. Primary Coolant Pump

motors are vented to atmosphere, permitting primary fluid to fill the motor cavity between the canned rotor and the canned stator. When the system is full, the vents are closed and the fluid in the cavity is circulated within the cavity by an auxiliary impeller mounted on the rotor shaft. Circulation of this water cools motor bearings and removes heat generated by electrical losses in the stator and rotor. The heat removed by this cooling water is in turn removed by passing through coils in the motor cavity. These coils have a water jacket surrounding them through which condensate from the secondary system passes and carries off heat losses of the motor. Between the motor and the pump impeller is a thermal shield, which is basically a labyrinth seal, and a still water space, which minimizes heat transfer between the primary fluid flowing through the impeller and the motor cavity cooling water.

One pump is inactive, and serves as a standby unit in the event of pump failure or power failure on one bus. The pumps are powered from separate 460-volt station service busses to ensure continuous operation in the event of the failure of one bus.

A certain amount of primary coolant is recirculated through the inactive pump to maintain the water temperature in the pump at no more than 10°F less than the active pump water temperature.

Pertinent performance data for each pump are tabulated below:

Rated power, electrical, kw	33
Hydraulic power, at 4000 gpm, hp	
Hot	23.5
Cold	28.4
Pump operating head, ft H_2O	28
Full-load operating temperature, at suction, °F	431.6
Cooling water temperature, from primary coolant pumps, °F	135
Primary coolant pump temperature, °F	135

Cooling System (Figures 1-6 and 2-8). Condensate, drawn from the condenser hot well by one of the condensate recirculating cooling pumps, is circulated through the water jackets of the pumps. In passing around the coils in the jacket it cools the primary water inside the coils to carry off the heat losses of the motor. The condensate is returned to the condenser hot well for reuse.

Control System (Figures 2-4 and 2-7). The controls for the operation of the primary coolant pumps are located on the right-hand section of the control console and consist of an ON-OFF selector switch for each pump and a transfer lock switch. The transfer lock switch is used to arrange the pump control circuit connections for either ROUTINE or ZERO POWER operation of the reactor. The pumps will not operate with this switch in the zero-power position.

During normal power operation, the transfer lock switch is placed in the ROUTINE position, and no control rod may be raised until one of the primary coolant pumps has been started. Either pump selector switch is operative. Also, if the primary coolant flow rate falls below 3500 gpm, a scram will occur. In addition, the power level of the reactor may be raised above a 200-w zero-power limit without producing a scram. If selector switch PRIMARY COOLANT

PUMP NO. 1 is turned ON, pump No. 1 will start and a relay will be actuated to permit the control rods to be raised to bring the reactor to power. Selector switch PRIMARY COOLANT PUMP NO. 2 operates in the same manner. If the temperature in the inactive pump line drops to more than 10°F below that in the active pump line, a relay is actuated which prevents switching over to the inactive pump.

Zero-power operation is performed by raising the control rods to make the reactor critical without circulating primary coolant through the system. When the transfer lock switch is placed in the ZERO POWER position, control rod motion is permitted with inactive primary coolant pumps and the pump selector switches will not close, starting circuit contactors. The transfer lock switch also prevents a scram due to inoperative pumps, provides scram protection if the power level accidentally reaches 200 watts while attempting zero-power operation, and prevents a scram caused by lack of primary coolant flow and low pressure in the primary system.

The pumps are connected in series in the condensate cooling system. Failure of the cooling system will be indicated on a flow rate indicator also connected in series in the system. The indicator contains electrical contacts which will close and sound an alarm in the control room if the cooling water supply fails. If such failure occurs, both pumps must be shut down automatically after 15 seconds by a time delay relay.

When neither pump is operating, the resistance bulbs in pump legs are not connected to the two-pen recorder. When a pump is started, the associated bulb is connected to this recorder.

Primary Coolant Pumps Operation (Figures 2-4 and 2-7)

Startup

CAUTION

> Do not start a primary coolant pump if the primary system pressure is below 50 psig. At lower pressures, cavitation may take place at the secondary impeller and improper lubrication will result. This in turn will lead to bearing failure if the pump is operated. Do not exceed 50 psi until the system has been at 200°F for 1/2 hour.

1. Check that local permissive switches are in the Run position.
2. Check that selector switches PRIMARY COOLANT PUMPS No. 1 and No. 2 are in the OFF position.
3. Turn transfer lock switch to ROUTINE position.
4. Check that cooling water flow is normal (15 gpm).
5. Turn PRIMARY COOLANT PUMP NO. 1 selector switch to the ON position.
6. Check P.C. WATER FLOW RECORDER on graphic section to see that the flow rate rises to 4000 gpm.

Normal Operation. Periodically check primary coolant flow rate. Check condensate cooling water flow rate and temperature. Check pump temperature. Normally one primary coolant pump will be operated from one start up to the following shutdown. Should it become necessary to use the standby pump, it will be started and the operating pump will immediately be stopped.

Shutdown. When primary coolant flow is no longer needed, turn operative pump selector switch to the OFF position.

Zero Power Operation. Turn transfer lock switch to the ZERO POWER position and maintain this setting throughout the zero-power run.

Seal Leakage System

Description (Figure 1-3). The seal leakage system consists of seven metallic water seal assemblies, which enclose the segments of the control rod shafts that penetrate the pressure wall, a seal leak-off collecting tank, two seal leakage return pumps, interconnecting piping, valves, and controls. The purpose of the seal leakage system is to assure that the contaminated primary system water in the pressure vessel does not escape past the control rod drive shafts where they penetrate the pressure vessel.

Each water seal assembly contains 12 metallic seal rings that surround the shaft to be sealed. The rings provide a close clearance annular leakage path from the pressure vessel or high-pressure end of the water seal assembly to the outside. In operation, water from the primary coolant make-up line is introduced into the high-pressure end of the water seal assembly. A small, controlled amount of this make-up water passes through the leakage path provided by the seal rings. This flow results in virtually no rubbing between the seal rings, so that wear is very small. The remainder of the make-up water introduced into the water seal assembly enters the pressure vessel. This arrangement results in containment of primary system water through controlled leakage which is largely confined to uncontaminated make-up water. The seal leak-off collecting tank is a stainless steel cylindrical unit and has a spherical head. It is 3 feet in diameter by approximately 5 feet 6 inches high. Inlet, outlet, and vent ports are provided for connection of the tank into the seal leakage system. Also fitted to the tank are a safety valve, high and low water level alarm switches, a lever control switch for each pump, and a 2-inch drain connection, normally blanked off. In operation, leakage from the control rod drive shaft seal assemblies flows into the seal leak-off collecting tank. The float-actuated level switches maintain the water level within limits by controlling the operation of the seal leakage return pumps. Hydrogen is supplied to the tank to maintain an oxygen-free blanket above the water in the tank. The supply is made through a line from the primary coolant make-up tank hydrogen system through a pressure control valve (PCV/10). The valve controls the hydrogen pressure at 2 psig. A safety valve (SV/16) located in the line opens at 5 psig. A safety valve (SV/17) on the tank opens at 15 psig and has a capacity of 1 cfm at that pressure. A trip valve (TV/10) is situated in the hydrogen supply line.

A standard 2-inch globe valve with its outlet port blanked off is used at the bottom of the seal leak-off tank and serves as a drain connection.

Each of the two return pumps in the seal leakage system is a centrifugal-type unit, having a 1-1/2 gpm capacity against a head of 100 psi. The pumps are driven by 1/2-hp induction motors operating off the No. 1 460-volt station service bus, and are equipped with combination air circuit breakers and magnetic contactors with control transformers. Only one of the seal leakage return pumps is normally used; the other serves as a standby unit. Pump discharge is effected through check valves to the primary coolant blowdown line.

Control System (Figures 2-7 and 2-9). Manual-automatic pushbutton stations are provided for the operation of each pump. Red indicating lamps are also provided on the graphic section of the main control panel to indicate which pump is operating.

After start, control of the pump motors is assumed by the level limit switches in the seal leak-off collecting tank.

Seal Leakage System Operation (Figure 2-10)
(See Special Procedures for Initial Start Up.)

Normal Start Up.

1. Open hydrogen valves H-1, H-4, and H-5. Close hydrogen valves H-2 and H-6.

2. Check to see that the air supply pressure to trip valve TV/10 is 60 to 100 psi, then open TV/10.

3. Check to see that the primary coolant blowdown system is set up for normal operation and that a water level exists in the tank.

4. Start both seal leakage return pumps, P-13A and P-13B. Determine that both can be operated, then put both on automatic control.

5. Adjust pressure control valve PCV/10 so that it will maintain 2-psig pressure on seal leakage tank TK-11.

Normal Operation.

1. Occasionally check the primary blowdown flow recorder to see that the seal leakage return pumps have been operating.

Shutdown. For normal plant shutdown this system is left in operation.

Blowdown System

Description (Figure 2-11). The primary coolant blowdown system is comprised of a blowdown cooler, motor-operated blowdown control valve, two pneumatic diversion valves, radiation monitors, and various indicators, recorders, etc. The function of the blowdown system is to continuously bleed off primary coolant, reduce its temperature and pressure, and direct its flow through a demineralizer to maintain the concentration of corrosion products in the primary loop below 2 ppm total solids.

The blowdown cooler is a counter-flow tubular heat exchanger of stainless steel construction located within the vapor container. The inside surface of the inner tube has an ALCOPLATE finish. Blowdown water is passed through the annulus and river water through the inner tube. In operation, the blowdown cooler will reduce the primary coolant water temperature to below 140°F.

The blowdown control valve (MO-1) (PC-17) is a motor-operated, manually controlled throttling valve located within the vapor container in that portion of the blowdown line immediately following the blowdown cooler outlet. The valve provides a means of controlling the blowdown rate needed to maintain the desired primary coolant purity.

A globe valve and pneumatically operated trip valve (TV/8) are located in the blowdown line outside the vapor container. Essentially, the trip and globe valves respectively serve as initial automatic, and final manual shut-off devices in the blowdown line.

A radiation monitoring station, beta-gamma sensitive over the range 0.01 to 10 mr/hr, is located outside the vapor container in a bypass arrangement just beyond the pneumatic trip valve. Primary coolant blowdown is constantly monitored for radiation at this station. If a radioactivity level of 7.5 mr/hr is detected, a motor relay will actuate an alarm and function to operate a pneumatic diversion valve in the system to divert primary blowdown to the hot waste tank.

The diversion valve in the blowdown line is a pneumatically-operated, three-way control valve. The valve requires 60 psi air pressure for operation and forms a junction in the blowdown piping with branches leading to the demineralizers and hot waste tank. The valve is slaved to the radiation monitoring station in the blowdown piping bypass arrangement. When no significant radioactivity is present in the blowdown, the diversion valve is positioned to direct blowdown to the demineralizers. Contaminated blowdown will cause the radiation monitor to reposition the diversion valve so that blowdown is diverted to the hot waste tank. Failure of air pressure to the valve will also cause the diversion valve to divert blowdown to the hot waste tank; restoration of air pressure will put the valve back under the control of the radiation monitor.

The safety valve (SV/12) in the line just after the diversion valve is set to relieve at 75 psig. Blowdown that escapes through the safety valve is piped to the hot waste tank.

The safety valve (SV/11) in the cooling water discharge line is set to relieve at 150 psig. Excessive cooling water pressure in the blowdown cooler will open the safety valve and water will be directed into the vapor container sump.

A gate valve and pneumatically-operated trip valve (TV/7) are located in the blowdown cooler cooling water discharge line outside the vapor container.

A radiation monitoring station, beta-gamma sensitive over the range 0.1 to 10 mr/hr, is located in a bypass arrangement in the cooling water line. This station is identical to the one used in the blowdown line and functions in the same manner.

The diversion valve (RMCV/2) in the blowdown cooling water discharge line, similar to the one used in the blowdown piping, forms a junction in the blowdown cooling water discharge piping with branches leading to the station waste line and hot waste tank. Normally, the valve is positioned to allow the blowdown cooling water to enter the station waste line; however, in the event of contaminated cooling water, the radiation monitor will actuate the diversion valve to direct flow to the hot waste tank.

Control System (Figures 2-4 and 2-7). An Open-Close rotary switch is provided on the control console for operation of the motorized blowdown valve. A torsion spring in the switch

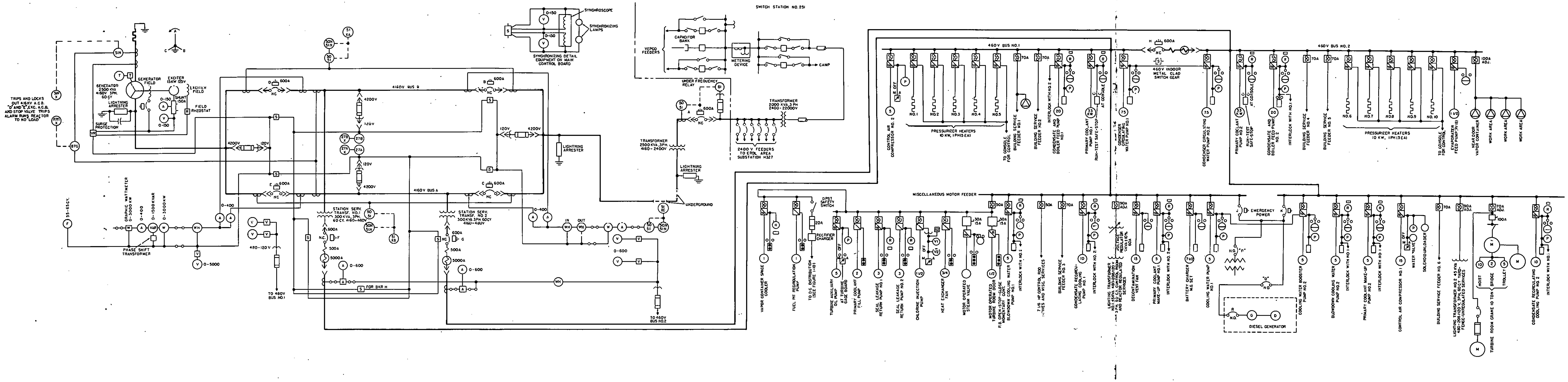


Figure 2-9. Electrical System, One-Line Diagram

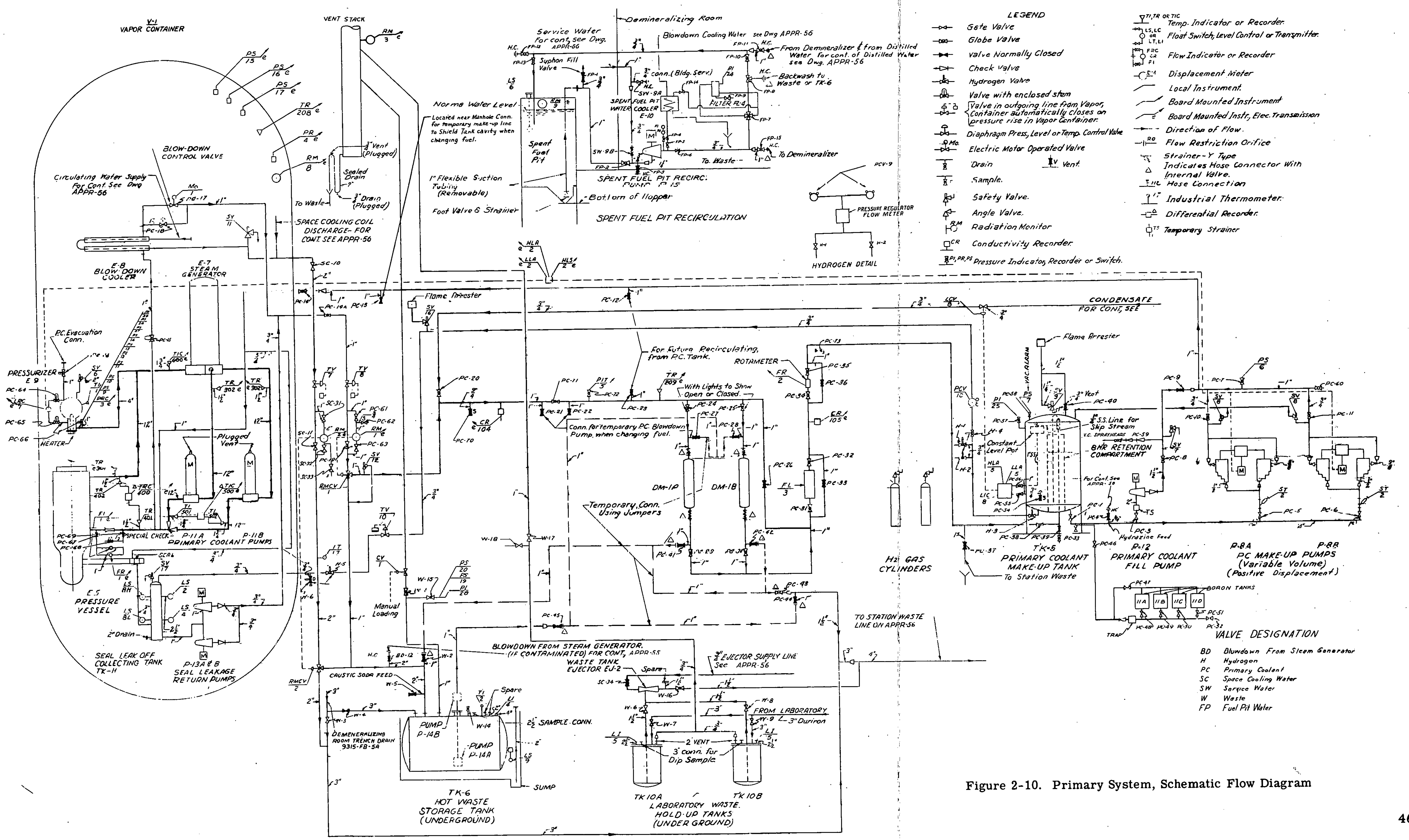


Figure 2-10. Primary System, Schematic Flow Diagram

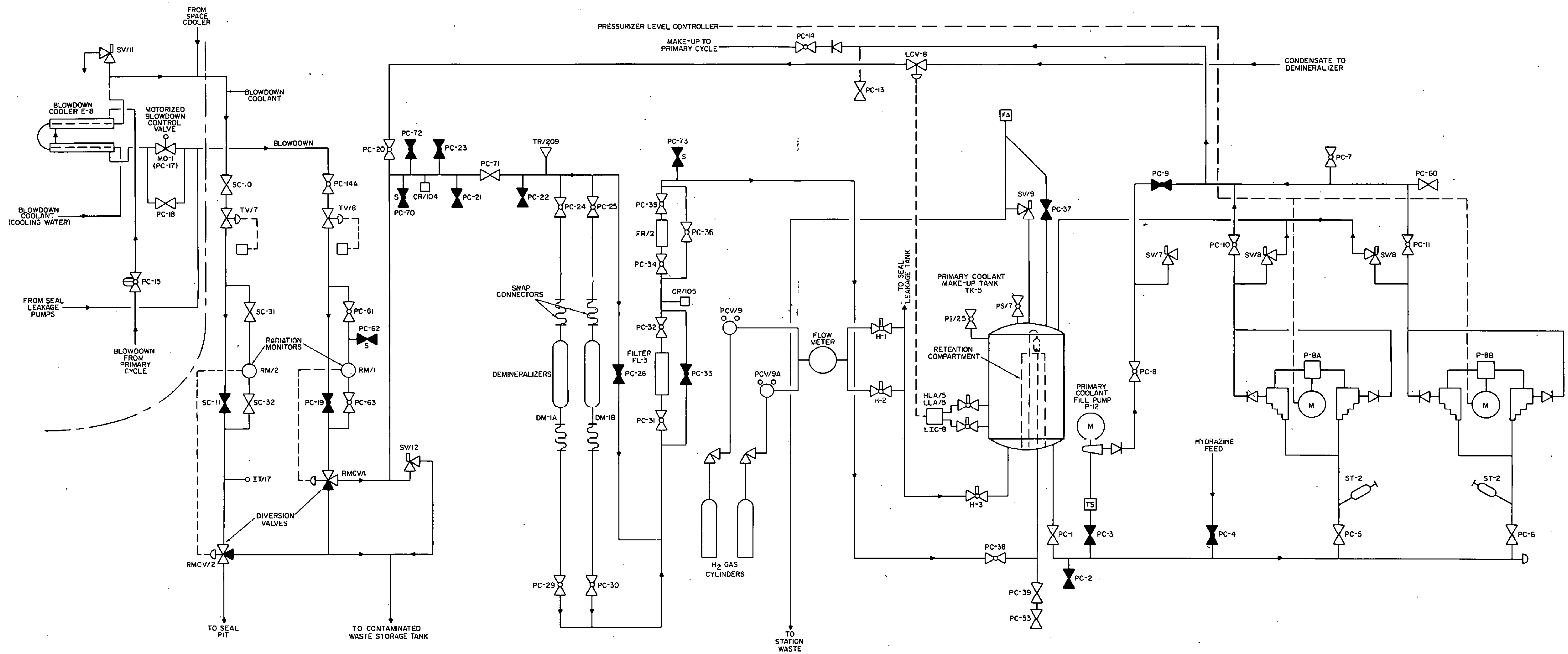


Figure 2-11. Primary Blowdown and Make-Up System, Schematic Flow Diagram

keeps it in a central-neutral position. A pressure switch on the blowdown line actuates a high-pressure alarm and interlock for the motorized blowdown valve. The pressure switch has set point and differential pressure adjustments. In the event of high blowdown pressure, the pressure switch will sound an alarm and will prevent further opening of the blowdown valve. In conjunction with the audible alarm a red pilot lamp on the annunciator console panel will light when blowdown pressure is abnormal.

Blowdown pressure may be read on a pneumatic indicator or the graphic panel. A local pressure indicator is also provided.

Blowdown rate is indicated on a strip chart recorder located on the graphic section of the control panel.

Blowdown conductivity can be obtained from a conductivity recorder on the graphic section of the control panel. Point No. 3 on the recorder will measure the conductivity of the blowdown going to the demineralizers.

The graphic section's blowdown system representation incorporates illuminated devices for the system's blowdown and diversion valves. The blowdown control valve device includes red and green pilot lamps. The automatically operated diversion valves are both represented by devices that include amber and blue pilot lamps. An illuminated blue lamp indicates normal flow and an illuminated amber lamp indicates that flow is being diverted to the hot waste tank.

Blowdown System Operation (Figures 2-7 and 2-11).

Startup.

1. Check to see that air pressure to valves TV/7, TV/8, RMCV/1, and RMCV/2 is between 60 and 100 psi.

2. Open valves SC-1, SC-2, SC-5, SC-7, SC-8, SC-9, SC-10, SC-11, SC-31, SC-32, SC-24, SC-25, and SC-37.

3. Close valves SC-26, SC-33, BD-12, W-2, and W-5.

4. Check that the circulating water system is in operation.

5. Start blowdown cooling water pump No. 1.

6. Open valves SC-3 and SC-6.

7. Open valves PC-14A, PC-19, PC-61, PC-63, PC-20, PC-71, and PC-72.

8. Close valves PC-62, PC-70, PC-21, PC-22, and PC-23.

Note

Valve PC-15 should be open and its protective cover installed before the vapor container is sealed.

9. Check to see that the primary coolant make-up system is operative and that demineralizers are in normal operation.

10. Turn the motorized blowdown control valve MO-1 selector switch to OPEN position to start blowdown. Adjust valve to obtain desired blowdown rate.

Normal Operation. Check blowdown rate at strip chart recorder.

Shutdown.

1. After the primary coolant make-up system has been shut down, put selector switch for blowdown control valve MO-1 in CLOSE position.

2. Close trip valve TV/8 and valve PC-14A.

3. Close cooling water valves SC-1 and TV/7.

Demineralizer and Filter System

Description (Figure 2-11). Coolant is blown down from the primary system to remove impurities from the system. Before recirculation to the primary make-up system, the water is passed through a demineralizer to lower its impurity content. The demineralizer is a cartridge-type, single-column, mixed-bed unit. It lowers the solids content of the blowdown from 2 to 0.5 ppm.

A spare demineralizer is connected in parallel. Both are situated behind individual concrete shields in a room south of the vapor container on the ground floor level. Quick disconnect hose connections facilitate fast removal of the contaminated demineralizer. Normally, the demineralizers will be installed in lead-lined shipping casks to reduce radiation hazards and to facilitate handling contaminated demineralizers.

Located downstream of the demineralizers is a micrometallic filter to remove any resins which may be carried from the demineralizer by the blowdown water. A bypass around the filter is provided to facilitate filter element changing. The filter is cylindrical in construction, sealed by neoprene and fiber gaskets, and contains a replaceable element or porous stainless steel through which the water flows.

The conductivity of the blowdown is measured before entry and after departure from the system as an indication of impurity content. A conductivity cell at each point transmits the measurement to a multi-point conductivity recorder located on the graphic section of the control panel. The temperature of the blowdown entering the demineralizer is continuously measured by an iron-constantan thermocouple. The temperature is recorded at a multipoint temperature recorder on the nuclear section of the control panel. The pressure of the entering blowdown is measured by a stainless steel diaphragm element, locally indicated, and transmitted to a control panel indicator. An alarm is sounded if the pressure rises to 55 psig and, simultaneously, further opening of the motorized blowdown control valve is prevented. The blowdown flow rate is measured, at a point downstream of the filter, by a rotameter. The flow rate, in gpm, is recorded at the graphic section of the control panel. A radiation monitor in the demineralizer room detects the gamma radiation level in the area. The level, in mr/hr, is recorded at a multipoint radiation recorder located on the radiation section of the control panel. An alarm is sounded if the level rises to 7.5 mr/hr.

Pertinent design data are tabulated below:

Demineralizer:	
Capacity, gph	200
Maximum allowable inlet temperature, °F	140
Outlet impurities, ppm	0.5
Design pressure, psi	100
Approximate life, mos	3 to 6
Filter:	
Capacity, gph	300

Demineralizer and Filter System Operation (Figures 2-10 and 2-11)

Startup.

1. Before starting the blowdown system, check that recorders and controllers in the system are receiving power and functioning properly (inlet and outlet conductivity recorders, inlet temperature recorder, inlet pressure indicator, flow recorder, and area radiation monitor).

2. Open inlet valve (PC-24 or PC-25) and outlet valve (PC-29 or PC-30) for one demineralizer.

3. Close filter bypass valve (PC-33).

4. Open inlet valve (PC-31) and outlet valve (PC-32) for the filter.

5. Start the blowdown system.

Normal Operation.

1. Check inlet temperature.

2. Periodically check all recording and indicating instrument readings.

3. Periodically sample inlet and outlet water for analysis.

4. Adjust conductivity meter temperature compensation once each shift.

5. Maintain a minimum of 0.5 gpm blowdown flow and adjust flow to maintain a maximum primary water conductivity of 2.0 micromhos.

6. The conductivity downstream of the demineralizer must be less than 1.0 micromhos. Change to the standby demineralizer upon definite trend above 1.0 micromhos.

7. Blowdown pressure should be less than 40 psig at 1 gpm blowdown; higher pressures indicate that the filter should be changed.

8. Primary blowdown temperature should be 125°F or less.

Shutdown. For normal plant shutdown, do not change valve settings on the demineralizer system.

Operating Hazards and Procedures.

WARNING

Radioactive nuclides in the primary coolant blowdown are deposited in the demineralizer. DO NOT ENTER DEMINERALIZER ROOM WITHOUT FIRST CHECKING DOSE RATE. Carry a portable dose rate instrument at all times while occupying this area.

Make-up System

Description (Figure 2-11). The primary coolant make-up system is comprised of two adjustable volume, variable speed, positive displacement make-up pumps and a 5000-gallon-capacity make-up tank which function to make up primary coolant losses. The system also incorporates a bottled hydrogen supply for inhibiting corrosion and a fill pump for initially filling the primary system.

The two make-up pumps are connected in parallel in the system, one serving as a standby unit. Each pump is a motor-driven, single-acting duplex unit with identical left and right step valve liquid ends. The pump suctions are submerged and each side of the pump can deliver 81 gph of make-up water at 1500 psig pressure. The 5-hp induction motor is run at a constant speed of 1400 rpm. This output is fed through an integral, mechanical, variable speed mechanism which is pneumatically actuated and can provide a 1400/188 rpm range of output for pump operation. The pneumatic input for the automatic operation of the motor's variable speed mechanism is obtained from the pressurizer level recorder controller. In operation, make-up water is drawn from the make-up tank through a Y-type perforated metal strainer to the pump inlet. Discharge is piped directly into the primary coolant line at a point just downstream of the primary coolant pumps.

The primary make-up tank is a 5000-gallon, stainless steel cylindrical unit with hemispherical ends. A cylindrical retention compartment, open at the top, is centered inside and on the bottom of the tank. In operation, flow from the demineralizer is directed through a loop within the retention compartment and discharged at the bottom of the compartment. A level indicator controller on the side of the tank measures the water level in the tank and regulates pneumatic pressure to the level control valve (LCV/8) in the condensate line leading to the demineralizer, thereby operating the valve to control the supply of additional water going into the make-up system and maintaining the make-up tank level. If the pressure of the gases in the upper volume of the tank exceeds 50 psig, a safety valve (SV/9) will unseat and the gases will escape to the flame arrester. A local indication of pressure is provided by a dial gauge at the tank. In the event of low pressure, a pressure switch will actuate an alarm at 15 psig.

Hydrogen gas is introduced into the primary water to protect the system from oxygen corrosion. Two 220-cubic-foot bottles, connected in parallel, are used one at a time. The gas is directed through a flow indicator, pressure control and hydrogen valves to a line leading into the bottom of the make-up tank. This will maintain a hydrogen concentration of 15 to 30 cc/kg of water in the primary loop.

The fill pump is a centrifugal-type unit and is driven by a 2-hp induction motor which is powered by the No. 1 460-volt station service bus. It can be used for initially filling the primary system and to supply the vapor container spray system. In normal plant operation the pump is inoperative and a valve in its discharge line is kept closed.

Control System (Figures 2-7 and 2-12). Two CLOSE-TRIP multipole rotary control switches are provided on the main control board for the operation of the make-up pumps. Each control switch will spring return after activation to a normal, central position. Red and green pilot lamps near each control switch indicate that the applicable make-up pump is operative or inoperative. Blue indicating lamps are also provided, one for each switch. An illuminated blue lamp near an inoperative or standby pump control switch indicates that automatic switchover to the standby pump can be accomplished. If this same lamp is out, it signifies that switchover cannot be accomplished. A pressure switch, sensitive to low pressure in the pumps' discharge line, interlocks both pumps. If low pressure is detected, the switch will automatically start the standby pump. Once started, the standby pump will continue to run until it is manually tripped. RUN-SAFE STOP selector switches are provided at each pump motor. These switches are normally left in the RUN position. Although the selector switch on a standby pump may be in the RUN position, the pump will not start unless either the control switch or pressure switch is actuated. The SAFE-STOP position will prevent the pump from being started when maintenance or repair are to be accomplished. A TEST selector switch is also located at each pump motor and provides a means of testing the operation of the pump without putting the control room switch in the close position.

A RUN-STOP pushbutton station is provided for the operation of the fill pump.

Make-Up System Operation (Figures 2-7, 2-11, and 2-12)

Valve Positions for Primary Make-Up Pump.

Valves to be open:
- PC-10 on discharge side of pump 8A
- PC-11 on discharge side of pump 8B
- PS-6 on pressure switch between the two pumps on discharge line
- PC-14 inlet supply line to primary coolant system

Valves to be closed:
- PC-9 discharge from primary coolant fill pump

Line-Up Intake.

Valves to be open:
- PC-1 outlet from primary coolant make-up tank
- PC-5 suction to pump 8A
- PC-6 suction to pump 8B

Valves to be closed:
- PC-2 primary coolant make-up tank drain valve
- PC-4 chemical feedline (connections to be opened when needed)
- PC-12 and PC-60 future connection valves

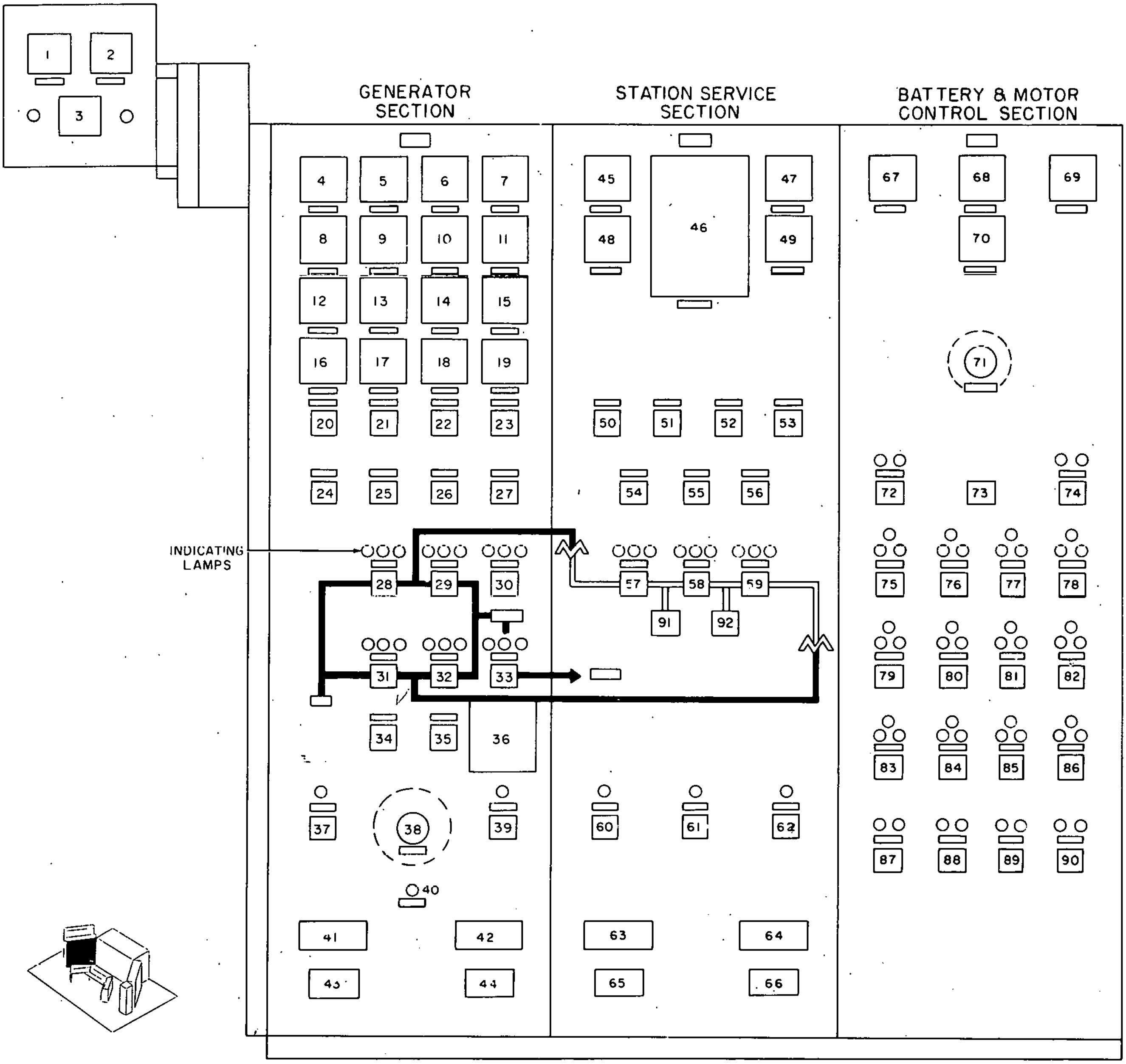


Figure 2-12. Electrical Section Control Panel

Startup.

1. Position valves as shown in figure 2-11, but close valve H-1 or H-2 so that only one gas cylinder is in use.

2. Check pressure at hydrogen gas cylinders.

3. Check compressed air supply to the level control. It should be between 60 and 100 psi.

4. Check to see that the selector switches at both make-up pumps P-8A and P-8B are in the RUN position. Blue indicator lamps on the control panel should light.

5. Close one pump control switch at the main control panel to start a make-up pump. Do not exceed 50 psig system pressure until 1/2 hour after temperature reaches 200° F.

Normal Operation.

1. Periodically check pressure of gas cylinder in use. When pressure drops to 45 psi, switch over to unused cylinder and replace the expended one. The hydrogen pressure in the line to the primary coolant make-up tank should be maintained at 19-20 psig.

2. To introduce hydrazine into the make-up system, open valve PC-4 and start the hydrazine chemical feed system. Refer to SECONDARY SYSTEM, Chemical Feed Systems.

3. Switchover of make-up pumps P-8A and P-8B can be accomplished at any time at the main control panel. Failure of the operative pump will cause an automatic switchover.

Shutdown. To shut down the make-up system, TRIP and lock out the control switches of both make-up pumps. Close valves PC-14, PC-10, and PC-11.

Spent Fuel Pit

A concrete pit, lined with 18-gage stainless steel and filled with water, is located outside the west side of the vapor container to receive and store spent reactor fuel elements. The pit is 23 feet 6 inches deep, 11 feet long, and 9 feet wide. See figure 2-13.

On the floor of the pit, 80 stainless steel pipes, 3 feet high and of 5-inch nominal diameter, are placed vertically in rows to store the fuel elements. Each pipe is capable of holding one element. The pipes are plated with cadmium which absorbs neutrons emitted by the fuel. Four 1/2-inch-diameter holes near the bottom of each pipe permit thermal circulation of water around the fuel element inside the pipe.

The water in the pit shields the surroundings from the residual radiation of the spent fuel. The normal water level is 19 feet 6 inches above the top of the fuel storage pipes, or more than twice the minimum of 9 feet 6 inches necessary to reduce the dose rate to tolerance. The water level in the pit is maintained at the same height as the water in the primary shield tank to prevent flow of primary shield water into the pit when the chute is unsealed at fuel transfer.

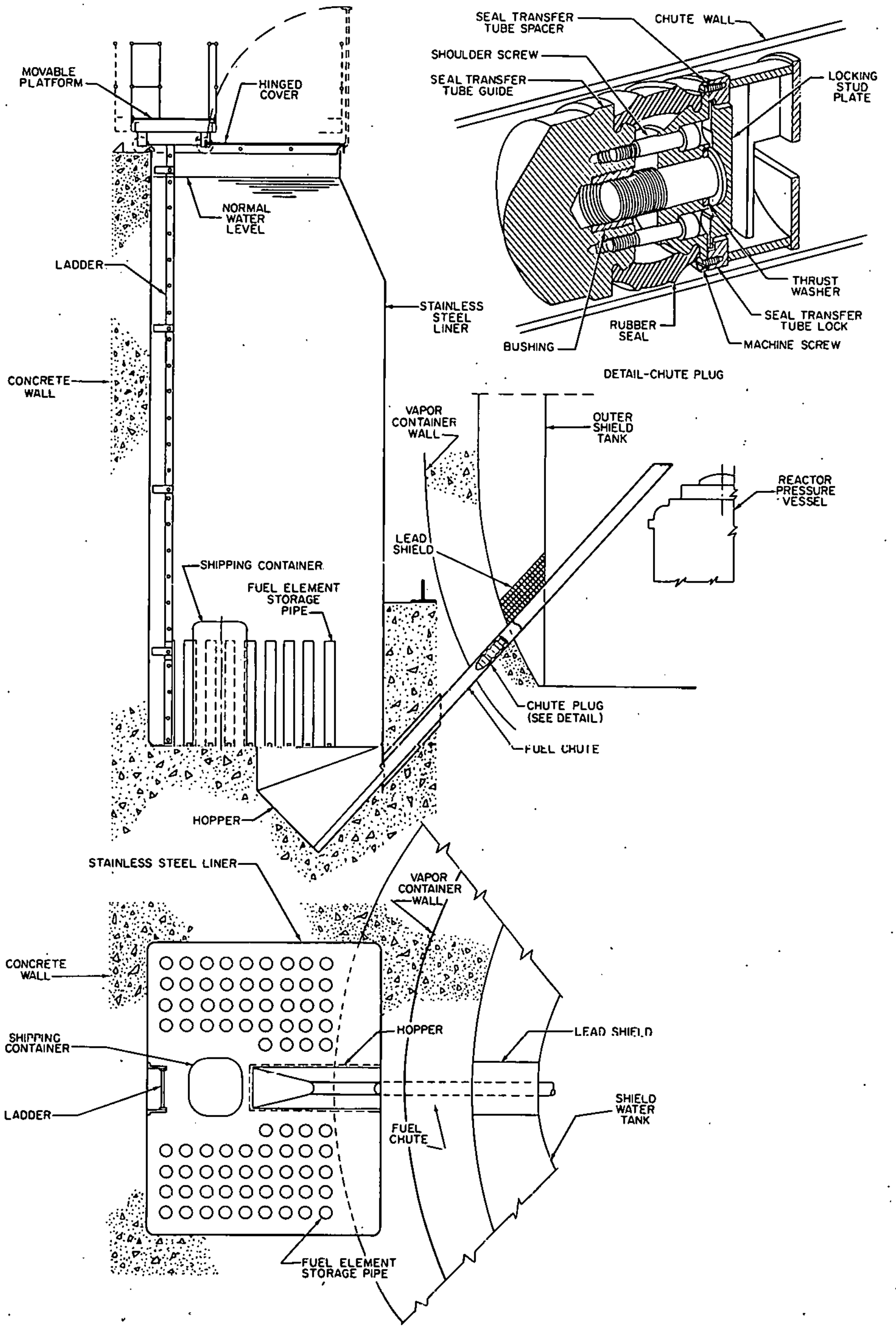


Figure 2-13. Spent Fuel Pit

A 6-5/8-inch outside diameter stainless steel pipe runs from inside the vapor container, near the top of the pressure vessel, through the vapor container wall, and into the bottom of the spent fuel pit. The pipe serves as a chute for the transfer of spent fuel elements from the reactor to the pit.

When not in use, the chute is sealed with a molded rubber compression element plug. The plug consists of two metal assemblies, the plug cone and the seal compressor, separated by the rubber seal. The lug on the plug cone is inserted in the lug slot of the chute wall and prevents axial motion of the cone. The lug lock on the seal compressor plate positions the compressor and through the compressor stop positions the plug cone to engage the lug and seat the cone on the cone rest. As the shaft is turned in the direction marked SEAL in figure 2-13, the shaft thread advances into the plug cone until the compressor stop prevents further motion. The shaft disc carries the seal compressor toward the cone, compressing the seal and causing it to expand to seal the chute. Unsealing and removal of the plug is accomplished in the reverse manner. The plug is located outside the vapor container wall to ensure pressure integrity of the container in the event a rupture of the chute occurs inside the container.

The chute penetration of the container wall is backed up by a lead shield ring, 9 inches thick, to prevent radiation streaming past the chute.

The chute enters a sloped hopper at the bottom of the spent fuel pit which receives each fuel element as it is lowered through the chute.

A movable platform rolls along tracks on two sides of the top of the pit to facilitate placing of fuel elements in the rows of storage pipes. A hinged aluminum cover closes the top of the pit and prevents rain from producing an overflow of the water in the pit. An aluminum ladder leads to the bottom of the pit for cleaning and maintenance. A lead-shielded shipping container may be lowered to the bottom of the pit for removal of fuel elements.

A pump and suitable piping (figure 2-14) is provided to fill the pit and to recirculate the water for cooling, filtering, or demineralization. The pump is a centrifugal type driven by a 1-hp, 3-phase induction motor powered from the 460-volt station service bus No. 1. A RUN-STOP pushbutton controls the motor, which is protected from overload by an air circuit breaker. A high-pressure safety shutoff switch, located just upstream of the pump, cuts out the pump motor at 50 psig to protect the system from overpressure. A bourdon tube gauge gives local indication of pressure at the discharge of the pump.

A flexible suction tube with foot valve and strainer may be inserted into the pit to withdraw water for recirculation or renewal. A three-way and a four-way plug valve permits the following circulation: flow from the pit through a filter and back to the pit; flow through temporary connections to the demineralizer and back to the pit; flow to the station waste line, simultaneously allowing distilled water to be drawn into the pit to maintain the proper level; or flow from the pit, through the cooling system, and back to the pit.

A float-actuated mercury switch, situated near the top of the pit, closes if the water level rises to within 12 inches of the top of the pit and sounds an alarm. A radiation monitor is located above the water and is sensitive to gamma radiation. The dose rate level is recorded at the control panel and an alarm is sounded if the radiation level rises to 7.5 mr/hr.

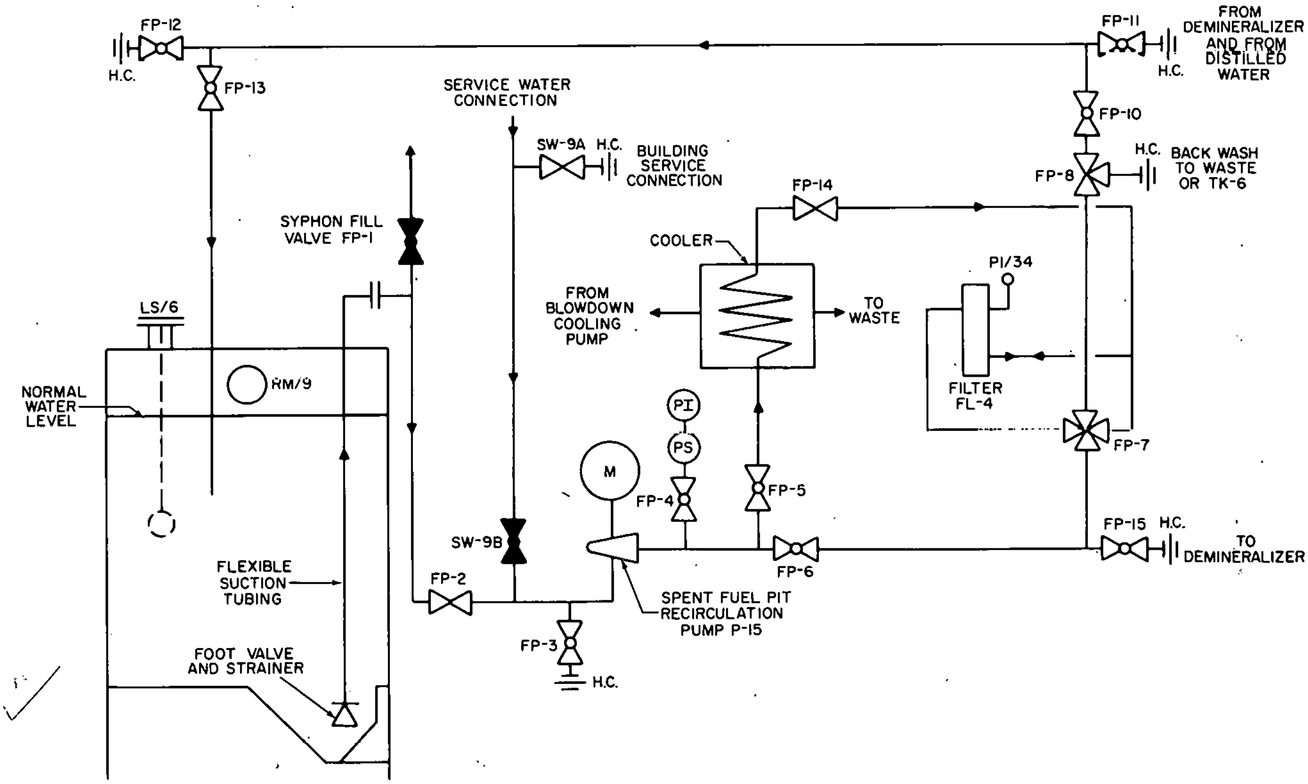


Figure 2-14. Spent Fuel Pit Recirculation System, Schematic Flow Diagram

Spent Fuel Pit Operation (Figure 2-14)

Procedures for operating the spent fuel pit recirculation system are listed below. Fuel handling procedures are described in Section 7, Fuel Handling.

Initial Filling. Perform the following operations prior to start of the first fuel disposal:

1. Make hose connection from distilled water tank to valve FP-11.
2. Open distilled water inlet line valves to fuel pit fill line.
3. Close valves FP-12 and FP-10.
4. Open valves FP-11 and FP-13.
5. Fill pit until normal water level is reached, then close valve FP-11.
6. Close distilled water inlet line valves.
7. Remove hose connection.

Filtration. Perform the following operations periodically after initially filling pit:

1. Set four-way valve FP-7 in ccw position.
2. Set three-way filter backwash valve FP-8 in cw position.
3. Close valves FP-12, FP-10, FP-15, FP-11, FP-5, FP-14, FP-3, and SW-9A.
4. Open valves FP-10, FP-13, FP-6, FP-4, and FP-2.
5. Insert flexible suction tube into pit.
6. Open valve SW-9B. Open valve FP-1 momentarily until flow occurs through syphon line. Then close valves FP-1 and SW-9B, in that order.
7. Depress spent fuel pit recirculation pump motor RUN pushbutton and partially fill filter unit and stop motor.
8. Add 1 liter of diatomite and install tube assembly.
9. Start pump again and run water to waste until completely clear.
10. Put valve FP-8 in ccw position and circulate water through filter until water in pit is clear. Then depress recirculation pump STOP button.
11. Put valve FP-8 in the cw position and valve FP-7 in the cw position. Start pump and flush filter to waste using approximately 60 gallons of water. Stop pump.
12. Withdraw flexible suction tube from pit.

13. If necessary, perform steps 1 through 7 of Initial Filling, above, to bring the water in pit up to normal level.

Replacement of Lost Water. Perform steps 1 through 6 of Initial Filling, above.

Cooling of Water. Perform the following operations to cool the spent fuel pit water when the water temperature exceeds 100°F:

1. Close valves FP-12, FP-11, FP-15, FP-3, and FP-6.

2. Open valves FP-10, FP-13, FP-14, FP-5, and FP-2.

3. Set four-way valve FP-7 in ccw position.

4. Set three-way filter backwash valve FP-8 in cw position.

5. Insert flexible suction tube into pit.

6. Open valve SW-9B. Then open valve FP-1 momentarily until flow occurs through syphon line. Then close valves FP-1 and SW-9B, in that order.

7. Depress recirculation pump motor RUN pushbutton.

8. Circulate water through cooler until spent fuel pit water temperature drops to 100°F.

9. Depress recirculation pump motor STOP pushbutton.

10. Close valves FP-10, FP-14, FP-5, and FP-2.

11. Withdraw flexible suction tube from pit.

Loss of Shielding Water. The water level in the tank must be maintained to provide adequate shielding from spent fuel radiation. If the primary shield cooling coils lose their cooling water supply, primary shield water would be lost due to boiling and the level in the primary shield tank would drop below the level in the spent fuel pit. Under these circumstances, if the fuel chute were opened, water would flow from the spent fuel pit through the fuel chute into the primary shield tank. In addition, evaporation from the surface of the water in the pit will gradually lower the level. As the water level in the pit drops, the dose rate above its surface will approach tolerance. The radiation monitor will sound an alarm at a dose rate of 7.5 mr/hr or above to warn plant personnel. Lost water must be made up by adding distilled water to the pit.

Contaminated Waste System

Description (Figure 1-4). The contaminated waste system is essentially comprised of a hot waste storage tank, tank discharge pumps, and associated indicators. These items are described below; for a general system description, refer to Section 1, Waste Disposal System.

The hot waste tank is situated underground and shielded with concrete. The tank receives primary blowdown, primary blowdown coolant, steam generator blowdown, or demineralizer room trench drain if they are too radioactive to be handled normally. The tank is cylindrical in shape and has ellipsoidal heads. It is constructed of stainless steel, and is 7 feet in outside diameter, 18 feet long, and has a wall thickness of 3/8 inch. The capacity of the tank is 5000 gallons. The tank is fitted with underground pipe connections which provide for delivery of contaminated waste, venting gases to the stack, discharging the tank, feeding caustic soda to the tank, and pressure, temperature, and level indicator attachment. A pipe from the tank to the ground surface permits the removal of dip samples for analysis. Fittings for two spare connections are installed.

Two tank discharge pumps are connected in series. One of the pumps is installed inside the tank and discharges to the suction of the second pump which is located outside of the tank. They are centrifugal-type units. The pumps are driven by 1/2-hp, 3-phase induction motors powered from the 460-volt station service bus No. 1.

A Bourdon tube pressure gauge, PI-28, is provided at the tank. The gauge dial is calibrated to read from 0 to 60 psig.

The tank is equipped with a float-actuated, bellows-operated dial indicator. It is calibrated to read 0 to 7 feet and actuates an alarm at the control room when the level rises to 5 feet.

A constant volume, Bourdon tube temperature indicator is connected to the tank. It is calibrated to read 0 to 400°F.

Two 275-gallon underground tanks are provided for the collection of contaminated laboratory waste. Each tank is provided with remote level indicators calibrated to read from 0 to 47 inches. The drain lines from the hot sink in the laboratory and the sample drain in the demineralizer room run to the laboratory waste tanks. The washing machine discharge may be directed to the seal pit or to the laboratory waste tanks, as desired. One tank is used at a time, leaving the other tank on standby or holding contaminated water while the radioactivity decays to a point that the water may safely be discharged to the seal pit.

A water ejector is provided to transfer the water from the laboratory waste tanks to the seal pit. Health physics personnel must sample this water and determine that it may safely be discharged before the tanks may be emptied.

The levels of the laboratory waste tanks and the hot waste tanks should be checked hourly to determine rate of waste collection.

Refer to Sample Removal and Discharge of Waste Tanks, below, for further information on this system.

Refer to Section 6 for tank level conversion tables.

Controls (Figures 2-4 and 2-7). A remotely controlled pneumatic control valve located in the hot waste tank vent enables the operator to close the vent if the stack radiation monitor indicates excessive airborne radioactivity is being released. The HOT WASTE TANK VENT station on the graphic section of the control panel is provided for the operation of the vent control valve. The station includes an ON-OFF switch. When the switch is turned to the OFF position, the supply of air pressure to the vent control valve is interrupted, permitting it to close by spring action. Return of the switch to the ON position restores the air supply and opens the valve. Signal lights indicating the valve's position are located on the control console. A red signal lights when the valve is closed and a white signal lights when the valve is open.

A RUN-STOP pushbutton is provided for control of the hot waste tank discharge pump motors. The motors are protected from overload by relays and from overcurrent by an air circuit breaker.

The diversion of radioactive primary blowdown or blowdown coolant to the hot waste tank is controlled by pneumatically operated, radiation-monitor-actuated control valves which are described in Section 2, Blowdown System.

Refer to Handling Vent Gases, below, for further information on this system.

Contaminated Waste System Operation (Figures 2-5 and 2-10)

Handling Primary Coolant Blowdown. Diversion of radioactive primary coolant blowdown to the hot waste tank is automatic if its radioactivity rises to 10 uc/cc. In case the automatic devices fail to operate under these conditions, the operator should close the motor-operated blowdown valve immediately to prevent the spread of radioactive waste.

Handling Blowdown Coolant. Diversion of blowdown coolant to the hot waste tank is automatic if its radiation level exceeds the background level by a detectable amount. In case the automatic devices fail to operate under these conditions, the operator should close the cooling water outlet valve (SC-10) nearest the vapor container wall immediately after stopping primary blowdown by closing the motor-operated blowdown valve.

Handling Steam Generator Blowdown. If the radiation monitor for this fluid indicates a level of 0.05 mr/hr or higher, a sample of the blowdown should be taken and analyzed in the laboratory. If the radioactivity of the sample exceeds 4×10^{-4} uc/cc beta-gamma, the operator should divert the blowdown to the hot waste tank by opening the steam generator blowdown diversion valve (BD-12) and closing the blowdown valve (BD-10) leading to the blow-off tank, and open blowdown valve (BD-14) inlet to hot waste tank. The dilution in the seal pit will reduce the total effluent activity to permissible levels.

Handling Demineralizer Room Trench Drain. The demineralizer room trench drain line valves will be normally closed. This will cause all spilled water to collect in the trench. This water will be drained to the hot waste tank by opening valve W-4 in the drain line. If a sample shows that this water is not contaminated, it may be discharged to the seal pit by opening valve W-3 in the drain line. These valves are to remain closed except when actually draining the trench to prevent airborne activity from entering the mineralizer room from the hot waste tank and to prevent radioactive water from entering the seal pit in the event of a spill.

Handling Vent Gases. If the stack effluent radiation monitor indicates a level of 2×10^{-9} uc/cc or greater, the operator should turn the manual loading station for the vent control valve to the OFF position to close the vent. After a suitable period, the vent valve may be opened to determine if the amount of airborne activity has decayed to within safe limits. Health physics personnel will determine the safe waiting period.

Caustic Soda Feed. Caustic soda may be fed to the tank, from the chemical feed system, at the direction of water treatment personnel. Caustic soda feed will counteract the corrosive effects of waste held in the tank.

Sampling Procedures.

1. Laboratory Waste Tanks (Tks 10A and 10B).

   a. These tanks will be sampled at a 40-inch level indication. The inlet to the tank in use will be closed and the inlet to the empty tank opened.

   b. Sampling of the desired tank will be accomplished by removing the cover plate on the sample standpipe, inserting a length of tubing into the standpipe, and withdrawing the desired sample. This is required instead of the "dip" sample because of the physical characteristics of the standpipe. In order to withdraw the sample, an aspirator and a 1-liter flask are required. The aspirator is adjusted so that suction will draw a representative sample through the tubing and into the liter flask. This flask is stoppered and carried to the laboratory in a plastic container to minimize the possibility of breakage or spillage.

   c. From the liter flask, a 10-milli-liter (ml) aliquot is taken. On the basis of the sample results, the full tank is discharged to the station waste line at a rate consistent with the determined concentration such that the concentration upon leaving the seal pit is below maximum permissible discharge level.

2. Hot Waste Tank (Tk 6).

   a. This tank will be sampled for dumping at a 1-foot level indication. The hot waste tank must be left open; i.e., the tank must be available for emergency diversion if need be during sampling. Resampling will be necessary at time of dumping to determine activity discharged.

   b. Sampling of the hot waste tank will be performed in the same manner as the laboratory waste tanks. The same aliquot (10 ml) will be taken for the final sample results.

   c. Because of possible cross-contamination, sampling equipment used for sampling the laboratory waste tanks and the hot waste tank will not be interchanged.

Discharge of Waste from Tank. The laboratory waste tanks are emptied in the following manner, on approval of the health physicist:

1. Open valve W-6 (W-8) and ejector discharge (W-16).

2. Close valve W-7 (W-9).

3. Open ejector inlet water valve (SC-34).

4. When the tank is emptied close valve W-6 (W-8) and ejector discharge (W-16) and water supply (SC-34) valves.

5. Open valve W-7 (W-7) if the tank is to be returned to service.

Note

Only one tank is to be in service and the other is to be in standby or holding waste while the activity decays.

Waste is discharged from the hot waste tank in the following manner:

1. Valves PC-43, PC-44, and PC-45 will be normally closed.
2. Connect a hose from PC-44 to PC-45.
3. Open valves PC-44, PC-45. (CV-1 and W-1 will be normally open.)
4. Start pumps P-14A and P-14B.
5. When tank level indicator shows 0.5 ft, shut off pumps P-14A and P-14B.
6. Close valves PC-44 and PC-45.
7. Remove hose.

Waste may be circulated through the demineralizer for decontamination in the following manner:

1. Connect a hose from valve PC-45 to valve PC-27 (PC-28).
2. Connect a hose from valve W-2 to valve PC-41 (PC-42).
3. Open valves PC-45, PC-27 (PC-28), PC-41 (PC-42), W-2.
4. Valves PC-24 (PC-25) and PC-29 (PC-30) will be closed and the other demineralizer in normal service.
5. Start pumps P-14A and P-14B.
6. When recirculation is completed, stop pumps and close valves PC-45, PC-27 (PC-28), PC-41 (PC-42), and W-2.
7. Remove hoses.

Sump Evacuation. A pipe from the demineralizer room extends to the sump of the vapor container. A hose is installed in this pipe and connected to a sump pump in the pit. A second hose is connected to this hose discharge valve and run to the demineralizer floor drain. The discharge valve is opened and the sump pump operated to remove the water. This water must be sampled prior to pumping and, if contaminated, dumped to the hot waste tank.

CAUTION

This operation must be undertaken only when the reactor is down.

Steam Generator

The steam generator is a shell and tube heat exchanger and is located inside the vapor container. Primary coolant from the reactor is circulated through its tubes to heat secondary system water in its shell to produce and superheat steam for the secondary system. For a complete description of the steam generator, refer to SECONDARY SYSTEM, Steam Generator.

Trip Valves

All vapor container outgoing pipes are fitted with pneumatically operated trip valves which provide seal protection in the event of damage to piping in the container. Closing by spring action, they are held in the open position for normal plant operation by an air supply of 60 to 100 psi. A pressure rise of 5 psi in the vapor container opens the pressure switch relay-actuated contacts, interrupting current through the solenoid valve coil in each trip valve air supply line. This loss of current opens the solenoid valves, interrupting the air pressure at each valve, which then closes by spring action. Any trip valve may subsequently be opened by depressing a pushbutton which energizes the coil of the solenoid valve, restoring air supply to the trip valve when the pressure drops below 5 psig. The trip valve trip and reset circuit is powered from the emergency DC system to ensure continuous operation in the event of power failure.

An integral switch at each valve lights two amber signals at the control panel and one red signal at the trip valve control cubicle when the valve opens. The air supply to each valve is regulated to maintain constant pressure.

The closing time for TV-PCV-1 and -2 is 12 seconds each.

Trip valves in the condensate recirculation system and in the steam dump system are supplied with air from a reserve tank which is designed to keep them open for approximately 30 minutes after loss of station service air.

SECONDARY SYSTEM

Steam Generator

Description (Figure 2-15). The steam generator, which links the primary and secondary systems, is located inside the vapor container. It is essentially a shell and tube heat exchanger, receiving primary coolant from the reactor. The primary coolant circulates through the tubes to produce and superheat steam in the shell for the secondary system.

The shell is a vertical steel cylinder, 45-5/8 inches in diameter and 13/16 inch thick, internally clad with 1/8-inch stainless steel. It is closed at the top by an ellipsoidal head with a 16-inch diameter weld cap, A channel, welded to the bottom of the cylinder, provides primary coolant inlet and outlet connections and support for the tube sheet. The channel is closed with a 43-inch-diameter cover, 6-7/8 inches thick, bolted in place with 26 2-1/4-inch alloy steel studs. The joint is sealed with a stainless steel ring gasket. The overall height of the steam generator is 16 feet 7-5/8 inches. The entire unit, as well as its inlet and outlet pipes, is covered with four inches of thermal insulation. A large support ring is welded to the shell to support the unit.

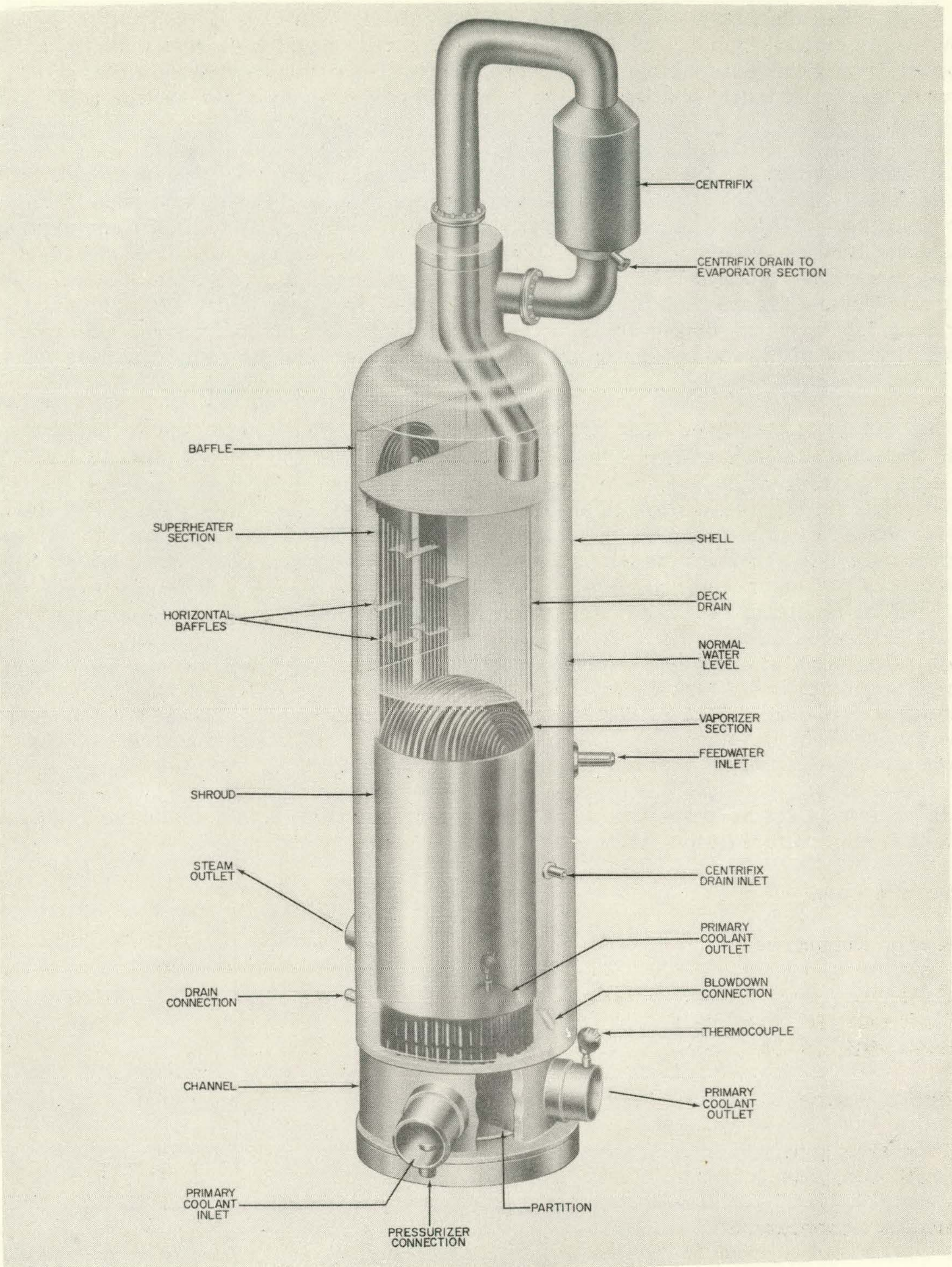


Figure 2-15. Steam Generator

The channel is divided by a 1/2-inch stainless steel partition which directs primary coolant to the tube inlets and prevents mixing of inlet coolant (450°F) with outlet coolant (431.6°F). A 1/4-inch stainless steel baffle divides the shell into two parts, a vaporizer section and a superheater section.

The stainless steel tubes, 3/4 inch in outside diameter and with a wall thickness of 0.065 inch, are arranged on a 1-inch triangular pitch in the vaporizer and in the superheater sections. The tubes are U-shaped to provide double-pass heat exchange and simplified construction to allow for tube expansion. There are 326 U-tubes in the vaporizer section and 44 U-tubes in the superheater section. The array of tubes is surrounded by a stainless steel cylindrical shroud 10 feet 2 inches high in the superheat region and 4 feet 10 inches high in the vaporizer section. In the vaporizer section, the shroud increases natural convection circulation of water by separating the hot leg from the cold leg of the unit. Horizontal baffles direct the flow through the tube bundle.

Feedwater enters the shell through a 2-1/2-inch pipe connection in the side of the generator, mixes with the fluid around the shroud, and flows down and under the shroud into the vaporizer section. Heat transferred through the tube walls from the primary coolant vaporizes the feedwater. The vapor flows upward through an external centrifugal moisture separator. A dip tube returns the separated moisture to the vaporizer section. The steam flows through the moisture separator and down through the superheater section of the steam generator. Substantially dry steam enters the superheater section. The superheated steam flows under the superheater shroud and out of the steam generator through an 8-inch pipe outlet.

A 2-inch pipe outlet discharges blowdown from the bottom of the shell through a cooler to the steam generator blow-off tank in order to reduce the impurity content of the secondary fluid. An ejector, operated on river water from blowdown cooling water pumps, is connected across the blowdown line to enable the operator to drain the shell at shutdown. A radiation monitor and a conductivity cell continuously monitor the blowdown.

A 1-inch drain connection at the bottom of the superheater section is provided to remove the condensate that may collect in this section.

Performance Data.

Operating pressures

Tube side, psia	1200
Shell side, full load, psia	200
Shell side, no load, psia	422

Design pressure

Tube side, psia	1500
Shell side, psia	500

Operating temperatures

Primary coolant inlet, full load, °F	450.0
Primary coolant outlet, full load, °F	431.6

Operating temperatures (cont)

Feedwater inlet, °F	246.1
Steam outlet, full load, °F	407.0
Steam outlet, no load, °F	450.0

Design temperatures

Tube side, °F	650.0
Shell side, °F	650.0

Operating flow rates

Steam outlet, full load, lb/hr	34,070.0
Feedwater inlet, full load, lb/hr	34,270.0
Feedwater inlet, full load, gpm	72.4
Blowdown, full load, lb/hr	200.0
Blowdown, full load, gpm	0.42
Heat transferred, full load, BTU/hr	34.1×10^6

Controls and Instrumentation (Figures 2-7 and 2-16). A pneumatically operated throttling valve is placed in the steam generator blowdown line to regulate the rate at which secondary fluid is blown down. A manual station at the control panel enables the operator to vary the air pressure supplied to the valve and thereby control the blowdown rate. The air pressure acts against a spring to close the valve. Thus, in the event of air supply failure, the valve will open by spring action and blowdown will be maintained. The blowdown flow rate, in gpm, is indicated locally and at the manual station. A portion of the steam generator blowdown is cooled and passed through a radiation monitor and a conductivity cell to waste. The conductivity of the blowdown is recorded at the control panel as a measure of impurity content. A radiation monitor gives continuous local indication of the blowdown gamma level. If this level becomes too high, the blowdown should be diverted to the hot waste tank by the operator.

A motor-operated shut-off valve is located in the steam outlet line. A pushbutton is provided on the control console to close this valve. Local pushbuttons are provided to open and to close this valve.

An automatic control system correlates feedwater flow rate, steam flow rate, and steam generator water level to actuate a feedwater flow control valve in order to maintain the proper water level in the steam generator.

A safety valve (SV/5) in the steam outlet line is set to open at a steam pressure of 500 psig to protect the system from overpressure.

Trip valves are placed in the steam dump line (TV/9), the main steam line (TV/PCV/1-1, TV/PCV/1-2), the drain line (TV/2), and the blowdown line (TV/5) to seal the vapor container in the event of internal pipe damage. Refer to PRIMARY SYSTEM, Trip Valves.

In addition to those measurements previously mentioned, the following quantities related to steam generator operation are recorded at the control panel:

1. Outlet steam pressure, psig
2. Outlet steam temperature, °F
3. Outlet steam flow rate, lb/hr
4. Primary coolant inlet temperature, °F
5. Primary coolant outlet temperature, °F
6. Steam generator shell water level, ± in. H_2O
7. Feedwater flow rate, lb/hr
8. Feedwater temperature, °F

Local indication of the outlet steam pressure and temperature is also given.

An alarm will sound to inform the operator of abnormalities in steam generator operation under the following circumstances:

1. Blowdown conductivity is greater than 10 micromho.
2. Blowdown gamma level is greater than 7.5 mr/hr.
3. Water level is more than 4 inches lower than normal.
4. Water level is more than 4 inches higher than normal.
5. Outlet steam pressure is greater than 435 psig.
6. Outlet steam temperature is greater than 445°F.

Any of these alarms will continue until the operator depresses an acknowledge button on the control console. In each case, a red signal light will remain on until the trouble is corrected, at which time a white signal light will go on again to signify normal operation. The signal lights are located on the control console.

The reactor will automatically be scrammed if the outlet steam pressure is above 455 psig, or if the outlet steam temperature is above 460°F.

Steam Generator Operation (Figures 2-7 and 2-16)

CAUTION

The water in the steam generator shell must be at a normal level before the reactor is brought up to power. Failure to observe this precaution will cause serious damage to the steam generator tubing.

Startup.

