2 PLANT DESIGN

200 GENERAL

Primary Plant

The primary plant consists of all the individual systems which directly or indirectly are involved in the removal of nuclear heat from the reactor. The primary plant contains the nuclear core in which the energy released through the fissioning of uranium is converted to heat, thereby increasing the temperature of the circulating light water moderator-coolant. The coolant gives up this heat during its forced circulation through a shell and U-tube heat exchanger where steam is produced for use in the secondary plant. The coolant is then recirculated through the nuclear core.

The primary plant is composed of the main coolant system, which is the basic system in this plant, and 17 auxiliary systems which, in one way or another, service the main coolant system. A composite diagram of the primary plant and secondary plant is shown on drawing No. 9699-FM-2A.

The largest single component in the main coolant system is the reactor vessel which contains the nuclear core. It is a cylindrical carbon steel vessel clad internally with stainless steel. The vessel is provided with a bolted closure at the top, which incorporates provision for seal welding and is also of carbon steel-stainless steel clad construction. On this closure head are mounted the supports for the 24 control rod drive mechanisms. The reactor vessel also contains four inlet and four outlet nozzles, all equally radially spaced and at the same elevation above the core. Four essentially identical closed piping loops are connected in parallel to the reactor via these nozzles.

To facilitate the control and recirculation of the coolant between the core and the heat exchanger, the following additional equipment is employed in the main coolant system. Each main coolant piping loop contains a canned motor pump to provide circulation of the coolant, a check valve to limit coolant by-passing of the reactor vessel when the pump is shut down, and two remote operated gate valves with which isolation of the loop from the reactor vessel is accomplished when desired. The heat exchanger in each of the loops is of shell and U-tube design with the U-tubes oriented vertically. The primary plant coolant is circulated through the tubes while steam is generated on the shell side of the tubes. All of the major surfaces in contact with primary plant coolant are of Type 304 stainless steel or equivalent. The major piping in the main coolant system is nominal 20 and 24 in. O.D. and designed for 2,300 psia at 550 F. Normally the main coolant system operates at temperatures between 496 F and 532 F and pressures of 1,850 to 2,150 psi gage.

In general, and where applicable, all equipment in the main coolant system is designed and fabricated to meet the requirements of ASME Boiler and Pressure Vessel Code, Section VIII or the ASA Code for Pressure Piping, the latest addenda and rulings.

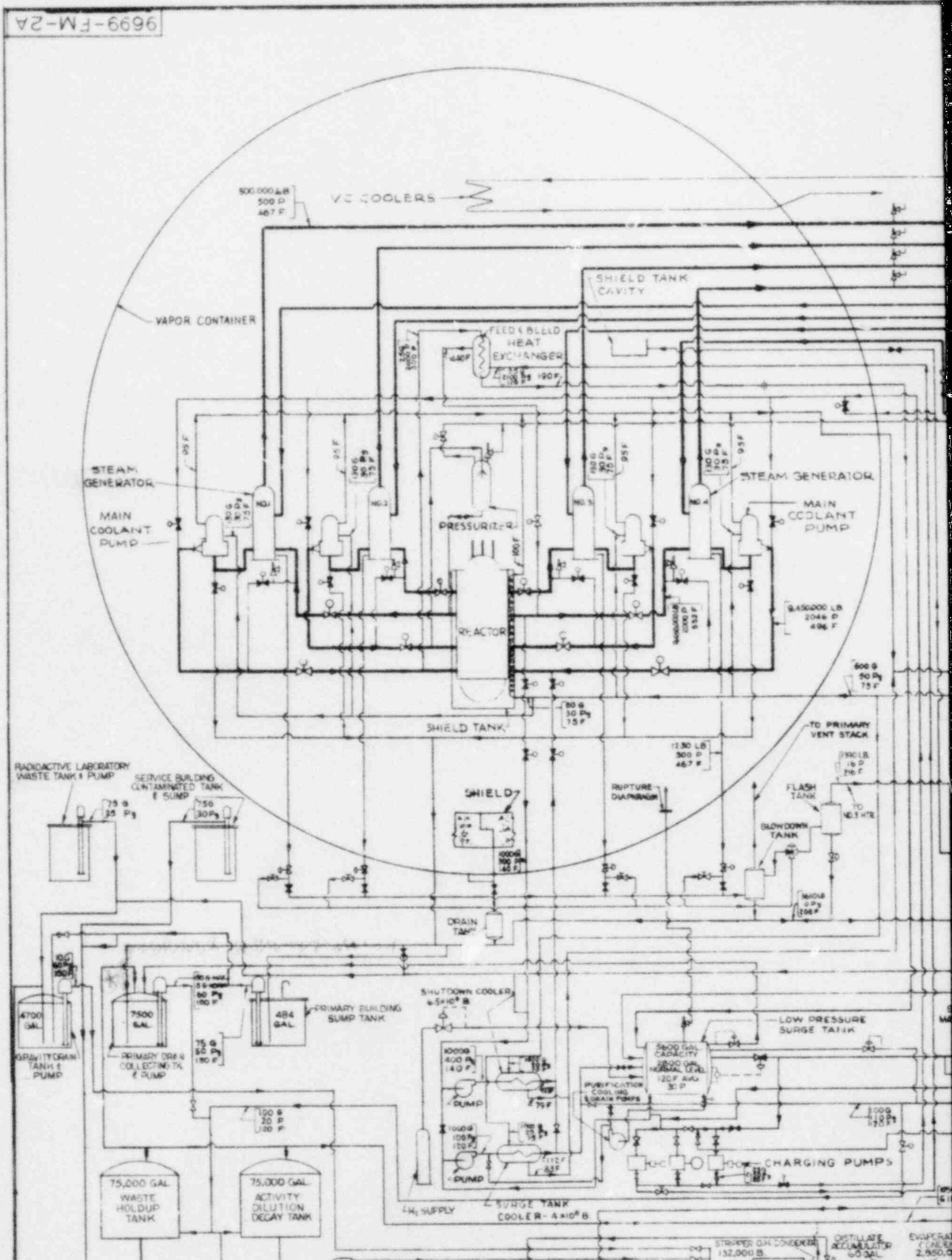
The entire main coolant system, as well as the high temperature - high pressure portions of the primary plant auxiliary systems, is located inside of the vapor container. This is a spherical steel envelope designed to contain the pressure build-up resulting from the major loss of coolant accident, i.e. the rupture of one 20 in. main coolant line and one secondary steam line which releases to equilibrium pressure and temperature the entire moderator-coolant and the contents of one steam generator secondary side.

To provide the necessary indication and control for safe and efficient operation of the nuclear core, the nuclear instrumentation system monitors the neutron flux in the neutron shield tank which surrounds the reactor vessel. This sytem indicates startup rate and flux level for all power ranges and scrams the core when the startup rate is high or when flux level is high or low. It also scrams the core when a low flow or low pressure condition exists in the main coolant system.

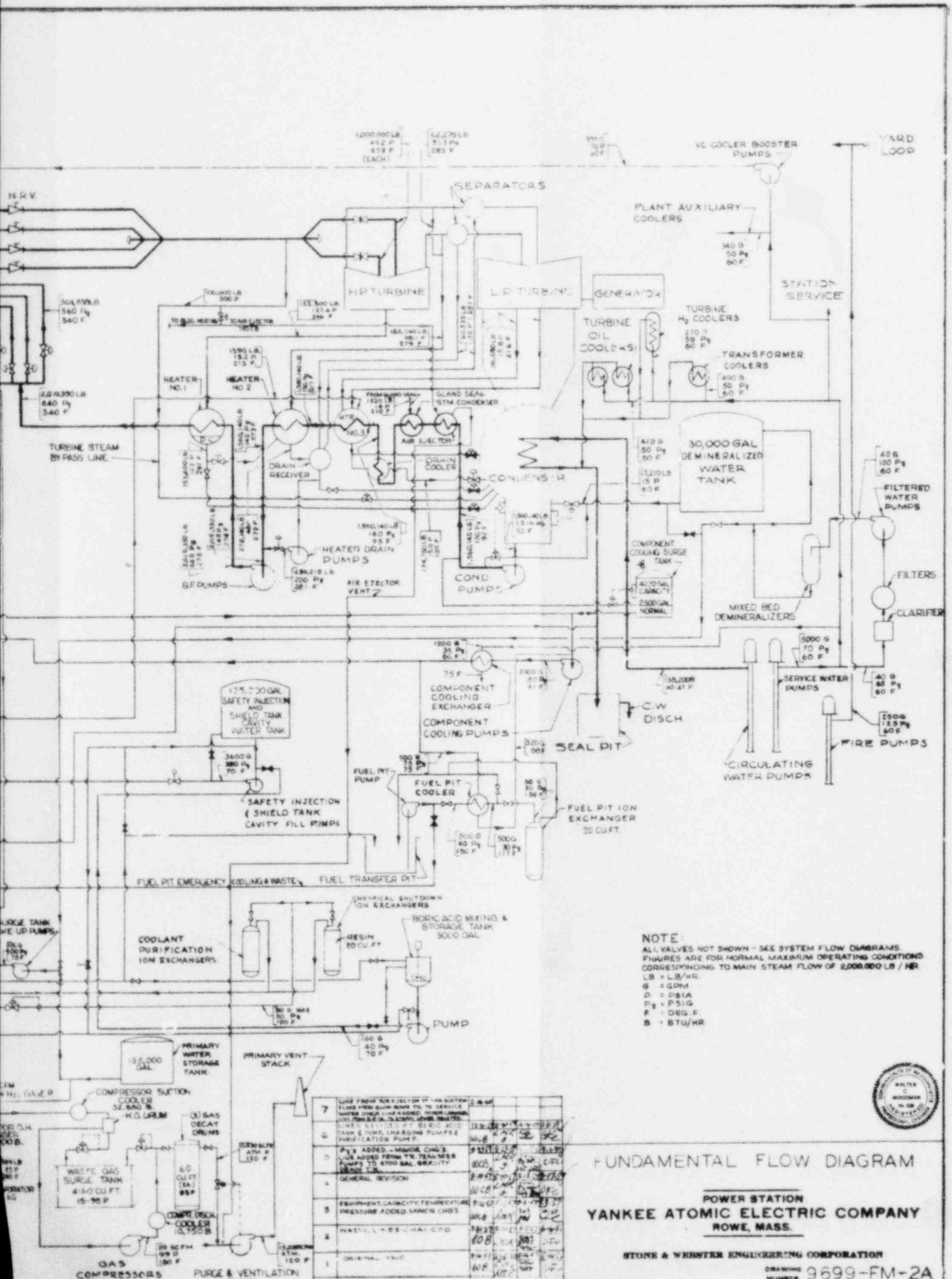
In the normal operating ranges, control of the primary plant is achieved by either manual or semi-automatic positioning of the control rods in the nuclear core. Steady state control of the plant is accomplished by the reactor control system about an essentially constant average main coolant temperature. The semi-automatic system is capable of restoring system average temperature from a high main coolant temperature condition resulting from a scheduled or transient load reduction. Semi-automatic positioning of the control rods, that is automatic rod insertion, is possible over all power ranges.

In order to preclude bulk boiling of the coolant in the main coolant system, a saturation over-pressure is always maintained. This over-pressure is established, maintained, and controlled by the pressure control and relief system which is connected to the main coolant system by a surge line. Pressure control is accomplished in the pressurizer vessel by maintaining a steam-water volume at an equilibrium temperature of 636 F. The heat required to vaporize the coolant in the pressurizer is supplied by electric immersion heaters. Plant load changes affect the temperature of the coolant in the main coolant system and, therefore, its expansion and contraction. These coolant density changes during normal plant load changes are accomodated by the expansion and contraction of the steam volume in the pressurizer. Coolant volume changes which cannot be accomodated by the pressurizer steam volume result in the blowing of safety relief valves on the pressurizer vessel during increasing volume surges or the scramming of the reactor vessel during decreasing volume changes.

Since the main coolant system is essentially a constant high pressure system, facilities must be provided for pumping low pressure make-up coolant to the high pressure system and conversely for reducing the pressure of any coolant bled from the main coolant system. These operations, as well as filling of the main coolant system, are the principal operations accomplished by the charging and volume control system. The temperature of the coolant bled from the main coolant system is reduced in passage through a regenerative heat exchanger and subsequently reduced in pressure by orifices in the bleed line to the low pressure surge tank. Introduction of coolant into the main coolant system is accomplished by means of the charging pumps via a charging line or a fill header.



(A) SEE Amend. #20, JRL 4-6-60.



FUNDAMENTAL FLOW DIAGRAM

POWER STATION

YANKEE ATOMIC ELECTRIC COMPANY

ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-2A

201 MAIN COOLANT SYSTEM

General

The main coolant system is provided in a pressurized water reactor plant to supply water at the required flow rate and temperature to meet the heat transfer and moderating requirements of the reactor core. This system transfers the heat generated in the nuclear core to the steam generators where it is utilized in producing steam for the turbine-electric plant.

The main coolant system consists of four closed piping loops connected in parallel to the single reactor vessel. The principal equipment in each of the loops are two gate type stop valves, a steam generating heat exchanger, a canned-motor type circulating pump, a check valve, 20 and 24 in. piping, and pressure, temperature and flow instrumentation. Each main coolant loop also includes a by-pass line which connects the hot leg to the cold leg, by-passing the reactor core. This by-pass line includes a gate type stop valve and a relief valve which discharges into the relief valve discharge header. Auxiliary system piping connections as well as pressure, temperature and flow instrument piping connections are also provided. The main coolant system is shown on drawing No. 646-J-421.

The main coolant system design provides for the transfer up to 2.045 billion Btu per hour from the reactor core. It utilizes this heat in evaporating water in the steam generators to supply approximately 2.384 million lb per hour of essentially dry and saturated steam to the main steam line which is used in the turbine-electric plant to generate 185 mw gross electrical output. In order to provide the required cooling capacity for the reactor core for this gross load, the main coolant system circulates 42.0 million lb per hour of water at an average temperature of 527°F maximum. The total volume in the main coolant system is 2,940 cu ft.

During normal operation at full power and corresponding to approximately 185 MWe output, the coolant enters the reactor vessel at a temperature of 506°F and leaves at a temperature of 548°F. The steam produced in the secondary sides of the generator is at a temperature of 480°F and pressure of 569 psi gage. The maximum moisture in the steam at rated load is not over $\frac{1}{4}$ of 1%. The feedwater returning to the steam generator is at a temperature of 355°F.

The main coolant system in combination with the steam-electric plant is designed for a normal rate of change of load of 3% of full load per min. The plant is also designed to accomodate either a positive or negative step change of load of 5% without reactor scram. In addition, the plant is designed, in case of emergency, to drop or scram its entire load almost instantaneously.

In order to maintain stresses in the reactor vessel below maximum levels, the heating as well as the cooling rate of the plant is limited to 50°F per hr.

If the main coolant and reactor vessel are iso-thermal at a temperature of 150°F the heat-up rate of the plant may proceed at 50°F per hr continuous to operating temperatures. If the main coolant and reactor vessel are iso-thermal at a temperature lower than 150°F, the heat-up of the plant may proceed at 50°F per hr to a main coolant temperature of 250°F. At 250°F, 2 hours are required to establish an iso-thermal condition between the main coolant and reactor vessel. When iso-thermal is established, the plant heat-up may proceed at 50°F per hr continuous to operating temperatures.

The normal pressure in the main coolant system is maintained at 2,000 $\pm$ 62 psi gage by the pressure control and relief system. If the operating pressure exceeds 2,385 psi gage, an automatically actuated, solenoid operated relief valve on the pressurizer will relieve steam. If this valve is incapable of limiting the pressure buildup, code safety valves set at 2,485 and 2,560 psi gage will open to relieve the system. If the pressure drops below 1,850 psi gage, the reactor will scram.

The water used as the main coolant during normal operation will at times contain boric acid as a reactivity shim. Additional boric acid is added to the main coolant prior to initiation of cooldown for refueling or maintenance work, since control rods alone are insufficient to keep the cold clean core subcritical.

The normal impurity content is less than 1 ppm, with dissolved oxygen at 0.14 ppm, and hydrogen at 2-3 ppm (25 - 35 ml S.T.P. per $K_g H_2O$). The chloride content should be less than 0.1 ppm.

The initial hydrostatic test pressure of the high pressure portions of the primary plant with no core installed in the reactor vessel, employing demineralized water, is 3,435 psi gage at a minimum temperature of 90°F. Cold leak test pressure of the high pressure portions of the primary plant with core installed in the reactor vessel, employing borated water, is 2,485 psi gage at a minimum temperature of 90°F.

All coolant leakage from the main coolant system is controlled. The major surfaces in contact with the main coolant are of stainless steel, Type 304.

All main coolant system apparatus which falls within the jurisdiction of the ASME codes is fabricated to meet the code requirements.

Steam Generators

The steam generators in the main coolant system consist of a shell and U-tube evaporator together with 3-stage moisture separating equipment. The shell of the unit is oriented with its axis vertical and has the moisture separating equipment located in the upper section of the shell above the tube bundle. The primary side inlet and outlet nozzles are located at the bottom of the vessel. The main coolant is the heating fluid and flows through the tubes. Steam is generated on the shell side at a pressure of 485 to 755 psi gage, depending upon load conditions. The shell blowdown from the steam generators is continuous and controls the chloride concentration to less than 0.5 ppm and solids concentration to less than 500-600 ppm.

The steam generators are constructed in accordance with the requirements of the ASME Code, Section VIII, Unfired Pressure Vessels, 1956 Edition, Paragraph U-1-e, under which they are classed as an unfired steam boiler. The primary side of the steam generators is designed to a pressure of 2,485 psi gage and the shell side to 1,035 psi gage. The design temperature for the primary side and shell side of the steam generator is 650 F and 600 F, respectively.

Provisions have been made in the outlet nozzle of the steam generator channel head for the installation of a removable filter which is used during the system flushing operation to remove foreign matter prior to plant operation.

Pumps

The main coolant circulating pumps are of the canned-motor type. Each pump unit consists of a hermetically sealed motor and centrifugal pump impeller mounted on a single shaft as an integral unit complete with heat exchanger, volute and high pressure motor terminals. The unit is mounted with the motor shaft vertical and with the motor above the pump. These pumps are designed for single speed operation.

For main coolant temperatures below 300 F, the pump design for four pump operation requires a minimum pressure of 100 psi gage which must be maintained at the pump inlet. As main coolant temperature is increased, this pressure must be raised accordingly. During normal operation at 496 F the minimum operation suction pressure is 685 psi gage. Each pump is capable of supplying 25,600 gpm (10.2 x 10^6 lb per hr) during normal operation, i.e. 496 F and 2,000 psi gage.

During decontamination or heat up of a cold isolated loop, each pump can be throttled to a minimum pumping capacity of approximately 2,500 gpm. Double acting thrust bearings are employed in the pump motor to obtain maximum reliability at reduced flow rates. During initial startup of the plant, the four main coolant pumps are employed to heat up the main coolant system from ambient to reactor startup temperature.

A pump-valve interlock is employed to prevent pump operation when the main loop stop valves and by-pass valves are not in the correct operating position. This interlock is part of the circuitry in the valve and pump controllers. The foregoing pump-valve interlocking in each main coolant loop includes (1) an interlock to prevent operation of a main coolant pump unless both main coolant valves or the 5" by-pass valve is open (2) an interlock to prevent restarting a pump unless the cold leg main coolant valve has been closed and the 5" by-pass valve has been opened.

The pressure containing parts of the main coolant pumps are designed to a pressure and temperature of 2,485 psi gage and 650 F and are in accordance with the ASME Code, Section VIII, where applicable.

Valves

Individual loop isolation is accomplished by employing remote operated gate type stop valves in the reactor outlet and return piping. These valves are normally fully open or fully closed. Valve travel time is 120 sec ± 10%. These stop valves are designed to open against a differential pressure of 200 psi and close against a 500 psi pressure differential and are capable of withstanding a 3,450 psi differential, in either direction when closed. The operators for these valves are of the electric motor type with torque control. The torque limit switch is used to control stem back seating pressure. In addition to the torque switch, limit switches also limit the travel of the valve stem in both directions.

The stem packing gland is designed for essentially leak free operation for long periods of time with a lantern ring and drain connection to permit controlled disposal of any leakage. One feature of these valves is that the inlet and outlet passages approximate a venturi, so that it is possible to employ 20 in. ends and an 18 in. valve orifice without sustaining a substantial pressure drop through the valve. A valve-temperature interlock is employed to prevent any isolated loop from being placed into operation unless the temperature of this loop is within 30 F of the highest cold leg temperature of the remaining loops. The valve is designed to its particular pressure and temperature (2,285 psi gage and 650 F) requirements according to the 1957 edition of ASA B16.5, Standard for Steel Pipe Flanges and Flanged Fittings, and other applicable codes.

Check valves are employed in the main coolant system to limit reverse flow through any one of the four main loops in the event of a pump shutdown in that loop. The valve is of the conventional swing type check valve, except for two features. The first is that flow openings are provided in the valve seat to permit a reverse flow of 100 gpm in the inoperative loop, under the condition of three main coolant pump operation. The purpose of this controlled reverse flow is to keep the inoperative loop at an equilibrium temperature with the rest of the main coolant system. The second feature is the balanced disc of the check valve. This disc is balanced so that when no-flow condition exists, the disc hangs open, well separated from the seat, leaving an open flow area. The disc does not close against the seat until back-flow commences. The basic valve is a nominal 20 in. body size with a nominal 24 in. inlet nozzle. The design and fabrication of this valve conforms with the requirements of the American Standard for Steel Pipe Flanges and Flanged Fittings, ASA B16.5, 1957 edition, and other applicable codes.

A 5 in. by-pass line located on the steam generator side of the main stop valves is provided to permit recirculation of main coolant in an isolated loop. Recirculation is used for warming a cool isolated loop prior to return to four loop operation and may be used in the decontamination of an isolated loop. A 5 in. motor operated gate valve is employed to prevent flow in the by-pass line when the main coolant system is in normal operation. This by-pass line is sized to allow approximately 2,500 gpm flow by isolated loop pump operation.

A 1 in. relief valve is provided in each loop to prevent over pressurization of an isolated main coolant loop. These valves are located in the by-pass line in each loop and discharge into the relief valve discharge header. These valves are set to relieve at a pressure of 2,735 psi gage.

Piping and Fittings

The stainless steel main coolant piping is of hollow forged and bored construction and corresponds to ASTM-A-376-55T-TP-304 material specification. The pipe fittings are cast ASTM-A-351-57T, CF8 material. The design and fabrication of the main coolant piping system is in accordance with the requirements of the ASA B31.1, 1955 edition, Code for Pressure Piping. The sizing of the pipe as to wall thickness is based upon a design pressure and temperature of 2,285 psi gage and 550 F with provision for variations in pressure and temperature as permitted by the Code for Pressure Piping.

Since the pipe material is austenitic stainless steel and the water quality is highly controlled, corrosion is negligible and no specific corrosion allowance is included in the pipe considerations.

The first-pass welding of the main coolant piping system is accomplished by manual inert gas tungsten arc welding utilizing a Type 308 stainless steel EB consumable insert ring. Subsequent passes are deposited by manual arc welding employing Type 308 stainless steel electrodes. Inspection of these welds include radiographic and dye-penetrant tests.

The velocity of the coolant through the 20 in. pipe is approximately 38 fps and approximately 26 fps through the 24 in. pipe.

Instrumentation and Control

The main coolant system instrumentation is provided to measure the temperature, pressure, and flow in the main coolant system and provides the necessary indications, alarms, and control signals required to operate the plant safely and efficiently.

Flow rates through the main coolant loops during plant operation are obtained by measuring the pressure drop across the steam generator. A differential pressure detector, whose taps are placed in the inlet and outlet channel of the steam generator, measures the pressure drop across the steam generator. This measured pressure drop is compared with the calculated pressure drop to determine the flow in the loop. The magnetic amplifier controller receives an output signal from a differential transformer mounted on the differential transformer cell, demodulates and amplifies this signal and sends it to a control board mounted indicator, reading in pounds per hour, a low main coolant flow scram bistable, a power level scram cut-back circuit, a multipoint recorder and the annunciator for individual loop low flow. A fail-safe on-off signal is sent to the fail-safe panel to indicate a failure in the instrumentation.

The hot leg narrow range temperature is detected in the inlet piping to the steam generator by means of a resistance type, short time constant temperature detector. The resistance temperature element is part of a bridge circuit that is connected to a magnetic amplifier controller. The output of the controller is a narrow range signal that varies between 510 F and 540 F. This narrow range continuous signal is sent to the reactor control system, for use in controlling the primary plant by maintaining a constant average temperature in the system, an indicator mounted on the control board and a multipoint recorder mounted on the rear of the control panel. The controller also sends an on-off high temperature alarm signal to the annunciator on the control board. A fail-safe on-off signal is sent to the fail-safe panel on the rear of the control board to indicate a failure in the instrument channel.

The cold leg narrow range temperature is detected in the outlet piping of the steam generator in the same manner as the hot leg narrow range temperature mentioned in the previous paragraph. The narrow range cold leg temperature instrumentation and the narrow range hot leg temperature instrumentation are identical except for the range and alarm setting, the cold leg narrow range being set for 485 to 515 F.

The cold leg wide range temperature is detected in the outlet piping of the steam generator by means of a resistance type temperature detector. The wide range instrumentation detects, controls, and indicates over a range of 70 F to 600 F and sends an on-off fail-safe signal to the fail-safe panel upon instrumentation failure. The controller is designed with magnetic amplifiers. The wide range instrumentation contains a magnetic amplifier type valve-temperature interlocking circuit. This interlock prevents any isolated loop from being placed into operation unless the temperature of this loop is within 30 F of the highest cold leg temperature of the remaining loops.

The system pressure is measured between the reactor and the stop valve in the hot leg of loop No. 1 which is connected to the pressurizer. The detector is a bourdon tube type pressure detector that produces a voltage output from an integrally mounted differential transformer. This output is sent to a magnetic amplifier controller where the signal is demodulated and amplified. One output is sent to a control board mounted indicator reading from 0 to 3,000 psi gage. The controller also sends signals to the annunciator on high pressure and on low pressure. The output of this channel is also sent to the pressure control and relief system pressure channel which is used in case the pressure detector in the latter channel becomes inoperative. There is also a low pressure scram signal sent to the alarm and scram panel which is used in conjunction with the pressure scram signal from the pressure control and relief system. There is also an on-off fail-safe signal to the fail-safe panel to indicate a failure in the instrumentation.

202 PRESSURE CONTROL AND RELIEF SYSTEM

General

The functions of the pressure control and relief system are to maintain the required main coolant pressure at the reactor outlet during steady state operation, to limit to an allowable range the pressure changes caused by main coolant thermal expansion and contraction during normal power plant load transients, and to prevent the pressure in the main coolant system from exceeding the design pressure.

The pressure control and relief system consists of a pressurizer vessel containing a 2-phase mixture of steam and water, replaceable direct immersion heaters, safety and relief valves, spray system, interconnecting piping, valves, and instrumentation as shown on drawing No. 646-J-422. The electrical heaters, located in the lower section of the pressurizer vessel, accomplish pressurization of the main coolant system by maintaining the water and steam at saturation temperature. The heaters are capable of raising the temperature of the pressurizer and contents at the desired rate during startup of the reactor plant. The heaters are turned on in successive steps when the system pressure decreases below the operating pressure.

The pressurizer vessel is designed to accommodate positive and negative surges of the main coolant system caused by normal power plant load transients. During a positive surge, the spray system causes steam to be condensed so that the pressure will not increase to a value which would actuate relief valves. During a negative surge, flashing of water and generation of steam by heater operation in the pressurizer keeps pressure above a minimum value fixed by the reactor core heat transfer design and safety requirements.

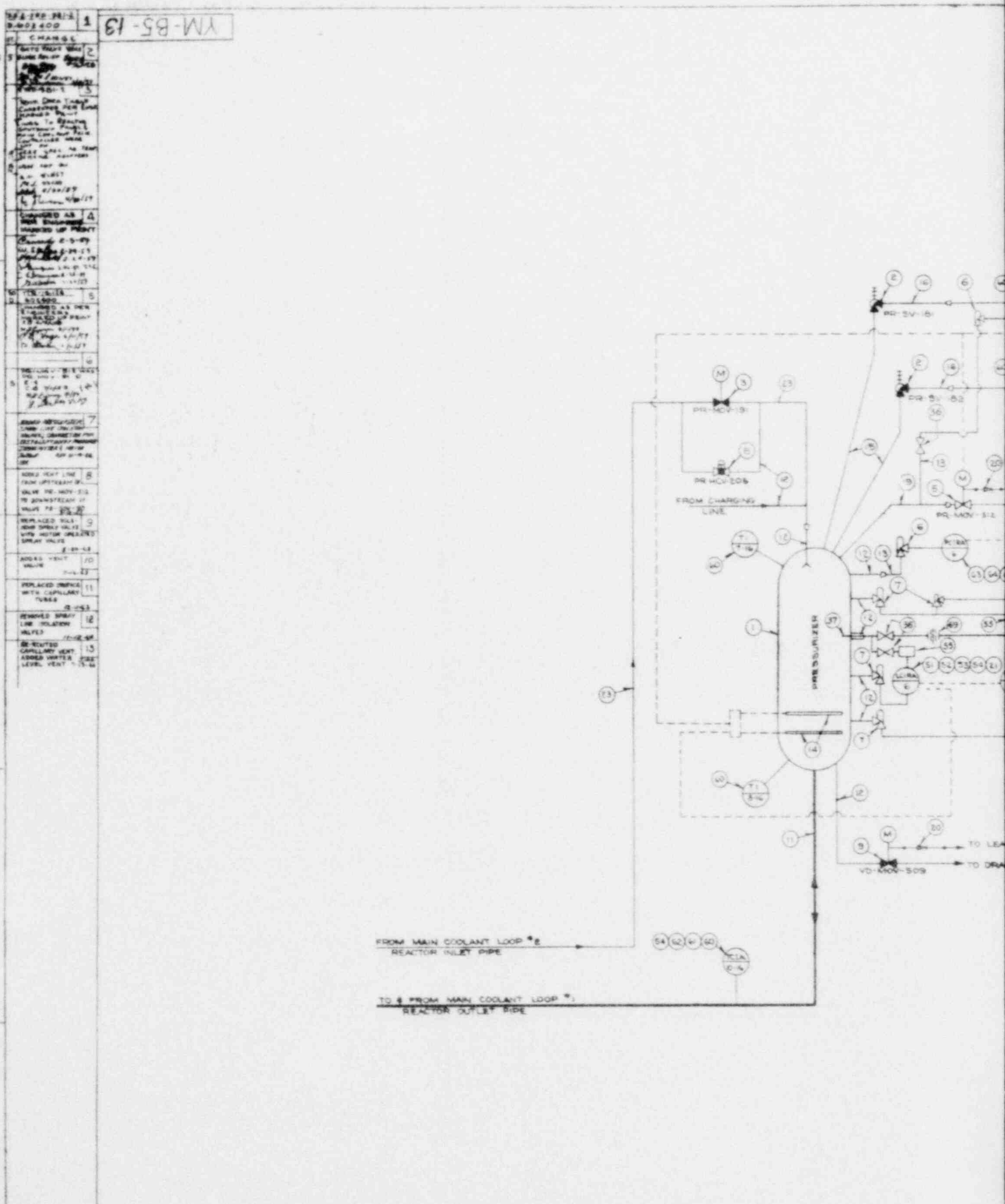
Safety valves and a solenoid operated relief valve are provided to accommodate large pressure surges which are beyond the pressure limiting capacity of the pressurizer and spray system. The safety valves are capable of preventing system pressure from exceeding the design pressure of 2,500 psia based on ASME Boiler Code, Section I where applicable for this type plant. The solenoid operated relief valve operates at a pressure of 2,400 psi gage to minimize the operating frequency of the code safety valves. Each main coolant system loop is provided with a water relief valve to relieve thermal expansion at 2,735 psi gage. Discharge of safety and relief valves is to the low pressure surge tank which acts as a blowdown and quenching tank. In turn, if the blowdown capacity of the low pressure surge tank is exceeded, it relieves to the vapor container, thereby maintaining complete enclosure of main coolant system pressure relief.

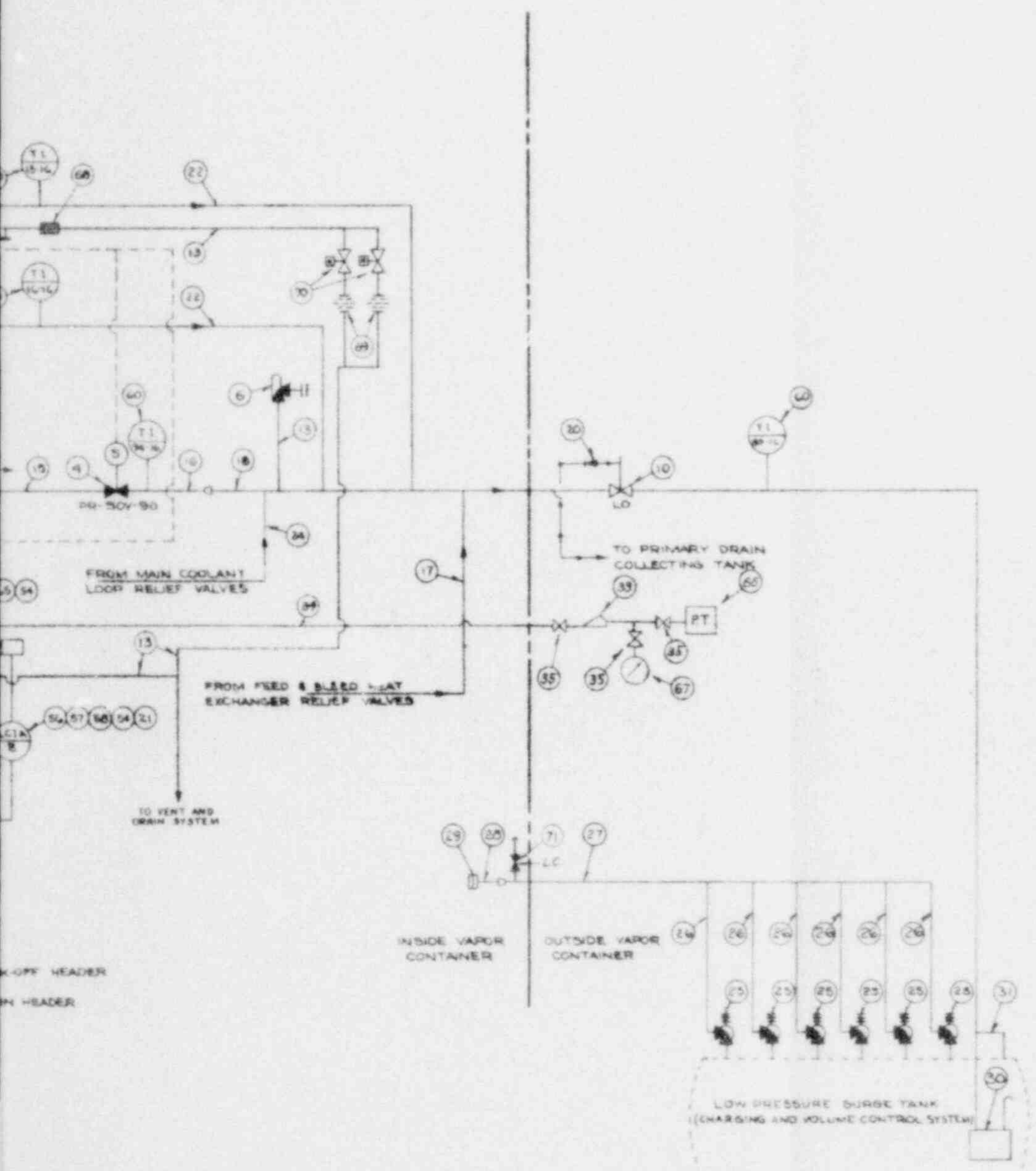
Pressurizer

A change in the turbine generator load will cause a change in the reactor core coolant water and fuel average temperatures. The magnitude of the temperature changes depends on the following:

The rate and magnitude of the turbine generator load transient

The magnitude of the moderator negative temperature and positive pressure coefficients of reactivity, and the fuel (Doppler) negative temperature coefficient of reactivity


YM-B5-13
CHANGE
PR-SV-181
PR-SV-182
PR-MOV-181
PR-HCV-206
FROM CHARGING LINE
PR-MOV-512
PRESSURIZER
TO LEA
TO DRA
VD-MOV-509
FROM MAIN COOLANT LOOP #2 REACTOR INLET PIPE
TO & FROM MAIN COOLANT LOOP #1 REACTOR OUTLET PIPE



TITLE - LARGE PRESSURIZED WATER NUCLEAR POWER PLANT PRESSURE CONTROL & RELIEF SYS (MECH) DWG 646J422 SUB 13			SHEET NO. 1		
NO.	MATERIAL & DESCRIPTION		SIZE	RATING	'E' SPEC.	GROUP NO.
1	PRESSURIZER ASSY	SST	295 FT³	2500 LB @ 668°F	563004	1
2	SAFETY VALVE	SST	2"x3"	2500 LB @ 680°F	567047	2
3	SPRAY STOP VALVE (M.O.)	SST	1½"	PR-V-91	567119	1
4	RELIEF VALVE (SOL OPER)	SST	2"x3"	2500 LB @ [illegible]	567125	1
5	GATE VALVE MOTOR OPERATED STEM LEAK-OFF	SST	2"	2500 LB @ 670°F		1
6	ANGLE VALVE - CAPPED	SST	¾"	2500 LB @ 670°F		3
7	ANGLE VALVE - CAPPED	SST	1"	2500 LB @ 670°F		4
8	HAND CONTROL VALVE - CAPPED	SST	1"			1
9	GATE VALVE MOTOR OPERATED STEM LEAK-OFF	SST	1"	2500 LB @ 670°F		1
10	GATE VALVE STEM LEAKOFF	SST	6"	300 LB @ 575°F		1
11	PIPING SCH 120S TYPE 316	SST	4"	2500 LB @ 680°F		[illegible]
12	PIPING SCH 80 S	SST	1"	2500 LB @ 670°F		[illegible]
13	PIPING SCH 80 S	SST	¾"	2500 LB @ 670°F		[illegible]
14	HEATER ELEMENTS	SST		6.25 KW EACH	563004	1
15	PIPING SCH 160 S	SST	2"	2500 LB @ 670°F		[illegible]
16	PIPING SCH 40 S	SST	3"	300 LB		[illegible]
17	PIPING SCH 40 S	SST	2"	300 LB		[illegible]
18	PIPING SCH 40 S	SST	6"	300 LB		[illegible]
19	PIPING SCH 160 S	SST	3"	2500 LB @ 670°F		[illegible]
20	BALL CHECK VALVE	CST	½"	600 LB		3
21	D/P CELL BYPASS VALVE (SET)					2
22	PIPING SCH 40 S	SST	4"	300 LB		[illegible]
23	PIPING SCH 160 S	SST	1½"	2500 LB @ 670°F		[illegible]
24	PIPING SCH 40 S	SST	1"	300 LB		[illegible]
25	SAFETY VALVE	SST	4"x6"	150 LB		[illegible]
26	PIPING SCH 40	CST	6"	150 LB		[illegible]
27	PIPING SCH 40	CST	12"	150 LB		[illegible]
28	PIPING SCH 40	CST	20"	150 LB		[illegible]
29	RUPTURE DISC	CST	20"			
30	EDUCTOR	SST	6"	150 LB		
31	PIPING SCH 10 S	SST	6"	150 LB		[illegible]
32	GATE VALVE - CAPPED	SST	1½"	2500 LB @ 670°F		
33	GAGE SURGE CHECK VLV	SST	½"			
34	PIPING SCH 160 S	SST	½"	2500 LB @ 670°F		
35	VALVE	SST	½"	2500 LB @ 670°F		
36	INTERNAL TUBE	SST	½"			

TITLE - LARGE PRESSURIZED WATER NUCLEAR POWER PLANT PRESSURE CONTROL & RELIEF SYSTEM (I & C) DWG 646J422 SUB 13		SHEET NO. 2							
		GROUP NO.							
NO.	MATERIAL & DESCRIPTION	CODE NO.	1	2	3	4	5	6	7	8
51	LEVEL DETECTOR	PR-LD-6	1							
52	LEVEL CONTROLLER	PR-LC-6	1							
53	LEVEL INDICATOR - RECORDER	PR-LIR-6	1							
54	ANNUNCIATOR	[illegible]		4						
55	CONDENSING CHAMBER		1		1					
56	LEVEL DETECTOR	PR-LD-8			1					
57	LEVEL CONTROLLER	PR-LC-8			1					
58	LEVEL INDICATOR	PR-LI-8			1					
59										
60	TEMPERATURE DETECTOR	[illegible]				7				
61	TEMPERATURE CONTROLLER	PR-TC-16, 16A				1				
62	TEMPERATURE INDICATOR	PR-TI-16				1				
63	PRESSURE DETECTOR	PR-PD-6					1			
64	PRESSURE CONTROLLER	PR-PC-6					1			
65	PRESSURE INDICATOR RECORDER	PR-PIR-6					1			
66	PRESSURE TRANSMITTER									
67	HEISE GAGE									
68	FILTER									
69	CAPILLARY TUBES									
70	NEEDLE VALVE									
71	VALVE									

GROUP #5 E SPEC. 567171-B
GROUP #4 E SPEC. 567172-B
GROUP #3 E SPEC. 567170-B
GROUP #2 E SPEC. 567201-B
GROUP #1 E SPEC. 567141-B

FLOW DIAGRAM Y [illegible] 5-13

WESTINGHOUSE ELECTRIC CORPORATION

TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT - PRESSURE CONTROL RELIEF SYS (MECH) (I & C)

DIMENSIONS IN INCHES SCALE NTS

DWG. [illegible] Curry | APPD. [illegible]

CHKD.

DIV. & PLANT LOCATION ATOMIC POWER DEPT

646-J-422

The magnitude of reactivity change due to an automatic or manual positioning of the reactor control rods.

The density change of the coolant water caused by the temperature change will result in a volume surge into or out of the pressurizer vessel. The compression or expansion of the steam volume causes a change in coolant water pressure. Pressure decreases must be limited so that the main coolant water in the reactor does not boil excessively, causing damage to the fuel or cladding. Pressure increases must be limited to prevent lifting the selfactuated safety valves, cuasing unnecessary wear. Since the reactor control system will not respond instantly to a change in the electrical load, the pressure control and relief system is designed to prevent excessive pressure change during the uncontrolled, or initial phase of the load transient.

The maximum step load change imposed on the turbine generator by the electrical interconnection is not expected to exceed plus or minus 10% of full power generation, and loading and unloading rates are not expected to exceed 3 to 5% of full power generation per minute. Sufficient time is available for reactor control response, so that the pressurizer volume surges will be less than the equivalent of a 10% uncontrolled load change.

The 295 cu. ft. pressurizer contains about 90 cu. ft. of water during normal operation. This volume can absorb a positive surge of 32 cu. ft. without causing safety valve operation and a negative surge of 38 cu. ft. without causing the main coolant pressure to drop to 1,800 psi gage.

The pressurizer vessel is classified as an electrically heated steam generator and is designed, constructed, and tested in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII (1956 Edition and latest addenda) and ASME Code Case Nos. 1224 and 1234. The maximum allowable working pressure and temperature are 2,500 psia and 668°F. This allows normal operating conditions of 2,150 psi gage and 646°F; although initially the plant will be operated at 2,000 psi gage and 636°F. All surfaces in contact with the water and steam are of Type 304 stainless steel or equivalent. The maximum rate of heating or cooling of the pressurizer recommended by the manufacturer is 200°F per hour.

The piping in the pressure control and relief system is sized, constructed, and tested in accordance with the requirements of ASA B31.1 - 1955 Code for Pressure Piping, Section 1 and 6.

A 4 inch pipe connects the bottom of the pressurizer to the reactor coolant outlet pipe on the reactor side of the loop No. 1 isolation valve. This pipe is subject to temperature changes of about 100°F caused by volume surges during load transients. Type 316 stainless steel is used rather than Type 304, since it has a higher allowable stress value and permits use of a thinner wall (schedule 120) piping. The thermal stresses caused by temperature transients have less effect on the thinner-walled pipe.

A manually operated vent line permits intermittent or continuous venting of oxygen and other non condensible gases from the vapor phase of the pressurizer to the Low Pressure Surge Tank. The vent or bleed flow is controlled between 0 and 40 lb/hr manual by positioning of needle valves in each of two parallel circuits containing capillary breakdown tubes.

Heaters and Heater Control

Direct immersion electrical heaters, having a total output of 300 kw, are installed in four flanged penetrations in the lower section of the pressurizer vessel. Twelve heaters, each rated at 6.25 kw capacity at 220 v, are welded to a diaphragm to form a heater bundle for each of the four vessel penetrations. The diaphragms may be gasketed or seal welded to the vessel. The 48 heaters are combined into twenty-four, 440 v series groups outside the secondary shielding in the vapor container. The 24 groups are combined into eight 3-phase groups of 37.5 kw capacity. Each 3-phase group is controlled at the reactor control board and can be placed on cycling, low pressure backup, or manual control. The cycling control energizes heaters at 1,970 psi gage and de-energizes at 2,030 psi gage. The low pressure backup control energizes heaters at 1,950 psi gage and de-energizes them at 1,980 psi gage.

Steady state heat losses through the pressurizer vessel insulation and due to circulation spray amount to approximately 20 kw. During normal operation, one heater group (37.5 kw) is placed on cycling control to maintain pressurizer pressure between 1,970 and 2,030 psi gage, and the remaining seven groups are placed on low pressure backup control. If necessary, a variable voltage controller can be wired into any group so that heater cycling duty is reduced.

The total 300 kw heater capacity increases the pressurizer temperature at 100°F per hour when the water volume is about 50 cu. ft. and at 45°F per hour when the pressurizer is completely filled with water. During startup operations, the pressurizer must attain a steam-water temperature of 385°F or must be filled completely with water and pressurized to approximately 200 psi gage in order that the primary coolant pumps have adequate suction pressure for operation.