1. Check that all steam generator recorders and controllers are receiving power and functioning properly.

2. Check that air supply pressure reading at control console is between 60 and 100 psi.

3. Check that condensate cooling system is operating.

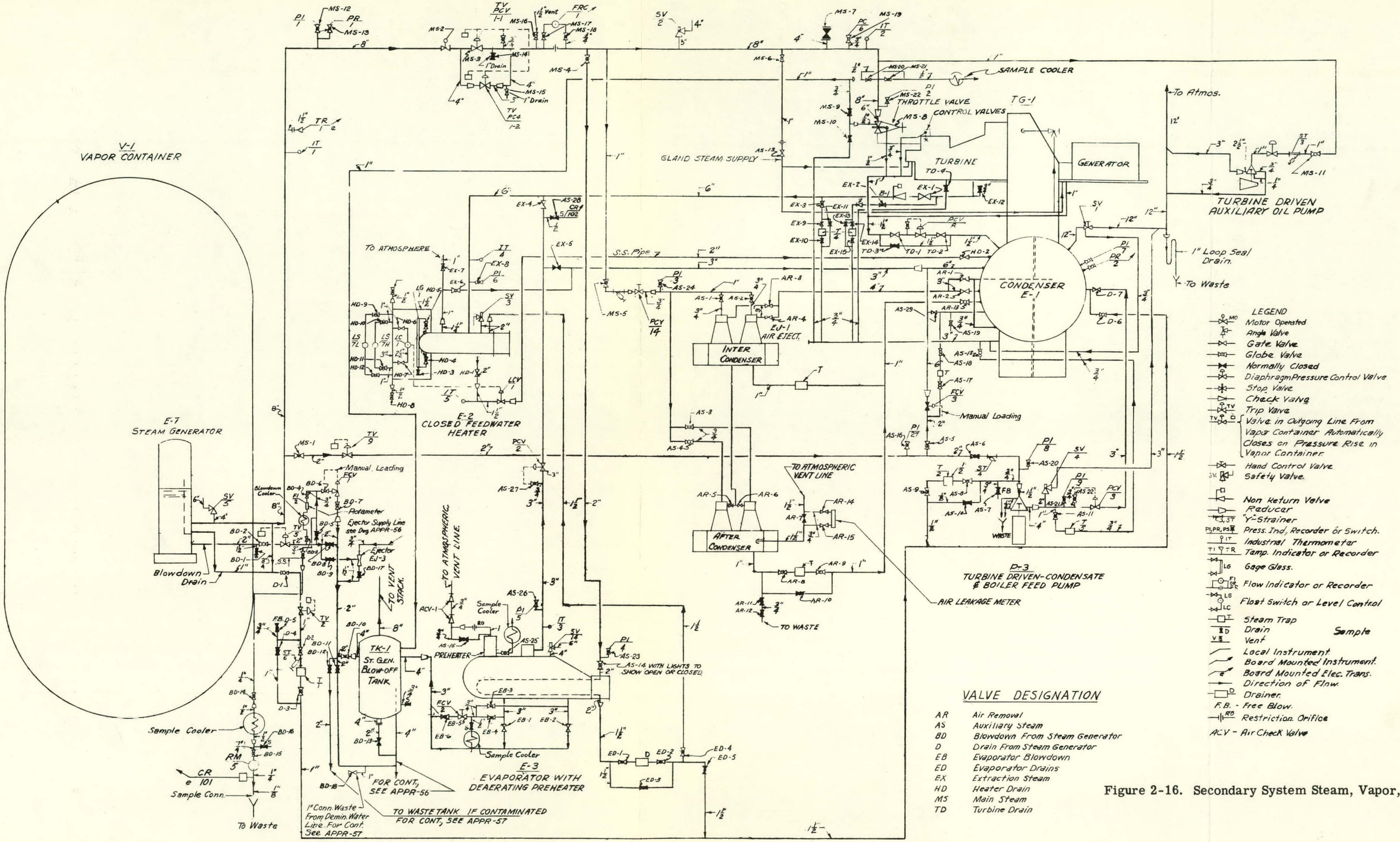


Figure 2-16. Secondary System Steam, Vapor, and Drain Lines, Schematic Flow Diagram

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4. Check that condenser hot well level is normal. Check circulating water supply to condenser. Check that distilled water tank level is adequate.

5. Check that boiler feed system is in operation (on manual control).

6. Bring steam generator level to normal value of -2 inches reading on recorder and check that initial chemical charge has been introduced.

7. Check that steam outlet motor-operated shut-off valve is completely open and that valves D-4 and FCV-3 are closed. Crack drain valves on steam header until the turbine is on the line.

8. Bring reactor up to power. Refer to Section 4 for procedures.

9. Chemical feed system may be started when steam is drawn from the steam generator.

10. Start blowdown system when steam generator begins to deliver steam.

11. Put steam generator level control valve (LCV/4) into normal operation, and check action.

Normal Operation.

1. Periodically check blowdown conductivity. Adjust blowdown rate, if necessary.

2. Periodically check all recorder readings.

Shutdown.

1. When turbine is shut down, open steam dump flow control valve (FCV/3) to bypass steam to condenser to cool the system.

2. When feedwater flow rate approaches 0, turn boiler feed pump selector switch to OFF position.

3. Close valve BF-24.

4. Close blowdown flow control valve (FCV/1). Normally the steam generator will remain full at shutdown. If it is desired to drain the system, proceed as follows:

   a. Open outlet valves (DL, D-4, D-5) in steam generator drain line.

   b. Open valves BD-9 and BD-17.

   c. Open blowdown cooling water supply valve to ejector.

   d. When steam generator blowdown line clears, close ejector water supply valve.

   e. Close valves BD-9 and BD-17.

Steam Turbine

Description (Figure 2-17). Steam from the steam generator is expanded in an eight-stage turbine which is located in the turbine room. The turbine, in expanding the steam, converts the thermal energy to mechanical power to drive the plant generator.

Steam leaves the steam generator, passes through a pneumatically operated pressure control valve, and is admitted to the turbine through a manually controlled, hydraulically operated throttle valve. The steam passes through the governor throttles, expands through the turbine nozzles, passes through eight impulse stages, and is exhausted to the condenser. Steam for the feedwater heater is bled off after the third stage of the turbine.

The turbine is equipped with an oil system to provide hydraulic oil for speed control and load limit, for the turbine throttle valve, and to provide lubricating oil for the turbine bearings and governor. Oil is circulated by two of four oil pumps. When the turbine is at or near rated speed, a pump, driven by reduction gearing on the turbine shaft, operates the oil system with the aid of a small pump driven off of the turbine shaft. Two auxiliary pumps, one motor driven and one turbine driven, serve as standby units. Also, one of these auxiliary pumps is used when starting or shutting down the turbine. A shell and tube heat exchanger cools the lubricating oil with condenser circulating water. Automatic devices within the system maintain the proper range of pressure for control purposes and switch over to a standby pump automatically when necessary.

Two pressure control valves in parallel in the main steam line leading to the turbine protect the system from excessive pressure. One of these operates over a low flow range for startup and shutdown; the other operates over a high flow range for routine operation. Both valves are of the air-to-open, spring-return type and also function as trip valves when actuated by vapor container pressure switches. (See PRIMARY SYSTEM, Trip Valves, above.) Each valve is equipped with an air pressure regulator to maintain constant pneumatic control pressure to the valve. Each is equipped with a range-setting positioner. A single pressure controller regulates both valves. As steam pressure downstream of the control valve varies, the controller acts to vary the air supply to the valves and adjusts the amount of throttling accordingly to maintain constant pressure.

The turbine throttle valve is used as a positive seating valve in the closed position to prevent steam from entering the turbine; it permits manually controlled throttling of the steam when starting the turbine and bringing it up to speed; it acts as a quick-closing device to shut off steam to the turbine when actuated by the turbine overspeed trip.

The turbine control system (figure 2-18) is composed of two main control elements: a double relay hydraulic speed control mechanism, and a load limiting and inlet pressure control system, both of which actuate a governing valve operating mechanism.

The speed control system functions to detect any change from set speed and to position the governing valves, through the governing valve operating mechanism, to increase or decrease the steam flow to the turbine nozzles to maintain the set speed. A flyweight speed governor, geared to the turbine shaft, adjusts a pilot valve which controls the hydraulic pressure to a primary operating cylinder in the governing valve operating mechanism. The primary operating cylinder piston adjusts a secondary pilot valve through connecting linkage, which controls the hydraulic oil pressure to a secondary operating cylinder. The secondary operating cylinder piston positions the governing

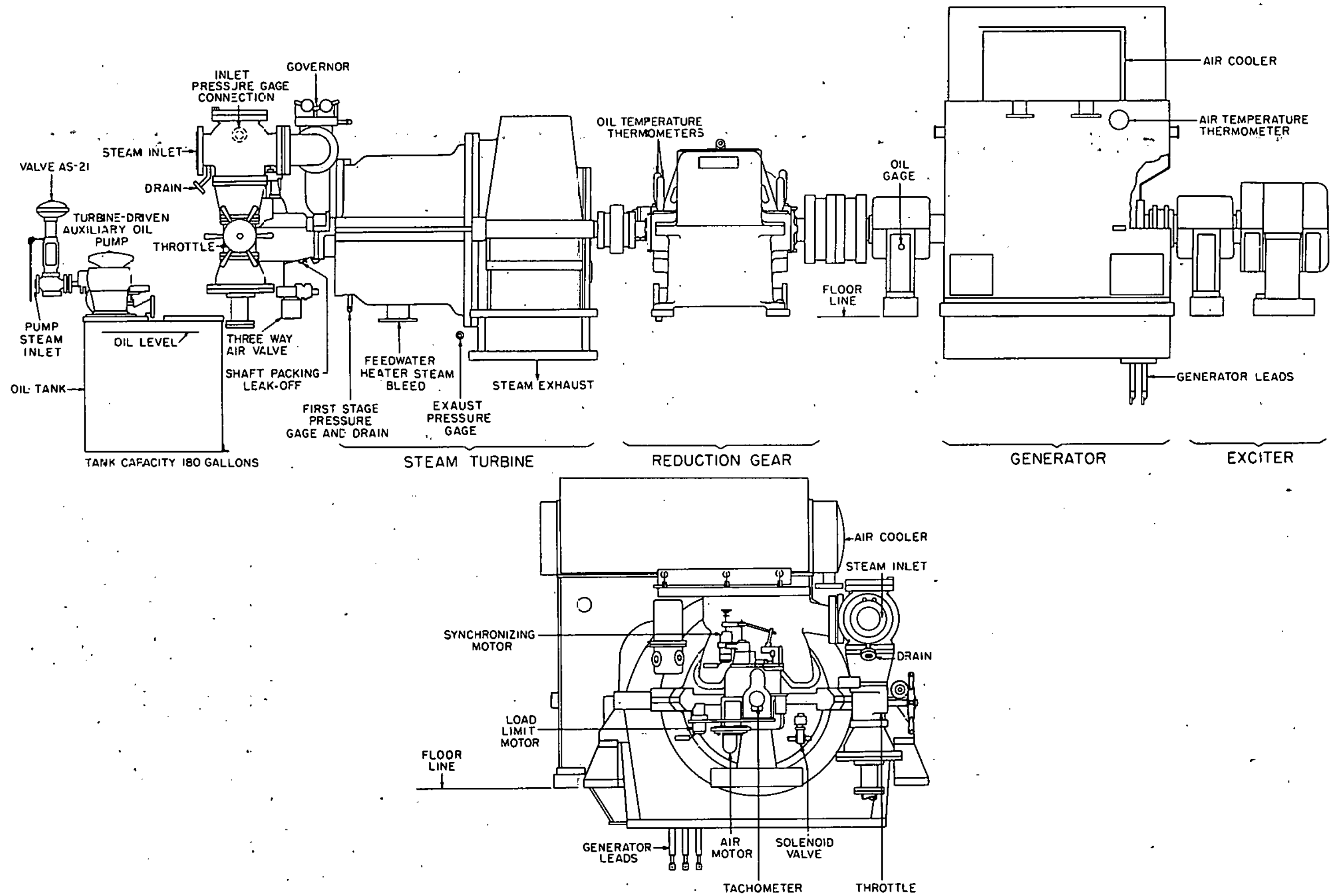

Figure 2-17. Steam Turbine

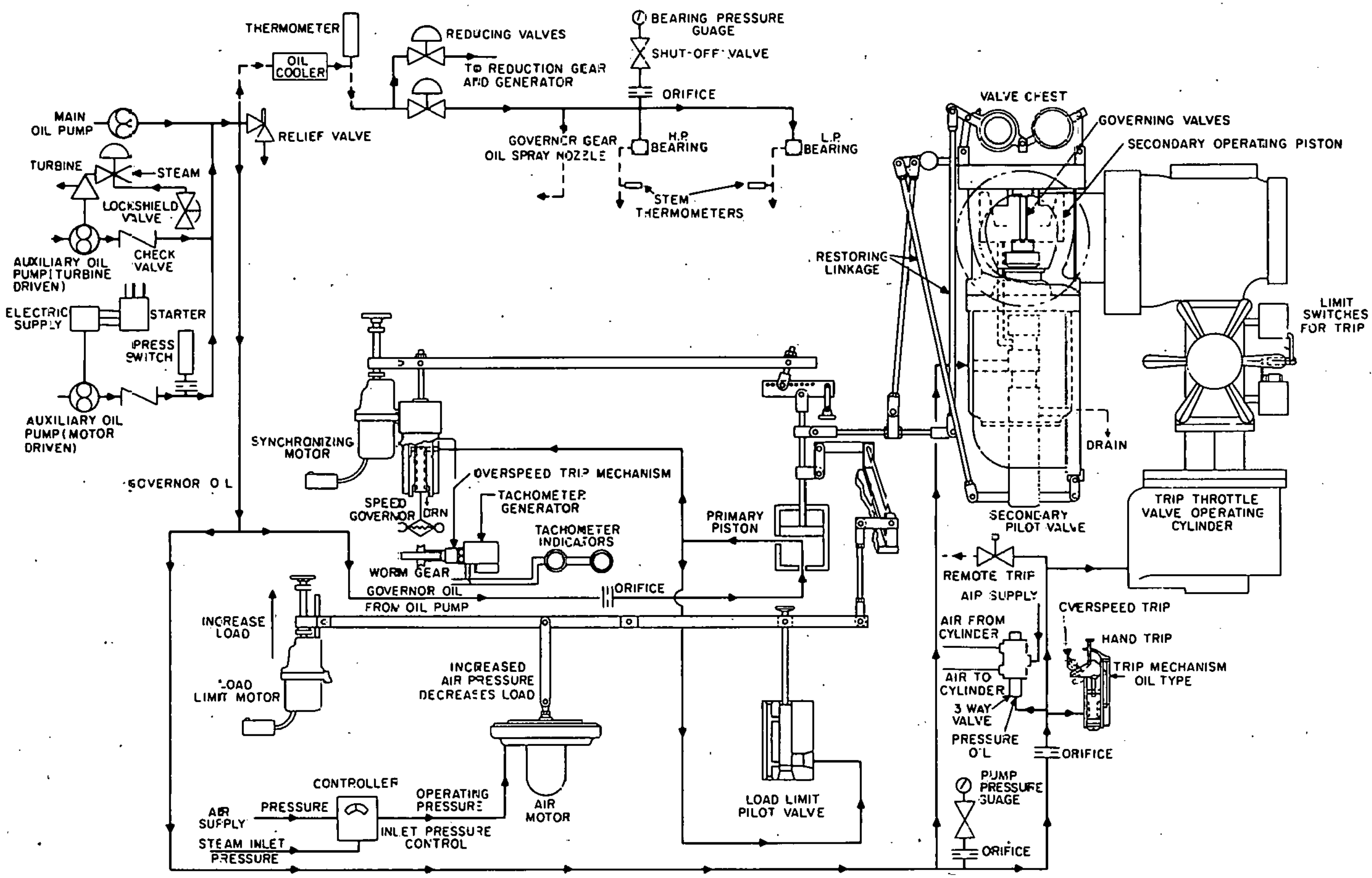

Figure 2-18. Steam Turbine Control System, Schematic Diagram

valves, through connecting linkage, to increase or decrease the steam flow into the turbine. Oil is supplied at constant pressure to the hydraulic system by the turbine oil system.

The speed of the turbine can be varied, within limits set by fixed high- and low-speed stops on the speed control mechanism. The speed control mechanism can be adjusted at the turbine with the speed changing hand nut or from the control room through the motor-operated speed changer.

The maximum load carried by the turbine can be set at any point within the load rating of the unit. The load limiting mechanism can be adjusted at the turbine with a hand nut or from the control room through the motor-operated load limiting device. With the speed control mechanism set at its high-speed stop, the positioner moves a load limit pilot valve, through connecting linkage, to control the pressure in the primary operating cylinder of the governing valve operating mechanism and thus position the governing valves to admit more or less steam to the turbine. This device will limit the maximum load carried by the turbine.

Inlet pressure control is obtained by means of an air motor which positions the load limit pilot valve to control oil pressure in the primary cylinder and thus adjust the governing valves. The air motor receives an air signal from a pneumatic controller which senses inlet steam pressure. When this pressure falls below the controller setting (145 psig), the air motor repositions the load limit pilot valve, through connecting linkage, to decrease the load.

In order to protect the turbine in the event of overspeed resulting from failure of the speed control system, an independently operated overspeed governor and emergency relay are provided for immediate and positive closing of the throttle valve to shut down the turbine. The relay is also adapted for use as a manual tripping device for shutting down the turbine. The relay incorporates a mechanical linkage which, when actuated by the overspeed governor, by the remote generator differential relay trip, by the ground overcurrent relay, by the reactor scram circuit, or by the manual trip lever, opens a spring-loaded dump valve in the oil pressure line to the throttle valve. This relieves the oil pressure on the pilot valve piston which in turn relieves the oil pressure on the hydraulic piston, and the throttle valve closes. This action also actuates an air valve which closes the extraction line non-return valve.

Performance Data (Normal Full Load).

Rated generated power, at 0.8 P.F., KW	2000
Maximum generated power, at 1.0 P.F., KW	2500
Turbine rated speed, full load, RPM	5489
Turbine speed, no load, RPM	5700
Speed regulation, %	3.85
Governor high speed stop, RPM	5820
Governor low speed stop, RPM	5215
Tripping speed, RPM	6050
Inlet steam pressure, at throttle, psig	175
Low initial pressure regulator setting, minimum, psig	145
Shaft seal steam pressure, psig	2-5
Feedwater heater bleed pressure, psig	16.9
Exhaust pressure, in. Hg absolute	2.5
Exhaust casing sentinel valve setting, psig	10
Inlet steam temperature, °F	404

Performance Data (Normal Full Load). (Cont'd)

Oil pump discharge pressure, at 130°F, psig	65
Bearing oil pressure, at 130°F, psig	10 ± 2
Motor-driven auxiliary oil pump pressure switch	
Closes at pressure, psig	49
Opens at pressure, psig	60
Turbine-driven auxiliary oil pump oil pressure regulator setting, psig	45
Oil pressure, at reduction gear, psig	10
Oil temperature	
Minimum before starting, °F	70
Minimum operating, °F	130
Normal, at bearings, °F	140 - 150
Maximum, at bearings, °F	175
Leaving cooler, °F	110 - 115
Air temperature, to generator	
Normal, °F	95
°C	35
Minimum, °F	86
°C	30
Maximum, °F	104
°C	40

Steam Turbine Operation

Startup.

Table 2-1. Valve Settings for Turbine Start Up

OPEN

TAG NO.	DESCRIPTION
D-1	Steam generator drain line block valve
D-2	Steam generator drain line trap upstream block valve
MS-2	Motor-operated main steam line block valve
D-3	Steam generator drain line trap downstream block valve
D-6	Steam generator drain line outlet to condenser
MS-1	Boiler feed pump turbine header block valve
MS-10	Turbine throttle valve drain to condenser
TV/PCV/1-2	Main steam line low flow pressure control valve
EX-1	Extraction line valve

Table 2-1. Valve Settings for Turbine Start Up (Cont'd)

OPEN

TAG NO.	DESCRIPTION
EX-2	Extraction line drain
EX-3	Extraction line drain
TD-1 & TD-2	Block valves back pressure regulator turbine seal drains
TD-4	Turbine drain
TD-5	Exhaust casing hand valve
MS-6	Steam block valve to turbine shaft seal
AR-1	Air ejector suction line valve
AR-2	Air ejector suction line valve
AR-8	After condenser trap block valve
AR-9	After condenser trap block valve
AR-13	After condenser drain line valve
AR-14	Air meter block valve
AR-15	Air meter block valve
AR-16	Vacuum breaker valve

CLOSED

MS-7	Connection for future steam line
MS-8	Turbine throttle
MS-9	Drain from turbine throttle valve
D-4	Steam generator drain line trap bypass
D-5	Steam generator drain line trap bypass free blow
TD-1	Turbine shaft seal steam discharge pressure control valve upstream block valve
TD-2	Turbine shaft seal steam discharge pressure control valve downstream block valve

Table 2-1. Valve Settings for Turbine Start Up (Cont'd)

CLOSED

TAG NO.	DESCRIPTION
TD-3	Turbine shaft seal discharge pressure control valve bypass
AS-6	Manual control valve for boiler feed pump turbine
AS-13	Steam manual control to turbine shaft seals
MS-5	Steam shut-off valve to air ejector
MS-11	Steam shut-off valve to turbine-driven auxiliary oil pump
MS-4	Evaporator header steam block valve
B-3 & B-5	Cooling water booster pump outlets
B-6 & B-2	Cooling water booster pump priming line shut-off valves
B-7	Cooling water booster pump priming line block valve
B-8 & B-12	Cooling water inlets to turbine oil coolers
B-10 & B-14	Cooling water outlets from turbine oil coolers
B-16	Cooling water inlet to generator air cooler
B-19	Cooling water outlet from generator air cooler
B-9 & B-13	Turbine oil cooler drains
AS-1	Steam inlet to first stage air ejector
AS-2	Steam inlet to first stage air ejector
AS-3	Steam inlet to second stage air ejector
AS-4	Steam inlet to second stage air ejector
AS-6	Block valve to boiler feed pump turbine
AR-3	Vapor inlet to first stage air ejector
AR-4	Vapor inlet to first stage air ejector
AR-5	Vapor inlet to second stage air ejector

Table 2-1. Valve Settings for Turbine Start Up (Cont'd)

CLOSED

TAG NO.	DESCRIPTION
AR-6	Vapor inlet to second stage air ejector
AR-7	Air meter bypass
AR-10	After condenser trap bypass
AR-11	After condenser drain
AR-12	After condenser drain
B-18	Generator air cooler drain
B-11	Turbine oil cooler water vent
B-17	Generator air cooler water vent
B-15	Turbine oil cooler water vent

To warm up the main steam line:

1. Open all vents and drains in the main steam line. As steam pressure builds up, slowly close valves to permit only discharge of condensate. Vent valves should be completely closed as soon as all air has been vented (approximately 5 psig) and drain valves should be left slightly open until turbine is up to full speed.

2. When steam generator steam pressure reaches 50 psig, slowly open valve MS-10 until it is completely open, then close valve until it is about one turn open.

3. Check that condenser circulating water pumps are in operation.

4. Open valves TV/9.

5. Check that boiler feed pump is in operation.

To start auxiliary oil pumps:

1. Check oil levels, bayonet gage on reservoir, and sight glass on generator.

2. Turn pump selector switch on turbine gage board momentarily to auto position and check that oil pressure rises to normal operating values.

3. Put turbine-driven auxiliary oil pump in operation by opening valve MS-11. Pump should start to rotate and sytem oil pressure should reach normal start up values.

To admit steam to turbine and start rotation:

1. Reset and open valve MS-8 until its pilot valve is completely open. Then continue to open slowly until turbine shaft starts to rotate, manually trip to check operation of tripping mechanism, and reset.

2. Before turbine coasts to a stop, open valve MS-8 sufficiently to maintain a speed of 500 RPM.

3. Check generator bearing oil slinger rings for rotation.

4. Admit steam to shaft seals by opening valve AS-13 part way and then closing TD-5 when all trapped condensate has been blown to condenser. Regulate steam pressure to seals at 3 to 5 psig by adjustment of valve AS-13.

5. Put one air ejector second stage element into operation. Close valve AR-16 and open valves AR-7, AR-3, AR-5, and MS-5. Adjust pressure control valve PCV-14 to give 150 psig at the air ejector inlet.

CAUTION

Do not admit steam to an air ejector unless all valves are properly set and water is flowing through the condensers.

6. Close valve MS-10.

7. Completely check oil system to make sure that all parts are functioning properly; especially check for unusual noises or vibration. If any is detected, shut down turbine immediately. Do not continue turbine operation until cause of difficulty is located and remedied. Check oil pressure at gear box.

8. Put air ejector first stage element in operation by opening valve AS-1.

To bring turbine up to rated speed:

1. Open valve MS-8 sufficiently to bring turbine speed up to 1100 RPM (hold 500 RPM for hot start up; see procedure in Section 4) and run for 30 minutes. Check for abnormal noise or oil pressure.

2. Gradually open valve MS-8 throttle valve, to bring turbine to 2200-2400 RPM. Increase speed rapidly to 3300 RPM, and then slowly to 5489 RPM, where the governor will take control and valve MS-8 may be opened wide and reclosed one half turn. After speed governor takes control, adjust the final speed with the hand speed changer. Do not stop between 2500 and 3000 RPM as critical speed is approximately 2800 RPM.

3. Check that turbine-driven auxiliary oil pump shuts down automatically when turbine approaches rated speed. Turn control switch for motor driven auxiliary oil pump to "auto" position.

4. When the unit is under load, close valve AS-13 in the steam supply line to the steam seals.

Put one cooling water booster pump in service when the oil temperature leaving the bearings reaches 110° F:

1. Open valves B-6 and B-7 to prime cooling water booster pump 4A.

2. See item 3 under Condenser Start Up.

To put one turbine oil cooler and the generator air cooler in service:

1. Open valve B-3.

2. Open valves B-8, B-10, B-16, and B-19.

3. Open valve B-11 to vent air from generator air cooler. Close when stream of water overflows.

CAUTION

Do not allow water to spill through floor pipe sleeves to the electric equipment below.

4. Open valve B-17 to vent turbine oil cooler. Close when stream of water overflows.

5. Throttle valve B-10 so as to obtain an oil temperature of 110° F to 115° F leaving the oil cooler.

6. Adjust valve B-19 so that the air temperature leaving the air cooler is 95° F (35°C). The maximum allowable air temperature is 104° F (40° C); the minimum is 86° F (30° C). A high-temperature alarm relay will actuate an alarm between 104°F and 108° F. (Temperature of generator windings, as shown on temperature indicator on generator panel, should never exceed 90° C.)

CAUTION

If the air temperature rises above 104° F and the trouble cannot be corrected before the temperature reaches 115° F, shut down the generator immediately.

7. Adjust valves B-10 and B-19 as load on turbine varies so as to maintain the above temperatures.

Shutdown.

1. Reduce electric load gradually. (See Generator and Exciter, Operation, below.)

2. If the turbine has operated continuously for less than one month, trip valve MS-8 with the manual trip button on the trip mechanism. If the turbine has operated continuously for more than one month, overspeed turbine by loosening locknut on high-speed stop, backing off high-speed stop, and adjusting speed-changing handnut. Increase speed until overspeed governor trips valve MS-8 or speed reaches 6120 RPM. If overspeed governor does not operate before 6100 RPM, trip valve MS-8 with manual trip button.

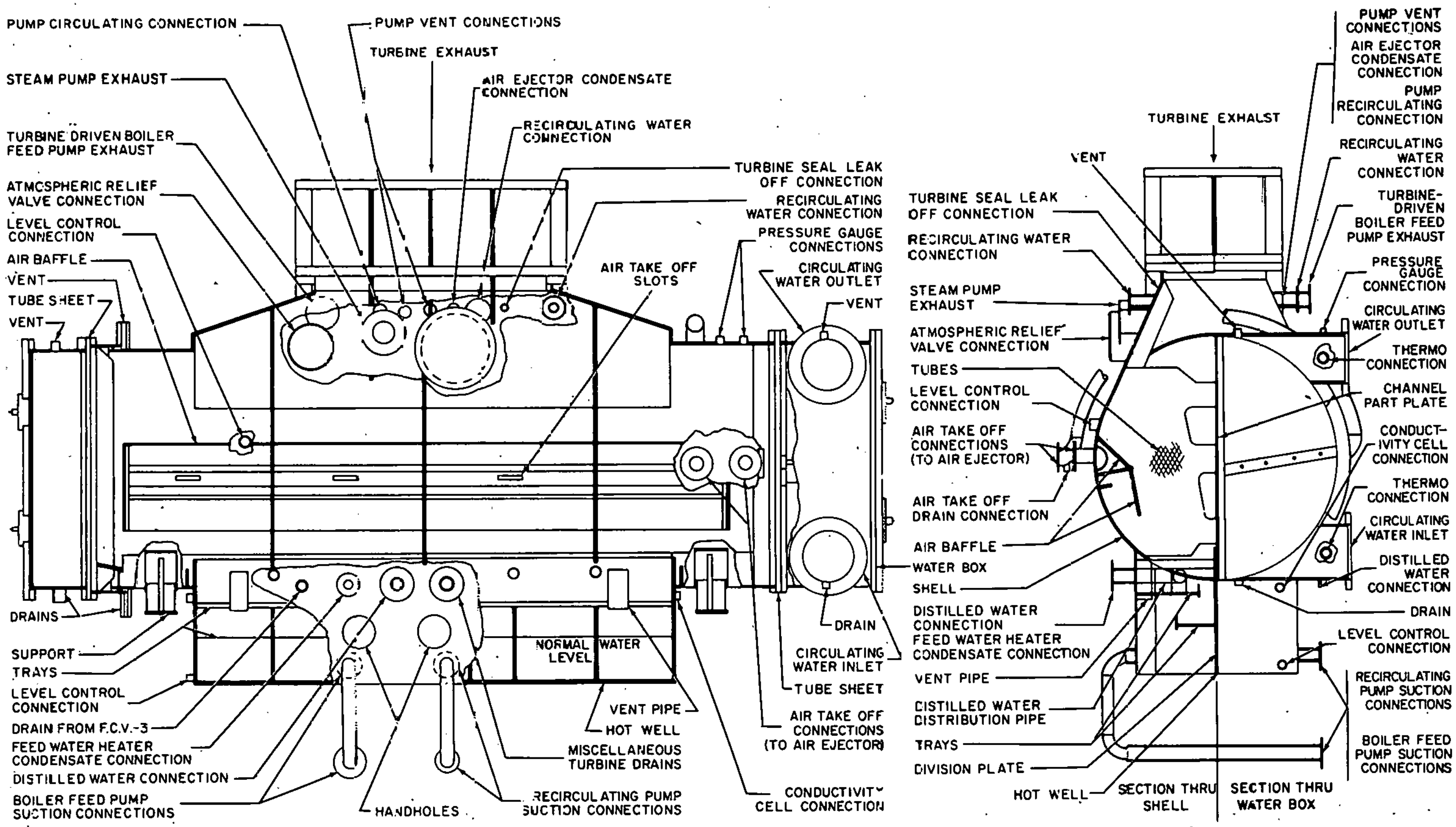

Figure 2-19. Condenser

Check overspeed governor before restarting turbine. If overspeed governor operates, let speed coast to 3800 RPM, reset overspeed governor, and open valve MS-8. Adjust speed-changing handnut to obtain speed of 5820 RPM. Reset high-speed stop. Trip valve MS-8 with manual trip button.

3. Check that one of the auxiliary oil pumps starts automatically when the oil pressure drops to about 45 psig. If neither auxiliary pump starts by the time the pressure falls to 50 psig, restart the turbine. Run turbine, to maintain oil pressure, until at least one auxiliary pump is operating.

4. Shut down air ejector and open vacuum breaker (AR-16).

5. Shut off steam seal supply and cooling water to the turbine oil cooler before the turbine stops rotating.

6. Stop cooling water booster pump.

7. Crack open valve MS-9.

8. Run auxiliary oil pump and circulate oil to the bearings to remove heat for a minimum of two hours.

9. Check all steam connections into the turbine to assure that all steam is blocked out of unit. Steam leakage would promote corrosion.

Condenser and Air Ejector.

Description (Figure 2-19). The secondary system turbine exhaust steam is condensed in a horizontal, shell and tube, double-pass, divided-flow condenser which is situated on the ground floor level directly below the turbine exhaust. A high degree of vacuum is maintained in the condenser shell by a two-stage, twin-element air ejector which is described below. The condenser converts the exhaust steam of the turbine to a liquid which, together with make-up water from the evaporator, is returned to the steam generator as feedwater. In addition, the vacuum of the condenser provides a low back pressure on the turbine, increasing the expansion of steam in the turbine and raising the efficiency of the secondary system.

The shell of the condenser is divided into two sections, each with a bank of tubes. Thus, half the condenser may be shut down for cleaning or repairs while the remaining half carries the condensing load.

The condensate, which collects in the hot well of the condenser, supplies the steam generator feedwater and cooling water for the primary coolant pumps and the reactor cooling coils. Condensate is also used to supply make-up water for the primary system.

In addition to the main turbine exhaust, the condenser load includes the following:

1. Feedwater heater condensate.

2. Air ejector condensate.

3. Turbine steam seal leak-off.

4. Condensate cooling water return.

5. Feedwater recirculation (for control of air ejector temperature differential).

6. Turbine-driven boiler feed pump exhaust (when operating).

7. At shutdown, steam dump from steam generator.

The condenser shell is a 58-inch-inside-diameter cylinder, 14 feet 2-1/8 inches long, fabricated of 1/2-inch-thick copper-bearing steel plate. A built-up turbine exhaust flange connection, of the same material, tops the shell. A rectangular reservoir, the hot well, protrudes from the bottom of the shell. The hot well is equipped with staggered trays which cascade the condensate into the well, aiding in removal of air. Naval brass tube sheets, 1 inch thick, are bolted in place at each end of the shell. The sheets support the 936-7/8-inch-outside-diameter, 18-gage, aluminum brass tubes through which condenser circulating water passes. Three plates, equally spaced within the shell, also support the 14-foot, 2-1/8-inch-long tubes. The tubes are roller expanded, belled, and tin-sweated to the tube sheet at the inlet end and are roller expanded, and tin-sweated to the tube sheet at the outlet end. Two sections of tubes are located on either side of the shell behind air baffles and serve to cool and demoisturize the air-rich vapor which is drawn off at these points by the air ejector. Water boxes, bolted over the tube sheets at each end of the shell, direct the circulating water in the desired flow pattern. The condenser is supported from the turbine exhaust flange.

Vents are provided in each water box for the removal of trapped air when starting condenser operation. A vent in the shell allows air to escape from the shell when subjecting it to a water test prior to start up. Drains in both water boxes and the shell permit removal of water at shut-down.

An atmospheric relief valve on the shell opens at 5 psig to protect the unit from excessive pressure.

The following condenser performance characteristics are measured:

1. Outlet temperature of condensate from hot well, °F. The temperature is recorded at the control panel.

2. Circulating water inlet and outlet temperatures, °F. The temperatures are recorded at the control panel and locally indicated.

3. Circulating water inlet and outlet pressures, psig. The pressures are locally indicated.

4. Hot well level. The level is visually indicated by a gage glass on the well.

5. Shell pressure, in. Hg vacuum - 30 to 0, psig - 0 to 15. The pressure is recorded at the control panel and locally indicated.

6. Feedwater line gamma level, mr/hr. The level is recorded at the control panel and locally indicated.

7. Condensate conductivity, micromho. The operator may select recording of the conductivity of one of four quadrants in the hot well. The recorder is mounted on the control panel.

8. Distilled water tank level, gallons H_2O. The level is indicated on the control panel and locally.

Air and other noncondensable gases are removed from the condenser by a two-stage, twin-element, steam jet air ejector of shell and tube construction. A mixture of air and vapor is drawn from the condenser shell by the suction of a steam jet nozzle. Operating steam and moisture from the air are condensed in the first stage condenser (inter-condenser) by the passage of feedwater through the inter-condenser tubes. The air in the first stage shell is drawn, by another steam jet, into the second stage condenser (after-condenser) where it is compressed to a pressure of approximately 32 in. Hg for discharge to the atmosphere after the condensation of operating steam. Steam, at 190 psia and 404° F, is bled from the main steam line, throttled to 150 psig by a pressure reducing valve, and then supplied to the jet nozzles. The steam mixes with the vapor drawn from the condenser and is compressed by passage through a diffuser directly downstream of the nozzle. Both stages operate in a similar manner, the first stage drawing vapor from the condenser shell, and the second stage drawing vapor from the first stage inter-condenser shell. The condensate from each stage is returned to the condenser hot well through ball-float drain regulators. The condensation of vapor in the air ejector shells also serves to heat the feedwater flowing through the tubes.

Each stage of the air ejector is equipped with two nozzle-diffuser elements. During normal operation, only one of these is used on each stage, the other serving as a standby. Both may be used, however, for start up of the condenser when a heavy load of air needs to be evacuated or in an emergency to counteract an air leak into the system until it can be repaired.

The inter-condenser and after-condenser are similar in construction. Each consists of a 10-inch-inside-diameter steel shell. Two muntz metal tube sheets fitted in the ends of each shell support the tubes. Water boxes on each end of the shell cause the feedwater to make two passes through the tubes of each stage. Each shell contains 60, 5/8-inch-outside-diameter, 18-gage admiralty metal tubes which are 6 feet long. The nozzle and the diffuser are the converging-diverging type and made of stainless steel and cast iron, respectively. A vent and a drain is incorporated in each shell and each water box. A relief valve in each shell opens at 15 psig to protect the unit from overpressure.

A Bourdon tube pressure gage gives local indication of the inlet steam pressure. An air meter in the atmospheric vent line gives a local reading of total load evacuated (air plus water vapor). A manually operated pressure reducing valve throttles the inlet steam to the desired pressure.

<u>Performance Data.</u>

Condenser:

Shell vacuum, full load, in. Hg	27.5
Circulating water flow rate, gpm	4260
Circulating water inlet temperature, °F	85
Circulating water outlet temperature, °F	98

Condenser (Cont'd)

Condensate temperature, °F	108.7
Hot well capacity	
ft^3	40
gal	298.4
Steam condensed, full load, lb/hr	20,700
Heat rejected, full load, BTU/lb	900
Steam duty, total, BTU/hr	27.6×10^6

Air ejector:

Dry air evacuated, full load, lb/hr	18
Total load evacuated, air and water vapor, lb/hr	60
Design vacuum, in. Hg	29
Steam required for each two-stage element, full load, lb/hr	240
Operating steam pressure, psig	150
Cooling water flow rate, minimum, gpm	24

Hot Well Level Control. The control system for maintaining the proper condensate level in the hot well is shown schematically in figure 2-20.

During periods of evaporator operation, the level in the hot well is maintained just above level controller No. 2. Under these conditions, level control valve No. 2 is open and level control valve No. 3 is closed. Feedwater is diverted at a point upstream of the air ejector to the distilled water tank at a rate of 630 lb/hr where it is stored for use during evaporator shutdown periods. This 630 lb/hr is supplied as a part of the evaporator output in addition to make-up water for system losses.

When the distilled water tank becomes full, an alarm is sounded and the operator must shut down the evaporator. The resultant loss of make-up water in the secondary system causes the hot well level to drop. When the level drops below level controller No. 2, the controller acts to close level control valve No. 2 and stop the diversion of feedwater to the distilled water tank. This slows down the rate at which the hot well level will drop, and at the same time overflow of the distilled water tank is prevented.

System losses will keep the hot well level dropping until the level is below level controller No. 3. This controller then acts to open level control valve No. 3 and draw from the distilled water tank to maintain the hot well level.

When the distilled water tank level becomes too low, an alarm is sounded, notifying the operator to start the evaporator. The addition of make-up water from this source raises the hot well level above level controller No. 3, which then acts to close level control valve No. 3 and stop flow out of the tank to the hot well. When the hot well level reaches level controller No. 2, the controller acts to open level control valve No. 2 and allows 630 lb/hr to flow into the tank. This stabilizes the hot well level at a point just above level controller No. 2 while the tank is being filled. When the tank is full, the cycle is repeated.

Two float-actuated switches sound an alarm if the hot well level continues to rise above level controller No. 2 or continues to fall below level controller No. 3.

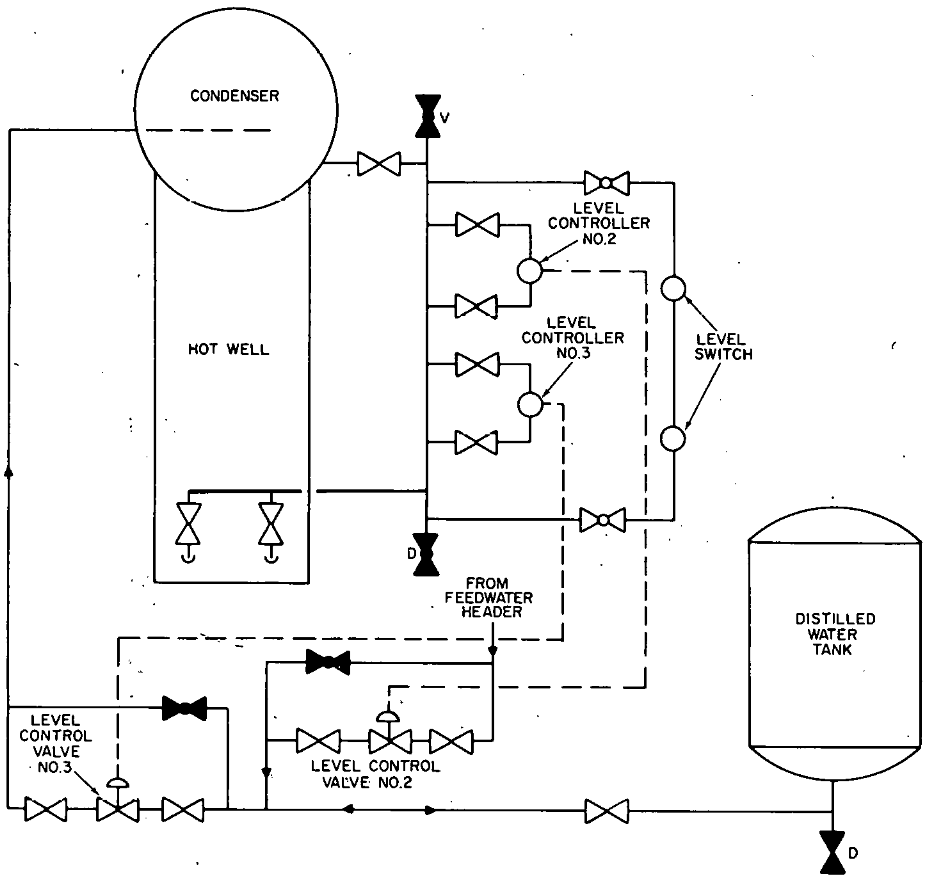

Figure 2-20. Hot Well Level Control, Schematic Flow Diagram

Condenser and Air Ejector Operation.

Table 2-2. Valve Settings for Condenser Start Up

TAG NO.	DESCRIPTION
	OPEN
CW-10 CW-6	Circulating water inlet to condenser
CW-16	Pressure switch shutoff valve
CW-13 CW-9	Circulating water outlet from condenser
CO-2	Distilled water tank block valve
CO-4	Inlet to hot well level control valve No. 3
CO-6 CO-7	Distilled water inlet to hot well
CO-9 CO-10	Hot well outlet to condensate recirculating cooling pumps
CO-36 CO-37	Hot well outlet to boiler feed pumps
CO-45	Hot well level control valve
CO-46	LCV-2 block valves
	CLOSED
CW-1 CW-2	Circulating water pump discharge line
CW-12 CW-8	Circulating water outlet line vent
CW-11 CW-7	Circulating water inlet line drain
CW-3	Circulating water hose connection inlet line
CW-4	Circulating water pump discharge line drain
CO-1	Distilled water tank drain

Table 2-2. Valve Settings for Condenser Start Up (Cont'd)

CLOSED

TAG NO.	DESCRIPTION
CO-5	Outlet from hot well level control valve No. 3
CO-3	Hot well level control valve No. 3 bypass
CO-47	Hot well level control valve No. 2 bypass

To establish circulating water flow through condenser:

1. Open valve CW-1 two turns.
2. Close condenser vent and drain valves.
3. Close header drain valves.
4. Start pump as follows:
   a. Put switches on control room in lockout position.
   b. Close circuit breakers to both pumps. Note green lights.
   c. Put local switches in RUN and TEST OFF positions.
   d. Put both control room switches in AFTER TRIP position and note green and blue light.
   e. Put one local switch in TEST position and check system operation. Note green light goes out, red light comes on.
   f. Return switch to TEST OFF position.
   g. Put second pump switch in TEST position. Note green light goes out, red light comes on.
   h. Put control room switch for second pump in CLOSE position.
   i. Return local switch to TEST OFF position.
5. Slowly open valve CW-1 as system fills with water.

CAUTION

The second circulating water pump is strictly a standby unit. Under no circumstances should both pumps be operated simultaneously.

To establish normal level in the condenser hot well:

1. Open valve CO-2.

2. Put level controller No. 3 in service.

3. Open valve CO-5 wide.

4. Check rising water level on hot well level glass.

Observe action of level controller No. 3 as level approaches normal. If level control valve No. 3 does not close automatically, close valve CO-5 and check level controller No. 3 and level control valve No. 3. The addition of water to the hot well may be manually controlled by valve CO-3.

To put hot well high-level control in service:

1. Open valves CO-45 and CO-46.

2. Check operation of level controller No. 2 and level control valve No. 2. If level rises higher than normal, draw off water from hot well as necessary by manual operation of valve CO-47 when a boiler feed pump is operating.

Table 2-3. Valve Settings for Air Ejector Start Up
All valves for normal boiler feed water flow are open.

TAG NO.	DESCRIPTION
	OPEN
AR-8 AR-9	Second stage trap block valves
AR-13	Condensate return to condenser
BF-17 BF-18	Air ejector block valves
CO-42 CO-43	Temperature control valve (TCV-6) block valves
CO-8 CO-8A	Air ejector recirculation valves
	CLOSED
MS-5	Steam inlet line to first stage
AS-1 AS-2	Steam inlet to first stage nozzles

Table 2-3. Valve Settings for Air Ejector Start Up (Cont'd)

CLOSED

TAG NO.	DESCRIPTION
AS-3 AS-4	Steam inlet to second stage nozzles
AR-10	Second stage condensate return trap bypass
AR-11 AR-12	Second stage condensate drain
AR-16	Vacuum breaker
CO-44	Air ejector temperature differential control valve bypass

To put air ejector in service:

1. Air ejectors will be put into service after the turbine is rolling.
2. Check condenser shell atmospheric relief valve (SV/1) and establish water seal.
3. Check that TC-6 is in operation.
4. Open the following valves in the order listed: AR-5, AR-3, MS-5, and AS-4.

CAUTION

In opening valve PCV-14, do not exceed maximum inlet steam pressure of 150 psig.

5. When condenser vacuum reaches 10 in. Hg, open valve AS-1.
6. Observe action of TCV-6 to assure that it maintains a maximum temperature differential of 15°F across the air ejectors.

To shut down right half of condenser (facing inlet water box):

1. Reduce turbine generator to 1/2 load.
2. Close valves CW-6, CW-9, CO-37, CO-10, and AR-1.
3. Open valves CW-7 and CW-8.

To shut down left half of condenser:

1. Reduce turbine generator to 1/2 load.

2. Close valves CW-10, CW-15, CO-36, CO-9, and AR-2.

3. Open valves CW-11 and CW-12.

Boiler Feed Pumps

Description. Three vertical, 20-stage centrifugal pumps are provided to circulate feedwater from the condenser hot well, through the air ejector tubes and the feedwater heater tubes, to the steam generator.

The pumps are located in the ground floor work area and are connected in parallel for alternate operation. Under normal conditions, one pump only is in service; the other two serve as standby units.

Two of the pumps are driven by induction motors; the third is powered by a two-stage steam turbine. Ordinarily, one of the motor-driven pumps is in service, the turbine-driven pump being used only in the event of electrical power failure. The steam for the turbine is drawn from the main steam line. The turbine is equipped with a speed governor and an overspeed safety trip. The back pressure on the turbine is controlled at 5 psig by pressure control PCV/3.

Bourdon tube pressure gages give local indication of feedwater inlet and outlet pressures and turbine steam inlet and exhaust pressures.

Performance Data.

Pump speed, RPM	3550
Pump capacity, each, gpm	75
Pump head, at 75 gpm	
ft H_2O	630
psig	273
Feedwater temperature, °F	108.7
Pump efficiency, %	66
Motor rated power, HP	20
Motor rated voltage, 3Ø, volt	440

Operation.

Table 2-4. Valve Settings for Boiler Feed Pump Start Up

OPEN

TAG NO.	DESCRIPTION
BF-11	Boiler feed pump No. 1 vent line
BF-7	Boiler feed pump No. 2 vent line
BF-3	Boiler feed pump No. 3 vent line

Table 2-4. Valve Settings for Boiler Feed Pump Start Up (Cont'd)

OPEN

TAG NO.	DESCRIPTION
BF-12	Boiler feed pump No. 1 minimum flow line
BF-8	Boiler feed pump No. 2 minimum flow line
BF-4	Boiler feed pump No. 3 minimum flow line
BF-13	Boiler feed pumps vent line outlet to condenser
BF-17	Inlet to air ejector tubes
BF-18	Water outlet from air ejector tubes
BF-19	Water inlet to feedwater heater tubes
BF-20	Water outlet from feedwater heater tubes
BF-24	Inlet to steam generator level control valve LCV/4
BF-25	Outlet from steam generator level control valve LCV/4
BF-29	Feedwater line inlet to vapor container
CO-8 CO-8A	Air ejector recirculation line outlets to hot well
CO-36 CO-37	Hot well outlets to boiler feed pumps
BF-9	Boiler feed pump No. 1 suction valve
BF-5	Boiler feed pump No. 2 suction valve
BF-1	Boiler feed pump No. 3 suction valve
CO-42	Inlet to air ejector temperature differential control valve
CO-43	Outlet from air ejector temperature differential control valve
CO-23	Shut-off valve, boiler feed pump gland water line
CO-39 CO-40 CO-41	Boiler feed pump gland water valves

Table 2-4. Valve Settings for Boiler Feed Pump Start Up (Cont'd)

OPEN

TAG NO.	DESCRIPTION
BF-31 BF-32 BF-33	Pressure indicating valves open on all three pumps
BF-10	Discharge valve boiler feed pump No. 1
BF-6	Discharge valve boiler feed pump No. 2
BF-2	Discharge valve boiler feed pump No. 3
CO-44	TCV-6 bypass
BF-16	Air ejector bypass
BF-21	Feedwater heater bypass
BF-26	Steam generator level control valve No. 4 bypass
BF-27	Chemical feed inlet to feedwater line downstream of feedwater heater
BF-22	Feedwater heater vent
BF-23	Feedwater heater drain to waste
BF-15	Chemical feed inlet to feedwater line upstream of air ejector
D-6	Turbine-driven boiler feed pump steam bypass outlet to condenser
AS-6	Steam shut-off valve, boiler feed pump turbine
AS-8	Inlet block valve, boiler feed pump turbine header trap
AS-9	Outlet block valve, boiler feed pump turbine header trap
AS-10	Trap bypass, boiler feed pump turbine header trap
AS-7	Turbine-driven boiler feed pump inlet steam free blow
AS-11	Turbine-driven boiler feed pump turbine exhaust drain
D-7	Turbine-driven boiler feed pump turbine exhaust outlet to condenser

To put one boiler feed pump in service:

1. Start No. 1 boiler feed pump, using procedure outlined for circulating water pump start up.

2. Open valve BF-10 slowly.

3. Adjust gland seal water and close pump vent valve.

4. Vent air from feedwater heater by opening valve BF-22. When water overflows vent, close valve.

5. Vent air from air ejector by opening water box vents. Close, when water overflows.

To put turbine-driven boiler feed pump in service:

1. Open valve D-6.

2. Open valves AS-8, AS-9, AS-11, AS-12, D-7, AS-20, AS-21, AS-22, BF-1, BF-2, BF-3, BF-4, CO-41, and AS-7.

3. Open valve AS-6 slowly until turbine shaft starts to rotate, continue opening slowly until turbine governor takes over speed control, then open valve wide.

4. Close valve AS-7 as soon as steam flowing from it is free from excessive moisture.

5. Check action of exhaust pressure control valve PCV/3, which should hold exhaust pressure at 5 psig as indicated on pressure gage PI/9.

Feedwater Heater

Description (Figure 2-21). Feedwater, pumped by one of the boiler feed pumps, is heated in a shell and tube heat exchanger prior to delivery to the steam generator. The feedwater heater is located in the turbine room. The feedwater makes four passes through the heater tubes, where it is heated by steam bled from the turbine, vapor produced by the evaporator, and evaporator condensate in the heater shell. The collected condensate in the shell of the heater is returned to the condenser for reuse.

The heater shell consists of a 16-inch-outside-diameter cylinder of 3/8-inch-thick steel. The cylinder is capped with an ellipsoidal head welded at one end and a water box bolted on the other end. A 2-3/8-inch-thick steel tube sheet separates the water box from the shell cylinder. The overall length of the heater is 16 feet 9 inches.

Fifty-six U-tubes, of 5/8 inch outside diameter and 14-foot straight length, spaced on a 13/16-inch triangular pitch, together with the tube sheet, tie rods, end plates, support plates and baffles, constitute the removable tube bundle of the heater.

The heater is equipped with a liquid level gage glass. An automatic level controller actuates a level control valve to regulate the flow to the condenser. Two float-actuated switches sound an alarm in the control room if the level becomes excessively high or low. A safety

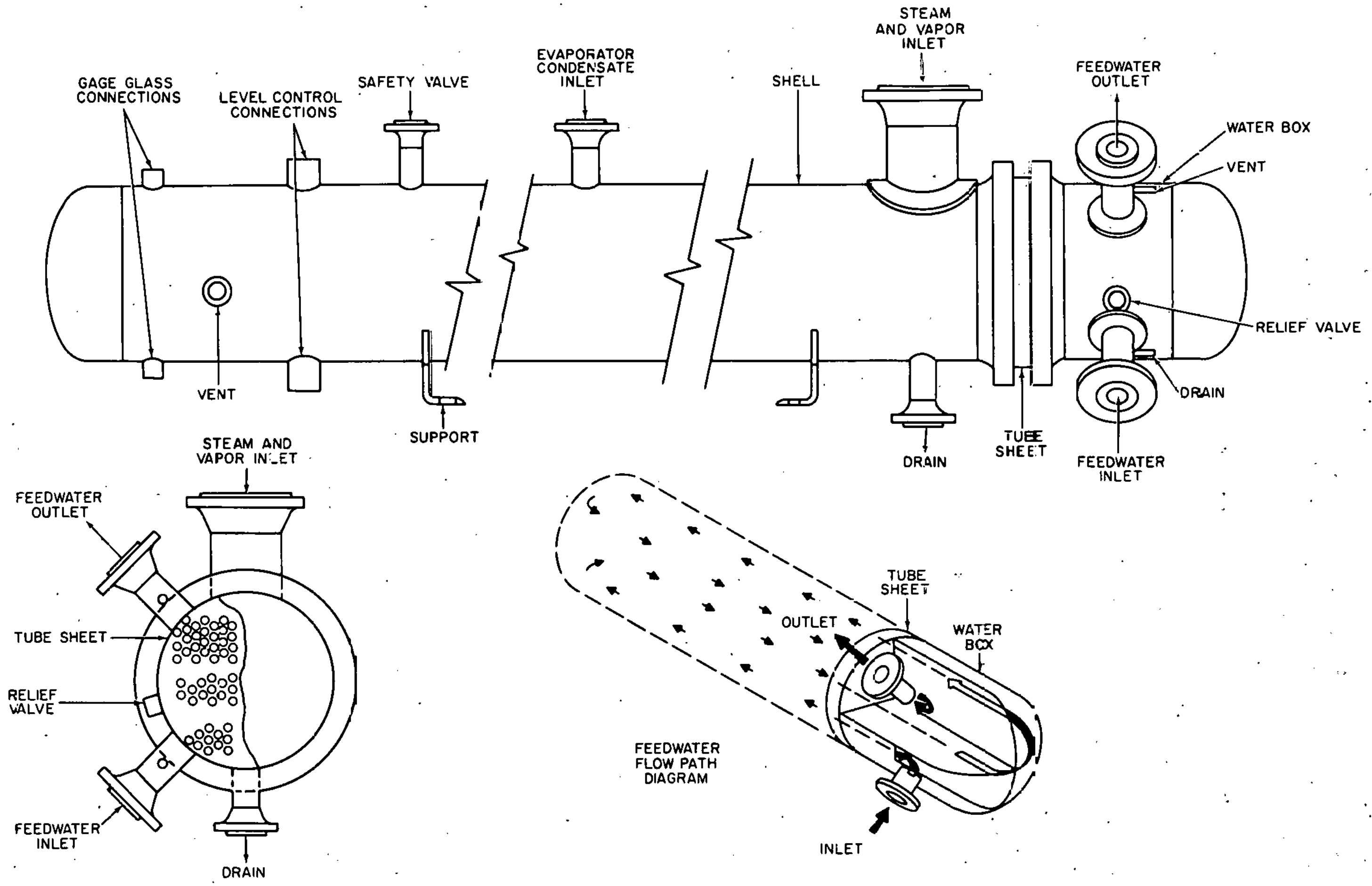

Figure 2-21. Feedwater Heater

valve on the shell is provided to protect the unit from excessive pressure. This valve will pass 12,270 lb/hr of saturated steam at operating pressure.

The following heater performance characteristics are measured:

1. Steam temperature is locally indicated.
2. Steam pressure is locally indicated.
3. Evaporator vapor temperature is locally indicated at the evaporator.
4. Evaporator vapor pressure is locally indicated at the evaporator.
5. Feedwater inlet temperature is locally indicated.
6. Feedwater outlet temperature is locally indicated and recorded at the control panel.
7. Feedwater flow rate is recorded at the control panel.

Performance Data.

Feedwater flow rate	
gpm	75
lb/hr	34,270
Feedwater inlet temperature, °F	116.2
Feedwater outlet temperature, °F	246.1
Steam inlet temperature, °F	256
Steam inlet pressure, psig	15.2
Shell pressure, psig	15.2
Shell design pressure, psig	160
Shell design temperature, °F	450
Tube design temperature, °F	300

Operation.

Table 2-5. Valve Settings for Feedwater Heater Start Up

OPEN

TAG NO.	DESCRIPTION
BF-19	Inlet to feedwater heater tubes
BF-20	Outlet from feedwater heater tubes
EX-6	Feedwater heater shell vent to condenser
EX-7	Feedwater heater shell air vent line

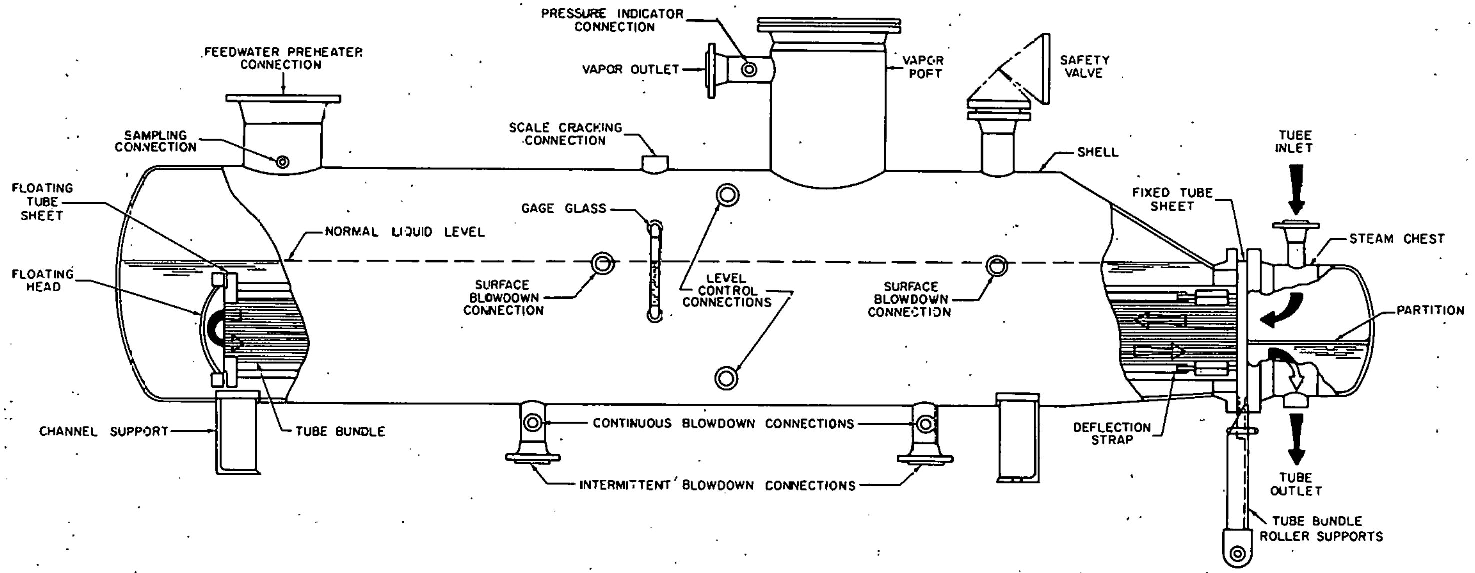

Figure 2-22. Evaporator

Table 2-5. Valve Settings for Feedwater Heater Start Up (Cont'd)

OPEN

TAG NO.	DESCRIPTION
CO-42	Inlet to air ejector temperature differential control valve
CO-43	Outlet from air ejector temperature differential control valve
	CLOSED
BF-21	Feedwater heater bypass
EX-1	Turbine steam bleed outlet to feedwater heater

To put feedwater heater in service:

1. Check that one boiler feed pump is in operation.
2. Open valve EX-1 slowly until it is wide open.
3. Close valve EX-7 when steam flows from it.
4. Observe action of level control valve LCV/1, which is controlled by level controller LC/1. Condensate should be maintained at the normal level as shown on the level gage glass.
5. Throttle valve EX-6 to about one turn open.

To take feedwater heater out of service:

1. Shut down evaporator or divert vapor and condensate to the condenser. See Evaporator, Operation, below.
2. Close valve EX-1 slowly.
3. Open valve BF-21 wide.
4. Close valve BF-19 and BF-20, in that order.
5. Open valve EX-7 wide.

Evaporator and Preheater

Description (Figure 2-22). Make-up water for the secondary system is supplied by distillation of service water in the evaporator, which is located in the turbine room. Water drawn from the service water tank by the evaporator feed pump passes through the preheater, where it is heated and deaerated, and into the shell of the evaporator, where it is vaporized by double-pass flow of steam in the tubes. Steam for this purpose is bled from the main steam line. The vapor rises through a centrifugal separator atop the shell, where moisture is removed and returned to the shell. A portion of the vapor produced rises into the preheater to heat the incoming service water. The remainder is piped to the shell of the feedwater heater, condensed, and then is carried to the condenser hot well for system use. Condensed steam from the evaporator tubes is also delivered to the feedwater heater shell. The vapor and condensate may be diverted to the condenser.

The evaporator shell consists of a 2-foot, 7-3/4-inch-outside-diameter cylinder of 3/8-inch steel. It is capped on one end with a welded spherical steel head. The opposite end tapers to an 18-inch outside diameter and is fitted with a flange to receive the fixed tube sheet and the steam chest. The steam chest is a partitioned, domed, cylindrical member bolted to the shell over the tube sheet. The partition directs the flow of steam in the desired path through the tubes. The overall length of the unit is 14 feet 8 inches. The removable tube bundle consists of 30, 3/4-inch-outside-diameter Cu-Ni tubes, a floating tube sheet and head assembly, a fixed tube sheet with roller supports, support and gusset plates, spacer pipes, deflection straps, and turnbuckles.

The preheater is a cylindrical open-type heater which cascades incoming service water down a series of staggered trays. Vapor is admitted at the bottom of the heater and disperses through the cascading water, heating it and drawing off air. The air is vented at the top of the heater. The vapor condenses and mixes with the service water and both fall to a ring-shaped reservoir from which the fluid overflows a weir into the evaporator shell. A safety valve mounted atop the shell is set to open at 50 psig to protect the unit from excessive pressure.

Scale may be removed from the outside surfaces of the tubes by alternately heating them and shocking them with cold water. The cold water causes the deflection straps to contract, which in turn shortens the distance between the tube sheets, causing the tubes to bow outward. This sudden deflection cracks the brittle layer of scale from the tubes.

Connections for continuous and intermittent blowdown of shell water are made at the bottom of the shell and run to the steam generator blow-off tank. The continuous blowdown serves to limit the impurity content of the water and thus increases the purity of the vapor; the intermittent blowdown is used after a tube descaling operation to remove the accumulation of solids which results.

The evaporator shell is equipped with a level gage glass, a level controller which regulates the service water inlet rate, and high- and low-level alarm switches.

Service water, for distillation, is supplied to the evaporator by the evaporator feed pump. The pump is a centrifugal unit and draws from the service water tank. It is driven by an induction motor.

Service water, for tube descaling, is drawn from the service water main, under its own head, through a separate line.

The following evaporator performance characteristics are locally indicated:

1. Vapor outlet pressure, psig.

2. Vapor outlet temperature, °F

3. Steam inlet pressure, psig

4. Water level

5. Feed pump discharge pressure, psig

Performance Data. Pertinent performance data are tabulated below. Design data are also included for purposes of reference.

Vapor outlet pressure, psig	15.2
Vapor outlet temperature, °F	250
Normal steam inlet pressure, psig	175
Feed pump discharge pressure, psig	46
Distillate solids content, ppm	1
Total capacity, lb/hr	2150
Preheater bleed, lb/hr	400
Net capacity, lb/hr	1750
Normal full load capacity, lb/hr	1050
Shell design pressure, psig	50
Shell design temperature, °F	600
Tube design pressure, psig	450
Tube design temperature, °F	450
Feed pump motor rated power, HP	5

Operation.

Table 2-6. Valve Settings for Evaporator Start Up

OPEN

TAG NO.	DESCRIPTION
ED-1	Inlet to condensate drain regulator
ED-2	Outlet from condensate drain regulator
ED-4	Condensate outlet to feedwater heater
EF-19	Sight glass drain
AS-15	Preheater air vent
AS-26	Sample point No. 5 evaporator overheads
AS-27	Back pressure control valve signal

Table 2-6. Valve Settings for Evaporator Start Up (Cont'd)

OPEN

TAG NO.	DESCRIPTION
EF-1	Evaporator feed pump suction
EF-2	Evaporator feed pump discharge
EF-4 EF-5	Level control valve block valves
EF-10 EF-13	Low-level alarm block valves
EF-11 EF-12	High-level alarm block valves
EF-14 EF-15	Level controller block valves
EF-17 EF-18	Sight glass block valves
EB-3 EB-4	Evaporator blowdown valves
	Overheads inlet to sample cooler
	Discharge from sample cooler
	Cooling water to sample cooler
	Vent from overheads to stack
	Instrument-free block valves

CLOSED

TAG NO.	DESCRIPTION
EB-1 EB-2	Evaporator drain valves
EB-5	Continuous blowdown flow rate control valve
EB-6	Blowdown block valve
EB-7	Blowdown sample point

Table 2-6. Valve Settings for Evaporator Start Up (Cont'd)

CLOSED

TAG NO.	DESCRIPTION
EF-3	Evaporator level control valve bypass
AS-14	Evaporator steam inlet valve
SW-22	Scale cracking water inlet
SW-20	Evaporator feed water to level controller
SW-21	Hose connection
AS-25	Sample point No. 7 from preheater
EF-6 EF-7	Evaporator feed pump to primary system
EF-16	Instrument header drain
ED-3	Condensate drain regulator bypass
ED-5	Condensate trap bypass to feedwater heater
ED-6	Condensate drain to the condenser
EX-4	Vapor outlet to feedwater heater
EX-5	Vapor outlet to the condenser

To put evaporator in service:

1. Start evaporator feed pump.
2. Check that water level is normal.
3. Crack open steam inlet valve AS-14.
4. Open valve EB-7 (blowdown to sample cooler).
5. Gradually open valve AS-14 until steam flow reaches 1700 lb/hr.
6. When conductivity reaches 3.5 micromhos, open valve EX-4 (vapor overhead to feed-water heater).

7. Close the vent from overheads to the stack.

8. Adjust temperature compensation on conductivity recorder at the beginning of each shift.

9. Blowdown should normally be 0.45 gpm but may be increased to maintain 60 to 70 ppm chlorides in the evaporator liquor.

NOTE

The evaporator should be put into service when the distilled water tank level reaches 3000 gallons. The tank low level alarm is set at 2800 gallons.

Evaporator Shutdown Procedure

1. Shut AS-14 (steam inlet valve).

2. Open the vent from overheads to the stack.

3. Close EX-4 (vapor overhead to the feedwater heater).

4. Close EB-7 (blowdown to the sample cooler).

5. Shut off the evaporator feed pump when the evaporator pressure has dropped to 0 psig.

Evaporator Cracking Procedure

1. Open the vent from overheads to the stack.

2. Open EB-1 and EB-2 (evaporator drains).

3. When the shell is empty, crack AS-14 and heat the tube bundle for 5 minutes.

4. Close AS-14.

5. Open SW-22 (cracking water valve) for 10 minutes.

6. Repeat steps 3, 4, and 5 twice.

7. Return the system to start up conditions.

Chemical Feed Systems

Feedwater Treatment System Description (Figure 2-23). Steam generator feedwater will be chemically treated with hydrazine, morpholine, and disodium phosphate as well as other chemicals that may be necessary. See WATER TREATMENT, Steam Generator Feedwater. The system which feeds these chemicals to the secondary system consists of three parallel branches. Each branch contains a chemical solution tank, a variable volume pump in series with the tank, and the necessary piping and valves to control the flow of these solutions. All three branches connect to a pipe manifold which in turn supplies the feedwater line at two points and the

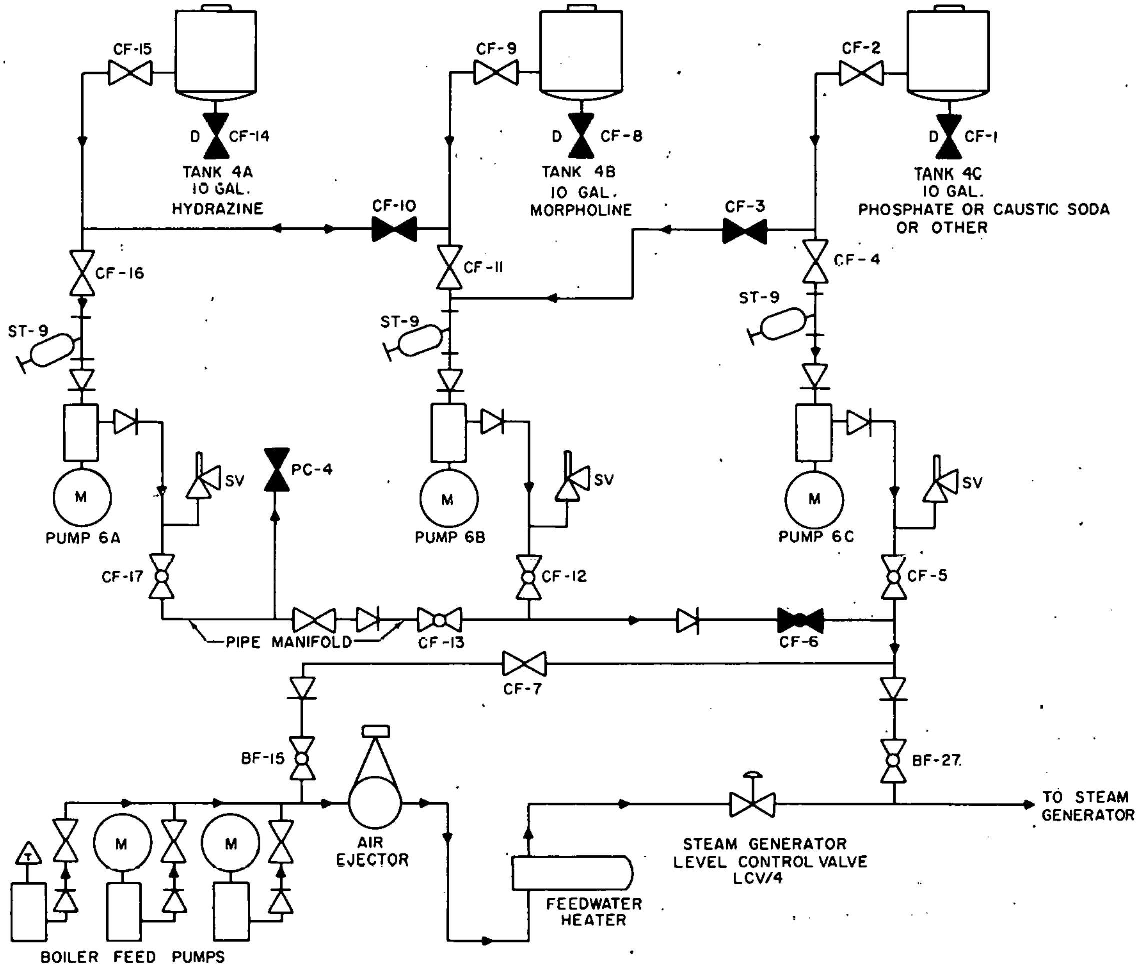

Figure 2-23. Feedwater Treatment System, Schematic Flow Diagram

primary make-up system. Provision is made in the piping for bypassing an inoperative pump. Piping and valves are arranged in such a manner that a variety of chemical feeds to different parts of the plant are possible.