The pressurizer heater sheath is designed to withstand an external pressure of 2,500 psia at 668°F. The terminal seal is designed to withstand an internal pressure of 2,500 psia at 668°F in the event that the heater sheath ruptures. Nominal design life of the heaters is 10,000 hour at full capacity with 5,000 on-off cycles and 2,500 hour at full capacity with 20,000 on-off cycles.

Sprays - Surge and Circulation

The pressurizer spray nozzle is located in the manway at the top of the pressurizer, so that the nozzle can be removed or replaced through the manway opening. The spray pipe (1 1/4 in. schedule 160 piping) is connected to the reactor coolant inlet pipe on the reactor side of the loop No. 2 isolation valve. This connection is in the form of a scoop inside the coolant piping, so that the coolant velocity head, plus the static pressure difference between this connection and the surge pipe connection, provides the maximum possible driving force for spray flow. A motor operated valve on the spray line is actuated when the pressurizer pressure reaches 2,300 psi gage and is closed when the pressure returns to 2,250 psi gage. The motor operated valve can be operated manually by a switch on the main control board. The calculated surge spray flow with four main coolant loops in service is between 45 and 50 gpm when the motor operated valve is open.

A needle valve controlled bypass around the surge spray motor operated valve permits a constant water flow through the pressurizer. This circulation spray flow prevents the surge line and spray line from cooling below operating conditions and provides water recirculation and interchange with the primary coolant system. An additional function of circulation spray is to maintain equilibrium saturated temperature and pressure conditions between the water and steam phases of the pressurizer in a condition of rising water level. The surge spray motor operated and needle valves may be isolated from the main coolant system by closure of isolation valves, one on each side of the valve station. Circulation spray flow rate is established as 0.4 gpm with four loops in operation. This amount is not expected to cause abnormal pressurizer heater control during plant heat up or when the pressurizer level control is on "manual" operation. Circulation spray flow rate can be evaluated by observing the temperature detector installed in the 4 inch surge line and by the electrical heater power required at steady state; therefore, no flow meter is provided in the incoming line.

Safety and Relief Valves - Pressurizer and Loops

Two self-actuated safety valves, connected to the steam volume of the pressurizer, are provided to prevent system pressure from exceeding the design pressure of 2,500 psia by more than 6%. These valves are designed to the ASME Code, Section I, where applicable to this type of plant. Each valve has a steam relief capacity of 92,000 lb per hour of saturated steam at set pressure plus 3% accumulation. One valve is set to open at 2,485 psi gage and the other at 2,560 psi gage. The maximum expected positive surge rate into the pressurizer occurs during a full load rejection accident which is not accompanied by a reactor scram. The computed maximum surge rate is 4.5 cu. ft. per second, which is equivalent to between 104,000 and 124,000 lb. per hour of steam, depending on the degree of superheat caused by the initial steam compression. Control is provided that would normally scram the reactor on turbine tripout, in which case pressure relief would not be required.

A solenoid operated relief valve is provided to reduce the possibility of self-actuated safety valve operation and leakage after improper reseating. This valve opens if system pressure reaches 2,400 psi gage and closes when system pressure returns to 2,350 psi gage. This valve can be operated manually by a switch on the main control board. The capacity of this valve is 50,000 lb. per hour of steam at 2,400 psi gage. A motor operated valve placed on the solenoid valve inlet piping is provided for isolation of the solenoid valve if the valve leaks excessively due to closing improperly. This valve is normally open during plant operation, so that time is not lost in opening during a transient requiring steam relief. If closed because of solenoid valve leakage, the motor operated valve opens automatically at 2,400 psi gage if the solenoid valve is set for automatic operation.

Each main coolant system loop is equipped with a water relief valve, located on the 5 inch bypass pipe and set to discharge 90 gpm at 2,735 psi gage. The valves are provided to prevent overpressure in isolated loops due to water expansion caused by operating a main coolant pump or by injecting hot feed water into the steam generator when the main coolant water is cold. The discharge piping from these valves joins the pressurizer relief valve discharge piping to the low pressure surge tank.

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Quenching in Low Pressure Surge Tank

The steam and/or water discharged from the pressure relief valves passes through closed piping to a blowdown eductor located in the water volume of the low pressure surge tank, which is part of the charging and volume control system. The discharge is quenched and cooled by the water flow induced by the eductor. The tank volume is 750 cu ft and is maintained half filled with water at or below 140 F during normal operation. A hydrogen gas-water vapor mixture is maintained at 15 psi gage in the tank.

The low pressure surge tank volume is capable of absorbing a discharge equivalent to three pressurizer steam volumes before the surge tank design pressure of 75 psi gage is exceeded. The pressure and temperature conditions following one complete steam volume discharge (1,065 lb at 1,150 Btu per lb) would be 26 psi gage and 186 F. If a pressure relief valve sticks open and continues to discharge for longer than the design period, a control signal, actuated by a pressure of 30 psi gage in the low pressure surge tank, starts the low pressure surge tank make-up pumps which inject water into the tank vapor space through spray nozzles to cool and depressurize the vapor. The pressure control setting is adjustable within a 15 - 75 psi gage range.

In the event a pressure relief valve does not reseat or the quenching capacity of the water in the low pressure surge tank is exhausted, six 4 by 6 in. safety valves mounted on the low pressure surge tank open at a pressure of 75 psi gage and can discharge up to 193,000 lb per hr of steam through a header that discharges into the vapor container. To prevent leakage of water vapor, hydrogen, and other gases into the vapor container during normal operation, the end of this discharge pipe is sealed with a rupture disc.

Instrumentation

Under normal operating conditions the level, pressure, and temperature in the pressurizer should remain relatively constant. During transient conditions, other than those requiring a reactor scram, the heaters, spray, and charging and volume control system maintain the pressure, temperature, and level within the design limits of the pressure control and relief system.

The pressurizer is equipped with two level detectors: a wide range detector used during filling and draining, and a narrow range detector used for control purposes. During normal operation, the charging and volume control system maintains the pressurizer water level at about 120 in. above the bottom of the vessel. A low level signal and alarm, set at 50 in., automatically deenergizes all pressurizer heaters, to prevent heater burnout if level decreases below this point. A water level of 45 in. will cover all heaters. A detailed description of the level control system is contained in Section 203.

The steam pressure in the pressurizer is detected by a 1,750 to 2,500 psi gage bourdon tube type detector with a secondary housing (2,500 psi gage design pressure) containing the flexed element. The output from the detector is taken from a differential transformer and sent to the magnetic amplifier controller where the signal is demodulated and amplified. A linear signal is sent to a miniature indicator recorder, mounted on the control board, to obtain a permanent record of the pressure changes in the pressurizer. An instrument line connection is located in the high side line to the wide range pressurizer level differential pressure cell. Connected to this line is an accurate Heise pressure gage, located outside the vapor container. A high pressure on-off signal actuates the spray valve and the high pressure alarm on the annunciator panel. A low pressure on-off signal actuates the low pressure alarm on the annunciator panel and the low pressure backup heater circuit. An on-off signal also is sent to the heater cycling circuit. An adjustable low pressure scram signal is sent to the alarm and shutdown panel when the pressure reaches the scram set point. A high pressure on-off signal is sent to the controllers of the electrically operated relief valve and the motor operated isolation valve to open both valves on a high pressure. An on-off fail safe signal is sent to the fail safe panel to indicate a failure in the instrumentation. The controller also accommodates a linear signal from the pressure channel in the main loop to be used in the event that the pressurizer pressure detector becomes inoperative.

The temperature channel in the pressure control and relief system consists of seven similar resistance type temperature sensing elements located at various points in this sytem. The steam phase and water phase in the pressurizer are both monitored by two identical detectors. A detector is placed in the surge line between the pressurizer and main loop that is indicative of flow in this line caused by the spray. There is one detector in each safety valve outlet pipe and one detector in the outlet piping of the electric operated relief valve to determine any leakage past these valves. One detector is located in the header outside the vapor container to determine if there is any leakage past the upstream valves. All seven detectors go through an eight position switch. The detector output is then sent to vacuum tube controller that amplifies the incoming signal and produces a continuous signal out to a control board mounted indicator. A low temperature in the surge line causes a low temperature alarm to be actuated at the annunciator panel if the temperature in the line drops due to lack of sufficient flow in this line. Only the surge line temperature detector is connected for the alarm function. An on-off fail safe signal is sent to the fail safe panel to indicate a failure in the instrumentation.

203 CHARGING AND VOLUME CONTROL SYSTEM

General

The charging and volume control system is an auxiliary system in the primary plant and is designed to accomplish the following major functions:

Water charging to the main coolant system

Water removal from the main coolant system

Boric acid addition and removal for control purposes

Quenching of relief and safety valve discharge

Pressurizer vessel cooling and decontamination

Noncondensible gas removal

Chemical addition

Water charging to auxiliary system and equipment

The arrangement of the charging and volume control system is shown on drawing No. 646-J-430. It contains the following major items of equipment, designed in accordance with the following codes:

Equipment	- ASME Section VIII - 1956 - Unfired Pressure Vessels
Piping	- ASA 31.1 - 1955 - Code for Pressure Piping, Sections 1 and 6
Valves, Fittings	- ASA B16.5 - 1953 - Code for Steel Piping and Flanged Fittings

High Pressure Charging Pumps

Three motor driven positive displacement charging pumps are provided in the charging and volume control system. The capacity of each pump is approximately 33 gpm, when operating against a discharge head of 2,100 psi gage. Two of the pumps serve as a spare for the other, and they can be operated singly or simultaneously, if required. Any pump can be isolated from the system for repairs. Two of the pumps are driven through variable speed fluid couplings, so that their flow can be controlled between 11 and 33 gpm. Pump No. 3 may be used in conjunction with the loop fill and chemical injection line to accomplish charging to any isloated loop while one or both of the other charging pumps is servicing the reactor vessel portion of the main coolant system. All of the high pressure charging pumps are provided with a pressure relief valve.

Feed and Bleed Heat Exchanger

The feed and bleed heat exchanger consists of a set of four small individual heat exchangers connected in series, which cool the bleed before it is reduced in pressure. Multiple exchangers are employed in order to reduce the size of metal parts and the corresponding high thermal stresses that may occur during severe thermal transient operation. The bleed flows through the tubes while the feed is passed through the shell side, thus recovering some of the heat otherwise lost in a bleeding process.

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A high degree of purity is maintained in the light water moderator-coolant in order to reduce the rate of activity build-up in the plant. Since metal corrosion products are the principal contributors to long lived activity, general corrosion is reduced to a minimum by limiting the dissolved oxygen concentration to a very low level. Maintenance of this condition is the function of the corrosion control system. During subcritical plant operation, dissolved oxygen scavenging is accomplished by injecting, with the charging pumps, a solution of hydrazine and water into the main coolant system. During power operation, a hydrogen atmosphere is maintained in the low pressure surge tank. There, hydrogen is dissolved into coolant which is subsequently pumped into the main coolant system. In the presence of ionizing radiation in the core the hydrogen combines with oxygen in the coolant.

To assist in maintaining a low level of induced radioactivity and to reduce the fouling of heat transfer surfaces in the main coolant system, undesirable impurities are removed from the coolant by the purification system. Coolant from the low pressure surge tank, after having been previously cooled and reduced in pressure in extraction from the main coolant system, is pumped through a mixed bed ion exchange vessel where it is filtered and demineralized. The purified coolant is then discharged to the charging pump suction header for return to the main coolant system.

A sampling system is incorporated in the primary plant to provide the facilities for determining the quality of the coolant at any time. This system permits remote extraction of a water sample from various locations in the plant and transportation of the sample via a piping system to the sample cooler where it is cooled. The sample is then analyzed for dissolved and suspended impurities. Where low pressure, low temperature, nonradioactive systems are accessible, local samples are extracted.

During plant operation, and even while shutdown, certain components in the main coolant system and auxiliary systems require cooling. This function is performed by the component cooling system which services the main coolant pumps, low pressure surge tank cooler, and neutron shield tank during normal operation, the shutdown cooler during shutdown, and the fuel pit cooler, sample cooler, and waste disposal system as required. The component cooling system is an intermediate system which dissipates the waste heat to the raw river water.

To facilitate the draining of the primary plant for maintenance purposes, a system of valves and headers is provided in the vent and drain system. This system permits draining the main coolant system, except the reactor vessel, to the primary drain collecting tank, where, in turn, the coolant may be dumped to the waste disposal system. As its name implies, this system includes facilities which permit venting of entrapped gases from various plant equipment to the primary drain collecting tank or to the vent stack.

Radioactive fluids which must be discharged from the primary plant (or the secondary plant) are disposed of through the waste disposal system. This system receives, contains, adequately treats and safely disposes of all radioactive wastes in such a manner as to yield concentrated liquid wastes and ashes. Low activity level liquid wastes are discharged to the river after being diluted with the secondary plant effluent cooling water. Gaseous waste, expected in small quantities, after suitable dilution with fresh air, is dispersed to the atmosphere.

Because there may be insufficient negative reactivity in the control rods to maintain a subcritical condition in the core at low temperatures, the addition of supplemental neutron absorbing capability is provided. This addition of negative reactivity is accomplished by the injection of boric acid solution into the main coolant system. A small quantity of highly concentrated solution is injected into the main coolant system during normal plant shutdown procedures by the chemical shutdown system. This system consists of a boric acid mixing and storage tank along with a transfer pump to supply the boric acid solution to the charging pump suction, which in turn, charges it into the main coolant system.

During shutdown of the plant, heat generation in the core continues due to the decay of fission products. To prevent the accumulation of this heat in the main coolant system, auxiliary cooling is provided by the shutdown cooling system. This system, which is essentially a small standby loop connected in parallel with the main coolant loops, contains a conventional shell and tube heat exchanger and a circulating pump. The core decay heat is transferred from the reactor vessel by the main coolant to the component cooling system. It is then subsequently transferred to the raw river water.

In the unlikely event of a rupture accident which would result in the loss of the moderator-coolant, a low concentration boric acid solution would be charged into the main coolant system to provide core cooling and negative reactivity and, thereby, minimize the consequences of the accident. This solution is pumped from a storage tank in the safety injection system through the fill header to each of the main coolant system loops. The safety injection system also supplies the borated water for flooding the shield tank cavity during normal refueling operations. This flooding furnishes additional radiation shielding above the reactor vessel while the vessel head is removed for access to the core.

Since some air-borne activity may be present in the vapor container atmosphere after depressurization of the main coolant system, and entry into the container is desired, a purge system is provided to dilute the air in the container. These purge facilities, as well as vapor container heating and cooling facilities, are provided in the vapor container atmosphere control system.

A radiation monitoring system is provided and has the following two purposes: to warn of any radiation health hazard which might exist, and to give early warning of plant malfunction which might result in a health hazard or plant damage. This system includes equipment for detecting, computing, and indicating radiation levels at selected locations inside and outside the vapor container.

Periodically the plant will be shut down for refueling, maintenance, and inspection. Because the systems which contain the moderator-coolant may become increasingly radioactive during plant lifetime, it will be necessary to reduce this contamination in systems to which immediate access is desired. The decontamination system provides the means for accomplishing decontamination of isolated main coolant system loops as well as the pressurizer vessel.

In order that the reactor may be refueled without hazard to personnel, facilities are provided for remote underwater removal and transfer of spent fuel assemblies from the reactor vessel to the spent fuel storage pit. Installation of new fuel assemblies is also performed remotely and under water. All of the remote handling provisions comprise the fuel handling system.

Secondary Plant

The secondary plant provides the means of converting to electricity the heat energy produced in the primary plant, together with a method of disposing of the total heat existent or produced in the primary system following a sudden shutdown of the turbine generator from full load to no load.

The electric power produced is delivered to the integrated transmission system of the New England utilities comprising the Yankee Atomic Electric Company.

The unit is designed as a base load plant and all equipment has been selected with that in mind. Due to the pioneering nature of this project, no provision is made in the layout for duplication or extension. Provision is made for future installation of a cooling tower in the event that operating experience proves it to be economical.

The secondary plant and equipment are shown on the following drawings Nos:

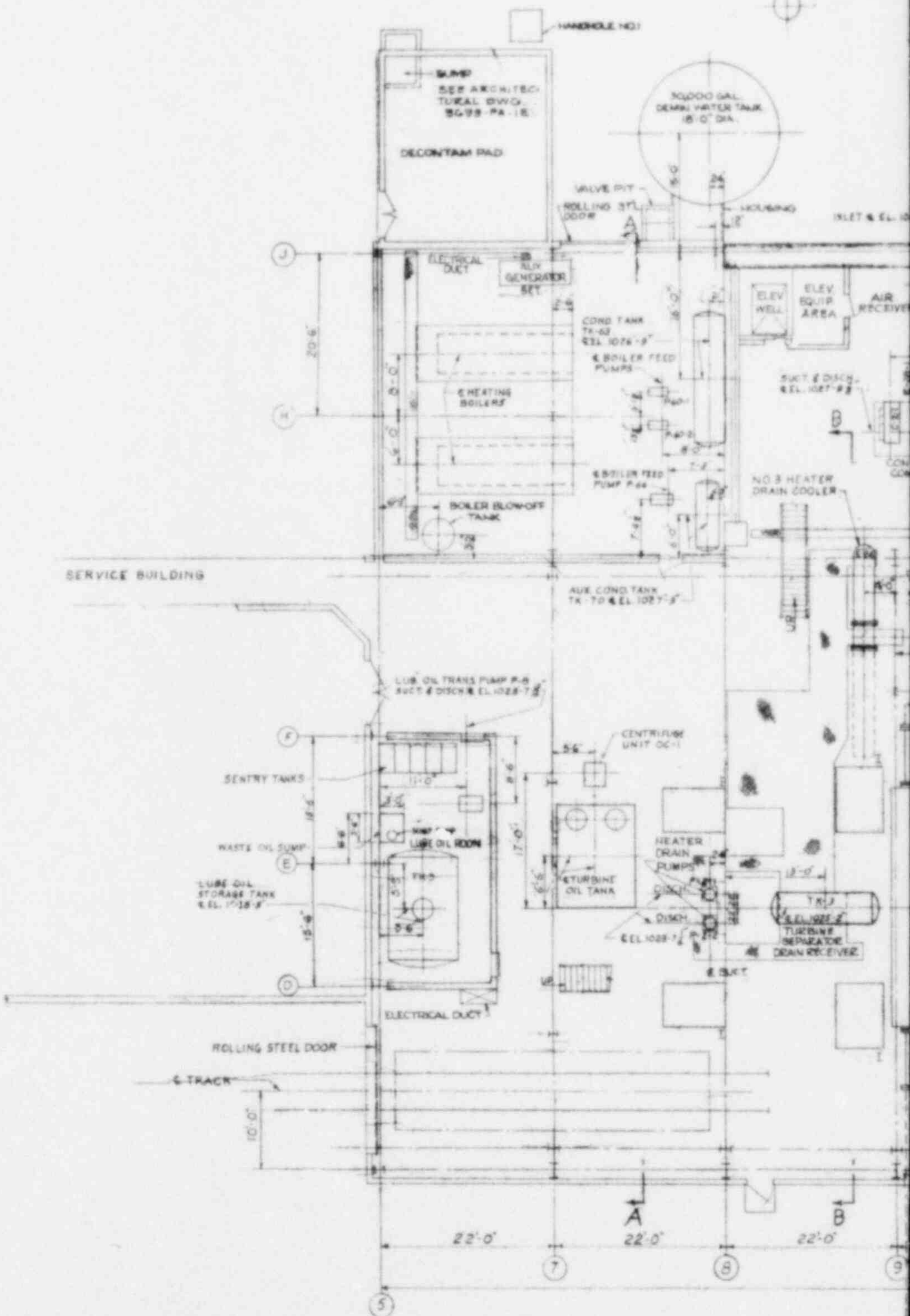
9699-FM-18A - Machine Location Plan - Operating Floor - Turbine Room
9699-FM-18B - Machine Location Plan - Ground Floor - Turbine Room
9699-FM-18C - Machine Location - Sections - Turbine Room
9699-FM-18D - Machine Location Plan - Mezzanine Floor - Turbine Room
9699-FM-38F - Circulating Water System - Plan
9699-FM-38J - Circulating Water System - Sections

The secondary plant consists of one 145,000 kw tandem compound steam turbine generator with three points of automatic extraction for feedwater heating, exhausting to an 85,000 sq ft single pass divided water box condenser, together with all auxiliaries and controls, erected in a building adjacent to and north of the vapor container and primary plant. Wings of this structure provide office space and service area, including heating boiler room, machine shop, laboratory, stores and water treating plant.

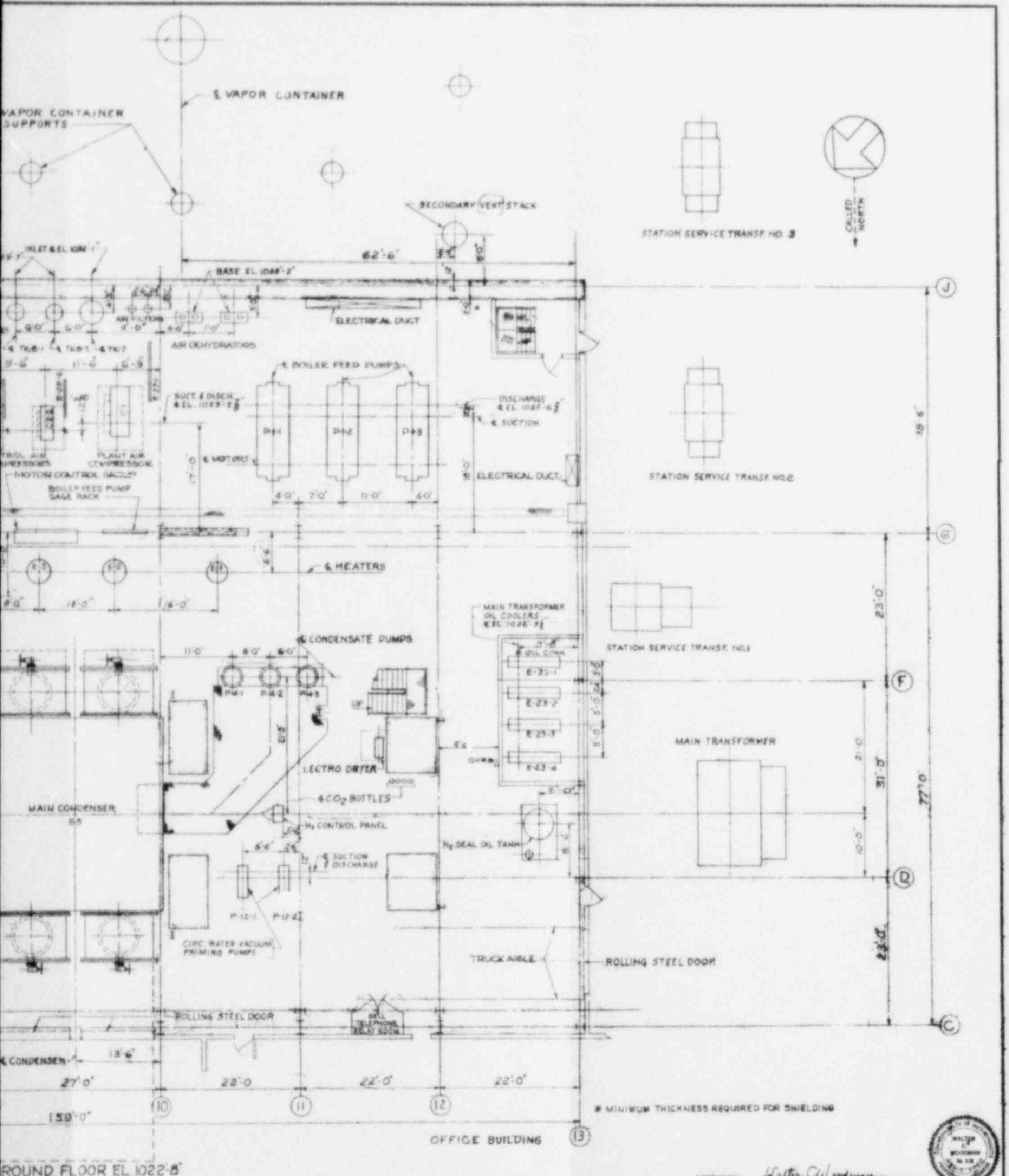
The turbine operating floor and control room are located at El. 1,052'-8". The condensate pumps, heater drain pumps, boiler feed pumps, air compressors and most of the auxiliary equipment are located on the condenser floor at El. 1,022'-8". A mezzanine floor at El. 1,037'-8" provides a switchgear room below the control room and access to gland steam controller, condenser vacuum piping tank, air ejector, and various piping systems. The three vertical feed-water heaters are in the auxiliary bay south of the turbine generator unit and are generally accessible from the mezzanine floor.

Main steam lines from the steam generators within the vapor container of the primary plant enter the turbine room aboveground, below the turbine operating floor El. 1,052'-8".

9699-FM-18B



NOTES
FOR MACHINE LOCATION PLAN OPERATING FLOOR S
FOR MACHINE LOCATION PLAN MEZZANINE FLOOR
FOR MACHINE LOCATION SECTIONS SEE DWG. NO. 9
FOR PLOT PLAN SEE DWG. NO. 9699-FY-6A
FOR MACHINE LOCATION PLAN SH. NO. 1 - VAPOR C



* MINIMUM THICKNESS REQUIRED FOR SHIELDING

ROUND FLOOR EL. 1022'-8"
SCALE 1/8"=1'-0"

...E DWG. NO. 9699-FM-18A
...SEE DWG. NO. 9699-FM-18D
...699-FM-18C

...ONTAINER, SEE DWG. 9699-FM-1A

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD	INSP	CORR	APPR
6	EQUIPMENT RELOCATED & RENAMED DIMENSIONS ADDED.	WLB	LMR		

ISSUE	DESCRIPTION	APPRD	INSP	CORR	APPR
5	SECONDARY STACK & B.F. PUMP RELOC. PROPOSED TELEPHONE RM. ADDED. ADDED & RENAMED MINOR CHANGES	WLB	LMR		CTC
4	LOCATED HEATING BOILERS, AIR COMPRESSORS & OIL COOLERS ADDED TRENCHES. DIMS. CH'G'D. ADDED. TRENCH REV. FILTERS ADDED	WLB	LMR		CTC
3	DIMENSIONS LOCATING EQUIPMENT ADDED & MINOR CHANGES	WLB			CTC
2	GENERAL REVISION	WLB			CTC
1	ORIGINAL ISSUE	EOB	COL		CTC

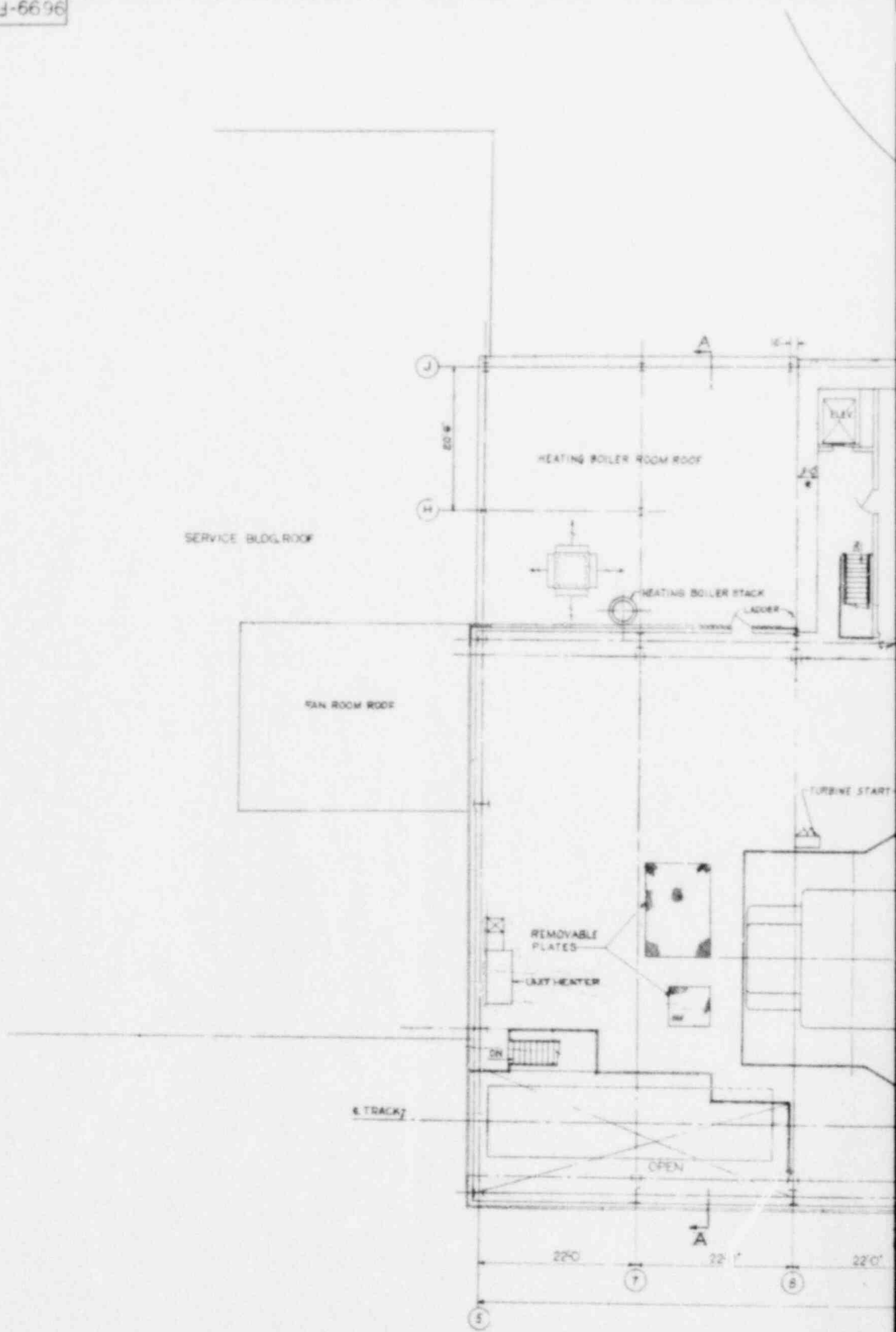
MACHINE LOCATION PLAN
GROUND FLOOR-TURBINE ROOM

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

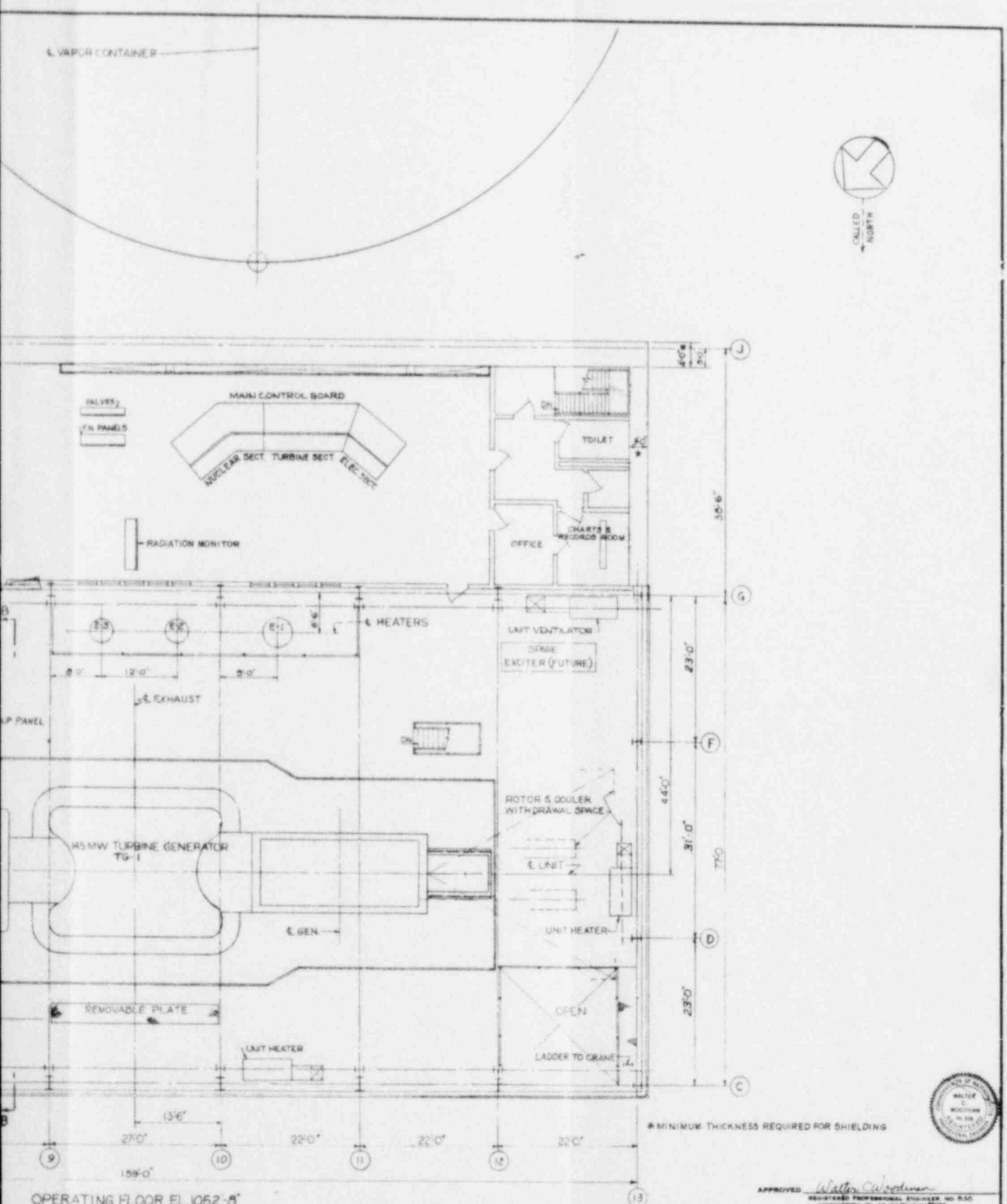
STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-18B

9699-FM-18A



NOTES
FOR MACHINE LOCATION-SECTIONS, SEE DWG. NO. 9699-FM-18C
FOR MACHINE LOCATION PLAN-MEZZANINE FLOOR, SEE DWG. NO
FOR MACHINE LOCATION PLAN-GROUND FLOOR, SEE DWG. NO. 96
FOR MACHINE LOCATION PLANS SH. NO. 1 VAPOR CONTAINER, SEE
FOR PLOT PLAN, SEE DWG. NO. 9699-FY-6A



OPERATING FLOOR EL. 1052'-8"

SCALE: 1/8" = 1'-0"

9699-FM-18D
9-FM-18B
DWG. NO. 9699-FM-1A

ISSUE	DESCRIPTION	CHKD.	INSP.	COOR.	APPR.
5					
4	UNIT HEATERS REVISED UNIT VENTILATOR CHANGED CARRIER EQUIP & DESKS REMOVED	[illegible]	[illegible]	[illegible]	[illegible]
3	DIMENS. LOCATING EQUIPMENT ADDED & MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
2	GENERAL REVISION	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER, NO. 8310 COMMONWEALTH OF MASSACHUSETTS

MACHINE LOCATION PLAN
OPERATING FLOOR-TURBINE ROOM

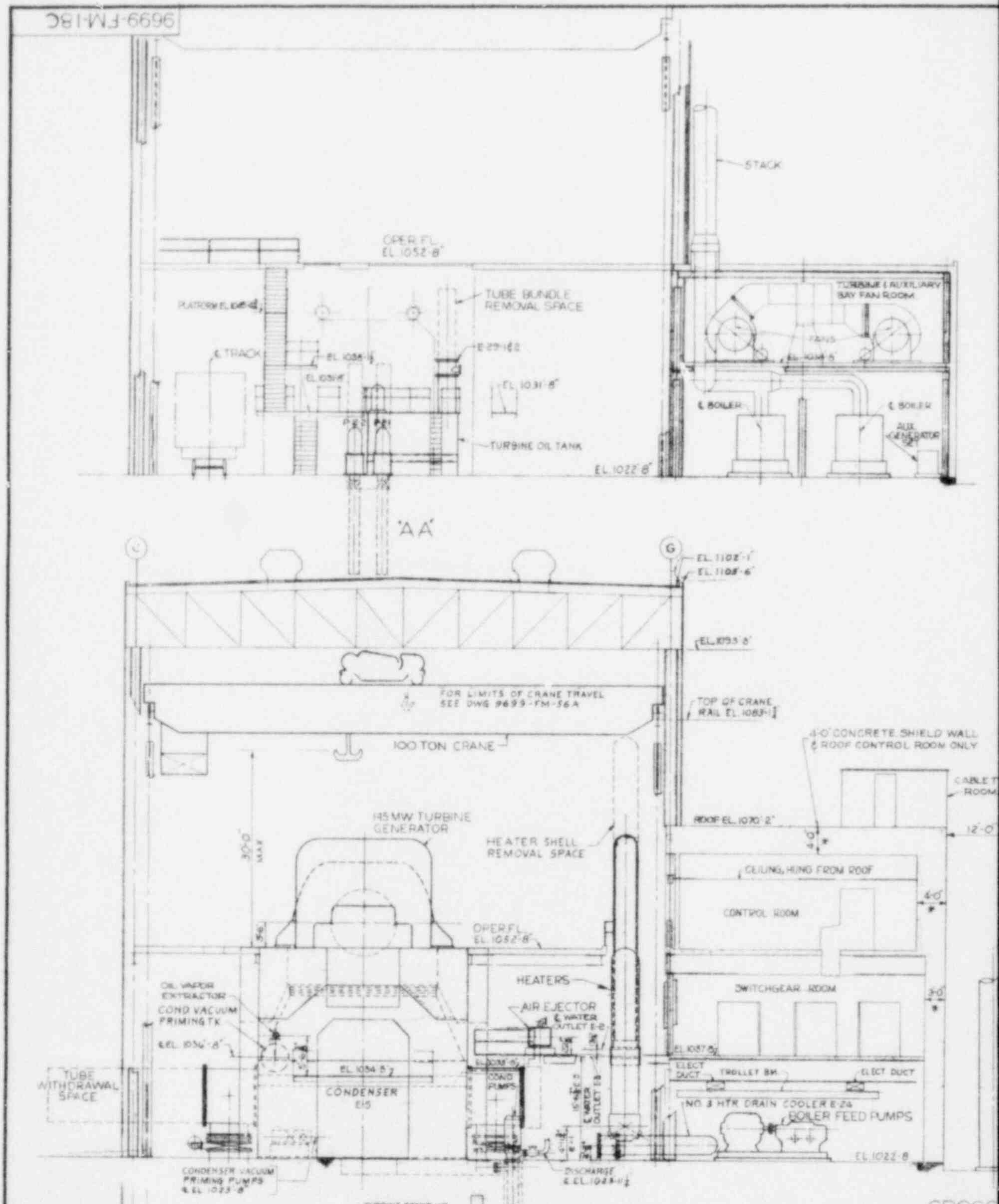
POWER STATION

YANKEE ATOMIC ELECTRIC COMPANY

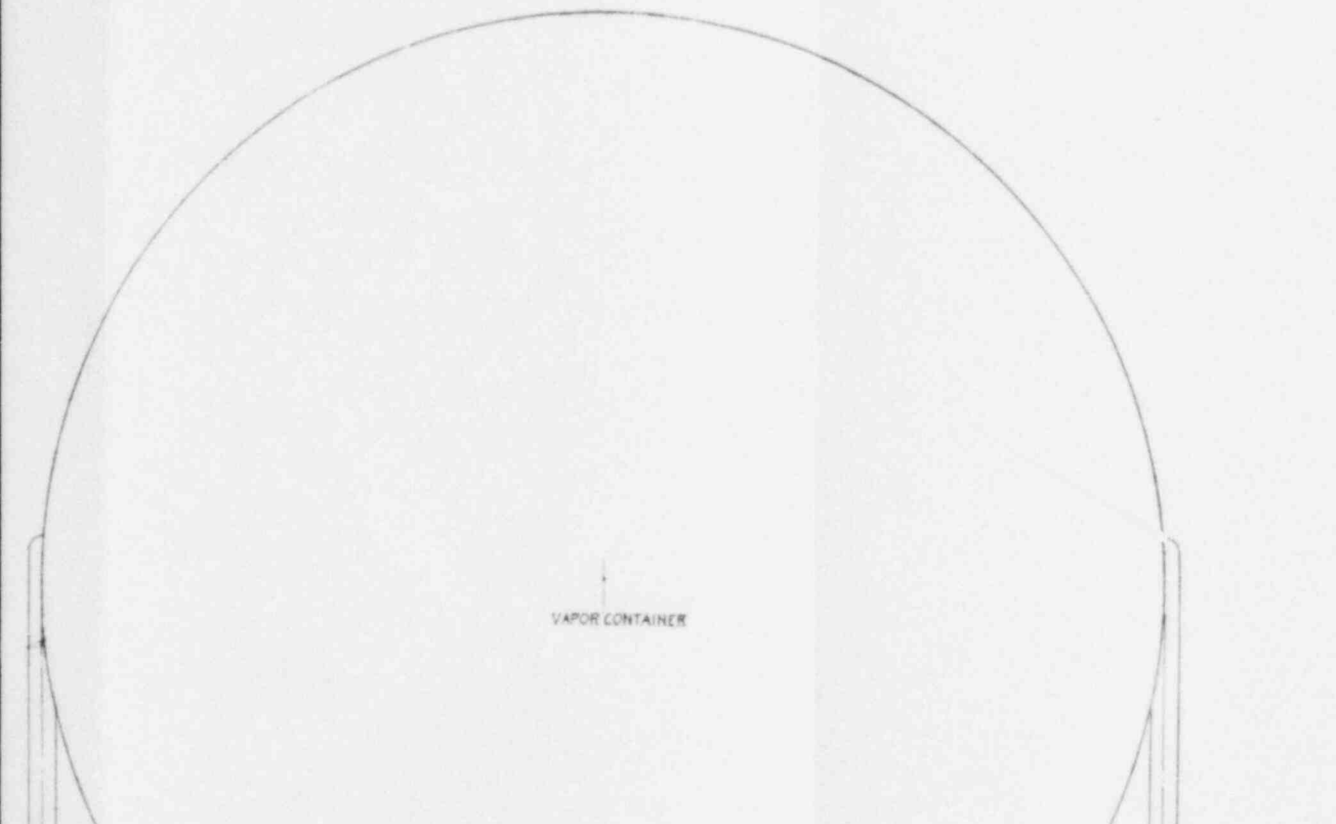
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-18A



9699-FM-18C
STACK
OPER FL.
EL. 1052'-8"
TUBE BUNDLE
REMOVAL SPACE
TURBINE & AUXILIARY
BAY FAN ROOM
FANS
℄ TRACK
EL. 1031'-8"
℄ BOILER
℄ BOILER
AUX GENERATOR SET
TURBINE OIL TANK
EL. 1022'-8"
"A-A"
EL. 1102'-1"
EL. 1108'-6"
EL. 1093'-8"
FOR LIMITS OF CRANE TRAVEL
SEE DWG 9699-FM-56A
TOP OF CRANE
RAIL EL. 1083'-1½"
100 TON CRANE
4'-0" CONCRETE SHIELD WALL
& ROOF CONTROL ROOM ONLY
CABLE
ROOM
ROOF EL. 1070'-2"
12'-0"
145 MW TURBINE
GENERATOR
HEATER SHELL
REMOVAL SPACE
CEILING HUNG FROM ROOF
CONTROL ROOM
4'-0"
OPER FL.
EL. 1052'-8"
OIL VAPOR
EXTRACTOR
HEATERS
COND VACUUM
PRIMING TK
AIR EJECTOR
SWITCHGEAR ROOM
TUBE
WITHDRAWAL
SPACE
CONDENSER
E15
COND
PUMPS
ELECT
DUCT
TROLLEY BM.
ELECT DUCT
NO. 3 HTR DRAIN COOLER E-24
BOILER FEED PUMPS
EL. 1022'-8"
CONDENSER VACUUM
PRIMING PUMPS
DISCHARGE
TURBINE START-UP
PANEL
CROSS
EL. 1052'-8"
℄ UNIT
℄ MOISTURE
SEPARATOR
GLAND
STEAM COND.
EL. 1037'-8"
DRAIN
TANK
EL. 1022'-8"
"B-B"
NOTES
FOR MACHINE LOCATION PLA
FOR MACHINE LOCATION PLA
FOR MACHINE LOCATION PLA
FOR PLOT PLAN SEE DWG. N
FOR MACH LOC PLANS SH



SECTION
SCALE $\frac{1}{8}$"=1'-0"

* MINIMUM THICKNESS REQUIRED FOR SHIELDING

N OPERATING FLOOR SEE DWG. NO. 9699-FM18A
N MEZZANINE FLOOR SEE DWG. NO. 9699-FM18D
N GROUND FLOOR SEE DWG. NO. 9699-FM18B
O. 9699-FY-6A
VAPOR CONTAINER SEE DWG. NO. 9699-FM-1A

ISSUE	DESCRIPTION	CHKD	INSP	CORR	APPR
5	ELEVATIONS, NOTE & EQUIPMENT ADDED. HOLDS REMOVED	WCB	[illegible]		
4	DIMENSIONS CHANGED. SIZE OF CRANE CHANGED. DWG ADDED. ELECT. DUCT ADDED. RAILROAD TRACK ADDED. EQUIP. ADDED.	WCB	[illegible]	[illegible]	[illegible]
3	DIMENS. LOCATING EQUIPMENT ADDED & MINOR CHANGES	WCB	[illegible]	[illegible]	[illegible]
2	GENERAL REVISION	WCB	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	GOB	[illegible]	[illegible]	[illegible]

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER NO. 558
COMMONWEALTH OF MASSACHUSETTS