Feedwater Treatment System Operation (Figure 2-23). Operating Data: Design pressure of feedwater treatment system:

Hydrazine:	575 cc/hr 600 psig
Morpholine:	575 cc/hr 600 psig
NaOH	2300 cc/hr 600 psig

Table 2-7. Valve Settings for Feedwater Treatment System Start Up

Note

All valves in this system are to be closed prior to commencement of start-up procedures.

TAG NO.	DESCRIPTION
CF-5	Pump 6C discharge
CF-4	Pump 6C suction from tank 4C
CF-2	Outlet from tank 4C
CF-9	Outlet from tank 4B
CF-11	Pump 6B suction from tank 4B or 4A
CF-13	Manifold valve between pumps 6A and 6B
CF-17	Pump 6A discharge
CF-16	Pump 6A suction
CF-18	Shutoff in line between pumps 6A and 6B
CF-15	Outlet from tank 4A
CF-1	Tank 4C drain
CF-8	Tank 4B drain

Table 2-7. Valve Settings for Feedwater Treatment System Start Up (Cont'd)

TAG NO.	DESCRIPTION
CF-14	Tank 4A drain
CF-10	Shutoff in junction line between pump 6A and 6B suctions
CF-6	Manifold valve between pumps 6C and 6B
CF-7	Manifold discharge valve
CF-12	Pump 6B discharge
CF-3	Shutoff in junction line between tank 4C outlet and pump 6B suction
BF-15	Chemical feed outlet to feedwater line, upstream of air ejector
BF-27	Chemical feed outlet to feedwater line, downstream of steam generator level control valve LCV/4

To feed hydrazine to primary make-up system:

1. Check that valves CF-15, CF-10, CF-12, CF-5, and CF-14 are closed.
2. Fill tank 4A with 10 gallons of 0.04% (by weight) hydrazine solution.
3. Open valves CF-15, CF-16, CF-17, CF-18, and PC-4, in that order.
4. Start pump 6A.
5. Adjust stroke of pump 6A as instructed by water treatment personnel.

To feed hydrazine to secondary system:

1. If hydrazine feed to primary make-up system is in progress, open valve BF-15, CF-7, CF-6, and CF-13 and adjust stroke of pump 6A as instructed by water treatment personnel. If hydrazine is not being fed to primary make-up system, follow steps 2 through 7, below.
2. Check that valves CF-15 and CF-14 are closed.
3. Fill tank 4A to capacity with 0.04% (by weight) solution of hydrazine.
4. Open valves CF-15, CF-16, CF-17, CF-18, CF-13, CF-6, CF-7, and BF-15, in that order.
5. Check that valves PC-4, CF-12, CF-5, and BF-27 are closed.

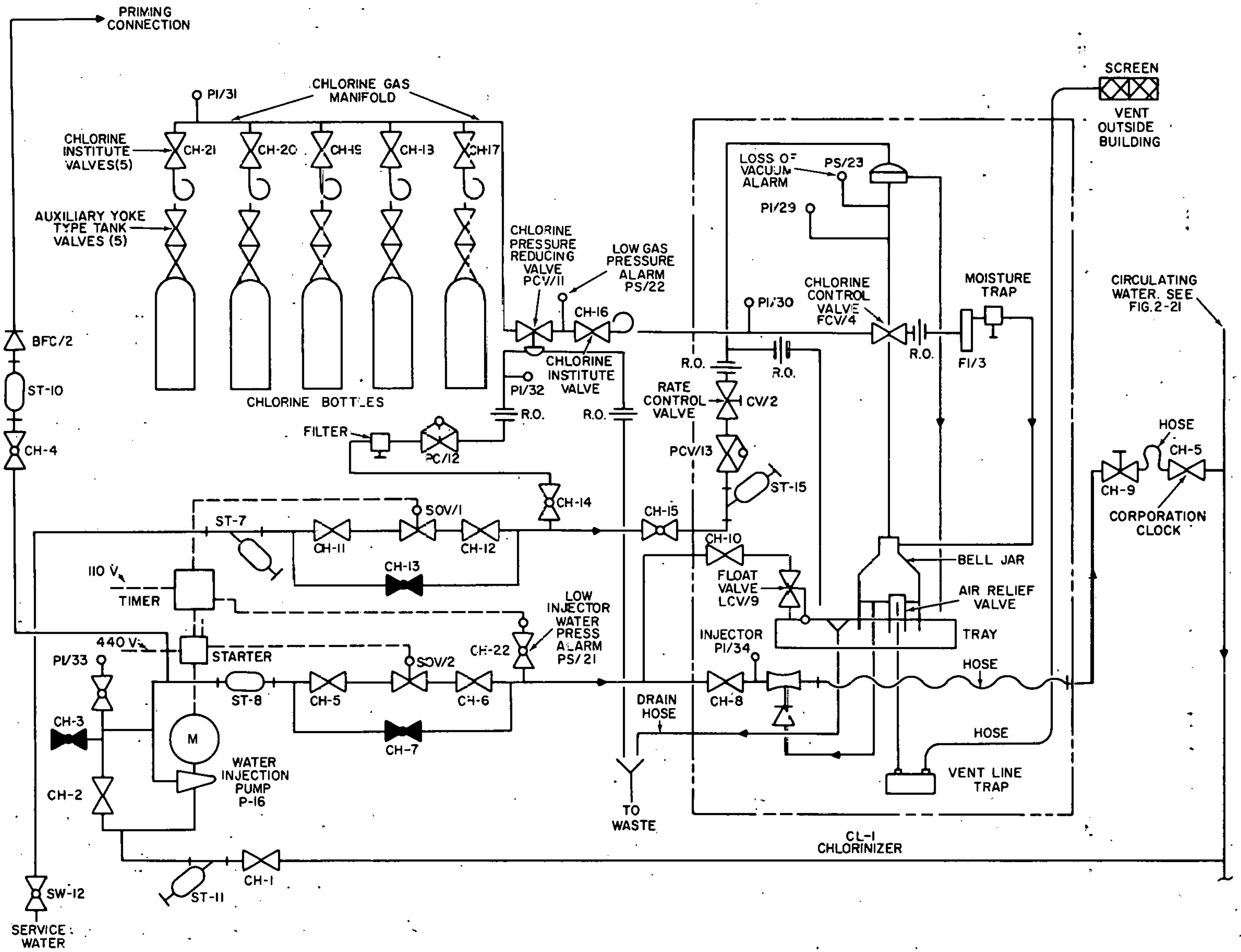

Figure 2-24. Chlorination System, Schematic Diagram

6. Start pump 6A.

7. Adjust stroke of pump 6A as instructed by water treatment personnel.

To feed morpholine to secondary system:

1. Check that valves CF-9, CF-10, CF-3, CF-13, CF-5, BF-27, and CF-8 are closed.

2. Fill tank 4B with 10 gallons of 1% (by weight) solution of morpholine.

3. Open valves CF-9, CF-11, CF-12, CF-7, and CF-6, in that order. Open valve BF-15 if closed.

4. Start pump 6B.

5. Adjust stroke of pump 6B as instructed by water treatment personnel.

To add chemical solutions from tank 4C to secondary system:

1. Check that valves CF-2, CF-3, CF-6, CF-7, and CF-1 are closed and that pumps 6A and 6B are not running.

2. Fill tank 4C as directed by water treatment personnel.

3. Open valves CF-2, CF-4, CF-5, and BF-27, in that order.

4. Start pump 6C.

5. Adjust stroke of pump 6C as instructed by water treatment personnel.

Chlorination System Description (Figure 2-24). Condenser circulating water is periodically treated with diluted chlorine solution. The system which performs this function draws chlorine gas from one or more chlorine bottles through a manifold into a chlorinizer where a concentrated chlorine solution is produced. This solution is drawn from the reservoir by an ejector powered by river water from a booster pump (water injection pump 16). The ejector mixes the chlorine solution with the injected water, diluting it, and drives the mixture through a hose connection to a nozzle in the side of the circulating pump discharge line. Service water is used to operate a chlorine gas pressure control valve (PCV/11) and a chlorine gas flow rate control valve (FCV/4).

An automatic timer determines the amount of chlorine solution injection by alternately starting and stopping the injection pump and by simultaneously opening or closing the solenoid valves in the river water line.

The injection pump is a turbine type, driven by a 1-1/2-HP induction motor powered from 460-volt bus No. 1.

Operation of Alarms

1. Loss of vacuum PS-23 in bell jar.

2. Low gas pressure (PS-22) bottle empty.

3. Low injector water pressure (PS-21).

Chlorination System Operation.

Table 2-8. Valve Settings for Chlorination System Start Up

OPEN

TAG NO.	DESCRIPTION
SW-12	Service water to chlorination system
CH-1	Chlorination pump suction
CH-2	Recirculating line
CH-5 & CH-6	Block valves, water injection line solenoid valve SOV/2
CH-11 & CH-12	Water solution line solenoid block valves SOV/1
CH-15	Shutoff valve to rate control valve
CH-4	Shutoff valve, injection pump priming line
CH-14	Control water shutoff valve to pressure control valve PCV/11
CH-16	Chlorine gas header shutoff valve
CW-5	Chlorine solution outlet to circulating water line
CH-8	Water shutoff valve to chlorinizer injector
CH-10	Water shutoff valve to chlorinizer tray
CH-9	Chlorine solution outlet
PI-33	Pressure indicating line valve
CH-22	PS-21 shutoff valve

CLOSED

TAG NO.	DESCRIPTION
CH-3	Temporary inlet connection

Table 2-8. Valve Settings for Chlorination System Start Up (Cont'd)

CLOSED

TAG NO.	DESCRIPTION
CH-21 CH-20 CH-19 CH-18 CH-17	Outlets from chlorine bottles to chlorine gas manifold
CH-7	Solenoid valve SOV/2 bypass
CH-13	Bypass SOV/1

To put chlorination system on automatic operation:

1. Start water injection pump 16 on automatic control.
2. Adjust valve CH-2 to obtain optimum pump discharge pressure.
3. Open valve CH-17 and associated chlorine bottle valve. Adjust chlorine gas pressure to 75 psig as shown on PI/31.
4. Adjust flow rate of water to chlorine flow control valve FCV/4 by use of control valve CV/2 so that rate of flow of chlorine, as shown on flow indicator FI/3, is the amount specified by water treatment personnel.
5. Set timer for duration of feed cycle specified by water treatment personnel.
6. When chlorine gas pressure drops to 25 psig, as shown on PI/31, or if chlorine gas low-pressure alarm sounds, remove the empty cylinder and open another chlorine bottle. Adjust chlorine gas pressure to 75 psig.
7. If chlorine gas flow rate exceeds 40 pounds per 24 hours, open an additional chlorine bottle to prevent possible freezing of chlorine because of rapid evaporation.
8. Clean the filter upstream from PCV-12 daily.

Water Systems

Condenser Water System. The condenser circulating water system is described in Section 1, GENERAL DESCRIPTION, SECONDARY SYSTEM, Condenser Water and Cooling Water System. Operating procedures for the condenser circulating water system are described under Condenser and Air Ejector, above. Schematic flow diagrams for the system are shown in figures 1-7 and 2-25.

Condensate Recirculating Cooling System Description. A general description of this system is in Section 1, GENERAL DESCRIPTION, PRIMARY SYSTEM, Cooling Systems. A schematic flow diagram of the system appears in figure 2-25. Components of the system are described below.

Condensate Recirculating Cooling Pumps. These pumps are three-stage, axial flow, vertically mounted units. They are lubricated by the water that is pumped. The pumps are vented through valved piping to the condenser to prime the pumps. Each pump is driven by a 10-HP induction motor powered from a station service bus.

A manual control switch, located on the electrical section of the control panel, is provided for each pump. A pressure switch in the pump discharge line automatically starts the standby pump if the discharge pressure falls below 60 psig. A safety valve (SV/13) in the discharge line opens at 150 psig to relieve the system of overpressure.

A hose connection is provided so that service water may be introduced into this system in an emergency. In this event, the drain line will be opened to allow the water to flow to waste.

Condensate Radiation Monitor. This monitor is described in Section 3, MONITORING DURING NORMAL PLANT OPERATION. It is located in a slip stream from the condensate recirculation line back to the condenser.

Condensate Recirculating Pressure Control Valve (PCV/4). This valve is a pneumatically operated control valve of the air-to-open, spring-return type. If the pressure drops to 60 psig in the condensate recirculating system, the valve opens to admit boiler feedwater to the condensate recirculating line to maintain sufficient cooling water flow.

Condensate Recirculating System Pressure Control Valve (PCV/5). This valve is in the return line to the condenser. It is a pneumatically controlled back pressure regulating valve. It maintains a pressure of 5 psig in the system.

Condensate Recirculating Cooling System Operation. Condensate discharge pressure is 75-80 psig. Flow rate is 50 gpm; temperature is 108-109°F.

Table 2-9. Valve Settings for Condensate Recirculating System Start Up

OPEN

TAG NO.	DESCRIPTION
CO-9 CO-10	Hot well outlets to condensate recirculating pumps
CO-13	Condensate recirculating pump No. 1 suction valve
CO-17	Condensate recirculating pump No. 2 suction valve
CO-16	Pump No. 1 vent

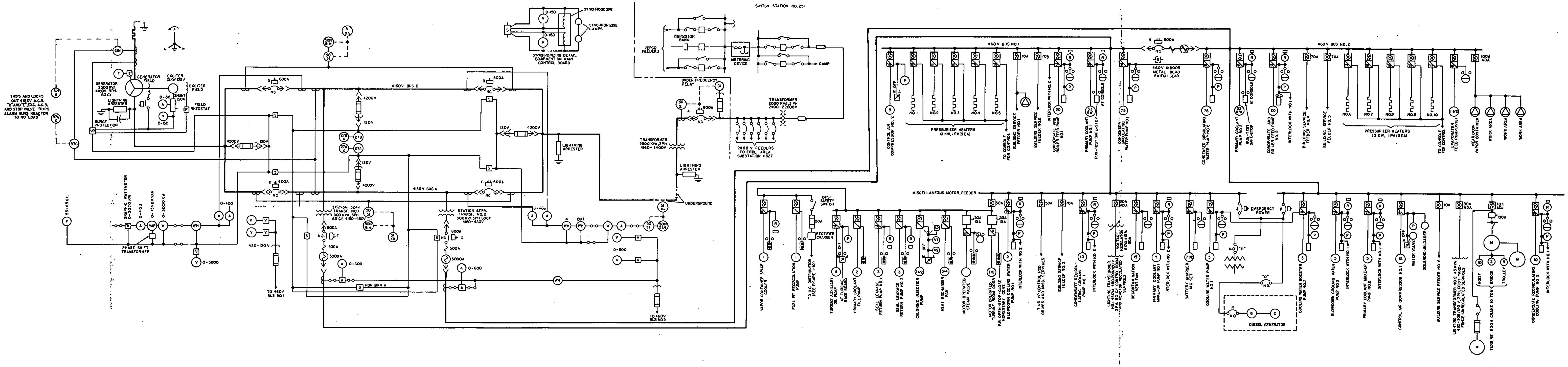

Figure 3-7. Electrical System, One-Line Diagram

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Table 2-9. Valve Settings for Condensate Recirculating System Start Up (Cont'd)

OPEN

TAG NO.	DESCRIPTION
CO-20	Pump No. 2 vent
CO-49 & CO-50	Pump discharge pressure gauge valves
CO-48	PS-4 shutoff valve
CO-23	Boiler feed pump gland water valve
CO-51 & CO-52	Radiation monitor block valves
CO-54	Signal to PCV-4
CO-55 & CO-56	FIC-5 block valves
CO-27A	Block valve P.C. pump cooling
CO-59	Signal to PCV-5
CO-28	Condensate recirculating line inlet to vapor container
CO-29	Condensate recirculating line outlet from vapor container
CO-31	Pressure control valve PCV-5 bypass
CO-32 & CO-33	Pressure control valve PCV/5 block valves
CO-34 & CO-35	Condensate recirculating line inlets to condenser
CO-21	Condensate recirculating pump vent line to condenser
CO-15 CO-19	Condensate recirculating pumps gland water lines
CO-22	Condensate recirculating pump gland water Shutoff valve
CO-25	Condensate make-up to primary make-up system
BF-14	Block valve upstream of pressure control valve PCV/4
CO-24	Block valve downstream of pressure control valve PCV/4

Table 2-9. Valve Settings for Condensate Recirculating System Start Up (Cont'd)

CLOSED

TAG NO.	DESCRIPTION
CO-11	Condensate recirculating system connection to the distilled water tank
CO-14	Condensate recirculating pump No. 1 discharge
CO-18	Condensate recirculating pump No. 2 discharge
CO-57	FIC-5 bypass
CO-58	Sample point
	Condensate outlet to chemical feed tank supply line
CO-27	Service water secondary back-up hose connection
CO-30	Condensate recirculating line to waste
CO-26	Spent fuel pit make-up
CO-53	Sample point at radiation monitor

To put one condensate recirculating cooling pump in service:

1. Open trip valve TV/6.
2. Turn condensate recirculating cooling pump 7A control switch to after trip position.
3. Start pump locally.
4. Open valve CO-14 slowly until wide open, then open CO-18.
5. Start second pump locally and stop the first pump.
6. Partially close valves CO-15 and CO-19 to avoid excessive leakage past pump gland.
7. Put running pump switch in close position.
8. Put local switches in Run and Test Off positions.

Service Water System Description (Figure 2-25). Service water, drawn from the Fort Belvoir mains, enters the plant area through a single main and is stored in a 5000-gallon service water tank. Enroute to the tank, service water bleeders branch off to supply the following need: two exterior fire hydrants, interior fire protection, domestic service, manhole water supply, vapor container spray head supply, spent fuel pit recirculating filter backwash supply, evaporator scale cracking supply, and service water secondary back-up to condensate recirculating system and main air compressor.

The service water tank discharges to the evaporator feed pump which delivers the water to the evaporator for distillation.

The service water tank is equipped with a level indicator controller (LIC/6) which transmits a reading of tank level to the control panel and regulates the service water inlet rate through a level control valve (LCV/6). A high- and low-level alarm is also provided.

Service Water System Operation.

Table 2-10. Valve Settings for Service Water System Start Up

OPEN

TAG NO.	DESCRIPTION
SW-2	Service water header valve
SW-4	Plant service water displacement meter upstream block valve
SW-5	Plant service water displacement meter downstream block valve
SW-7	Service water distribution header block valve
SW-11	Vapor container manhole fill line and evaporator scale cracking connection supply line block valve
SW-8	PI-26 valve
SW-15 & SW-16	Service water tank level control valve LCV/6 block valves
SW-18	SW tank discharge valve
SW-27 & SW-28	Inlets to vapor container spray heads
SW-33	Tank level controller shutoff valve
SW-29 & SW-30	V.C. Entrance gauge glass valves
SW-31 & SW-32	LS-5 Shutoff valves
SW-24 & SW-25	V.C. Entrance drains

CLOSED

TAG NO.	DESCRIPTION
SW-1	Service water header valve
SW-3	Plant service water displacement meter bypass
SW-6	Domestic service supply line block valve
SW-10	Spray header block valve
SW-12	Chlorinator supply line block valve
SW-13	Service water secondary back-up line to condensate recirculating system, block valve
SW-14	Service water tank level control valve LCV/6 bypass
SW-17	Service water tank drain

Table 2-10. Valve Settings for Service Water System Start Up (Cont'd)

CLOSED

TAG NO.	DESCRIPTION
SW-21	Hose connection valve on scale cracking line
SW-22	Evaporator scale cracking connection shutoff valve
SW-9 & SW-9B	Spent fuel pit recirculating filter back wash
SW-9A	Spent fuel pit fill line hose connection
SW-19	Vapor container manhole shutoff valve
SW-23	Vapor container manhole fill line trycock
SW-20	Header valve on alternate evaporator feed line
SW-26	Header valve to vapor container spray heads

To put service water system in operation:

1. Open valve SW-1.
2. Check domestic service system to assure that all valves are properly adjusted.
3. Open valve SW-6 gradually.
4. Gradually open valves at ends of all branch lines to bleed air from the system. When continuous water flows, close valves.
5. Observe action of level control valve LCV/6 and level controller LIC/6. If control does not function properly, close valve SW-15 and regulate level manually by use of valve SW-14.

To fill vapor container manhole:

1. Close manhole hatches and secure.
2. Close drain valves SW-24 and SW-25.
3. Open valve SW-19 one turn. Filling time is 20 minutes.
4. Open valve SW-23. Close when water overflows.
5. Check action of low-level switch LS/5 and level switch LS/5 as water level rises.
6. Close valve SW-19.

Compressed Air System

Description (Figure 2-26). Compressed air for the operation of pneumatic instruments and controls throughout the plant is supplied by an air compressor-receiver system. A standby air compressor is available for use during main compressor shutdown. Air enters the main com-

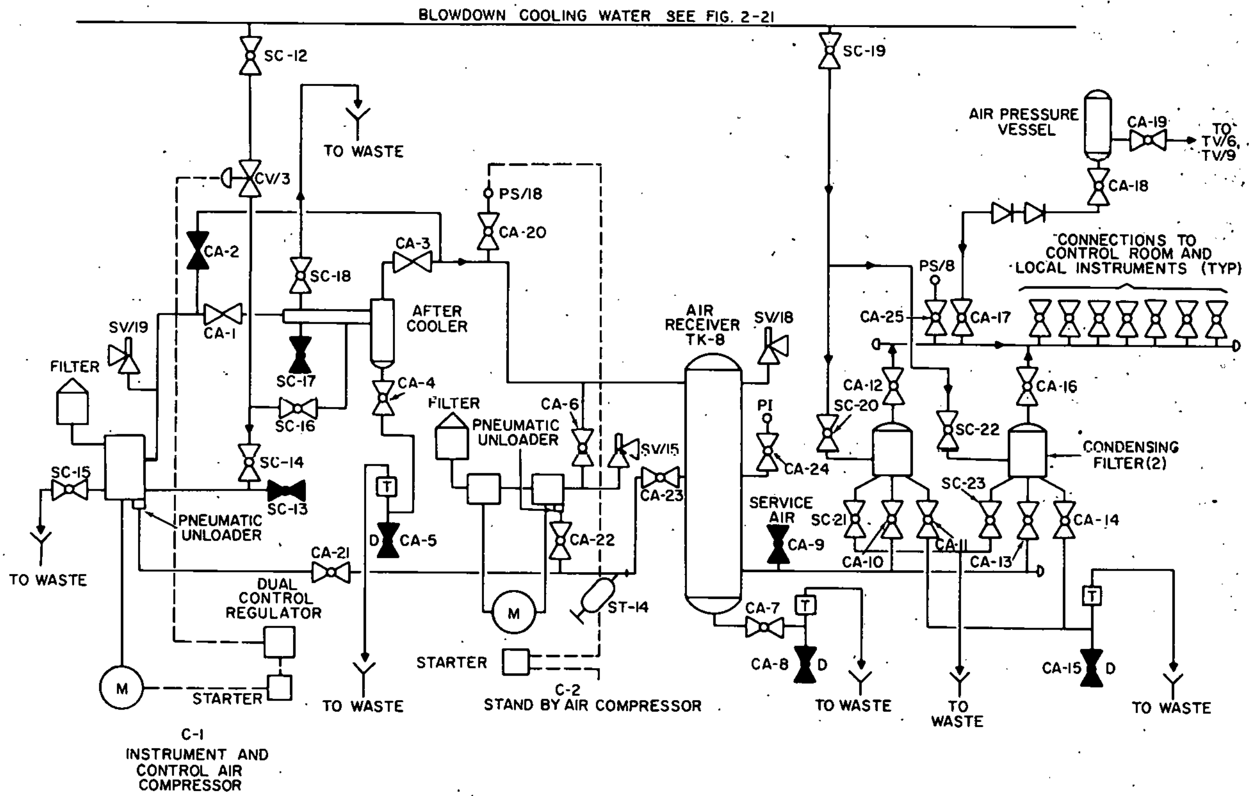


Figure 2-26. Compressed Air System, Schematic Diagram

pressor through a filter, is compressed, and passes through an after-cooler to the air receiver. It is drawn from the tank, through moisture condensing filters, to a manifold. The manifold supplies air to all pneumatic instruments and controls in the plant and to an air pressure vessel for trip valve supply. All air cooling, in the compressor, after-cooler, and condensing filters is performed by the passage of cove water through the equipment. This water is piped to the station waste line after use.

The main compressor is a one-stage, double-acting, reciprocating unit. It delivers 50 cfm free air at a pressure of 100 psig. The compressor is driven by a 15-HP induction motor powered from 460-volt bus No. 2. Cove water is circulated in the compressor water jacket to cool the unit during operation.

The air is discharged from the compressor and passes through the after-cooler tubes, where cove water in the surrounding shell cools it to 105°F. Moisture, condensed from the air by the cooling, is drained off to the station waste line through a trap.

Air leaves the after-cooler and enters a receiver of approximately 20-cubic-foot capacity. The receiver is equipped with a pressure gauge and a condensed moisture drain outlet. The safety valve (SV/18) relieves at 150 psig.

Air is drawn from the receiver through two condensing filters. Each of these filters contains a condensing section of tube coils for cooling water, and a filter section. The rated capacity of each unit is 30 scfm at 100 psig. Condensed moisture is drained from the bottom of the filters through a common trap to the station waste line.

The standby air compressor is a two-stage, single-acting, reciprocating unit. The compressor delivers 18.3 cfm free air at a pressure of 100 psig to the receiver. No water cooling is provided. The standby unit is driven by a 5-HP induction motor powered from the 460-volt bus No. 1. A pressure switch (PS/18) automatically starts the standby compressor if the after-cooler discharge pressure drops to 70 psig. Another pressure switch (PS/8), located downstream of the condensing filter, sounds an alarm if the outlet pressure of the system falls to 70 psig.

Operation.

Table 2-11. Valve Settings for Compressed Air System Start Up

OPEN

TAG NO.	DESCRIPTION
CA-3	After-cooler air outlet
CA-6	Standby compressor air outlet
CA-10 & CA-13	Condensing filter air inlets
CA-12 & CA-16	Condensing filter air outlets
CA-4	After-cooler condensate drain outlet
CA-7	Receiver condensate drain outlet
CA-11 & CA-14	Condensing filter condensate drain outlets

Table 2-11. Valve Settings for Compressed Air System Start Up (Cont'd)

TAG NO.	DESCRIPTION
	OPEN
CA-21, CA-22 & CA-23	Control line block valves
CA-1	After-cooler air inlet
CA-20	PS-18 valve
CA-24	Air receiver PI valve
CA-25	PS-8 valve
CA-17	Air outlet to trip valve air pressure vessel supply line
CA-18	Air inlet to trip valve air pressure vessel
SC-12	Cooling water inlet to main compressor and after-cooler supply lines
SC-14	Cooling water inlet to main compressor water jacket
SC-15	Cooling water outlet from main compressor water jacket
SC-16	Cooling water inlet to after-cooler shell
SC-18	Cooling water outlet from after-cooler shell
SC-19	Cooling water inlet to condensing filter supply lines
SC-20 SC-22	Cooling water inlets to condensing filter tubes
SC-21 SC-23	Cooling water outlets from condensing filter tubes
	CLOSED
CA-5	After-cooler trap drain
CA-8	Receiver trap drain
CA-15	Condensing filter trap drain
CA-2	After-cooler air bypass
CA-19	Trip valve air pressure vessel outlet to trip valves
CA-9	Instrument air outlet
SC-13	Main compressor cooling water drain
SC-17	After-cooler cooling water drain

To put main compressor in service and set up standby compressor for automatic switchover:

1. Turn main compressor regulator selector switch to CONSTANT SPEED position.
2. Check that receiver pressure builds up to 100 psig.
3. Turn standby compressor motor control switch to AUTO position.
4. Open trip valve air pressure vessel outlet to trip valves (CA-19).

WATER TREATMENT

Service Water

Source. Service water for the APPR-1 plant is drawn from the Fort Belvoir mains. These mains are normally supplied from Accotink Creek, and in emergencies draw from any or all of three wells in the area.

Analysis. The average composition of service water from the Fort Belvoir mains is tabulated below:

pH 7.4

Constituent	PPM
Dissolved solid	85.0
Hardness, as $CaCO_3$	45.0
non-carbonate	24.0
Sulfate	27.0
Bicarbonate	26.0
Alkalinity, as $CaCO_3$	21.0
Calcium	16.0
Silica	10.0
Chloride	8.5
Sodium	8.1
Carbon dioxide	1.6
Magnesium	1.2
Nitrate	1.0
Total iron	0.2
Fluoride	0.1

Control Data (Normal Operating Range)

Primary Make-up Water	
Resistivity, ohm-cm	1,000,000
pH	6.5 - 9.0
Hydrogen, cc/1	15 - 45
Chlorides, ppm	0.5

Note

When primary make-up water resistivity drops to 700,000 ohm-cm or less for a period of 36 hours, a new demineralizer should be put into service and the old one removed.

Primary Blowdown	
Resistivity, ohm-cm	500,000
pH	7.0 - 9.0
Hydrogen, cc/1	15 - 45

Evaporator Effluent	
Resistivity, ohm-cm	250,000
pH	6.5 - 7.0
Evaporator Blowdown	
Total solids, ppm	600
Boiler Feed Water (Hotwell, Distilled Water Tank, Steam)	
Resistivity, ohm-cm	100,000
pH (Morpholine control)	8.5 - 9.2
Oxygen, ppm	0.03
Secondary Blowdown Water	
Resistivity, ohm-cm	100,000
Hardness, ppm	1.0
Chlorides, ppm	0.5
pH	8.0 - 9.2
Oxygen, ppm	0.03
Hydrazine, ppm	0.1 - 0.5
Circulating Water (Cove Water)	
Chlorine, ppm residual during intermittant feed	0.5

Note

Frequency of chlorine feed will vary with the seasons. Feed is to be frequent enough to prevent algae and slime growth in the condenser and plant pipings.

Shield Water	
Potassium dichromate, ppm	500 - 1000
pH	8.0

ELECTRICAL POWER

General

The main power ring bus, station service feeders and busses, and associated switchgear and instruments are shown in a one-line representation in figure 2-9. These systems are described briefly in Section 1, GENERAL DESCRIPTION, under ELECTRICAL SYSTEMS.

The systems are protected from the harmful effects of various types of failure by appropriate circuit breakers. The ring bus contains breakers B, C, D, and E. This equipment is described below under 4160-Volt Bus and Switchgear. The ring bus connection to the ERDL bus is made by breaker A, which is described below under Service Transmission. The station service system contains breakers F, G, and H. This equipment is described below under 460-Volt Bus and Switchgear.

During normal plant operation, breakers A, B, C, D, E, F, and G are closed; breaker H is open. Thus, power from the generator is carried through both sides of the ring to the ERDL busses, as well as through both station service feeders to plant equipment.

In the event of a short circuit in either bus A or B of the ring, the two breakers in the bus (C and E, or B and D) are automatically tripped and the other bus carries the entire load.

Should the voltage on one of the 4160-volt busses drop, because of breakers tripping or any other reason, the breaker (F or G) in the station service feeder from that bus is tripped. Breaker H is then automatically closed so that the remaining feeder can supply both 460-volt busses.

In the event ground overcurrent from the generator reaches the left-hand side of the ring, on either bus A or B, or from bus A or B to the generator, breakers D and E are automatically tripped to isolate the generator and so prevent damage to the system. A breaker in the generator field circuit is also tripped. Breakers D and E will also be tripped if the turbine is shut down. Power is then drawn from the VEPCO system, through the right-hand side of the ring, to supply station service equipment. It is essential that certain plant equipment, particularly the primary coolant pumps, the pressurizer heaters, and the condensate recirculating cooling pumps continue to operate even though the plant is running at no load.

An overcurrent trip on breaker A acts to open the breaker to protect the system from overload by VEPCO. If the breaker A trip fails to operate, it is backed up by overcurrent trip relays on the right-hand side of the ring which will trip breakers B, C, and A to isolate the system from VEPCO. This arrangement also protects the ERDL busses and VEPCO from short circuits on the APPR-1 system. An underfrequency relay will trip breaker A if the APPR-1 frequency drops, due to overload, and frequency control is lost.

An auxiliary circuit, linked by potential transformers across phases A and B of the busses, provides a means for checking the synchronization of frequency and voltage on either side of an open circuit breaker. Breaker synchronizing switches are interlocked with the breaker closing switches so that synchronization must be checked prior to closing breakers A through H. This will prevent connecting an APPR-1 powered portion of the circuit with a VEPCO powered portion of the circuit if the APPR-1 generator is out of synchronism. Simultaneously, the line voltages on each side of an open breaker are checked and should be equalized by adjusting the excitation of the APPR-1 generator. One transferable operating handle is provided for all the synchronizing switches. It is therefore possible to synchronize across only one breaker at a time.

Breaker A is interlocked with breakers B and C so that it must be closed before B and C. VEPCO power must be conducted at least as far as breakers B and C so the APPR-1 frequency and voltage may be synchronized with VEPCO before connecting the APPR-1 system to the VEPCO system.

Table 2-12. List of Air Circuit Breaker Tripping Devices

AIR CIRCUIT BREAKER	TRIPPING DEVICE
A	Control switch Time-delay overcurrent relay Underfrequency relay
B, C	Control switch Instantaneous overcurrent relay Time-delay overcurrent relay

Table 2-12. List of Air Circuit Breaker Tripping Devices (Cont'd)

AIR CIRCUIT BREAKER	TRIPPING DEVICE
D, E	Control switch Generator differential overcurrent relay Ground overcurrent relay Reactor scram relay
F, G	Control switch Undervoltage relay Inverse time magnetic trip attachment Selective short time overcurrent trip attachment
H (Normally open)	Control switch Inverse time magnetic trip attachment Selective short time overcurrent trip attachment

If a breaker is tripped by relays, they should not be reclosed until the trouble has been located and corrected. Check and reset relay targets. If breakers D and E have tripped, the lock-out switch must be reset manually before the breaker can be reclosed. Breaker A may be reclosed once but if it reopens must not be reclosed again.

Operating indicating lights on the control panel show the operating status of the breakers. A red light indicates the breaker is closed; a green light indicates the breaker is open and in an operating position; an amber light indicates the breaker has been tripped by relay action. If all lights are off, the breaker is in a non-operating position. An alarm sounds in the control room in the event a breaker is tripped by relay action.

The following electrical system performance characteristics are measured and are indicated on the control panel:

1. Exciter armature voltage, in volts.

2. Exciter armature current, in amperes.

3. Generator air temperature, in °C.

4. Ring bus phase current input, in amperes.

5. Ring bus line voltage, in volts.

6. Ring bus three-phase power, in kilowatts; also recorded on the control panel.

7. Ring bus three-phase reactive power, in kilovolt-amperes reactive (kolo-vars).

8. Ring bus frequency, in cycles per second.

9. Station service line voltage, in volts; also indicated at the 460-volt switchgear.

10. Station service phase current, in amperes, for each bus. Also indicated at the 460-volt switchgear.

11. Station service three-phase energy, in kilowatt hours (total of busses 1 and 2).

Total generation, net plant output, and VEPCO plant input in kilowatt hours is measured by meters in the 4160-volt switchgear.

A drop in the VEPCO power input to the Fort Belvoir system to 500 KW will sound an alarm in the control room.

4160-Volt Bus and Switchgear

The switchgear for the 4160-volt busses is located in metal clad housing situated outside the plant building. This equipment includes the busses themselves, circuit breakers, relays, relay and instrument transformers, watt-hour meters, and wiring terminals.

The air circuit breakers utilize magnetic forces produced by the load current and an air stream from a booster air cylinder to interrupt the arc formed upon tripping. A breaker contains three electrically isolated sections, one for each phase of the system. When a control switch on the electrical section of the control panel is placed in the CLOSE position, a relay energizes a solenoid coil in the breaker to close the contacts. When a trip coil in the breaker is energized by a relay or by the control switch, a mechanical device is actuated to open a lock on the breaker and spring action opens the contacts of the breaker. The breakers are mounted in the switchgear cabinets in such a manner that they can be lowered for removal to perform maintenance and raised for replacement to operating condition. The procedure for these operations is described in the INSPECTION AND SERVICE MANUAL, Section 4, MAINTENANCE AND REPLACEMENT.

CAUTION

The breaker mechanism is designed only for electrical closing and a maintenance closing lever is supplied only for use in making adjustments. Never attempt manual closing with the breaker in service, for, under such conditions, sufficient closing force and speed cannot be applied. This could result in severe arcing, damage to the breaker, and risk of injury to the operator.

Breaker D, which links 4160-volt bus B to the generator, is tripped by either a moderate, long time fault current or a large, short time fault current on bus B by combined time delay overcurrent and instantaneous overcurrent relays. Four such relays are provided. Three are connected across the phases to protect against phase-to-phase faults. The other is connected between a phase and neutral to protect against phase-to-ground faults from any phase. If either of these relays detects a fault current, an auxiliary relay will also trip breaker B to isolate the bus.

A generator phase-to-phase short circuit causes a differential relay to energize an auxiliary relay which trips breakers D and E. A generator phase-to-ground short circuit actuates a time delay overcurrent relay which energizes an auxiliary relay to trip the same breakers. This will isolate the ring bus from the generator.

Breaker E is also interconnected with breaker C, and they operate in the same manner as breakers D and B, both being tripped simultaneously in the event bus A receives a phase-to-phase or phase-to-ground fault.

460-Volt Bus and Switchgear

The switchgear for the 460-volt busses is located in metal clad housing situated in the electrical equipment room on the ground floor level. The two station service transformers, in their own housings, are located nearby. The switchgear includes the busses themselves, circuit breakers, relays, relay and instrument transformers, and wiring terminals. The air circuit breakers are of the electrically operated type, rated at 600 amperes and 600 volts. They each contain an inverse time magnetic trip and a selective short time overcurrent trip. The inverse time magnetic trip acts to trip the breaker in the event of a prolonged fault of moderate value. The selective short time overcurrent trip acts quickly to trip the breaker if a sudden, high fault occurs.

If 4160-volt bus A loses power, an undervoltage relay energizes an auxiliary relay which in turn trips breaker G and closes breaker H to connect both 460-volt busses and maintain power supply to 460-volt bus No. 2. Similarly, if 4160-volt bus B goes out, another undervoltage relay and auxiliary relay trip breaker F and close breaker H to supply power to bus No. 1 through bus No. 2.

Each component powered from a 460-volt station service bus is protected by an individual, manually operated air circuit breaker, with the exception of the D-C rectifier-charger, which is fused. The 460-volt switchgear is located in two-section cabinets near the station service transformers. Also contained in these cabinets are the equipment control circuits, including control transformers and starter relays. The individual air circuit breakers for the equipment powered from the miscellaneous motor feeder are locally situated.

Service Transmission

Service transmission equipment consists of the 2500-KVA transformer, a 3-pole, 4160-volt disconnect switch at the 2500-KVA transformer, breaker A in the 4160-volt switchgear cabinet, and the existing ERDL 2400-volt switchgear. All of this equipment is located at substation H327.

Breaker A, which connects the rings bus to the ERDL busses, is tripped by one of three overcurrent relays when overcurrent occurs in either direction. Each of these relays will respond either to a prolonged moderate fault current or an instantaneous, high fault current. An underfrequency relay is also provided for breaker A. An interlock with breakers B and C makes it impossible to energize the breaker A solenoid coils to close breakers B and C until breaker A has been closed. Breaker A may also be tripped manually at the breaker or by a control switch at the control panel.

OPERATING CHARACTERISTICS - APPR-1

VEPCO DISTRIBUTION NETWORK

The one-line diagram, figure 2-27, represents schematically the electrical interconnection between the Army Package Power Reactor (APPR-1) and the Virginia Electric and Power Company power supply to Fort Belvoir.

The control scheme governing operation of the brochure has been formulated to insure that operation of the APPR-1 will be characterized by the following essential features:

1. The APPR-1 is never to operate automatically as an emergency source of power for all or any part of Fort Belvoir. The nuclear plant will be operated to supply power to the Fort network in absence of VEPCO power only as a result of express negotiations between the Commanding Officer of the Fort and the Chief of Engineers.

2. The APPR-1 is never supposed to feed power to the VEPCO network outside the Fort.

3. Any condition that totally interrupts VEPCO supply of power to the Fort is supposed to automatically separate the APPR-1 ring bus from the Fort network.

4. If, for any reason, the APPR-1 ring bus becomes separated from the Fort network, reconnection must be accomplished by manual closing of breakers by the APPR-1 operator.

Referring to figure 2-27, the significant operational characteristics of the breakers are as follows:

1. With the APPR-1 generator shut down, all breakers except D and E will be closed. Power for the APPR-1 auxiliaries will be fed to the ring bus through the tie line from H327.

2. When power from the APPR-1 generator is to be impressed on the network, parallelization will normally be accomplished by closing breakers D and E simultaneously.

3. Breakers 308 and 313 are monitored by reclosing relays to provide three timed reclosures in case of faults on the VEPCO feeders to the breakers. The reclosing relays are supervised by voltage and synchronous check relays to prevent the breakers from reclosing when the VEPCO lines and the bus at switch station No. 251 are energized unless the two sources are synchronized.

4. Breaker No. 1 is interlocked with breakers 308 and 313 in such a way that it will open if breakers 308 and 313 are opened simultaneously. Breaker No. 1 is also supervised by a voltage relay connected to a pot transformer on the APPR-1 side of the breaker in order to prevent breaker No. 1 from reclosing unless the feeder between it and breaker No. 13 is de-energized.

5. Breaker A is interlocked with breaker No. 1 to open in case breaker No. 1 opens.

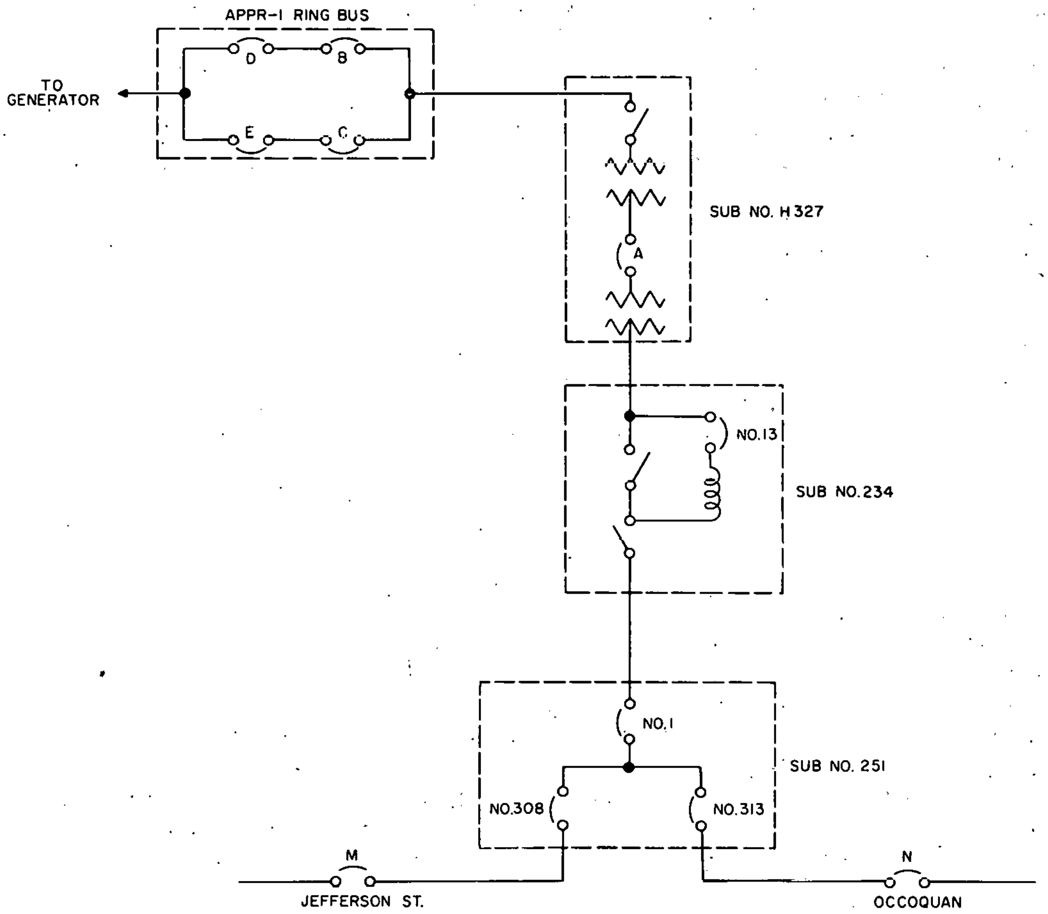


Figure 2-27. Post Substation Connections to APPR-1

6. Breaker A is also interlocked with breaker No. 13 to open in case breaker No. 13 opens. That is, opening of either breaker No. 1 or breaker No. 13 will cause breaker A to open.

7. Breaker No. 13 is supervised by overcurrent relays which are set to open No. 13 ahead of No. 1 in the event of fault from the H327 substation. Breaker No. 13 is not an automatically reclosing breaker. It can only be reclosed manually at the 234 substation.

8. Breaker A is interlocked with breakers B and C in such a way that it cannot be closed unless breakers B and C are open.

9. Breaker A is supervised by an underfrequency relay which will open breaker A in case the frequency on the network drops for any reason. The principal duty of this relay is to insure the opening of breaker A in case breakers M and N might be opened at the same time for any reason whatever. The loads on the VEPCO feeders between breakers M and N and 308 and 313 are such that the frequency on the network will drop instantaneously and appreciably in the event M and N should be open at the same time.

10. If breaker A opens for any reason, an audible alarm and a visual signal at the APPR-1 control station will be activated.

11. If breaker A opens while the network is receiving power from both VEPCO and the APPR-1, the APPR-1 operator can open breakers B and C, so as not to lose power to the APPR-1 auxiliaries, close breaker A, and then reparallel at breakers B and C.

12. Breaker A is not an automatically reclosing breaker. It can be closed manually at H327 or by switch at the APPR-1 control station only.

13. A telemeter signal activated by the VEPCO meter at switch station No. 251 is relayed to a following meter at the APPR-1 control station which can be set to activate an audible alarm when VEPCO power coming to switch station No. 251 bus falls below a predetermined level, probably 500 KW. This alarm will warn the APPR-1 operator in case the load in the Fort begins to fall close to the output level of the APPR-1 generator. He can then cut back on APPR-1 generation to insure that the APPR-1 will not feed power out over the VEPCO feeders in case the load in the Fort continues to decrease.

ECPE 2 May 1957

MEMORANDUM FOR RECORD:

SUBJECT: Joint Use of ERDL Substation H327 and 22 KV Circuit (South Post)

1. Energizing of the 4160-volt feeder to the APPR-1 plant will inaugurate an unusual condition in substation H327. One portion will be under the operational control of the Post Engineer, another portion under control of the Nuclear Power Branch.

2. It is imperative that all persons concerned have a complete understanding of the jurisdiction exercised by each party. Coordination of operations is necessary for (1) protection of life and property and (2) minimum disruption to the operation of each system.

3. The specific equipment involved in substation H327 includes:

a. Under operational control of the Post Engineer:

(1) One 2000-KVA, 22000-2400-volt, 3-phase transformer.

(2) One complete set of 2400-volt metal-clad switchgear and the feeders therefrom.

(3) One bank of 2400-220/110-volt lighting transformers.

b. Under operational control of the Nuclear Power Branch:

(1) One 2400-volt metal-clad air circuit breaker, designated as Breaker "A."

(2) One 2500-KVA, 4160-2400-volt, 3-phase transformer.

(3) One gang-operated, 4160-volt disconnect switch and 4160-KV feeder to APPR-1.

c. The 2400-volt bus of the ERDL switchgear listed under a(2) above is solidly tied to the ERDL side of Breaker "A." This portion is therefore common to both systems.

4. Operational SOP

a. The 4160 feeder is the main source of auxiliary power for APPR-1. After an interruption the APPR-1 operator is authorized to restore power over Breaker "A" as soon as power is available.

b. The APPR-1 will not resynchronize with ERDL after a power interruption without first checking with the Post Engineer's representative. The APPR-1 control room will be supplied with an up-to-date listing of responsible P.E. personnel and where they may be reached at any hour of the day or night. After 1700 hours APPR-1 will phone the P.E. Duty Officer (Ext. 6181) who will contact P.E. personnel for emergency duty.

c. Normal synchronizing with or separation from ERDL may be performed without notification, but the Post Engineer requirements will be considered in emergencies.

d. Power flow through substation H327 and the voltage level hold on the 2400-volt bus will be maintained as requested by the Post Engineer insofar as possible.

e. Nuclear Power Branch personnel or authorized contractor personnel will notify the Post Engineer before entering H327 to perform switching, except in case of emergency.

f. NPB personnel will not interfere with any ERDL equipment. Post Engineer personnel will not operate any APPR-1 circuit equipment. All persons authorized to perform switching in H327 will be acquainted with the equipment under the jurisdiction of their department.

g. Standard power system clearance procedures will be used to isolate the APPR-1 system from ERDL circuits whenever required by Post Engineer operations. The same procedure, with Breaker "A" racked down and tagged and the 4160 disconnect open and tagged, will be used to permit work on the APPR-1 system.

h. Post Engineer personnel affected will be made aware of the new system problems created by the additional source of power. The APPR-1 operator will be notified before any planned switching on the 22-KV system which would isolate the APPR-1 from VEPCO.

i. NPB personnel will enter and maintain 48-volt control circuit fuses in substation 251 (Richmond Highway). APPR-1 personnel will sign the station register before leaving substation 251 and also notify the Post Engineer Office.

j. The Post Engineer will notify APPR-1 when an outage is planned on South Post breaker No. 1, and when it is all right for APPR-1 to come back on the system. In the event of any emergency, the same procedure will be observed.

k. The Post Engineer will rank APPR-1 as priority No. 2 in restoration of service following emergency outage.

l. Substation master keys will be furnished to authorized NPB personnel listed on an official list for entrance to subs 251, 234, and 327. Authorized NPB personnel will sign the station register upon entering any substation above.

m. Post Engineer will notify the APPR-1 any time 22-KB breakers No. 1 and No. 13 are bypassed.

n. Post Engineer will notify the APPR-1 shift supervisor (phone 2-2213 or 2-7197) of scheduled outages.

o. Nuclear Power Branch will submit a monthly statement to the Post Engineer showing kilowatt hours output of APPR-1. Meter readings should be made on the 24th day of each month except when date falls on a Saturday or Sunday, when reading should be taken on the 22nd of the month.

p. Supervisory operation and maintenance personnel of NPB and the Post Engineer will see that all affected personnel are familiar with the provisions of the memorandum.

FOR THE POST ENGINEER:

/s/ O. W. Svaeri
O. W. SVAERI
Chief, Utilities Br.

/s/ L. W. Hyatt
L. W. HYATT
Electrical Engineer

/s/ H. W. Rudd
H. A. RUDD
Electric Supt.

FOR NUCLEAR POWER BR:

/s/ J. A. Bacci
J. A. BACCI
Major, CE

/s/ E. E. Laing
E. E. LAING

Generator and Exciter

Description (Figure 2-17). The generator is a 6-pole A-C machine. Its field excitation is supplied by a 4-pole D-C compound exciter operated on the same shaft as the generator. The generator is Y-connected, with grounded neutral, so as to deliver a phase sequence A-B-C. The generator is coupled to the turbine through reduction gearing which reduces turbine shaft speed in an overall gear ratio of 4.57/1. The reduction gear lubrication is supplied by the turbine oil system. The generator and exciter shaft bearings are oil, ring type, self-lubricating.

A voltage regulator, in the shunt field circuit of the exciter, automatically controls the generated voltage by regulating the generator field excitation. It is essentially an automatically controlled exciter field rheostat. A manually controlled field rheostat, situated on the electrical section of the control panel, is provided for startup, shutdown, control, if the regulator is out of service, and to compensate for large variations of voltage which would occur with large changes in load.

The generator is cooled by circulation of air through a closed circuit from its housing through the shell of an air cooler and return. Condenser circulating water from the cooling water booster pumps is passed through the tubes of the cooler. The cooled air is returned to the generator.

The generator controls available to the operator consist of a turbine load limit control switch, a synchronizing governor motor control switch, a voltage regulator adjusting rheostat, an exciter field rheostat, control switches for circuit breakers A, B, C, D, E, F, G, H, and the generator field breaker, a synchroscope and a synchronizing circuit containing breaker synchronizing switches, a frequency meter, synchronizing lights, and incoming and outgoing voltage meters. In addition, a temperature transfer switch is provided to measure generator winding temperatures. All of these controls are located on the electrical section of the control panel and are shown on figure 2-12.

Performance Data.

Generator rated power output at 0.8 power factor, KW	2000
Generated line voltage at full load, volt	4160
Generated line current at full load, amp	347
Generator speed	
at full load, RPM	1200
at no load, RPM	1247
Generator frequency	
at rated speed, cps	60
Generator air temperature,	
minimum permissible	
°C	30
°F	86
normal operating	
°C	35
°F	95
maximum permissible	
°C	40
°F	104

Performance Data (Cont'd)

Exciter rated power output, KW	15
Exciter rated terminal voltage, volt	125
Excitation current, rated, amp	120

Operating Procedures. To apply load to the generator:

1. Check that generator speed is in vicinity of 1200 RPM.

2. Check that circuit breakers D and E are open and in operating position.

3. Check that generator air cooler is operating.

4. Turn field rheostat clockwise fully until maximum resistance is in the field.

5. Close generator field circuit breaker.

6. With the voltage regulator adjusting rheostat set at mid position, adjust excitation current with exciter field rheostat so that generator terminal voltage builds up to approximately 4160 volts as measured on the generator voltmeter.

7. Turn load limit control switch to increase load position. Hold until load limit device is set for maximum value.

8. Check voltage at 4160 and adjust frequency to 60 cycles with governor motor switch on main electrical control panel.

9. Turn synchronizing switch for breaker D to ON position. Check difference in frequency on synchroscope located on swinging synchronizing panel of electrical section of control panel. Adjust speed of generator to approximately 1200 RPM (60 cycles) by use of governor speed motor control switch so as to synchronize generator frequency with VEPCO. Adjust so the pointer on the synchroscope is rotating slowly in the FAST direction.

10. Vary generator output voltage to match incoming voltage by use of the exciter field rheostat and make fine adjustments with the voltage regulator adjusting rheostat. The voltage regulator adjusting rheostat should be in the middle third of its range when this is completed. If not, adjust exciter field rheostat to bring it in this range.

11. When the synchroscope pointer comes to within 5° of 12 o'clock in fast direction, close circuit breaker with control switch.

12. Immediately turn governor motor control switch to raise position to load generator to at least 200 KW but not more than 500 KW.

13. Turn synchronizing switch to OFF position and turn load limit control switch to LOWER position until decrease in reading of generator KW meter shows it has taken control.

14. Place synchronizing switch handle in place for breaker E and turn to ON position. Check for equal voltage on both incoming and outgoing voltmeters and that synchroscope pointer is at 12 o'clock. Close circuit breaker with control switch and turn synchroscope switch to OFF position.

15. If plant is to operate independently, adjust generator load with load limit control switch until line KW meter reads zero and then open breakers B and C. Turn load limit control switch to RAISE to return control to turbine speed governor. Then adjust speed with governor motor control switch to give 60 cycles on generator frequency meter and voltage with voltage regulator adjusting rheostat to give 4160 volts on generator voltmeter.

16. If plant is to operate in parallel with VEPCO, turn generator governor motor control switch to RAISE until governor reaches maximum position and turn voltage regulating adjusting rheostat to RAISE to obtain desired generator KVAR output for the existing load on the generator or substation voltage. If new position of rheostat is out of middle third of its range, readjust as in step 10. Do not increase KVAR output if substation voltage reaches 2500 volts or station service voltage reaches 490 volts. Do not let power factor go below 80%.

WARNING

The voltage regulator is very sensitive to rate of change. Make voltage adjustments very slowly.

Never allow the power factor to be leading. This would pull vars from VEPCO, under-excite the generator, and possibly cause it to drop out of step.

17. Check all process and nuclear instruments.

18. Turn the load limit control switch to the INCREASE position to apply load at a rate no faster than 200 KW per minute until desired load is reached. The KVAR load should be adjusted concurrently with the load change. The excitation current must never exceed 104 amps.

19. Check generator air and oil temperature. Adjust circulating water flow, if necessary. Throttle flow on discharge side only.

To take load off generator:

1. Turn load limit control switch to DECREASE position to reduce load on generator. Reduce load at a rate no faster than 200 KW per minute.

2. When load limit control has reduced generation to 200 KW, reduce generator KVAR output to zero with voltage regulator adjusting rheostat.

3. Turn the speed changer to the LOWER position until generator KW decreases to zero.

4. Trip breakers D and E.

5. Reduce excitation current to zero with voltage regulator adjusting rheostat and exciter field rheostat.

6. Trip generator field circuit breaker.

Under certain circumstances, the turbo-generator units may have to be shut down unexpectedly because of oil pump failure, abnormal noise or vibration in the turbine, or other mechanical difficulties. A unit may also have to be shut down because of insulation failure in the generator. In case of mechanical difficulties, the operator must judge the urgency of the shutdown. In the case of insulation failure in the generator, certain relays will operate to remove the generator from the line.

If time permits, without damage to the equipment, the procedure outlined above should be followed. If it is necessary to stop the turbo-generator immediately, press the trip button at the throttle valve. When the throttle valve closes, a limit switch mounted on the valve will operate to disconnect the generator from the bus by opening main breakers D and E.

If the generator is disconnected from the VEPCO system (losing frequency control) and the generator load is reduced to partial or no load, the turbine speed governor will adjust and hold the speed at some value between synchronous speed (5489 RPM) and the high-speed stop (5820 RPM), depending upon the load. The operator should turn the speed changer in the DECREASE direction until the speed drops, and then turn the load limit device to the maximum load position. Adjust the speed to synchronous speed (5489 RPM) with the speed changer. When ready to synchronize and reconnect the generator to VEPCO, follow the procedure described above under the heading to apply load to the generator.

To de-energize the voltage regulator and put the generator under control of the exciter field rheostat alone:

1. Turn the exciter field rheostat in a small amount until the exciter voltage and/or the A-C voltage begins to fall.

2. Turn the voltage regulator adjusting rheostat slowly in the RAISE direction until the exciter voltage and/or the A-C voltage returns to its initial value.

3. Repeat steps 1 and 2, as necessary, until the voltage regulator adjusting rheostat is turned to its extreme RAISE position.

To replace the voltage regulator in control:

1. Turn the voltage regulator adjusting rheostat slowly in the LOWER direction until the exciter voltage and/or the A-C voltage begins to fall.

2. Turn the exciter field rheostat out slowly until the exciter voltage and/or the A-C voltage returns to the initial value.

3. Repeat steps 1 and 2 until the exciter field rheostat has been returned to the desired operating point.

Emergency Equipment

Description (Figure 1-10). A D-C power distribution system is incorporated in the plant to provide emergency lighting in the event of power failure from APPR-1 and VEPCO as well as to power instruments and provide operating power for the switchgear controls. The system, rated at 125 volts, can supply power to the 4160-volt and 460-volt switchgear, to the 4160-volt test cabinet, to the control room instrument power supply, to an inverter supplying emergency instrumentation power, to the laboratory for test purposes, to the instrument repair room for test purposes, to the compressed air control system solenoid valve power supply, to the annunciator (alarm and signal light) power supply, to a 400-cps motor-generator set which supplies the control rod position indicating system, and to emergency plant lights. The system receives power from a rectifier-charger and/or a motor-generator set, both powered from 460-volt bus No. 1. The rectifier has limited capacity compared to the other D-C sources. A 60-cell, 125-volt, D-C battery connected in parallel with these sources stores energy from either or both for emergency use and peak momentary load periods.

The rectifier-charger is an electronic device which draws A-C power from the bus and delivers D-C power at a regulated constant voltage and variable current. It is a self-contained unit located on the north wall of the electrical equipment room. It is connected to the miscellaneous motor feeder of 460-volt bus No. 1 through a two-pole, fused safety switch.

The motor-generator set is located in the electrical equipment room and consists of a 7-1/2-HP motor which is connected directly to 460-volt bus No. 1 through an air circuit breaker and a 5-KW, D-C compound generator. The generator output is delivered to the D-C distribution system through a D-C contactor. The generator is interlocked with the motor starter circuit and with the battery hood exhaust fan so that its circuit breaker cannot close unless both of the starters are energized.

The D-C batteries consist of two racks of 30 cells each and are located in the electrical equipment room. The cells are connected to each other in series to add their individual average voltages of 2.15 volts to obtain a total average voltage of 129 volts.

A D-C ground detector is provided for this system and indicates the magnitude of any grounds in the D-C system.

Operating Procedures.

Rectifier-Charger:

1. When power is available at 460-volt bus No. 1, close miscellaneous motor feeder circuit breaker at motor control center.

2. Open the rectifier-charger D-C disconnect switch.

3. Turn the rectifier-charger current-limit control knob to the extreme counterclockwise position.

4. Close the rectifier-charger A-C switch.

5. Close the D-C disconnect switch.

CAUTION

Upon startup of the rectifier-charger for the first time and upon startup after tube replacement, delay 20 minutes between steps 4 and 5.

6. Adjust the rectifier-charger voltage control knob to 129 volts.

7. Adjust the current-limit control knob for 12.5 amperes (rated).

8. The unit is self-regulating and requires only periodic level setting checks during operation.

Motor-Generator Set:

1. Close motor-generator motor circuit breaker.

2. Adjust generator field rheostat to obtain no-load voltage of 2 volts greater than the battery voltage.

3. Close generator output air circuit breaker.

4. Adjust generator field rheostat to obtain output voltage of 129 volts.

5. The output of the motor-generator set is manually controlled by a field rheostat and should be checked periodically and whenever a change in D-C power demand occurs. Adjust generator field rheostat to maintain rated voltage of 129 volts. This will cause the rectifier-charger to automatically cut its output to zero while the generator is capable of supplying the load.

General:

1. Close the following D-C supply breakers at the D-C distribution cabinet: 460-volt switchgear supply, 4160-volt switchgear supply, main control board supply, emergency instrumentation inverter supply, solenoid valve supply, and annunciator supply.

2. The emergency lighting D-C supply breaker at the D-C distribution cabinet should be closed at all times. The emergency lights should be checked for burnout of any lamp on a weekly inspection. The throwover D-C contactor, located near batteries, will transfer automatically upon A-C power failure.

The operator should check the voltage and amperage readings on the battery charger and the D-C bus ground indicating meters for an abnormal condition at least twice every shift, and more often if necessary to ensure reliable operation. If the D-C voltage falls below 125 volts, electricians should be called at once to check the circuit and battery charger. Any abnormalities or difficulties should be reported to the shift supervisor immediately.

ROUTINE OPERATING INSTRUCTIONS
EXIDE BATTERIES

Size and Type: 60-DOE-17

RATING 60-DOE-17	DISCHARGE RATES	LIMITING DISCHARGE VOLTAGE BATTERY	LIMITING DISCHARGE VOLTAGE PER CELL
25	Amps. for 8 hours	105	1.75
52.8	Amps. for 3 hours	105	1.75
100.8	Amps. for 1 hour	105	1.75
272	Amps. for 1 minute	105	1.75

Float the battery continually across the bus, maintaining an average bus voltage close to 129 volts for 60 cells (2.15 volts per cell).

It is essential that the voltmeter be kept in close calibration, as an error of only a few volts might have considerable effect upon the reliability and life of the battery.

Check floating voltage at least four times daily.

With the battery fully charged, the voltage should be adjusted by starting below the desired value and increasing in steps. Short intervals should be allowed between each step of the adjustment. Use the voltage control only; leave the current control at maximum rectifier output.

When necessary to discharge, do not, except in an emergency, allow the specific gravity to drop more than 60 points below normal operating gravity. At this point, there is practically no reserve capacity remaining; therefore, the discharge should ordinarily be stopped before this point is reached. In no event allow the voltage to drop below 105V.

Recharge as soon as possible after an emergency discharge. Any rate may be used that does not produce gassing or a cell temperature exceeding 110°F. Cell temperature is measured with a thermometer. Always reduce the rate before the above limits are reached, finishing the charge at the normal rate of 25 amperes or less.

Once every month, or after any appreciable discharge of the battery, raise the voltage to 138 volts (2.33 volts per cell) for a 24-hour period. After this charge has been completed, normal floating conditions should be resumed.

Select a conveniently located cell as a pilot cell. Add water sufficiently often to keep the height of the electrolyte approximately constant at the indicated level line. Record the specific gravity and temperature of the pilot cell weekly. With proper voltage adjustment the gravity will remain practically constant within 3 to 5 points of the full charge gravity.

SOP FOR BATTERY MAINTENANCE

RESPONSIBILITY: The shift supervisor on the 2300 - 0700 shift will be responsible for this maintenance.

PURPOSE: To assure proper care and maintenance is given the batteries.

SCOPE: This SOP includes the schedule for inspections, recharging, forms used, and channels for reports. (Technical battery information is included in EXIDE form 4676 and typed instruction sheet pasted to the left of batteries 30 and 31.)

PILOT CELL: A pilot cell will be established and changed semiannually unless conditions dictate otherwise. It will be the cell that shows the lowest specific gravity value compared to other batteries on the rack.

SCHEDULE: Each Monday at 0200 hours, pilot cell values for specific gravity, temperature of electrolyte, corrected specific gravity, and cell voltage will be read and recorded.

MONTHLY: On the 26th of each month at 0200 hours all cell values for specific gravity, temperature of electrolyte, corrected specific gravity, and cell voltage shall be read and recorded.

EQUALIZING CHARGE: Upon completion of the monthly recordings, an equalizing charge of 138-140 volts will be given the batteries for a period of 24 hours. Allow the battery to stabilize for another 24 hours. Again read and record all cell values for specific gravity, temperature of electrolyte, corrected specific gravity, and cell voltage, a total of 48 hours between readings.

WATER: NOTE: DO NOT ADD WATER OR ELECTROLYTE TO ANY CELL WITHOUT PERMISSION.

FORMS USED: All values will be recorded on DA Form 11-24. (If not available, notepaper will suffice.)

DISPOSITION: Completed forms will be placed on the Plant Operating Superintendent's desk.

INSTRUMENTATION AND CONTROL

General List.

Table 2-13. List of Special Control Valves

Note

For the location of special control valves, see figures 2-10, 2-16, 2-24, 2-25, and 2-26.

TAG NO.	DESCRIPTION
Control Valves	
CV/1	Contaminated waste storage tank vent shutoff valve. Pneumatically operated. Manual air loading station at control panel.
CV/2	Chlorinizer chlorine injection rate control valve. Manual control.

Table 2-13. List of Special Control Valves (Cont'd)

TAG NO.	DESCRIPTION
CV/3	Air compressor cooling inlet valve.
Flow Control Valves	
FCV/1	Steam generator blowdown flow rate control valve. Pneumatically operated, air-to-close type. Manual air loading station at control panel.
FCV/2 (EB-5)	Evaporator blowdown flow rate control valve. Manually operated, locally.
FCV/3	Steam bypass to condenser. Pneumatically operated, air-to-open, spring-return type. Manual air loading station at control panel.
FCV/4	Chlorinizer chlorine injection rate control valve. Service water operated by control valve CV/2.
Level Control Valves	
LCV/1	Feedwater heater shell level control valve. Pneumatically operated, controlled by level controller LC/1.
LCV/2	Condenser hot well high-level control valve. Pneumatically operated, controlled by LC/2.
LCV/3	Condenser hot well low-level control valve. Pneumatically operated, controlled by LC/3.
LCV/4	Steam generator shell level control. Pneumatically operated, controlled by level controller LRC/4, feedwater flow rate controller FRC/2, and steam pressure recorder PR/1.
LCV/5	Evaporator shell level control valve. Pneumatically operated, controlled by level controller LC/5.
LCV/6	Service water tank level control valve. Pneumatically operated, controlled by level controller LIC/6.
LCV/8	Primary make-up tank level control valve. Pneumatically operated, controlled by level controller LIC/8.
LCV/9	Chlorinizer tray level control valve. Float-operated.

Table 2-13. List of Special Control Valves (Cont'd)

TAG NO.	DESCRIPTION
Motor-Operated Valves	
MO-1 (PC-17)	Primary blowdown coolant flow rate control valve. Control switch on control panel.
MS-2	Steam main shutoff valve. Control switch on control console.
Non-Return Valve	
	Extraction steam line. Controlled by turbine oil system through an air valve.
Pressure Control Valves	
TV/PCV/1-1 TV/PCV/1-2	Combined trip valve and steam main pressure control valve. Low- and high-range units. Pneumatically operated.
PCV/2	Evaporator vapor discharge pressure control valve. Pneumatically operated.
PCV/3	Turbine-driven boiler feed pump exhaust pressure control valve. Pneumatically operated.
PCV/4	Condensate cooling water system feedwater inlet pressure control valve. Pneumatically operated.
PCV/5	Condensate cooling water system back pressure control valve. Pneumatically operated.
PCV/8	Back pressure regulator, turbine gland steam.
PCV/9	Hydrogen feed pressure control valves.
PCV/10	Manually operated. Hydrogen to seal leakage tank.
PCV/11	Chlorine pressure control valve. Service water operated.
PCV/12	Water to PCV/11.
PCV/13	Chlorinizer water pressure control valve.
PCV/14	Steam to air ejector.
PCV/15	Hydrogen for instrument testing.

Table 2-13. List of Special Control Valves (Cont'd)

TAG NO.	DESCRIPTION
Radiation Monitor-Controlled Valves	
RMCV/1	Diverts primary blowdown to contaminated waste tank upon high radiation level. Pneumatically operated.
RMCV/2	Diverts primary blowdown coolant to contaminated waste tank upon high radiation level. Pneumatically operated.
Safety Valves	
SV/1	Condenser shell.
SV/2	Steam main.
SV/3	Feedwater heater shell.
SV/4	Turbine-driven boiler feed pump turbine exhaust.
SV/5	Steam main (inside vapor container).
SV/6	Pressurizer.
SV/7	Primary coolant fill pump outlet.
SV/8	Primary coolant make-up pump outlet.
SV/9	Primary coolant make-up tank.
SV/10	Feedwater heater tube side.
SV/11	Primary blowdown cooler coils.
SV/13	Condensate recirculating cooling pump outlet.
SV/14	Evaporator shell.
SV/15	Standby air compressor outlet.
SV/16	Hydrogen system to seal leakoff tank.
SV/17	Seal leakage tank.
SV/18	Air receiver.
SV/19	Instrument air compressor outlet.
SV/20a, b, c	Chemical feed pumps.

Table 2-13. List of Special Control Valves (Cont'd)

TAG NO.	DESCRIPTION
Solenoid Valves	
SOV/1	Chlorinizer service water feed shutoff valve. Injection pump timer operated.
SOV/2	Chlorinizer ejector water injection shutoff. Ejector pump timer-operated.
Temperature Control Valve	
TCV/6	Air ejector temperature differential control valve.
Trip Valves	
TV/PCV/1-1 TV/PCV/1-2	Combined trip valve and steam main pressure control valve. See TV/PCV/1-1 and TV/PCV/1-2 under pressure control valves above.
TV/2	Steam generator drain line.
TV/5	Steam generator blowdown line.
TV/6	Shield tank cooling water outlet line.
TV/7	Primary blowdown coolant outlet line.
TV/8	Primary blowdown line.
TV/9	Steam dump line to condenser.
TV/10	Hydrogen to seal leakage tank.

Note

Refer to valve tables listed under Operating Procedures for specific components throughout Section 2, for listing and description of other valves in the plant.