COMMONWEALTH OF MASSACHUSETTS
WALTER C. WOODMAN
No. 558
REGISTERED PROFESSIONAL ENGINEER

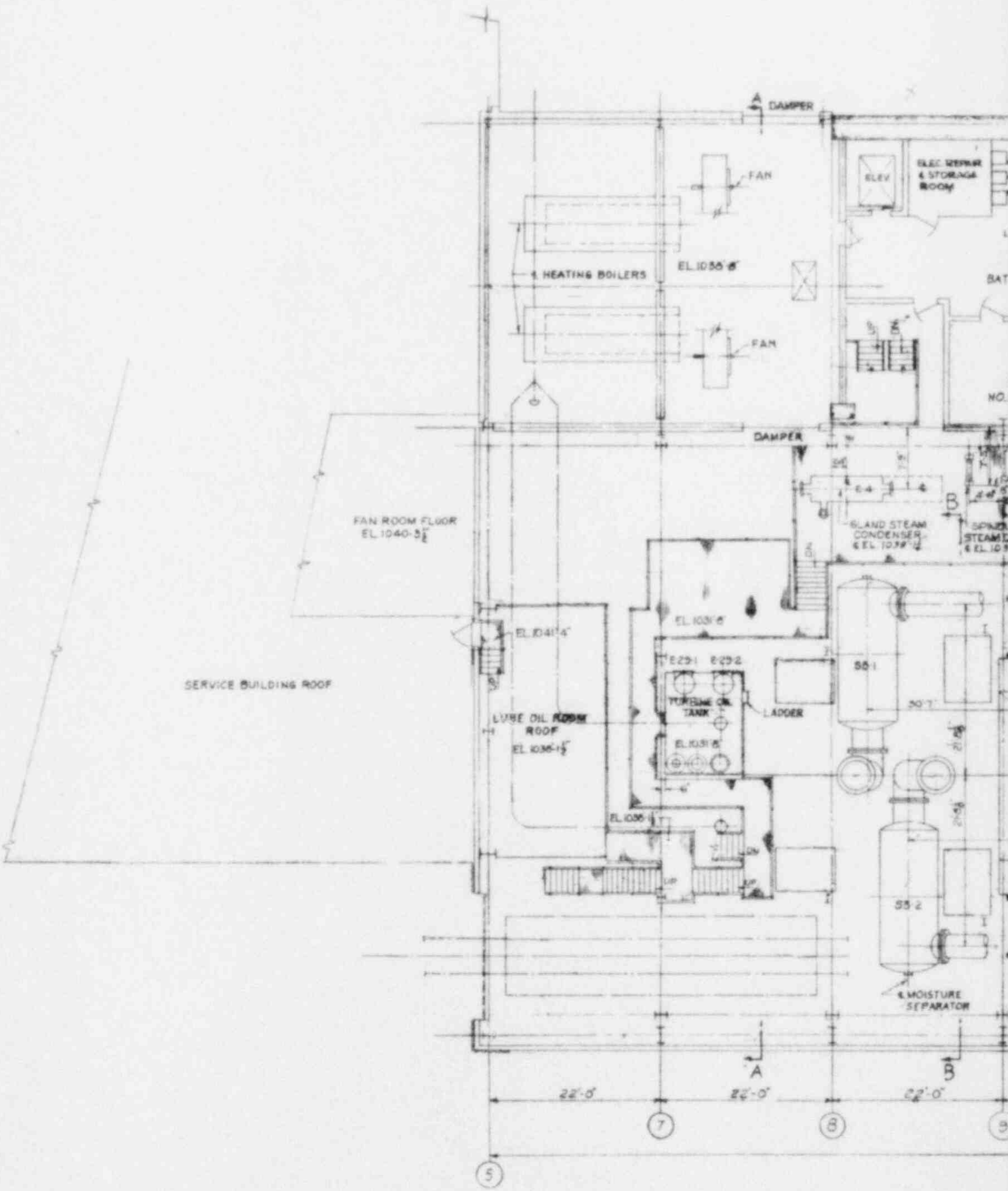
MACHINE LOCATION — SECTIONS
TURBINE ROOM

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

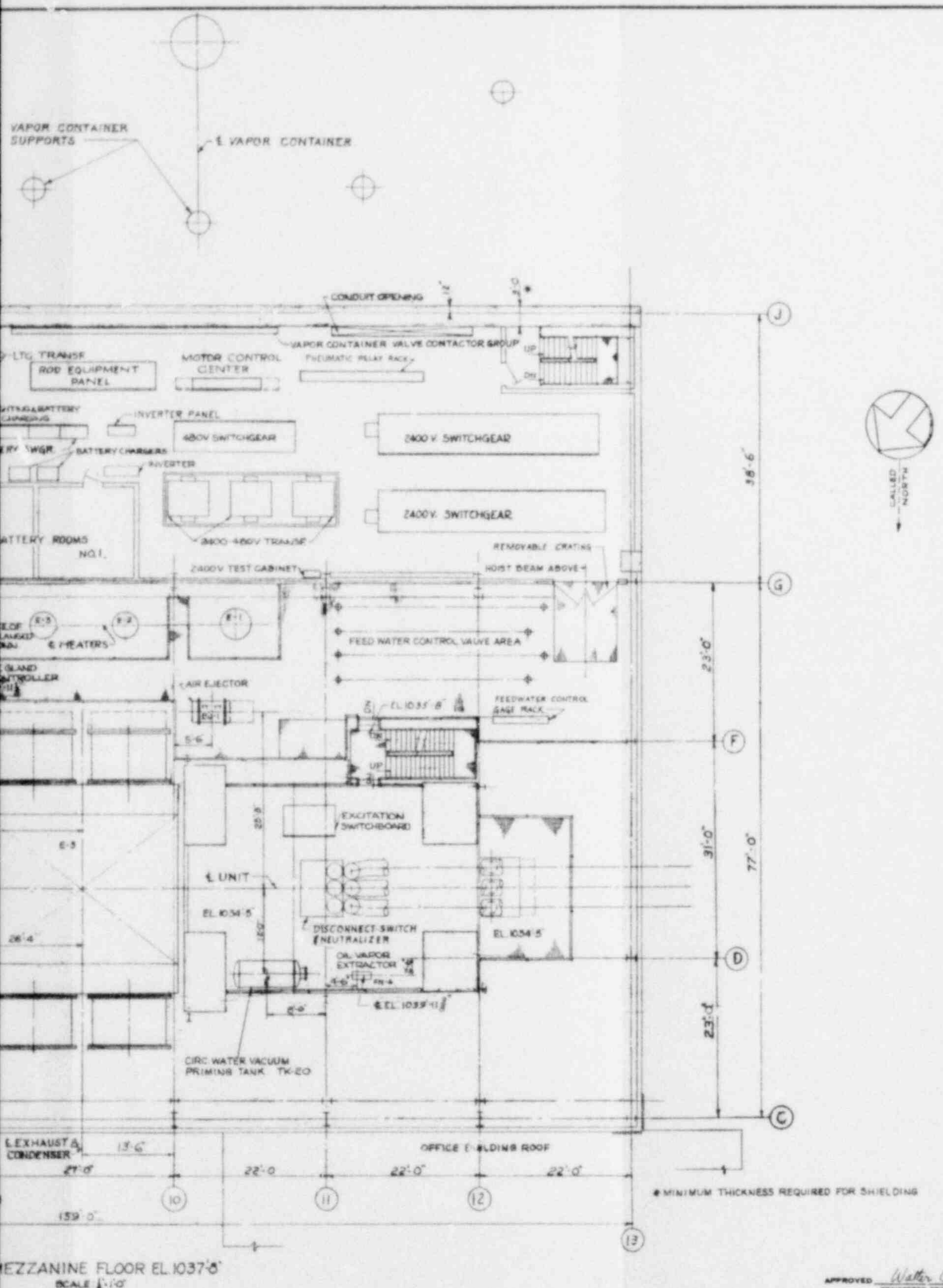
STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-18C

9699-FM-18D



NOTES
FOR MACHINE LOCATION PLAN
FOR MACHINE LOCATION PLAN
FOR MACHINE LOCATION-SECT
FOR PLOT PLAN SEE DWG. NO
FOR MACH. LOC. PLANS SH. N



* MINIMUM THICKNESS REQUIRED FOR SHIELDING

MEZZANINE FLOOR EL.1037'8"
SCALE 1/8"=1'0"

OPERATING FLOOR SEE DWG NO.9699-FM-18A
GROUND FLOOR SEE DWG NO.9699-FM-18B
IONS - SEE DWG NO 9699-FM-18C
9699-FY-6A
O.1 VAPOR CONTAINER SEE DWG 9699-FM-1A

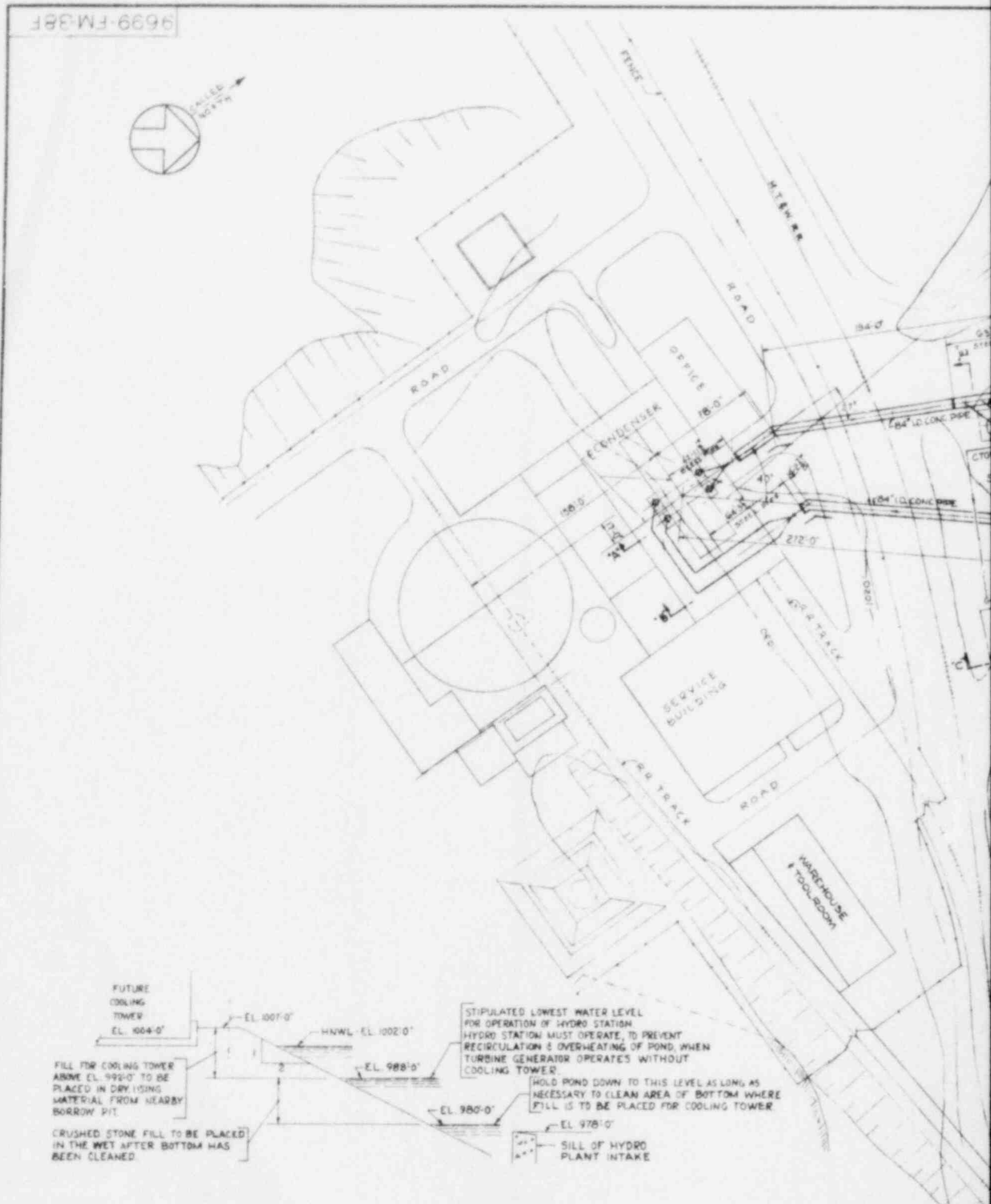
APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER, NO 5?8
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5	EQUIPMENT NAMES CHANGED DIMENSIONS ADDED	[illegible] WB	[illegible]		
4	EQUIPMENT ADDED [illegible] EQUIPMENT CHANGED, MINOR CHANGES PLATFORM ADDED	[illegible] WB	[illegible]	[illegible]	[illegible]
3	DIMENS LOCATING EQUIPMENT ADDED B.P. CONT. PANEL ADDED & MINOR CHANGES	[illegible] WB	[illegible]	[illegible]	[illegible]
2	GENERAL REVISION	[illegible] WB	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible] WB	[illegible]	[illegible]	[illegible]

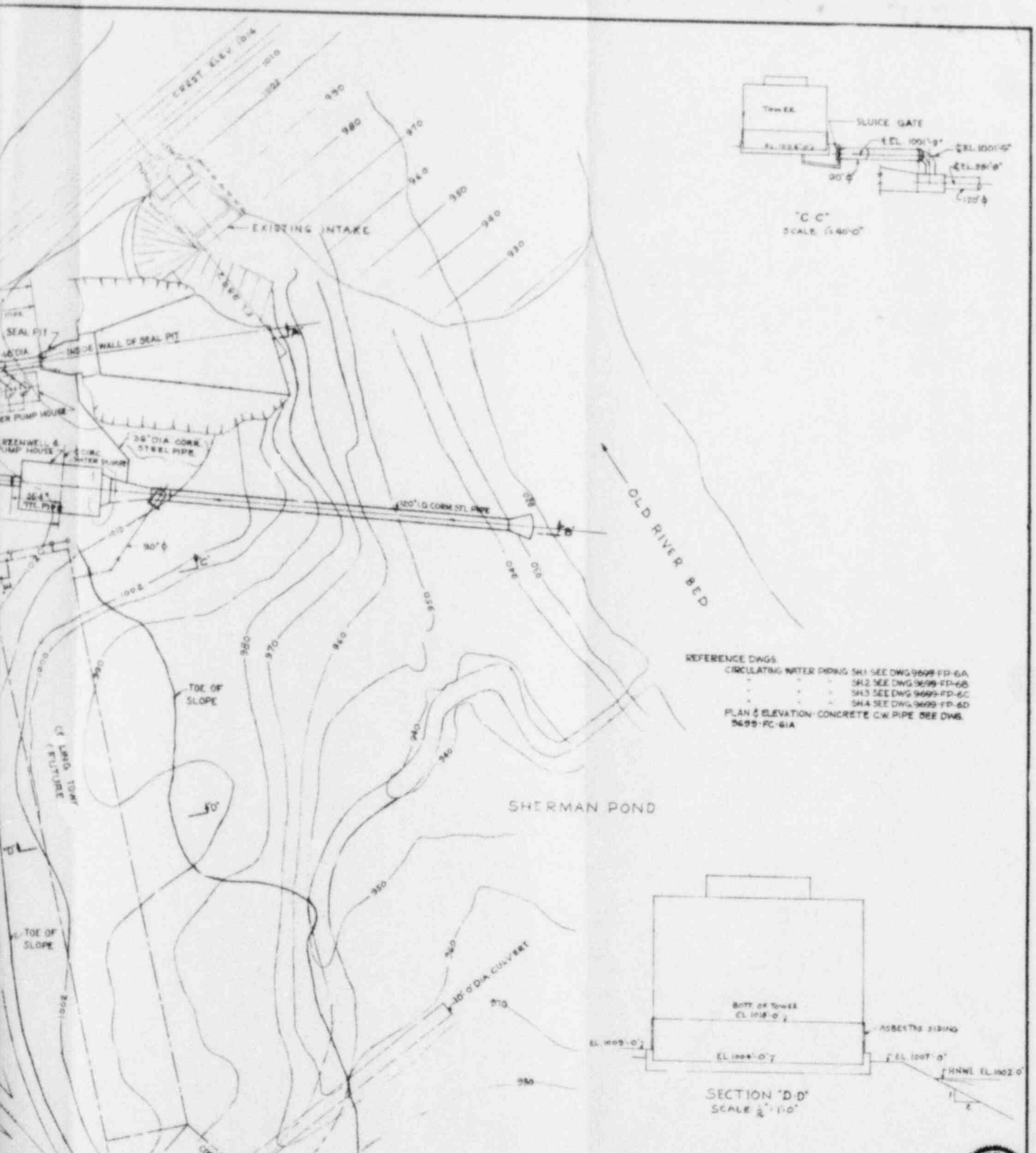
MACHINE LOCATION PLAN
MEZZANINE FLOOR-TURBINE ROO..
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-18D



PLAN
SCALE 1"=40'-0"



REFERENCE DWGS.
CIRCULATING WATER PIPING SH.1 SEE DWG 9699-FP-6A
SH.2 SEE DWG 9699-FP-6B
SH.3 SEE DWG 9699-FP-6C
SH.4 SEE DWG 9699-FP-6D
PLAN & ELEVATION - CONCRETE C.W. PIPE SEE DWG. 9699-FC-61A

NOTE:-
FOR SECTIONS "A-A", "B-B" & "E-E" SEE CIRCULATING WATER SYSTEM - SECTIONS - SEE DWG NO. 9699-FM-38

APPROVED Fred A. Sawyer
REGISTERED PROFESSIONAL ENGINEER NO. 7979
COMMONWEALTH OF MASSACHUSETTS

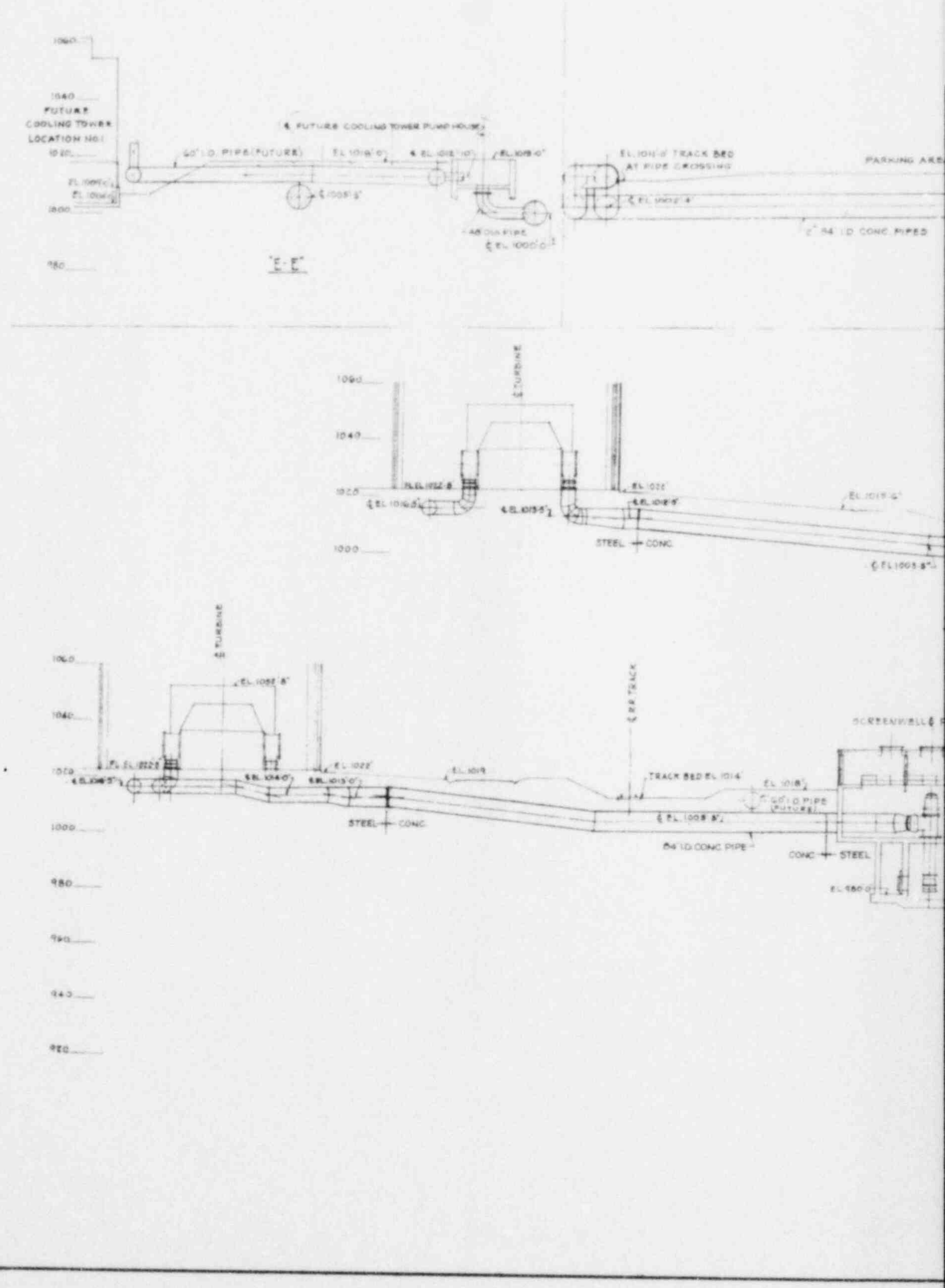
ISSUE	DESCRIPTION	CHKD	INSP	CORR	APPR
5					
4					
3					
2	PIPE SIZE CHANGED, SCREEN WELL REVISED				
1	ORIGINAL ISSUE				

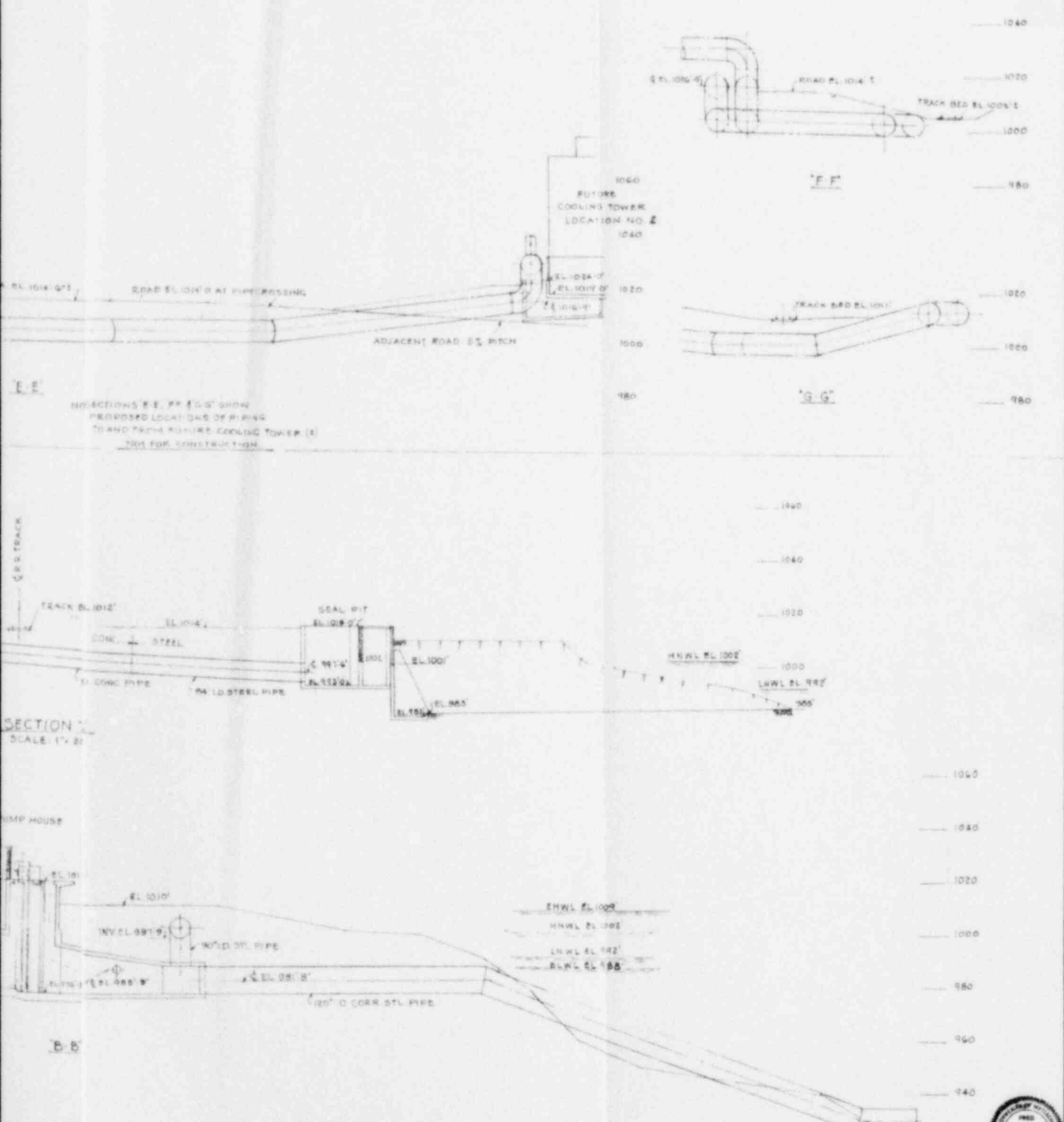
CIRCULATING WATER SYSTEM PLAN

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-38F


FUTURE COOLING TOWER LOCATION NO.1
℄ FUTURE COOLING TOWER PUMP HOUSE
60" I.D. PIPE (FUTURE)
48 DIA PIPE
"E-E"
EL. 1011-0" TRACK BED AT PIPE CROSSING
PARKING AREA
84" I.D. CONC. PIPES
℄ TURBINE
STEEL
CONC.
℄ R.R. TRACK
TRACK BED EL. 1014'
84" I.D. CONC. PIPE
SCREENWELL
1060
1040
1020
1000
980
960
940
920



NOTE:-
FOR LOCATION OF SECTIONS SEE CIRCULATING WATER SYSTEM-PLAN- DWG NO. 9699-FM-38F

APPROVED Fred A. Sawyer
REGISTERED PROFESSIONAL ENGINEER NO. 7878
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5					
4					
3					
2	SCREENWELL REVISED, PIPE EL. CHANGED				
1	ORIGINAL ISSUE				

CIRCULATING WATER SYSTEM SECTIONS

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

SCALE: 1" = 20'-0"

DRAWING NUMBER 9699-FM-38J

Condenser circulating water is taken from nearby Sherman Pond, one of a series of lakes in the controlled Deerfield River system, and is piped from the Circulating Water Pump House, underground to the condenser, thence underground to the seal pit where it is discharged back into the pond near the Sherman Hydroelectric Plant intake.

The arrangement of equipment and piping is shown diagrammatically on flow diagrams included with the descriptions of the individual systems of the secondary plant.

The component parts of the secondary plant are of type conventionally used in large central stations, arranged to provide the best possible thermal economy of reactor plant output without sacrifice of safety or economy.

The expected turbine heat rate at 1.5 in. Hg abs back pressure is 11,283 Btu per kw-hr. at the 185 MWe load. The average auxiliary power requirement at this load is expected to be 9,350 KW. The expected station heat rate at the 185 MWe load is 11,900 Btu per kw-hr.

Complete heat balance data are given on the following drawings:

9699-FM-45A - Heat Balance Diagram - 157 MW Load

9699-FM-45B - Heat Balance Diagram - 145 MW Load

9699-FM-45C - Heat Balance Diagram - 125 MW Load

9699-FM-45D - Heat Balance Diagram - 72 MW Load

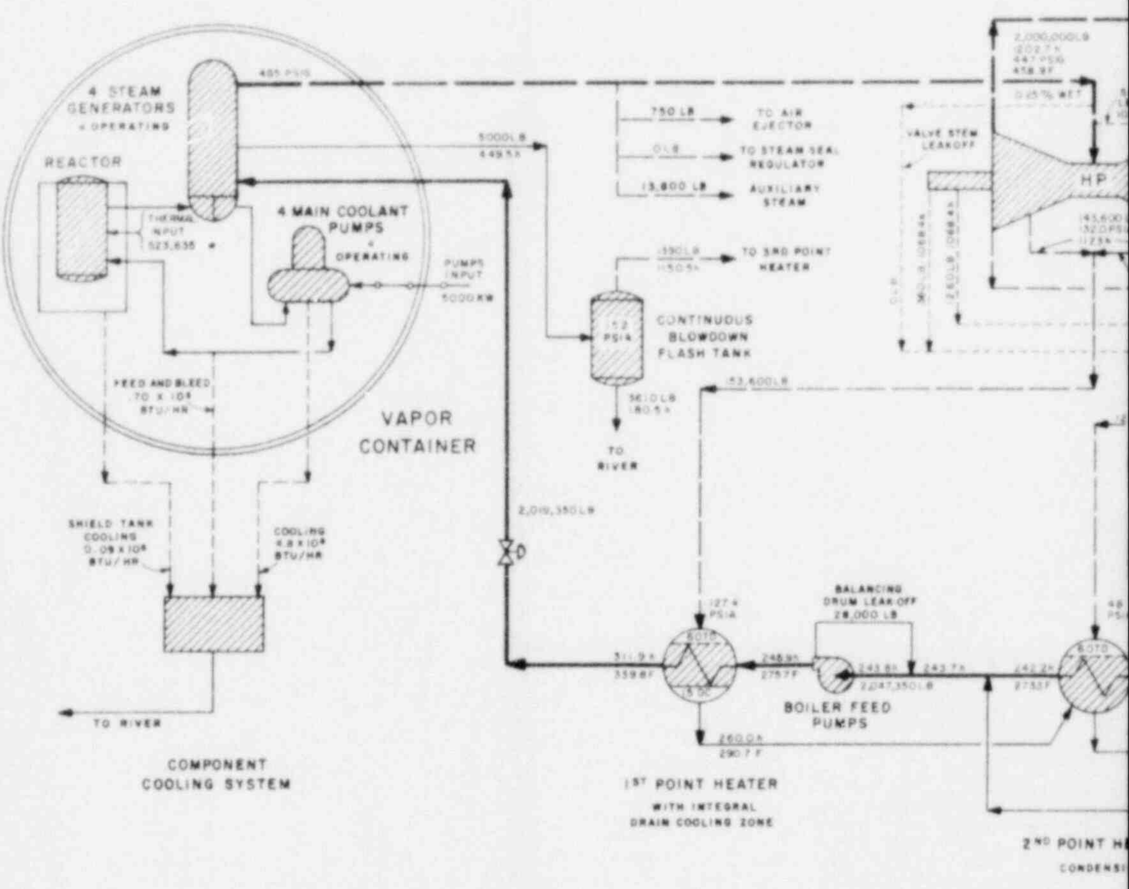
9699-FM-45E - Heat Balance Diagram - 111 MW Load

9699-FM-45F - Heat Balance Diagram - 170 MW Load

9699-FM-45H - Heat Balance Diagram - 185 MW Load

The secondary plant is designed primarily for the 145 MW rated capability of the turbine generator. However, it was recognized that the unit possessed higher gross capability and that design margins applied to the secondary plant auxiliary equipment were adequate to permit a gross turbine capability of more than 185 MW.

9699 FM-45A



BASIS OF HEAT BALANCE CALCULATIONS

STEAM LOSSES - 5000 LB AT ALL LOADS
STEAM GENERATOR BLOWDOWN .25 % OF STEAM GENERATION
STEAM GENERATOR OUTLET PRESSURE AND THROTTLE PRESSURE TAKEN FROM CURVE YAE-43
EXTRACTION LINE PRESSURE DROPS CALCULATED AT 1,840,000 LB/HR THROTTLE FLOW AND EXPRESSED AS THE FOLLOWING PERCENTAGE OF THE ABSOLUTE PRESSURE AT THE TURBINE CONNECTION TO THE EXTRACTION LINE

LINE	1ST POINT	2ND POINT	3RD POINT
PERCENT	3.5	5.0	4.2

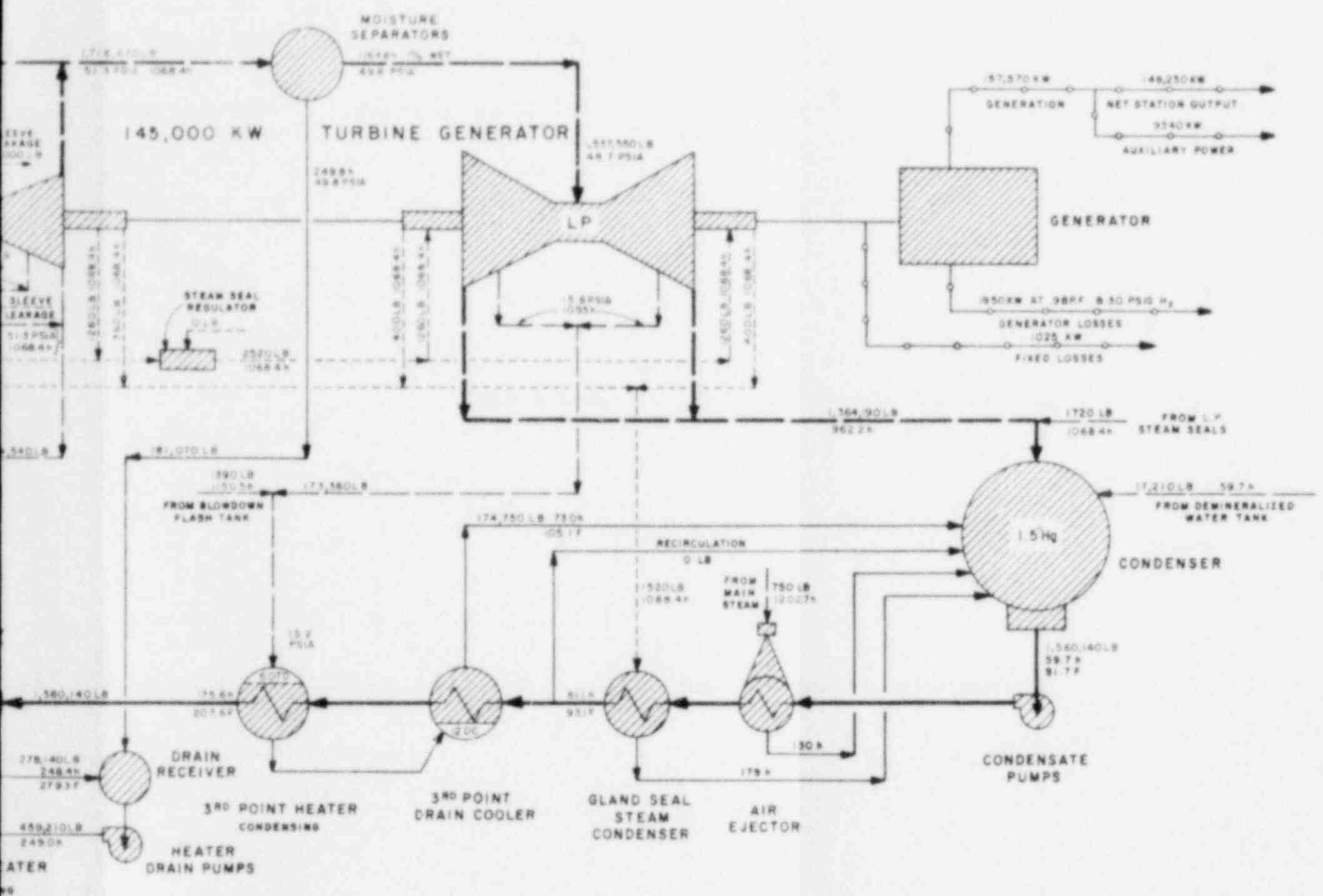
EXTRACTION PRESSURES SHOWN AT OR NEAR TURBINE ARE PRESSURES AT THE TURBINE CONNECTION TO THE EXTRACTION LINE
HEATER ENTRANCE PRESSURES ARE SHOWN OUTSIDE HEATER SYMBOLS
THE PERCENT PRESSURE DROP BETWEEN THE HIGH PRESSURE TURBINE EXHAUST AND LOW PRESSURE TURBINE INLET = 5.0%
THE PERCENT PRESSURE DROP FROM THE HIGH PRESSURE EXHAUST AND THE WATER OUTLET SIDE OF THE MOISTURE SEPARATOR = 3.0%
BASE HEAT BALANCE COMPUTED FOR 1.5" Hg BACK PRESSURE. ALL FLOWS, PRESSURES, TEMPERATURES AND ENTHALPIES REMAIN UNCHANGED AT OTHER BACK PRESSURES EXCEPT AS FOLLOWS: 1 - VALUES SHOWN IN THE TABLE 2 - ENTHALPY AND TEMPERATURE OF CONDENSATE TO AIR EJECTOR, TO GLAND SEAL CONDENSER, TO THE 3RD POINT DRAIN COOLER AND THE 3RD POINT HEATER. 3 - FLOW, ENTHALPY AND TEMPERATURE OF DRAINS FROM THE 3RD POINT DRAIN COOLER
CIRCULATING WATER TEMPERATURES SHOWN ARE THOSE REQUIRED TO PRODUCE BACK PRESSURES SHOWN WITH 138,000 GPM (2 PUMP OPERATION) WITH THE POND ELEVATION 997 FEET; 85,000 GPM (1 PUMP OPERATION) WITH THE POND ELEVATION 992.5 FEET
HEAT BALANCES BASED ON WINTER CONDITIONS
EFFICIENCY OF NUCLEAR STEAM GENERATOR - 99.5%.

AUXILIARY POWER REQUIREMENTS HAVE BEEN CALCULATED FOR ALL EQUIPMENT

THE FOLLOWING ITEMS VARY WITH LOAD
- 3 MAIN CONDENSATE PUMPS, 2 OPERATING
- 3 BOILER FEED PUMPS, 2 OPERATING
- 2 HEATER DRAIN PUMPS, 1 OPERATING

THE FOLLOWING ARE THE IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT FULL LOAD
- 4 MAIN COOLANT PUMPS, 4 OPERATING
- 3 MAIN COOLANT CHARGING PUMPS, 1 OPERATING
- 2 COMPONENT COOLING WATER PUMPS, 1 OPERATING
- 2 MAIN CIRCULATING WATER PUMPS, 2 OPERATING
- 3 SERVICE WATER PUMPS, 2 OPERATING
- 2 CONTROL AIR COMPRESSORS, 1 OPERATING
- 4 VAPOR CONTAINER AIR COOLER FANS, 4 OPERATING
- 1 FUEL PIT PUMP
- 2 PURIFICATION COOLING AND DRAIN PUMPS, 1 OPERATING
- 48 PRESSURIZER HEATERS, 2 OPERATING
- LIGHTING AND INSTRUMENTS

THE FOLLOWING ARE ADDITIONAL IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT 15% OF FULL LOAD FOR INTERMITTENT SERVICE
- 2 LOW PRESSURE SURGE TANK MAKE-UP PUMPS, 1 OPERATING
- 2 CIRCULATING WATER PRIMING PUMPS, 1 OPERATING
- 1 SERVICE AIR COMPRESSOR
- 2 ELEVATORS, 1 OPERATING
- 2 BATTERY CHARGERS, 2 OPERATING
- 1 TURBINE ROOM CRANE



LEGEND

— — —	STEAM
———	WATER
—o——o—	POWER
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR.
TD	TERMINAL DIFFERENCE, DEGREES FAHR.
DC	TERM. DIFF. OF DRAIN COOLER, DEGREES FAHR.
KW	KILOWATTS
"Hg	PRESSURE, IN. OF MERCURY ABS.
PSIA	PRESSURE, LB. PER SQ. INCH ABS.
PSIG	PRESSURE, LB. PER SQ. INCH GAGE.

$$\text{TURBINE HEAT RATE} = \frac{3412.75(157,570 + 1950 + 1025) + 1,364,190(962.2 - 59.7) + 174,750(73.0 - 59.7) + 1720(1068.4 - 59.7)}{157,570} = 11,315 \text{ BTU PER KWH}$$

CONDENSER BACK PRESSURE "Hg	3RD POINT HEATER EXTRACTION FLOW LB	TURBINE EXHAUST FLOW LB	TURBINE EXHAUST ENTHALPY BTU/LB	GENERATION KW	NET STATION OUTPUT KW	TURBINE HEAT RATE BTU/KWH	STATION HEAT RATE BTU/KWH	CIRCULATING WATER TEMP 2 PUMPS F
4.0	126,260	1,411,290	1001.6	143,165	133,825	12,455	13,485	–
3.5	135,050	1,404,500	994.2	145,985	136,645	12,215	13,205	89.5
3.0	141,050	1,396,500	987.3	148,530	139,190	12,005	12,960	83.5
2.5	149,950	1,387,600	978.9	151,620	142,280	11,760	12,680	76.5
2.0	160,510	1,377,040	970.4	154,715	145,375	11,525	12,410	69.0
1.5	173,360	1,364,190	962.2	157,570	148,230	11,315	12,170	56.5
1.0	190,250	1,347,300	955.2	159,710	150,370	11,165	11,995	38.5
0.75	201,550	1,336,000	958	158,090	148,750	11,280	12,125	–

ISSUE	DESCRIPTION	CHKD	INSP	ORD	APPR
5					
4					
3					
2					
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	

HEAT BALANCE DIAGRAM-157 MW LOAD
MAXIMUM CAPABILITY FOR DESIGN

POWER STATION

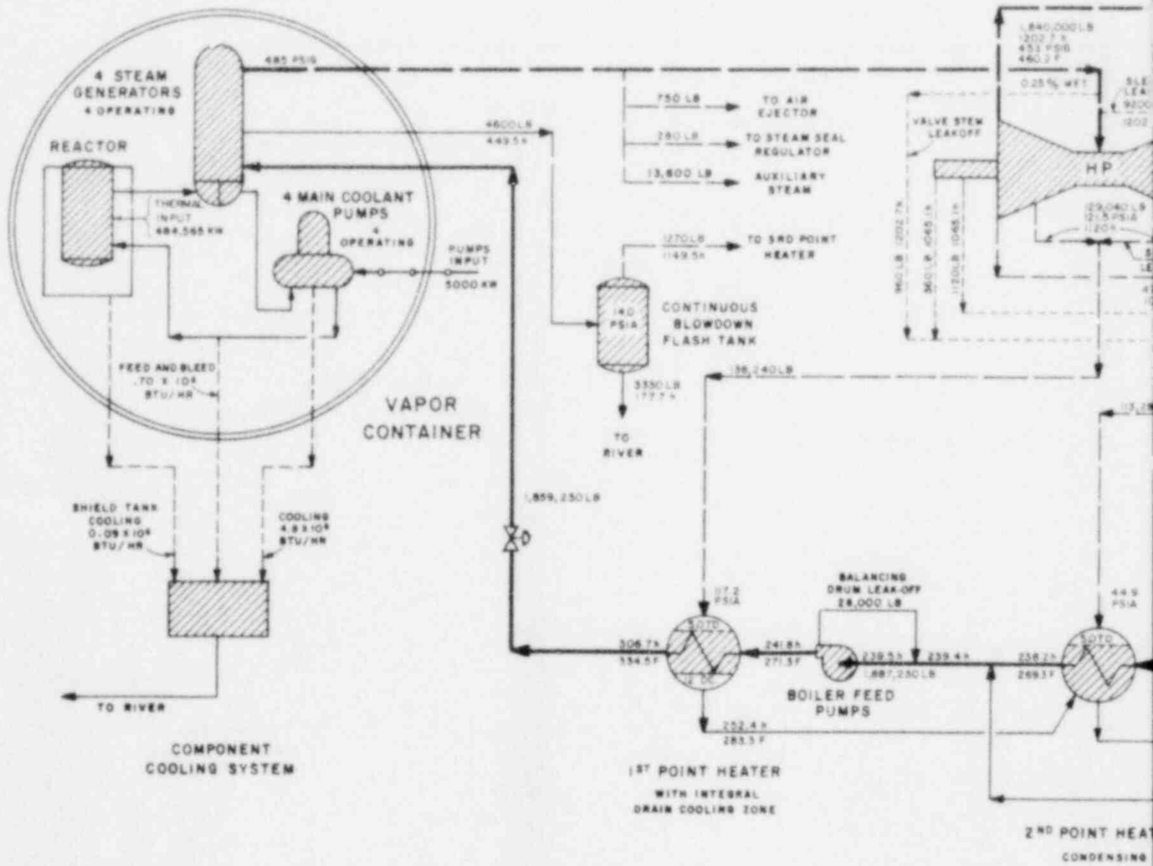
YANKEE ATOMIC ELECTRIC COMPANY

ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699 FM-45A

9699 FM-45B



BASIS OF HEAT BALANCE CALCULATIONS

STEAM LOSSES - 5000 LB AT ALL LOADS
STEAM GENERATOR BLOWDOWN .25% OF STEAM GENERATION
STEAM GENERATOR OUTLET PRESSURE AND THROTTLE PRESSURE TAKEN FROM CURVE YAE-42
EXTRACTION LINE PRESSURE DROPS CALCULATED AT 1,840,000 LB/HR THROTTLE FLOW AND EXPRESSED AS THE FOLLOWING PERCENTAGE OF THE ABSOLUTE PRESSURE AT THE TURBINE CONNECTION TO THE EXTRACTION LINE