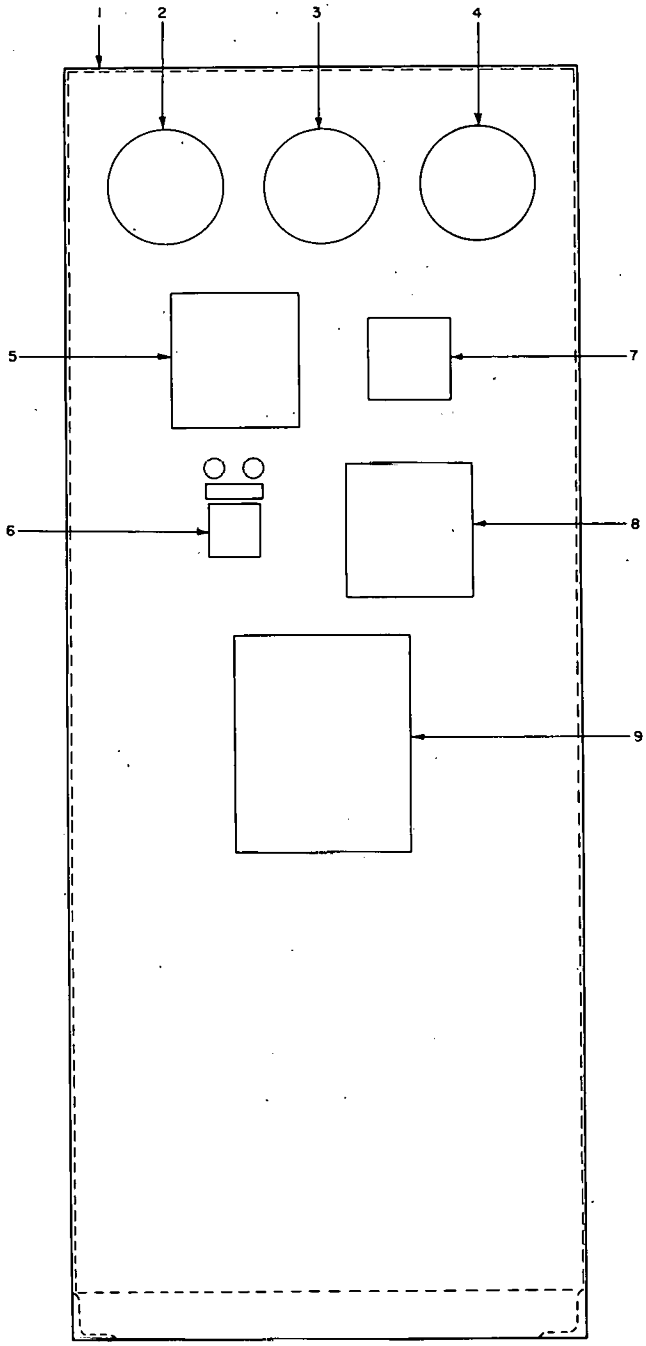


Figure 2-28. Turbine Gage Board

LEGEND FOR FIGURE 2-28

1. Turbine gage board
2. Main steam pressure gage
3. Turbine first stage pressure gage
4. Turbine exhaust pressure gage
5. Turbine speed tachometer
6. Motor-driven auxiliary oil pump control switch
7. Generator signal receiver
8. Generator signal transmitter
9. Turbine initial pressure regulator

Table 2-14. List of Plant Process Instruments

Note

For location of plant process instruments, see figures 2-10, 2-16, 2-24, 2-25, and 2-26. Nuclear instrumentation is described in Section 2, COMPONENT DESCRIPTION AND OPERATION, under PRIMARY SYSTEM, REACTOR. Radiation monitoring instrumentation is described in Section 3, SAFETY INSTRUCTIONS AND PRECAUTIONS, under MONITORING DURING PLANT OPERATION. Instruments mounted on the control panel are shown and listed in figures 2-5, 2-7, and 2-12. Control console instruments are shown and listed on figure 2-4. Turbine gage board instruments are shown and listed on figure 2-28.

TAG NO.	DESCRIPTION	READ
Conductivity Recording Instruments		
CR/101	Steam generator blowdown.	Control room
CR/102	Condensate. Five units, one in each quadrant of condensor hot well, one in evaporator overhead sample line.	Control room
CR/104	Primary blowdown, upstream of demineralizers.	Control room
CR/105	Primary blowdown, downstream of demineralizers.	Control room
Flow Rate Instruments		
FI/1	Primary coolant flow scram servo.	Control room
FI/2	Steam generator blowdown indicator	Locally Control room
FI/3	Chlorinizer chlorine gas indicator.	Locally
FI/4	Primary coolant blowdown. Flow integrator (associated with FR-2)	Control room
ER/1	Primary coolant recorder.	Control room

Table 2-14. List of Plant Process Instruments (Cont'd)

TAG NO.	DESCRIPTION	READ
FR/2	Primary blowdown recorder.	Control room
ERC/1	Main steam recorder controller. Controls level control valve LCV/4.	Control room
FRC/2	Feedwater recorder controller. Controls level control valve LCV/4.	Control room
FIC/5	Primary coolant pump cooling water.	Locally
Level Instruments		
LI/2	Distilled water tank indicator	Control room
LI/4	Contaminated waste storage tank indicator.	Locally
LI/5	Laboratory waste hold-up tank indicators.	Locally
LRC/4	Steam generator recorder controller. Controls level control valve LCV/4.	Control room
LRC/7	Pressurizer recorder controller. Controls primary coolant make-up pump output.	Control room
LIC/6	Service water tank indicator controller. Controls level control valve LCV/6.	Control room
LIC/8	Primary coolant make-up tank indicator controller. Controls level control valve LCV/8.	Locally
LC/1	Feedwater heater controller. Controls level control valve LCV/1.	
LC/2	Condenser hot well high-level controller. Controls level control valve LCV/2.	
LC/3	Condenser hot well low-level controller. Controls level control valve LCV/3.	
LC/5	Evaporator controller. Controls level control valve LCV/5.	
LS/1H	Condenser hot well high-level alarm switch.	
LS/1L	Condenser hot well low-level alarm switch.	

Table 2-14. List of Plant Process Instruments (Cont'd)

TAG NO.	DESCRIPTION	READ
LS/2	Seal leak-off tank high-level switch.	
LS/3H	Evaporator high-level alarm switch.	
LS/3L	Evaporator low-level alarm switch.	
LS/4	Seal leak-off tank low-level switch.	
LS/5	Vapor container manhole low-level alarm switch.	
LS/6	Spent fuel pit high-level alarm switch.	
LS/7H	Feedwater heater high-level alarm switch.	
LS/7L	Feedwater heater low-level alarm switch.	
LS/8H	Seal leakage tank high-level switch.	
LS/8L	Seal leakage tank low-level switch.	
LS/9	Hot waste pit.	
LS/10	Vapor container sump.	
LS/11	Inner shield tank.	
LS/12	Outer shield tank.	
HLA/1	Steam generator high-level alarm.	
LLA/1	Steam generator low-level alarm.	
HLA/2	Pressurizer high-level alarm.	
LLA/2	Pressurizer low-level alarm.	
HLA/3	Distilled water tank high-level alarm.	
LLA/3	Distilled water tank low-level alarm.	
HLA/4	Service water tank high-level alarm.	
LLA/4	Service water tank low-level alarm.	
HLA/5	Primary coolant make-up tank high-level alarm.	

Table 2-14. List of Plant Process Instruments (Cont'd)

TAG NO.	DESCRIPTION	READ
LLA/5	Primary coolant make-up tank low-level alarm.	
LG/1	Feedwater heater level glass.	Locally
LG/2	Condenser hotwell level glass.	Locally
LG/3	Evaporator level glass.	
Pressure Instruments		
PI/1	Steam generator steam outlet indicator.	Locally
PI/2	Turbine throttle steam inlet indicator.	Locally
PI/3	Air ejector steam inlet indicator.	Locally
PI/4	Evaporator steam inlet indicator.	Locally
PI/5	Evaporator vapor outlet indicator.	Locally
PI/6	Feedwater heater steam inlet indicator.	Locally
PI/7	Condenser shell indicator.	Locally
PI/8	Turbine-driven boiler feed pump steam inlet indicator.	Locally
PI/9	Turbine-driven boiler feed pump exhaust indicator.	Locally
PI/10	Circulating water pump discharge indicators.	Locally
PI/11	Circulating water condenser inlet indicators.	Locally
PI/12	Circulating water condenser outlet indicators.	Locally
PI/13	Booster pump discharge.	Locally
PI/14	Condensate recirculating cooling pump discharge indicators.	Locally
PI/15	Turbine oil cooler cooling water inlet indicator.	Locally
PI/16	Boiler feed pump suction indicator.	Locally
PI/17	Boiler feed pump suction indicator.	Locally
PI/18	Boiler feed pump discharge indicators.	Locally

Table 2-14. List of Plant Process Instruments (Cont'd)

TAG NO.	DESCRIPTION	READ
PI/19	Condensate recirculating cooling pump suction indication.	Locally
PI/38	P.C. blowdown cooling pump discharge indicators.	Locally
PI/21	Generator air cooler cooling water outlet indicator.	Locally
PI/24	Spent fuel pit recirculation filter indicator.	Locally
PI/25	Primary coolant make-up tank indicator.	Locally
PI/26	Service water plant inlet indicator.	Locally
PI/27	Steam dump line outlet indicator.	Locally
PI/28	Contaminated waste storage tank indicator.	Locally
PI/29	Chlorinizer chlorine feed indicator.	Locally
PI/30	Chlorine indicator.	Locally
PI/31	Chlorine manifold gas indicator.	Locally
PI/32	Chlorine gas pressure control valve service water supply indicator.	Locally
PI/33	Chlorinizer injection pump indicator.	Locally
PI/34	Chlorinizer injector water supply indicator.	Locally
PI/35	Turbine inlet.	Locally
PI/36	Turbine first stage.	Locally
PI/37	Turbine exhaust.	Locally
PI/38	Evaporator feed pump discharge.	Locally
PI/39	Pressurizer instrument test.	Locally
PR/1	Steam generator steam outlet recorder.	Control room
PR/2	Condenser shell recorder.	Control room
PR/4	Vapor container atmosphere recorder.	Control room

Table 2-14. List of Plant Process Instruments (Cont'd)

TAG NO.	DESCRIPTION	READ
PRC/3	Pressurizer recorder controller. Controls pressurizer fine heaters.	Control room
PC/6	Steam main controller. Controls PCV 1-2 and PCV 1-2.	Locally
PC/12	Chlorinizer control service water controller.	
PIC/5	Primary blowdown demineralizer inlet. Prevents opening PC-17 on high B.D. press.	Control room
PS/1	Circulating water pump standby switchover.	
PS/2	Cooling water booster pump switchover.	
PS/3	Boiler feed pump stand-by switchover.	
PS/4	Condensate recirculating pump stand-by switchover.	
PS/5	Blowdown cooling water pump stand-by switchover.	
PS/6	Primary coolant make-up pump stand-by switchover.	
PS/7	Primary coolant make-up tank vacuum alarm.	
PS/8	Compressed air manifold low air pressure alarm.	
PS/9	Pressurizer heater control switch. PS/9, PS/10, and PS/11 are in a coincidence circuit.	
PS/10	Pressurizer heater control switch.	
PS/11	Pressurizer heater control switch.	
PS/12	Pressurizer low-pressure scram switch. PS/12, PS/13, and PS/14 are in a coincidence circuit.	
PS/13	Pressurizer low-pressure scram switch.	
PS/14	Pressurizer low-pressure scram switch.	
PS/15, PS/16, PS/17	Vapor container atmosphere switches. Actuate trip valves and scram.	
PS/18	Air compressor stand-by switchover.	

Table 2-14. List of Plant Process Instruments (Cont'd)

TAG NO.	DESCRIPTION	READ
PS/19	Contaminated waste storage tank high-pressure switch.	
PS/20	Contaminated waste storage tank low-pressure switch.	
PS/21	Chlorinizer water injection switch. Actuates pump starter.	
PS/22	Low chlorine gas pressure alarm.	
PS/23	Chlorinizer vacuum alarm.	
PS/24, PS/25, PS/26	Main steam line, high pressure, coincidence circuit scram.	
PS/27, PS/28, PS/29	Pressurizer line. High pressure coincidence circuit scram.	
PS/30	Inner shield tank alarm.	
PS/31	Outer shield tank alarm.	
Temperature Instruments		
TI/1	Pressurizer steam indicator.	Control room
TI/2	Contaminated waste storage tank indicator.	Locally
ΔTIC/500	Differential temperature indicator controller, active-inactive primary coolant pump legs.	Control room
TI/501	Primary coolant pump P-11A leg indicator. Connected to ΔTIC-500.	
TI/502	Primary coolant pump P-11B leg indicator. Connected to TIC-500.	
TIC/600	Primary coolant steam generator inlet indicator controller. Scrams reactor on high temperature.	Control room
TR/1	Steam generator steam outlet recorder.	Control room
TR/201, TR/202	Circulating water condenser inlet recorders.	Control room

Table 2-14. List of Plant Process Instruments (Cont'd)

TAG NO.	DESCRIPTION	READ
TR/203, TR/204	Circulating water condenser outlet recorders.	Control room
TR/205	Condensate from condenser	Control room
TR/206	Feedwater recorder, downstream of feedwater heater.	Control room
TR/207	Spare thermocouple.	Control room
TR/208	Vapor container atmosphere recorder.	Control room
TR/209	Primary blowdown demineralizer inlet recorder.	Control room
TR/301	Primary coolant reactor outlet recorder.	Control room
TR/302	Primary coolant steam generator outlet recorders.	Control room
TR/302a, TR/302b	Resistance bulbs, for primary coolant pumps. Record with purple pen, depending on which pump is in use.	Control room
TR/400	Primary coolant temperature difference across reactor, recorder controller.	Control room
TR/401	Primary coolant reactor inlet recorder. Connected to TRC/400.	
TR/402	Primary coolant reactor outlet recorder. Connected to TRC/400.	
TC/6	Air ejector differential temperature controller. Controls temperature control valve TCV/6.	
THC/1	Primary coolant pump cooling water temperature indicator.	Control room
IT/1	Steam generator steam outlet thermometer.	Locally
IT/2	Turbine throttle steam inlet thermometer.	Locally
IT/3	Evaporator vapor outlet.	Locally
IT/4	Feedwater heater steam inlet thermometer.	Locally
IT/5	Feedwater heater drain.	Locally
IT/6	Circulating water condenser inlet thermometers.	Locally
IT/7	Circulating water condenser outlet thermometers.	Locally

Table 2-14. List of Plant Process Instruments (Cont'd)

TAG NO.	DESCRIPTION	READ
IT/8	Feedwater thermometer, upstream of air ejector.	Locally
IT/9	Feedwater thermometer, downstream of air ejector.	Locally
IT/10	Feedwater thermometer, downstream of feedwater heater.	Locally
IT/11	Generator air cooler cooling water inlet thermometer.	Locally
IT/12	Generator air cooler cooling water outlet thermometer.	Locally
IT/13	Turbine oil cooler cooling water outlet thermometer.	Locally
IT/14	Condensate cooling water initial temperature thermometer to shield tank.	Locally
IT/15	Condensate cooling water final temperature thermometer from shield tank.	Locally
IT/16	Blowdown cooler water initial temperature thermometer. Water to space cooler.	Locally
IT/17	Primary blowdown coolant outlet thermometer.	Locally
IT/20	Primary coolant make-up tank outlet thermometer.	Locally

Control Room (Figures 2-4, 2-5, 2-7, and 2-12). The APPR-1 control room is the nerve center of the plant. The operator can view all control panel instruments from behind the control console. Major plant indicators, recorders, and controls are situated on these panels.

The control console (figure 2-4), situated centrally in the room, is a desk-high, U-shaped unit with three panels. To the left of the operator is an annunciator panel containing the trouble signal lights, acknowledge switches, panel test buttons, and lights. Directly in front of the operator is a control rod drive control panel containing individual rod position indicators. individual and gang rod drive switches, rod position limit lights, a manual scram button, a scram circuit reset button, and power and reactor ON-OFF switches and signal lights. To the right of the operator is a panel containing the linear power range selector, pressurizer heater controls, a blowdown valve control switch, the transfer lock switch, the primary coolant pump control switches, parameter indicator, and valve controls.

Beyond the control console the operator can see the various plant control panels. They are, from left to right: the electrical panel, the graphic panel, the nuclear panel, and the radiation panel.

The electrical panel (figure 2-12) contains a generator control section, a station service control section, and a battery and motor control section. A swinging bracket contains synchronizing and voltage indicators. A mimic bus mounted across the electrical panel outlines the major features of the electrical system and shows the relationship between various electrical controls.

The graphic panel (figure 2-7) consists of plant cycle indicators and signal lights arranged to depict schematically the flow of plant process fluids through their cycles. Plant component relationships and operating characteristics are also shown. Signal lights indicate operative pumps and fluid flow paths throughout the plant. Tripping of vapor container trip valves is shown by signal lights.

The nuclear panel (figure 2-5) contains all the nuclear power indicators and recorders for the plant. In addition, nuclear measurement amplifiers are mounted on this panel. Two temperature recorders give strip chart records of various process temperatures throughout the plant.

The radiation panel (figure 2-5) contains an eight-point radiation monitor recorder, radiation monitoring electronic units, and a multi-point temperature indicator.

Scrams and Alarms

Table 2-15. Plant Malfunction Causing Alarm and Reactor Scram

CAUSE	SCRAM AND ALARM OCCURS AT
Low period	3 seconds
High reactor flux	130%
Low primary coolant flow	3500 gpm
High primary coolant temperature	480°F
Low pressurizer pressure	1040 ± 15 psig
High pressurizer pressure	1455 + 0 - 30 psig
High steam generator pressure	550 + 0 - 25 psig
High steam generator temperature	480°F
Reactor power level above zero power run safety limit	200 W
Manual scram	By operator

Table 2-16. Plant Malfunction Causing Alarm Only

Primary System

CAUSE	ALARM SOUNDS AT
Low period	10 seconds
Log count rate recorder fission channel	Off scale
Log count rate recorder BF_3 channel	Off scale
Low voltage in ion chamber	300 volts
Safety amplifier No. 1 and No. 2	Trouble in amplifier
1. Failure of power supply negative voltage.	
2. Discontinuity in leads to either ion chamber.	
3. Filament burnout of any magnet control tube.	
4. High flux in any chamber.	
5. Burnout of chamber current amplifier tubes.	
Low primary coolant flow	3700 gpm
Log N and period amplifier	Trouble in amplifier
Note: The alarm condition is actuated when the function switch is in other than the operate condition; i.e., "GND," "LoCal," "HiCal," and "Bypass."	
High primary coolant temperature	460°F
Low pressurizer pressure	1140 ± 15 psig
High pressurizer pressure	1325 ± 15 psig
Low pressurizer level	16 in.
High pressurizer level	22.5 in.
High primary coolant blowdown pressure	55 psig
Low primary make-up tank level	3500 gal.
High primary make-up tank level	4500 gal.

Table 2-16. Plant Malfunction Causing Alarm Only (Cont'd)

Primary System (Cont'd)

CAUSE	ALARM SOUNDS AT
High primary blowdown radiation level	1 r/hr
High primary blowdown coolant radiation level	1 mr/hr
High primary blowdown conductivity, to demineralizer	5 micromho
High-level seal leakage tank	22 in.
Low-level seal leakage tank	8 in.
Low primary make-up tank pressure	10 psig
High vapor container pressure	5 psig

Secondary System

CAUSE	ALARM SOUNDS AT
High steam generator pressure	435 ± 15 psig
High steam generator level	4 in. above normal
Low steam generator level	4 in. below normal
Low condenser hot well level	3 in. below normal
High condenser hot well level	3 in. above normal
Low distilled water tank level	2800 gallons
High distilled water tank level	4500 gallons
Low service water tank level	4500 gallons
High service water tank level	3500 gallons
Low feedwater heater shell level	2 in. below normal
High feedwater heater shell level	2 in. above normal
Low evaporator shell level	4 in. below normal

Table 2-16. Plant Malfunction Causing Alarm Only (Cont'd)

Secondary System (Cont'd)

CAUSE	ALARM SOUNDS AT
High evaporator shell level	4 in. above normal
High steam generator blowdown radiation level	10 mr/hr
High condensate radiation level	7.5 mr/hr
High condensate conductivity	5 micromho
High-temperature steam from generator	445 psig

Electrical System

CAUSE	ALARM SOUNDS AT
High generator air temperature	106 ± 2°F
Low bearing oil pressure	8 psig
Generator overcurrent	Differential ground trip
Line overcurrent	Line overcurrent trip
Station service undervoltage	Station service feeder breaker trip
Station service throwover	Automatic throwover station service bus
Low VEPCO input	.5 mw
Station service feeder overcurrent	Station service feeder breaker trip
Overcurrent in station service motors	Component breaker trip
Battery-charging motor-generator set	Breaker trip

Table 2-16. Plant Malfunction Causing Alarm Only (Cont'd)

Electrical System (Cont'd)

CAUSE	ALARM SOUNDS AT
Emergency lighting on	Breaker closing
Primary coolant starter circuits de-energized	Breaker open

Miscellaneous

CAUSE	ALARM SOUNDS AT
Low control air pressure	70 psig
Low vapor container manhole water level	18 in. below top of stand pipe
High waste pit level	12 in.
High control room radiation level	7.5 mr/hr
High vapor container interior radiation level	75 r/hr
High vapor container entrance radiation level	7.5 mr/hr
High spent fuel pit area radiation level	7.5 mr/hr
High demineralizer area radiation level	7.5 mr/hr
High stack effluent radiation level	7.5 mr/hr
High seal pit discharge radiation level	7.5 mr/hr
High vapor container sump level	3' 3" from top
High hot waste tank pressure	12 lb
Low hot waste tank pressure	2" vacuum
High level, spent fuel pit	45'-0" elevation (6" below pit top)
Chlorination room (loss of vacuum)	3 psig control pressure
Low chlorine gas pressure	20 psig
Low injector water pressure	20 psig

SECTION 3

SAFETY INSTRUCTIONS AND PRECAUTIONS

See Manual "Health Physics Manual for the Army Package Power Reactor," APAE Memo No. 78

INTRODUCTION

Exposure to radiation, either external or internal, may result in cell injury or death of living tissues. Regardless of the specific type of radiation involved (i.e., alpha, beta, x, gamma, etc), the harmful effect in the cell is the same; the degree of injury depends primarily upon the amount of energy absorbed by the cell. An individual must be protected from one or both of the two fundamental hazards which arise from external radiation sources located outside the body and internal radiation sources located inside the body.

External radiation may be x-rays, gamma rays, neutrons, or beta particles. These radiations are an external hazard because of their ability to penetrate the tissues from outside the body. An internal radiation hazard exists when radioactive materials enter the body by ingestion, inhalation, or through breaks in the skin. All radioactive materials which emit alpha, beta and/or gamma radiations and are in a finely divided solid, liquid, or gaseous state can be absorbed and deposited within the body.

To safeguard personnel from the harmful effects of radiation, radiological monitoring instrumentation is provided in APPR-1. Certain operating rules and procedures have been established to ensure that no one is subjected to more harmful radiation than is absolutely necessary.

Personnel working in and about the power plant must know how much radiation they can be exposed to without harm, what detection equipment and devices are available, how to use these items, and what procedures and rules will minimize the hazards of working in and about APPR-1.

MAXIMUM PERMISSIBLE LEVELS

General

The maximum permissible levels of radiation to which an individual can be exposed may be generally defined as the level of radiation that is not expected to cause appreciable bodily injury.

Exposure to radiation shall at all times be kept to a practicable minimum; however, even within the numerical limits of the levels established herein, there cannot be a complete disregard of the exposure received by the individual.

In the case of external radiation, exposure can be minimized by considering the time the person is in the radiation field, distance between the person and the source of radiation, and by shielding the person from the source when work in a radiation field is necessary. When it serves no useful purpose, exposure to radiation should be avoided.

In the case of internal radiation sources, the potential hazards are eliminated or minimized by adherence to safety rules and procedures with respect to protective clothing, respiratory protection, etc, along with immaculate housekeeping with respect to radioactive contamination control.

Permissible Exposure from External Sources

Controlled Areas. Table 3-1 lists the total allowable weekly dose to which an individual over 18 years of age may be exposed within a week (any seven consecutive days).

Table 3-1

Permissible Total Weekly Doses in Critical Organs
Under Various Conditions of Exposure

Condition of Exposure		Dose in Critical Organ (mrem)			
Part of Body	Radiation	Skin	Blood-Forming Organs	Gonads	Eye
Whole Body	Any radiation with Half-value Layer greater than 1 mm of soft tissue	600	300	300	300
Whole Body	Any radiation with Half-value Layer less than 1 mm of soft tissue	1500	300	300	300
Hands, Forearms, Feet, Ankles, Head, and Neck	Any radiation	1500 Provided no other critical organ exceeds 300 mrem			

Note

With the written approval of Health Physics it may be permissible to receive more than the permissible weekly dose in special cases.

Uncontrolled Areas. No radiation source will be used in any manner to create, in an uncontrolled area, a radiation level of more than 2 mrem in any one hour (maximum of 50 hours), or a radiation level of more than 100 mrem in any seven consecutive days (i.e., 0.6 mrem/hr).

Note

With the written permission of Health Physics, these levels may be exceeded if it can be shown that the proposed higher levels will not cause an individual to receive a radiation dose in excess of 10% of the limits of table 3-1.

Permissible Exposure from Internal Sources

Note

Health Physics will determine where and when an individual may no longer be exposed to a potential internal source in all areas or what protective equipment and measures are required to safeguard personnel working in a dangerous area. Therefore, it is the responsibility of the individual to observe all rules and precautions set forth by Health Physics for the control of these exposures.

GENERAL RADIOLOGICAL SAFETY RULES

The following general rules are safe practices and will be followed by all personnel when working with or around radioactive materials, contamination, or sources.

The fundamental purposes of these general rules are to prevent the ingestion, inhalation, or other modes of entry of radioactive materials into the body (thereby becoming internal sources); to reduce the amounts of external radiation to levels as far below the maximum permissible limits as is reasonably possible; and to prevent the spread of radioactive contamination to uncontrolled areas.

Consult the Health Physics Manual (APAE Memo 78) for further details.

1. Extreme cleanliness and immaculate housekeeping will be maintained in all radiation areas where spreadable activity is present. All persons working in such an area will:

   (a) Check body for any exposed breaks in skin (i.e., open cuts or abrasions) before the start of work each day. In the event breaks are present, work involving spreadable activity shall be avoided or shall not be started until adequate protection is provided by approved methods.

   (b) Monitor hands, hair, face, and protective clothing with appropriate instrumentation frequently during the day.

   (c) Wash hands before eating or smoking and at the end of each work period.

   (d) Survey all exposed areas of body and personal clothing with appropriate instrumentation at the end of each work period, just prior to leaving the controlled area.

2. There will be no eating, smoking, and/or preparation of food or drink in any radiation area in which spreadable activity is handled or stored. Personnel wishing to smoke, eat, or drink will do so only after washing and monitoring hands.

3. Milk bottles or other reusable food containers will not be used to store radioactive materials.

4. If any part of exposed areas of the body or personal clothing give an indication of being contaminated, they will be washed and rechecked until decontaminated to permissible levels before leaving the area.

5. Laboratory coats and rubber gloves will be worn when working with or around spreadable activity of any level.

6. Tools and other miscellaneous equipment used in radiation areas where spreadable activity is present will be regarded as contaminated and will not be released to uncontrolled areas unless a survey indicates the item is within the permissible limits.

7. All procedures employing special handling tools and/or equipment should be rehearsed as a dry run before work with active materials is begun. Any defective handling equipment should be repaired or replaced and tested before use in the actual operation.

8. All experiments using 1 mc or more of spreadable activity will be conducted in hoods or glove boxes provided with forced ventilation and high-efficiency air filters. The exhaust duct from these areas will be provided with a sampler as recommended by Health Physics.

9. Sealed radiation sources will be stored in adequately shielded containers when not in use.

10. Maximum practical distance and shielding together with minimum practical personnel exposure time will be observed when handling radioactive sources.

MONITORING DURING PLANT OPERATION

Monitoring instrumentation for APPR-1 consists of fixed monitors and detectors, portable monitors and survey instruments, and laboratory instrumentation. Each of these classifications of instruments is discussed in the following paragraphs.

Fixed Monitors and Detectors

The fixed monitors and detectors are a permanent integral part of the power plant; they function to detect and record the presence and levels of radiation at selected points throughout the plant and to alarm the operator of abnormal situations which may become hazardous to personnel. This radiation monitoring instrumentation indicates area background levels, the presence and degree of radioactive materials in the primary and secondary systems, and the presence of radioactive materials in the air and water that leaves the plant. A 10-channel Remote Area Monitoring System is used to detect area background levels (area monitoring) and radiation in the primary and secondary systems (operational monitors). Ionization chambers (monitors) are located at various points about the plant and are connected to the main control unit recorder and alarm in the control room. Five chambers are used for area monitoring and four for operational monitoring. One channel is available for future needs. Figure 3-1 illustrates the area and operational monitoring system.

<u>Area Monitors</u>. These chambers indicate and record the radiation level in various plant areas; they are gamma-sensitive and are remotely calibrated in the control room by an internal source located at each chamber. Each station is recorded on the multi-point recorder on control room radiation panel over the range from 0.01 to 10 mr/hr, and actuates an audible alarm in the control room when the radiation level exceeds 7.5 mr/hr (tolerance based on a 40-hour work week). One exception is the chamber located inside the vapor container, which

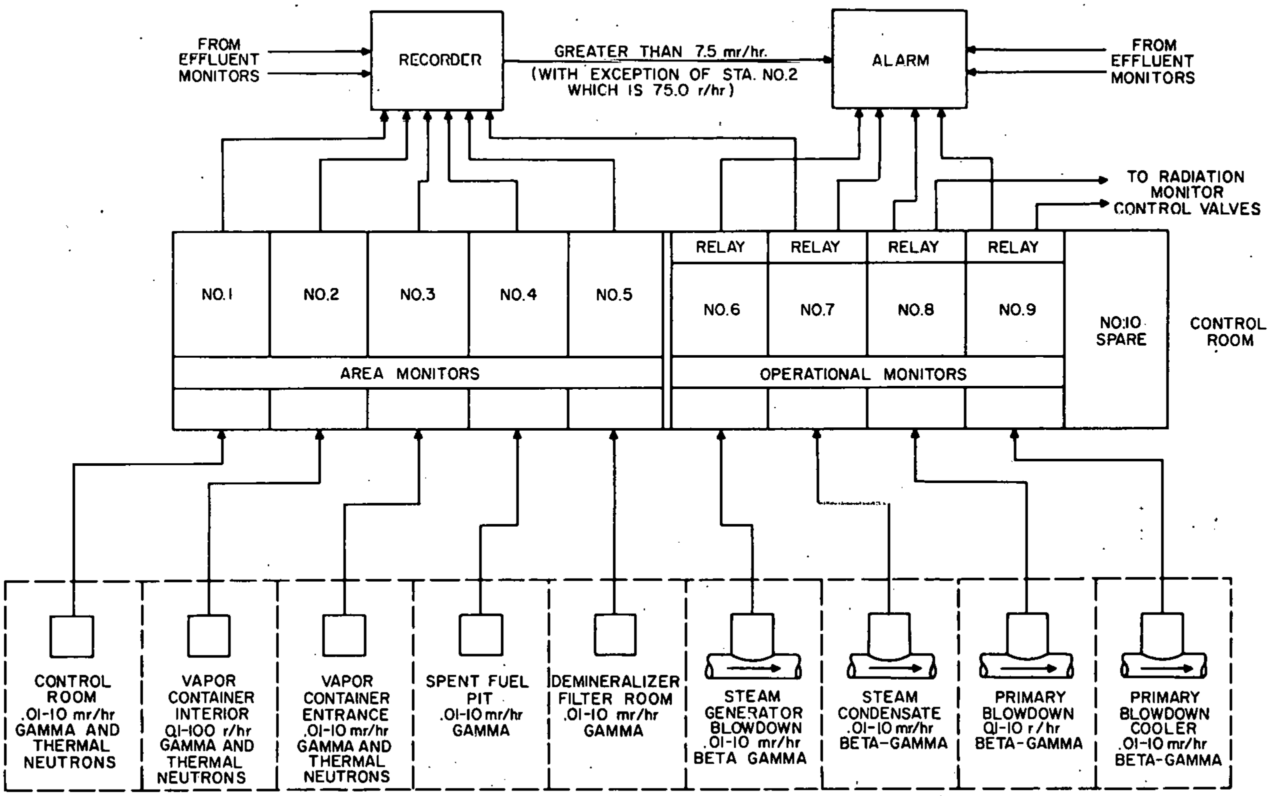


Figure 3-1. Area and Operational Monitoring System

will alarm at 75 r/hr. The normal radiation level at this point during operation is approximately 10 r/hr.

Three chambers located in and about the vapor container are sensitive to thermal neutrons. The recorder will indicate the combined effects of gamma and thermal neutrons at these points. Details of the area monitoring stations are as follows:

1. Control Room. The chamber is located at the northernmost point on the vapor container wall, four feet above the floor; it is remotely calibrated for gamma and also is sensitive to thermal neutrons. This chamber monitors a normally occupied work area at a point where the highest radiation level is expected.

2. Vapor Container Interior. The chamber is located inside the upper portion of the vapor container, about three feet above the floor grating, on a railing opposite the access opening; it is calibrated for gamma radiation over the range 100 to 100,000 mr/hr, and is also sensitive to thermal neutrons. The main function of this station is to indicate the radiation level near the access opening, thereby determining when entry to the vapor container is feasible after shutdown. Secondly, an abrupt change during operation would indicate or verify to the operator the presence of abnormal operating conditions.

3. Vapor Container Entrance. The chamber is located on the outside of the water-filled access hatch on the ground floor level; it is remotely calibrated for gamma and also is sensitive to thermal neutrons. This chamber monitors a frequently occupied work area at a point where the highest radiation level is expected. It also will detect the loss of shielding water in the hatchway, or verify this condition when indication is given by an independent liquid level alarm.

4. Spent Fuel Pit. The chamber is located immediately under the fixed pit cover plate, next to the vapor container wall; it is remotely calibrated for gamma and monitors the work area at the top of the fuel pit. It will also indicate any loss of water in the fuel pit when spent fuel is stored therein.

5. Demineralizer Filter Area. The chamber is located near the doorway, just inside the demineralizing equipment room; it is remotely calibrated and sensitive to gamma radiation only. This chamber monitors the radiation level in this potential radiation work area at the point of entry. Since the area is entered infrequently, the chamber also serves to indicate any abnormal change in radiation level, signifying a possible need for corrective action or investigation in this area.

Operational Monitors. Four special chambers sensitive to 0.2 Mev beta and gamma radiation are located in the primary and secondary systems to detect potential leaks and alert operations that a hazardous condition is developing. Each chamber is in direct contact with the flowing stream and can be removed without interrupting system flow. The chambers then detect and warn the operator of abnormal radioactivity in the primary and secondary systems. The radiation level of the steam condensate line is recorded; levels at other points are not recorded. Samples of fluid can be taken at each monitoring point for a laboratory analysis. Each chamber is connected to a meter relay through the master control unit in the control panel and is to be field set to actuate alarms at significant levels of radiation. A small portable source is provided for routine checking of the chamber operation. Details of the operational monitoring stations are as follows:

1. Steam Generator Blowdown. The chamber is located in the blowdown sample line; it will detect leakage of primary water into the secondary system at the steam generator and has a range of 0.01 to 10 mr/hr. Any increase in radiation level above normal background will be detected and alert operations to take a sample for a radioactive concentration analysis.

2. Steam Condensate. The chamber is located in the condensate cooling water pumps discharge line and monitors for leaks that may develop in a tube on the superheater side of the steam generator and which would contaminate the entire secondary system. The range is 0.01 to 10 mr/hr, and any increase in radiation level above normal background will be detected and alert operations to take a sample for analysis. Because the buildup of activity in the condensate may be obscured by dilution and blowdown, this point is recorded so that the long-term trend may be studied and evaluated.

3. Primary Blowdown. The chamber is located in the primary blowdown line, where it enters the demineralizer filter room, is shielded from the demineralizers, and will detect a fuel element rupture by indicating a radiation level increase above the normal operation water activity level. The range is 0.1 to 100 r/hr and a meter relay will actuate an alarm should the radiation level go above the field set value. The alarm relay will also actuate diversion valve RMCV/1, as outlined in Section 2, PRIMARY SYSTEM, Blowdown System.

4. Primary Blowdown Cooler. The chamber is located in the cooling water line, where it enters the Demineralizer-Filter room, is shielded from the demineralizers, and monitors for blowdown cooler leaks which would allow primary water to mix with the cooling water normally discharged to Gunston Cove. The range is 0.1 to 10 mr/hr and an increase above normal background radiation will alert operations to take a sample for analysis. A significant leak will cause an increase in radiation which will actuate an alarm to operate diversion valve RMCV/2, as outlined in Section 2, PRIMARY SYSTEM, Blowdown System.

Effluent Monitors. This instrumentation monitors all process air and water as it leaves the plant site. Figure 3-2 illustrates the effluent monitoring system.

The air monitor detects and records the radiation level of beta-gamma airborne material, and actuates a warning system when the activity in the air leaving the plant approaches potentially hazardous levels. In operation, a blower pulls air from the stack into a shielded detection chamber, where it passes through filter paper. A Geiger-Mueller tube operates a counting rate meter to continuously indicate the beta-gamma activity deposited on filter paper surrounding the tube. The instrument has three ranges and an automatic range-changing mechanism. When activity reaches 2000 c/m, an amber blinking light comes on and an alarm sounds for 15 seconds. At high range (10,000 c/m), a red blinking light comes on and an alarm is sounded intermittently in the control room. The activity level is continuously recorded on the control room monitoring recorder.

The water monitor detects and records gamma activity level and warns operations if the level approaches potentially hazardous levels. In operation, the gamma water monitor is

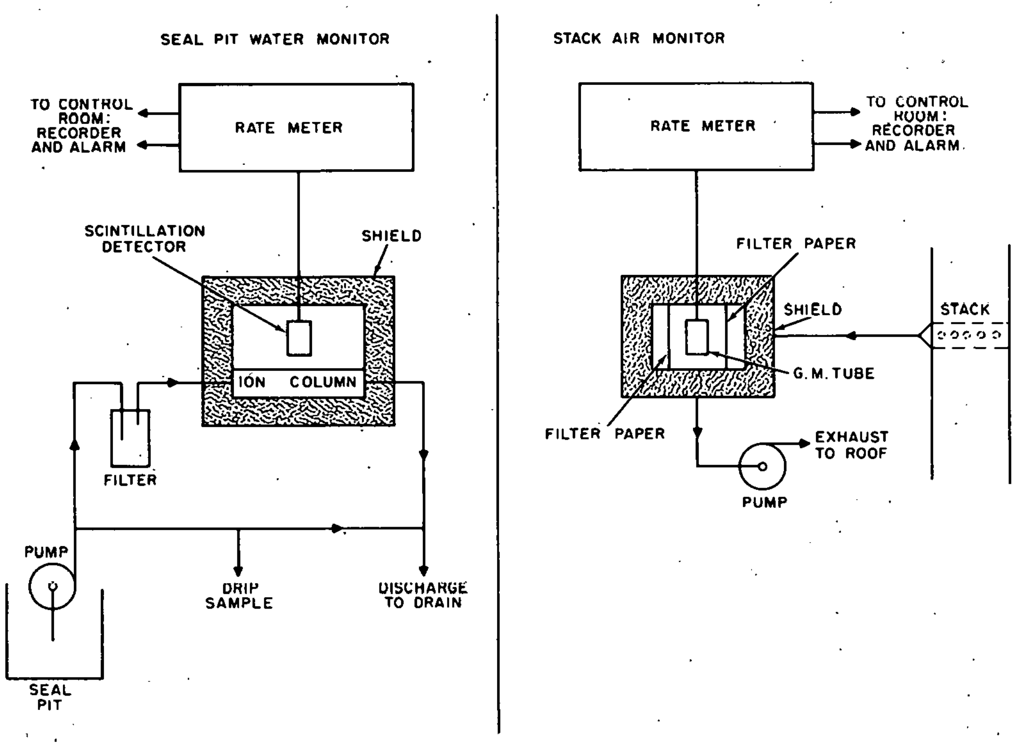


Figure 3-2. Effluent Monitoring System

basically the same as the air monitor except for the collecting and detecting systems. The collecting system is made up of a filter and shielded ion exchange columns. A gamma scintillation detector within the shield operates a counting rate meter which continuously indicates the activity deposited in the ion exchange column. The rest of the system is similar to the air monitor described above. The actual average concentration of alpha and beta-gamma activity in discharge water can be obtained by laboratory analysis of the continuous drip sample provided.

CAUTION

If the seal pit monitor is shut down in freezing weather, the system must be drained.

Portable Monitors and Survey Instruments

Portable instrumentation is provided to detect, determine, and record total integrated exposures to operating personnel and to maintain these exposures at or as far below the maximum permissible levels as is practicable. Both internal and external radiation sources are included and considered. Several portable instruments are required to properly evaluate each type of radiation present and to control the conditions under which they may present internal and external hazards. The instrumentation provided indicates the extent of external radiation hazards by establishing beta and gamma dose rates in radiation work areas, detecting the presence of neutrons, and detecting and recording the total integrated personnel exposures from beta, gamma, and thermal neutrons. The instrumentation indicates the extent of internal radiation hazards by establishing the level of alpha and beta-gamma surface and personnel contamination and by determining the level of airborne alpha and beta-gamma activity. Table 3-2 lists the portable instrumentation provided and its application.

Constant Air Monitors

In the event either the stack or mobile air monitor exceeds 10,000 c/m (changes to the highest scale), or exceeds a constant build-up rate of 335 c/m/hr, notify an H.P. representative. These values indicate airborne activity is approaching the maximum permissible concentration with an additional safety factor of 3 for the mobile monitor. These calculated values assume long-lived activity and a sample flow rate of 3.5 cfm.

Non-hazardous short-lived activity may build up at much more rapid rates than indicated above, but should stabilize to constant or decreasing count rates within one hour. In this event, notify an H.P. representative whenever 10,000 c/m is exceeded and he will evaluate the activity present and take the necessary action.

Laboratory Instrumentation

Counting instrumentation is provided to quantitatively measure alpha and beta-gamma concentrations in air and water samples taken in and about the power plant. It is also provided for evaluating other miscellaneous samples such as contamination wipe tests, background samples, etc.

The basic laboratory instrumentation consists of gasflow proportional, scintillation, and end-window Geiger-Mueller counting equipment with accessories.

Table 3-2

Portable Monitors and Survey Instruments

Quantity	Type of Instrument
2	Geiger Mueller Survey Meter, Electronics, Model PR-6
1	Victoreen Alph Meter, Model 356
1	Juno Dose Rate Meter, Model 3
1	Slow/Fast Neutron Detector, RCL MK11, Model 2806
1	Portable Air Monitor, Nuclear Instruments Co.

Radiation Work Permits

Before any work may be performed in any radiation area or work that may involve any radioactive equipment or sources, a Radiation Work Permit must be obtained.

This permit will be issued in duplicate by the health physicist on duty only after he has made a radiation survey and has determined the conditions to which personnel may be exposed. The dose rate, allowable working time, type of hazards, protective equipment required, the time the permit is issued and the probable duration of work must be entered on the work permit.

The Radiation Work Permit must be signed by the health physicist and the Shift Supervisor and recorded in the operating log.

Each man working on the job must log on the work permit the time he started work, the time he finished work, and the amount of radiation he received.

The work permit must be canceled upon completion of the work.

The Shift Supervisor is responsible for the safe performance of all work and adherence to all safety regulations.

The original and duplicate copies of the work permit shall be kept near the entrance of the radiation area until work, or the permit, is terminated. Upon termination of the permit, the original will be returned to Health Physics, and the copy to plant supervision, for filing.

DEFINITION

A clearance is a definite operating arrangement whereby an authorized person acting individually, or as a representative of a crew, may have lines de-energized, valves closed, etc, and also electrical and mechanical equipment removed from or held out of service until released by him.

PURPOSE

The purpose of a clearance is to safeguard those whose operating, construction, or repair duties require them to work on or near electrical and mechanical equipment, and also to prevent damage or unauthorized removal from service of equipment for repair or adjustment that might unnecessarily affect others.

COVERAGE

No person or group of persons shall be considered protected from live or other equipment, or shall be authorized to work on equipment which is subject to clearance procedure until a clearance has been issued to him, or to the foreman in charge of the work on the line or equipment involved.

RESPONSIBILITY

The operator issuing the clearance is fully responsible for the facilities or equipment covered by the clearance being safe for the work to be done, including changing conditions after the clearance is issued.

The Shift Supervisor to whom a clearance is issued becomes fully responsible for the safety of the personnel and equipment covered by the clearance until the clearance is released. He is responsible for checking the protection provided and shall not require work to be performed that is considered unsafe. He shall also place any locks, blocks, or similar devices to prevent operation, and attach protective grounds when deemed necessary to assure safe conditions. He is also responsible for the removal of such devices.

It shall be the responsibility of the operator issuing the clearance to be informed at all times as to the status of the work covered by the clearance. The person receiving the clearance must therefore keep the operator properly informed of conditions and status of work.

AUTHORITY TO OBTAIN CLEARANCES

Clearances will be issued to the Shift Supervisor only. In case of emergency, the control room operator may issue clearances to others at his discretion.

CLEARANCE REQUESTS

Requests for a clearance should be directed to the Control Room Operator. Requests for clearances must be definite. In order to prevent misunderstanding, the operator shall repeat back to the person requesting the clearance the designation of the equipment or lines to be cleared, time the clearance is desired, the extent of the clearance, work to be done, estimated time of its completion, and the time required to place facilities back in service in case of an emergency. Ample advance notice shall be given the operator to permit completion of all arrangements and operations required prior to the time clearance is desired.

ISSUANCE OF CLEARANCES

Clearances are preferably granted directly in person. If granted over the intercommunication system or telephone, the operator must be certain of identification.

EQUIPMENT REQUIRING A CLEARANCE

All electrical or mechanical equipment affecting operating or standby equipment under the control of the operator requires the issuance of a clearance by the operator, unless specifically exempted by the Superintendent.

EQUIPMENT NOT REQUIRING CLEARANCE

Certain electrical and mechanical equipment in the power plant, such as shop tools or secondary lighting equipment, may be operated or removed from service for repair on orders of the Shift Supervisor without issuance of a regular clearance. Even though a clearance is not required, there shall be provided suitable protection for workers from any adjacent high-voltage circuits or other hazardous equipment. In addition, the responsible workman will notify the Control Room Operator of his intentions, open the source of power, and apply a properly completed Hold Card to the isolating device.

CLEARANCE ON TIE OR SUPPLY LINES

Clearances on the ERDL tie line circuits will be handled by the Shift Supervisor and Post Engineer electrical personnel.

The lines of demarcation are:

4160-Volt Main Feeder

The 2400-volt main bus side of Breaker "A" is under the jurisdiction of the Post Engineer.

480-Volt Emergency Feeder

The primary fuses on the high side of the 2400/480-volt emergency transformer bank are under the jurisdiction of the Post Engineer.

CLEARANCE INSTRUCTIONS

Clearance instructions which are a part of the standing operating instructions or which may be issued by responsible operating personnel must be followed in the exact order given.

CLEARING EQUIPMENT

The Control Room Operator shall be responsible for the tagging of all equipment. He will personally tag control room equipment and controls. The Equipment Operator shall tag all breakers, blocks, and other safety devices which are not located in the control room. The person obtaining clearance must check the clearing and tagging of equipment-isolating devices as an extra precaution.

OPERATION OF EQUIPMENT COVERED BY A CLEARANCE

Operation of any equipment covered by a clearance shall be subject to the orders of the person receiving the clearance. All operations of equipment shall be carried out only after tags have been removed and only by a responsible operator on duty, unless permission is expressly granted to others to perform individual operations. Operation of the control room switchboards will be carried out only by the operator on duty. If tags must be replaced after testing, the time of replacement and signature of supervisor shall be entered on the tag.

CLEARANCE NUMBERS AND RECORDS

a. Number. Each clearance will be assigned a number when issued. This number will be placed on all Hold Cards used under this clearance.

b. Logging. The operator shall log in the station clearance log book all clearances before they are issued. Red stamping will be used to call attention to clearance entries.

Log book issuing entries will contain the following minimum data:

Clearance No.______________ Time__________

Circuit (or Equip.) ________________________

Purpose of Clearance_______________________

Issued to _____________________________

Hold Cards Placed at _______________________

Log book clearance release entries, in black stamping, will contain the following minimum data:

Clearance No. (Issuing No.)__________ Time__________

Circuit (or Equip.) ______________________________

Released by ___________________________________

Upon releasing a clearance the operator shall also write "Released," in ink, across the corresponding log entries of the clearance.

CAUTION CARDS

Caution cards are issued to call attention to abnormal, hazardous, or unusual conditions, or to special operating instructions which are to be followed.

Caution cards shall be numbered, using "X" as a prefix, and be issued and released in accordance with the procedure for clearances.

Log book entries, in blue or black ink, on red stamping will contain the following minimum data:

FOR ISSUING

Caution Cards No. X ____________ Time ________________

Issued to ____

Circuit (or Equip.) Covered ____________________________

Special Instructions _________________________________

Caution Cards Placed at _______________________________

FOR RELEASING

Caution Tag No. X (Issuing No.) Time ________________

Circuit (or Equip.) Covered ____________________________

Released by _______________________________________

TAGGING EQUIPMENT

a. Hold Card. The Hold Card (RED ENG 1925), properly completed, must be attached to the main circuit breaker or disconnect switch, isolating valves, and any other possible sources of energy prior to the issuance of a clearance. A clearance is not issued until all Hold Cards are filled out, placed, and logged.

The minimum data required on the Hold Card includes:

1. Clearance number
2. Log page
3. Location and operation
4. Issued to
5. Placed by
6. Date and time
7. Work to be done (equipment not requiring a clearance only)

Upon release of the clearance and removal of the card, the operator signs and dates under "Removed By." All cards are returned to the Control Room for filing.

b. Caution Cards. Caution cards (YELLOW ENG 1924), while not used in connection with the issuance of clearances on equipment or facilities, are used to advise of special operating conditions pertaining to equipment or facilities. They are attached to appropriate control or other points.

c. Outdoor Tagging. All Hold Cards or Caution Cards attached to outdoor switching points will be inserted into transparent plastic covers for protection from the weather.

d. Tagging of Door Front Circuit Breakers. Certain plant circuit breakers can be operated with the enclosure door open or closed.

To be completely safe, tags should be placed both at the circuit breaker toggle switch and on the outside operating handle. A blank Hold Card may be used on the inside operating handle, calling attention to the completed tag on the outside door.

RELEASE OF CLEARANCES

a. Clearances must be released promptly upon completion of the work for which they are obtained, and by the Shift Supervisor only. As in the issuance of clearances, all instructions for its release shall be repeated and clearly understood prior to taking any action.

b. Where it becomes necessary to transfer responsibility for the work covered by the clearance from one shift to the next, the Shift Supervisor releasing responsibility will advise the Shift Supervisor assuming the responsibility of all pertinent information regarding the scope of the clearance and details of the work. After he has obtained this information, the person assuming charge will advise the Control Room Operator that he has assumed responsibility and will initial the log book entry covering the clearance. If the clearance is in effect on subsequent shifts, the original initials will suffice. The Shift Supervisor will examine the log before taking over the shift to be certain that he has assumed responsibility for all clearances in force.

Standard Operating Procedures in Order of Performance

CLEARANCE

1. Issue.

   a. Maintenance personnel or others request a clearance from Control Room Operator (CRO) to work on equipment.

   b. After checking the possibilities and problems, the CRO contacts the Shift Supervisor (SS) for authority to proceed.

   c. Health Physics is contacted when applicable.

   d. Proper entries are made in the Clearance Order logbook and tags made out under a given clearance order number.

   e. The equipment is isolated and tagged, usually by the Equipment Operator (EO), the CRO and EO checking the adequacy of the procedure.

   f. The CRO issues the clearance to the SS and notes same in the station log.

   g. The SS checks all valves and switches for position and adequacy of tagging.

h. The SS permits personnel to go to work, also issuing a Radiation Work Permit, if required.

i. No one is permitted to work on cleared equipment without authority of the SS.

2. Release.

a. Upon completion of the work, maintenance personnel inform the SS that they are clear of the equipment.

b. It is the SS's responsibility to see that all persons working under the clearance are clear of the equipment and are notified that the equipment is being returned to service.

c. The SS notifies the CRO that all persons are clear and that he is releasing his Clearance Order No.____ on the given equipment.

d. This fact is noted in the station log and the clearance order book.

e. The CRO requests the EO to remove all recorded tags under this clearance, specifying the positioning of the switch or valve.

SECTION 4

PLANT OPERATION

INTRODUCTION

This section contains procedural steps which the operator will follow in order to operate the APPR-1. Phases of plant operation from initial startup of a hot or cold plant, through normal and abnormal operation, to planned and abnormal shutdowns are covered. Emergency procedures are also included. References are to Check Lists included in Section 5, CHECK SYSTEM.

WARNING

DO NOT ENTER VAPOR CONTAINER WITH THE REACTOR OPERATING AT A POWER LEVEL OVER 200 KW. Relatively safe entry may be made after reactor shutdown, provided care is taken and the radiation dose level is continuously checked.

The Demineralizer-Filter Room is radioactively hazardous. The door to this area will be kept locked at all times during plant operation. It shall be the Shift Engineer's responsibility to determine the hazards involved in entering this area and to require adherence to the necessary safety precautions.

The blank plates will be installed and the valves closed in the vapor container ventilation lines at all times during plant operation.

The valves on the rod drive pit drain pipe and the valves on the boron injection and spray system entering the vapor container must be closed when the reactor is operating at a power level of over 200 kw.

The primary coolant pumps must not be operated with less than 50 psi pressure on the primary system.

The primary system pressure must not exceed 50 psi unless the system temperature is at least 200° F and has been at this temperature for a minimum of 30 minutes. The system pressure should be increased above 50 psi only when the temperature is increased in accordance with the startup procedures.

The upper penetration of the vapor container is an above-tolerance area. Personnel must obtain permission from the Shift Operating Engineer to enter this area. The barrier will be locked in place over the ladder at all times during plant operation except as authorized by the Shift Supervisor.

NORMAL OPERATING PROCEDURES

Cold Startup

1. Make electrical power available to both service busses. (See Check List No. 1.)

2. Start the main air compressor, using service water for cooling, and set the auxiliary compressor up for standby service. (See Check List No. 2.)

3. Make all instruments and pneumatically controlled valves ready for service. Reset all trip valves. (See Check List No. 3.)

4. Check levels in the following:
   a. Distilled water tank.
   b. Service water tank.
   c. Primary coolant makeup tank.

5. Check that rod drive seal water valves (high and low pressure) are open.

6. Check water levels in the primary system, the steam generator and the condenser hot well, and refill if necessary. (See Check Lists No. 4 and No. 5.)

7. Line up the demineralizer system for normal operation. (See Check List No. 6.)

8. Line up the blowdown system. Check that the blowdown valve bypass is closed and that the shutoff valve is open. Check that switch No. 14 in the electric distribution panel by the V.C. entrance is closed and that the "Run-Stop" switch for the blowdown valve is in the "Run" position.

9. Put pressurizer heaters in operation to raise pressurizer temperature at a maximum rate of 50°F per hour. Blow down as required to prevent the primary system pressure from exceeding 50 psig. When the pressurizer reaches saturation temperature (297.5°F), steam will form and displace water in the pressurizer. When normal water level is established, operate heaters as necessary to maintain 50 psig until after the reactor is critical and system heating has started. The pressure is not to be raised above this point until the system temperature has been at or above 200°F for a minimum of 30 minutes.

   NOTE

   If the system temperature is greater than 125°F, this step should follow step No. 14.

10. Check the operation of the seal leakage pumps. Be sure there is water in the tank before operating pumps. (See Check List No. 7.)

11. Have the Chemist take a primary blowdown sample and determine chemical treatment desired.

12. Put one circulating water pump into normal operation. (See Check List No. 8.)

13. Put the chlorinater into normal operation.

14. Start up the blowdown cooling system. (See Check List No. 9.)

15. Change from service water to cove water for the main air compressor system cooling.

16. Start up the condensate recirculating water system. (See Check List No. 10.)

17. When normal level is established in the pressurizer and the system pressure is 50 psig, start up the primary make-up system. (See Check List No. 11.)

18. Adjust the primary blowdown between 0.5 and 1.0 gpm and regulate the make-up pump speed to maintain the pressurizer level.

19. Vent and check the operation of both primary coolant pumps. Put one in operation and reset the low flow scram. (See Check List No. 12.)

NOTE

Pressure must be 50 psig before starting the primary coolant pumps.

WARNING

An experienced Reactor Operator must operate or supervise the operation of the reactor at all times.

20. Perform nuclear control console and panel instrument checks. (See Check List No. 13.)

21. Shut off vapor container ventilation system.

22. Close vapor container and fill entrance with water. (See Check List No. 14.)

23. Bypass the low pressure scram and bring the reactor critical. Raise the power level to approximately 200 kw. and heat the system at a rate such that the Δt between the system and the wye valve rib does not exceed 45° F. (See Check List No. 15.)

24. When system temperature has been at 200° F or greater for 30 minutes (should be approximately 225° F at this time), put heaters into operation to raise the pressurizer temperature at a rate not exceeding 50° F per hour.

NOTE

The pressurizer temperature should be a minimum of 100° F higher than the primary loop at all times when the reactor is at power in routine operation.

25. When system pressure reaches 1100 psi, put the low-pressure scram in normal operation. Note that alarm points 35 and 68 can be made normal.

26. Continue heating the system. When the pressurizer temperature reaches normal operating temperature (primary pressure at 1200 psi), put two heaters on the fine bus on automatic and four heaters on the coarse bus on automatic. Check that system pressure remains normal.

27. When steam pressure approaches 200 psi or the steam generator level gets low, start up the boiler feed system. (See Check List No. 5.)

28. Line up the feed water heater for normal operation. (See Check List No. 16.)

29. When steam pressure reaches 200 psig, start warming up the turbine generator and put it on the line after the proper warmup and checks. (See Check List No. 17.)

30. After the turbine is rolling and the gland seals established, put the air ejectors into normal operation. (See Check List No. 18.)

31. Check the operation of TCV-6.

32. When the turbine oil temperature reaches 115°F, start up the cooling water booster system. (See Check List No. 19.)

33. Put the steam generator level control (LRC-4) on automatic when steam flow permits.

34. Start the chemical feed system as directed by the Chemist.

STARTUP - HOT.

WARNING

> It is absolutely essential that neutron multiplication be "seen" on startup instruments before the critical condition of the reactor is approached. The Shift Engineer is responsible that control rods are not withdrawn above the safe level without seeing multiplication.

General

1. After the initial startup (cold), subsequent plant startup procedures will depend upon the neutron level in the reactor. Other factors the operator must consider before a hot startup are the type of shutdown that the reactor was subjected to (planned or abnormal), the temperatures and pressures throughout the system, length of time the reactor has been shutdown and how long it was operating at power before shutdown. All these factors will have bearing on the rate at which the hot startup is to be made and the instrument readings to be expected.

2. If the reactor is scrammed accidentally, or due to some minor malfunction, and is to be started up immediately, the procedure is quite simple. When the reactor is scrammed, breakers D and E are automatically tripped and the turbine generator will be shut down. The condenser vacuum will have been broken, the air ejectors shut off, and the turbine gland steam shut off by the operator. All other systems will remain in operation.

3. When starting up, the operator will bring the reactor control rods back out in the normal manner. Bring all rods out simultaneously until a point is reached where the reactor shows some sub-critical multiplication, then elevate the safety rods out to 19 inches, and the shim rods and the regulating rod up to a point where the reactor is almost critical. This will be at a position very near the position they were in before shutdown, provided the temperature drop has not been excessive. Rods should be moved one at a time when within 2 inches of the critical position or when the critical position is unknown.

4. Rods will then be raised until the reactor is critical and the primary temperature begins to rise to its former level. This condition of startup is the safest and the main parameter to watch is not neutron level but temperature, although period and neutron levels must not exceed limiting conditions and cause another scram.

5. If the plant is to be brought up to power-producing conditions from a standby condition, the operator should closely watch the reactor mean temperature after return to power.

6. After shutdown, the xenon poison will build up in the reactor. This will require additional rod withdrawal to attain criticality. This poison will gradually burn off, and insertion of the rods to compensate for this will be necessary. A rod position below that of the hot startup critical position will result. As the poison begins to build up again (in about 4 hours), the rods will have to be withdrawn until a new equilibrium position is reached.

HOT STARTUP PROCEDURES (With Station Service Power)

Situation:

1. Reactor has scrammed; VEPCO still "on line", ACB "A" did not trip.

2. Normal emergency procedures were begun at time of scram. (See "Emergency Shutdown After Scram" Procedures.)

3. Trouble located and cleared, and plant ready to start within two (2) hours of scram.

4. All auxiliary systems are still operating, except those which must be shut down within the time assumed in 3, above.

Startup:

1. Place pressurizer heaters in automatic operation if they were turned off.

2. Verify that all plant auxiliaries are operating properly. (See Check List No. 20.)

3. Start bringing reactor to criticality when primary pressure reaches 1000 psig (if it ever fell below), or slightly above low pressure scram. Low pressure scram may be bypassed with the Shift Supervisor's permission. Bring the temperature of the primary system to 440°F, raising the temperature at a rate such that the difference between temperatures of the primary water and temperature of the "Y" valve rib does not exceed 45°F.

4. Start turbine generator and air ejectors, and take on electrical load. (Check List No. 17 - Note turbine warm-up table.)

5. Put steam generator level control (LRC-4) in automatic operation when steam flow reaches such a rate that level control will operate satisfactorily.

6. Make a general check of the plant to determine that all equipment is functioning properly.

HOT STARTUP PROCEDURES (After loss of Station Service Power)

Situation:

1. Failure on VEPCO side of ACB "A" caused ACB "A" to open and reactor to scram.

2. Power available and trouble corrected.

3. Normal emergency shutdown procedure (without power) has been followed. All important electrical loads in the plant are switched to "Lockout" position.

4. At some time prior to or soon after reloading the turbine-generator, the target at ACB "A" is reset (locally).

Start-up:

1. Verify that ACB's "B", "C", "D", and "E" are open.

2. Close ACB's "A", "B", and "F" to get power to station service bus No. 1.

3. Start battery charger M-G set.

4. Close ACB's "C" and "G".

5. Place pressurizer heaters on "Auto", and start to reestablish pressure in primary system. (Do not raise pressurizer temperature faster than 50°F per hour.)

6. Start one circulating water pump.

7. Start blowdown cooling water pump.

8. Start main air compressor (auxiliary compressor will be in operation).

9. Open all trip valves.

10. Start one primary make-up pump and adjust primary blowdown if necessary.

11. Start a condensate recirculating pump.

12. Start a boiler feed pump and establish the steam generator water level by manual operation of the level control valve.

13. Start a primary coolant pump.

14. Start bringing the reactor critical. Bypass the low pressure scram if the pressure has dropped below 1050 psi.

15. Bring the average temperature of the primary system to 440°at a rate such that the "Y" valve Δt does not exceed 45° F.

16. Start the turbine generator and air ejectors, and take on electrical load when the steam pressure is 200 psi and the reactor is critical. (Check List No. 17 -- Note turbine warm-up table.)

17. Raise electrical load as the steam pressure rises. Do not allow the turbine inlet pressure to drop below 190 psi during this operation.

18. Place the steam generator level control (LRC-4) on automatic operation when the steam flow rate permits.

19. Check the operation of all plant components.

NORMAL OPERATION

With the reactor at operating temperature and pressure, the system is largely self-regulating and load variations are automatically accommodated. Only occasional, small rod movements are needed to meet requirements for reactivity changes.

Variations in Load

When the turbine generator operates independently of VEPCO, an increase in electric demand on the power plant will momentarily decrease the speed of the turbine generator until its speed governor responds to admit more steam and the turbine speed rises until it is once again normal. Upon a decrease in electric demand, the turbine generator speed will rise momentarily until the speed governor cuts back steam flow, at which time the speed will fall again to normal. Fine speed adjustments will be made manually with the speed changer to achieve closer regulation than the 2 per cent accuracy of the governor.

When the turbine generator is connected to VEPCO, the speed and voltage will be controlled by VEPCO regardless of generator load. The load will then be controlled by the load-limiting device.

The flow of steam to the turbine generator is controlled by a low initial pressure regulator whose operation is independent of the speed governor. If electric demand is out of proportion to the steam supply available, the speed governor, alone, would tend to open wide; however, the regulator prevents steam pressure at the turbine generator throttle valve from falling below 145 psig, thereby matching the output of the turbine generator to the steam flow available. The travel of the steam admission valve gear is limited in the opening direction by a load-limiting or load-setting device which prevents the load from going above a predetermined value. The VEPCO tie line will take load swings above the limit settings. Load changes are reflected in the primary system by changes in the differential temperature across the reactor and in changes in nuclear power level.

Routine Observations

During normal operation at full load, instruments should be observed frequently and consistently so as to detect promptly any irregularity in operating condition which might lead to a hazardous situation. Section 6 lists instrument readings to be expected during full load operation.

SHUTDOWN (Planned)

The planned shutdown of the APPR-1 power plant is a normal operation. Shutdown of the reactor means shutting down to the neutron source level.

Situation

1. Plant is operating at or near full load.

2. VEPCO power is available to both station service busses.

Procedures

1. Remove electrical load from the generator. (Check List No. 21.)

2. Shut down the turbine-generator. (Check List No. 22.)

3. Shut down the cooling water booster pump system.

4. Shut down the reactor. (Check List No. 23.)

5. Switch off the pressurizer heaters.

6. Shut down the evaporator, if in operation. (See Evaporator Operating Procedures.)

7. Shut off the boiler feed pump.

8. Dump steam to the condenser to hasten cool-down if desired, but do not exceed rates of change of temperatures set for startup.

9. Shut off secondary blowdown.

10. When desired temperatures have been reached, shut down the following:
    a. Primary coolant pump.
    b. Condensate recirculating pump.
    c. Primary make-up pump. Primary temperature must be below 180° F.
    d. Close P.C. blowdown valve when P.C. make-up pumps are secured.

11. Shut down the hydrogen system, if desired.

12. Shut down the seal leakage pumps, if desired.

13. Shut down air compressors, if desired.

14. Shut down blowdown cooling water pumps after primary blowdown is secured or P.C. temperature is below 125° F and the main air compressor is using service water or is secured.

15. Shut down chlorination system. (See Chlorinizer Operating Procedures.)

16. Shut down circulating water pump and drain the system if temperature is below 32° F. (Chlorinator, main air compressor, blowdown cooling water and cooling water booster pumps must be off.)

WARNING

The primary system pressure must be reduced to 50 psig by the time the system temperature reaches 200° F.

Residual Heat Dissipation

Dissipation of heat during shutdown should present no problems if the gradual temperature drop rates described above are adhered to. During shutdown the major dissipation of heat occurs through the dumping and condensing of steam in the condenser. Various plant units will cool at a sufficiently slow rate to require circulation of cooling water for some time after reactor shutdown.

ABNORMAL OPERATIONS.

General

Abnormal operations concern plant operating procedures which differ from usual practice yet involve little or no danger to equipment or personnel. Those conditions which present actual or potential danger are dealt with under EMERGENCY PROCEDURES.

Switching to Standby Equipment

In order to ensure continuous plant operation, many of the plant's auxiliary units are provided in duplicate, one of the items serving as a standby unit. Where the stoppage of a unit for even a short length of time is critical, automatic devices have been provided to switch on the standby unit upon failure of the operating one. Where the stoppage of a unit for a short length of time can be tolerated, provisions are made for a manual switchover to the standby unit. In every instance, a visual indication of which unit is operating is provided on the graphic section of the control panel and, in addition, indicating lamps are provided on the console which indicate equipment failures in conjunction with an audible alarm.

Listed below are items in the plant that have standby units.

Tag No.	Equipment	Switchover
P-1A P-1B	Condenser Circulating Water Pumps	Automatic

Tag No.	Equipment	Switchover
P-2A P-2B P-3	Condensate & Boiler Feed Pumps (P-3, turbine driven)	Automatic
P-4A P-4B	Cooling Water Booster Pumps	Automatic
P-5A P-5B	Blowdown Cooling Pumps	Automatic
P-7A P-7B	Condensate Recirculating Cooling Pumps	Automatic
P-8A P-8B	Primary Coolant Make-up Pumps	Automatic
P-11A P-11B	Primary Coolant Pumps	Manual

Loss of Vacuum

If the vacuum in the condenser is lost, the turbine generator should be kept in service exhausting to atmosphere through atmospheric relief valve SV-1. Generally, the incident is attributable to failure of both circulating water pumps; severe air leakage into the condenser; plugging of the air ejector steam jets; and/or accidental opening of atmospheric relief valve SV-1.

1. Upon vacuum loss there will be a rapid increase in steam flow due to the turbine governor attempting to maintain the load constant. Reduce the electrical load so that steam flow as indicated on flow recorder FRC/1 is returned to the rate which existed just prior to the loss of vacuum.

2. If, after 15 minutes, vacuum cannot be re-established, shut down the turbine generator.

NOTE

Prolonged operation (over 15 minutes) exhausting to atmosphere would seriously reduce the distilled water supply.

Condenser Leakage

Leakage of circulating water into the steam side of the condenser will pollute the condensate in the condenser hot well. Conductivity recorder CR/102 will sound an alarm and the following procedure should be immediately initiated:

1. Using the multipoint switch, check the conductivity cells in the condenser to determine which half of the condenser is the source of the pollution.

2. If high conductivity shown by one or two cells indicates that the leakage is confined to one half of the condenser, reduce the load on the turbine generator to half load and isolate the leaky half of the condenser until repairs are made.

3. If the leakage has increased the concentration of solids in the steam generator water, temporarily increase the blowdown rate.

4. Sample the water in the distilled water tank. If it is polluted, operate the evaporator at full capacity so that tank TK-2 overflows, thereby assisting in improving the purity of the secondary water system.

5. If excessive leakage occurs in both sides of the condenser, shut down the entire plant until repairs are completed.

ABNORMAL SHUTDOWN

General

Abnormal shutdown refers to unplanned shutdown due to mal-functioning of plant equipment, improper operation, or electrical faults where the difficulty causing shutdown is not of an urgent nature. Plant malfunctioning which requires urgent action is dealt with under EMERGENCY PROCEDURES.

Loss of Load - Auxiliary Power Still Available

(See Figure 2-16).

If there is a sudden loss of electrical load on the turbine generator, as would happen upon the opening of certain circuit breakers, the speed governor will cut back the steam flow to maintain the unloaded turbine at full rated speed. Proceed as follows:

1. Reduce turbine generator speed to normal with the governor motor.

2. Observe steam generator steam pressure. If the pressure rises to 425 psig, dump steam to the condenser to prevent further pressure rise.

3. After the electrical trouble has been cleared, the turbine generator may be re-synchronized and returned to the line in the normal manner.

SHUTDOWN AFTER SCRAM (Auxiliary Power Still Available)

1. Break vacuum using valve on air ejector.

2. Close steam extraction line valve.

3. As turbine slows down, check that one of the auxiliary oil pumps starts up.

4. Take over control of boiler feed pump manually to maintain proper water level in steam generator.

5. If cause of scram can be remedied, follow "Hot Startup" procedure. If not, follow "Planned Shutdown" schedule.

EMERGENCY PROCEDURES

Emergencies are considered to be those situations arising due to equipment failures or improper operation which could result in injury to personnel or serious damage to equipment.

SHUTDOWN PROCEDURES AFTER SCRAM

(Without Station Service Power)

Figure 4-1 shows the electrical circuit by which the emergency power sources ("construction line" and 60 KW Diesel generator set) are connected to the APPR-1 system.

The Diesel generator will be used to ensure a safe plant shutdown when it is not possible to get electrical power from USAERDL Substation H-327. For shutdown only -- not restart of the plant -- the generator will operate those components which furnish vital control and cooling for the plant, namely, the air compressor, electrically-driven turbine oil pump, and condensate recirculating pump. Parenthetical abbreviations after item numbers refer to normal crew positions (CRO = Control Room Operator; IM = Instrument Man; EO = Equipment Operator). On a full shift, these indicate the most logical person to perform each duty. All work must be coordinated with the Control Room Operator, who will reassign duties as necessary to keep the work going smoothly and as fast as possible.

<u>Situation</u>:

1. Reactor scrams and ACB "A" opens.

2. Power is not available through Substation H-327 for plant startup, or plant conditions are felt to be unsafe for startup.