LINE	1ST POINT	2ND POINT	3RD POINT
PERCENT	3.5	5.0	4.2

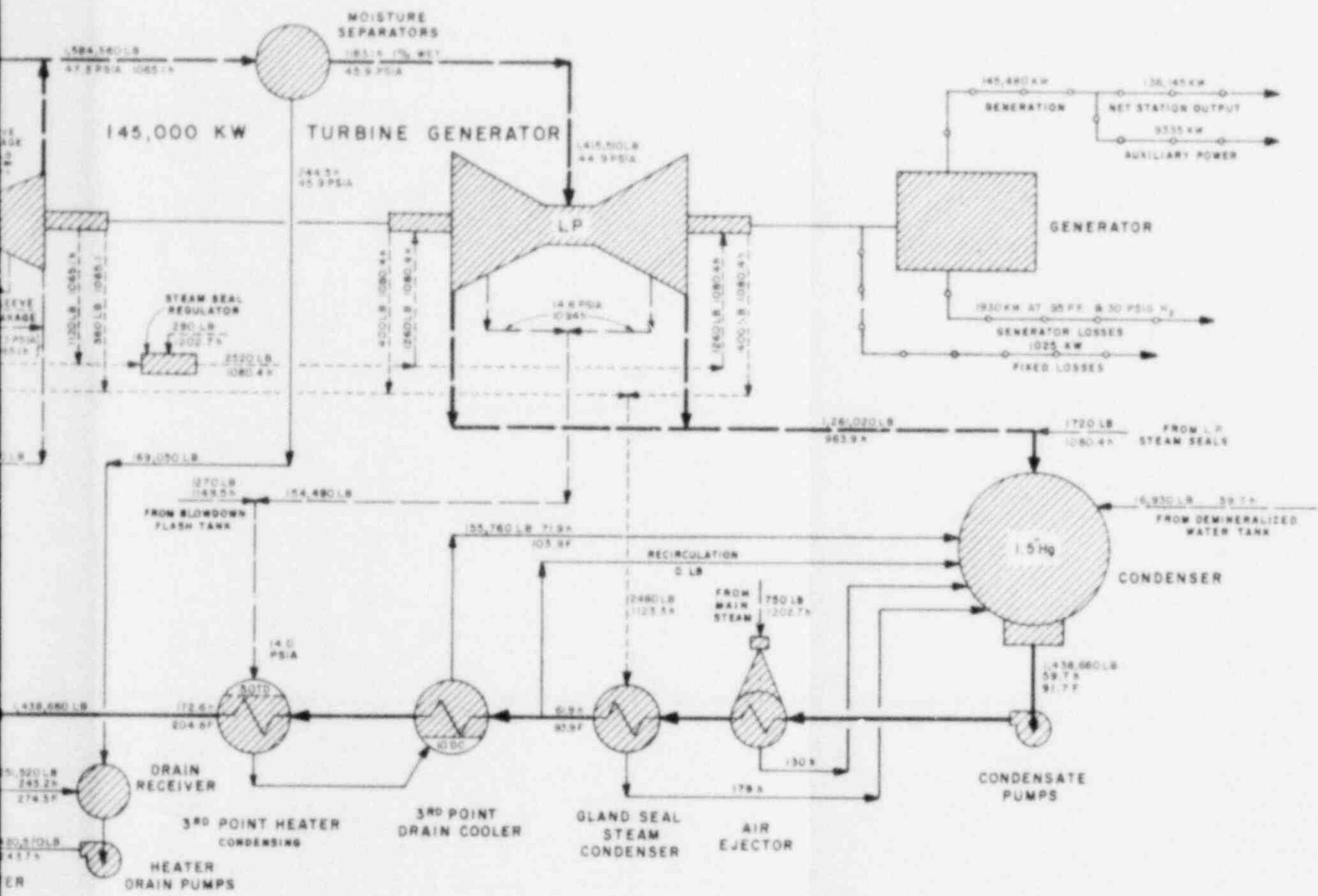
EXTRACTION PRESSURES SHOWN AT OR NEAR TURBINE ARE PRESSURES AT THE TURBINE CONNECTION TO THE EXTRACTION LINE
HEATER ENTRANCE PRESSURES ARE SHOWN OUTSIDE HEATER SYMBOLS
THE PERCENT PRESSURE DROP BETWEEN THE HIGH PRESSURE TURBINE EXHAUST AND LOW PRESSURE TURBINE INLET = 5.0%
THE PERCENT PRESSURE DROP FROM THE HIGH PRESSURE EXHAUST AND THE WATER OUTLET SIDE OF THE MOISTURE SEPARATOR = 3.0%
BASE HEAT BALANCE COMPUTED FOR 1.5" Hg BACK PRESSURE. ALL FLOWS, PRESSURES, TEMPERATURES AND ENTHALPIES REMAIN UNCHANGED AT OTHER BACK PRESSURES EXCEPT AS FOLLOWS: 1 - VALUES SHOWN IN THE TABLE. 2 - ENTHALPY AND TEMPERATURE OF CONDENSATE TO AIR EJECTOR, TO GLAND SEAL CONDENSER, TO THE 3RD POINT DRAIN COOLER AND THE 3RD POINT HEATER. 3 - FLOW, ENTHALPY AND TEMPERATURE OF DRAINS FROM THE 3RD POINT DRAIN COOLER.
CIRCULATING WATER TEMPERATURES SHOWN ARE THOSE REQUIRED TO PRODUCE BACK PRESSURES SHOWN WITH 138,000 GPM (2 PUMP OPERATION) WITH THE POND ELEVATION 997 FEET; 85,000 GPM (1 PUMP OPERATION) WITH THE POND ELEVATION 992.5 FEET.
HEAT BALANCES BASED ON WINTER CONDITIONS
EFFICIENCY OF NUCLEAR STEAM GENERATOR - 99.5%

AUXILIARY POWER REQUIREMENTS HAVE BEEN CALCULATED FOR ALL EQUIPMENT

THE FOLLOWING ITEMS VARY WITH LOAD
- 3 MAIN CONDENSATE PUMPS, 2 OPERATING
- 3 BOILER FEED PUMPS, 2 OPERATING
- 2 HEATER DRAIN PUMPS, 1 OPERATING

THE FOLLOWING ARE THE IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT FULL LOAD
- 4 MAIN COOLANT PUMPS, 4 OPERATING
- 3 MAIN COOLANT CHARGING PUMPS, 1 OPERATING
- 2 COMPONENT COOLING WATER PUMPS, 1 OPERATING
- 2 MAIN CIRCULATING WATER PUMPS, 2 OPERATING
- 3 SERVICE WATER PUMPS, 2 OPERATING
- 2 CONTROL AIR COMPRESSORS, 1 OPERATING
- 4 VAPOR CONTAINER AIR COOLER FANS, 4 OPERATING
- 1 FUEL PIT PUMP
- 2 PURIFICATION COOLING AND DRAIN PUMPS, 1 OPERATING
- 48 PRESSURIZER HEATERS, 2 OPERATING
- LIGHTING AND INSTRUMENTS

THE FOLLOWING ARE ADDITIONAL IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT 15% OF FULL LOAD FOR INTERMITTENT SERVICE
- 2 LOW PRESSURE SURGE TANK MAKE-UP PUMPS, 1 OPERATING
- 2 CIRCULATING WATER PRIMING PUMPS, 1 OPERATING
- 1 SERVICE AIR COMPRESSOR
- 2 ELEVATORS, 1 OPERATING
- 2 BATTERY CHARGERS, 2 OPERATING
- 1 TURBINE ROOM CRANE



LEGEND

— — —	STEAM
———	WATER
—o—o—	POWER
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR.
TD	TERMINAL DIFFERENCE, DEGREES FAHR.
DC	TERM DIFF. OF DRAIN COOLER, DEGREES FAHR.
KW	KILOWATTS
"Hg	PRESSURE, IN. OF MERCURY ABS.
PSIA	PRESSURE, LB. PER SQ. INCH ABS.
PSIG	PRESSURE, LB. PER SQ. INCH GAGE

$$\text{TURBINE HEAT RATE} = \frac{3412.75(145{,}480 + 1930 + 1025) + 1{,}261{,}020(963.9 - 59.7) + 155{,}760(71.9 - 59.7) + 1720(1080.4 - 59.7)}{145{,}480} = 11{,}345 \text{ BTU PER KWH}$$

CONDENSER BACK PRESSURE "Hg	3RD POINT HEATER EXTRACTION FLOW LB	TURBINE EXHAUST FLOW LB	TURBINE EXHAUST ENTHALPY BTU/LB	GENERATION KW	NET STATION OUTPUT KW	TURBINE HEAT RATE BTU/KWH	STATION HEAT RATE BTU/KWH	CIRCULATING WATER TEMP 2 PUMPS F
4.0	110,880	1,304,650	1006.0	131,245	121,910	12,575	13,705	–
3.5	117,160	1,298,350	998.3	133,970	124,635	12,320	13,405	–
3.0	124,560	1,290,950	990.7	136,610	127,275	12,080	13,125	86.0
2.5	132,790	1,282,720	981.9	139,625	130,290	11,820	12,825	79.5
2.0	142,600	1,272,910	973.2	142,505	133,170	11,580	12,545	71.0
1.5	154,490	1,261,020	963.9	145,480	136,145	11,345	12,270	60.0
1.0	170,100	1,245,410	955.7	147,845	138,510	11,165	12,060	43.0
0.75	180,580	[illegible]	956.7	147,070	137,735	11,220	12,130	–

ISSUE	DESCRIPTION	CHKD	INSP	COOR	APPR
5					
4					
3					
2					
1	ORIGINAL ISSUE				

HEAT BALANCE DIAGRAM-145MW LOAD

POWER STATION

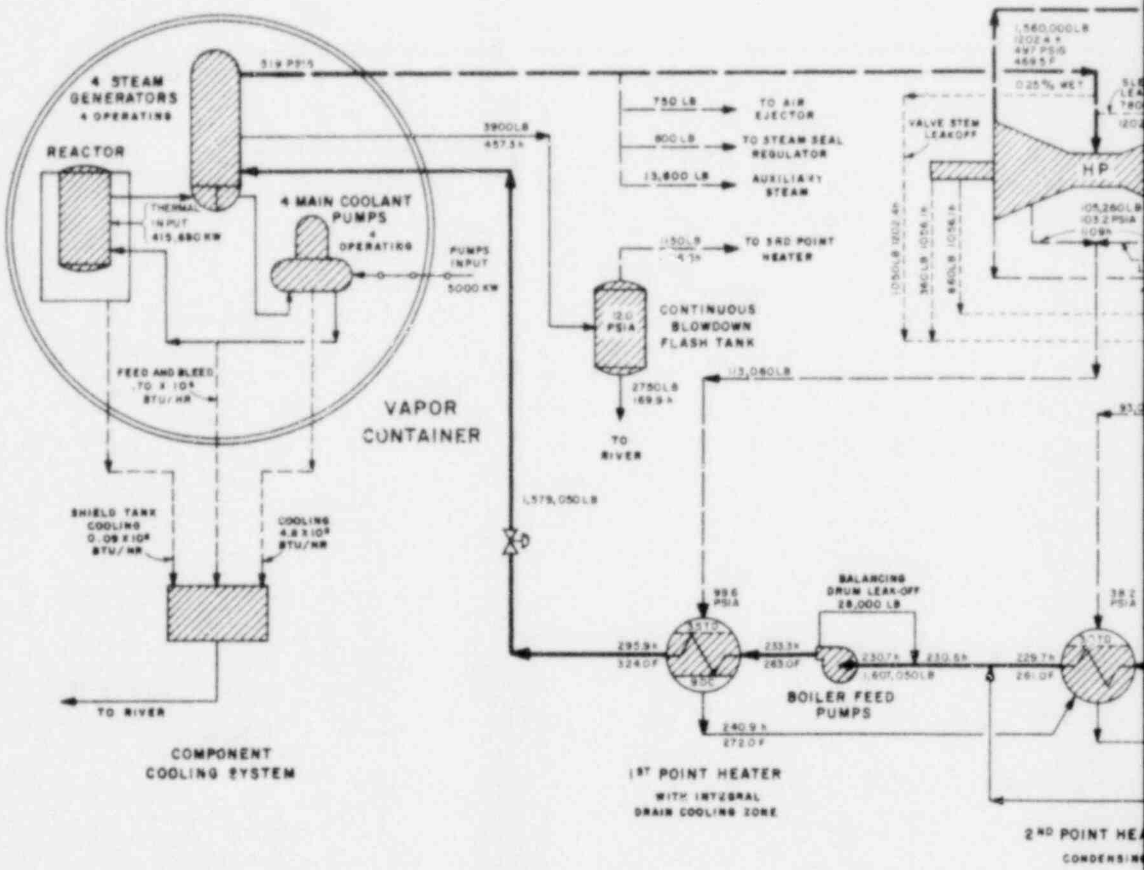
YANKEE ATOMIC ELECTRIC COMPANY

ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699 FM-45B

9699 FM-45C



BASIS OF HEAT BALANCE CALCULATIONS

STEAM LOSSES - 5000 LB AT ALL LOADS
STEAM GENERATOR BLOWDOWN .25% OF STEAM GENERATION
STEAM GENERATOR OUTLET PRESSURE AND THROTTLE PRESSURE TAKEN FROM CURVE YAE-42
EXTRACTION LINE PRESSURE DROPS CALCULATED AT 1,840,000 LB/HR THROTTLE FLOW AND EXPRESSED AS THE FOLLOWING PERCENTAGE OF THE ABSOLUTE PRESSURE AT THE TURBINE CONNECTION TO THE EXTRACTION LINE

LINE	1ST POINT	2ND POINT	3RD POINT
PERCENT	3.5	5.0	4.2

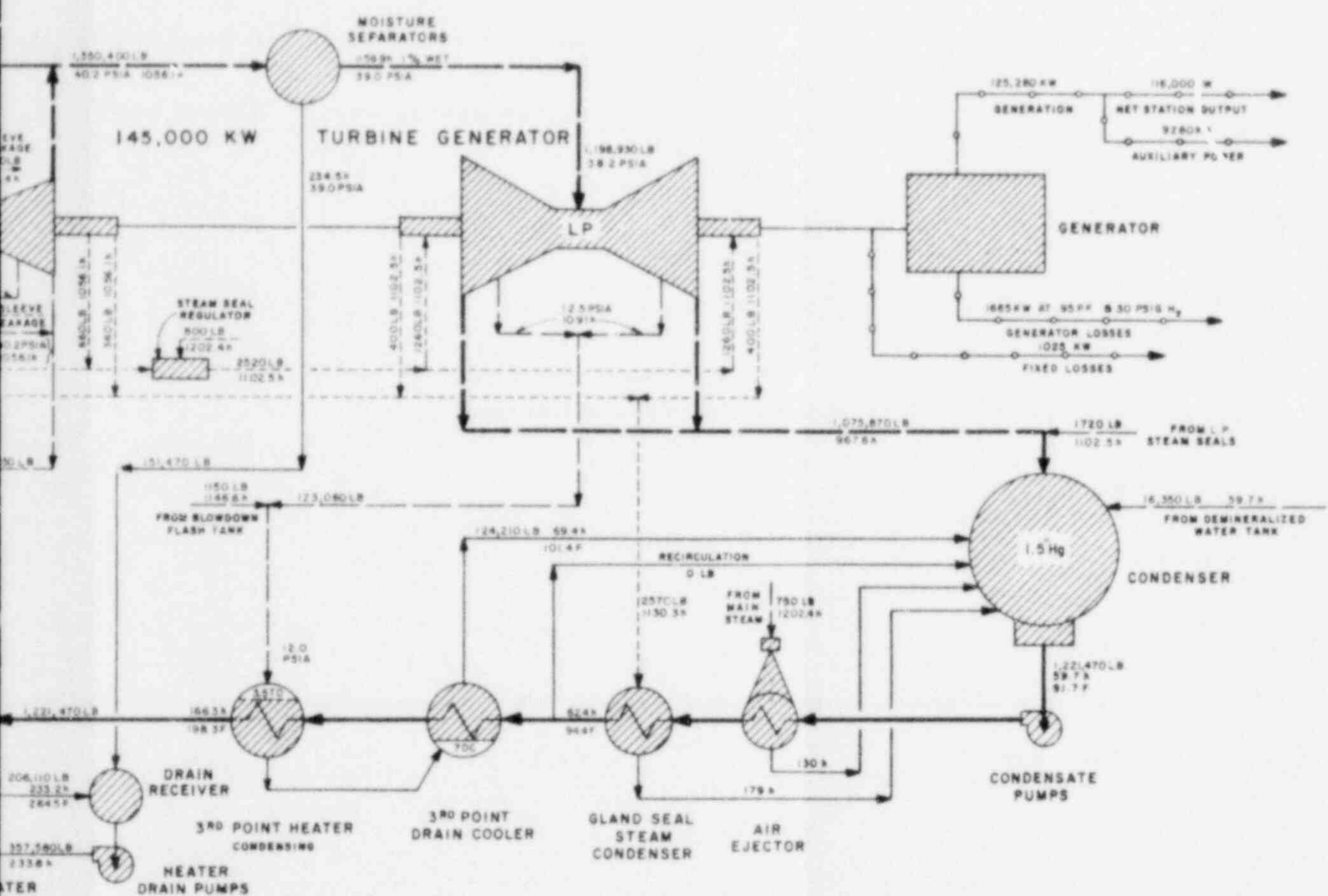
EXTRACTION PRESSURES SHOWN AT OR NEAR TURBINE ARE PRESSURES AT THE TURBINE CONNECTION TO THE EXTRACTION LINE
HEATER ENTRANCE PRESSURES ARE SHOWN OUTSIDE HEATER SYMBOLS
THE PERCENT PRESSURE DROP BETWEEN THE HIGH PRESSURE TURBINE EXHAUST AND LOW PRESSURE TURBINE INLET = 5.0%
THE PERCENT PRESSURE DROP FROM THE HIGH PRESSURE EXHAUST AND THE WATER OUTLET SIDE OF THE MOISTURE SEPARATOR = 3.0%
BASE HEAT BALANCE COMPUTED FOR 1.5"Hg BACK PRESSURE. ALL FLOWS, PRESSURES, TEMPERATURES AND ENTHALPIES REMAIN UNCHANGED AT OTHER BACK PRESSURES EXCEPT AS FOLLOWS: 1 - VALUES SHOWN IN THE TABLE. 2 - ENTHALPY AND TEMPERATURE OF CONDENSATE TO AIR EJECTOR, TO GLAND SEAL CONDENSER, TO THE 3RD POINT DRAIN COOLER AND THE 3RD POINT HEATER. 3 - FLOW, ENTHALPY AND TEMPERATURE OF DRAINS FROM THE 3RD POINT DRAIN COOLER.
CIRCULATING WATER TEMPERATURES SHOWN ARE THOSE REQUIRED TO PRODUCE BACK PRESSURES SHOWN WITH 136,000 GPM (2 PUMP OPERATION) WITH THE POND ELEVATION 997 FEET; 85,000 GPM (1 PUMP OPERATION) WITH THE POND ELEVATION 992.5 FEET.
HEAT BALANCES BASED ON WINTER CONDITIONS
EFFICIENCY OF NUCLEAR STEAM GENERATOR - 99.5%

AUXILIARY POWER REQUIREMENTS HAVE BEEN CALCULATED FOR ALL EQUIPMENT

THE FOLLOWING ITEMS VARY WITH LOAD
- 3 MAIN CONDENSATE PUMPS, 2 OPERATING
- 3 BOILER FEED PUMPS, 2 OPERATING
- 2 HEATER DRAIN PUMPS, 1 OPERATING

THE FOLLOWING ARE THE IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT FULL LOAD
- 4 MAIN COOLANT PUMPS, 4 OPERATING
- 3 MAIN COOLANT CHARGING PUMPS, 1 OPERATING
- 2 COMPONENT COOLING WATER PUMPS, 1 OPERATING
- 2 MAIN CIRCULATING WATER PUMPS, 2 OPERATING
- 3 SERVICE WATER PUMPS, 2 OPERATING
- 2 CONTROL AIR COMPRESSORS, 1 OPERATING
- 4 VAPOR CONTAINER AIR COOLER FANS, 4 OPERATING
- 1 FUEL PIT PUMP
- 2 PURIFICATION COOLING AND DRAIN PUMPS, 1 OPERATING
- 48 PRESSURIZER HEATERS, 2 OPERATING
- LIGHTING AND INSTRUMENTS

THE FOLLOWING ARE ADDITIONAL IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT 15% OF FULL LOAD FOR INTERMITTENT SERVICE
- 2 LOW PRESSURE SURGE TANK MAKE-UP PUMPS, 1 OPERATING
- 2 CIRCULATING WATER PRIMING PUMPS, 1 OPERATING
- 1 SERVICE AIR COMPRESSOR
- 2 ELEVATORS, 1 OPERATING
- 2 BATTERY CHARGERS, 2 OPERATING
- 1 TURBINE ROOM CRANE



LEGEND

— — —	STEAM
———	WATER
—o—o—	POWER
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR.
TD	TERMINAL DIFFERENCE, DEGREES FAHR.
DC	TERM. DIFF. OF DRAIN COOLER, DEGREES FAHR.
KW	KILOWATTS
"Hg	PRESSURE, IN. OF MERCURY ABS.
PSIA	PRESSURE, LB. PER SQ. INCH ABS.
PSIG	PRESSURE, LB. PER SQ. INCH GAGE.

$$\text{TURBINE HEAT RATE} = \frac{3412.75(125{,}280 + 1665 + 1025) + 1{,}075{,}870(967.6 - 59.7) + 124{,}210(69.4 - 59.7) + 1720(1102.5 - 59.7)}{125{,}280} = 11{,}305 \text{ BTU PER KWH}$$

CONDENSER BACK PRESSURE "Hg	3RD POINT HEATER EXTRACTION FLOW LB	TURBINE EXHAUST FLOW LB	TURBINE EXHAUST ENTHALPY BTU/LB	GENERATION KW	NET STATION OUTPUT KW	TURBINE HEAT RATE BTU/KWH	STATION HEAT RATE BTU/KWH	CIRCULATING WATER TEMP 2 PUMPS F
4.0	85,750	1,113,180	1014.1	111,605	102,325	13,840	14,030	-
3.5	91,120	1,107,810	1005.9	114,125	104,845	13,510	13,690	-
3.0	97,455	1,101,475	998.1	116,460	107,180	12,160	13,395	90.0
2.5	104,490	1,094,440	988.4	119,345	110,065	11,870	13,040	83.5
2.0	112,870	1,086,060	978.7	122,155	112,875	11,595	12,720	75.5
1.5	123,060	1,075,870	967.6	125,280	116,000	11,305	12,375	65.0
1.0	136,420	1,062,510	957.4	127,940	118,600	11,070	12,105	49.5
0.75	145,370	1,053,560	954.8	128,385	119,105	11,030	12,050	38.5