<u>Procedure</u>:

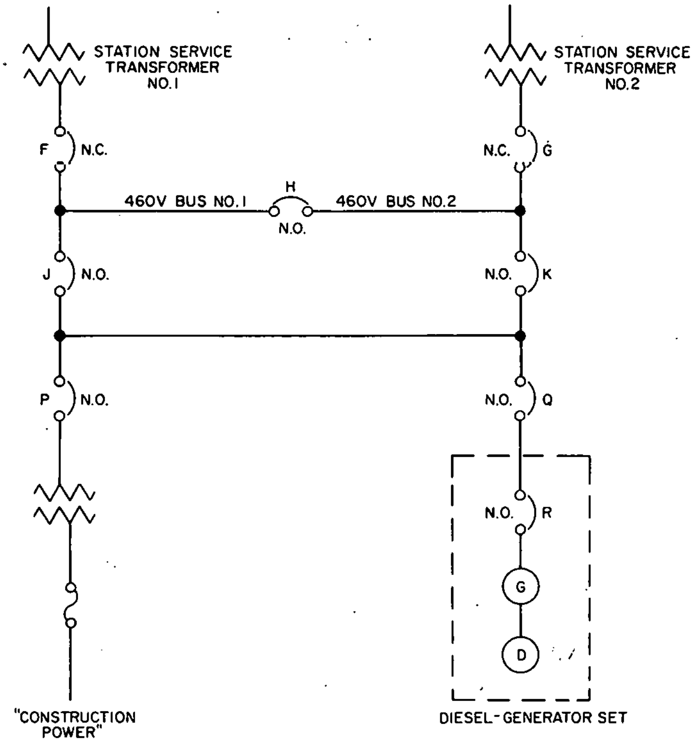
1. (CRO) Close trip valves on primary coolant blowdown line (TV-8) and on steam generator blowdown line (TV-5).

2. (CRO) If power is not available at ERDL Substation H-327, announce over the operating network "Proceed with Emergency Shutdown using Diesel set." Announce, specifically, who will perform various crew assignments (IM, CRO, EO); or, if only two persons are available, announce that CRO will control whole job on Operating Network.

3. (EO) Close air ejector steam valves.

4. (EO) Open condenser vacuum breaker valve at air ejector.

5. (CRO) Open all 4160- and 460-volt bus breakers on Control Room electrical panel, including all pump switches and M-G set.



N.O. NORMALLY OPEN
N.C. NORMALLY CLOSED
P. MANUALLY OPERATED 480V SAFETY SWITCH, FIRST LANDING, STANDBY TRANSFORMER.
Q. SAFETY SWITCH-ELECT. EQUIP. ROOM FOR DIESEL-GENERATOR SET.
R. CIRCUIT BREAKER AT DIESEL-GENERATOR SET.

Figure 4-1. Emergency Power Circuit to APPR-1

6. (IM) In Electrical Equipment Room, open the following circuit breakers:

   Building Service Feeders 1, 2, 3, 4, 5, 6
   Reactor Services
   Lighting Transformers 1 and 2
   Turbine Room Crane
   Main Air Compressor
   460 Volt Outlets
   Seal Leakage Pumps.

Leave the following circuits in the position indicated:

   Miscellaneous Feeder - Breaker closed
   Standby Air Compressor - Breaker closed
   Turbine Oil Pump (electrical - "Manual" or "Auto" position.)

7. (IM) Check to see that ACB "P" is locked out. Close switch "Q" on Diesel set; start Diesel generator set. Then close "R", notifying Control Room when this is done.

8. (CRO) When it is reported that Diesel set is operating and breakers "Q" and "R" are closed, close breakers "J" and "K", energizing station service busses, starting electrical turbine oil pump and standby air compressor. Check to see that these motors are operating satisfactorily.

9. (EO) Start one condensate recirculating pump.

10. (EO) Shut down the chlorinator.

11. (IM) Close lighting transformer No. 1 breaker on 460-volt circuit. This reduces some of the DC load. Check "Phano-charger."

12. Start battery-charging M-G set.

13. Additional load up to about 90 amperes or 60 KW is available from Diesel set.

14. Following are important precautions which should be observed during cooldown:

    a. Open all isolating valves for turbine-driven boiler feed pumps and steam dump valve. (Check List No. 25.)
    b. Close block valve at feedwater control valve if steam generator level rises above normal.
    c. Observe steam generator pressure, and manually open steam dump valve (FCV-3) if pressure exceeds 425 psig. Maintain level in steam generator with boiler feed pump No. 3 as required. Maintain condensate level in condenser hotwell by manual operation of level control by-pass valve.
    d. Check primary coolant pump temperature; primary coolant temperature, and pressurizer temperature on 24-point temperature indicator. Maximum temperatures of 350° F, 460° F, and 580° F should not be exceeded.
    e. Connect oscillograph to log count rate (BF_3) amplifier.

15. (CRO) If power becomes available through ERDL Substation 327, and if all trouble in the plant is cleared satisfactorily, start up the plant following Procedure for Hot Startup After Loss of Station Service Power. Open breakers "R" and "Q" and shut down Diesel when no longer needed.

LEAKAGE OF PRIMARY COOLANT INTO SECONDARY SYSTEM

Should a leak develop in a tube or tubes of the steam generator E-7. the higher pressure, radioactive primary coolant will leak into the shell side of the steam generator. Such a leak will be indicated by radiation monitors which will sound an alarm; a sudden rise in the steam generator level, as indicated by level recorder controller LRC/4; a decrease in pressurizer E-9 level, as indicated on level recorder controller LRC/7; and a decrease in primary coolant make-up tank TK-5 level, as indicated on level indicator controller LIC/8. The action to be taken upon discovery of a leak will depend upon the magnitude of the leak and radioactive considerations.

If a tube in steam generator E-7 ruptures, pressure vessel E-5 will be shut down automatically by the rise in main line steam pressure. The pressure in the steam generator will rise very rapidly and pressure control valve TV/PCV/1 will hold the steam pressure on the main steam line to turbine generator TG-1 at 200 psig. Safety valve SV/5 will open at 500 psig pressure and discharge steam inside the vapor container. The pressure on the steam generator should be reduced and the plant shut down as follows:

1. Close valves TV/PCV/1-1, TV/PCV/1-2, TV/9 and MS-1.

2. Shut off the heaters in pressurizer E-9.

3. Keep the following pumps in service for the reasons indicated:

P-1A or P-1B	Circulating Water Pump	To condense steam and cool the condensate
P-7A or P-7B	Condensate Recirculating Cooling Pump	To cool shield tank and primary coolant pumps
P-8A or P-8B	Primary Coolant Make-Up Pump	To assist in cooling the primary coolant system

4. Put the idle primary coolant make-up pump in service and operate both pumps at full stroke.

5. Break the condenser vacuum.

6. Check to see that the motor-driven auxiliary oil pump automatically starts when the turbine oil pressure drops to about 40 psig.

7. Shut off turbine gland seal steam when the condenser pressure reaches atmospheric.

8. Continue shutdown as outlined under SHUTDOWN (Planned), Shutdown Procedures, steps 4 through 14.

Loss of Instrument and Control Air (See Figure 2-26)

If instrument and control air compressor C-1 fails, standby air compressor C-2 should start automatically. If both compressors fail, shut down the entire plant immediately. The reserve air supply in air receiver TK-8 will last only 30 to 45 minutes. The plant must be shut down and cooled as much as possible in this time.

NOTE

> Without compressed air, all the trip valves on the pipe lines to the vapor container will close.

EMERGENCY PROCEDURE AFTER A NUCLEAR INCIDENT

In the event of a nuclear incident, all block valves in lines entering and leaving the vapor container must be closed. This will insure control of all fission products within the vapor container.

The following items will indicate a nuclear incident:

1. Sudden drop of the primary pressure.
2. Sudden rise of the vapor container pressure to 20 psia or more.
3. Sudden drop of pressurizer level.

Check that the primary pressure continues to fall whereas the vapor container pressure remains constant or continues to rise. If this does not take place, the primary relief valve has probably popped.

PROCEDURE

Immediate action by Control Room Operator:

1. Scram the reactor.
2. Close the main steam valve and the primary and secondary blowdown trip valves.
3. Announce the condition over the P.A. system.
4. Secure the primary coolant pump.
5. Secure the primary make-up pump.
6. Turn the pressurizer heaters off.
7. Secure the boiler feed pump.

8. Secure the condensate recirculating pump.

9. Secure the cooling water booster pump.

10. Close the primary and secondary blowdown valves.

Immediate action by the Instrument Man:

1. Check that all trip valves tripped and trip if necessary.

2. Go to the demineralizer room and close blowdown cooling water outlet block valve SC-10.

3. Close primary coolant blowdown block valve PC-14A.

4. Check that the following are closed:
   a. Decontamination fan suction valve.
   b. Decontamination fan discharge valve to the vapor container.
   c. Sump drain valves.

Immediate action by Equipment Operator:

1. Close the following valves:
   a. Block valve CO-27A condensate recirculating water to the primary coolant pumps.
   b. Block valve CO-28 condensate recirculating water to the shield tank.
   c. Block valve CO-29 condensate recirculating water from the vapor container.
   d. Block valve BF-29 boiler feed water to the steam generator.
   e. Block valve SC-9 blowdown cooling water to the vapor container.
   f. Block valve MS-1 steam dump line.
   g. Block valve H-5 hydrogen to the seal leakage tank.
   h. Valve MS-12 steam pressure indicator shutoff.
   i. Valve MS-13 steam pressure recorder shutoff.
   j. Block valve P.C.-14 primary coolant make-up line.
   k. Block valve BD-2 steam generator blowdown line.
   l. Block valve D-1 superheater drain line.

2. Check that the following valves are closed:
   a. Block valve BD-1 steam generator drain.
   b. H-6 hydrogen line drain.
   c. BF-28 boiler feed water line drain.

Subsequent action by Control Room Operator:

1. Notify the Health Physicist if there is none on duty.

2. Start a log on the vapor container pressure recording pressure at 15 minute intervals.

3. Continually check the radiation levels throughout the plant.

4. Attempt to put the fission channel into operation.

5. After the air compressor is on service water, secure the blowdown cooling water pump.

6. Secure the circulating water pump after blowdown cooling water and chlorinator pumps are secured.

Subsequent action by Instrument Man:

1. Open breakers to all pressurizer heaters.

2. Open breakers to the seal leakage return pumps.

3. Open breakers to the primary coolant pumps.

4. Open breakers to the rod drives.

5. Open the reactor service breaker.

6. Open the miscellaneous service breaker.

7. Shut off switch to receptacles on the vapor container.

8. Shut off switches to lights in the vapor container.

9. Shut off the 400-cycle generator.

10. Shut off the space cooler.

Subsequent action by the Equipment Operator:

1. Break the condenser vacuum and check the turbine auxiliary oil pump operation.

2. Put the main air compressor on service water.

3. Secure the chlorinator.

4. Prepare to start injecting boron solution into the vapor container through the spray system.

EMERGENCY SHUTDOWN BY BORON POISONING OF CORE

For the case of stuck control rods which will not allow complete core shutdown with rods alone, boron injection using the primary make-up pumps will be used to complete the shutdown.

In all cases envisioned, the reactor will be sub-critical at scram temperature and will only become critical at some reduced temperature. The transient will involve several hours and the resultant stable condition is not hazardous. However, it is obvious that some means must be provided to shut down the reactor.

In making this provision it was decided to size the equipment for the worst case with three rods stuck out. Twenty (20) grams of B-10 in a core volume of 11 liters of water will make the reactor sub-critical on cooldown to room temperature at any time during the reactor lifetime. The following procedure can be repeated as many times as desired to add additional poison to the system.

The volume of the primary system, including the primary coolant make-up tank, is 6300 gallons. Reducing this volume to 2300 gallons, by draining the make-up tank to the 1000 gallon level, will require 8380 grams of natural boron or 106 pounds of boric acid to attain the desired poison concentration in the primary system. Boric acid has been selected as the best poison from the standpoint of clean-up of the system.

PROCEDURE

1. Drain primary make-up tank to 1000-gallon indication on level recorder.
2. Transfer 200 gallons of PC water to one 250-gallon boron injection tank.
3. Add 30 pounds boric acid to boron injection tank.
4. Plug in motor-driven agitator and stir contents of boron injection tank for at least 30 minutes.
5. Line up primary coolant blowdown to bypass demineralizers and filter.
6. Open block valve between boron injection tank and primary make-up pumps.
7. Line up both primary make-up pumps and start both pumps feeding primary system.
8. Open motor-operated primary blowdown valve to full open position.
9. Continue pumping from boron injection tank until visually empty.
10. Secure make-up pumps and blowdown.
11. Repeat steps 2 through 10 until at least four batches have been injected into system.

BORON INJECTION WHEN SPRAY IS USED

According to APAE No. 2 (Hazards Report for APPR-1), the spray water used after the maximum credible accident is to contain 1/4 percent by weight of boron.

Four 250-gallon tanks are provided with valving to a manifold which leads to the primary fill pump (capacity: 20 gallons per minute). A line with valve is provided from the fill pump directly to the spray nozzle. When pumping to the spray nozzle, the valve to the primary system is closed. The contents of the four 250-gallon tanks can be pumped into the vapor container in sequence on 15-minute intervals. For each tank 10 minutes is allowed for pumping, 5 minutes for manipulating the valves to the common manifold, and 45 minutes for dissolving the boron compound. Boric acid has a solubility of 0.22 lbs. per gallon at 32°F which is well in excess of the 0.12 lbs. per gallon corresponding to 1/4 percent by weight of boron. Sixty-five hundred pounds of boric acid will be stored at the site for use in the spray system if ever needed.

PROCEDURE

1. Fill all four boron injection tanks with approximately 200 gallons each of water.

2. Add 25 pounds of boric acid to each tank.

3. Plug in motor-driven agitators for all four tanks and stir contents of tanks for a minimum of 30 minutes.

4. Line up valving to pump from the boron injection tanks to the spray heads in the vapor container using the primary fill pump.

5. Start primary fill pump and continue pumping until vapor container pressure is reduced below 20 psia.

6. Secure primary fill pump.

7. Secure boron injection tank valves and suction and discharge valves around primary fill pump.

SECTION 5

CHECK SYSTEM

The following are operation check lists referred to in Section 4. For more detailed information on any specific plant component, refer to Section 2, "Components Description and Operation".

CHECK LIST NO. 1

To make electrical power available to both station service busses and the lighting system:

1. Switch the following to the "Lock Out" position:

   a. All SB-1 switches on the battery and motor control panel:

      (1) Condenser recirculating water pump No. 1
      (2) Condenser recirculating water pump No. 2
      (3) Condensate and boiler feed pump No. 1
      (4) Condensate and boiler feed pump No. 2
      (5) Condensate recirculating cooling pump No. 1
      (6) Condensate recirculating cooling pump No. 2
      (7) Cooling water booster pump No. 1
      (8) Cooling water booster pump No. 2
      (9) Primary cooling make-up pump No. 1
      (10) Primary cooling make-up pump No. 2
      (11) Cooling water blowdown pump No. 1
      (12) Cooling water blowdown pump No. 2
      (13) Decontamination fan
      (14) Battery charger M-G set DC and AC switch
      (15) Evaporator feed pump.

   b. At the right side of the console:

      (1) Primary coolant pump No. 1
      (2) Primary coolant pump No. 2

   c. At the right side of the console, turn the "Power On" key to the "Off" position.

   d. Turn heater control switches 1-10 to the "Off" position.

   e. Turn local switches for both air compressors, chlorine injection pump, primary coolant fill pump, turbine auxiliary oil pump, vapor container space cooler motor, spent-fuel pit recirculating pump, chemical feed pumps, seal pit monitor pump, seal leakage pumps, and hot waste tank pumps to the "Off" position.

CHECK LIST NO. 1 (Cont'd)

2. See that the following circuit breakers are closed:

Cubicle No.	Equipment Item or Service
1	Pressurizer heater No. 1
2	Pressurizer heater No. 2
3	Pressurizer heater No. 3
4	Blowdown cooling water pump No. 1
5	Cooling water booster pump No. 1
6	Primary coolant pump No. 1
7	Pressurizer heater No. 4
8	Pressurizer heater No. 5
9	Battery charger-MG set
10	Circulating water pump No. 1
11	Pressurizer heater No. 6
12	Pressurizer heater No. 7
13	Evaporator feed pump
14	Circulating water pump No. 2
15	Pressurizer heater No. 8
16	Pressurizer heater No. 9
17	Pressurizer heater No. 10
18	Blowdown cooling water pump No. 2
19	Cooling water booster pump No. 2
20	Primary coolant pump No. 2
21	Building-service feeder No. 4
22	Building-service feeder No. 5
23	Primary coolant makeup pump No. 2
24	Instrument air compressor No. 1
25	Condensate recirculating pump No. 2
26	Condensate and boiler feed pump No. 2
27	Space only
28	Space only
29	440-volt power outlets
30	Station crane
31	Lighting transformer No. 2
32	Building service feeder No. 6
33	Space only
34	Instrument air compressor No. 2
35	Reactor service
36	Miscellaneous motor feeder
37	Lighting transformer No. 1
38	Building service feeder No. 3
39	Building service feeder No. 1
40	Building service feeder No. 2
41	Primary coolant makeup pump No. 1
42	Decontamination fan
43	Condensate recirculating pump No. 1
44	Condensate boiler feed pump No. 1

CHECK LIST NO. 1 (Cont'd)

3. Go to ERDL substation H-327 and visually check to see that the disconnect switch and circuit breaker are in operating position.

4. Go to DC battery charging area, main DC distribution panel, and close the following switches:

   a. No. 10, to close relays of 4160-volt panel.
   b. No. 11, to close 460-volt switchgear.

5. Close ACB "A" located on the ring bus panel. Light should then turn red.

6. To close ACB's "B" and "C":

   a. Place synchronizing key in synchronizing switch above ACB "B". Turn to "ON" position, observe synchronizing voltage, lights, and synchroscope on the swinging panel, upper left end of the electrical control panel. Close ACB "B" to red light, red flag position.

   b. Turn synchronizing key "Off". Place this key in the synchronizing switch below ACB "C" and turn "On". Again observe the swinging panel. Close ACB "C" to red light, red flag position.

7. On station service panel, close breakers "F" and "G". In order to close these breakers, place synchronizing key in switch above the breaker and turn to "On" position, as in 5, above.

8. Check to see that generator control M-G set breaker is in the trip position, and that motor control M-G set breaker is in the trip and "Lockout" position. (These are located on battery and motor control panel.)

9. Close battery charger M-G set breaker located in Electrical Equipment Room.

10. Place local control in "Run" and "Test Off" positions. Inform Control Room of this. Control Room operator can then put the motor control M-G set switch in the close position, which causes red light and red flag to appear. (Battery exhaust hood fan must be running to permit generator contact to close.)

11. Turn battery M-G set switch to "Battery". Observe voltage. Turn to "Generator" position; regulate voltage to match battery voltage; then close generator control M-G set breaker to red light, red flag position.

12. Start bringing batteries up to full voltage charge not exeeeding 25 amps charging current.

CHECK LIST NO. 2

To put main air compressor into service:

1. Lubrication: Check oil level.

2. Line up electrically to start locally.

3. Line up intake and discharge lines.

4. Line up and start flow of coolant water from primary blowdown coolant pump or service water header to the air compressor, condensifilter, and aftercooler.

5. Line up the drains of aftercooler and compressor.

6. Start up locally; place on "Continuous".

7. Check that the compressor loads and unloads at the proper pressures.

8. Check condensifilter and receiver trap operation.

CHECK LIST NO. 3

To make all instruments and pneumatically controlled valves ready for service:

I. Control Room.

1. Close switches 1, 5, 7 and 8 in the D.C. panel, No. 1 in No. 1 A.C. distribution panel, and switch No. 12 in lighting transformer distribution panel in the turbine room.

2. Close the 30-ampere D.C. switch located inside the rear of the graphic cubicle and the 100-ampere A.C. switch inside the graphic cubicle.

3. Turn the "power" key on the control panel to the "On" position.

4. Run the annunciator test, stopping on No. 7, "Resilence and reacknowledge."

5. Advise pump room to "Reset" trip valves.

   a. Check that amber lights on the graphic panel come on.

   b. Check that blowdown cooling and primary blowdown flow red lamps on graphic panel are lit.

6. Turn on the following instruments, verifying that they have charts, that charts drive, and that pens are inked.

a. Linear power recorder	On nuclear panel
b. Log N. recorder	On nuclear panel
c. Power level recorder	On nuclear panel
d. Period recorder	On nuclear panel
e. Fission ch. log count recorder	On nuclear panel
f. BF-3 ch. log count recorder	On nuclear panel
g. 12-point temperature recorder	On nuclear panel

h.	Reactor and steam gen. temp. recorder	On nuclear panel
i.	FC log count rate meter	On nuclear panel
j.	FC scaler	On nuclear panel
k.	FC A1D amplifier	On nuclear panel
l.	BF-3 log count rate meter	On nuclear panel
m.	BF-3 scaler	On nuclear panel
n.	BF-3 A1D amplifier	On nuclear panel
o.	Temp indicator (prec. ind.)	Radiation panel
p.	Radiation recorder	Radiation panel
q.	Jordon radiation units	Radiation panel
r.	Conductivity recorder	Graphic panel
s.	Verify that all Tel-O-Set recorders on have charts, are inked and that charts drive	Graphic panel
t.	Primary flow indicator	Rear of graphic cub
u.	Primary flow scram servo	Rear of graphic cub
v.	Steam gen level indicator	Rear of graphic cub
w.	Pressurizer level ind	Rear of graphic cub
x.	Vapor container pressure indicator	Rear of graphic cub
y.	Pressurizer pressure controller	Rear of graphic cub
z.	Delta T across reactor recorder	Rear of graphic cub
aa.	Delta T across pump leg indicator	Rear of graphic cub
bb.	Turn on Sorenson voltage regulator.	

7. Put annunciator on "System Reset", step 8. Acknowledge and silence all alarms. The following points will be alarmed. Activation of any other point must be investigated and corrected, or satisfactorily explained before proceeding:

	ALARM POINT	FUNCTION
a.	12	Trouble Safety Amplifier No. 1
b.	14	High Pressurizer Level
c.	18	Reactor Scram
d.	21	Low Pressure Bearing Oil
e.	30	Trouble Safety Amplifier No. 2
f.	35	Low Pressurizer Pressure Scram
g.	36	Period Scram
h.	42	Low Level Vapor Con. Manhole
i.	51	Low Primary Flow
j.	53	Low Primary Flow Scram
k.	57	Generator Differential
l.	65	P.C. Starter Circuits De-energized
m.	68	Low Pressurizer Pressure

8. Verify air supply to control room instruments:

   a. Air gauge on manifold in rear of graphic cubicle reads 20 psi.

   b. Upper air gauge on manifold on upper right, inside graphic cubicle, reads 9 psi.

c. Lower air gauge on manifold on upper right, inside graphic cubicle, reads 20 psi.

9. Read the following instruments on graphic panel and parameter meter and back of graphic cubicle, if noted. Readings should be approximately as noted and consistent among themselves.

	PARAMETER POINT	GRAPHIC PANEL	REAR OF CUBICLE
a.	No. 3 reads 50	Steam Generator Level reads -2"	15"
b.	No. 6 reads 100	Service Water Tank reads 5000 gal	none
c.	No. 7 reads 100	Pressurizer Level reads 42"	42"
d.	No. 8 reads 100	Primary Makeup Tank reads 5000 gal	none
e.	No. 9 reads 100	Distilled Water Tank reads 5000 gal	none
f.	No. 11 reads 50	Condenser Pressure reads 0 psi	none
g.	No. 13 reads 15	Vapor Container Press reads 15 psi	15 psia

10. Verify that "AUTO-SEAL-MANUAL" switch is in "AUTO" position on:

    a. Service water tank level indicator on graphic panel.

    b. Primary makeup water tank level indicator on graphic panel.

11. Verify that feedwater "Manual-Auto" control is in manual position and that air output is 0.

12. After the plant is in operation, verify that condenser circulating water inlet and outlet recorded temperatures are the same as temperatures read on industrial thermometers as follows:

    a. TR201 is same as IT 6a
    b. TR202 is same as IT 6b
    c. TR203 is same as IT 7a
    d. TR204 is same as IT 7b

II. IN PLANT

1. When advised by Control Room, "Reset" trip valves on trip valve control cabinet. Note that red lamp comes on as each valve is reset.

2. Verify that shutoff valves to differential converters are open on:

    a. Service water tank
    b. Distilled water tank
    c. Primary makeup tank

CHECK LIST NO. 3 (Cont'd)

3. In Demineralizer Room.

   a. Check that bypass valves are closed and block valves are open to:

      (1) Primary blowdown radiation monitor
      (2) Primary blowdown coolant radiation monitor

   b. Shut off valves are open to pressure transmitter PIC-5.

   c. Bypass valve is closed and block valves open to flow rotameter, FR/2.

   d. Shut off valves are open and CR 104 and CR 105 are inserted and collars tightened.

   e. Check that the blowdown flow integrator is plugged in.

4. Verify that bypass valves are closed and block valves open to:

   a. LCV-6 Service water tank control valve

   b. LCV-8 Primary makeup tank

5. Steam generator level controls:

   a. Read remote level indicator.

   b. Check that bypass valve is closed and block valves are open to feedwater control valve, LCV-4.

   c. Set the valves to the feedwater flow indicator as follows:

      (1) Shut off valves at orifice plate open.
      (2) Shut off valves at meter open.
      (3) Equalizing valve at meter is closed.
      (4) Vent valves at meter are closed.

   d. Set the valves to the steam flow indicator as follows:

      (1) Shut off valves at the flow nozzle open.
      (2) Shut off valves at the meter open.
      (3) Equalizing valve at the meter closed.
      (4) Drain valves on sediment traps at meter closed.

6. Hotwell:

   a. Check that block valves to the level control system are open.

   b. Observe that gauge glass is at normal level and that shutoff valves to the glass are open.

   c. Check that vent and drain valves on level control system are closed.

d. Check that high level controller shutoff valves are open.

(1) That bypass is shut and block valves open to LCV-2.
(2) Check that air supply to controller is 20 psi.
(3) Check that diaphragm pressure of controller is 3 psi.

e. Check that block valves to the high level alarm are open.

f. Check that low level controller shutoff valves are open.

(1) That bypass valve is shut and block valves are open to LCV-3.
(2) That air supply to controller is 20 psi.
(3) That diaphragm pressure of controller is 3 psi.

g. Check that block valves to the low level alarm are open.

h. Check that valves are open, conductivity cells are inserted into hotwell, and that collars are tightened.

7. Feedwater heater

a. Check that shutoff valves to level control system are open.

b. Check that shutoff valves to controller are open and drain valve and vent valve are closed.

c. Check that controller supply air is 2 psi.

d. Check that controller diaphragm air is 3 psi.

e. Check that block valves are open and bypass valves shut to LCV-1.

f. Check that block valves are open on level glass and that water level is normal.

g. Check that shutoff valves to high and low level alarms are open.

8. Evaporator

a. Check that shutoff valves to level control system are open.

b. Check that shutoff valves to controller are open and drain and vent valves are closed.

c. Check that gauge glass reads normal level and that block valves are open.

d. Check that supply air to controller is 20 psi.

e. Check that controller diaphragm air is 3 psi.

f. Check that block valves are open and bypass valves are closed to LCV-5.

g. Check that shutoff valves to the high and low level alarms are open.

9. Hydrogen system

   a. Check pressure of hydrogen bottles.

   b. Check that hydrogen line valves to seal leakage tank and primary makeup tank are open.

   c. Check pressure on primary makeup tank.

   d. Check hydrogen pressure on seal leakage line.

10. Air ejector minimum flow controller

    a. Verify air supply to air ejector minimum flow controller is 20 psi, and that switch 2 in the instrument shop lighting cabinet is closed.

    b. Check that block valves are open and bypass is closed at TCV-6.

    c. Check that minimum flow return line valves at condenser are open.

11. Check turbine initial pressure regulator.

    a. Set point at 145 psi.

    b. Supply air 20 psi.

    c. Output air 3 psi at operating conditions and 20 at shutdown.

12. Recirculating system.

    a. Check that supply air to PCV-4 controller is 20 psi, output air is 20 psi, and the valve is open.

    b. Check that shutoff valve to PCV-4 controller is open.

    c. Check that block valves to PCV-4 are open.

    d. Check that back pressure control valve PCV-5 bypass valve is closed and block valves are open.

       (1) Supply air to controller is 20 psi.
       (2) Output air from controller is 20 psi.
       (3) Check that shutoff valve to controller is open.

    e. Block valves to radiation monitor are open.

13. Turbine driven feed pump exhaust steam control PCV-3.

    a. Check that supply air to controller is 20 psi.

    b. Check that output air from controller is 20 psi.

14. Check that condenser vacuum indicator reads approximately 0 and transmitted air is approximately 9 psi and that shutoff valve to the indicator is open.

15. Steam pressure control valves PCV 1-1 and 1-2.

    a. Controller PC-1.

        (1) Set point reads 200 psi.
        (2) Supply air reads 20 psi.
        (3) Output air reads 15 psi.

    b. Valve positioner.

        (1) Supply air reads 30 psi.
        (2) Output air reads 30 psi.
        (3) Instrument air reads 15 psi.

    c. Check that shutoff valve to controller is open.

16. Check that steam pressure blind transmitter supply air is 20 psi and that shutoff valve is open and the drain valve is closed.

17. Secondary blowdown

    a. Check that the air supply pressure to FI-2 is 30 psi.

    b. Check that the meter reads 0 per cent.

    c. Check that bypass valve is closed and block valves are open to FI-2.

    d. Check that block valve to FCU-1 is open.

18. Primary make-up varitrol drives

    a. Check air supply to varidrives of the P.C. make-up pumps.

    b. Check that supply air to reversing relay is 20 psi.

19. FIC-5

    a. Check that block valves are open and the bypass valve is closed.

b. Check operation of interlock on P.C. pumps.

20. Check that shutoff valves are open to pressure switches and pressure indicator on the main steam line.

III. VAPOR CONTAINER

1. Primary flow indicator and flow scram servo

   a. Check that block valves and shutoff valves to the dp cells are open and that the equalizing valve is closed.

   b. Check that drain valves are closed.

2. Pressurizer level

   a. Check that block valves are open and that the equalizing valve and drain valves are closed.

3. Steam generator level

   a. Check that block valves are open and that the equalizing valve and drain valves are closed.

4. Panel "A"

   a. Check that the block valve is open and that the drain is closed.

   b. Check that the valve to the pressure switches and the valve to the pressure controller are open.

CHECK LIST NO: 4

To check primary and secondary water levels.

1. To check primary water level.

   a. Start the primary fill system and pressurize the primary system to not more than 50 psi. Crack the vents and bleed the air from the pressurizer and the primary coolant pumps.

   b. Close the vents as soon as solid water appears.

WARNING

The primary water is radioactive and must be handled accordingly.

CHECK LIST NO. 4 (Cont'd)

2. To check the secondary water level.

   a. Check the condenser hotwell level in the sight glass. Check that the gauge glass shutoff valves are open.

   b. Check the level in the steam generator on the indicator behind the graphic panel. (See Check List No. 5 for boiler feed pump startup.)

CHECK LIST NO. 5

To start one boiler feed pump:

1. Lubrication: Check motor oil level.

2. Turn shafts of all three pumps to see that they move freely.

3. Line up suctions of all pumps.

4. Be sure gland seal line is open from discharge side of recirculating water pump.

5. Open equalizing lines of all pumps.

6. Line up boiler feed to minimum flow lines, recirculating system backup, air ejectors, feedwater heaters, and steam generator. Leave the discharge valves closed.

7. Start one pump, check operation and open all discharge valves.

8. Start second pump, check operation, stop the first pump and turn control over to control room.

9. Place first pump on "Standby"

10. Check the following:

    a. Pump suction pressure (PI-17).
    b. Pump discharge pressure (PI-18).
    c. Air ejector inlet temperature (IT-8).
    d. Air ejector outlet temperature (IT-9).
    e. Temperature at outlet of feedwater heater (IT-10).
    f. Check that hotwell level controls are working.

CHECK LIST NO. 6

To start the demineralizer system:

1. Check that the radiation monitor and diversion valve are in operation and that the diversion valve is set to direct the water to the demineralizer.

2. Check that the rotometer block valves are open and the bypass valve is closed.

CHECK LIST NO. 6 (Cont'd)

3. Check that the filter block valves are open and the bypass closed.

4. Open the inlet and discharge valves of the desired demineralizer and check that the inlet and discharge valves of the other demineralizer are closed. The online demineralizer light on the graphic panel should be lit.

5. Check that the conductivity cells are properly installed.

6. Open the block valve at the P.C. makeup tank and at the vapor container wall.

7. Check the operation of the rotometer when flow is established.

NOTE

The blowdown cooling water system must be in operation if the water is 125°F or more.

CHECK LIST NO. 7

To check on the operation of the seal leakage system:

1. Line up electrically by closing the individual pump breakers.

2. Check that the demineralizer system is in normal operation.

3. Put the local switches in the "Run" position (one at a time) and check that the pumps operate.

4. Return the local switches to the "Stop" position. This puts the pumps in automatic operation.

CHECK LIST NO. 8

To start up circulating water pump:

1. Open inlet valves to condenser.

2. Open return line valves from condenser.

3. Close condenser vent and drain valves.

4. Close inlet drain valves.

5. Close header drain at dock.

6. Line up electrically to start locally.

7. Start one pump locally and check operation and gradually open discharge valve to establish flow in system.

CHECK LIST NO. 8 (Cont'd)

8. Open discharge valve of second pump and start.

9. Stop first pump.

10. Control Room take over pump operation.

11. Leave local switches in "Run" and "Test Off" positions.

CHECK LIST NO. 9

To start up blowdown cooling system:

1. Lubrication: Check oil level.

2. Line up both pumps electrically to start locally.

3. Line up intake side of both pumps,

4. Line up blowdown cooler, space cooler, header to sample coolers, main air compressor, aftercooler, condensifilters, and the return line to the seal pit. Leave the discharge valves closed.

5. Open prime lines. Check that valve B-7, at condenser return line, is open.

6. Start up one pump, vent and open the discharge valves of both pumps.

7. Start second pump, check operation, stop first pump and turn control over to control room.

8. Place first pump in standby in Control Room.

9. Be sure radiation monitor diversion valve is working properly.

CHECK LIST NO. 10

To start up condensate recirculating pump:

1. Line up suctions of both pumps.

2. Line up discharges of both pumps to primary shield cooler, recirculating water pump glands, primary coolant pumps, level control valve for primary makeup tank and return to condenser. Leave the discharge valves closed.

3. Open both equalizing lines on each pump.

4. Line up both pumps electrically to start locally.

5. Start one pump; see that it is working and open both pump discharge valves.

CHECK LIST NO. 10 (Cont'd)

6. Start second pump and check operation; stop first pump and turn control over to Control Room; close discharge equalizing lines.

7. Place second pump on "Standby".

8. When recirculating water pump is started, read temperatures of cooling water to primary pumps, point 2 and 3 on precision indicator. Should read approximately the same as IT-15.

9. Check the following:

   a. Pump discharge pressure (PI-14).

   b. Pump inlet pressure (PI-19).

   c. Vapor container inlet temperature (IT-16).

   d. Vapor container outlet temperature (IT-15).

   e. Primary coolant pump coolant flow rate (FIC-5).

   f. See that diaphragm air on PCV-5 is reduced to about 5 psi.

CHECK LIST NO. 11

To start a primary make-up pump:

1. Lubrication:

   a. Check the oil level in the small lube pumps.

   b. Check the gear case oil level.

2. Line up the suctions of both pumps to the P.C. make-up tank.

3. Line up the discharges to the vapor container.

4. Line up both pumps electrically to start locally.

5. Start one pump; check its operation and stop it.

6. Start the second pump; check its operation and turn control over to the control room.

7. Put the first pump into "Standby".

8. When pressurizer level and pressure have been established:

   a. Check that the pressurizer pressure indicator on the graphic panel, parameter point 12 and the indicator on the rear of the graphic cubicle agree.

CHECK LIST NO. 11 (Cont'd)

b. Verify the set point on the indicator controller.

9. When blowdown system is placed in operation, read:

   a. Blowdown flow on graphic panel and parameter point 5.

   b. Demineralizer outlet flow rate (FR-2).

   c. Blowdown pressure on graphic panel and parameter point 24.

CHECK LIST NO. 12

To start up primary coolant pump:

1. Check that pump cooling water flow is normal.

2. Line up electrically to operate from Control Room.

3. Be sure primary system pressure is 50 psig.

4. Vent both P.C. pumps.

5. Start one pump and check flow rate; shut down pump and re-vent.

6. Start second pump and check on flow rate; shut down pump and re-vent.

7. Start one pump and leave in operation.

8. When primary coolant pump is started:

   a. Read flow rate on graphic panel, parameter point 4 and indicator on rear of cubicle.

   b. When flow reaches 3700 gpm, annunciator point 51 can be made normal.

   c. When flow reaches 4000 gpm, alarm point 53 can be made normal.

      (1) Put "Run-Bypass" switch in "Bypass" position.

      (2) Raise set point above flow rate. Control light will be extinguished and reset light will come on. Point 53 will alarm indicating scram relay operative.

      (3) Return set point to normal. Control light will come on.

      (4) Depress "Reset Button" and reset light will be extinguished. Alarm point 53 can be made normal.

      (5) Put "Run-Bypass" switch in "Run" position.

CHECK LIST NO. 13

Perform nuclear console and panel instrument check:

1. Preliminary:

   a. Turn reactor key to "On" position.

   b. Turn transfer lock switch to "Zero Power" position.

   c. Check that B minus voltage alarm lights on safety amplifier annunciators have extinguished and reset safety amplifiers. Alarm points 12 and 30 can be made normal.

   d. Reset generator differential trip. Alarm point 57 can be made normal.

2. Period amplifier:

   a. Turn meter selector switch to "Gnd" and verify that Log N meter needle goes to lowest scale mark and period meter needle goes to 00.

   b. Turn selector to "Low Cal" and adjust log N meter to lower delta calibration marker and check that recorder agrees with this reading.

   c. Turn selector to "High Cal" and adjust meter to higher delta calibration marker and check that recorder agrees with this reading.

   NOTE

   This will alarm point 72.

   d. Turn selector switch to "operate" position. Depress period amplifier and console "Reset" buttons.

   NOTE

   Alarm points 18, 36, 48, and 72 can be made normal. Magnet current lights on the safety amplifiers will be illuminated.

   e. Depress "period test" button and hold. Period meter will rise to approximately 3 seconds, the scram light will come on, and the magnet current lights on the safety amplifiers will be extinguished. The generator differential trip will be actuated. Alarm points 11, 18, 36, and 57 will be annunciated.

   f. Release "period test" button and when meters have settled, depress reset button on the period amplifier. Scram light will be extinguished and alarm points 11 and 36 can be made normal.

3. Depress reset button on console. Alarm point 18 can be made normal.

4. Safety amplifiers No. 1 and No. 2:

   a. Turn selector to plus 300 volts and record.

   b. Turn selector to minus 300 volts and record.

   c. Turn selector to Mag B plus 300 volts and record.

   d. Turn selector to each magnet current position and check that each magnet current is 75 milliamps.

5. Start up channels.

   a. Fission chamber

      (1) Calibrate the log count rate meter 60 cps.

      (2) Turn on chamber voltage on A1D amplifier.

      (3) Turn scaler counting switch to manual count.

NOTE

Scaler will indicate counting rate below one count per second.

   b. BF_3 channel

      (1) Calibrate the log count rate meter 60 cps.

      (2) Turn on scaler high voltage and adjust to prescribed voltage.

      (3) Turn scaler counting switch to manual count.

NOTE

Use oscilloscope to verify a counting rate of at least 2 neutrons per second.

6. Compensated ion chamber power supplies.

   a. Check that high voltage is 600 volts.

   b. Check that compensating voltage is set at prescribed voltage.

7. Linear power channel.

   a. Check that range change selector switch is set at lowest range (5×10^{-10} amps).

   b. Turn zero check on and set recorder to zero.

   c. Turn zero check off.

CHECK LIST NO. 14

To close and fill vapor container manhole:

1. Check line up of high and low pressure seal leakage manifolds (all valves must be open).
2. Shut off two large valves on pipes which connect VC vent fan to VC and sump pump valve of rod drive mechanism pit. Install blank flanges in VC vent lines.
3. Close spray head line valves.
4. Make general inspection of VC.
5. Close and tighten both doors.
6. Close drain valves.
7. Open fill valve.
8. Fill until water reaches midpoint of site glass.
9. Switch alarm to normal position.
10. Crack drain valves to check alarm.
11. Re-fill standpipe.
12. Close all valves except to the sight glass.

CHECK LIST NO. 15

To bring reactor to critical, then to 1 per cent of full power for heat up to 440°F.

1. Be sure appropriate starting instruments "see" the source.
2. Raise the 7-rod bank slowly to a point one and one-half (1-1/2) inches from its lowest position.
3. Withdraw the two (2) safety rods to 19 inches, watching instruments to be sure reactor is not critical. Do not proceed beyond this point unless you already see subcritical multiplication.
4. Go to critical on the 5-rod bank, withdrawing only one rod, a maximum of one inch at a time.

NOTE

AT NO TIME DURING THE CORE LIFETIME SHOULD THE DIFFERENCES IN WITHDRAWAL BETWEEN ANY TWO RODS OF THE 5-ROD BANK BE GREATER THAN TWO (2) INCHES.

CHECK LIST NO. 15 (Cont'd)

5. Using one rod at a time of the 5-rod bank, place the reactor on a period of greater than 30 seconds and bring the reactor up to 1 per cent of full power. Build up temperature to about 440°F at such a rate as not to exceed 45° Δt across the "Y" valve flange.

CHECK LIST NO. 16

To put feedwater heater into operation:

1. Line up level control and alarm valves (be sure to open stop valves on level control valve line).

2. Check block valves and bypass valve to assure water is going through heater.

3. Open third stage steam valve; check pressure in shell.

4. Check temperatures.

5. Check operation of LCV-1.

6. Check setting of vent valve.

CHECK LIST NO. 17

To start turbine-generator, and take on electrical load:

1. Lubrication: Check oil levels.

   a. Bayonet gage on reservoir.

   b. Sight glasses on generator bearings.

2. Open turbine drains:

   a. Turbine throttle valve.

   b. Main steam intake line.

   c. Steam chest drain.

   d. Two drains on third stage extraction line.

3. Start turbine-driven oil pump.

4. Start electric motor-driven oil pump. Check operation and shut down.

5. Reset the differential trip. Check the position of the load limiter and the speed governor.

6. Cock turbine throttle valve.

7. Open turbine throttle valve to rotate turbine and check the generator oil rings.

8. Trip throttle valve manually, and re-cock.

9. Open throttle valve and run turbine up to 500 rpm.

10. Turn on gland steam: Line up drain first, then open intake; check that gage on return line reads 2-5 psig.

11. Listen for noise, etc.

12. Put second stage air ejector into operation.

13. Check oil rings for operation.

14. Check oil temperature into and out of cooler, and pressure on reduction gear box.

15. Put the first stage air ejector into operation when the vacuum reaches 10 inches.

16. For hot start-up, warm up the turbine in accordance with the following table.

TIME UNIT HAS BEEN DOWN	WARM-UP TIME AT 500 RPM
Less than 1/2 hour	5 min.
1 hour	10 min.
1-1/2 hours	20 min.
2 hours	30 min.

17. Throttle to 1000-1200 rpm slowly; run there for 30 minutes; then close drain valves.

18. Throttle to 2200-2400 rpm gradually, then through 2800 without hesitation or stopping to about 3300-3500 rpm. Take about 5-10 minutes to go from 1200 to 5489 rpm.

19. Take over on speed changer, and open throttle valve fully.

20. Be sure to start up oil cooler when oil temperature reaches 115°F.

21. Check that all the resistance is in the excitation circuit.

22. Adjust turbine speed to approximately 5500 rpm.

23. Close the excitation breaker and adjust the generator voltage to approximately 4160 volts.

24. Synchronize with VEPCO.

    a. Turn the synchroscope on at ACB "D".

CHECK LIST NO. 17 (Cont'd)

b. Match voltage with VEPCO voltage and adjust speed such that the synchroscope indicator rotates slowly in the fast direction.

c. Close ACB "D" just before the synchroscope indicator reaches 12 o'clock.

d. Immediately take on about 300-kw load with the speed changer.

e. Turn the synchroscope off and move the key to ACB "E."

f. Turn on synchroscope, check synchronization, and close ACB "E."

g. Turn synchroscope off.

25. Take control of the turbine over the load limiter and release the speed changer.
26. Slowly take on kw and KVAR load.

CHECK LIST NO. 18

To put the air ejectors into operation:

1. Line up intake sides of steam and "vapor" lines, and check flow of coolant (B.F.) water from boiler feed pumps.
2. By-pass air flow rate meter.
3. Line up condensate lines from intercondenser and after condenser.
4. Open vapor line intake to one primary and one secondary ejector; open exhausts to intercondenser and after condenser.
5. Open steam valve to the second stage nozzle.
6. Watch temperature change of water through condensers and vacuum in condenser.
7. When condenser vacuum reaches 10-15 inches Hg, open steam valve to the first stage nozzle.

CHECK LIST NO. 19

To start up cooling water booster pump:

1. Lubrication. Check oil level.
2. Line up suction and discharge sides of both pumps, through oil coolers and generator air cooler, back to circulating water system. Leave the discharge valves closed.
3. Line up both pumps electrically to start locally.
4. Start one pump, check operation.
5. Open both pump discharge valves.

6. Fill oil coolers and air cooler.
7. Start the other pump; then stop first pump. Check operation and turn control over to Control Room.
8. Place first pump on "Standby".
9. Check discharge pressure (PI-13).

CHECK LIST NO. 20

Plant auxiliaries to be checked for operation in Hot Startup (after about two hour shutdown).

1. Circulating water pump.
2. Blowdown cooling water.
3. Cooling water booster pump.
4. Primary coolant pump.
5. Boiler feed pump.
6. Condensate recirculating pump.
7. Chemical feed pumps (if required).
8. Primary coolant make-up pumps.
9. Main air compressor.
10. Seal leakage return pump.
11. Battery charger M-G system.
12. Air ejector system.
13. Service water system.

CHECK LIST NO. 21

To remove electrical load from generator:

1. Regulate load limiter control switch to reduce load at a rate of not over 100 kw per minute. Decrease KVAR load simultaneously.
2. When power is down to 200 kw, take over control with speed changer. Remove remaining KW and KVAR loads with speed changer and voltage regulator.

CHECK LIST NO. 21 (Cont'd)

3. Trip ACB's "D" and "E".

4. Reduce excitation current to zero with exciter field rheostat.

5. Trip generator field circuit breaker.

6. Shut down air cooler by closing valves B-13 (B-19) and B-12 (B-16) to shut off cooling water.

CHECK LIST NO. 22

Planned turbine shutdown:

1. Close extraction steam line valve AS-23 (EX-1).

2. If turbine has operated continuously for less than one month, trip throttle valve (MS-8) with manual trip button. If turbine has operated continuously for over one month, overspeed turbine by loosening locknut on high speed stop, backing off on high speed stop, and adjust speed changer. If overspeed governor does not trip throttle valve automatically by the time turbine reaches 6100 rpm, trip throttle valve with manual trip button.

CAUTION

DO NOT ALLOW TURBINE SPEEDS TO EXCEED 6120 RPM. IF OVERSPEED GOVERNOR DOES NOT TRIP, THIS SAFETY DEVICE SHOULD BE REPAIRED PRIOR TO RE-STARTING TURBINE.

3. If overspeed governor operates, let turbine coast to 3800 rpm, then reset overspeed trip by lifting up on manual trip button.

4. Cock and open throttle valve.

5. Adjust turbine speed to 5820 rpm with speed changer.

6. Reset high speed step.

7. Check gland seal pressure.

8. Trip throttle valve manually.

9. Break condenser vacuum using valve provided on air ejector.

10. Check to see that an auxiliary oil pump comes on by the time the oil pressure drops to 40 psig. If not, re-start turbine and continue operation until one auxiliary oil pump can be started, and then shut down turbine.

11. Crack open drain from turbine throttle valve (MS-9).

CHECK LIST NO. 22 (Cont'd)

12. Shut off coolant flow to oil coolers. If an excessive rise in oil temperature occurs, restart coolers.

13. When vacuum reaches zero, shut off shift seal steam.

14. Operate auxiliary oil pump for a minimum of 2 hours after shutdown, or until turbine is cooled sufficiently.

15. When no longer needed, shut down cooling water booster pump.

CHECK LIST NO. 23

Planned reactor shutdown.

1. Turn selector switch on the Log N and period amplifier to "GND" position.

2. Scram the reactor with the manual scram button.

3. Check the nuclear instruments and shut them off when no longer required.

4. When the power level drops to about 20 per cent on 5×10^{-10} range of the linear power recorder, turn on the fission channel.

5. Turn the 400-cps genertor off.

6. Approximately 4 hours after reactor scram, turn the BF_3 channel on. Do not set the high voltage above 2000 v.

CHECK LIST NO. 24

To shut down the hydrogen system:

1. Close valves H-1 and H-2 on discharge of the hydrogen bottles.

2. Close the hydrogen bottle valves.

3. Close valve H-4 on the line to the seal leakage tank.

WARNING

If work is to be done on this system, it must be purged of all hydrogen.

CHECK LIST NO. 25

To start up turbine-driven boiler feed pump:

1. Line up intake and discharge sides of pump.

CHECK LIST NO. 25 (Cont'd)

2. Check lubrication.

3. Line up minimum flow line; open pump well vent; open prime line valve; open gland seal line, and line to discharge pressure gage.

4. Line up turbine exhaust.

   a. Open exhaust outlet to condenser.

   b. Check operation of exhaust pressure control valve (PCV-3).

5. Line up steam supply to turbine.

   a. Open stop valves on impulse trap line.

   b. Open inlet steam free blow valve.

   c. Open steam shut-off valve to let condensate blow out of line; then close shut-off valve and steam free blow valve.

   d. Open steam shut-off valve to steam turbine.

6. As soon as pump discharge pressure builds up, close priming line valve.

SECTION 6

PERFORMANCE DATA

Quantity Measured	Design Value	Operating Range
STEAM PLANT		
MONITORED RADIATION LEVELS		
Linear Power	---	$5x10^{-5}$
Reactor power level, KW	10,000	10,000
Reactor period, sec	00	-200 - +200
Log neutron flux density, log N/cm^2-sec	100	54 - 58%
Log count rate, log N/sec	Off scale	Off scale
Primary blowdown coolant gross beta and gamma rate, microcurie/cc	---	10^{-1}
Steam generator blowdown beta and gamma rate, microcurie/cc	---	10^{-9} - 10^{-6}
PRESSURE VESSEL (E-5) OPERATION		
Water inlet temperature, °F	431.6	431 - 432
Water outlet temperature, °F	450.0	448 - 450
Water temperature rise, °F	18.4	17 - 19
Water inlet flow rate, gpm	4000	3800 - 4000
Cooling water inlet temperature, °F	109	109— 112
Cooling water outlet temperature, °F	---	115 - 120
PRESSURIZER (E-9) OPERATION		
Steam pressure, psig	1185.3	1190 - 1260
Steam temperature, °F	567.2	565 - 568
Minimum level, in	15	15

Quantity Measured	Design Value	Operating Range
PRESSURIZER (E-9) OPERATION (Cont'd)		
Normal operating level, in	18.75	19 - 21
Maximum level, in	22.5	22.5
STEAM GENERATOR (E-7) OPERATION		
Primary inlet flow rate, gpm	4000	3800 - 4000
Primary inlet temperature, °F	450.0	448 - 450
Primary outlet temperature, °F	431.6	431 - 432
Minimum secondary water level, in. H_2O	-4	-6
Normal operating secondary water level, in. H_2O	0	0 - -2
Maximum secondary water level, in. H_2O	+4	+2
Steam pressure, psig	185.3	200 - 220
Steam temperature, °F	407.0	415 - 425
Steam flow rate, lb/hr (Turbine-driven boiler feed pump and dump valve inoperative)	34,070	32,000
Feedwater flow rate, gpm	72.4	62 - 65
Blow-off conductivity, micromho		
Secondary blowdown flow rate, gpm	0.42	2 - .4
TURBINE (TG-1) OPERATION		
Steam inlet pressure, psig	175.3	185 - 190
Steam inlet temperature, °F	404	400 - 417
Steam extraction pressure, psig	16.9	16 - 17
Steam extraction temperature, °F	253.3	250 - 255
Back pressure, in. Hg abs	2.5	1 - 2

Quantity Measured	Design Value	Operating Range
CONDENSER (E-1) OPERATION		
Condenser pressure, in. Hg abs	2.5	1 - 2
Condensate temperature, °F	108.7	104 - 110
Cooling water inlet temperature, °F	85	72 - 92
Cooling water outlet temperature, °F	98	80 - 104
Cooling water inlet pressure, psig	0 - 3	1 - 3
Cooling water outlet pressure, inches Hg	-15	-10 - -20
Condensate conductivity, micromho	5	3 - 5
AIR EJECTOR (EJ-1) OPERATION		
Feedwater inlet temperature, °F	108.7	100 - 115
Differential temperature across ejector, °F	7.5	10 - 20
Feedwater outlet temperature, °F	116.2	110 - 125
Steam inlet pressure, psig	150.0	150
Air removal rate, cu. ft./min	---	1 - .5
VAPOR CONTAINER (V-1)		
Air pressure, psia, Maximum	30	15
Ambient temperature, °F, Maximum	125	110 - 125
FEEDWATER HEATER (E-2) OPERATION		
Feedwater inlet temperature, °F	116.2	110 - 125
Feedwater outlet temperature, °F	246.1	250 - 255
Steam inlet pressure, psig	15.2	16 - 18
Steam inlet temperature, °F	250.0	250 - 255
Condensate outlet temperature, °F	146.2	135 - 160
Feedwater conductivity, micromho	5	3 - 5

Quantity Measured	Design Value	Operating Range
EVAPORATOR (E-3) OPERATION		
Steam inlet pressure, psig	175	185 - 190
Outlet pressure, psig	15.2	15 - 18
Outlet temperature, °F	250	250 - 255
PRIMARY BLOWDOWN COOLER (E-8) OPERATION		
Cooling water inlet temperature, °F, Max.	85	91
Cooling water outlet temperature, °F, Max.	100	110
PRIMARY COOLANT MAKE-UP TANK (TK-5) OPERATION		
Water inlet flow rate, gpm	75	0.5 - 1.5
Make-up water temperature, °F, Max.	105	85 - 110
Tank pressure, psig, Max.	35	19
Tank pressure, psig, Min.	---	10
Minimum level, gal.	3500	3500
Normal operating level, gal.	4200	4100
Minimum level, gal.	4500	4500
Primary make-up water conductivity, micromho	---	.5 - .7
SERVICE WATER TANK (TK-3) OPERATION		
Minimum level, gal.	3500	3500
Normal operating level, gal.	4500	4500
DISTILLED WATER TANK (TK-2) OPERATION		
Minimum level, gal.	3000	3000
Normal operating level, gal.	4500	3000 - 4500
SPENT FUEL PIT		
Minimum level, gal.	14,400	14,400
Maximum level, gal.	15,200	15,200

Quantity Measured	Design Value	Operating Range
CONTAMINATED WASTE STORAGE TANK (TK-6) OPERATION		
Tank temperature, °F	---	60 - 80
Tank pressure, psig (design 45 psig)	30	0
Maximum level, gal.	5000	3000
LABORATORY ACTIVE WASTE HOLD UP TANK (TK-10A,B) OPERATION		
Maximum level, gal.	300	300
DEMINERALIZERS (DM-1A,B) AND FILTER (FL-3) OPERATION		
Water inlet temperature, °F	140	90 - 125
Water inlet conductivity, micromho	4	1 - 2
Water outlet conductivity, micromho	/1	.5 - .7
Blowdown pressure, psig	30	22 - 75
TURBINE OIL COOLER OPERATION		
Cooling water inlet pressure, psig	---	30 - 35
Cooling water outlet pressure, psig	-15	-10 - -20
Cooling water inlet temperature, °F	85	72 - 92
Cooling water outlet temperature, °F	---	85 - 100
GENERATOR AIR COOLER OPERATION		
Cooling water inlet temperature, °F	85	72 - 92
Cooling water outlet temperature, °F	94	78 - 100
Cooling water outlet pressure, psig	-15	-10 - -20
HYDROGEN CYLINDER OPERATION		
Primary make-up line gas pressure, psig	20 - 25	20 - 23
MOTOR-DRIVEN BOILER FEED PUMP (P-2A,B) OPERATION		
Water inlet pressure, in. H_2O	-30	-27 - -28
Water outlet pressure, psig	---	300 - 540

Quantity Measured	Design Value	Operating Range
TURBINE-DRIVEN BOILER FEED PUMP (P-3) OPERATION		
Water inlet pressure, in. Hg abs	2.5	1 - 2
Water outlet pressure, psig	---	300 - 540
Steam inlet pressure, psig	185.3	190
Turbine back pressure, psig	5	3
PRIMARY COOLANT PUMP (P-11A,B) OPERATION		
Outlet temperature, °F	431.6	432
Pump temperature differential, °F	10	±1
Cooling water temperature, °F	105	104 - 110
Cooling water flow rate, gpm	15	15.5
CIRCULATING WATER PUMP (P-1A,B) OPERATION		
Outlet pressure, psig	15	16-20
CONDENSATE RECIRCULATING PUMP (P-7A,B) OPERATION		
Inlet pressure, in. Hg abs	2.5	1 - 2
Outlet pressure, psig	90	85 - 87
COOLING WATER BOOSTER PUMP (P-4A,B) OPERATION		
Outlet pressure, psig	---	10 - 36
EVAPORATOR FEED PUMP (P-18) OPERATION		
Outlet pressure, psig	---	48 - 51
SPENT FUEL PIT RECIRCULATING PUMP (P-15) OPERATION		
Outlet pressure, psig	---	20 - 25
PRIMARY COOLANT FILL PUMP (P-12) OPERATION		
Water temperature, °F	85	65 - 85
Outlet pressure, psig	35	47 - 52

Quantity Measured	Design Value	Operating Range
ELECTRICAL SYSTEM		
GENERATOR AND EXCITER		
Generator stator, air and water temperature, °C	35	40 - 50
Generator speed, RPM	1200	1200
Generator output line current, amp	347	280 - 295
Generator output line voltage, volt	4160	4225
Generator output power, KW	2000	2025
Generator output reactive power, kvar	1200	0 - 300 out
Generator output frequency, cps	60	60
Exciter armature current, amp max. (Generator excitation)	104	60 - 95
Exciter output voltage, volt max.	125	65 - 90
4160-VOLT CIRCUIT		
Output line current, amp	---	260 - 280
Net output power, KW	1820	1825
460-VOLT CIRCUIT (STATION SERVICE)		
Line voltage, volt	460	470 - 490
Line current, amp	---	220 - 230
125-VOLT DC SYSTEM		
DC Generator output current, amp	38.7	15 - 20
DC line voltage, volt	129	129
Battery current, operating, amp	10	9
Battery current, charging, amp	10	15 - 20

Quantity Measured	Design Value	Operating Range
MISCELLANEOUS DATA		
MONITORED AREA RADIATION LEVELS		
Control room gamma dose rate, mr/hr	---	.05
Vapor container gamma dose rate, mr/hr	---	20
Vapor container entrance gamma dose rate, mr/hr	---	.05
Spent fuel pit gamma dose rate, mr/hr	---	.05
Demineralizer-filter gamma dose rate, mr/hr	---	20
WATER IMPURITY CONTENT		
Service water solids content, ppm	85	85
Primary make-up water solids content, ppm	0.5	0.5
Secondary make-up water solids content, ppm	1	1
Secondary make-up water oxygen content, cc/liter	0.005	1 - 3.0
Condensate oxygen content, cc/liter	0.03	.03
Primary make-up chloride content ppm (less than)	0.5	.005
Secondary make-up chloride content, ppm (less than)	0.5	.005
Demineralizer outlet water solids content, ppm	---	.2
Demineralizer inlet water oxygen content, cc/liter	---	.002

CONVERSION CHART

CONTAMINATED WASTE TANK

LIQUID LEVEL IN FEET	GALLONS OF LIQUID
0.5	154
1.0	425
1.5	762
2.0	1201
2.5	1617
3.0	2051

CONVERSION CHART

CONTAMINATED WASTE TANK (Cont'd)

LIQUID LEVEL IN FEET	GALLONS OF LIQUID
3.5	2495
4.0	2939
4.5	3373
5.0	3789
5.5	4229
6.0	4566
6.5	4836
7.0	4990

LABORATORY WASTE TANK CALIBRATION

LEVEL INDICATOR	GALLONS	LEVEL INDICATOR	GALLONS
7	40.9	28	163.9
8	46.8	29	168.8
9	52.7	30	174.6
10	58.5	31	180.5
11	64.4	32	186.3
12	70.2	33	192.2
13	76.1	34	198.1
14	81.9	35	203.9
15	87.8	36	209.8
16	93.6	37	215.6
17	99.5	38	221.5
18	105.4	39	227.3
19	111.2	40	233.2
20	117.1	41	239.0
21	122.9	42	244.9
22	128.8	43	250.8
23	134.6	44	256.6
24	140.5	45	262.5
25	146.4	46	268.3
26	152.2	47	274.2
27	158.1		

Discharge Rate - All Valves Full Open - 9.8 gallons per minute

SECTION 7

SPECIAL PROCEDURES

Remove Fuel Chute Plug

After the removal of the primary shield tank cover, the spent fuel chute plug may be removed. The T-shaped tool on the end of an extension shaft is inserted into the spent fuel chute (figure 7-1) and engaged in the top of the plug. This tool is then rotated counterclockwise seven to eight turns until it hits the stop. The tool is withdrawn through a slot in the head of the plug and rotated 90° into a horizontal slot in the head of the plug. Both the plug and the tool can then be withdrawn. The plug is replaced by reversing this procedure.

Tightening Nuts on Reactor Vessel Studs

1. Install all nuts finger tight with the nut runner.

2. Tighten two opposite nuts to 100 ft.-lbs. torque with the power wrench (figure 7-2).

3. Tighten two more opposite nuts approximately 120° from the first pair to 150 ft.-lbs. torque.

4. Tighten a third pair of opposite nuts approximately 120° from the second pair to 150 ft.-lbs. torque.

5. Re-tighten the first pair of nuts to 150 ft.-lbs. torque.

6. Tighten the remaining nuts to 150 ft.-lbs. torque. No particular order is necessary for the remaining nuts.

Operating Instructions for Model 9900 Power Wrench Set

Installation

1. Before using the power wrench on nuts make sure that the wrench output is rotating in the proper direction to tighten or loosen nuts. <u>To reverse rotation</u> the power wrench must be turned over.

2. Position the whole assembly across the reactor cover so that the anchor will set on two of the nuts and the socket is on the nut being driven. Rotate the socket as necessary to engage the nut by ratcheting the input drive of the power wrench.

3. To operate the power wrench, install the No. 54 tension indicator or the No. 63 work handle into the input drive extension.

4. The power wrench works on a ratcheting principle. Rotate the input drive counterclockwise until it stops; position the work handle to the desired position and work with a back and forth motion.

To Tighten Nuts

1. Follow above steps.

2. Use No. 63 work handle for tightening and No. 54 tensioner for final torque measurement. Final torque reading on No. 54 tensioner should be 150 ft.-lbs.

3. When the power wrench is used to tighten nuts to a high torque, it will become locked in place. To free wrench, rotate the input drive in a clockwise direction until the pawl release "T" handle can be rotated counterclockwise. While holding "T" engaged, rotate the input drive back in a counterclockwise direction to end of travel. The power wrench should be free for removal from nut. If not, repeat step 3.

NOTE

Under some conditions when the unloader disengages to release wrench a sharp "snap" may be heard. This is normal and will not affect the operation of the wrench.

To Loosen Nuts

1. Follow the installation steps.

NOTE

Check rotation direction of power wrench output.

2. The pawl releaser "T" handle may be removed since it will not be used in this operation.

3. Use No. 63 work handle for loosening nuts.

Remove Vessel Cover Nuts

Once the nuts have been loosened, an extension shaft carrying a socket with two spring-loaded ball retainers is inserted into the primary shield tank. This socket is installed over each of the nuts in turn and, as the socket is applied, the retaining balls in the socket enter matching holes in the nut. As the nuts are run off, the retaining balls prevent the nuts from falling out of the socket. Located around the periphery of the water tank are sixteen short stowage studs on which the nuts are stowed.

Install Stud Caps

To prevent damage to the studs when the cover is removed, three stud caps are installed on studs which are approximately 120° (5 studs) apart. The spacing is not uniform because of the use of 16 studs. The tool that installs these caps is an extension shaft with a square driver which is inserted in a square hole in the caps.

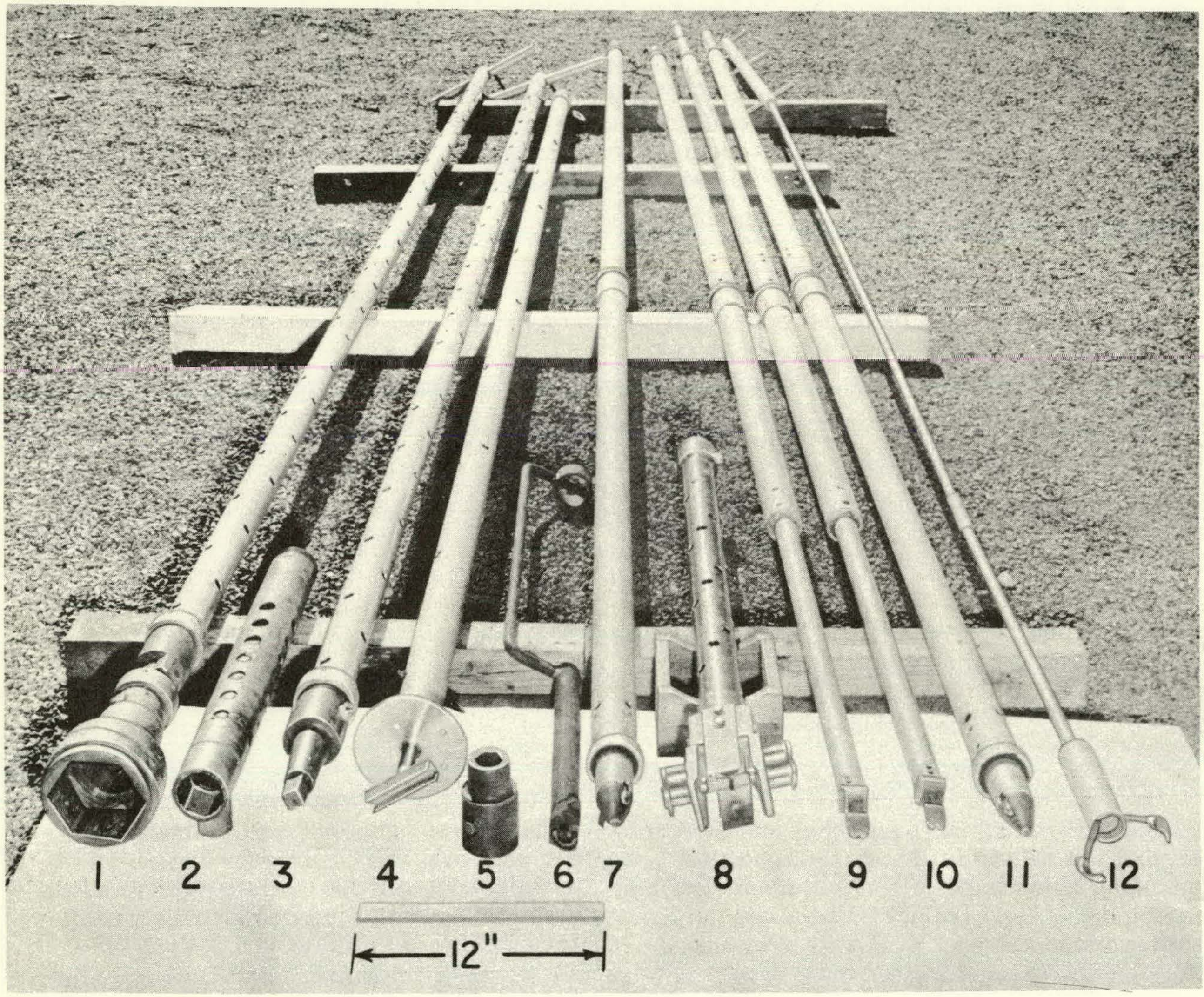


Figure 7-1. Extension Tools Used in Loading and Unloading Reactor Core

LEGEND FOR FIGURE 7-1

1 Snap-on socket for pressure vessel head nuts
2 Jack screw socket
3 Stud protector handling tool
4 Tool for handling spent fuel tube plug
5 Socket for hold-down nuts of upper core support grid
6 Tool for opening quadrant gates of upper support grid
7 Stationary fuel element handling tool
8 Control rod cap tool
9 Control rod handling tools. One is used in vapor container; the other, in the spent fuel pit
10 Control rod handling tools. One is used in vapor container; the other, in the spent fuel pit
11 Stationary fuel element handling tool used in the spent fuel pit
12 Grappling tool for recovery of any dropped objects

Free Vessel Cover (If Required)

At this point it may be possible to remove the cover by lifting. However, in the event of tightness between the octagonally-shaped pressure ring and cover, four jack screws located approximately 90° apart on the outside diameter of the cover may be used to pry the top free. These jack screws can be turned by an extension tool carrying a socket, in the same fashion as the nut runner and stud cap tool.

Operating Instructions for Sling

Installation

1. Put the eye on top of the sling on to the hook of the crane and lay the three sling hooks on the floor.

2. Install the stud cap runner (C9-45-2013) to the handle (C9-45-1003).

3. Push the stud cap runner into the socket on the screw of one of the sling hooks.

4. Lower hook into tank with the handle and engage with the pin on the cover.

5. Turn the sling hook screw clockwise until it stops. (This prevents hook from coming disengaged with cover.)

6. Pull handle up and repeat with other two sling hooks.

NOTE

The leg of the sling with the "Tugit" hoist must be engaged with the pin which lies on the radial centerline.

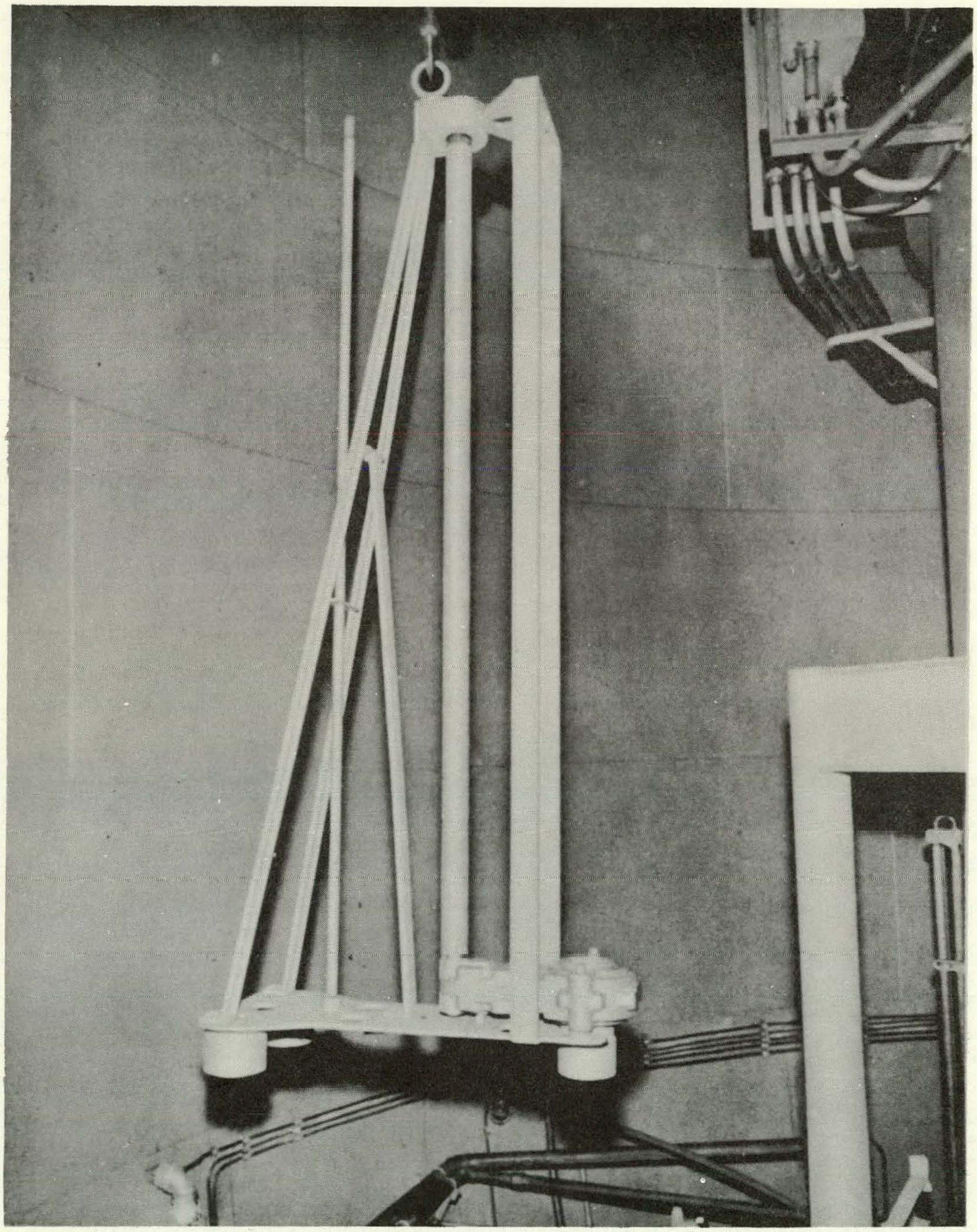


Figure 7-2. Model 9900 Power Wrench Set

Removing Cover

1. Center crane over reactor vessel and lift cover straight up with crane about 3 feet. Flip lever on handle of "Tugit" hoist to "up" and lift cover to vertical position.

2. Raise cover with crane and set in rack on side of shield tank.

3. Remove sling from crane. Store sling on side of shield tank.

NOTE

It is not necessary to remove the sling hooks from the cover.

Installing Cover

1. Put sling on crane hook.

NOTE

Make sure that stud caps are in place and the two seals are in place.

2. Lift cover out of rack and move towards center of shield tank.

3. Push lever on handle of "Tugit" hoist to down. Let cover down to horizontal position.

4. Lower cover in place with crane.

5. Use handle (C9-45-1003) with stud cap runner (C9-45-2013). Put cap runner in sockets of sling hook screw and back screw off. Remove hook from pin and bring to surface with handle. Repeat for other two hooks.

Unlock Core Support Upper Plate Doors

The four Acme thread nuts which hold down the cover doors on the reactor core support are loosened. This is accomplished with an extension shaft and socket. Since these four nuts are captive, they are not removed, but are stowed against a stop nut at the top of their travel.

Open Upper Plate Doors

The four doors over the reactor core have lifting eyes. An extension shaft with a hook is connected to the lifting eye and raises the doors into a vertical position. As they are raised, the doors follow a cam which permits them to enter a slot when placed in the vertical position. This ensures that a door will not close accidently during the refueling operation. Since the doors overlap, care must be exercised to open and close the doors in the proper order.

Remove Stationary Fuel Elements

The stationary fuel elements are now removed by inserting an expandable tool on an extension shaft into the top opening of the element. After expanding the tool, the fuel element is raised to a position over the spent-fuel chute. The tool and fuel element are then lined up with the chute, which is at an angle of 47° 30' with the horizontal. The tool and fuel element are allowed to proceed down the chute until the fuel element enters a hopper at the bottom of the spent-fuel pit. The workman then releases the fuel element and extracts the tool. This procedure is repeated for all the stationary fuel elements.

Place Elements in Spent Fuel Rack.

As each element is released in the spent-fuel pit hopper, it must be removed to permit insertion of the next one. Located on the floor of the spent-fuel pit are storage pipes for both fuel and absorber elements. The fuel or absorber element is picked up by an extension tool from the hopper, which is raised from its angular position to a vertical position. The element is then raised above the mouth of the rack openings and lowered into the rack. Space for 80 elements is provided. Also located on this floor is space for a lead shipping cask, into which the individual elements may be inserted for shipment from the site.

Remove Control Rod Caps

Before the control rod elements may be removed, the locking caps must be removed. This also is accomplished by an extension tool with a special unlocking device at the end. The tool is lowered onto the cap, rotated, and the cap removed. This tool, similar to the sockets, has a retaining device that permits raising the cap from its level on the control rods to a level above and outside the pressure vessel. There the caps can be installed on seven dummy control rod ends located within the diameter of the dummy studs.

Remove Control Rod Absorber and Fuel Elements

In each control rod there are two elements that must be removed. The top element is an absorber which has a 3/8-diameter lifting pin. The removal tool has a pair of fingers that encircle this pin when the operating end of the tool is inserted into the control rod. The tool is so designed,that, if it is inserted 90° out of line, it will neither connect with the lifting pin nor go further in and damage the absorber plates. With proper insertion of the tool, the absorber element can be picked up and raised from its level in the control rod to a position directly above the spent-fuel chute. The absorber is then introduced into the mouth of the spent-fuel chute and lowered down the chute until it bottoms in the spent-fuel pit hopper. The operator then releases the absorber and extracts the tool. The tool is returned to the vertical position and inserted in the same control rod. The same method is used for removing the fuel element. This, of course, is repeated in the other six control rods.

Recharging

When all the elements of the control rods are removed, the core is ready for recharging. This can be accomplished essentially in reverse order to the unloading procedure. New fuel elements can be brought into the vapor container through the manhole and handled out of water until lowered through the primary shield water and placed in position in the core structure. Guides are provided to slip over the tops of the control rods to facilitate insertion of fuel and absorber elements.

To Establish Seal Leakage Tank Hydrogen Blanket

Valve setting prior to establishing blanket

	Open Valves
H-5	Block valve to seal leakage tank
TV-10	Trip valve to seal leakage tank
	Close Valves
	Hydrogen cylinder valves
H-1 and H-2	Block valves to hydrogen cylinders
H-3	Block valve to P.C. make-up tank
H-4	Block valve to seal leakage tank hydrogen system
H-6	Hydrogen line drain

Procedure

1. Break the union in the seal leakage hydrogen line between H-4 and SU-16 and slowly bleed off any residual hydrogen.
2. Remove the flame arrester from SU-17 (seal leakage tank).
3. Attach a flange with a hose connection to the discharge of SU-17.
4. Connect a hose between this connection and PC-13 on the primary make-up line.
5. Block SU-17 open.
6. Line up the primary fill pump for normal operation.
7. Close valve PC-14 and open valve PC-13
8. Start the P.C. fill pump and fill seal leakage system until water flows out of the broken union.
9. Stop the fill pump and close valves PC-13 and SV-17.
10. Remove hose and flange connection to SV-17 and reinstall the flame arrester.
11. Reconnect the union between H-4 and SV-16.
12. Open the valve to one hydrogen cylinder and adjust the discharge pressure to 20 psi with PCV-9.
13. Open H-1 or H-2 and H-4 and adjust discharge pressure to seal leakage system to 3 psi with PCV-10.

14. Put seal leakage pump No. 1 into normal operation to pump water out of the seal leakage tank.

15. Observe hydrogen pressure on seal leakage line and stop the pump as necessary to prevent pulling a vacuum on the system.

To Establish Hydrogen Blanket on the P.C. Make-up Tank

1. Close valve H-3 and open valves PC-40 and SV-9 on the P.C. make-up tank.

2. Put the make-up system to the P.C. make-up tank into normal operation with a condensate recirculating pump in operation.

3. Run the set point of the P.C. make-up tank level controller to the maximum position.

4. When the tank overflows, return the level control set point to normal and close PC-40 and SV-9.

5. With 20 psi hydrogen pressure on the hydrogen line, slowly open valve H-3.

6. Open valve PC-54 and drain water to waste until the tank level can be read on the level indicator. Maintain 15-20 psi on the hydrogen line throughout this operation.

7. Close valve PC-54.

LEGEND FOR SCHEMATIC FLOW DIAGRAMS

FIGURES 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-8, 2-6, 2-8,
2-9, 2-14, 2-17, 2-18, 2-19, 2-20, 2-21

SYMBOLS

- TURBINE
- MOTOR
- VENTURI
- DRAINER
- TRAP
- STRAINER
- TEMPORARY STRAINER
- FLAME ARRESTER
- HIGH PRESSURE FILTER
- LOW PRESSURE FILTER
- GLOBE VALVE
- GLOBE VALVE-ENCLOSED STEM
- GATE VALVE
- NORMALLY CLOSED VALVE
- CHECK VALVE
- VENT
- DRAIN
- SAMPLE
- HYDROGEN VALVE
- PNEUMATICALLY OPERATED CONTROL VALVE
- THREE-WAY CONTROL VALVE
- TRIP VALVE
- SAFETY VALVE
- MOTOR-OPERATED VALVE
- SOLENOID VALVE
- MANUALLY-OPERATED CONTROL VALVE
- FOUR-WAY VALVE
- SNAP CONNECTION
- EXPANSION JOINT
- CAPPED FLANGE
- ORIFICE
- RESTRICTION ORIFICE
- WATER, STEAM, OR VAPOR FLOW PATH
- HOSE CONNECTION
- CONTROL CONNECTION
- MOTOR DRIVE CONNECTION
- EQUIPMENT CABINET OUTLINE

LEGEND FOR SCHEMATIC FLOW DIAGRAMS (Cont'd)

ABBREVIATIONS

ACV AIR CHECK VALVE
BFC BALL FLOAT CHECK
CR CONDUCTIVITY RECORDER
CV CONTROL VALVE
DM DEMINERALIZER
DM DISPLACEMENT METER
EJ EJECTOR
FB FREE BLOW
FCV FLOW CONTROL VALVE
FI FLOW INDICATOR
FIC FLOW INDICATOR CONTROLLER
FL FILTER
FR FLOW RECORDER
FRC FLOW RECORDER CONTROLLER
HLA HIGH LEVEL ALARM
IT INDUSTRIAL THERMOMETER
LC LEVEL CONTROLLER
LCV LEVEL CONTROL VALVE
LI LEVEL INDICATOR
LIC LEVEL INDICATOR CONTROLLER
LLA LOW LEVEL ALARM
LRC LEVEL RECORDER CONTROLLER
LS LEVEL SWITCH
PC/ PRESSURE CONTROLLER
PCV PRESSURE CONTROL VALVE
PI PRESSURE INDICATOR
PIC PRESSURE INDICATOR CONTROLLER
PR PRESSURE RECORDER
PRC PRESSURE RECORDER CONTROLLER
PS PRESSURE SWITCH
RM RADIATION MONITOR
RMCV RADIATION MONITOR CONTROLLER VALVE
SOV SOLENOID VALVE
ST STRAINER
SV SAFETY VALVE
TC TEMPERATURE CONTROLLER
TCV TEMPERATURE CONTROL VALVE
THC THERMOCOUPLE
TI TEMPERATURE INDICATOR
TIC TEMPERATURE INDICATOR CONTROLLER
TK TANK
TR TEMPERATURE RECORDER
ΔTIC DIFFERENTIAL TEMPERATURE INDICATOR CONTROLLER
ΔTRC DIFFERENTIAL TEMPERATURE RECORDER CONTROLLER
TV TRIP VALVE

VALVE DESIGNATIONS

AR AIR REMOVAL
AS AUXILIARY STEAM
B COOLING WATER FROM BOOSTER PUMP
BD STEAM GENERATOR BLOWDOWN
BW BLOWDOWN COOLING
BF BOILER FEED
CA COMPRESSED AIR
CF CHEMICAL FEED
CH CHLORINIZATION
CO CONDENSATE
CW CIRCULATING WATER
EB EVAPORATOR BLOWDOWN
ED EVAPORATOR DRAIN
EF EVAPORATOR FEED
F SECONDARY FILL
H HYDROGEN
MS MAIN STEAM
PC PRIMARY COOLANT
SC BLOWDOWN COOLING WATER
SW SERVICE WATER
W WASTE

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INSPECTION AND SERVICE MANUAL

ARMY PACKAGE POWER REACTOR
APPR-1

This manual covers the basic operating instructions to assist the operator in handling the Army Package Power Reactor. This information is based on construction as of date material was compiled.

ALCO PRODUCTS, INC.
SCHENECTADY 5, N.Y.

FEBRUARY 1958

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SECTION 1

INTRODUCTION

This manual contains the inspection checks, maintenance procedures, and routine adjustments which should be periodically performed on the Army Package Power Reactor (APPR-1) to insure its continued operation. Instruction for the removal and replacement of worn or defective components, lubrication instructions, and descriptions of special tools and test equipment required to maintain the plant and information on their use are also included.

Detailed data on the plant's components are contained in manufacturers' publications which have been referred to in Section 3 of this publication. Before any maintenance work is undertaken, refer to the APPR-1 Operating Manual for a review of the Radiological Safety Instructions presented therein.

A Radiation Work Permit from Health Physics personnel is required before any work is performed on the primary system components or other equipment on which contamination is suspected.

SECTION 2

INSPECTION

The inspection checks listed in this section of the manual are to be completed by the operating personnel, in order to determine need for further maintenance on the equipment. It is not intended to cover the actual repair, calibration, replacement, etc. of the equipment in this section of the manual. In general, these inspections will be visual in nature, thus requiring very little disassembly of equipment.

WARNING

Prior to entering the Vapor Container after shutdown, be sure to have an approved Radiation Work Permit and abide by the instructions set forth on same. Any deviation from these instructions should have prior approval of the Shift Supervisor and Health Physics personnel.

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
PRIMARY SYSTEM					
GENERAL					
Check all area radiation monitors	-	-	-	X	-
Check all primary system process instruments	-	-	-	X	-
VAPOR CONTAINER (V-1)					
Check ventilation fan for proper operation	Prior to startup after each shutdown				
Check interior and exterior access opening seals for damage	Each time access door is opened				
Check spray head operation	-	-	-	X	-
Check access opening water level sight glass	X	-	-	-	-
Visually check exterior of concrete secondary shield for cracks	-	-	-	-	X

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
VAPOR CONTAINER (V-1) (Cont'd)					
Visually check all piping equipment in the vapor container	Each shutdown				
Check control rod drive limit switch operation	-	-	-	X	-
Check control rod drive position indicator connections and setting	-	-	-	X	-
PRESSURIZER (E-9)					
Visually check casing insulation for soundness	At shutdown only				
Check thermocouple well for leakage	-	-	-	X	-
PRIMARY COOLANT MAKE-UP TANK (TK-5)					
Check vent valve for proper operation	-	-	-	-	X
VALVES					
Check all valves for leakage	-	X	-	-	-
Check all safety valve settings	-	-	-	X	-
Check automatic control valves for malfunctions	-	-	-	X	-
Check operation of motor operated valves	-	-	-	X	-
Check operation of all trip valves	-	-	-	X	-
SECONDARY SYSTEM					
GENERAL					
Conduct general inspection tour of turbine room; check valve settings, level gages, pump operation, instrument readings; check couplings and piping for leaks; check for malfunction of equipment; perform all hourly inspection checks listed below	X	-	-	-	-

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
GENERAL (Cont'd)					
Check all area radiation monitors	-	-	-	X	-
Check all secondary system process instruments	-	-	-	X	-
STEAM GENERATOR (E-7)					
Check thermocouple wells for leakage	-	-	-	X	-
TURBINE (TG-1)					
Check mounting for vibration effects, such as loosening of supports, cracks in foundation, etc.	-	-	-	X	-
Check alignment of mechanical coupling to generator	-	-	-	-	X
Check seals for excessive leakage	-	-	-	-	X
Check lubricating pump operation	-	-	-	-	X
Check relief valve setting in oil pump exhaust line	-	-	-	-	X
Check setting of governor hand speed changer	Each shutdown				
Check setting of governor trip throttle valve bypass screw	Each shutdown				
Check setting of set screw on governor trip mechanism	At turbine shutdown				
Inspect gear train to generator for corrosion and tooth failure	-	-	-	-	X
CONDENSER (E-1)					
With candle flame, check casing for air leakage into condenser	In the event of loss of vacuum				
Check water level in atmospheric relief valve seal	X	-	-	-	-

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
FEED-WATER HEATER (E-2)					
Check condensate level gage	X	-	-	-	-
Check water relief valve for proper operation	-	-	-	-	X
PUMPS					
Check bearing heat by hand	X	-	-	-	-
Check for excessive vibration	X	-	-	-	-
Check all mechanical couplings	-	-	-	-	X
Check seals for excessive leakage	X	-	-	-	-
Check that pumps receive proper lubrication	X	-	-	-	-
PIPING					
Check expansion joints	-	-	-	-	X
Check temperature instrument wells for leakage	-	-	-	-	X
WATER TREATMENT DEVICES					
Check chemical treatment equipment	-	-	-	-	X
Check chlorinizer operation	-	-	-	-	X
ELECTRICAL SYSTEM					
GENERAL					
Conduct general inspection tour of control, turbine, pump, and electrical equipment rooms; check indicating lamps, switch and control settings; check for malfunction of equipment; perform all hourly inspection checks that follow	X	-	-	-	-

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
GENERATOR					
Check frame, foundation, and foundation bolts for soundness	-	-	-	X	-
Check for excessive vibration	X	-	-	-	-
Check for excessive localized heating	X	-	-	-	-
Check overspeed trip setting	At shutdown				
Check that bearing lubrication is adequate	X	-	-	-	-
Check insulation surfaces for dry cracks or other evidence of deterioration	-	-	-	-	X
Check alignment of couplings	-	-	-	-	X
Check tightness of rotor pole bolts	-	-	-	-	X
Check all cable connections to exciter and control devices	-	-	-	X	-
Check insulation resistance of windings to ground	-	-	-	-	X
Check resistance of field windings	-	-	-	-	X
Check resistance of stator windings	-	-	-	-	X
EXCITER					
Check frame, foundation, and foundation bolts for soundness	-	-	-	X	-
Check for excessive vibration	X	-	-	-	-
Check for excessive localized heating	X	-	-	-	-
Check that bearing lubrication is adequate	X	-	-	-	-
Check brush-rigging setting	-	-	-	X	-

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
EXCITER (Cont'd)					
Check brushes for free movement in holder	-	-	X	-	-
Check that brush pressure is between 1-1/2 and 2 lb per sq in. of contact area	At change of brushes				
Check brush fit against commutator	At change of brushes				
Check commutator for high and low bars	-	-	-	X	-
Check commutator for grooving	-	-	X	-	-
Check commutator for eccentricity	-	-	-	-	X
Check commutator for developing black spots or roughness	-	-	X	-	-
Check insulation surfaces for dry cracks or other evidence of deterioration	-	-	-	-	X
Check insulation resistance of windings to ground	-	-	-	-	X
Check pigtail connections for tightness	-	-	-	X	-
Check all cable connections to generator and control devices	-	-	-	X	-
Check resistance of field windings	-	-	-	-	X
Check resistance of armature winding	-	-	-	-	X
AUXILIARY EQUIPMENT MOTORS					
Check for excessive vibration	X	-	-	-	-
Check for excessive localized heating	X	-	-	-	-
Check that bearing lubrication is adequate	X	-	-	-	-
Check alignment of couplings	-	-	-	-	X

INSPECTION CHECK	HOUR	DAY	WEEK	1/2YEAR	YEAR
AUXILIARY EQUIPMENT MOTORS (Cont'd)					
Check insulation resistance of windings to ground	-	-	-	X	-
Check windings phase-to-phase resistance	-	-	-	-	X
Check all cable connections to bus and control devices	-	-	-	-	X
Check insulation surfaces for dry cracks or other evidence of deterioration	-	-	-	-	X
WIRING					
Check terminal connections	-	-	-	-	X
Check insulation for soundness	-	-	-	-	X
Check cable supports; pay particular attention to those near motors or other machinery	-	-	-	-	X
Check wiring for accidental grounds	-	-	-	-	X
TRANSFORMERS					
Check lead connections	-	-	-	X	-
Check for excessive heating	At 4- to 8-hour intervals				
Check oil level	-	-	-	-	X
Check dielectric strength of oil	-	-	-	X	-
CAPACITORS					
Check lead connections	-	-	-	-	X
Check for evidence of dielectric breakdown (short)	-	-	-	-	X

Time interval between checks: HOUR, DAY, WEEK, 1/2YEAR, YEAR.

WARNING

Charged capacitors are dangerous. Before conducting electrical tests, be certain that leads are disconnected and charge has been dissipated through a resistor in series. Keep the terminals shorted at all times while working on the capacitors.

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
RELAYS, CIRCUIT BREAKERS, SWITCHES, ETC.					
Check lead connections	-	-	-	-	X
Check internal connections	-	-	-	-	X
Check accessible contact surfaces for dirt, corrosion, or wear	-	-	-	-	X
Check relay DC tripping source current and voltage	-	-	-	-	X
Check settings of time delay relays	-	-	-	-	X
Check adjustment of air circuit breakers	-	-	-	X	-
Calibrate all relays	-	-	-	-	X
OTHER EQUIPMENT					
Check specific gravity of battery electrolyte	-	-	X	-	-
Check battery lead connections	-	-	-	X	-
Check generator lightning arrester ground connection	-	-	-	X	-
Check motor-generator set for excessive vibration	X	-	-	-	-
Check motor-generator set for excessive localized heating	X	-	-	-	-
Check motor-generator set windings resistance	-	-	-	-	X

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
OTHER EQUIPMENT (Cont'd)					
Check motor-generator insulation surfaces for dry cracks or other evidence of deterioration	-	-	-	-	X
Check all motor-generator set lead connections	-	-	-	-	X
Check motor-generator set generator brush alignment	-	-	-	X	-
Check motor-generator set generator brush pressure	At brush change				
Check motor-generator set generator brushes for wear	Once a month				
Check motor-generator set generator commutator for pitting or wear	Once a month				
Check converter for excessive vibration	X	-	-	-	-
Check converter windings resistance	-	-	-	X	-
Check converter for excessive localized heating	X	-	-	-	-
Check converter lead connections	-	-	-	-	X
Check generator neutral grounding resistor for short circuits	-	-	-	-	X
Check generator voltage regulator stabilizer adjustment setting	-	-	-	-	X
Check generator voltage regulator voltage-adjusting rheostat setting	-	-	-	-	X
Calibrate generator voltage regulator	-	-	-	-	X

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
FUEL HANDLING SYSTEM					
CHUTE AND ASSOCIATED EQUIPMENT					
Check fuel chute plug rubber seal for deterioration	At fuel transfer only				
Check for proper functioning of fuel chute plug locking mechanism	At fuel transfer only				
Check fuel handling tools	Prior to use				
SPENT FUEL PIT					
Check spent fuel pit recirculating pump casing and couplings for soundness	Prior to use				
Check spent fuel pit filter (FL-4) element for accumulation of sludge	After each use				
VALVES					
Check operation of primary blowdown and primary blowdown coolant radiation monitor controlled valves by bypassing to contaminated waste storage tank	-	-	-	X	-
RADIATION MONITORING EQUIPMENT					
Calibrate all radiation monitors equipped with calibration sources	-	-	X	-	-
Visually check all plant process instrument wiring junctions and insulation for soundness	-	-	-	-	X
Check instrument air compressor stuffing box for damage	-	-	-	X	-
Check instrument air compressor valves and valve passages for accumulation of dirt	-	-	-	-	X
Check instrument air compressor piston rings for wear	After each 500 hours of operation				

INSPECTION CHECK	TIME INTERVAL BETWEEN CHECKS				
	HOUR	DAY	WEEK	1/2 YEAR	YEAR
VENTILATION SYSTEM					
Check fan drive	-	-	-	-	X
Check grilles for dirt accumulation	-	-	-	-	X

SECTION 3

MAINTENANCE AND REPLACEMENT

Maintenance of the APPR-1 plant is divided into two major categories. They are:

a. In-place maintenance

b. Removal and replacement of defective major components.

In-place maintenance consists of any maintenance procedure, either preventive or corrective, which can be performed on a component without removing it from the system in which it functions. Removal and replacement of defective components involves the steps that must be taken to remove components that have become defective and that cannot be repaired in place. Maintenance procedures for both categories are in this section of the manual listed alphabetically by component name.

CLEANING

Periodic cleaning is one of the necessary tasks that must be performed to obtain optimum performance from the components of the APPR-1 plant. Accumulation of dirt and foreign matter in a component often detracts from its performance and places it under a strain, thus reducing its life expectancy. The cleaning schedule outlined below contains a list of the cleaning duties that must be performed on each major component as well as the frequency with which they must be performed. This schedule should be strictly adhered to by maintenance personnel. For the steps involved in the disassembly of components for cleaning, refer to the applicable manufacturer's manuals.

TABLE 3-1 CLEANING SCHEDULE

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
PRIMARY SYSTEM					
Primary Coolant Make-up Pumps (P-8A, P-8B). (See Milton Roy Co. Instruction Manual for Installation, Operation and Maintenance of Motor Driven Controlled Volume Pumps.)					
Clean the supply air and Varitrol system of the Varidrives to remove dirt and foreign matter that has accumulated.	-	-	X	-	-

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Drain the moisture from the bottom of the filter and drip trap that is connected to the Varitrol.	X	-	-	-	-
Clean all parts of the pumps thoroughly.	-	-	X	-	-
Vacuum Pump for Primary Coolant Circuit. (See Operating Instructions and Parts Data for Kinney Vacuum Pumps Model KS-27.)					
Disassemble the pump and clean it thoroughly. Make sure to remove the solenoid valve and clean the inside of the tube and core.	-	-	-	-	X
Primary Coolant Fill Pump (P-12)					
Clean the pump thoroughly.	-	-	X	-	-
Demineralized Water Filter (FL-3). (See Micro Metallic Corporation Release No. 210, Operation and Care of Micro Metallic "PSS" Filter Units.)					
Clean the filter thoroughly under Health Physics supervision. (Filter should be replaced when primary blowdown pressure reaches 40 psig at 0.5 gpm blowdown rate.)	As required by blowdown pressure				
Strainers.					
Remove element and clean thoroughly under supervision of Health Physicist	-	-	-	X	-

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
SECONDARY SYSTEM					
Turbine (TG-1). (See GEI-54328, General Electric Steam Turbine Instructions.)					
Clean the exterior of the turbine and all exposed associated parts.	-	X	-	-	-
Clean the air motor of the primary relay and load limit and inlet pressure control. Also clean the air supply line to the controller.	-	-	-	-	X
Disassemble all associated valves and clean them thoroughly.	-	-	-	-	X
Remove the upper half casing of the speed reducing gear unit and clean all oil grooves and passages in the bearings and all joint seating with a clean, dry, lint-free cloth.	-	-	-	-	X
Condenser (E-1). (See The Lummus Co. Instructions for Operation and Maintenance of Surface Condenser Equipment.)					
Push an air lance through each tube. In the event that fouling of tubes occurs, push a water lance through each tube to remove foreign matter. For the methods to be used in cases of severe fouling, refer to The Lummus Company Instructions.	-	-	-	-	X

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Wash all tube sheets clean.	-	-	-	-	X
Feedwater Heater (E-2) (See ALCO Products, Inc. manual, Feedwater Heater.)					
Clean inside of tubes by chemical flushing or mechanical scouring as necessary.	-	-	-	-	X
Remove the tube bundle and clean the exterior of the tubes.	-	-	-	-	X
Air Ejector (EJ-1). (See Instructions for Operations and Maintenance of Surface Condenser Equipment.)					
Clean the inside surfaces of the air ejector tubes.	-	-	-	-	X
Clean nozzles.	-	-	-	-	X
Evaporator (E-3). (See ALCO Products, Inc. manual, Evaporator.)					
Clean the evaporator and connected piping.	-	-	-	-	X
Clean the inside tube surfaces with a rotary tube cleaner or a stiff wire brush. Flush away the waste with water. Chemical cleaning may be used, if necessary.	-	-	-	-	X
Descale the tubes by the method described under MISCELLANEOUS IN-PLACE MAINTENANCE.	Dependent upon use				

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Remove the tube bundle and clean it thoroughly, paying particular attention to the ends.	-	-	-	-	X
Circulating Water Pumps (P-1A & P-1B). (See Operation and Maintenance Instructions for Peerless Hydrofoil Pumps.)					
Remove the motor cover and clean the flange faces, registers, and other parts.	-	-	-	-	X
Evaporator Feed Pump (P-18). (See Ingersoll-Rand Instructions and Repair Parts Book for Motor-pump, Form 7870.)					
Clean the pump thoroughly.	-	-	-	-	X
Condensate Recirculating Cooling Pump (P-7A, P-7B).					
Clean the pump thoroughly.	-	-	-	-	X
Cooling Water Booster Pumps (P-4A & P-4B). (See Ingersoll-Rand Instructions and Repair Parts Book for Cradle-Mounted Pumps, Form 7758-C.)					
Clean the pump thoroughly.	-	-	-	-	X
Main Steam Pressure Control Valve (TV/PCV/1). (See Mason-Neilan Instructions No. 3002, Air Operated Control Valves.)					
Drain dripwell of air pressure filter-regulator to remove any accumulation of oil or moisture. (See Mason-Neilan Instructions No. 1021.)	X	-	-	-	-

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Clean filter element of the air pressure filter regulator by blowing compressed air through the inside of it. This will remove any dirt that has accumulated on the outside surface of the element.	-	-	-	-	X
Clean the pen of the pressure controller. (See Mason-Nielan Instructions No. 1021.)	-	-	X	-	-
Clean the pilot filter of the pressure controller.	-	-	-	-	X
Clean the pilot metering orifice for the nozzle air supply of the pressure controller. Use the clean-out plunger that is supplied for this purpose.	-	-	-	X	-
Clean the pilot filter caps of the pressure controller. The filter caps and metering orifice can be removed for cleaning while the pilot remains fastened to the pilot block.	-	-	-	-	X
Remove the nozzle of the pressure controller from the nozzle block and blow it out with clean air.	-	-	-	-	X
Disassemble the resistance unit of the pressure controller and blow out the parts. Wipe all of the parts with a clean lint-free cloth.	-	-	-	-	X

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Seal Pit Monitor Pump (P-17). (See Aurora Pump Division, New York Air Brake Co. Bulletin III.)					
Remove the strainer and clean it.	-	-	-	-	X
Open the bearing housing and clean it thoroughly. Repack with new grease.	-	-	-	-	X
Turbine Oil Cooler. (See GEI-54328, General Electric Steam Turbine Instructions.)					
Flush out the interior of the tubes.	At turbine overhaul				
Remove the bundle from the shell and hose the exterior of the tubes with steam or hot water.	At turbine overhaul				
Auxiliary Centrifugal Oil Pump. (See GEI-2065F, which is part of GEI-54328, General Electric Steam Turbine Instructions.)					
Clean the strainer in the oil tank.	-	-	-	X	-
Disassemble the pump and clean it thoroughly.	-	-	-	-	X
Clean the oil tank and flush.	At turbine shutdown				
Steam Traps. (See Armstrong Steam Trap Service Guide Bulletin No. 2391.)					
Remove all sediment and other dirt from the trap. If necessary, immerse the mechanism in gasoline or kerosene.	-	-	-	-	X

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Strainers					
Remove element and clean thoroughly.	-	-	-	X	-
Main Air Compressor. (See Ingersoll-Rand Instructions and Duplicate Lists for Class ER-1-NL-1 Straight-Line Horizontal Heavy-Duty Compressors, Form P-3020.)					
Clean the metallic rings of the partition plate stuffing box.	-	-	-	-	X
Clean the strainer in the air air supply line preceding the three-way, solenoid valve in the dual control regulator. To clean this strainer properly, remove it from the line and blow it out with compressed air.	-	-	-	-	X
Clean the solenoid valve in the dual control regulator. A rattling noise in the solenoid valve when it is open is usually caused by an accumulation of dirt and foreign material around or between the movable and fixed cores. To obtain access to the valve for cleaning purposes, remove the solenoid assembly by unscrewing the connecting bushing from the valve body. Then clean the tube and core thoroughly.	-	-	-	-	X

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Clean the compressor cylinder valves. During monthly inspection, remove any dirt or foreign matter that has accumulated in valves or valve passages.	-	-	-	-	X
Clean the belts on the motor belt drive.	-	-	-	-	X
Clean the packing rings of the aftercooler. Telltale holes in the packing rings should be kept free of dirt and foreign matter to facilitate early detection of leakage.	-	-	-	-	X
Flush out the cooling water passage of the aftercooler to remove any dirt or mud that has accumulated. Open the water inlet valve and drain valve and flush out the dirt that has accumulated. Flushing at maximum water flow should be continued until water leaving the cooler at the funnel is perfectly clear. If flushing is impossible or if scale is present, remove the tube nest from the shell and clean thoroughly.	-	-	-	X	-
Remove the drain plug of the crankcase and drain the oil. This will remove most of the sediment that has accumulated during the course of operation.	-	-	-	X	-

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Standby Air Compressor. (See Ingersoll-Rand Operating Instructions for Type 30 Compressors, Form 1003-C.)					
Clean the air receiver valves.	-	-	-	-	X
Clean the filter pads of the air intake filter. Remove the filtering element to blast with compressed air.	-	-	-	-	X

WARNING

If the air filter is removed and cleaned with gasoline or kerosene, make sure that it is completely dry before replacing it. Otherwise an explosion may result.

COMPONENT AND CLEANING DUTY	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Clean the check valve.	-	-	-	-	X
Clean the safety valve.	-	-	-	-	X
Blow off the motor windings of the electric motor with a jet of air.	-	-	-	-	X
Varnish the motor windings.	-	-	-	-	X
Compressed Air System Condensing Filters. (See Hankison Corp. Condensifilter Operating Instructions.)					
Open condensate trap and drain it of any dirt and foreign matter that has accumulated.	-	X	-	-	-
ELECTRICAL POWER					
Generator and Exciter. (See GEH-7095, which is part of GEI-54328, General Electric Steam Turbine Instructions.)					
Clean the coils with a suitable cleaning fluid as outlined in GEH-7095.	-	-	-	-	X

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Clean the interior of the generator and exciter by blowing them out with compressed air.	-	-	-	-	X
Clean the exciter commutators, brushes, and brush riggings by wiping them with a clean, dry, lint-free cloth.	-	-	-	X	-
Clean the bearings and bearing insulation with a clean, dry, lint-free cloth.	-	-	-	-	X
Measure air gap clearance to determine bearing wear.	-	-	-	-	X
Generator Air Cooler. (See GEH-562C, which is part of GEI-54328, General Electric Steam Turbine Instructions.)					
Clean out the interior of the tubes with rubber washers propelled by compressed air or by any other standard method of cleaning condenser tubes.	-	-	-	-	X
Remove the tube bundle and clean the exterior of the tubes with water. If dirt is difficult to remove, boil the tubes in a solution of washing soda.	-	-	-	-	X
Power Transformers. (See General Electric Instructions, Power Transformers, GEI-57302.)					
Clean bushings to remove dirt and dust.	-	-	-	X	-
When changing the oil, check for evidence of oil sludging. If sludging is apparent, clean the internal parts by forcing	When necessary				

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Power Transformers. (Cont'd)					
oil under pressure from a small nozzle onto the internal parts, before filling with new oil.					
D-C System Rectifier Charger. (See GEH-1495B, General Electric Instructions, Phano-Chargers.)					
Remove any dirt or dust that has accumulated on tubes and other components.	-	-	-	-	X
Switchgear. (See G.E. Req. ALB-59931-2, composite instructions manual.)					

WARNING

Be certain that all equipment carrying electrical power is de-energized before attempting cleaning.

Clean the bushings of all instrument transformers, removing all foreign matter from the upper and undersides of the petticoats. If the dirt is loose, cleaning with a wet cloth will suffice. If the dirt is difficult to remove, use trichloroethylene or ammonia. After cleaning a bushing, wash the surface thoroughly with clean water.	-	-	-	X	-
Clean the contacts of the control and instrument switches.	-	-	-	-	X
Clean the contacts of the multicontact auxiliary relays as outlined in GEH-1755, which is part of G.E. Req. ALB-59931-2.	-	-	-	-	X

TABLE 3-1 CLEANING SCHEDULE (Cont'd)

COMPONENT AND CLEANING DUTY	FREQUENCY OF PERFORMANCE				
	DLY	WKLY	MONTHLY	SEMI-ANNUALLY	ANNUALLY
Clean the contacts of the Magne-blast air circuit breakers with a fine file or sandpaper if they appear to be rough.	-	-	-	-	X
Clean insulation parts of the Magne-blast air circuit breakers to remove dirt and dust.	-	-	-	-	X
Clean contacts of closing relays in accordance with GEI-23988B, which is part of G.E. Req. ALB-59931-2.	-	-	-	-	X
Clean the entire switchgear structures and their connections thoroughly. Remove any dust, dirt, or foreign matter that has accumulated on the parts. Wipe buses and supports clean with trichloroethylene.	-	-	-	-	X
Clean the primary disconnecting device contacts with trichloroethylene. If sulphide deposits have accumulated on contacts, remove them with a good grade of silver polish.	-	-	-	-	X
Lighting System Voltage Regulator. (See General Electric Instructions, Inductrol, GEI-43278.)					
Clean voltage regulator contacts. Follow the procedures for cleaning dirty or oily contacts and rough or burned contacts outlined in GEI-39847, which is part of GEI-43278.	-	-	-	-	X
Dust all parts.	-	-	-	-	X

MISCELLANEOUS IN-PLACE MAINTENANCE

Miscellaneous in-place maintenance of the components of APPR-1 is covered thoroughly in each of the applicable manufacturer's publications. The most pertinent points are discussed in this section. For the step-by-step procedures involved in performing each of the maintenance duties discussed and for disassembly procedure for each component, refer to the manufacturer's publications. General procedures, replacement of components, and in-place maintenance of components follow in alphabetical order.

Air Circuit Breakers (4160-460V)

Manufacturer's Literature. General Electric Switchgear Instructions, Power Circuit Breakers, GEI-23903E.

Isolating Procedure. Magne-blast air circuit breakers must be isolated by plant operation at the main control console. Maintenance personnel will not isolate these circuit breakers. Refer to the General Procedures section of this manual for general information on isolation procedures.

Contacts. After removing box barrier, the contacts on the two outside phases may be readily inspected. The contacts on the center phase can be seen with the aid of a mirror and a flashlight. If the contacts are in good condition, there is no need of removing the arc chute. However, if the surface of the contacts needs smoothing with a fine file or sandpaper, the arc chutes can be removed.

Arc Chute. If the arc chutes must be removed for contact maintenance or disassembled for inspection, the following maintenance should be performed:

a. Scale formed over the surface of the chute must be removed; loose particles collected in the muffler should be blown out.

b. Cracks which have formed in the fins of the arc chute are to be expected in ceramic materials of this type when subjected to the severe heat of an arc. These cracks do not interfere with the operation of the device in any way and should be disregarded. If the chute has had any mechanical injury because of dropping or accidental striking which has resulted in actual breaking off of fins, replacement of the arc chute is necessary.

Insulation Parts. The insulation parts on the breaker should be kept clean and dry. Smoke or dust collected between inspection periods should be wiped off. If dampness is apparent, heaters should be installed to insure dryness.

Bushings. The surface of the bushings should be smooth and unscratched. If the insulation surface has been damaged, it should be well cleaned and then retouched with GE-1170 clear varnish or GE-1202 (clear) or GE 1210 Glyptal. Allow to dry smooth and hard.

Mechanism. Careful inspection should be made to check for loose nuts or bolts and broken cotter pins. The latch surface should be inspected for wear and the surface of the rollers should be inspected for chipping or other evidences of damage.

Lubrication. These circuit breakers should be oiled each six months by applying a few drops of machine oil SAE 20 or 30 to the bearings. Cams and rollers should be wiped clean and a thin coat of General Electric Lubricant D50H15 or equal applied to these surfaces.

When the breaker has operated not more than 500 times, it must be isolated and removed; thorough inspection and necessary maintenance adjustments should be made in accordance with maintenance instructions in "Switchgear, General Electric, Magne-Blast Air Circuit Breakers Type AM," pages 8, 9, 10, section GE1-23903E.

Contact Cleaning. For cleaning fine silver contacts, a flexible burnishing tool should be used. This consists of a flexible strip of metal with an etched roughened surface, resembling a superfine file. The polishing action is so delicate that no scratches are left, yet corroded material will be removed rapidly and thoroughly.

Main Contact Replacement. Remove the arc chute assembly. All of the parts are held together between the U-shaped bracket by a long screw extending through a hole in the blowout magnet. If this screw is removed, the entire assembly can be lifted out. The main stationary contact can then be easily replaced and the replacement securely tightened.

The reassembly procedure can be simplified by fitting the pole pieces to the sides of the arc chutes, placing the permanent magnet between the pole pieces, and then transferring the entire assembly into the U-shaped bracket. Care must be exercised when reassembling the magnet; the end which is numbered is placed on the left side of the relay when viewed from the front. Otherwise, the reversed polarity will cause the arc to blow downward.

Air Ejector (EJ-1) (Figure 3-1)

Manufacturer's Literature. Lummus Company "Instructions for Operation and Maintenance of Surface Condenser Equipment."

General. Proper functioning of the air ejector depends upon maintaining the constant steam pressure on which the ejector was designed to operate. Adequate flow of condensate through the ejector condenser tubes is necessary. The two-stage twin air ejectors are so designed that they can operate simultaneously or one at a time.

Cleaning. If nozzle becomes clogged with dirt or deposits, it must be removed and cleaned. Cleaning is best accomplished by use of a small brush. However, a reverse flow of air or steam through the nozzle may produce the desired results.

General Maintenance. Nuts and bolts should be tightened periodically. If leaks around flanges cannot be stopped by tightening flange bolts, replace gaskets. Refer to the GASKETS in this section for instructions on replacement of gaskets.

Air Pressure Filter Regulator

Manufacturer's Literature. Mason-Neilan, "Instructions No. 1021, No. 74 Air Pressure Filter -- Regulator"

At frequent intervals, drip cock to dripwell at filter should be opened to allow accumulated oil and/or moisture to be discharged (daily). Also, at this time, the air supply pressure to regulator should be checked to see if it is at its preset value (20 psig most cases). In case adjustment is required, the Instrumentation Section should be notified unless other arrangements have been made previously.

Bearings

Lubrication (Also see Section 4 of this manual).

For proper lubrication of all contact surfaces, use only a film of oil or grease. Use the lightest lubricant possible to maintain the film. Overlubrication is a common fault and often causes overheating. Normally, bearings are packed at the factory and need lubrication only twice a year. Some of the APPR plant equipment is equipped with sealed bearings which require no lubrication.

Sleeve bearings are lubricated by means of a ring oiler, sight-feed oiler, bottle-feed oiler, oil flooding or splashing with oil. Anti-friction (ball and roller) bearings are lubricated with either grease or oil. Kingsbury-type thrust bearings are lubricated with oil.

Replenish the lubricant in sleeve bearings at intervals dictated by specific equipment requirements. Flush the bearings and reservoirs every six months and refill with fresh lubricant. Use hot mineral oil for flushing. Repack anti-friction bearings annually but do not pack the bearing housing more than 2/3 full. Overfilling will rupture grease seals.

To prevent rupture of grease seals when using a grease gun, remove the pressure relief plug from the bearing housing and use low pressure on the gun. When grease flows from the relief plug opening, stop lubricating. As added protection against overlubrication, operate the pump at normal running temperature and allow excess grease to escape before replacing plug. Some equipment is provided with an additional grease outlet at one side of the center of the cap. During lubrication, when grease flows from the grease outlet, stop lubricating.

Check for Wear. Examine sleeve bearings for defects in the bearing surface. At least 80 percent of the surface should have a polished surface appearance. All metal-to-metal surfaces, such as those between the two halves of the boxes, must be perfectly clean. Paint, metal particles, or dirt may prevent establishment of proper clearance. Most split bearings do not have gaskets but depend on accurate machining for an oil-tight seal. If gaskets are used, be sure they are thick enough. This thickness must permit bearing halves to be held securely but not so tightly that they are distorted, nor so loose that they can move. If oil leakage is a problem, a plastic oil-proof sealing compound sparingly used between the two metal surfaces is permissible. Measure bearing clearance with a thickness or feeler gage, dial indicator, or by taking a set of leads. Bearing clearances are normally not greater than 0.002 inch +0.001 for each additional inch of shaft diameter, unless otherwise specified by the equipment manufacturer. If the clearance measured by any of the three methods is greater, determine whether the play is in the bearing or in some other part of the machine before attempting repair. Taking leads, which is the most accurate method for determining bearing clearances, shows definitely whether or not the clearance is in the bearing. Replace or repour Babbit bearings if clearance is excessive.

NOTE

> Repouring and refitting Babbit bearings must be done by experienced personnel.

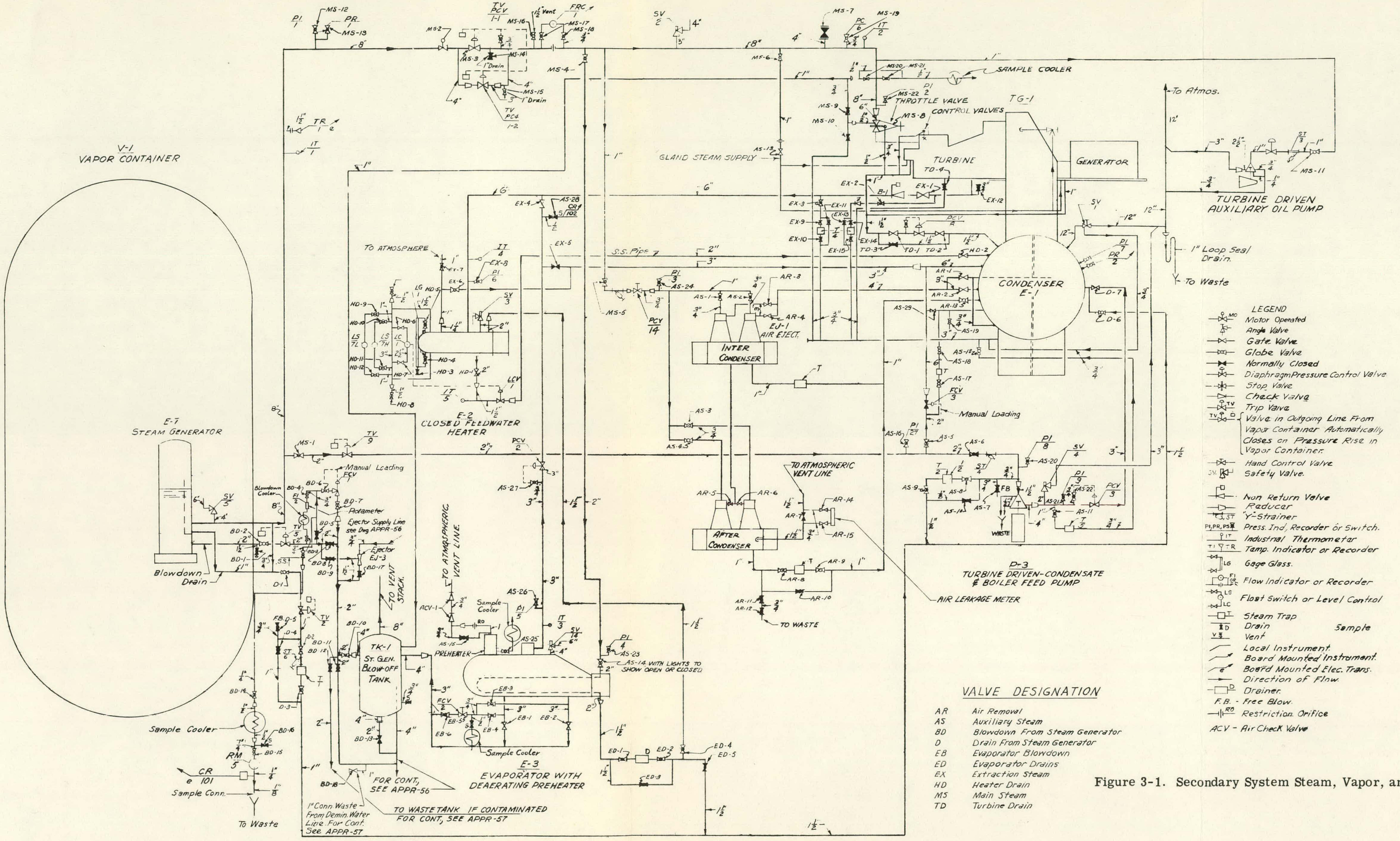

Figure 3-1. Secondary System Steam, Vapor, and Drain Lines, Schematic Flow Diagram

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Flush anti-friction bearings with cleaning solvent. Observe all necessary precautions for fire hazards or for toxic fumes when using cleaning solvent. Do not allow washed bearings to remain unprotected after flushing. Dip them immediately in clean oil. In handling anti-friction bearings, take extreme care not to expose them to dust or dirt. Place them on clean newspapers or rags, instead of directly on the work benches or other unclean surfaces. Carefully examine each bearing for nicked balls or races and excessive clearance. Rotate the bearing slowly by hand; defects can often be detected in this way. Clearances greater than 0.010 inch laterally and 0.015 inch endwise in a bearing may result in troublesome operation. Before continuing bearing in use, check the effect of the clearance on the other tolerances in the machine. Renew the bearing if necessary. In removing bearings, use a press if available; never remove bearings by means of pressure applied through balls or rollers.

To check Kingsbury thrust shoes, measure clearance in the thrust shoes with a feeler gage. Move the shaft in one direction in contact with shoes and insert a feeler gage between the shoes and thrust sleeve on the opposite side. Clearance should be from 0.004 to 0.008 inch. If it is not possible in the particular bearing to use a feeler gage directly on the shoes, use a feeler gage or dial indicator and measure the end play by moving the shaft. If the clearance is greater than 0.010 inch, the bearing should be adjusted, if possible. Adjustment may require the replacement of worn shoes. Rebabbitting of shoes may be necessary in some types of these bearings.

<u>Installation</u>. New bearings are sealed in a moisture-proof wrapping and should not be opened before they are ready for use.

Bearings should be opened on a clean surface. When installing a ball bearing, do not force the bearing on the shaft with pressure on the outer ring. Do not force a bearing on a shaft that is either badly worn or too large. Use a bearing of proper size for the shaft and tap into place by using a metal tube placed against the inner ring.

Do not clean a new bearing. New bearings are already clean, and when unwrapped must be used at once. After the bearing has been correctly installed, tighten the bearing covers to keep out dirt.

Belt Drives

<u>General</u>. Three elements especially hard on V-belts are grit, oil, and sunlight. Belts should be kept clean, free of oil, and protected from sunlight as much as possible. Mineral oil is especially destructive, as it will penetrate deep into the belt and cause separation of the cover from the carcass. Most oils will cause swelling and rapid disintegration of rubber belts.

Do not use any belt dressings, resins, or other adhesive substances on the running surfaces of the belts. Such materials may temporarily improve traction between the belts and the sheave grooves, but the belt surfaces will ultimately become glazed, and the belts will slip more than before the application.

<u>Proper Fit.</u> A V-belt should saddle in the sheave groove so that the top surface rides slightly above the highest point of the sheave. Stresses are then distributed properly throughout the belt section, and contact area is insured. A low-riding belt may bottom in the sheave groove, relieving wedging action on the sides, which causes slipping and burring. If the belt rides too high it loses contact area.

Monthly Tension Check. Tension of belt drives must be adjusted as wear and stretching occur. Slapping and whipping of the belt during operation are evidence of improper tension. A good method of checking for proper tension is by striking the belt with your hand while the belt is idle. Slack belts feel dead under this test, while properly adjusted belts vibrate and feel alive.

Care should be taken to tighten belts no more than necessary to prevent slippage under full load. Too much tension will cause trouble with the bearing of both driving and driven mechanisms.

Annual Alignment Check. Proper sheave alignment prolongs the life of the belt. To check alignment, use a long straightedge or string across the outer faces of the sheaves. Check alignment of V-belt sheaves between the center lines of the two sheaves.

Care of Sheaves. Check and replace chipped or badly worn sheaves. Worn sheaves will wear out belts prematurely.

Replacement of Belts. When replacing a belt, never force it onto the sheave. Slack off the sheave adjustment so that the belt can be easily slipped on. When a replacement is necessary in a set of multiple-drive V-belts (such as used on the main air compressor), replace the entire set with a new matched set. Otherwise the new, unstretched belts, being shorter than the old ones, will have to carry most of the load until their initial stretch has taken place. The excessive, uneven load will shorten the life of the belt.

Primary Blowdown Cooler (E-8, Figure 3-2)

The primary blowdown cooler is located inside the Vapor Container, on the downstream side of the steam generator primary loop. The cooler is a U-tube double-pass counter-flow tubular heat exchanger of stainless steel construction. The inside surface of the inner tube has an ALCO-Plate finish. Blowdown water is passed through the annulus and river water through the inner tube. In operation, the blowdown cooler will reduce the primary coolant water temperature to below 140°F.

Blowdown Cooling Water Pumps (P-5A and P-5B, Figure 3-3)

Manufacturer's Literature. Ingersoll-Rand, "Instructions and Repair Parts Book for Cradle-mounted Pumps, Form 7758-C."

Packing. These pumps use standard soft asbestos packing impregnated with graphite. One seal case and fine rings of packing are required. Refer to the "Packing" in this section of the manual for instructions on packing replacement and adjustment.

Alignment. Refer to page 4 of the manufacturer's literature and "Electric Motors, Care of" in this section for instructions on coupling alignment.

Blowdown Return Pump (P-19)

Manufacturer's Literature. Ingersoll-Rand, "Instructions and Repair Parts Book for Motorpump, form 7870" (Model IRVNL 5).

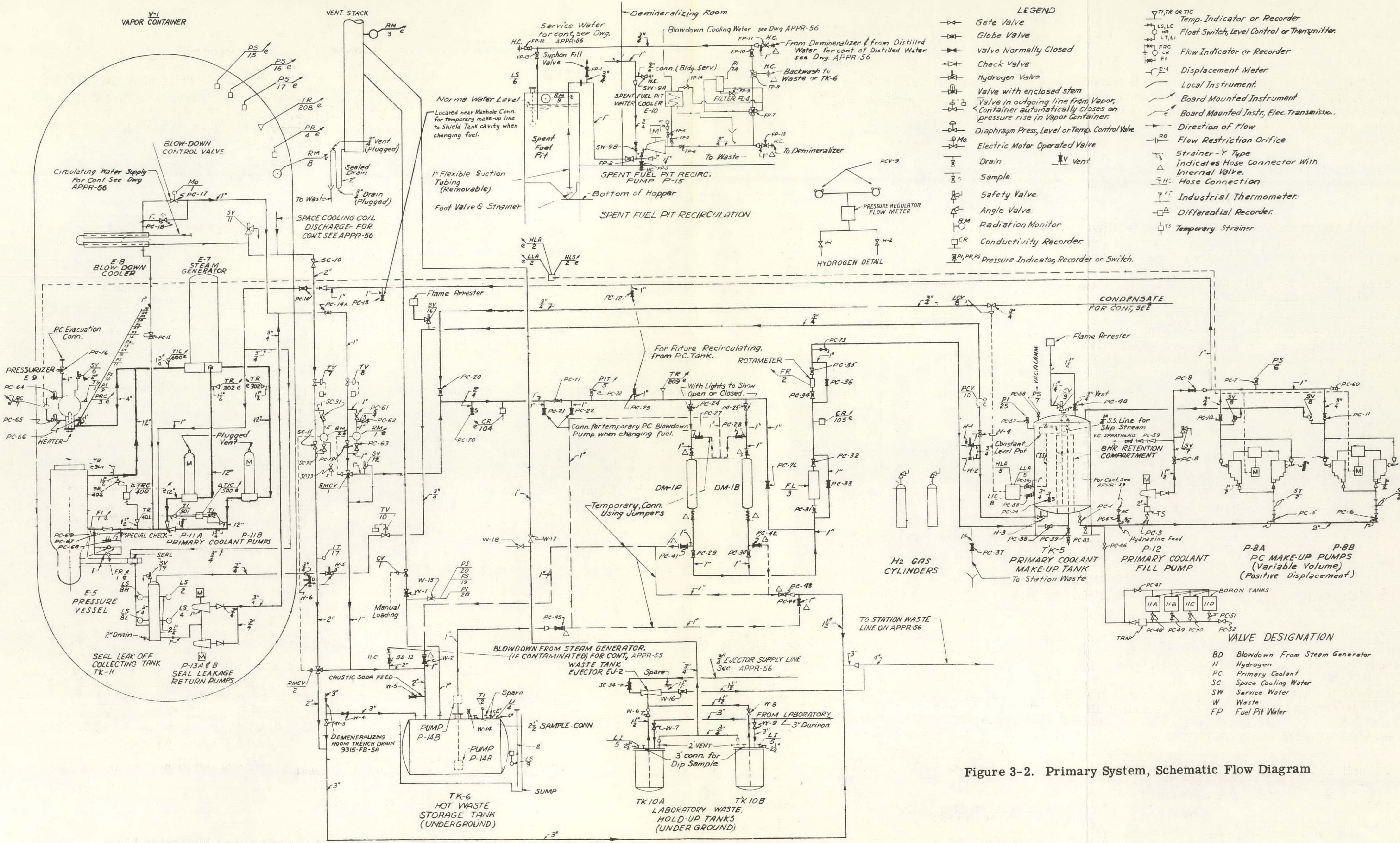

Figure 3-2. Primary System, Schematic Flow Diagram

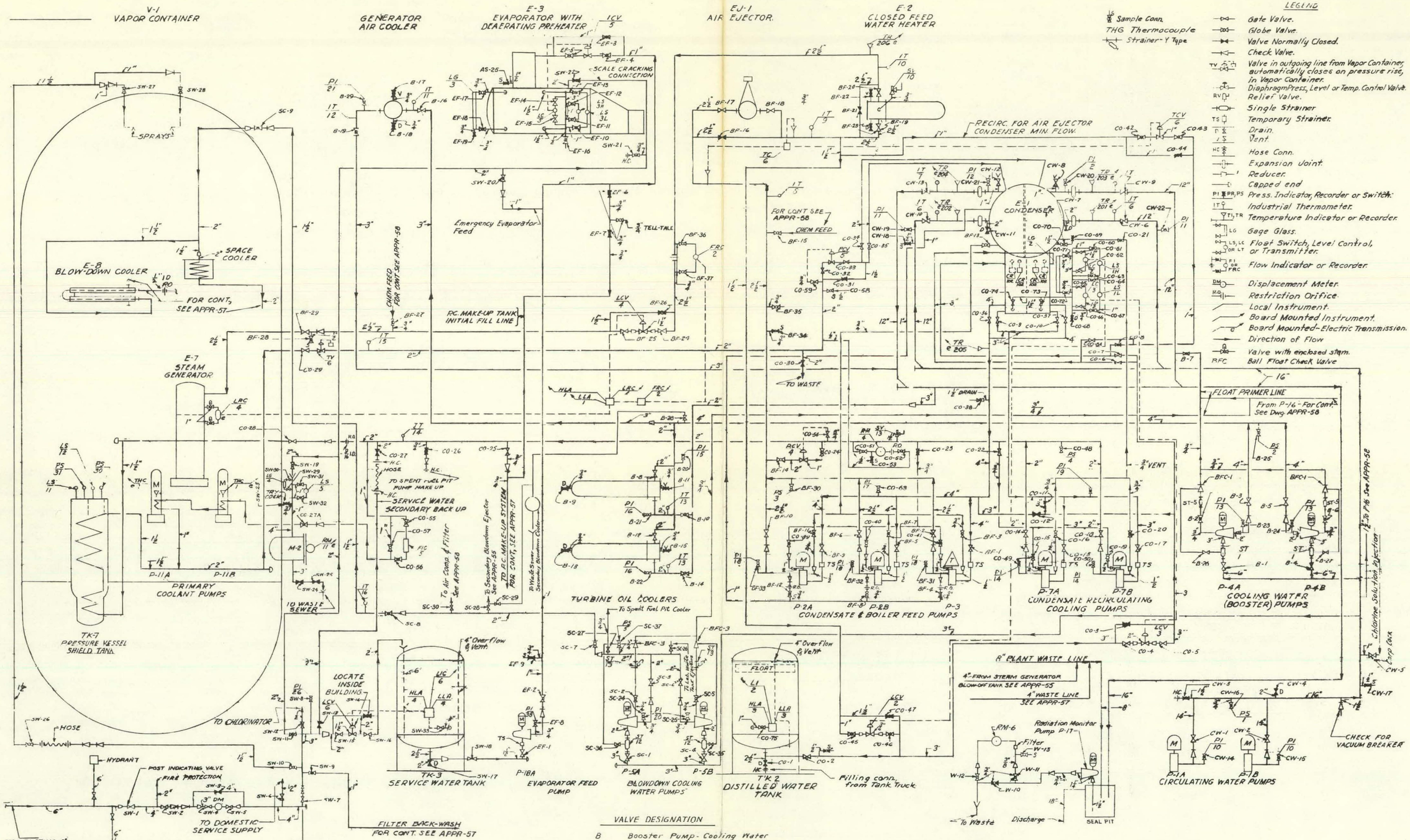

Figure 3-3. Secondary System Condensate, Circulating, and Feedwater Lines, Schematic Flow Diagram

NOTE

This pump is in the portable class and will be used for intermittent service.

Electric Motor. Lubricate the electric motor bearings with silicon grease, once every 12 months of operation. Refer to the "Electric Motors, Care of" section of this manual for instructions on care and cleaning of electric motors.

Packing. The packing in this pump is soft asbestos impregnated with graphite. The pump requires one seal case and five rings of packing. Refer to "Packing" in this section of the manual for additional instructions on replacement and adjustment of packing.

Alignment. No alignment is required since this pump uses a solid shaft between pump and motor.

Boiler Feed Pumps (P-2A, P-2B, and P-3, Figure 3-3)

Manufacturer's Literature. Byron Jackson Company, "BJ Centrifugal Pumps." Disassembly, page 19; and assembly, page 21.

NOTE

To remove one of the pumps, it will be necessary to use the overhead hoist in the turbine room. Remove access plate in the floor of the turbine room and lower rigging to the pump.

Packing. Inspect the stuffing box to see that there is a visible flow of water from the packing. If necessary, adjust the packing gland as instructed in the General Procedures section of this manual. If packing must be replaced, refer to "Packing" in this section of the manual for instructions on repacking pumps.

Running Clearance of Impellers. Disconnect the driver half of the coupling from the pump half of the coupling by removing the bolts. Remove the two screws which hold the adjusting plate to the driver half coupling, thus allowing the impellers to come to rest on the case seats.

Insert a steel rod into the hole provided in the pump coupling flange and a similar rod into the hole in the adjusting plate flange.

Hold the pump half coupling and rotate the adjusting plate until the gap between the plate and the face of the driver half coupling is 0.010 inch. Use feeler or thickness gages. Rotate the driver shaft to align the bolt holes in driver half coupling and in adjusting plate. Install progressively until secure, thereby closing the gap and raising the impellers to coupling bolts; tighten evenly and progressively until tight.

Rotate the shaft to be certain impellers are free. Readjust if impellers drag.

Lubrication. The sleeve bearings within the pump and supporting column are lubricated by the liquid being pumped and require no attention.

General Maintenance and Cleaning. Refer to "Electric Motors, Care of" in this section of the manual for instructions on care of pumps and electric motors.

Boiler Feed Pump P-3 Turbine Drive

Manufacturer's Literature. Coppus Engineering Corporation, "Installing and Operating Instructions for Coppus Steam Turbines Type TF."

Removal Procedure. To remove the boiler feed pump turbine drive, proceed as follows:

1. Take turbine drive out of operation as instructed in Section 2 of the OPERATING MANUAL.

2. Disconnect all piping connections to the turbine.

3. Disconnect drive coupling.

4. Remove mounting bolts.

5. Remove turbine. Use hoist.

Steam Packing Seals. There are four carbon rings of three segments each in each of the two split gland housings. The rings are held on the shaft by means of garter springs. Stop washers prevent rotation of the rings. If leakage becomes excessive, replace the rings. Refer to the manufacturer's literature for detailed instructions.

Governor Packing. A small stuffing box is provided for the governor spindle. If a steam leak exists, add twisted palmetto packing and tighten the gland. Refer to "Packing" in this section of the manual for instructions on packing adjustment.

BRUSHES, FITTING

NOTE

> Use sandpaper. Do not use emery cloth or emery paper to fit brushes. Emery contains magnetic iron particles which will cling to motor components and may cause a short circuit.

When fitting brushes, disconnect and tag all power connections to the motor. Lift the brushes to be fitted and insert a strip of fine sandpaper of grade 00 between the brushes and commutator. Make sure the abrasive side of the sandpaper is in contact with brush. With the brushes held down by normal spring pressure, pull the strip of sandpaper in the direction of forward rotation of the armature. Lift the brushes when returning the brushes for another pull. When fitting is complete, remove the sandpaper and use a vacuum cleaner to remove accumulated dust.

After fitting the brushes, check to make sure the contour of the brushes conforms to the curvature of the commutator.

If brushes must be replaced while the motor is in operation, replace only one brush at a time. Curvature of the contact surface of each brush should be performed to match the curvature of the armature.

CAPACITORS

Little maintenance is required except for occasional inspection, at which time exposed capacitor bushings should be cleaned and connections should be checked for tightness.

Do not attempt any repairs which may open the sealed internal assembly or allow the liquid within the capacitor to come in contact with air or other contaminants. If a unit becomes damaged mechanically, causing leakage, stop the leak (if possible) at once by soldering (using alcohol-rosin flux only) or covering the hole mechanically and return the capacitor to the factory for inspection or refilling by the special processes employed by the manufacturer. Do not attempt to add any insulating liquid to a capacitor. Observe the following procedure to remove capacitor from line:

(1) De-energize the capacitor power source.

(2) Disconnect the leads attached to the capacitor bushings.

WARNING

> Before touching a bushing or bushing lead, discharge the capacitor by placing insulated conductors across all bushings simultaneously. Do not touch bushing until it is certain that the capacitor has been discharged.

(3) Remove bolts securing capacitor to its foundation.

(4) Remove the capacitor.

Chemical Pumps, Packing Replacement and Care

The best packing performance and packing and plunger life will be obtained by careful installation and break-in of the packing as follows:

1. Carefully clean the stuffing box of old packing and dirt and grease. If the stuffing box is equipped with a lantern ring, be sure to remove it and all the old packing beyond it. Inspect the plunger for "scoring" and roughness, as either condition will quickly ruin any type of packing. Replace the plunger if necessary.

2. Cover each piece of packing (including adapter rings), with a light packing grease.

3. Insert each piece of packing individually into the stuffing box, starting with the proper adapter ring. Tamp each piece firmly into place. Stagger all joints and be sure that so-called "scarf" joints are properly lapped.

4. Locate the lantern ring (if one is used) so that its forward edge (toward the liquid end) is just below the grease fitting over the stuffing box. It will move up to its correct

position when the packing is compressed. Be sure to use the proper adapters on both sides of the lantern ring.

5. Fill the stuffing box to within about 1/4" of the end to allow the entrance and proper guiding of the gland or gland follower. The packing set should end with a proper adapter.

6. Insert gland and pull up evenly until packing is tightly compressed. Hold the packing under this compression for about 10 minutes to allow it to firmly "set" in the stuffing box.

7. Release the gland completely and pull up just a little more than finger tight. If packing lubricant is to be used, inject just enough into the grease fitting provided to "feel" tight. Release gland again and pull up just a little more than "finger" tight.

8. Start pump, at full stroke but without pumping load. Run for about 1/2 hour.

9. At the end of this break-in period put the pump into full operation. Adjust the stroke for the desired chemical feed. For the first few hours of operation, slight leakage should be tolerated. After that the gland should be pulled up evenly and very gradually over a period of 12 to 24 hours until the leakage is minimized.

With "Vee" or automatic type of packing it is possible to obtain "drop tight" operation by very careful adjustment of the gland – extreme care must be taken not to overtighten with this type of packing as it will then lose all of its desirable operating characteristics. It will also probably overheat and deteriorate very rapidly.

With compression types of packing it is more difficult to get drop-tight operation. If it is possible to tolerate a little leakage at the gland, the leaking liquid will help to lubricate the packing and plunger and greatly extend the life of both.

CIRCUIT BREAKERS

To remove a power circuit breaker, perform the following steps:

1. Operate the manual trip button to open the circuit breaker and then de-energize the voltage input to the circuit breaker.

2. Open the cabinet door and then check the meter panel to see that the input has been de-energized.

3. Operate the elevating mechanism to lower the circuit breaker wheels until they rest on the guide rails.

4. Pull the circuit breaker out of the cabinet until the bushings are clear of the cabinet.

5. Disconnect the external heads.

WARNING

> Before disconnecting any external head, check the bushings with a voltmeter capable of measuring 5,000 volts ac. If there is voltage present on any head, locate and de-energize the input power source.

6. Roll the circuit breaker out of the cabinet.

Circulating Water Pumps (P-1A and P-1B, Figure 3-3)

Manufacturer's Literature. Peerless Pump Division, "Operation and Maintenance Instructions for Peerless Hydrofoil Pumps 1054."

Running Clearance of Impellers. Tighten the top shaft nut until the pump can be rotated manually. Raise the shaft 3/16 inch above the seals by turning the top shaft nut. The shaft must not turn while the nut is being turned.

Make several successive lower impeller settings at 1/64-inch intervals, being sure to lock the top shaft nut after each setting. Run the pump after each setting and observe the point at which the power meter indicates a sudden increase in power consumption. Set the impeller back to a point slightly higher than that at which the sudden power increase was observed. The power increase is caused by the impellers rubbing on the pump seals. The position just above this is the desired impeller setting.

Alignment of Coupling. Refer to "Pump Coupling Alignment" in this section of the manual for alignment checking instructions.

Packing. Each packing ring should be dipped in heavy cylinder oil before being installed. Refer to "Packing" in this section for detailed instructions on packing adjustment.

General Maintenance and Cleaning. Refer to "Electric Motors, Care of" in this section of the manual for instructions on care and cleaning of pumps and electric motors.

Removal Procedure

1. Remove all electrical connections from the electric motor.

2. Disconnect the piping from the discharge elbow and move disconnect piping clear of pump.

3. Secure a suitable sling to the eyebolts on top of the electric motor. Using the hoist, take up weight of motor.

4. Disconnect the coupling between the motor shaft and the head shaft.

5. Remove the bolts securing the motor to the flange of the discharge elbow.

6. Using the sling and hoist, remove the motor from the discharge elbow.

7. Install three eyebolts in the top flange of the discharge elbow. Secure a sling to the eyebolts and take up weight of the pump with the hoist.

8. Remove the nuts and bolts securing the pump to the pump platform.

9. Using hoist, carefully lift pump out of sump.

For detailed instructions on installation of a new pump, refer to Peerless Pump Division publication No. 1056, entitled "Instruction for the Installation of Peerless Hydrofoil Pumps Using Open Line Shaft."

Closing Relays

Manufacturer's Literature. General Electric Switchgear Instruction, Closing Relays, GEI-23988B.

Maintenance. A semiannual check should be made to ensure that the relay units are picking up below the limits given under adjustments and that the contact gaps and wipers have not been disturbed.

Contacts. Frequent inspection should be made of the contacts of all switchgears and controllers. When troubleshooting or inspecting these items, personnel should look for the following deficiencies:

a. Loose connections
b. Broken connections
c. Opens or shorts in magnetic cords
d. Loose contacts
e. Worn contacts
f. Dirty contacts
g. Dirty pole faces
h. Improper tension (poor adjustment)
i. Improper insulation
j. Operation in high ambient temperatures
k. Improper placement of arc chutes
l. Moisture and dirt

Dust may be removed from switches and controllers and their contacts by dry compressed air at 30 to 50 pounds psig. If this method fails to remove surface dust and dirt, the contacts should be wiped with a safety-type cleaning fluid. Do not use high pressure when cleaning contacts with compressed air, since excessive air pressure may drive metallic dust and dirt into insulation or cause particles to lodge between moving parts of contactors and relays.

The method used for cleaning contacts is important. Cleaning of copper contacts is usually done with fine sandpaper; however, a fine file is permissible if the contact shape is maintained. Silver contacts seldom require cleaning even though they look black because of the silver oxide. Since silver oxide is a conductor, dressing is not necessary. Never use a file or sandpaper on silver contacts. When contacts are replaced, the surface against which they are bolted is thoroughly cleaned. This surface is usually a current-carrying joint and bolting new contacts to a dirty surface will cause future trouble. Traces of copper oxide should be removed.

Emery cloth or coarse files should never be used. Emery particles may adhere to moving parts and contact surfaces, causing unnecessary wear. Coarse, crude filing wastes contact material and make it difficult to maintain original contact shape.

Commutators

Maintenance of Commutators. Good commutation and flow of current in electric motors is indicated during normal operation by the absence of sparking or burning of brushes, commutator bars, and collector rings.

Good commutation is the result of the best electrical and mechanical brush-to-commutator conditions. Continuous close contact between brushes and the commutator or collector ring is necessary. Thus the surfaces of both brushes and ring must be smooth and concentric. The ring must be properly undercut and finished. The brushes must be properly shaped and adjusted. The armature must be correctly balanced. In addition, the development of a uniform copper-oxide-carbon film on the commutator or collector ring is necessary. This film is formed by oxidation, heating, and ozone action and varies in color from copper to black. The ring surface should appear highly polished and without color shading around the brush contacts. Successful commutation can be obtained only through proper inspection, cleaning, and maintenance, as described below.

Inspection of Commutators. Check all commutator bars for flats, burrs, and looseness. Looseness is indicated by irregularly high and low bars. Those conditions cause brush chatter and result in broken brushes. Check for streaks and grooves; check commutator riser connections for thrown solder. Check the mica for pitted condition and the presence of oil, grease, dirt, and embedded particles of carbon and copper. Check that mica is sufficiently undercut.

Cleaning of Commutator. Use a lint-free cloth moistened with a safety-type petroleum solvent or equivalent to remove dirt, oil, and grease. Clean the commutator only when the motor is not running.

Use a piece of dry canvas wrapped on a stick to do final cleaning and polishing of the commutator. Hold the canvas against the rotating commutator ring. A good commercial cleaner improves the work and eliminates the use of sandpaper. Clean the back of the commutator with air pressure or vacuum suction.

Another and simpler method of polishing the commutator is to apply a light load to the motor for several hours. Increase the load as brush contact improves with operation. Continue until the motor is able to carry its rated full load.

Maintenance of Brushes. Use the grade of brushes recommended by the motor manufacturer. Make sure brush pigtails are securely connected to brushes and brush holders. Also make sure brushes move freely in their holders but are not loose enough to vibrate. Chipped or half-worn brushes should be replaced. Clean brush holders before installing new brushes.

Use a spring scale with a capacity of from 1 to 10 pounds to check brush tension. Correct brush tension is given in the Manufacturer's Specification for the particular motor. Brush tension is specified in psi.

COMPRESSED AIR SYSTEM CONDENSING FILTERS

To remove one of these filters, it must first be isolated from the system by closing the four valves directly below the filter and the one valve above the filter. (Refer to Figure 3-4; valves CA-3, CA-5, CA-11, BW-17, and BW-19 or valves CA-4, CA-6, CA-12, BW-18, and BW-20, depending on which filter is involved.)

NOTE

> If the compressed air system is in operation, it will be necessary to place the standby filter in operation before shutting down the operating filter. The standby filter is put in operation by opening the four valves directly below the filter and the one valve above the filter.

To physically remove a filter, use the following procedures (refer to Hankison Corporation Drawing No. M-8310 for details of construction and part numbers; refer to Hankison Corporation Drawing No. 8017 for piping details):

1. Unbolt the union in the horizontal run of 3/4-inch pipe above the filter.
2. Unbolt the union in the vertical run of 3/4-inch pipe below the filter.
3. Unbolt the union in the vertical run of 1/2-inch pipe below the filter.
4. Unscrew the nut couplings at the bottom of the filter of the two vertical tube runs below the filter.
5. While supporting unit, unscrew the three mounting bolts in the bottom face of the mounting brackets.
6. Remove filter. Replacement is the reverse procedure of removal except that a new or overhauled filter is used.

Condensate Recirculating Cooling Pumps (P-7A and P-7B, Figure 3-3)

Manufacturer's Literature. Ingersoll-Rand, "Instructions for Installing and Operating Vertical Turbine Pumps, Form 7764-A."

Lubrication. All pump bearings are lubricated by the water flowing through the pumps and require no special attention except at startup. Water should be admitted to the stuffing box prior to startup and allowed to run down the shaft and wet the bearings.

Both the radial and the thrust bearings of the electric motor are ball types and are grease lubricated. Lubrication should be checked semi-annually and the bearings flushed and repacked yearly.

Packing. Split ring packing is used for both the shaft sleeve and stuffing box packing. Refer to "Packing" in this section of the manual for detailed procedures on using this packing and for packing adjustment. Each packing ring should be dipped in heavy cylinder oil before being installed.

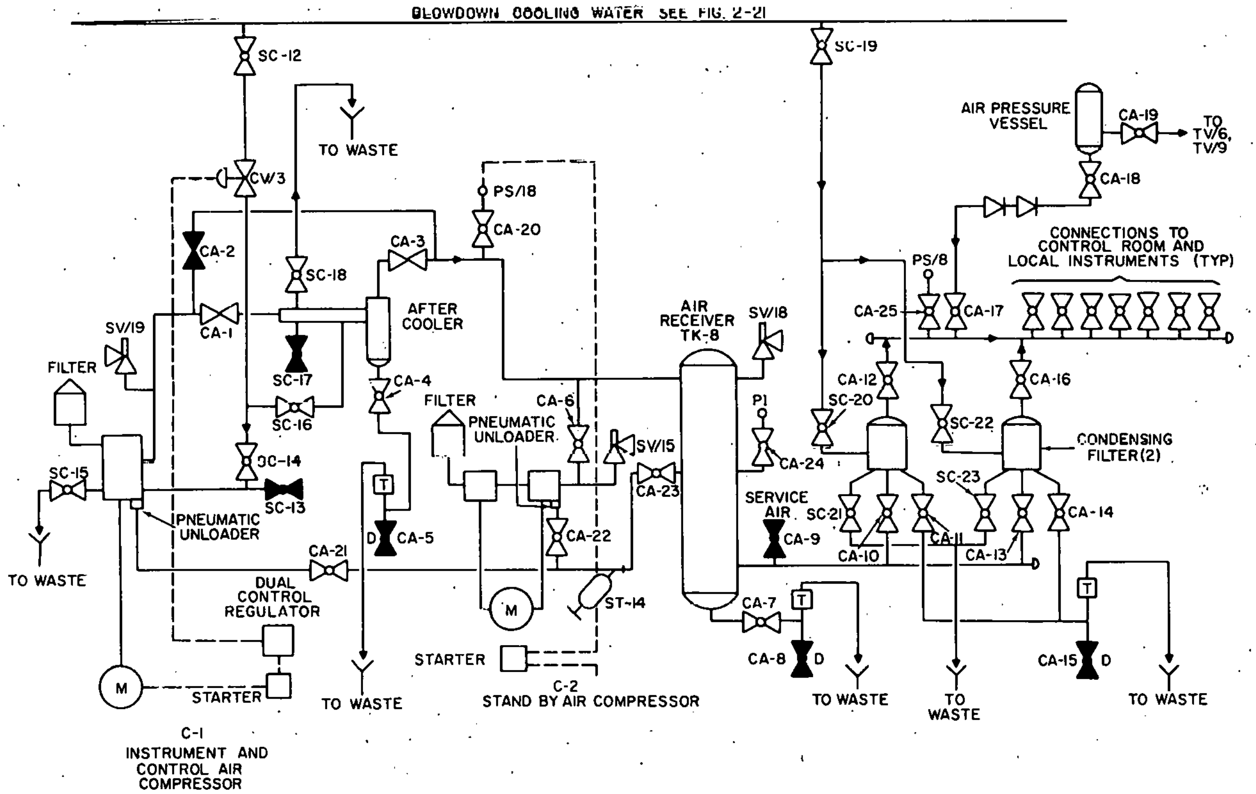

Figure 3-4. Compressed Air System, Schematic Diagram

Coupling Alignment. Refer to "Pump Coupling Alignment" in this section of the manual for alignment checking procedures. Note that this is not a flexible coupling and alignment should be accurately maintained.

Running Clearance of Impellers. Vertical adjustment of pump clearances is obtained on the pump half coupling by means of a nut threaded to the end of the pump shaft. A pin on the pump half coupling engages a slot on the side of the adjusting nut to lock the adjustment. To change the adjustment, remove the snap ring at the bottom of the coupling and loosen the socket head cap screws, allowing the pump rotor to drop down, while keeping a pinch bar meanwhile under the pump half coupling to prevent it from dropping too hard. Lower the rotor with the pinch bar until it strikes the bottom. With the rotor in the down position, slide the pump half coupling down to clear the adjusting nut. Run the adjusting nut up until it strikes against the driver half coupling. Back off the adjusting nut until the first slot engages with the locking pin when the pump half coupling is forced up to meet the driver half coupling. Insert cap screws and tighten, replace snap ring, and check if shaft turns freely. If not, lower pump half coupling and screw down adjusting nut by one more slot. Reconnect coupling and check again for free rotation of shaft.

Should the ammeter reading of the current to the pump be high or keep increasing after the unit is started, this indicates that the impeller has developed a rub because of the shaft stretching or because of expansion as a result of temperature. Shut the unit down and adjust the rotor clearance until it runs freely.

General Maintenance and Cleaning. Refer to "Electric Motors, Care of" in this section of the manual for instructions on care and cleaning of pumps and electric motors.

Removal of Condensate Recirculating Pumps. To remove either of the condensate recirculating cooling pumps, proceed as follows:

1. Isolate the pump as instructed in "Isolation" in this section of the manual.

2. Remove all electrical connections from electric motor.

NOTE

To remove the pump, it will be necessary to use the overhead hoist in the turbine room. Remove the access plate in the floor of the turbine room and lower suitable rigging to the pump.

3. Using two slings and the turbine room overhead hoist, raise the pump from the pit and lower it to a horizontal position. Exercise care to prevent damage to the long sections.

To install a new pump, refer to the Ingersoll-Rand publication entitled "Instructions for Installing and Operating Vertical Turbine Pumps."

Condenser (E-1, Figure 3-1)

Manufacturer's Literature. Lummus Company "Instructions for Operation and Maintenance of Surface Condenser Equipment."

General. The condenser is of duplex design and one half may be isolated and serviced while the other half is used to sustain plant operation at half load. Refer to the operating manual for the procedure to be used in isolating half of the condenser.

Checking for Leaks. The entire condenser should be tested for tube leaks whenever there is any indication that a leak may exist. Decrease in the vacuum obtainable would indicate excessive air leakage into the condenser. Conductivity of the condensate or water analysis may also indicate leaks. If there is any leakage between the tubes and the tube sheet, the tubes must be re-rolled. Tubes which have leaks through the tube wall should be plugged until replacement is possible.

WARNING

> Hydrogen gas may develop and accumulate in the condenser. Do not bring any open flame or any tool that may cause a spark near the condenser until it has been thoroughly blown out with steam or air.

Condenser Atmospheric Relief Valve (SV/1, Figure 3-1)

Manufacturer's Literature. Atwood & Morrill, Drawing No. 1516F.

General Maintenance. Refer to "Valves" in this section of the manual for detailed instructions on care and maintenance of valves.

Maintenance of the horizontal atmospheric relief valve consists of routine duties. The packing in the stuffing box will have to be tightened or changed after long service. It is also important to keep the condensate drain in the bottom of the valve body properly water-sealed. The water seal condition is checked hourly by the water level sight glass.

Contaminated Waste Tank Pumps (P-14A and P-14B, Figure 3-2)

Manufacturer's Literature. Chempump, "How to Install and Operate the Chempump, Series E."

These pumps require no periodic preventive maintenance or lubrication. Replacement of worn parts can only be accomplished after removal of the pump from the system; therefore, no in-place maintenance is possible.

Removal Procedure. To remove the contaminated waste tank pumps proceed as follows:

NOTE

> To gain access to pump P-14A, it will be necessary to enter the contaminated waste tank.

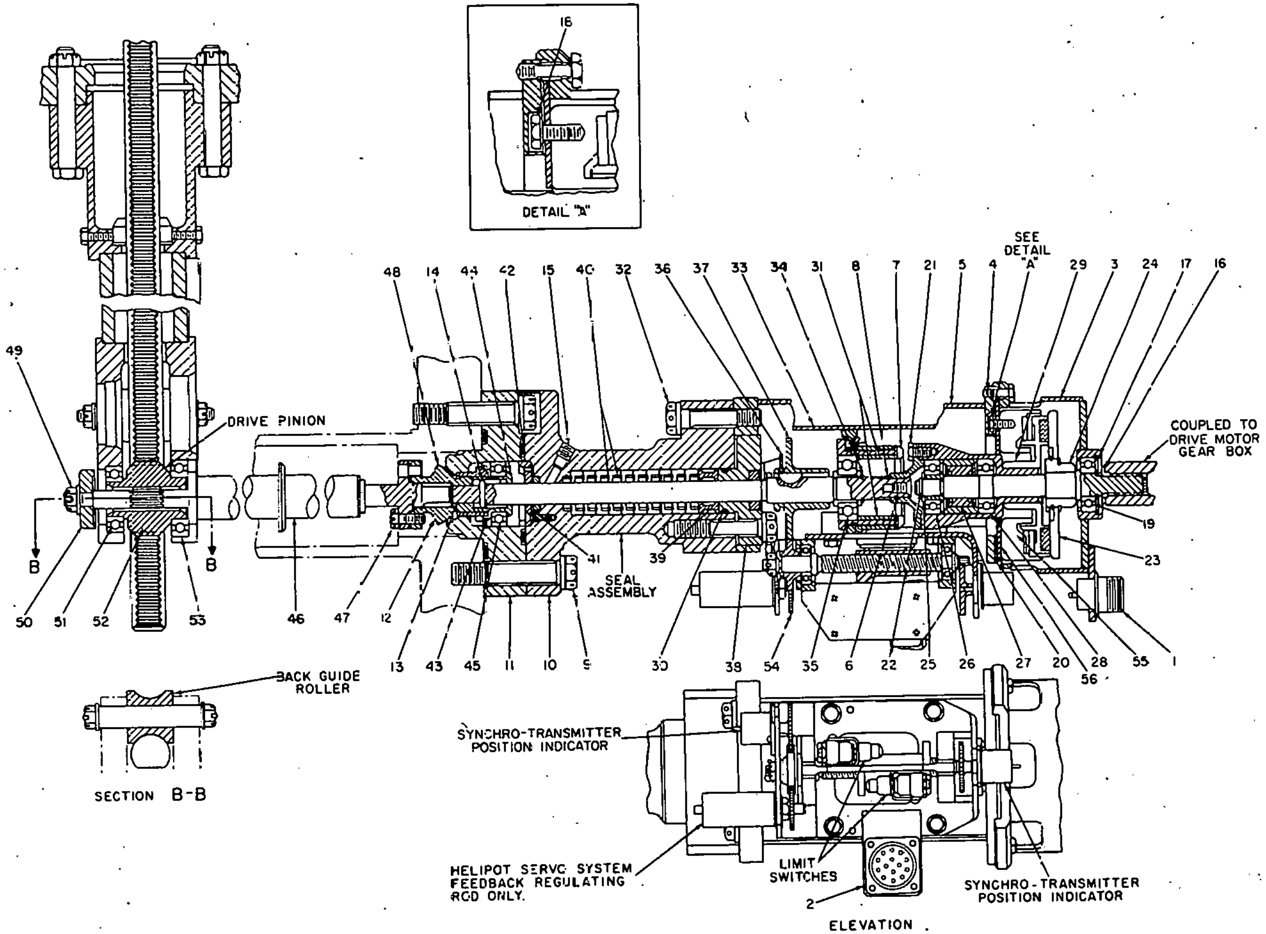

Figure 3-5. Control Rod and Drive Mechanism

WARNING

Fluid in the contaminated waste tank and water remaining in the pump will be radioactive. Do not attempt removal of pumps without prior consultation with health physics personnel. Carefully monitor the dose rate above the tank, while working in the area, to avoid overexposure to radiation.

1. Remove bolts securing pump body to suction and discharge flanges.

2. Remove the pump.

3. Unscrew and remove the two flanges from the piping.

For detailed instructions on overhaul and installation procedures, refer to the Chempump Series E bulletin.

CONTROL ROD DRIVE MECHANISM AND MOTOR (Figure 3-5)

WARNING

Do not enter vapor container until approximately eight hours after reactor has been shut down. Before entering, check the radiation level on the control panel monitor. Observe all necessary health physics precautions to avoid overexposure to radiation. Keep duration of exposure to a minimum.

Isolating Procedure

1. Remove primary makeup water pressure from high-pressure side of seal (15, Figure 3-5) by closing appropriate valves.

2. Remove electrical connector from (1) to electrically isolate the clutch drive assembly.

3. Remove electrical connector from (2) to electrically isolate microswitches and servo mechanism.

4. Remove electrical connector from motor.

The control rod drives constitute one of the major components of the reactor. They are highly precisioned pieces of equipment, and therefore a great deal of care must be exercised when disassembly, inspection, repair, and assembly is being done. There are (4) major assemblies that make up the complete rod drive unit, as follows:

(1) Motor

(2) Drive shaft assembly

(3) Instrument Pad, limit switch, and seal assembly.

(4) Rod drive shaft assembly

Disassembly procedure of the rod drive components is as follows:

1. Drive Shaft Assembly

   a. Punch out pin of either universal, being careful not to lose snap ring when universal is separated. Note: See print R9-11-1007.

2. Removal of Motor

   a. Remove universal pin connecting motor shaft to drive shaft.

   b. Remove motor mounting bolts.

   c. Remove motor.

3. Magnetic Clutch Assembly (Figure 3-5)

   a. Clutch removal

      (1) Back off four cap screws No. 4 until free from support housing, pull straight back to remove clutch.

   b. Clutch Disassembly

      (1) Remove four cap screws from receptacle No. 1 and remove housing from bracket. Remove snap ring from plug housing and pull apart.

      (2) Remove snap ring No. 16.

      (3) Remove snap ring No. 17.

      (4) Remove four cap screws No. 18. Clutch housing and bearing No. 19 may be removed as a unit.

      (5) Bearing No. 19 may be removed for inspection.

      (6) Remove shim No. 20.

      (7) Remove eight cap screws from splined hub of overrunning clutch No. 21.

      (8) Remove snap ring No. 22.

      (9) Remove clutch plate and shaft No. 23 together. Snap rings in front and rear of clutch plate may be removed and clutch release spring and splines may be checked.

      (10) Remove two set screws from hub No. 24 and remove hub from shaft.

      (11) Remove spacer bushing No. 25.

(12) Remove bearing No. 26.

(13) Remove overrunning clutch No. 27.

(14) Remove bearing No. 28.

(15) Remove set screw from magnetic clutch hub No. 29. Magnetic clutch can now be separated from windings.

NOTE

Some of the control rod drives turn in a clockwise direction and some in a counterclockwise direction.

The overrunning clutch must be installed so that the control rod can be driven down in case of magnet failure. Be sure to check clutch for correct rotation before putting clutch in service.

To check this, make certain magnet current is OFF. Rotate clutch in direction to drive control rod up. If clutch slips and does not raise the control rod, but holds to drive the control rod down, it is correctly mounted. If the clutch drives up and not down, without magnet current, remove the overrunning clutch and turn 180° and reinstall, being sure square key is pushed all the way down.

Clutch will operate in the desired manner. All control rod drive clutches are interchangeable.

4. Instrument Pad and Drive Assembly (Figure 3-5)

   a. Back off four cap screws No. 30 until free of mounting, and remove limit switch assembly. Note: Any repair on instrument pad assembly should be done by instrument personnel.

   b. Remove special nut No. 31.

   c. Remove spacer No. 8.

   d. Remove four bolts No. 32 and remove housing No. 33, from high-pressure seal assembly.

   e. Remove snap ring and washer No. 34.

   f. Remove bearing No. 35.

   g. Remove gear retainer No. 36.

   h. Remove gear No. 37.

   i. Press out pin No. 14.

j. Remove shaft No. 8.

k. Remove flange No. 38 with low-pressure seal and O-ring.

NOTE

When replacing flange No. 38, clearance between flange and seal housing must be the same all the way around the flange. Check clearance with feeler gauge; draw bolts down even.

l. Inspect low-pressure seal and O-ring for damage.

m. Remove seal spacer ring No. 39.

n. Remove seal rings No. 40.

o. Remove end plate bushing No. 41.

NOTE

Instrument pad assembly should be the last major component assembled to the rod drive assembly. The reason for this is that the limit switch must be set to prevent the control rod from being driven down too far. The procedure for doing this is as follows:

With the control rod all the way to the bottom and the lower limit switch tripped to the off position, continue to turn driven gear in the downward direction about three more teeth. The instrument pad is now ready to mount. Extreme care must be taken to insure that driven gear No. 54 on the limit switch meshes with the driving gear No. 37 before bolts are drawn down.

5. Seal Assembly Removal (Figure 3-5)

a. Remove drive shaft.

b. Remove electrical cables.

c. Remove cover from limit switch.

d. Remove instrument pad assembly.

e. Remove clutch assembly.

f. Back off on special nut until finger tight.

NOTE

System should be pressurized to at least 200 PSI

g. Close drain lines and remove from seal.

h. Loosen bolts in flange No. 10; if leak occurs, attach special tool to thread in shaft and pull out to set the valve No. 48.

i. Remove bolts No. 9 from flange No. 10.

j. Turn shaft 90° and pull out on seal assembly.

k. Remove gasket No. 42.

6. Control Rod Drive Shaft (Figure 3-5)

a. Removal and disassembly

(1) Drain primary system.

(2) Bend up tabs on lockwasher No. 43.

(3) Remove threaded bushing No. 44.

(4) Remove bearing No. 45 and lockwasher No. 43.

(5) Remove nut bearing No. 14.

(6) Remove flange No. 11.

(7) Remove control rod drive shaft No. 46.

b. Disassembly of Control Rod Drive Shaft

(1) Remove cap screws No. 47, and remove valve No. 48 from shaft.

(2) Remove slotted nut No. 49.

(3) Remove collar No. 50.

(4) Remove bearing No. 51.

(5) Remove gear No. 52 from spline.

(6) Remove bearing No. 53.

NOTE

For the most part, assembly is the reverse of the disassembly procedure. However, the limit switches and clutch assemblies may be assembled as a component part at any time.

Cooling Water Booster Pumps (P-4A and P-4B, Figure 3-3)

Manufacturer's Literature. Ingersoll-Rand, "Instructions and Repair Parts Book for Cradle-Mounted Pumps, Form 7758-C."

Lubrication. The two ball bearings in the cradle are oil lubricated. Oil level in the cradle must be maintained. Refer to the Lubrication Schedule, Section 4, of this manual for instructions.

Packing. The packing is lubricated by a slight leakage of water from the pump. Refer to "Packing" in this section of the manual for instructions on adjustment of packing.

Coupling Alignment. Refer to "Pump Coupling Alignment" in this section of the manual for detailed instructions on coupling alignment procedures.

General Maintenance and Cleaning. Refer to "Electric Motors, Care of" in this section of the manual for instructions on care and cleaning of pumps and electric motors.

Removal of Cooling Water Booster Pumps. To remove either of the cooling water booster pumps, proceed as follows:

1. Isolate the pump as instructed in "Isolation" in this section of the manual.

2. Remove electrical connections from the pump motor.

3. Disconnect piping from the suction and discharge ports.

4. Disconnect the coupling between the motor shaft and the pump shaft by removing the nuts and bolts securing the two halves of the coupling.

5. Remove all bolts securing the pump to the foundation and remove pump.

When reassembling the pump and motor, refer to "Pump Coupling Alignment" of this section of the manual for detailed instructions on coupling alignment. Refer to the Ingersoll-Rand Instructions and Repair Parts Book for Cradle-Mounted Pumps, Form 7758-C, for detailed instructions on dismantling and reassembly.

D-C System Rectifier Charger. To remove the d-c system rectifier charger, proceed as outlined below:

1. De-energize the a-c input and d-c output of the charger.

2. Disconnect all external heads.

CAUTION

Before touching any head, be certain that no voltage is present by checking the head with a voltmeter.

3. Remove the mounting bolts.

4. Remove the charger.

If a new d-c system rectifier charger is installed, make a ground connection between the charger and the charger enclosure.

Decontamination Fan

Manufacturer's Literature. Buffalo Forge Company "Maintenance and Installation Data."

Isolation procedure. Lock out and tag control switch No. 87 on the electrical section control panel.

Lubrication. Lubrication and maintenance of the ball bearings are of primary importance. For detailed instructions, refer to Lubrication Schedule, Section 4, of this manual.

Packing. The stuffing box is located on the fan housing at the point where the shaft enters. Replacement of the packing is necessary only once in several years. To replace the packing, back off the packing gland, remove the old packing, and install the new packing. Take up on the packing gland to the point where it exerts enough pressure to flex the packing to make a single contact with the shaft and the stuffing box.

Belt Tension. Correct belt tension is most important in obtaining maximum drive efficiency. Belts should be slightly stretched for best results. However, avoid excessive belt tension, since it will put too much load on the bearings.

Balance Check. The fan should be properly balanced at all times. If a fan is allowed to operate while unbalanced, it may eventually loosen the foundation bolts, burn out the bearings, spring the shaft, and cause damage to the fan wheel. However, some other defect in the fan may cause it to show similar symptoms. If the fan vibrates excessively, do not attempt to balance it until the following procedures have been observed:

1. Check that the shaft is not bent. Rotate the fan by hand and observe the shaft with the naked eye. If uncertain as to whether or not the shaft is bent, check it with a shaft indicator.

2. Check the alignment of the belt drive. Correct alignment requires that the fan shaft and the motor shaft be parallel. Use a straightedge or taut cord to line up the driving and driver sheaves.

3. Check that the fan wheel is secured to the shaft and is not slipping.

4. Inspect the bearings to see that they are properly lubricated and are not worn or damaged.

5. Check the foundation bolts for tightness.

6. Check to see that the fan blades are free of dirt. Remove pieces of dirt and foreign matter from fan blades with a scraper, wire brush, compressed air, or steam.

If the unbalanced condition of the fan still exists, refer to the manufacturer's literature, page 13, for detailed instructions on balancing the fan.

Demineralizers DM-1A and DM-1B

Requirement for removing or replacing demineralizers will be determined by the Water Chemist. All work on the demineralizer units will be performed under the supervision of the Health Physicist. The units are normally operated in the shipping cask, to provide radiation shielding.

1. Adjust valving as below in isolating units prior to removal:

EXHAUSTED UNIT	OPEN VALVES TO OTHER UNIT:	CLOSE UNIT VALVES:
DM-1A	PC 11, PC 13	PC 10, PC 12
DM-1B	PC 10, PC 12	PC 11, PC 13

2. After isolating unit, release quick-disconnect couplings from the system piping, and then remove the coupling and hose from the unit. Drips and drainage must be collected in pails or with absorbent material. Cap the inlet and outlet connections on the unit.

3. Move track and trolley mounted chain hoist to cubicle of desired demineralizer and, working at arms length, rap no-leak hose connections, sharply but not heavily, with a machinist's hammer to loosen. Continue to loosen and disengage hose connections by turning with hand.

4. Keeping the body and head shielded as much as possible, engage the hook of the chain hoist with the D-ring on top of the demineralizer cannister. Raise cannister sufficiently to slide out pipes which support cannister at top of lead cask, then lower cannister into lead cask and disengage chain hoist hook.

5. Pass a 1/2-inch cable sling through the lifting ring of the lead plug for the lead cask and lower plug into cask.

6. Remove cable sling from plug and pass through lifting lugs of the lead cask and engage both eyes of the sling with chain hoist hook. Raise cask sufficiently to clear step at demineralizer cubicle and walk cask along chain hoist track to point nearest demineralizer room door.

7. Lower cask onto heavy skid or blocking and remove from demineralizer room with fork lift. Store in a convenient location until shipped from plant. Health Physicists survey may require storage in a controlled area.

8. Pressure test a new unit, using the head of the distilled water tank at valve CO-8. If free from leaks, connect on line by following the procedure above in reverse. The new unit should be connected immediately; however, it should not be put on line until it has been placed in the shipping cask to provide shielding.

Drain Regulators. To remove drain regulators, follow procedures similar to those for steam traps, noted above.

Electrical Instruments. To remove electrical instruments, proceed as follows:

1. Remove power from unit by opening appropriate instrument switch.

2. Remove all lead connections.

3. Remove all mounting fastenings.

4. Remove instrument.

CAUTION

Handle all instruments with care to avoid damage to sensitive mechanisms. Check manufacturer's publication for special precautions to be observed in the handling of any instrument.

Electrical Instrument Transformers

Manufacturer's Literature. General Electric Instructions for Instrument Transformers, GEH-230U.

WARNING

Before performing maintenance on transformers, de-energize both primary and secondary windings. Check winding potential with a voltmeter of suitable rating to make sure that de-energization has been attained.

NEVER OPEN-CIRCUIT THE SECONDARY WINDING OF AN ENERGIZED CURRENT TRANSFORMER OR SHORT-CIRCUIT THE SECONDARY WINDING OF AN ENERGIZED POTENTIAL TRANSFORMER.

Maintenance. The principal maintenance requirements for these devices consist of cleaning bushings to prevent flashover and maintenance of secondary contact surfaces to keep contact resistance low.

The cleaning of bushings should be performed periodically at intervals that vary with the location of the transformer. Do not permit a surface coating of dirt to accumulate. The procedure for cleaning is described on page 6 of the manufacturer's publication.

Secondary contact surfaces should be kept smooth and clean and must mate perfectly. If corrosion and/or dirt becomes deposited on mating contact surfaces, the surfaces should be hand dressed with a fine file, emery cloth, or other suitable fine abrasive.

If inaccurate instrument readings are apparent and calibration of the instrument does not remedy the inaccuracy, test the instrument transformer in accordance with the procedures outlined on page 3 of the manufacturer's publication.

Cleaning. The outside of the motor should be wiped clean periodically and all loose gear and obstructions in the vicinity of the motor should be removed to prevent obstruction of motor ventilation. If the motor overheats and no other cause is apparent, it is possible that the interior of the motor has an accumulation of dirt. Disassemble the motor and use low-pressure compressed air to remove the dirt.

Lubrication. Great care should be exercised when lubricating the motor. The motor should be in operation during lubrication or at least have been warmed up before lubrication takes place. For detailed lubrication procedures, refer to the Lubrication Schedule, Section 4, of this manual. The motor should be checked for overheating for several hours after lubrication. For cleaning of commutators refer to the paragraph headed "Commutators" in this section.

Meggering. All electric motors should be meggered semi-annually. If the insulation reading is less than one megohm, the motor should be removed from service. Check the insulation for deterioration, dirt, and moisture. If moisture is the apparent cause, operate the motor for short intervals and note whether the condition improves. If reading drops to 1/2 megohm, remove the motor and dry out according to instructions in the following text.

Drying Motor Windings. Dampness and moisture lower the electrical resistance of insulation on the motor windings. Damp or moist windings must therefore be dried before the motor is operated.

Normally, the motor should be baked in an oven but, if baking facilities are not readily available, the following methods (1 and 2 below) are recommended.

CAUTION

> These methods are to be employed by experienced personnel only. Mishandling of motors may result in complete destruction of their usefulness.

Regardless of the method used, the windings should not be heated above 90°C as determined from the resistance or by using a resistance temperature detector. The temperature should not exceed 75°C as measured on a thermometer. The rate of heating should be controlled to insure that the maximum allowable temperatures will not be reached in less than 2 hours and preferably in not more than 6 hours.

1. Short Circuit Method.

This method of drying is applicable only to motors which can be mechanically driven. Operate the motor at rated speed with all phases of the armature winding short-circuited. Excite the field to produce a heating current in the armature. The armature current required for adequate heating is approximately 60 to 100 percent of the rated armature current. Drying should be continued at temperatures not exceeding the maximum (above) until resistance of the insulation reaches a satisfactory value as indicated by the following formula:

$$RI = (\text{Rated voltage}/1{,}000) + 1 \text{ Meg}$$

where: RI = Resistance of insulation in megohms.

2. Direct-Current Method

This method of drying is applicable to stationary motors. A low-voltage, high-amperage, d-c source of electric power (such as a welding generator) is necessary. The maximum current in any phase of the armature winding should be limited to that necessary to give the temperature time relation mentioned above. Field windings can be dried by applying a separate source of d-c power to the field winding. Do not use motor brushes to carry the field current, but connect the leads to copper bands clamped around the collector rings.

3. Transformer Method

During periods of prolonged shutdown, the pump motor should be regularly checked for insulation resistance to ground. If the resistance to ground decreases steadily, the following drying procedure should be followed. Connect a single-phase transformer to any two of the line terminals. The transformer should be capable of passing 6 percent of the rated current through the field winding. This will provide sufficient heat to prevent normal condensation of moisture in the motor. Measure and record the phase-to-ground resistance, using a 500-volt megger. The measured resistance should not be less than 1 megohm.

Evaporator and Preheater (E-3)

Manufacturer's Literature. ALCO Products, Inc.

Inspection for Leaks. Proper operation of these units depends upon keeping the units watertight. Check for leaks daily. Replace the gasket if a leak cannot be corrected by tightening the joint.

Whenever a gasketed joint is opened, the old gasket must be replaced. Refer to the manufacturer's literature for instructions on gasket replacement.

If a leak develops in a tube wall, plug the tube until the secondary system is shut down and the defective tube can be replaced. Refer to the manufacturer's literature for instructions.

If a leak develops between a tube and tube sheet, the tube joint must be re-rolled. Refer to the manufacturer's literature for instructions.

Descaling the Tubes. The tubes must be descaled regularly as determined by operating conditions. Until a descaling schedule has been established the operation should be performed at least once during every 24 hours of continuous operation. To descale the tubes, perform the following steps:

1. Shut down the evaporator, if it is in operation, following the procedure in Section 2 of the OPERATING MANUAL.

2. Open valves EB-1 and EB-2 (Figure 3-1) to drain the shell.

3. Open valve SW-20 to admit scale-cracking water. Allow the water to flow five minutes and then close the valve.

4. Open valves AS-26 and AS-27 to admit steam to tubes. Allow the steam to flow about five minutes and then close the valves.

5. Open valve SW-20 and allow water to flow for 10 minutes before closing the valve.

6. Repeat steps four and five at least two more times or until there are no scales in the cracking water.

7. Open valves to drain the shell. Close valves EB-1 and EB-2 before starting the evaporator again. Starting instructions are contained in Section 2 of the OPERATING MANUAL.

Evaporator Feed Pump (P-18, Figure 3-3)

Manufacturer's Literature. Ingersoll-Rand, "Instructions and Repair Parts Book for motorpump, Form 7870."

Removal of Evaporator Feed Pump. To remove the evaporator feed pump, proceed as follows:

1. Isolate the pump in accordance with "isolation" procedures.

2. Remove electrical connections from the pump motor.

3. Disconnect piping from suction and discharge ports.

4. Remove all mounting bolts and remove the pump.

Packing. The packing used is soft asbestos impregnated with graphite. The pump requires five rings of packing. Refer to "Packing" in this section of the manual for detailed instructions on installation and adjustment of packing. Dip each ring of packing in heavy cylinder oil before installing.

After a new packing has been installed, remove the internal seal needle valve and fill the seal bushing with suitable grease. Replace the needle valve and turn the handle through several revolutions until resistance to further turning is felt.

Motor. Refer to "Electric Motors, Care of" in this section of the manual for instructions on care and cleaning of electric motors.

Exciter

General Maintenance. Refer to "Generator" in this section of the manual.

In addition to the maintenance checks listed under "Generator," the brushes and commutator surfaces should be checked bimonthly or during periodic shutdown. Worn brushes should be replaced with brushes of the same grade. The commutator surfaces should be checked for burnt spots or burrs.

WARNING

Commutation adjustment should be made only by specially trained personnel.

Specifications:

Poles - 4
KW - 15
Rpm - 1200
Voltage - 125
Amperage - 120

Feedwater Heater (E-2, Figure 3-1)

Manufacturer's Literature. ALCO Products, Inc.

Inspection for Leaks. The feedwater heater should be inspected daily for leaks. If a leak cannot be corrected by tightening the joint, the gasket must be replaced. Refer to the manufacturer's literature for detailed instructions.

A leak may also occur in a tube wall. In this case, plug the tube until the plant can be shut down and the tube replaced. If a leak occurs between a tube and tube sheet, re-roll the joint. Refer to the manufacturer's literature for instructions.

FILTER, MICROMETALLIC

WARNING

Disassembly or replacement of this filter is to be performed only by the Chemist under supervision of the Health Physicist. Before removal of a filter, an area must be established in the laboratory hood shielded by lead bricks and provided with a layer of absorbent paper. A mirror should be arranged to permit operations from behind the shield. Up to 3 r/hr radiation may be anticipated from a filter unit.

a. Removal of Unit

NOTE

This operation must be performed in the minimum time, to reduce amount of crud bypassed into primary make-up tank while filter is off-line.

1. Isolate filter unit by opening bypass valve PC-17 and closing filter valves PC-15 and PC-16. Tag valves.

2. Place splash pan under filter unit. Slowly loosen clamp on filter unit to permit water pressure to be relieved. When pressure is relieved, remove cover of unit.

3. Following Health Physics survey of unit, remove filter unit from housing, and place in a 500 ml beaker.

4. Install a clean filter unit and fill housing with demineralized water from primary make-up tank.

5. Replace cover.

6. Open valve PC-15 slowly to determine that unit is free from leaks. Open valve PC-16 and close bypass valve PC-17. Remove tags.

7. Wash splash pan at Sample Point 1 and complete decontamination in laboratory.

b. Cleaning of Unit

1. Place beaker containing filter unit in a splash pan, and place the pan behind lead shielding in laboratory hood.

2. Mount filter unit across top of beaker, using a short length of 1/4-inch tubing for an axle.

3. Wash as much crud as possible from the filter unit into the beaker, using a wash bottle while rotating the unit on the axle.

4. Complete cleaning by gently boiling the unit in 5 percent nitric acid for up to one hour. DO NOT USE HYDROCHLORIC ACID AT ANY CONCENTRATION.

5. Filter all solutions containing suspended crud through filter paper and dry the filter paper. Place the filter paper into a small glass bottle to be discarded as solid contaminated waste, labeling the bottle as to content and activity level. DO NOT DISCARD CRUD INTO SINK.

Flame Arresters (FA, Figure 3-2).

There are three flame arresters located at different points in the hydrogen system. Hydrogen is highly explosive and flame arresters must be provided wherever hydrogen might be bled off for any reason. Location of these flame arresters are as follows: No. 1 is located just downstream of the hydrogen tanks and regulating valves; No. 2 is located on the discharge side of the relief valve on top of the make-up tank; No. 3 is located on the discharge side of the relief valve on top of the seal leakage tank.

Gaskets

General. Gaskets supply the give that makes a tight seal in a rigid joint. There are many different types of gaskets and gasket meterial. When installing a new gasket, consideration should be given to pressure, temperature, dimensions of sealing area, and whether the gasket is resisting liquid, vapor, or gas.

When a joint is leaking, the gasket should be renewed at the earliest opportunity. Until the gasket can be renewed, the joint should be taken up in an attempt to prevent the flange from becoming scored or wire drawn.

The following are helpful suggestions for best results with gaskets.

1. Remove corrosion and burrs from seal surfaces. Make flanges as parallel as possible. If warped, reface or replace flanges so gasket compresses evenly over its area.

2. Select gasket for job conditions, using ring type where possible. Wherever possible, use gasket material recommended by manufacturer of equipment being worked on.

3. Use thinnest gasket possible, but try thicker, softer one where rough faces cannot be machined smooth.

4. For high-pressure applications where flanges are too far apart, use a metal spacer with a gasket on each side.

5. Do not make gasket by hammering on material against flange. Material may distort and keep flanges from seating. Use a good gasket cutter.

6. Cut bolt holes slightly larger than bolts so gasket will not bulge around bolts and prevent proper seating.

7. Size gasket correctly or exposed flange faces may corrode and require machining next time joint is opened.

8. Make gasket inside diameter just slightly more than inside diameter of line. This keeps hydrostatic end force to minimum and prevents obstructions to flow by gasket squeezing into line.

9. Graphite one or both sides of gasket if joint must be broken from time to time. Mix graphite with water, never with oil. Oil deteriorates any rubber in the gasket.

10. Smear graphite paste on bolts and run nuts down before reassembling joint. Replace damaged or corroded bolts and nuts.

11. Tighten nuts in correct sequence to load gasket evenly. Tighten again under operating conditions.

12. Shellac gasket to housing on crankcase doors and strainers that are frequently opened. Smear cup grease on other side of gasket.

Replacement Procedure

1. Remove the old gasket. Take necessary steps to relieve pressure before breaking any joint. Remove all bolts if flanges are sealed with a full gasket; however, if the gasket is a ring type, remove only enough bolts to slip it out. Use a flange spreader, or steel wedges driven in at opposite edges, to open the joint. Scrape out the old gasket, making certain every particle is removed. Be careful not to harm the flange faces.

2. Lay out the new gasket. Find the diameter of the bolt circle by placing dividers at the bottom of two opposite holes in the flange. Lay out the bolt circle, using this distance as the diameter. Use dividers to measure the distance between bolt holes. Draw a line through the center of circles to position opposite holes. Lay out bolt holes a little larger than the actual size of bolts. If the flange is accessible, spread graphite on its face and make an impression on the gasket material. This will give a good image of the gasket.

3. Cut out the gasket. Use gasket cutters if available. Leave one corner on the gasket so it can be held for positioning on the flange. Tin snips will do the job. Place the material on a hard wood surface and punch the holes. Never hammer the gasket, since this causes formation of lumps. A lumped gasket reduces the probability of a good seal.

4. Install the gasket. Slip one bolt through the flanges and the gasket. Position the gasket and install the remaining bolts. After a short period of operation under working pressure, retighten the bolts.

Generator. Generator life and performance are dependent upon proper care and maintenance. An addition to requisite periodic schedules of inspection and maintenance, the overall condition and operation of the machine should be checked each day.

Manufacturer's Literature. General Electric Turbine Instructions, GEI 54328, Section GEH-709S.

Lubrication. Refer to the Lubrication Schedule, Section 4, of this manual, for information on recommended lubricants and lubricating intervals.

1. Flush and refill generator oil reservoirs yearly. More frequent flushing will depend upon the continuity of service to which the unit is subjected.

2. Keep the bearing housings filled to the proper level (3/4 level in sight glass). Each bearing housing has a 2-gallon oil capacity.

3. If necessary to add oil during operation, add slowly to allow cooler oil to mix with warm oil in housing, and caution should be exercised to keep from filling above proper level.

4. Check to see that oil is not leaking along the shaft from the bearing housing to the generator housing. If oil leak occurs, seals will have to be replaced. If such a leak persists, a danger of oil entering into generator housing and damaging the windings would exist.

5. Check bearing oil rings to see that they are round and free from defects. When the unit is operating, the oil rings should rotate freely to give proper lubrication.

Coupling Alignment. Refer to "Pump Coupling Alignment" in this section of the manual for instructions on aligning the generator couplings. After the machine has been operated for a short period of time, recheck the alignment of the couplings as there may have been settlement of the foundation or movement of the equipment to which the generator is connected. Thereafter the coupling alignment should be checked at periodic intervals, the frequency of which will be dependent upon the service to which the generator is subjected.

Coupling Servicing

An annual inspection of couplings will be necessary to check for excessive wear on teeth due to malalignment or poor lubrication. At this time, flush out coupling and repack. See Lubrication Schedule, Section 4 of this manual.

General Maintenance Data. Refer to "Electric Motors and Generators, Care of" in this section of the manual for detailed instructions on maintenance of brushes and collector rings, drying out of electrical windings, and meggering.

The machine should be kept free from dust, dirt, oil, and water. Cleanliness in the care and operation of the unit are essential for trouble-free operation.

Generator Air Cooler. Windings are cooled by air circulating through a closed circuit from the generator housing through the shell of an air cooler and return. Condenser circulating water is passed through the air cooler tubes to remove heat from the circulating air.

1. Periodically check the surface air cooler tubes for leaks. To locate a leaking tube, remove the two water boxes of the suspected section and apply water or air under pressure to each tube by plugging one end of the tube and inserting a fitted air or water nozzle to the other end of the tube. The nozzle should be provided with a gage and valve so that as soon as the tube is under static pressure, the supply (air or water) can be shut off and any reduction in pressure noted on the gage. As a temporary expedient, plug both ends of leaking tubes.

   Leaks coming from rolled joints in the tube sheet may be located by partially removing the section from beneath the machine. With the water boxes in place, water pressure that exceeds working pressure by 10 to 15 pounds should be applied to the section. By means of an inspection light suitably located behind the tube sheet, leaking joints can be located. Tubes that have faulty joints should be re-expanded.

   If enough tubes are or become faulty and cooling is impaired, it will be necessary to replace them, as outlined in the Manufacturer's Literature.

Prevention of Moisture Condensation. Condensation in the air-cooling system must be prevented in order to avoid the possibility of water being carried into the generator and possibly depositing on windings. The temperature at which moisture will condense depends on moisture content in the air. Since it is almost impossible to maintain airtight joints in duct work because of internal and external pressures, a continued leakage of air into and out of ducts will occur. The moisture content inside the ducts will be determined by the moisture content of air in the room. A curve should be plotted to show the limits of moisture content that will result in condensation inside the ducts. As the air temperature approaches the limits at which condensation will occur, the flow of water to cooler should be reduced. This will allow the temperature of the generator air coolant to increase, thereby allowing the air to hold the moisture content.

Specifications:

Type - AT1-HL 6 poles
Kva - 2500 Kw - 2000
Rpm - 1200
Voltage - 4160 volts
Maximum continuous current - 347 amps

Hagan Instrumentation. The instruments listed below should require no routine maintenance other than normal weekly inspection and cleaning.

Hagan Drum Level Controller,
Hagan Feedwater Controller,
Hagan Flow Balancing Relay,
Hagan Manual Control Station,
M-H Dial Indicating Gauge,
Ashcroft 6-inch Gauge,
M-H Manual Loading Station
M-H Pressuretrol, and
Automatic Switch Company Solenoid Valves

Housekeeping

1. Good housekeeping is an essential part of the safety program.

2. Do not place materials and tools where they can be stumbled over or where they can fall on someone.

3. Material must be piled neatly and safely.

4. Greasy waste or rags must be placed in approved waste cans.

5. Grease or oil spilled on any floor must be cleaned up at once.

6. At the end of the day's work, all material and tools must be cleared away and stored in a safe place.

Hydrogen Gas Pressure Regulators (PCV-8, PCV-9A, and PCV-10)

Manufacturer's Literature. (PCV-8 and PCV-9A) Harris Calorific Company Instruction Sheet for No. 92-SC-K Hydrogen Regulator.

(PCV-10) Harris Calorific Company Instruction Sheet for No. 40-H Line Regulators.

If working pressure creeps (slowly increases several psi beyond the working pressure) or if frequent or continued discharge of gas from the safety valve develops, replace the regulator with a new unit. Refer to the Removal and Replacement section of this manual for detailed instructions.

WARNING

Use only non-sparking tools. Keep flames away from areas where hydrogen is in use.

Removal Procedure. To remove pressure regulator, proceed as follows:

1. Isolate regulator PCV-9 or PCV-9A by closing the cylinder valves and valves H-1 and H-2. See "Isolation" in this section of the manual.

2. Isolate regulator PCV-10 by closing valves H-4 and H-6. Tag the valves.

3. Unfasten piping connections.

4. Remove the regulator.

Inspection. See Section 2.

INSTRUMENTATION

In order to ensure continuous trouble-free operation of the APPR-1, regular routine maintenance will be required on the instruments. During normal operation, the major portion of the routine maintenance of instruments is cleaning. All instruments should be kept free of dust and dirt. It is recommended that the interior of all cases, panels, and cubicles be cleaned with an air blower weekly.

All drip wells in the air system should be blown down weekly or as found to be necessary. Maintenance operations should be closely co-ordinated with the chief operator on duty. Consult table 3-1 before servicing any instrument and be sure that plant operations will not be interrupted when the instrument is taken out of service. Check all air piping annually for leaks.

Service Notes

Note 1. These components may be serviced only after certain conditions have been met to prevent a scram and/or electrical interlocks have been taken into consideration.

Note 2. Servicing these components may cause an audible and visual alarm on the 72-point annunciator. The alarm can be silenced by operating the acknowledge switch on the annunciator panel.

Note 3. These components can only be serviced during shutdown because of their physical location and/or function.

Note 4. These components may be serviced if the process they control is transferred from automatic to manual control.

Note 5. These components may be serviced if the air signal line to them is not opened to atmosphere.

Note 6. These components may be serviced during normal operation.

The following is the key for work to be performed on components:

a. Clean unit interior and mechanism.

b. Check adjustment (gain) of amplifier.

c. Clean interior, mechanism, and pens.

d. Lubricate mechanism.

e. Check electron tubes.

f. Clean type face and reink ink pads.

g. Calibrate and adjust component (instrument).

h. Check, clean, and adjust control and alarm contacts.

i. Clean restrictions, nozzle, and orifices.

j. Test and replace electronic, electrical, and mechanical components.

Nuclear Instrumentation

Component	Weekly W	Monthly M	Quarterly Q	Annually A	Service Note
1. WL-6307 Proportional Counter				a, j	3
2. A1A BF_3 Proportional Counter Pre-Amp				a,b,e,g,j	3
3. A1D Linear Amplifier	a	b,g,h	c	j	1,2
4. Log Count Rate Amplifier	a	b,g,h	c,e	j	1,2
5. Log Count Rate Scaler	a	b,g,h	c,e	j	6
6. Log Count Rate Recorder Elect. Strip Chart Pot.	a, b	d	e,f,g,h,i	j	2
7. WL-6376 Fission Proportional Counter				a,j	3
8. A1A Fission Proportional Counter Pre-Amp				a,b,e,g,j	3
9. A1D Linear Amplifier	a	b,g,h	c,e	j	1,2
10. Log Count Rate Amplifier	a	b,g,h	c,e	j	1,2
11. Log Count Rate Scaler	a	b,g,h	c,e	j	6
12. Log Count Rate Recorder Elect. Strip Chart Pot.	a,b	d	e,f,g,h,i	j	2
13. WL-6377 Ion Chamber				a,j	3

	Component	W	M	Q	A	Service Note
14.	Power Supply, Linear Power Chamber	a		e,g	j	1,2,4
15.	Range Selector Switch, Linear Power				a,j	6
16.	Linear Power Recorder Elect. Strip Chart Pot.	a,b	c,d	e,f,g	j	6
17.	Servo Set Point Control Assembly	a		g	j	6
18.	Regulating Rod Servo Control Unit	a		e,g	j	6
19.	Junction Box for Linear Power Recorder-Amplifier	a		e,g	j	6
20.	Indication of Servo Deviation	a			j	6
21.	Linear Power Amplifier	a,b		e,g	j	6
22.	Power Supply, Voltage Regulator, Log N & Period		a	g		1,2,4
23.	Power Supply, Log N & Period Chamber	a		e,g	j	1,2,4
24.	WL-6377 Ion Chamber				a,j	3
25.	Log N & Period Amplifier	a,b		e,g.h	j	1,2 (cannot disconnect without scram)
26.	Log N Recorder Elect. Strip Chart Pot.	a,b	c,d	e,f,g,h	j	1,2
27.	Period Recorder Elect. Strip Chart Pot.	a,b	c,d	e,f,g,h	j	1,2
28.	WL-6377 Ion Chamber (3)				a,j	3
29.	Safety Amplifier (2) Paired (A and B)	a,b		e,g,h	j	1,2 (cannot disconnect without scram)
30.	Power Level Recorder Elect. Strip Chart Pot. 3 Point Recorder	a,b	c,d	e,f,g,h	j	6

	Component	W	M	Q	A	Service Note
31.	Radiation Monitor Recorder Elect. Strip Chart Pot. 8 Point Record	a,b	c,d	e,f,g,h	j	2
32.	Radiation Monitor Relay (3)			h	j	1,2
33.	Radiation Diversion Valve (2)			i,h		1,2
34.	Radiation Monitor Control Unit	a,b		e,g,h	j	2 check batter-ies
35.	Remote Radiation Units					
	Control Room RM-7			g,h		2
	Vapor Container RM-8			g	g,h	3
	Vapor Container Entrance RM-11			g,h		2
	Spent Fuel Pit RM-9			g,h		2
	Demineralizer Room RM-10			g,h		2
	Steam Gen Blowdown RM-5			g,h		2
	Condensate RM-4			g,h		2
	Pri Coolant Blowdown RM-1			g,h		2
	Pri Coolant Blowdown Cooling Water RM-2			g,h		2
36.	Stack Air Monitor RM-3	a,b		e,g,h	j	2
37.	Seal Pit Monitor RM-6	a,b		e,g,h	j	2
38.	Mobile Air Monitor	a,b		e,g,h	j	6
39.	Mobile Air Monitor Recorder		c,d	e,f	j	6
40.	Landsverk Charger-Reader	a,b		e,g	j	6
41.	Scaler, Scintillation Head	a,b		e,g	j	6
42.	Scintillation Head	a		c,g,j		6
43.	Scaler, Proportional Counter	a,b		e,g	j	6
44.	Proportional Counter Converter	a,b	c	e,h,j		6
45.	Geiger Counter (2)	a		e,g,j		6
46.	Alpha Survey Meter	a		e,g,j		6

Component	W	M	Q	A	Service Note
47. Cutie Pie Survey Meter	a		e,g,j		6
48. Juno Survey Meter	a		e,g,j		6
49. Alpha Neutron Survey Meter	a		e,g,j		6
50. Neutron Probe	a		e,g,j		6
51. Alpha-Probe	a		e,g,j		6
Primary System Instrumentation					
1. Vapor Container Pressure Detector PR4-1				a,g,j	3
2. Vapor Container Pressure Transmitter PR-4-2	a,b		e,g,i	j	6
3. Vapor Container Pressure Recorder Tel-O-Set PR4-3	a	i	g	j	6
4. Misc. Temp. Recorder TR-200 Elect. Strip Chart Pot 12 Point Record	a,b	d	e,g	j	6
5. Vapor in Vapor Container Detector TR200-208				j	3
6. Pri Coolant Blowdown Water to Demineralizer Detector TR200-209				j	6
7. Vapor Container Pressure Coincidence Pressure Switch PS-15, PS-16, PS-17, 0-40				g,h,j	3
8. Vapor Container Sump Level Switch LS-10				g,h,j	3
9. Inner Shield Tank Level Sw. LS-11				g,h,j	3
10. Inner Shield Tank Press. Sw. PS-30 0-18				g,h,j	3
11. Outer Shield Tank Level Sw. LS-12				g,h,j	3

	Component	W	M	Q	A	Service Note
12.	Outer Shield Tank Press. Sw. PS-31 0-18				g,h,j	3
13.	Vapor Container Manhole Level Switch LS-5				g,h,j	6
14.	Pri Coolant Flow Detector FR1-1				j	3
15.	Pri Coolant Flow Transmitter FR1-2	a		b,d,e,i	j	2
16.	Pri Coolant Flow Recorder FR1-3 Tel-O-Set	a	i	g	j	5
17.	Pri Coolant Flow Alarm FR1-4			a,h	j	5
18.	Pri Coolant Flow Scram Detector FI1-1				j	3
19.	Pri Coolant Flow Scram Rec-Relay FI1-2	a		b,d,e	j	1
20.	Pri Coolant Blowdown Flow FR2-1			a,g,i	j	6
21.	Pri Coolant Blowdown Flow Recorder FR2-2 Tel-O-Set	a	i	g	j	6
22.	Air Supply Regulator to Flow Transmitter FR2-3		a	i	j	6
23.	Regulator Indicator FR2-4				g	6
24.	Pri Coolant Pump Cooling Flow F1C-5				g	1
25.	Hot Waste Storage Tank Level L1-4				g,h,i,j	3
26.	Air Supply Regulator to Level Transmitter L1-4				a,i,j	3
27.	Hot Waste Storage Tank Level Indicator				a,j	6
28.	Hot Waste Storage Tank Level-Pump Permissive Pressure-Switch PS-				a,g,j	6
29.	Hot Waste Storage Tank Low Pressure Sw. PS-20 30-0-50				a,g,j	6

Component	W	M	Q	A	Service Note
30. Hot Waste Storage Tank High Pressure Sw. PS-19 0-60				a,g,j	6
31. Hot Waste Pit High Level Switch LS-9				a,g,j	3
32. Seal Leak Off Level Switches LS-2, LS-4, 8L, 8H				a,g,j	3
33. Pressurizer Level Detector LRC7-1				g,j	3
34. Pressurizer Level Transmitter LRC7-2				e,g,h,i,j	1,3
35. Pressurizer High and Low Level Alarm LRC7-3, 4				h,j	1,2,5
36. Pressurizer Level Recorder LRC7-7	a	i	g	j	5
37. Pressurizer Level Reversing Relay				i,g,j	4,5
38. Pri Make-Up Tank Level LIC8-1		a	g,i	j	2
39. Air Supply Regulator LIC8-5	a		i	j	2,4
40. Regulated Air Indicator LIC8-6		a		j	6
41. Pri Make-Up Tank Pressure Indicator PI-25 0-30		a	g	j	5,2
42. Pri Make-Up Tank High and Low Level Alarm LIC8-2, 3			h	j	2,4
43. Pri Make-Up Tank Level Indicator LIC8-4		a		j	5
44. Pri Make-Up Tank Level Controller Tel-O-Set LIC8-8	a	i	g	j	4
45. Pressurizer Pressure Detector PRC3-1				g,j	3
46. Pressurizer Pressure Transmitter PRC3-3			a	b,e,g,i,j	1,3
47. Pressurizer Pressure High and Low Alarm PRC 3-5, 6			h	j	2

Component	W	M	Q	A	Service Note
48. Pressurizer Pressure Recorder Tel-O-Set PRC3-7 (17)	a	i	g	j	5
49. Hydrogen to Seal Leak Off Tank PCV-10				g,i,j	3
50. Seal Leakage Hydrogen Trip Valve TV-10				g,i,j	3
51. Hydrogen to PC Make-Up Tank PCV-9				g,i,j	3
52. Pri Coolant Blowdown Pressure PIC5-1		a	g,i	j	1,2
53. Pri Coolant Blowdown Indicator (local) PIC5-5					
54. Pri Coolant Blowdown Pressure Indicator Tel-O-Set PIC5-2	a	i	g	j	5
55. Pri Coolant Blowdown Pressure Alarm and Interlock PIC5-3, 4			h	j	1,2
56. Outlet Coolant Temp. from Reactor and Steam Gen. Recorder TR-300 Elect. Strip Chart Pot. 2 Pen Record	a,b	c,d	e,f,g	j	6
57. Detector Coolant Leaving Reactor, Coolant Leaving Steam Gen. TR300-301, TR300-302a, TR300-302b				j	3
58. Temperature Difference Coolant Entering and Leaving Reactor TR400-401, TR400-402				j	3
59. ΔT Reactor Transmitter Elect. Cir. Chart Pot. with Integrator TR400-403	a,b	c,d	e,f,g,i	j	1
60. ΔT Reactor Recorder Tel-O-Set TR400-404	a	i	g	j	5
61. Detector Dead Leg Temp. Pri Coolant Pumps TIC500-501, 502				j	3

	Component	W	M	Q	A	Service Note
62.	Dead Leg Temp. Transmitter Elect. Cir. Chart TIC500-503	a,b	c,d	e,f,g,i	j	1
63.	Dead Leg Temp. Indicator Tel-O-Set TIC500-504	a	i	g	j	6
64.	Pri Coolant Temp. Scram Detector TR600-1				j	3
65.	Pri Coolant Temp. Scram Elect. Cir. Chart Pot. TIC-600-2		a,b	e,g	j	1
66.	Pri Coolant Blowdown MO-1				g,i,j	3
67.	Control for MO-1				h,j	3
68.	Pri Coolant Flow Integrator		a,c	d,e,g,h,i	j	6
69.	Misc. Temp. Indicator Elect. Precision Indicator (24P) TI-1	a,b	d	e,g	j	6
1 & 24	Pressurizer Dome				j	3
2	PC Pump #1				j	3
3	PC Pump #2				j	3
4	Side of reactor core					
5	Side of reactor core					
6	3" outside of reactor					
7	3" outside of reactor					
8	3" outside of reactor					
9	3" outside of reactor					
10	3" outside of reactor					
11	6" below reactor					
12	3.5" below reactor					
13	Rod drive barrier					
14	Gamma heating, reactor					

	Component	W	M	Q	A	Service Note
15	Gamma heating, reactor					
16	Gamma heating, reactor					
17	Y valve line					
18	Y valve line					
19	Spare					
20	Spare					
21	Spare					
22	Spare					
23	Reactor outlet					
70.	Hot Waste Tank Temperature TI-2					3
71.	Conductivity Recorder Elect. Strip Chart Pot. 6 Point Record CR-1	a,b	c,d	e,f,g,h,i	j	2
72.	Pri Coolant to Demin. Cond. Detector CR-104				j	6
73.	Pri Coolant from Demin. Cond. Detector CR-105				j	6
74.	Hot Waste Storage Tank Vent CV-1			g,i	j	6
75.	Control for CV-1			g,i	j	6
76.	Pri Make-Up Level Control Valve LCV-8			g,i	j	4
77.	Pri Coolant Blowdown Trip Valve TV-8				g,i,j	3
78.	Pri Coolant Blowdown Cooling Water Trip Valve TV-7				g,i,j	3
79.	Pressurizer Gross Heater Bus Press. Switch PS-9, PS-10, PS-11 0-2500				g,h,j	3

Component	W	M	Q	A	Service Note
80. Pressurizer Pressure High Press. Scram Press. Sw. PS-27, PS-28, PS-29 0-2500				g,h,j	3
81. Pressurizer Pressure Low Press. Scram Press. Sw. PS-12, PS-13, PS-14 0-2500				g,h,j	3
82. Hot Waste Storage Tank Pressure Indicator PI-28 0-60				g,j	6
83. Pressurizer Instr. Test Pressure Indicator PI-39 0-2000				g,j	6
84. Control Rod Indicator and Control System				a,h,j	3
85. Motor-Generator 400 cycles		a	h	j	3
86. Pressurizer Heater Control Switches and Relays				j	3
87. Control and Interlock Relays				h,j	3
88. Graphic Panel, Valve and Pump Signal Light Test Circuit, Sw, and Relays	a		h	j	6 (3)

Secondary System Instrumentation

A. Pressure Indicators

Component	W	M	Q	A	Service Note
1. Steam from Gen. to Turbine PI-1 0-600			g		6
2. Steam Inlet to Turbine PI-2 0-400			g		6
3. Steam to Air Ejector PI-3 0-400			g		6
4. Steam to Evaporator PI-4 0-400			g		6
5. Vapor from Evaporator PI-5 30-0-30			g		6
6. Extract Steam, Turbine to FW Heater PI-6 30-0-30			g		6

Component	W	M	Q	A	Service Note
7. Condenser Shell PI-7 30-0-15			g		6
8. Steam to Turbine Boiler Feed Pump PI-8 0-600			g		6
9. Exhaust Steam from Turbine BF Pump PI-9 30-0-15			g		6
10. Discharge Circulating Water Pumps PI-10 2 ea 0-30			g		6
11. Circ. Water to Condenser PI-11 2 ea 30-0-15			g		6
12. Circ. Water from Condenser PI-12 2 ea 30-0-15			g		6
13. Discharge, Cooling Water Booster Pumps PI-13 2 ea 0-60			g		6
14. Discharge, Condensate Recirc. Pumps PI-14 2 ea 0-160			g		6
15. C.W. Inlet to Turbine Oil Coolers PI-15 0-30			g		6
16. C.W. Outlet from Turbine Oil Coolers 2 ea PI-16 30-0-30			g		6
17. Suction, Boiler Feed Pumps PI-17 30-0-15			g		6
18. Discharge, Boiler Feed Pumps PI-18 3 ea 0-800			g		6
19. Suction, Condensate Recirc. Pumps PI-10 30-0-15			g		6
20. Discharge, Blowdown Cooling Water Pumps 2 ea 0-100			g		6
21. Outlet, Generator Air Cooler PI-21 30-0-30			g		6
22. Discharge, PC Fill Pump PI-22 0-60			g		6
23. Discharge, Spent Fuel Recirc. Pump PI-24 ________			g		6

Component	W	M	Q	A	Service Note
24. Domestic Water to Service Water Tank PI-26 0-100			g		6
25. Steam Dump to Condenser PI-27 0-600			g		6
26. Stem of Chlorine Control Valve PI-29 ______			g		6
27. Chlorinizer Supply Line PI-30			g		6
28. Chlorine Gas Manifold PI-31			g		6
29. Diaphragm of Chlorine Press. Control Valve PI-32			g		6
30. Chlorinizer Water Injection Pump Discharge PI-33			g		6
31. Chlorine Injection PI-34			g		6
32. Turbine Inlet PI-35 0-400			g		6
33. Turbine 1st Stage PI-36 0-200			g		6
34. Turbine Exhaust PI-37 30-0-30			g		6
35. Discharge, Evap. Feed Pump PI-38 0-100			g		6
B. Pressure Switch					
1. Disc. Circulating Water Pumps PS-1 0-14			g,h		6
2. Disc. Cooling Water Booster Pumps PS-2 0-35			g,h		6
3. Disc. Boiler Feed Pumps PS-3 0-600			g,h		6
4. Disc. Condensate Recirc. Pumps PS-4 0-100			g,h		6
5. Disc. Blowdown Cooling Water Pumps PS-5 0-100			g,h		6
6. Disc. P.C. Make-Up Pumps PS-6 0-1500			g,h		6

Component	W	M	Q	A	Service Note
7. P.C. Make-Up Tank PS-7 0-60			g,h		6
8. Instrument Air Header PS-8 0-150			g,h		6
9. Instrument Air Receiver PS-18 0-150			g,h		6
10. Main Steam Line, High Press. Scram PS-24, 25, 26 0-2500			g,h		6
11. Water Supply to Chlorine Ejector PS-21 20-80			g,h		6
12. Chlorine Supply Line PS-22 20-80			g,h		6
13. Chlorine Control Valve PS-23 0.2-15			g,h		6
C. Industrial Thermometer					
1. Steam from Boiler to Turbine 1T-1 100-550				g	6
2. Steam at Inlet to Turbine 1T-2 100-550				g	6
3. Vapor from Evaporator 1T-3 30-300				g	6
4. Extract Steam from Turbine to F.W. Heater 1T-4 30-300				g	6
5. Drain from F.W. Heater 1T-5 30-300				g	6
6. Circ. Water to Condenser 2 ea 1T-6 0-100				g	6
7. Circ. Water from Condenser 2 ea 1T-7 0-100				g	6
8. Feed Water to F.W. Heater before Ejector 1T-8 30-180				g	6
9. Feed Water to F.W. Heater after Ejector 1T-9 30-180				g	6
10. Feed Water from F.W. Heater 1T-10 30-300				g	6

Component	W	M	Q	A	Service Note
11. Cooling Water to Gen. Air Cooler 1T-11 0-100				g	6
12. Cooling Water from Gen. Air Cooler 1T-12 0-100				g	6
13. C.W. Outlet from Turbine Oil Cooler 1T-13 2 ea 0-100				g	6
14. C.W. to Shield Tank Coil 1T-14 30-180				g	6
15. C.W. from Shield Tank to Condenser 1T-15 30-180				g	6
16. C.W. to Space Cooler 1T-16 0-100				g	6
17. C.W. from Space Cooler 1T-17 30-180				g	6
18. Outlet from P.C. Make-Up Tank 1T-20 30-180				g	6
D. Misc. Temp.					
1. Condenser Water Inlet TR200-201				j	6
2. Condenser Water Inlet TR200-202				j	6
3. Condenser Water Outlet TR200-203				j	6
4. Condenser Water Outlet TR200-204				j	6
5. Condensate from Condenser TR200-205				j	6
6. Feed Water from F.W. Heater TR200-206				j	6
E. Conductivity Cells					
1. Steam Gen. Blowdown CR-101				j	6
2. Boiler Feed Water CR-102				j	6
3. Condenser Hotwell CR-102 (4 ea)				j	6
4. Evaporator Blowdown (CR-102)				j	6

Component	W	M	Q	A	Service Note
F. Trip Valves					
1. Steam Gen. Drain Trip Valve TV-2				g,i,j	3
2. Steam Gen. Blowdown Trip Valve TV-5				g,i,j	3
3. Shield Cooling Return Trip Valve TV-6				g,i,j	3
4. Steam to Turbine B.F. Pump and Dump Trip Valve TV-9				g,i,j	3
G. Level Switch					
1. Condenser Hot Well LS-1H High-Level Switch, LS-1L Low-Level Switch			g,h		2
2. Evaporator LS-3H High-Level Switch LS-3L Low-Level Switch			g,h		2
3. Spent Fuel Pit (Tank) LS-6 Low-Level Switch			g,h		2
4. Feed Water Heater LS-7H High-Level Switch LS-7L Low-Level Switch			g,h		2
H. Miscellaneous					
1. Secondary Steam Flow Detector FRC1-3				i,j	3
2. Steam Flow Transmitter FRC1-1		a	c,g,i	j	4
3. Steam Flow Recorder Tel-O-Set Strip Chart FRC1-2	a	i	g	j	4
4. Pressure Regulator FRC1-4	a		i	j	4
5. Boiler Feed Water Flow Detector FRC2-1				i,j	3
6. Boiler Feed Water Flow Transmitter FRC2-2		a	c,g,i	j	4

Component	W	M	Q	A	Service Note
7. Boiler Feed Water Flow Recorder, Tel-O-Set FRC2-3	a	i	g	j	4
8. Feed Water Controller FRC2-4	a		g	j	4
9. Steam Gen. Blowdown Flow Detector FI2-1			g,i	j	4
10. Steam Gen. Blowdown Flow Indicator Tel-O-Set FI2-2	a	i	g	j	6
11. Steam Gen. Blowdown Flow Control FI2-3			g,i	j	4
12. Air Supply Indicator FI2-5				g	6
13. Air Supply Regulator FI2-4	a		i	j	6
14. Chlorine Gas Flow FI3				g,i	3
15. Chlorinizer Tray Float LCV-9				g	3
16. Lab. Waste Tank Level LI5 2 ea				g	6
17. Evaporator Level LC-5				g	4
18. Condenser Low Level LC-3			g,i	j	4
19. Condenser High Level LC-2			g,i	j	4
20. Feed Water Heater Level LC-1			g,i	j	4
21. Steam Gen. Level Detector LRC4-1				g	3
22. Steam Gen. Level Transmitter LRC4-2	a,b			g,i,e	3
23. Steam Gen. High and Low Level Alarm LRC4-4, 5			h		2,4
24. Steam Gen. Level Recorder Tel-O-Set LRC4-7	a	i	g	j	5
25. Steam Gen. Level Transmitter LRC4-8	a,b		g,i		2,4
26. Drum Level Controller LRC4-9	a		g	j	4

Component	W	M	Q	A	Service Note
27. Flow Balancing Relay LRC4-10	a		g	j	4
28. Manual-Auto Control LRC4-11	a		g,i	j	4,5
29. Pressure Regulator LRC4-12a, 12b	a		i	j	2,4
30. Service Water Tank Level LIC6-1		a	g,i		2,4
31. Regulator, Air Supply to LIC6-1, LIC6-5	a		i	j	2,4
32. Indicator, Regulated Air Supply LIC6-6		a		j	5
33. Service Water Tank Level Indicator LIC6-7		a		j	5
34. Service Water Tank High and Low Level Alarm LIC6-2, 3			h	j	2,4
35. Service Water Tank Indicator Tel-O-Set LIC6-4	a	i	g	j	5
36. Service Water Tank Level Control LIC6-8 Tel-O-Set Controller	a	i	g	j	4
37. Distilled Water Tank Level Detector LI2-1		a	g,i	j	2,4
38. Distilled Water Tank Level Indicator Tel-O-Set LI2-4	a	i	g	j	2
39. Distilled Water Tank Level Indicator LI2-7		a		j	5
40. Distilled Water Tank Level High and Low Level Alarm LI2-2, 3			h	j	2
41. Regulator, Air Supply LI2-5		a		j	2
42. Indicator, Air Regulated LI2-6		a		j	2
43. Feed Water Heater Level Gage Glass LG-1				j	6
44. Condenser Hot Well Level Gage Glass LG-2				j	6

	Component	W	M	Q	A	Service Note
45.	Evaporator Level Gage Glass LG-3				j	6
46.	Vapor Container Manhole Level Gage Glass LG-4				j	6
47.	Steam Pressure Transmitter PR1-1		a,d	e,g,i	j	2
48.	Steam Pressure Alarm PR1-2			h	j	2
49.	Steam Pressure Recorder Tel-O-Set PR1-3	a	i	g	j	5
50.	Condenser Pressure Transmitter PR2-1		a	g,i	j	5
51.	Air Supply Regulator PR2-3	a		i	j	6
52.	Regulated Air Indicator PR2-4		a		j	6
53.	Condenser Pressure Recorder Tel-O-Set PR2-2	a	i	g	j	6
54.	Initial Steam Pressure Controller PC-6		a		g,i,j	3
55.	Vapor from Evaporator PCV-2			g,i	j	6
56.	B.F. Pump Turbine Exhaust Steam PCV-3			g,i	j	6
57.	Condensate Secondary Supply to Shield Tank Cooling PCV-4			g,i	j	6
58.	Shield Tank Cooling Return to Condenser PCV-5			g,i	j	1,3
59.	Gland Steam Leak-off PCV-8				g,i,j	3
60.	Steam to Turbine Pressure Controller		a		g,i,j	3
61.	Regulator, Air Supply		a		j	3
62.	Steam Trip and Regulating Valves PCV1-1, PCV1-2		a		g,i,j	3
63.	Valve Positioners (2 ea)		a		j	3

	Component	W	M	Q	A	Service Note
64.	Regulator, Air Supply for PCV1-1, PCV1-2 (2 ea)		a		j	3
65.	Solenoid Valves (2 ea)		a		j	3
66.	Limit Switches (2 ea)		a		g,h,j	3
67.	Chlorine Gas PCV-11				j	(3)
68.	Water to PCV-11, PCV-12				j	(3)
69.	Water to Chlorinizer PCV-13				j	(3)
70.	Steam to Air Ejector PCV-14				j	3
71.	Air Ejector, Air Flow to Atmosphere				j	3
72.	Hydrogen for Instrument Testing PCV-15					
73.	Steam Temperature TR1-1				j	2
74.	Steam Temp. Transmitter TR1-2		a,b	e,g,i	j	1,2
75.	Steam Temp. Recorder Tel-O-Set TR1-4	a	i	g	j	1,2,5
76.	Steam, High-Temp. Scram TR1-3			h		1,2,3
77.	Set Point, Air Ejector Min. Flow TC6-3			g,i	j	4
78.	ΔT, Air Ejector TC6-1, 2				j	4
79.	ΔT, Air Ejector Transmitter TC6-4		a,d	e,g,i	j	4
80.	Regulator, Air Supply TC6-6	a		i	j	4
81.	Regulated Air Indicator TC6-7		a		j	4
82.	Air Ejector Temp. Controller Tel-O-Set TC6-5	a	i	g	j	4
83.	Temp. Control Valve TCV-6			g,i	j	6
84.	Control Air Indicator for TCV-6				j	6

Component	W	M	Q	A	Service Note
85. Steam Gen. Blowdown Valve FCV-1			g,i	j	6
86. Steam Dump to Condenser FCV-3			g,i	j	3
87. Control for FCV-3			g,i	j	6
88. Feed Water Flow Control Valve LCV-4			g,i	j	4 (3)
89. Systems Parameter Indicator			g	j	6
90. Systems Parameter Switch and Solenoids				j	3
91. 72 Point Annunciator, Control Relays, System Parameter Relays and Contacts	a,h			j	(3)
92. Battery Charger	a		h	j	6
93. Electrical Switchgear Control and Interlock System				h,j	3
94. Fort Belvoir Load Telemeter Circuit, Amplifier, Relays				h,j	2
95. Trip Valve Cubicle, Control and Indicator System				h,j	3
96. Evaporator Blowdown Flow Indicator			a		6
97. Intercommunication System, Handsets, Speakers, Amplifiers, and Controls		a,b	e,g,h,j		6
98. Television System, Cable System, Amplifier, Camera, Camera Control, and Monitors				a,b,e,h,j	6

Isolation and Tagging

Isolation. Except in an emergency, maintenance personnel will not switch, isolate, or remove any equipment from service without first notifying the operator in the main control room and securing the necessary permission. A suitable entry recording the isolation will be made in the operating log. In addition, the VEPCO operator of the electrical system serving ERDL must be notified before any switching is done on the 4160 Volt System. This is necessary to enable VEPCO to institute prearranged emergency procedures in case circuit breakers are tripped.

After isolating electrical circuits, use a voltmeter and make sure that the isolated circuits are de-energized. When using the voltmeter to check a-c voltages, check between each line and ground and line to line. When checking three-phase voltages, check all three phase combinations; i.e., a to b, b to c, and c to a; also check between each phase and ground. To prevent injury to personnel and damage to equipment, make sure the capacity of the voltmeter is adequate for the intended use.

Tagging. All equipment that is being isolated must be tagged. The person in charge of the work must check each workman before starting work to insure that each man knows what equipment is in operation or energized and what equipment is isolated.

When any line, feeder, circuit, switch, or equipment is taken out of service for installation, inspection, repair, or maintenance work, the Supervisor must place tags on all main or control switches, valves, and other points established at each post to insure that equipment remains de-energized until released. The tags must be filled out completely to indicate their location; the name of person requesting the holding of the line, feeder, circuit, valve, or apparatus; the date and hour the tags were placed; and the name of the person placing or removing the tags. Tags must not be transferred from one person to another or removed except by the person who installed them or the Shift Engineer.

The tag is attached to operating handles and remote control points in the control room, and at the disconnect switches, control boxes, or valves. Tags shall be constructed of reinforced paper stock.

Level Controllers

Manufacturer's Literature. Refer to the following Fisher Governor Company publications:

Instructions, Fisher Level-Trol, Series 2500-249 and 259, Form No. 1013.

Instructions for Installing, Adjusting and Operating Self Contained Pressure Reducing Valve, Type 67 Series, Form No. 769B.

Instructions for Installation, Operation and Maintenance of Type 667 Diaphragm Control Valves, Form No. 1203.

Instructions for Installation, Operation and Maintenance of Types 657 and 657R Diaphragm Control Valves, Form No. 1204.

Instructions for Installing, Adjusting and Operating Fisher Figures 49M and 49MP Explosion Proof Mercury Tube Switches, Form No. 484B.

Maintenance Adjustments. Faulty operation of a controller may be due to poor adjustment or defects of the Level-Trol unit, the pressure reducing valve, or the control valve. If the unit is equipped with a mercury switch alarm, poor adjustment or defects of the switch may tend to conceal faulty operation of the other units.

Faulty mercury switch operation may be caused by a cracked mercury tube, a misaligned mercury tube holder, or a defective actuating bellows. A cracked mercury tube will admit air which will cloud the mercury and render the switch ineffective. In such a case, the mercury tube must be replaced. A misaligned mercury tube holder will result in faulty electrical contact timing with respect to level changes. The tube position may be adjusted by loosening the adjusting screw on the bottom of the holder, rotating the tube to the correct position, and retightening the screw. A defective actuating bellows is indicated if no other source of trouble can be assigned. If inspection of the bellows shows a leak or permanent deformation, replace the bellows. Refer to detail (Dwg. No. CB9794) on Instructions for Installing, Adjusting and Operating Fisher Figures 49M and 49MP Explosion Proof Mercury Tube Switches, Form No. 484B.

Supply pressure to the Level-Trol units is controlled by a pressure-reducing valve. If this pressure is not steady at 20 psig and no reason exists to suspect the accuracy of the supply pressure gage, the pressure-reducing valve should be adjusted as described in Form No. 769B.

If the control valve is not functioning properly, first check the lines and fittings for leaks. If leaks are not indicated, readjustment of the valve stem length may remedy the difficulty. This procedure is described in Form No. 1203 and Form No. 1204. (If the valve stem does not move freely in response to diaphragm motion, check stuffing box tightness.) If this condition is not corrected, dismantle and check the inner valve and valve guides, stuffing box tightness, and diaphragm condition. Refer to Form No. 1203 and Form No. 1204.

Faulty Level-Trol unit operation may be caused by maladjustment of the proportional band setting or of the level adjustment dial, a defective diaphragm, a plugged air pressure line, a defective torque tube, a defective float, or a sticking inner valve. Refer to pages 6 and 9 of Form 1013 for corrective procedures.

VALVE SETTINGS FOR LEVEL CONTROL BYPASSING

LEVEL CONTROL VALVE	OPEN BYPASS VALVE	CLOSE VALVES
LCV/1, Feedwater heater level	Shutdown Feedwater Heater, bypass heater by opening valve BF-16	
LCV/2, Condenser hot well high level	CO-45	CO-43, CO-44
LCV/3, Condenser hot well low level	CO-4	CO-2, CO-3
LCV/5, Evaporator level	EF-8	EF-6, EF-7

Level Switches

Manufacturer's Literature. Magnetrol Operating and Maintenance Instructions Form M-47.

Preventive Maintenance. Preventive maintenance is of key importance to a safety device. This maintenance includes keeping the unit clean, checking mercury switch condition, and checking wiring.

Keep the float chamber of the switch clean by blowing down the fluid in the chamber daily. At six-month intervals, visually inspect the inside of the float chamber and the float for dirt accumulation and corrosion.

Visually check mercury switches every month. If mercury appears cloudy, the switch tube is cracked. Under these circumstances the switch must be replaced. Check incoming wire insulation monthly. Replace all wires with brittle insulation. Check for loose connections.

Lighting System Voltage Regulator. The procedure to be followed in removing the lighting system voltage regulator is outlined below:

1. De-energize the voltage regulator.

2. Disconnect all external wiring connections, observing the caution notice of the preceding paragraph.

3. Remove the mounting bolts.

4. Remove the voltage regulator.

Relays. To remove a relay, perform the steps outlined below:

1. De-energize the relay.

2. Remove the nuts on the mounting studs behind the mounting surface.

3. Remove all external wiring connections.

NOTE

Remove external wiring connections by heating the solder joint and working the wire free or cutting the wire as close to the solder joint as possible.

4. Remove the relay.

Lubrication Schedule. See Section 4 of this manual.

Main Air Compressor

Manufacturer's Literature. Ingersoll-Rand, "Instruction Book and Duplicate Parts List for Ingersoll-Rand Class ER-1-NL-1 Straight-Line Horizontal Heavy-Duty Compressors, Form P-3020."

Lubrication. Lubricating oil for the crankcase must be a highly refined petroleum oil as recommended by a reliable oil company. Recommended specifications are found on page 1, section 3B of the manufacturer's literature. Check oil level every eight hours of operation.

Carbon rings supply the only lubrication for the cylinder. No further lubrication is required.

Piston Clearance Adjustment. Clearance between piston and cylinder wall should be checked every 500 hours of operation. This is accomplished by removing the head and checking the clearance between the piston and cylinder wall with feeler gauges. Minimum clearance is 0.015 inch on bottom and 0.064 inch on top.

To restore the original clearance to the cylinder, loosen the piston rod lock nut at the crosshead and turn the piston rod 90 degrees in a clockwise direction (when facing the frame end of the compressor), placing the figure 2 on top. For the next adjustment, loosen the piston rod locknut and turn the piston rod 180 degrees in a counterclockwise direction, placing the figure 3 at the top. For the last adjustment, loosen the piston rod locknut and turn the piston rod 90 degrees in a counterclockwise direction, placing the figure 4 on the top. When maximum wear has taken place in position 4, the piston wearing rings must be replaced. After clearance adjustment between piston and cylinder wall has been made, clearance between piston and head at maximum piston travel, forward and rear positions, should be checked before operating the compressor. Minimum clearance is 3/32 inch on front end, and 5/64 inch on drive end.

NOTE

After adjustment, turn the compressor one revolution by hand before starting the motor.

Alignment. Check that the motor sheave is aligned with the compressor sheave and that the shafts are parallel.

Belts. Refer to "Belt Drives" in this section of the manual for instructions on care and maintenance of belt drives.

After Cooler. Inspect tell-tale holes in the rubber packing rings for signs of water or air leakage. Should leakage occur, replace the rubber packing rings. For detailed instructions on disassembly of the after cooler, refer to the manufacturer's literature.

When disassembly is required, isolate cooler as follows:

1. Close after cooler air inlet valve CA-15 and tag.

2. Close after cooler air outlet valve CA-1 and tag.

3. Close condensate outlet valve CA-7.

4. Close valve BW-13 and tag.

5. Close valve BW-14 and tag.

6. Open valve CA-16.

7. Open valve BW-15 to drain the after cooler.

Electric Motor. Refer to "Electric Motors, Care of" in this section of this manual for instructions on care and cleaning of electric motors.

Main Steam Pressure Control Valve (TB/PCV/1-1 and TB/PCV/1-2, Figure 3-1)

Manufacturer's Literature. Mason-Neilan "Instructions No. 3002 - Air Operated Control Valves."

Packing. The packing gland should be kept firmly against the packing. Be sure that both ends of the flange exert equal pressure on the gland. To replace packing, valve must be disassembled. Refer to the manufacturer's literature for disassembly instructions. When adjusting the new packing, refer to "Packing" in this section of the manual for detailed instructions on packing adjustment.

Packing Box Lubricator. Keep the lubricator filled and turned in firmly but not too tightly. The lubricant is intended as an aid to the packing. Too little lubricant is preferable to too much.

Cleaning. During annual shutdowns, disassemble the valve and clean all parts thoroughly with a clean, soft cloth. For detailed disassembly instructions, refer to the manufacturer's literature under the heading, No. 138 Valves. Make sure that the valve seats are free of dirt and foreign matter. If the seats need grinding, grind only a small amount. Excessive grinding will not improve seating.

Meggering. See Meggering under "Electric Motors and Generators."

Motor Windings, Drying of. See Motor Windings, Drying of under "Electric Motors and Generators."

Motor Controllers

Cleaning. The controller should be inspected and cleaned at least once a year, depending upon conditions existing at place of usage and maintenance schedules. The removal of dust by blowing dry compressed air under 30 to 50 psig is one method of freeing controller from dust.

Do not use high-pressure air because it may drive metallic particles and dirt into insulation or lodge particles in moving parts. Additional cleaning may be obtained by wiping or washing with a safety-type cleaning fluid.

It may be necessary to dry out the controllers if excessive accumulation of moisture enters the controller. A slow gradual heat should be applied to controller for drying. Overheating could damage insulation.

Inspection. Inspection may indicate the necessity of redressing or polishing. This should be accomplished as outlined in the section on contacts.

Heater Element. If the controller does not operate properly (that is, will not trip out at about 125 percent of full load or trips out below full load), the heater element should be checked out and replaced if necessary.

If Motor Contactor Will Not Operate

(1) Check rest pushbutton.

(2) Check holding coil for loose contacts or burned out coil.

(3) Check heater strip.

(4) Check incoming and outgoing connections for voltage and open circuits.

(5) Check remote switches.

If major repairs are necessary or if adjustment requires removal, de-energize incoming leads before removing motor controller from mounting.

Multicontact Relays. Multicontact Auxiliary Relay Instructions GEH-1755B contains the details of construction, operation, and maintenance of these relays. An annual inspection and check of the pick-up voltage should be made. If the pick-up voltage is not correct. the relay must be adjusted. Refer to GEH-23988B, page 4.

Multi-Record Instruments

1. Re-ink the ink pads as necessary to maintain a legible record. Re-ink with colors as tabulated below:

3 Record		8 Record		6 & 12 Record		
Record No.	Color	Record No.	Color	Record No.		Color
1	Purple	1	Purple	1	1	Purple
2	Red	2	Red	2	2	Red
3	Black	3	Black	3	3	Black
		4	Blue	4	4	Blue
		5	Purple	5	5	Green
		6	Red	6	6	Brown
		7	Black		7	Purple
		8	Blue		8	Red
					9	Black
					10	Blue
					11	Green
					12	Brown

2. Clean the type face as often as required to maintain a legible record.

M-H Combination Air Filter and Pressure Regulator

1. Remove and clean the air filter weekly.

2. Check to see that the relief hole is free from dirt or other foreign material.

3. Check to see that the regulator is adjusted to supply 20 psi.

M-H Differential Converter with Pneumatic Transmission

1. Remove the pilot valve restriction screw each month and clean with a 0.005-inch diameter wire. Remove the filter and check its condition. Replace it if it is dirty. To check for proper operation of the nozzle, make sure that the restriction screw is seated firmly and lift the flapper off the nozzle; the transmitted pressure should drop below 1.0 psi. If the pressure does not drop, clean the nozzle. Refer to the manufacturer's literature for detailed instructions.

2. Check the damping dashpot oil level monthly. To do this, remove the dashpot from the instrument and check that the oil is 3/32 to 1/8 inch above the centering disk. If it is not, fill with 30,000 centistroke silicone oil.

3. Check the calibration monthly with calibration weights.

M-H Eccentric Scale Indicating Receiver with Pneumatic Transmission and Nonindicating Pneumatic Pressure Transmitter. Service the pilot relay and transmitter and flapper assembly, using the same procedures outlined for the M-H Single Point Electro-Pneumatic Transmitter.

M-H Electronik Precision Indicator, Circular Scale Electronik with Pneumatic Transmission, and Circular Chart Recording Potentiometer with Pneumatic Transmission

1. Oil the instrument monthly. Refer to the manufacturer's instruction book for detailed instructions.

2. If it becomes necessary to adjust the sensitivity because of sluggish instrument response, follow the procedure outlined for the M-H Electronik Strip Chart Potentiometer.

3. Replace the battery when it is no longer possible to standardize the instrument.

4. Clean the recording pen monthly in alcohol.

5. Remove the restriction screw from the pilot monthly and clean with a 0.005-inch diameter wire.

6. Remove the filter monthly and replace if it is dirty.

7. Clean the nozzle opening with a 0.012-inch diameter wire.

M-H Electronik Strip Chart Potentiometers

1. Oil the instrument monthly. Refer to manufacturer's literature for detailed instructions.

2. If it becomes necessary to adjust the sensitivity because of sluggish instrument response, use the following procedure. Insert a small screwdriver with a long shank through the hole in the top of the amplifier chassis. Turn the adjustment screw clockwise until the motor pinion begins to oscillate. Back off the adjustment screw until the oscillation stops. If no oscillation occurs as the adjustment screw is turned clockwise, the correct sensitivity setting is at the extreme clockwise position.

3. Replace the battery when the battery condition indicator is on the line marked RENEW.

4. On single record and two-pen instruments, check the ink supply daily, refill as needed, and clean the pens monthly in alcohol.

M-H Electro-Pneumatic Integrator

1. Check vacuum tube monthly and replace it if the tube tester shows it to be weak.

2. Every three months, disassemble the three removable gears from the counter gear train. Clean the gears, gear studs, teeth of motor pinion, and counter drive gear with an organic solvent. Oil the gear studs lightly with any high-grade light oil and then reassemble.

3. Clean and check the counter motor relay contacts every six months. Adjust contact arms if necessary to assure positive closing of the contacts.

M-H Pneumatic Valves

1. When putting the valve on stream, admit line pressure to the valve gradually, to give the control loop time to reach steady conditions.

2. Clean valve stem weekly to prevent an excess of dirt and grit from being carried into the packing.

3. Check weekly for air leaks.

4. Turn the lubricator screw weekly until a stiffening of resistance is felt.

M-H Single Point Electro-Pneumatic Transmitter

1. Oil instrument monthly. Refer to manufacturer's instruction book for detailed instructions.

2. Replace the battery when the battery indicator flag begins to show red.

3. If it becomes necessary to adjust the sensitivity because of sluggish instrument response, follow the procedure as outlined for the M-H Electronik Strip Chart Potentiometer.

4. Each month, remove the restriction screw from the pilot relay and clean the restriction, using a 0.005-inch diameter wire. Remove the filter and inspect the filter material. Replace if necessary.

5. Each month, clean polished surface of the flapper screw of the transmitter and flapper assembly. Clean the nozzle opening with a 0.012-inch diameter wire.

<u>M-H Tel-O-Set Controller</u>

1. Clean restrictions each month.

NOTE

The two-mode controller has three restrictions located in its base. Remove only one restriction at a time, perform the following steps, and replace it before removing the next restriction, to avoid interchanging the restrictions. To clean a restriction, remove the restriction screw and pass a 0.005-inch diameter wire through the capillary. Rinse the restriction in alcohol and dry thoroughly. Check the condition of the "O" ring. Replace it if it fails to make a tight seal when the restriction is replaced. Reassemble to controller and tighten firmly.

2. Clean the controller nozzle each month. Remove the nozzle closure screw and pass a 0.013-inch diameter wire gently through the nozzle.

CAUTION

Be careful not to disturb the flapper inside the controller and do not remove the nozzle assembly or turn the nozzle. This would impair the calibration of the controller.

Reassemble the closure screw to the controller.

3. Check the exhaust parts monthly to ensure that they are free from dirt or other foreign materials.

<u>M-H Tel-O-Set Indicator and M-H Tel-O-Set Recorder</u>

1. Check the junction of all pneumatic lines and gasketed surfaces monthly for leaks.

2. Check damping restrictions each month. Remove the restriction screw, inspect the stem and seat, and remove any foreign matter with a clean, dry cloth. Check the condition of the "O" ring. Replace it if it fails to make a tight seal when the restriction screw is replaced. Readjust the restriction to damp out any transient pulsations (noise) from the pneumatic transmitter. Turning the restriction screw in a clockwise direction increases the damping action.

NOTE

Do not over-damp, since this will reduce the response of the instrument.

3. Check the ink supply daily and refill as needed. Clean the pen monthly by running a fine wire through it and soaking in alcohol. Dry thoroughly after cleaning. Adjust the pen pressure as needed to give continuous inking with a minimum of pressure. On instruments with integral manual loading pressure regulators, clean the restriction and replace the filter each month if needed, or if the regulator develops a slow up-scale response.

Packing

Types of Packing. In order of use, the most commonly used types of pump packing are woven, braided, shredded, metallic, and plastic. Use the packing recommended by the equipment or packing manufacturer and stock adequate supplies of the kinds needed.

Normal Operating Conditions. All packings contain a lubricant, and most packings must be additionally lubricated to prevent overheating during pump operation. In pumps which handle nonabrasive liquids, the liquid itself serves as the lubricant. Hence, some pumps are equipped with a water seal and a lantern gland. Pump packing should be adjusted to produce a slight drip from the gland; however, the packing should not leak excessively.

NOTE

Packing cannot compensate for a misaligned, eccentric, excessively vibrating, or bent pump shaft and scored packing sleeve. Check for these conditions whenever packing is causing trouble.

Replacement of Packing.

1. Release pressure from the pump discharge and close valves necessary to isolate the suction side; if corrosive liquids are being handled, drain and flush the pump.

2. Unbolt or unscrew the gland and push it back as far as possible, away from the stuffing box.

3. Remove all packing. Use two packing hooks, one on each side. Aim hooks at bore of stuffing box to prevent scratching the pump shaft. Be sure all packing is removed and clean the box thoroughly to prevent new packing from sticking.

4. Make a visual inspection for bent shaft, grooves, or shoulders. If the neck bushing clearance in the bottom of the box is great, use a stiffer bottom ring or replace the neck bushing.

5. Use a dial indicator and check for eccentricity of the pump shaft. If the indicator runs out more than 0.003 inch, the pump should be taken out of service and overhauled to correct this condition.

6. Do not reuse old and lifeless packing. If a lantern ring is used, a continuous addition of packing will displace it and render it useless. To find the correct size of packing to use, measure the bore of the stuffing box and subtract the shaft diameter from it. Divide the difference by two. Do not guess at the correct size.

7. When installing packing where lubricants can be used, it is advisable to lubricate each ring as it is installed in the stuffing box. This will enable the packing to maintain equilibrium and will contribute to ease of installation. Graphite and oil are good lubricants.

8. Obtain a rod of the same diameter as the pump shaft. Secure one end of the rod in use. Wind packing around rod and out each ring separately about 1/16 inch short of a complete ring around the rod. Cutting off rings while packing is wrapped around the rod produces rings with parallel ends. Parallel ends on the packing will prevent too much leakage when packing is tight and ends come together. The 1/16 inch short will allow packing to swell and yet be loose enough to allow lubrication.

9. Foil-wrapped packing must be installed so that edges on the inside will face the direction of pump shaft rotation. If installation is not made in this manner, thin edges will flake off, reducing the life of the packing.

10. Swab new metallic packings of the foil and lead-core types with lubricant supplied by the packing manufacturer. However, if the rod is oily, do not swab it.

11. Open ring joints sidewise, especially the lead-core and metallic types. This prevents distortion of the molded circumference and possible breakage of the ring at a point opposite the gap.

12. Position the first packing ring and a split wooden bushing around the pump shaft. Tighten the gland nut against the wooden bushing and force the packing ring to the bottom of the stuffing box. Install additional rings in the same manner. Stagger the joints 180 degrees if only two rings are to be installed. Stagger the joints 120 degrees for three-ring and 90 degrees for four-ring installations. Packing should be placed on horizontal shaft pumps so that the joint of the last shaft ring is on the bottom of the shaft.

13. Install packing so that the lantern ring aligns with the cooling liquid opening. As the packing is compressed, the lantern ring will move into the stuffing box. Leave space for the gland to enter the box. Tighten the gland finger tight.

14. Always install cross-expansion packing so that plies slope toward the fluid pressure from the housing. Place sectional rings so the slope between the inside and outside ring is toward the pressure. Watch these details for best results when installing new packing in the stuffing box.

Adjustment of Packing

NOTE

Pump must be running during packing adjustment.

Tighten the gland with a wrench, back off, and tighten finger tight. Allow the packing to leak until it seats itself. After the packing is seated, there should be a slight drip from the gland.

If the packing leaks, tighten each hexagon nut 1/6 turn (one flat) at a time, then wait 10 minutes and check for leakage. After 10 minutes, the packing will distribute itself in the packing box and, if leakage persists, the nuts can be tightened another flat.

Plant Process Instruments. To remove these units, proceed as follows:

1. Isolate unit by closing adjacent valves or isolating connecting piping or equipment. Refer to figures 3-1 through 3-4 and 3-6 for the necessary associated valving.

2. Drain unit of fluid.

3. Disconnect any electrical or pneumatic connections.

4. Unfasten all piping connections.

5. Unfasten any support connections.

6. Remove instrument.

Power Transformers

Manufacturer's Literature. General Electric Instructions, Power Transformers, GEI-57302.

Maintenance

1. Clean heat radiation surfaces and bushings during periodic shutdown.

WARNING

Do not clean the bushings while the transformer is energized. Accidental contact with the high-voltage connection may result in serious injury or death.

2. Check the cleanliness and dielectric strength of the insulating oil every six months, as outlined in the Manufacturer's Literature.

Power Transformer Removal. To remove a power transformer, follow the procedure outlined below:

1. De-energize the transformer input power source.

2. Disconnect the input and output leads.

WARNING

Before touching any head, check the input terminals with a voltmeter capable of measuring 5,000 volts ac. If voltage is present on the terminals, locate and de-energize the power source.

3. Disconnect the ground connection.

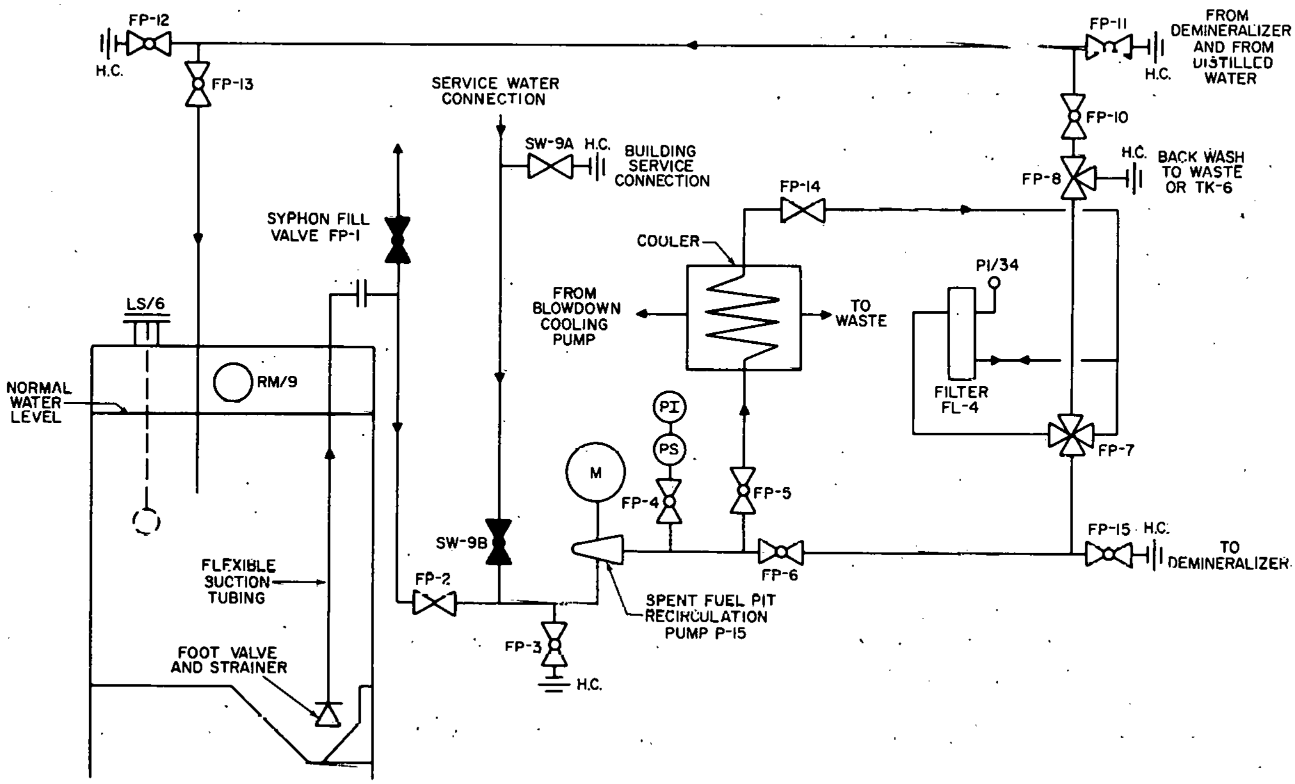

Figure 3-6. Spent Fuel Pit Recirculation System, Schematic Flow Diagram

4. Remove the mounting bolts.

5. Remove the transformer, using a hoist or crane capable of lifting at least 10 tons.

WARNING

When installing a new transformer, be sure to ground the tank before making any external connections. Ground the tank by means of the grounding connection provided at the bottom of the tank, using number 4/0 or larger ground cable.

Pressure Controller

Manufacturer's Literature. Mason Neilan, "Instructions No. 2008, 60000 Series Pressure Controller."

Pen Maintenance. Always use the pen lifter when changing charts and when inking. When inking, be careful not to flood pen. New pens should be moistened before adding ink.

To clean a pen, soak it in alcohol or wipe with alcohol-wetted cotton.

Chart Replacement. To remove the chart, raise the pen and the set point index with the pen lifter. Turn the chart knob counterclockwise and remove chart.

To install a new chart, slide the chart under the time pointer and bearing plate on the pen movement and over the chart knob. Turn the chart knob clockwise until the lugs hold the chart lightly. Turn chart to align the time pointer with the proper time graduation on the chart. Tighten the chart knob.

NOTE

The pen lifter will set the pen and the set point index on the chart when the cover is closed.

Pressure Gages

Manufacturer's Literature. Ashcroft Gage Data Sheet No. 76.

Maintenance. Preventive maintenance consists of periodic calibration, which should be performed at yearly intervals unless inaccuracy occurs between these regular periods. If gage inaccuracies, such as poor zero setting, pointer oscillation, or nonuniform pointer movement, are noticed and if the difficulties cannot be attributed to external causes, calibrate the gage. Adjust gage mechanism and/or replace defective parts to obtain accurate calibration. Replace any broken gage bezels to keep dirt out of the gage mechanism.

Lubrication

CAUTION

Never oil gage mechanism. Oil will mix with dust or dirt and cause sluggish and inaccurate gage action.

Pressure Switches

Manufacturer's Literature. Mercoid Pressure Control Instruction Sheets Forms B-3 and B-54. Barksdale-Meletron Pressure Switch Instruction Sheets Model 372.

Cleaning. If switch operation is erratic and the cause cannot be laid to water hammer or pressure surges in the line, sediment accumulation in the Bourdon tube is indicated. Remove the tube and flush out with a suitable noncorrosive solvent.

Accuracy. Loss of accuracy may be due to poor set point adjustment. Check and readjust if necessary. If adjustment is correct, inspect Bourdon tube element for permanent distortion. Replace if distorted.

Primary Coolant Fill Pump. To remove the primary coolant fill pump, proceed as follows:

1. Isolate the pump.

2. Disconnect the piping from the suction and discharge ports of the pump.

3. Remove electrical connection from the motor.

4. Remove all bolts securing pump to base and remove the pump.

Primary Coolant Fill Pump (P-12, Figure 3-2)

Manufacturer's Literature. Ingersoll-Rand, "Instructions and Repair Parts Book for Motorpump, Form 7870."

NOTE

These valves will normally be in the shut-off positions since the pump is used at infrequent intervals for short periods of time. When maintenance operations have been completed, do not open valves unless pump is to be put into immediate operation.

Packing. The packing used is soft asbestos impregnated with graphite. The pump requires five rings of packing. Refer to "Packing" in this section of the manual for detailed instructions on installation and adjustment of packing. Dip each ring of packing in heavy cylinder oil before installing.

After a new packing has been installed, remove the internal seal needle valve and fill the seal bushing with suitable grease. Replace the needle valve and turn the handle through several revolutions until resistance to further turning is felt.

Motor. Refer to "Electric Motors, Care of" in this section of the manual for instructions on care and cleaning electric motors.

Primary Coolant Make-Up Pumps (P-8A and P-8B, Figure 3-2)

Manufacturer's Literature. Milton Roy Company, "Instruction Manual for Installation, Operation and Maintenance of Motor Driven Controlled Volume Pumps."

Packing. Maintenance of the stuffing box is of primary importance. If daily inspection shows leakage, tighten the gland a small amount. Excessive tightening will not be any more effective in correcting a leak and will only place a greater load on the motor. Recheck for leakage after 15 minutes of operation. If necessary, tighten gland again. If leak is not corrected by this procedure, replace the packing. For instructions on replacing the stuffing box packing, refer to the General Procedures section of this manual.

After a new set of packing has been installed, lubricate through the pressure fitting over the lantern ring. Tighten the gland slowly during the first few hours of operation to insure a good packing seal. At all times use only sufficient gland pressure to prevent movement of the packing in the stuffing box. It is necessary to tighten the gland only to the point where it exerts enough pressure to flex the packing to make a simple contact with the plunger and the stuffing box. Tightening beyond this point only tends to shorten the life of the packing and place unnecessary load on the motor.

Stroke Adjustment. Loosen the crankpin nut. Move the crankpin in the slot closer to the crank center to shorten the stroke or towards the outer circumference to lengthen the stroke. Be certain to tighten the crankpin nut before starting up the pump.

NOTE

The specified adjustment of plunger stroke will be determined by water treatment personnel.

Alignment. If one of the primary coolant make-up pumps becomes misaligned, side-slap or side-play will occur. This will be particularly apparent in the crank - crank pin - connecting rod - wrist pin - crosshead assembly. To properly align the pump, loosen the bolts which attach it and/or the motor to the floor and adjust it so that the low-speed shaft of the driver is exactly at right angles to the center line axis of the plunger. With the pump in this position, tighten the bolts.

Motor. Refer to "Electric Motors, Care of" in this section of the manual for care and cleaning of electric motors.

Removal of Primary Coolant Makeup Pumps. To remove either of the primary coolant make-up pumps, proceed as follows:

1. Isolate the pump.
2. Disconnect the piping from the suction and discharge parts.
3. Remove the mounting bolts which secure the pump to the base plate.
4. Remove the crank nut and crank washer from the crank pin.
5. Slide the connecting rod off the crank pin and remove the pump.

After installing a new pump, refer to "Pump Coupling Alignment" in this section of the manual for adjustment and alignment procedures.

Primary Coolant Pumps (P-11A and P-11B, Figure 3-2)

Manufacturer's Literature. Westinghouse Electric Corp., "Instruction Book Totally Enclosed Mixed Flow Pump, Model Q-350-A1, Sep 1956, IB 5710-6A."

NOTE

> These units are sealed and are not accessible for maintenance. No local maintenance will be performed on these pumps since isolation of the pump would necessitate a shutdown of the plant. The pressure in the primary system must be at least 50 psig prior to running these pumps.

Pumps, Care of. Pumps in APPR-1 are of four general types; piston pumps, centrifugal pumps, rotary pumps, and jet pumps. With proper preventive maintenance, pumping equipment gives little trouble. Normal operating sounds, allowable vibrations, correct operating temperatures, and pressures for each pump must be known. Deviation from normal operating conditions must be investigated immediately.

Each pump is discussed in detail elsewhere in this manual and this information must be consulted to determine normal operating conditions, special precautions, and the necessary maintenance. The instructions below must be followed to insure proper and continuous pump service.

Normal Operation

1. Make a visual examination hourly of all operating pumps.

2. Check pump pressure readings. Investigate and account for unusual changes.

3. Check bearing temperatures and lubrication. See that packing is dripping at proper rate. Refer to sections covering packing adjustment and the specific pump under consideration.

4. Check to see that all valves are in the correct operating position.

5. Note reading of all instruments affecting pump operation such as temperature and pressure gages.

6. Alternate use of operating and standby pumps weekly.

7. This switching operation applies to all pumps which are operated constantly or automatically. Standby pump maintenance applies to all pumps except the primary coolant pump, which is on standby. Only one primary coolant pump is to be run at a time.

Pump Coupling Alignment. Misalignment of the pump and drive motor causes pump bearing failures, broken shafts, seizing, and rapid wear of coupling cushions. Therefore, the alignment must be carefully checked and, if necessary, adjusted after the pump is secured to its foundation. The check should be made both before and after making pipe connections. In order to prevent pump misalignment, piping must be properly supported and must not be forced into place at the pump. Where possible, flexible piping connections to the pump are recommended.

To check alignment, place a straightedge across the coupling. The straightedge must rest evenly on both parts of the coupling. Rotate the coupling as necessary and repeat the check three times at 90-degree intervals. To correct misalignment, shim the pump and/or motor until the cylindrical surfaces of the coupling halves are within 0.005 inch of parallelism, as measured with a feeler gage under the straightedge. Proper clearance varies with size, type, and operating temperature of the pump. Manufacturer's literature should be checked for each pump.

If misalignment is suspected as the cause of pump troubles or failure, use a dial indicator and feeler gages to check alignment of the coupling halves. Shim the pump and/or motor until the dial indicator shows that coupling halves are within 0.003 inch of parallelism.

Pump Motors. The following standard procedure may be followed for the removal of pump motors:

1. Refer to the OPERATING MANUAL and perform all steps to shut down the equipment with which the motor is associated. Observe all necessary precautions.

2. Check that the circuit breaker in the motor circuit is open and tagged.

3. Disconnect all electrical connections from the motor.

4. On belt drives, remove the belting. On direct drives, disconnect the motor coupling.

5. Remove all mounting bolts.

6. Remove motor. Use hoist if necessary. When replacing a pump motor with either a belt drive or direct drive, make sure that the motor and pump are in perfect alignment. Refer to "Pump Coupling-Alignment" in this section of the manual for instructions on alignment procedures. Also check the motor for correct direction of rotation. In each case refer to the manufacturer's literature for detailed instructions.

Reactor. Normal maintenance of the reactor consists of fuel-handling procedures. Fuel handling is described in the OPERATING MANUAL, Section 7, SPECIAL PROCEDURES.

Relays. Refer to "Instrumentation" in this section.

REMOVAL AND REPLACEMENT OF COMPONENTS

Under certain circumstances, it will become necessary to remove certain components. If a component is operating improperly, it may have to be removed for overhaul, replacement, or cleaning. This section contains instructions concerning the removal of components. Replacement of components is in general the opposite of removal. When handling a component, maintenance personnel should take care not to damage it or the equipment to which it is connected.

Safety Procedures for Electrical Maintenance

WARNING

> Work on electrical circuits or equipment of any kind is potentially dangerous and extreme caution must be exercised by all personnel engaged in maintenance work. Electrical shock is extremely dangerous to the nervous and respiratory systems of the body. All personnel will be thoroughly familiar with an approved method of applying artificial respiration.

General. Never assume that it is safe to work on a circuit and/or piece of equipment. Personally check to see that the circuit and/or equipment has been de-energized and that protective measures that will prevent power being applied while work is in progress have been taken (i.e., circuit breakers or switches opened and tagged, fuses removed and holders tagged, leads disconnected and tagged, etc.).

Never work on energized circuits or equipment except in an emergency situation or when operating conditions prohibit de-energizing the circuit.

When working on energized circuits and equipment, at least two men will perform the work. Utilizing two workmen is also desirable at other times.

Prior to starting any work on electrical circuits and/or equipment, the operator on duty will be notified. He will also be notified when such work is completed.

Personal Safety.

NOTE

PERSONAL SAFETY IS AN INDIVIDUAL RESPONSIBILITY.

1. Consider the possible results of each act before performing it.

2. Ascertain that the working conditions are safe. Do not depend on the opinions of others.

3. Wear protective equipment, such as goggles, gloves, aprons, etc., when working with solvents.

4. Avoid wearing items, such as rings, watches, key chains, etc.

5. Wear rubber gloves when working within reach of energized equipment operating between 300 and 5000 volts.

Handling of Electrical Circuits.

1. Consider all voltages as dangerous, regardless of how low they may be.

2. Treat dead circuits with the same caution as live circuits. This practice will develop a caution that may prevent an accident in case power is inadvertently turned on.

3. When circuits are opened for repairs, alterations, or inspections, lock or block open control devices and remove or open fuses and disconnect devices. Tag all control devices.

4. Before working on a circuit at a point remote from the control switch, short-circuit the conductors to ground at a point between the switch and the point where the work is to be performed.

5. Before applying power to a circuit upon completion of work, be sure to disconnect all potential transformers and other devices which could allow dangerous feedback, and have the cognizant supervisor check the circuit completely.

6. Before breaking the circuit of current transformer secondaries, the leads will be grounded and short-circuited between the transformer and the point at which the circuit is to be broken.

7. Before power is again applied to the transformer, all conditions will be checked by the cognizant supervisor.

Capacitors. Allow five minutes after circuit is opened before short-circuiting capacitor terminals. All capacitors should be short-circuited and remain shorted before any work is performed on them. This will preclude any danger of an accident resulting from residual charge.

Grounding of Equipment. All electrical equipment, such as motors, generators, switch boxes, transformers, etc., should have been adequately grounded when installed. Any instance of improperly grounded equipment should be promptly reported to the proper authority.

Isolation and Tagging. All isolation and tagging of equipment is to be performed in strict adherence to the Safe Clearance Procedures as outlined in the OPERATING MANUAL, pages 3-18 to 3-27, inclusive.

Except in an emergency, maintenance personnel will not switch, isolate, or remove any equipment from service without first notifying the operator in the control room and securing the necessary permission.

After isolating electrical circuits, use an adequate voltmeter to insure that the isolated circuits are de-energized. The voltmeter range should not only be adequate, but should be previously tested on a known live circuit.

On equipment above the range of the voltmeter, an adequately insulated test ground wire should be used, being sure to shield the eyes before application of the ground. This operation is performed by (1) attaching the insulated wire solidly to ground, (2) taping the other end of the wire to an approved hot-stick, leaving a bare portion of the wire protruding, and (3) making certain that the wire will touch the proper "dead" circuit, avert and shield the eyes and apply the ground wire. Whether using a voltmeter or ground wire, all phases should be checked.

(On open, bare-wire construction of distribution or transmission lines, an approved ground chain is thrown over all wires at mid-span.)

Seal Leakage Between Pumps (P-13A and P-13B, Figure 3-2)

Manufacturer's Literature. Chempump, "How to Install and Operate the Chempump Series E."

These pumps require no periodic preventive maintenance or lubrication. Replacement of worn parts can only be accomplished after removal of the pump from the system; therefore, no in-place maintenance is possible.

NOTE

This pump may be removed only during plant shutdown periods.

Removal Procedures.

1. Close valve between seal leakage tank and pumps suction on suction line.

2. Remove bolts from flanges on suction and discharge lines of pumps.

3. Remove bolts securing pump body to deck.

4. Disconnect electricity.

5. Remove pump.

6. If pump is going to be out for any length of time, put blank flanges on suction and discharge lines and put the other pump back in service.

Seal Pit Monitor Pump (P-17, Figure 3-3)

Manufacturer's Literature. Aurora Pump Division, New York Air Brake Company.

1. "Installation and Operating Instructions for APCO Turbine Type Pumps, Section 111.5-H, dated Nov. 1, 1951."

2. "Instructions for Disassembly and Reassembly of APCO Single Impeller Pumps With Mechanical Seals, 4RS Series, Section 111.5QS, dated Feb. 1, 1956."

Packing. Refer to "Packing" section of the manual for instructions on replacement and adjustment of packing.

Lubrication. Refer to the Lubrication Schedule, Section 4, of this manual for lubrication instructions.

Flexible Coupling Alignment Check. Check alignment by applying a straightedge across the coupling. The straightedge must be in full contact with both rims at the top, bottom, and both sides. If alignment is necessary, place thin shims at the mounting bolts of the electric motor or pump. Recheck alignment as described above. Final alignment check should be made after a short period of operation.

General Maintenance and Cleaning. Clean the pump bearings with solvent once a year and re-grease. Wash the strainer in solvent once a year.

Refer to "Electric Motors, Care of" in this section of the manual for instructions on care and cleaning of electric motors.

Removal of Seal Pit Monitor Pump. To remove the seal pit monitor pump, proceed as follows:

1. Isolate the pump.

2. Remove all electrical connections to pump motor.

3. Disconnect the piping from the suction and discharge parts of the pump.

4. Disconnect the coupling between the motor shaft and the pump shaft.

5. Remove the bolts securing the pump to the base and remove the pump.

When installing a new pump, the coupling between the pump shaft and the motor shaft must be carefully aligned. Refer to "Pump Coupling Alignment" of this section of the manual for detailed instructions on alignment of couplings.

Spent Fuel Pit Recirculation Pump (P-15, Figure 3-6)

Manufacturer's Literature. Roy E. Roth Company, "Roth 21 and 22 Series Turbine Pumps - Installation and Operation Instructions."

Before Starting the Pump. Turn pump shaft over by hand to make sure it is free. The pump is equipped with packing gland, which should be adjusted for proper setting. Check the rotation of the driver. Both pumps always rotate clockwise when facing the shaft extension end.

Do not operate the pump for more than a few seconds at a time at a discharge pressure less than one third the pressure for which the pump was designed. Never attempt to stop all leakage from the stuffing box.

Lubrication. Using a zerk gun, lubricate the bearings of the pump after every thirty days of continuous operation using recommended grease.

Packing. The stuffing box of each Roth 21 or 22 series pump is normally packed with one ring of lead foil packing at each end, with "plastallic" (Garlock No. 927) packing (shredded lead foil and asbestos impregnated with graphite) in between. When it is necessary to repack the stuffing box completely, remove the gland and pull out all the old packing. Put in one ring of lead foil packing (Durametallic B-71, for example) followed by four or five rings of plastallic packing and then another ring of lead foil. These must be pushed into place successively with the gland. With the pump operating, take up on the gland nuts slowly and evenly until all the packing is solidly in place, then back off the gland nuts until they are finger tight. Minimum leakage of six drops per minute is required to properly lubricate the shaft. 60 drops per minute would not be considered excessive.

Pump. Refer to "Pumps, Care of" in this section of the manual for instructions on care and maintenance of pumps.

Electric Motor. Refer to "Electric Motors, Care of" in this section of the manual for instructions on care and cleaning of electric motors.

Standby Air Compressor

Manufacturer's Literature. Ingersoll-Rand, "Operating Instructions for Type 30 Compressors, Ingersoll-Rand Company, Form 1003-C."

Belts. Refer to "belts" in this section of the manual for instructions on care and maintenance of belt drives.

Lubrication. Refer to the Lubrication Schedule, Section 4 of this manual, for lubrication instructions.

Electric Motor. Refer to "Electric Motors, Care of" of this section of the manual for instructions on care and cleaning of electric motors.

Steam Traps

Manufacturer's Literature. "Armstrong Steam Trap Service Guide Bulletin No. 2391."

General Maintenance. All steam traps shall be opened once a year to check condition of operating mechanism.

If inspection reveals that valve seat has a sharp smooth edge and there is a narrow bright ring all the way around the ball valve, valves and seats should be replaced but must be replaced only as matched sets. Refer to paragraph 25 of the Armstrong Bulletin for detailed instructions on valve and seat replacement.

Replace valve levers and retainers whenever valves and seats are replaced. Refer to paragraphs 26, 27, and 28 of the Armstrong Bulletin.

If the pins of the guide pin assembly are badly worn, replace entire assembly. Refer to paragraphs 29 and 30 of the Armstrong Bulletin. Make certain to align the guide pins (as described in paragraph 30) after replacing a guide pin assembly.

Removal of Steam Traps. To remove steam traps, proceed as follows:

1. Isolate by closing adjacent valves in connecting piping.

2. Drain the trap and adjacent piping.

3. Disconnect piping connections.

4. Remove trap.

Strainers. Straight-through-type strainers will have to be removed periodically for inspection and cleaning. Follow procedures outlined above for steam traps. Y-type strainers do not have to be removed from the line for these purposes.

Stuffing Box Leakage. See "Stuffing Box Leakage" under "valves."

Switches. Detailed maintenance instructions to be followed in caring for the switches are contained in General Electric Switchgear Instructions, Control and Instrument Switches, GEH-908M. The switches should be inspected annually and the contacts checked for pitting, coating, wear, and sufficient wipe. Contacts that are pitted or coated with sulphide should be scraped gently or dressed with a fine file. Broken shunts and badly pitted contacts should be replaced. Refer to GEH-908M, pages 6 and 7.

If, with a contact closed, there is a small opening or no opening between the moving contact and the moving contact support, there will be insufficient wipe. This condition indicates that the parts of the moving contact that bear on the cam or the cam itself has become worn and must be replaced. Refer to GEH-908M, page 7.

Removal of Switches. Control switches may be removed as follows:

1. De-energize the switch by placing it in the open position.

2. De-energize the switch input power source.

3. Disconnect all head connections, observing the caution notice given above.

4. Remove all mounting screws.

5. Remove the switch from its mounting or panel.

Tagging. See "Isolation and Tagging."

Turbine (TG-1, Figure 3-1)

Manufacturer's Literature. General Electric, "Steam Turbine Instructions, GEI-54328."

Vibration Check. Check weekly for excessive vibration. This condition is caused by equipment that is improperly aligned or supported. Secure all loose fastenings and keep the bolts between the caps and standards well tightened.

NOTE

> If vibration is still excessive after alignment and tightening, the manufacturer should be consulted immediately. Under no circumstances should untrained personnel attempt to balance the turbine rotor.

Oil Cooler Check. Check the turbine oil cooler weekly for leaks. If a leak in one of the coolers becomes evident by an accumulation of a layer of water in the oil tank, switch to the standby cooler immediately, to avoid further contamination of oil. (Refer to the manufacturer's literature for overhaul procedures to correct leak conditions.)

Turbine Bleed Line Non-return Valve (B-1, Figure 3-1)

Manufacturer's Literature. Atwood & Morrill Co., Drawing Number 3202-F.

Packing. Packing should be changed whenever it shows signs of wear or corrosion. Worn packing is indicated by noticeable leaks from the stuffing box or cylinder cap. Refer to "Packing" in this section of the manual for detailed instructions on adjustment of packing.

Valve Seats. Valve seats should be ground or replaced when worn. To check valve seat, the line must be secured and tagged through normal clearance procedure. (See Isolation and Tagging.) Remove cover at top of valve and remove disc. If necessary to replace disc facing (stainless steel) or the valve seat, lap in the new part to assure good contact. See section on "Valves."

Air Cylinder. The air cylinder is used to drive linkage which is under spring tension to allow the valve to open and close under normal operation. It also allows the spring to take control and to maintain the valve closed in an adverse condition which stops back flow of steam to the turbine through extraction line by releasing air pressure under piston. The air cylinder has a connection for high-pressure air supply below the piston and also a leak off connection above the piston for a manually operated test valve. If excessive air leaks occur at cylinder, a stuffing box is at the point where the piston rod passes through the top of the air cylinder. Check to see that packing is sufficient and tighten if necessary. There is also a rubber seat on top of the piston so when the closing piston is up, the rubber seat prevents practically all air leakage by the piston. Renewal of this seat may be accomplished by dropping the bottom cylinder, which will leave the piston entirely exposed. Removal of the brass washers holding the seat in place will allow replacement.

Vacuum Pump for Primary Coolant Circuit

Manufacturer's Literature. "Operating Instructions and Parts Data for Kinney Vacuum Pumps Model KS-27 and Model KS-47." (The pump used in this installation is Model KS-27-PL-DV.)

General. If the pump is not operating satisfactorily, a few checks should be made before dismantling it. In order to maintain the vacuum within the pump, all associated piping and equipment should be vacuum tight. A distinct discharge valve slap should be heard when the pump is pulling a good vacuum.

Lubrication. Lubricate the outboard ball bearing at intervals specified in Section 4.

Pump Tests. Install a McLeod-type gage to the connection in the closed head of the pump or the pump side of the valve. The gage should show a vacuum of 10 to 15 microns.

Operate the pump for about 15 minutes. Refer to the OPERATING MANUAL for instructions. If the oil in the separator is cool while the pump is hot, check the solenoid valve operation. A rattling noise from the solenoid indicates foreign material collected around the core. Remove the solenoid and clean the inside of the tube and core.

Shaft Seal Assembly. Maintenance of the shaft seal assembly is discussed on page 10 of the Kinney Instructions under the heading Mechanical Shaft Seal or Packing. Inspect the seal as described and replace the seal if necessary.

Belt. If the pump stalls, check for a loose belt. Pressure exerted on the belt should not depress it more than two inches.

Motor. Refer to "Electric Motors, Care of" in this section of the manual for instructions on care and cleaning of electric motors.

Dismantling Vacuum Pump for Primary Coolant Circuit. To dismantle the pump, proceed as follows:

1. Drain out all the oil possible. Close the oil seal valve. Drain oil through drain valve. If pump is in operating condition, open the gauge connection on the vacuum side to the atmosphere and run the pump for about 30 seconds.

2. Drain oil sealing housing by removing drain plug nearest pump head on bottom of housing.

3. Remove belt from pump sheave.

4. Disconnect wiring from solenoid valve.

5. Disconnect water lines and vacuum line.

6. Remove bolts securing pump to base and remove pump from base.

Valves. The most frequently encountered difficulties in valve operation are:

1. Leakage through the valve

2. Stuffing box leakage

3. Sticking valve stem

4. Loose valve disc

Leakage Through Valves. Valve leakage is generally caused by the disc and seat failing to make a tight joint. Dirt, scale, waste, heavy grease, or other foreign material may lodge on the seat in such a way as to prevent the disc from seating. Try blowing out the valve with compressed air. If this is not successful, the valve must be disassembled and cleaned.

Scores in the seat or disc may be the cause of leakage. If disassembly and inspection reveal that damage is slight, the valve may be made tight by grinding; if damage is more extensive, the valve must be reseated and then ground.

Leakage may be caused by a bent spindle guide or a bent valve stem. These parts must be replaced.

In bronze valves fitted with seat rings, leakage through the valve may be around the threads of the seat rings. Remove the seat rings, clean the threads, and remake the joint. If damage to the threads is extensive, it may be necessary to recut the threads in the valve and install a new seat ring.

Stuffing Box Leakage. Stuffing box leakage can usually be controlled by taking up on the packing gland or repacking the stuffing box. Refer to the packing section of this manual for instructions on adjusting packing glands. Persistent stuffing box leaks are generally caused by a bent or scored valve stem or by use of the wrong packing. Replace the stem with a new part or replace packing.

Sticking Valve Stems. A stuffing box too tightly packed may cause valve stems to stick. Loosen and adjust the packing gland. Unevenly set gland nuts may cause valve stems to stick. Loosen and adjust the packing gland. Paint or rust on the valve stem may cause sticking. Clean the stem.

If a valve is jammed shut while hot, release the strain by carefully slacking up the yoke nuts or bonnet nuts. If a valve is jammed open while cold, a wrench may be used to start turning the stem. Take care not to spring the valve.

Loose Valve Stem. In some types of valves, it is possible for the disc to become loose or even separate from the valve stem. This will result in little to no control over the valve. The valve must be disassembled and the disc tightened or positioned on the valve stem.

Vapor Container Manhole. No leakage of shielding water from the manhole can be tolerated during reactor operation. Inspect seals whenever the manhole is opened. A damaged or deteriorated seal will cause leakage; replace the damaged seal with a new unit.

If routine inspection of the closed manhole reveals leakage, tighten the manhole cover bolts until leakage stops. Tighten bolts in succession, no more than a quarter turn at a time. If this procedure fails to eliminate the leak, the seal must be replaced at first shutdown. Check the water level at frequent intervals to maintain proper level until first scheduled shutdown occurs.

At first shutdown, drain the manhole as instructed in the OPERATING MANUAL. Replace the faulty seal and refill the manhole according to instructions given in the OPERATING MANUAL.

Voltage Regulators-Inductrol

Manufacturer's Literature. General Electric Manual GEI-43278 Inductrol.

Isolating Procedure. Place the regulator in neutral position and open disconnect switches on both the primary and secondary sides of the regulator. Tag these switches as outlined in "Isolation and Tagging" in this section of the manual. If the unit is motor-driven, open the circuit supplying power to the operating motor and tag out.

Maintenance. The Inductrol requires very little maintenance; the bearings are grease packed and protected by a dust cap, and the Textolite gears are graphite-impregnated. The motor is totally enclosed and has grease-packed ball bearings and requires no greasing.

a. Regulator Troubles

Regulator stalls and is difficult to turn by hand. Worm or sector gears may have changed their position on the shaft. Correct by readjustment of gears.

Either top or bottom bearing for the rotor shaft may be tight. Dismantle regulator for inspection and correction of trouble.

Foreign materials may have become jammed in gears.

Brake release may be inoperative, allowing brake to drag continuously.

b. Erratic Operation

Check for loose connections or binding in the moving parts of the regulator.

Voltage Regulators for 400-Cycle, 120-Volt Unit. Isolation and maintenance procedures are the same as those for the Inductrol units.

LEGEND - FIGURE 3-7. ELECTRICAL SYSTEM ONE-LINE DIAGRAM

SYMBOLS

- VOLTAGE REGULATOR
- ELECTRICALLY OPERATED AIR CIRCUIT BREAKER
- COMBINATION AIR CIRCUIT BREAKER AND MAGNETIC CONTACTOR
- COMBINATION AIR CIRCUIT BREAKER AND MAGNETIC CONTACTOR WITH CONTROL TRANSFORMER
- MANUALLY OPERATED AIR CIRCUIT BREAKER
- AIR CIRCUIT BREAKER
- INVERSE TIME MAGNETIC TRIP ATTACHMENT
- SELECTIVE SHORT TIME OVER-CURRENT TRIP ATTACHMENT
- AMMETER
- FREQUENCY METER
- TEMPERATURE INDICATOR
- GRAPHIC WATTMETER
- REACTIVE POWER METER
- VOLTMETER
- WATT-HOUR METER
- WATTMETER
- AMMETER SWITCH
- TEMPERATURE INDICATOR SWITCH
- VOLTMETER SWITCH
- SYNCHRONIZING SWITCH
- PACKAGE UNIT CONTROL
- ON-OFF SELECTOR SWITCH WITH RED AND GREEN INDICATING LIGHTS
- ON-OFF SELECTOR SWITCH WITH INDICATING LIGHTS, MAIN-AUXILIARY
- MAINTAINED CONTACT RUN-STOP PUSHBUTTON STATION
- MAINTAINED CONTACT RUN-STOP PUSHBUTTON STATION WITH INDICATING LIGHTS
- CONTROL SWITCH WITH INDICATING LIGHTS
- PRESSURE SWITCH
- SOLENOID SWITCH
- TEST SWITCH
- LOCAL TEST SELECTOR SWITCH
- RED SIGNAL LIGHT
- INDUCTION MOTOR - NUMERAL INDICATES HP UNLESS OTHERWISE NOTED
- THREE PHASE PLUG RECEPTACLE
- CURRENT TRANSFORMER
- POTENTIAL TRANSFORMER
- FUSE
- RESISTOR
- DISCONNECT DEVICE

DEVICE NUMBERS

27 AC UNDERVOLTAGE RELAY
50 AC INSTANTANEOUS OVERCURRENT RELAY
51 TIME-DELAY OVERCURRENT RELAY
62 TIMER
87 DIFFERENTIAL RELAY

ABBREVIATIONS

N.O. NORMALLY OPEN
N.C. NORMALLY CLOSED
G GENERATOR
N NEUTRAL
X AUXILIARY RELAY
Y AUXILIARY RELAY

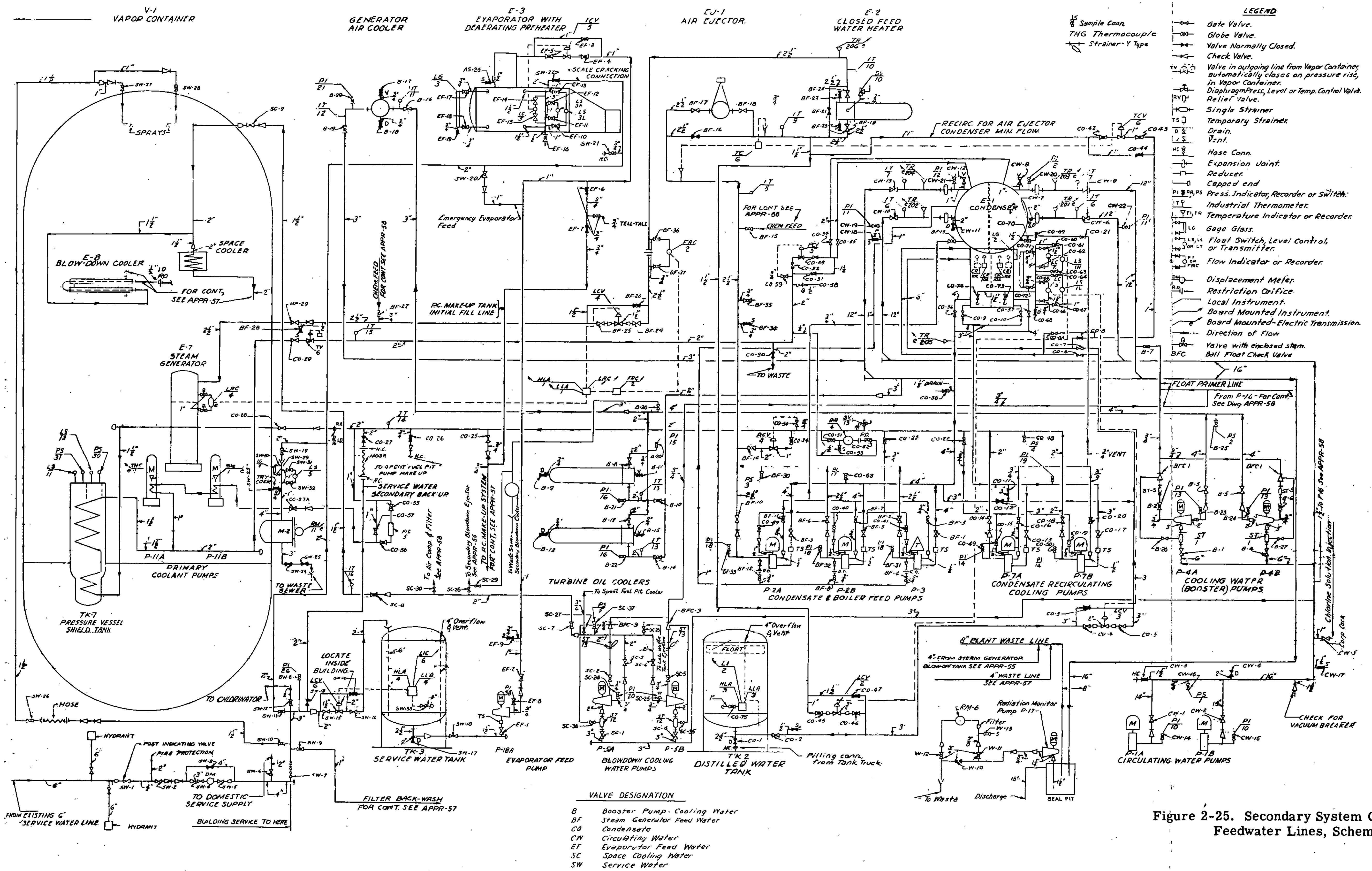

Figure 2-25. Secondary System Condensate, Circulating, and Feedwater Lines, Schematic Flow Diagram

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SECTION 4

LUBRICATION SCHEDULE

PRIMARY SYSTEM

LUBRICATION POINT	LUBRICANT	FREQUENCY
Primary Coolant Make-up Pumps		
Packing	Nordcoseal #147-S Grease	48 hrs operation
Crosshead and Crankpin	Gulf EP44	
Lubrication reservoir		Maintain proper level
U.S. Reduction gear	Gulfcrest 55	Change monthly
DeLaval Reduction gear	Gulf Senate 158F	
Drive motor and Varidrive Bearings	Gulfcrown Grease #2	Change every six mos.
Primary Coolant Fill Pump		
Drive motor bearings	Gulfcrown Grease #2	Change every six mos.
Vacuum Pump for Primary Coolant Circuit		
Reservoir	Kinney Type "A" Dry Vacuum Oil or Gulfcrest 55	Maintain proper level and change if water is permitted to enter
Outboard ball bearing	Gulfcrown Grease #2	Change every six months
Drive motor	Gulfcrown Grease #2	Change every six months
Decontamination Fan		
Fan Bearing Grease Fittings Motor Bearings	Gulfcrown Grease #2	Change yearly
Spent Fuel Pit Recirculation Pump		
Drive motor	Gulfcrown Grease #2	Change yearly
Pump bearings	Gulfcrown Grease #2	Change yearly

LUBRICATION POINT	LUBRICANT	FREQUENCY
Turbine		
Oil tank	Gulfcrest 55	Maintain proper level. Change when analysis dictates
Couplings	Gulfcrown Grease #2	Change every six months
Turbine Throttle Shaft	Gulfcrown Grease #2	One turn on grease cup weekly
Turbine Throttle Bevel Gears	Gulfcrest 55	Keep oil cups filled
Boiler Feed Pumps		
Motor drive bearings - Upper	Gulfcrest 44	Keep oil cups filled
- Lower	Gulfcrown Grease #2	Change every six months
Turbine drive worm gear grease cup	Gulfcrown Grease #2	Half-turn of grease cup handle every 24 hours of operation
Turbine drive governor oil cups	Gulfcrest 55	Adjust rate of flow to one drop per minute when in operation
Grease cups	Gulfcrown Grease #2	One turn every 24 hours of operation
Evaporator Feed Pump Motor	Sealed bearings	
Pump	Liquid being pumped	
Main Circulating Water Pumps		
Motor drive bearings	Gulfcrown Grease #2	Change every six months
Pump packing gland	Gulfcrown Grease #2	1/2 turn grease cup 24 hrs.
Condensate Recirculating Cooling Pumps		
Motor drive bearings	Gulfcrown Grease #2	Change every six months
Cooling Water Booster Pumps		
Motor drive and coupling	Gulfcrown Grease #2	Change every six months
Cradle	Gulfcrest 44	Maintain proper level

LUBRICATION POINT	LUBRICANT	FREQUENCY
Seal Pit Monitor Pump		
Motor Bearings	Gulfcrown Grease #2	Change once every 3 months
Pump Bearings	Gulfcrown Grease #2	Change every 3 months
Main Air Compressor		
Compressor Crankcase	Gulfcrest 55	Maintain proper level change monthly
Drive motor bearings	Gulfcrown Grease #2	Change every six months
Standby Air Compressor		
Crankcase	Gulfcrest 55	Change every 500 hours of operation
Drive motor bearings	Gulfcrown Grease #2	Change annually
Turbine Room Crane		
Mechanical load brake	Gulfcrest 55	Few drops on linkage monthly
Reducer gear cases Bridge drive Trolley drive Hoist drive	Gulf Senate 158F	Change yearly
Bridge and truck wheel gears	Gulfcrown Grease #2	Every six months
Cooling Water Booster Pump		
Motor bearings	Gulfcrown Grease #2	Change every six months
Coupling	Gulfcrown Grease #2	Change every six months
Pump bearings	Gulfcrest 44	Keep oil cup filled
Chemical Feed Pumps		
Motor bearings	Gulfcrest 55	One drop 2 times weekly
Worm gear reducer	Gulf Senate 158F	Change every six months
Worm gear bearings	Gulfcrown Grease #2	1/2 shot weekly

LUBRICATION POINT	LUBRICANT	FREQUENCY
Primary Coolant Pumps	No external lubrication required	
Seal Leakage Pumps	No external lubrication required	
Hot Waste Pumps	No external lubrication required	
Chlorinator Injection Pump		
Motor bearings Pump shaft bearings	Gulfcrown Grease #2	Change every six months
Blowdown Return Pump (Portable)		
Motor bearings	Gulfcrown Grease #2	Change yearly
DC-AC Convertor		
Shaft bearings	Gulfcrown Grease #2	Change every six months
Electric Products Battery Charger		
Shaft bearings	Sealed bearings	
Mason-Nielan Automatic Valves	Nordcoseal	Add every six months operation
Motor Operated Valves		
Main Steam		
Motor	Sealed bearings	
Gear box	Gulf Precision #0	Change every six months
Primary Blowdown		
Motor	Sealed bearings	
Gear box	Gulf Precision #0	Change every six months

Note: When changing grease in motor bearings, it is meant that old lubricant be forced out, using a grease cup installed in place of one plug and other plug removed. Grease is added until new grease shows at drain plug. We can assume then that new grease has replaced the old.

LEGEND - SCHEMATIC FLOW DIAGRAMS

FIGURES 3-1, 3-2, 3-3, 3-4, 3-6.

SYMBOLS

TURBINE

MOTOR

VENTURI

DRAINER

TRAP

STRAINER

TEMPORARY STRAINER

FLAME ARRESTER

HIGH PRESSURE FILTER

LOW PRESSURE FILTER

GLOBE VALVE

GLOBE VALVE-ENCLOSED STEM

GATE VALVE

NORMALLY CLOSED VALVE

CHECK VALVE

VENT

DRAIN

SAMPLE

HYDROGEN VALVE

PNEUMATICALLY OPERATED CONTROL VALVE

THREE-WAY CONTROL VALVE

TRIP VALVE

SAFETY VALVE

MOTOR-OPERATED VALVE

SOLENOID VALVE

MANUALLY-OPERATED CONTROL VALVE

FOUR-WAY VALVE

SNAP CONNECTION

EXPANSION JOINT

CAPPED FLANGE

ORIFICE

RESTRICTION ORIFICE

WATER, STEAM, OR VAPOR FLOW PATH

HOSE CONNECTION

CONTROL CONNECTION

MOTOR DRIVE CONNECTION

EQUIPMENT CABINET OUTLINE

LEGEND - SCHEMATIC FLOW DIAGRAMS (Cont'd)

ABBREVIATIONS

ACV	AIR CHECK VALVE
BFC	BALL FLOAT CHECK
CR	CONDUCTIVITY RECORDER
CV	CONTROL VALVE
DM	DEMINERALIZER
DM	DISPLACEMENT METER
EJ	EJECTOR
FB	FREE BLOW
FCV	FLOW CONTROL VALVE
FI	FLOW INDICATOR
FIC	FLOW INDICATOR CONTROLLER
FL	FILTER
FR	FLOW RECORDER
FRC	FLOW RECORDER CONTROLLER
HLA	HIGH LEVEL ALARM
HLS	HIGH LEVEL SWITCH
IT	INDUSTRIAL THERMOMETER
LC	LEVEL CONTROLLER
LCV	LEVEL CONTROL VALVE
LI	LEVEL INDICATOR
LIC	LEVEL INDICATOR CONTROLLER
LLA	LOW LEVEL ALARM
LLS	LOW LEVEL SWITCH
LRC	LEVEL RECORDER CONTROLLER
LS	LEVEL SWITCH
PC	PRESSURE CONTROLLER
PCV	PRESSURE CONTROL VALVE
PI	PRESSURE INDICATOR
PIC	PRESSURE INDICATOR CONTROLLER
PR	PRESSURE RECORDER
PRC	PRESSURE RECORDER CONTROLLER
PS	PRESSURE SWITCH
RM	RADIATION MONITOR
RMCV	RADIATION MONITOR CONTROLLER VALVE
SOV	SOLENOID VALVE
ST	STRAINER
SV	SAFETY VALVE
TC	TEMPERATURE CONTROLLER
TCV	TEMPERATURE CONTROL VALVE
THC	THERMOCOUPLE
TI	TEMPERATURE INDICATOR
TIC	TEMPERATURE INDICATOR CONTROLLER
TK	TANK
TR	TEMPERATURE RECORDER
ΔTIC	DIFFERENTIAL TEMPERATURE INDICATOR CONTROLLER
ΔTRC	DIFFERENTIAL TEMPERATURE RECORDER CONTROLLER
TV	TRIP VALVE

LEGEND - SCHEMATIC FLOW DIAGRAMS (Cont'd)

VALVE DESIGNATIONS

AR	AIR REMOVAL
AS	AUXILIARY STEAM
B	COOLING WATER FROM BOOSTER PUMP
BD	STEAM GENERATOR BLOWDOWN
BW	BLOWDOWN COOLING
BF	BOILER FEED
CA	COMPRESSED AIR
CF	CHEMICAL FEED
CH	CHLORINIZATION
CO	CONDENSATE
CW	CIRCULATING WATER
EB	EVAPORATOR BLOWDOWN
ED	EVAPORATOR DRAIN
EF	EVAPORATOR FEED
F	SECONDARY FILL
H	HYDROGEN
MS	MAIN STEAM
PC	PRIMARY COOLANT
SC	SERVICE WATER COOLING
SW	SERVICE WATER
W	WASTE

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