ISSUE	DESCRIPTION	CHKD	INSP	CORD	APPR
5					
4					
3					
2					
1	ORIGINAL ISSUE				

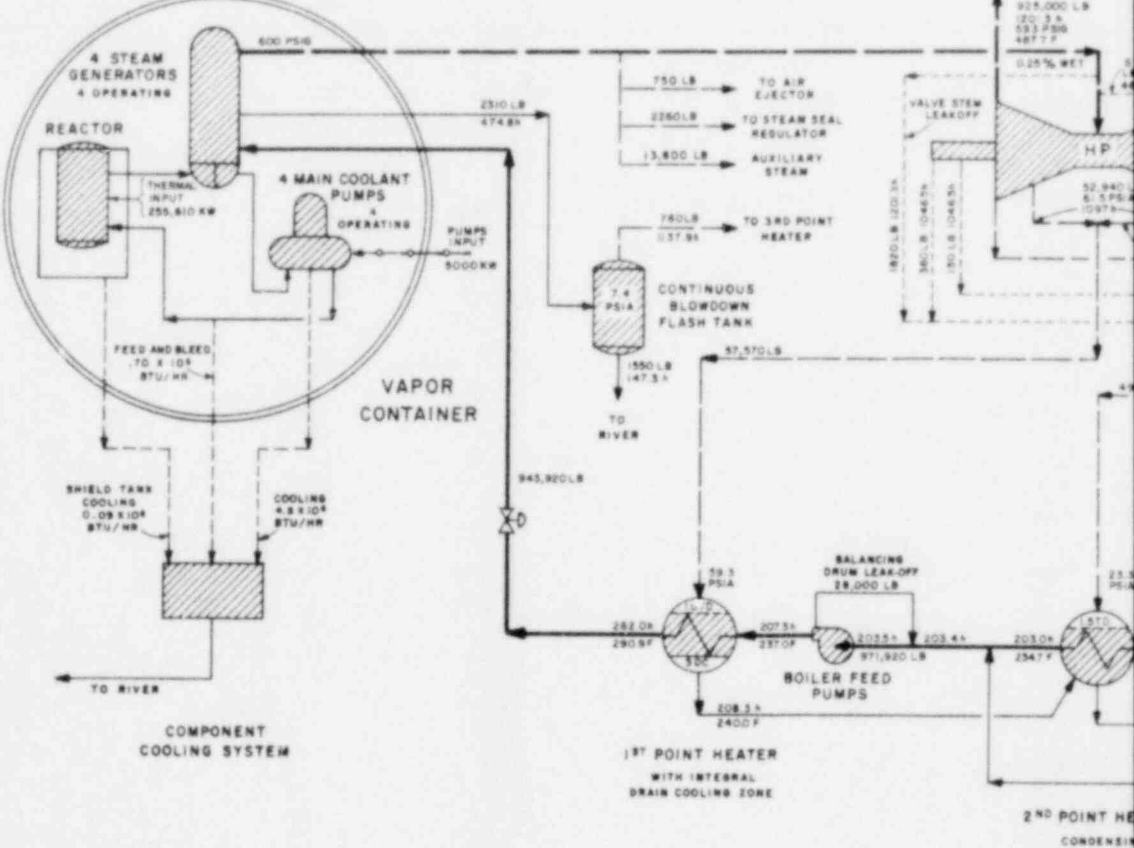
HEAT BALANCE DIAGRAM-125MW LOAD

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699 FM-45C

9699 FM-45D



BASIS OF HEAT BALANCE CALCULATIONS

STEAM LOSSES - 5000 LB AT ALL LOADS
STEAM GENERATOR BLOWDOWN .25% OF STEAM GENERATION
STEAM GENERATOR OUTLET PRESSURE AND THROTTLE PRESSURE TAKEN FROM CURVE YAE-42
EXTRACTION LINE PRESSURE DROPS CALCULATED AT 1,840,000 LB/HR THROTTLE FLOW AND EXPRESSED AS THE FOLLOWING PERCENTAGE OF THE ABSOLUTE PRESSURE AT THE TURBINE CONNECTION TO THE EXTRACTION LINE

LINE	1ST POINT	2ND POINT	3RD POINT
PERCENT	3.5	5.0	4.2

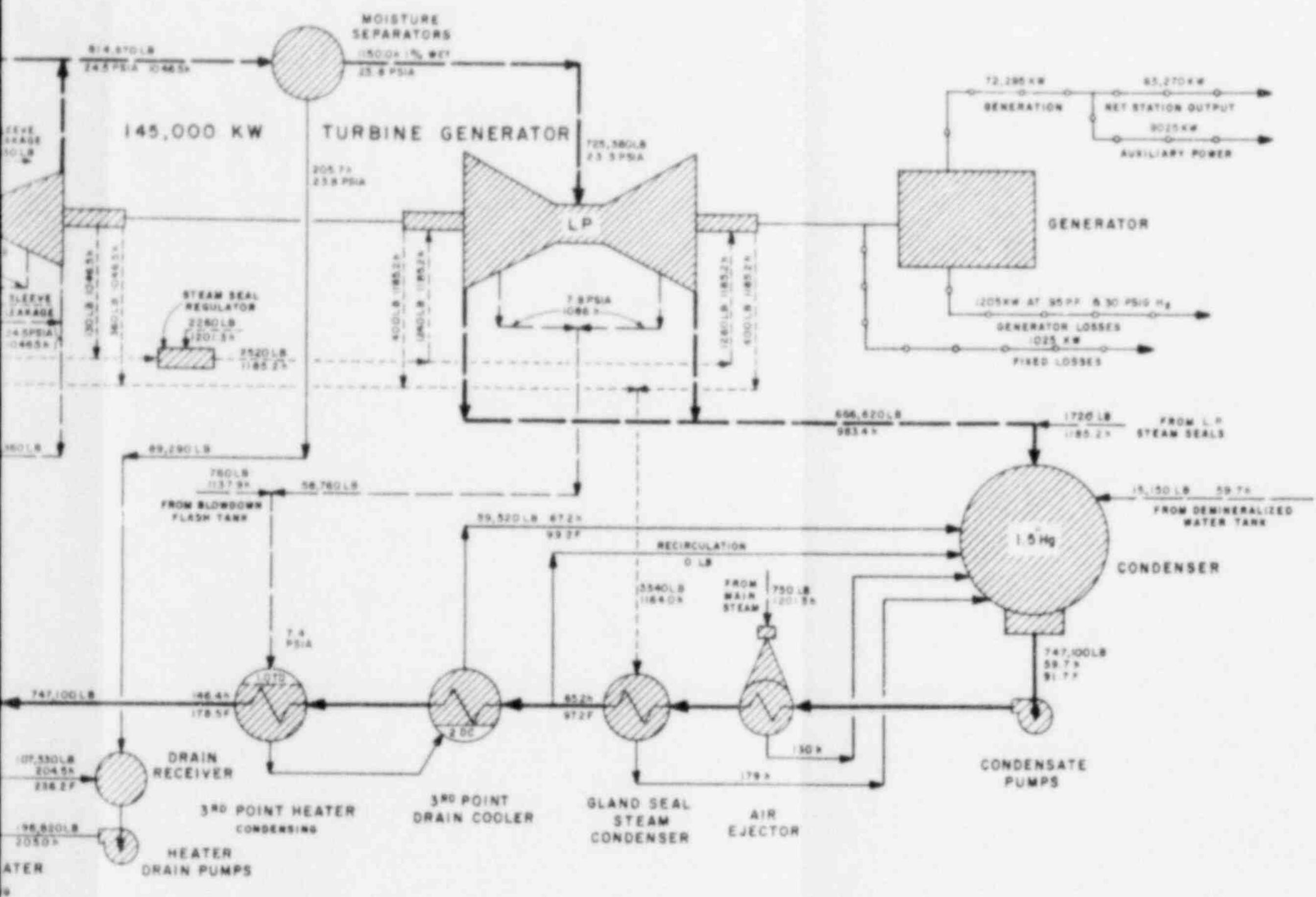
EXTRACTION PRESSURES SHOWN AT OR NEAR TURBINE ARE PRESSURES AT THE TURBINE CONNECTION TO THE EXTRACTION LINE
HEATER ENTRANCE PRESSURES ARE SHOWN OUTSIDE HEATER SYMBOLS
THE PERCENT PRESSURE DROP BETWEEN THE HIGH PRESSURE TURBINE EXHAUST AND LOW PRESSURE TURBINE INLET = 5.0%
THE PERCENT PRESSURE DROP FROM THE HIGH PRESSURE EXHAUST AND THE WATER OUTLET SIDE OF THE MOISTURE SEPARATOR = 3.0%
BASE HEAT BALANCE COMPUTED FOR 1.5" Hg BACK PRESSURE. ALL FLOWS, PRESSURES, TEMPERATURES AND ENTHALPIES REMAIN UNCHANGED AT OTHER BACK PRESSURES EXCEPT AS FOLLOWS: 1 - VALUES SHOWN IN THE TABLE. 2 - ENTHALPY AND TEMPERATURE OF CONDENSATE TO AIR EJECTOR, TO GLAND SEAL CONDENSER, TO THE 3RD POINT DRAIN COOLER AND THE 3RD POINT HEATER. 3 - FLOW, ENTHALPY AND TEMPERATURE OF DRAINS FROM THE 3RD POINT DRAIN COOLER.
CIRCULATING WATER TEMPERATURES SHOWN ARE THOSE REQUIRED TO PRODUCE BACK PRESSURES SHOWN WITH 138,000 GPM (2 PUMP OPERATION) WITH THE POND ELEVATION 997 FEET; 85,000 GPM (1 PUMP OPERATION) WITH THE POND ELEVATION 992.5 FEET.
HEAT BALANCES BASED ON WINTER CONDITIONS
EFFICIENCY OF NUCLEAR STEAM GENERATOR - 99.5%

AUXILIARY POWER REQUIREMENTS HAVE BEEN CALCULATED FOR ALL EQUIPMENT

THE FOLLOWING ITEMS VARY WITH LOAD
- 3 MAIN CONDENSATE PUMPS, 2 OPERATING
- 3 BOILER FEED PUMPS, 2 OPERATING
- 2 HEATER DRAIN PUMPS, 1 OPERATING

THE FOLLOWING ARE THE IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT FULL LOAD
- 4 MAIN COOLANT PUMPS, 4 OPERATING
- 3 MAIN COOLANT CHARGING PUMPS, 1 OPERATING
- 2 COMPONENT COOLING WATER PUMPS, 1 OPERATING
- 2 MAIN CIRCULATING WATER PUMPS, 2 OPERATING
- 3 SERVICE WATER PUMPS, 2 OPERATING
- 2 CONTROL AIR COMPRESSORS, 1 OPERATING
- 4 VAPOR CONTAINER AIR COOLER FANS, 4 OPERATING
- 1 FUEL PIT PUMP
- 2 PURIFICATION COOLING AND DRAIN PUMPS, 1 OPERATING
- 48 PRESSURIZER HEATERS, 2 OPERATING
- LIGHTING AND INSTRUMENTS

THE FOLLOWING ARE ADDITIONAL IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT 15% OF FULL LOAD FOR INTERMITTENT SERVICE
- 2 LOW PRESSURE SURGE TANK MAKE-UP PUMPS, 1 OPERATING
- 2 CIRCULATING WATER PRIMING PUMPS, 1 OPERATING
- 1 SERVICE AIR COMPRESSOR
- 2 ELEVATORS, 1 OPERATING
- 2 BATTERY CHARGERS, 2 OPERATING
- 1 TURBINE ROOM CRANE



LEGEND

— — —	STEAM
———	WATER
—o—o—	POWER
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR.
TD	TERMINAL DIFFERENCE, DEGREES FAHR.
DC	TERM. DIFF. OF DRAIN COOLER, DEGREES FAHR.
KW	KILOWATTS
"Hg	PRESSURE, IN. OF MERCURY ABS.
PSIA	PRESSURE, LB. PER SQ. INCH ABS.
PSIG	PRESSURE, LB. PER SQ. INCH GAGE

$$\text{TURBINE HEAT RATE} = \frac{3412.75(72{,}295+1205+1025)+666{,}620(983.4-59.7)+1720(1185.2-59.7)+59{,}520(67.2-59.7)}{72{,}295} = 12{,}070 \text{ BTU PER KWH}$$

CONDENSER BACK PRESSURE "Hg	3RD POINT HEATER EXTRACTION FLOW LB	TURBINE EXHAUST FLOW LB	TURBINE EXHAUST ENTHALPY BTU / LB	GENERATION KW	NET STATION OUTPUT KW	TURBINE HEAT RATE BTU/KWH	STATION HEAT RATE BTU/KWH	CIRCULATING WATER TEMP 2 PUMPS F
4.0	35,310	690,070	1042.0	61,220	52,195	14,255	17,035	-
3.5	38,690	686,690	1031.7	63,240	54,215	13,800	16,400	-
3.0	42,670	682,710	1022.6	64,990	55,965	13,425	15,890	-
2.5	47,090	678,290	1010.9	67,215	58,190	12,980	15,280	-
2.0	52,360	673,020	997.6	69,710	60,685	12,520	14,651	85.0
1.5	58,760	666,620	983.4	72,295	63,270	12,070	14,055	73.5
1.0	67,160	658,220	966.4	75,305	66,280	11,590	13,415	61.5
0.75	72,770	652,610	957.4	76,820	67,795	11,360	13,115	52.0

ISSUE	DESCRIPTION	CHKD	HBP	CHK	APPR
5					
4					
3					
2					
1	ORIGINAL ISSUE				

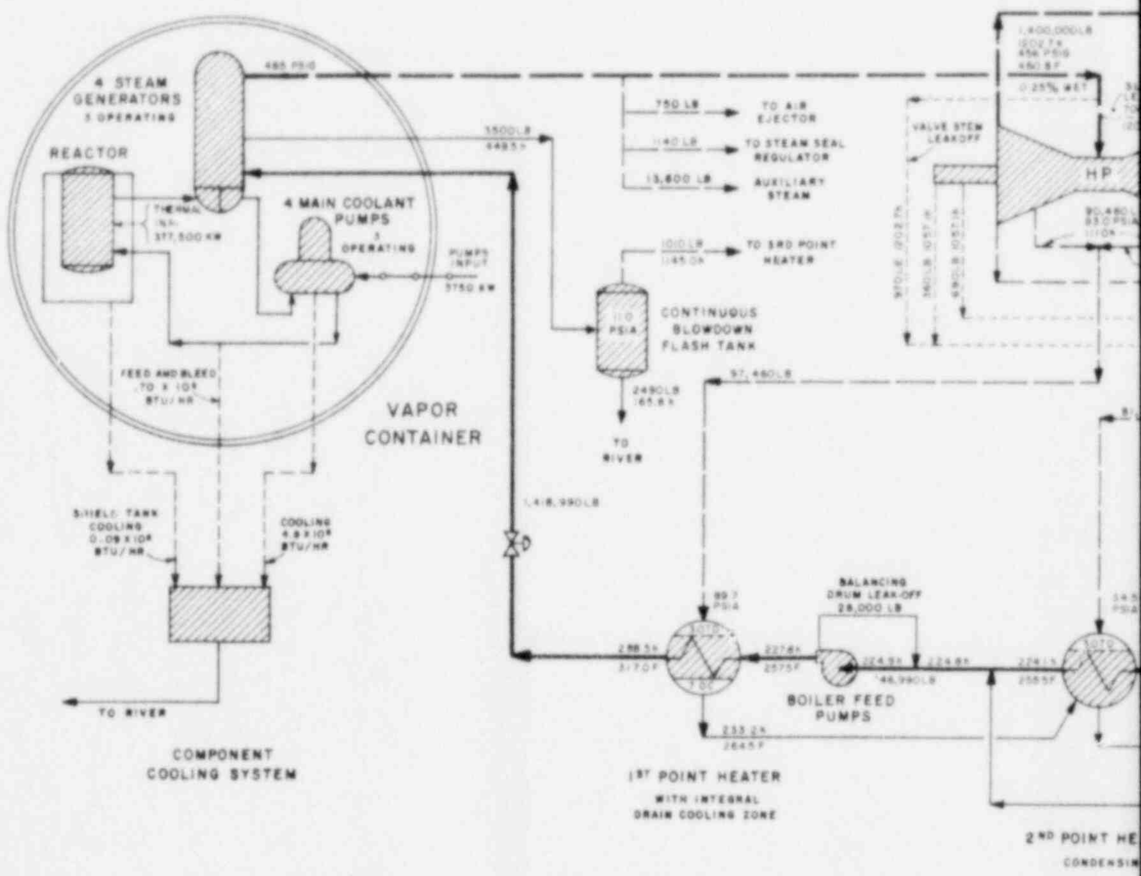
HEAT BALANCE DIAGRAM - 72 MW LOAD

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699 FM-45D

9699 FM-45E



BASIS OF HEAT BALANCE CALCULATIONS

STEAM LOSSES - 5000 LB AT ALL LOADS
STEAM GENERATOR BLOWDOWN .25 % OF STEAM GENERATION
STEAM GENERATOR OUTLET PRESSURE AND THROTTLE PRESSURE TAKEN FROM CURVE YAE-42
EXTRACTION LINE PRESSURE DROPS CALCULATED AT 1,840,000 LB/HR THROTTLE FLOW AND EXPRESSED AS THE FOLLOWING PERCENTAGE OF THE ABSOLUTE PRESSURE AT THE TURBINE CONNECTION TO THE EXTRACTION LINE

LINE	1ST POINT	2ND POINT	3RD POINT
PERCENT	3.5	5.0	4.2

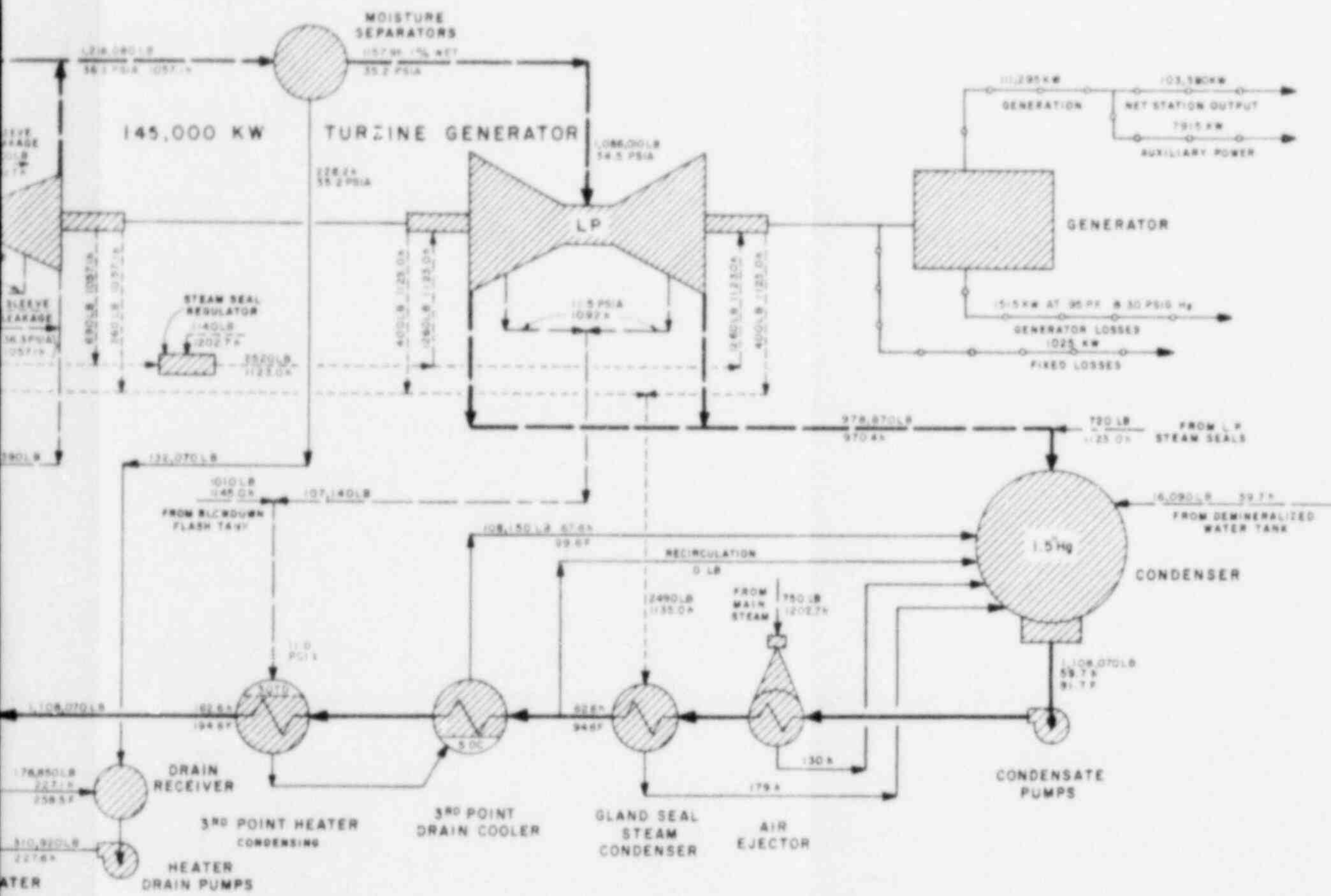
EXTRACTION PRESSURES SHOWN AT OR NEAR TURBINE ARE PRESSURES AT THE TURBINE CONNECTION TO THE EXTRACTION LINE
HEATER ENTRANCE PRESSURES ARE SHOWN OUTSIDE HEATER SYMBOLS
THE PERCENT PRESSURE DROP BETWEEN THE HIGH PRESSURE TURBINE EXHAUST AND LOW PRESSURE TURBINE INLET = 5.0%
THE PERCENT PRESSURE DROP FROM THE HIGH PRESSURE EXHAUST AND THE WATER OUTLET SIDE OF THE MOISTURE SEPARATOR = 3.0%
BASE HEAT BALANCE COMPUTED FOR 1.5" Hg BACK PRESSURE. ALL FLOWS, PRESSURES, TEMPERATURES AND ENTHALPIES REMAIN UNCHANGED AT OTHER BACK PRESSURES EXCEPT AS FOLLOWS: 1 - VALUES SHOWN IN THE TABLE. 2 - ENTHALPY AND TEMPERATURE OF CONDENSATE TO AIR EJECTOR, TO GLAND SEAL CONDENSER, TO THE 3RD POINT DRAIN COOLER AND THE 3RD POINT HEATER. 3 - FLOW, ENTHALPY AND TEMPERATURE OF DRAINS FROM THE 3RD POINT DRAIN COOLER.
CIRCULATING WATER TEMPERATURES SHOWN ARE THOSE REQUIRED TO PRODUCE BACK PRESSURES SHOWN WITH 138,000 GPM (2 PUMP OPERATION) WITH THE POND ELEVATION 997 FEET, 85,000 GPM (1 PUMP OPERATION) WITH THE POND ELEVATION 992.5 FEET
HEAT BALANCES BASED ON WINTER CONDITIONS
EFFICIENCY OF NUCLEAR STEAM GENERATOR - 99.5%

AUXILIARY POWER REQUIREMENTS HAVE BEEN CALCULATED FOR ALL EQUIPMENT

THE FOLLOWING ITEMS VARY WITH LOAD
- 3 MAIN CONDENSATE PUMPS, 2 OPERATING
- 3 BOILER FEED PUMPS, 2 OPERATING
- 2 HEATER DRAIN PUMPS, 1 OPERATING

THE FOLLOWING ARE THE IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT FULL LOAD
- 4 MAIN COOLANT PUMPS, 3 OPERATING
- 3 MAIN COOLANT CHARGING PUMPS, 1 OPERATING
- 2 COMPONENT COOLING WATER PUMPS, 1 OPERATING
- 2 MAIN CIRCULATING WATER PUMPS, 2 OPERATING
- 3 SERVICE WATER PUMPS, 2 OPERATING
- 2 CONTROL AIR COMPRESSORS, 1 OPERATING
- 4 VAPOR CONTAINER AIR COOLER FANS, 4 OPERATING
- 1 FUEL PIT PUMP
- 2 PURIFICATION COOLING AND DRAIN PUMPS, 1 OPERATING
- 48 PRESSURIZER HEATERS, 2 OPERATING
- LIGHTING AND INSTRUMENTS

THE FOLLOWING ARE ADDITIONAL IMPORTANT ITEMS WHICH ARE CONSIDERED NOT TO VARY WITH LOAD. AUXILIARY POWER FOR THESE ITEMS HAS BEEN CALCULATED AT 15% OF FULL LOAD FOR INTERMITTENT SERVICE
- 2 LOW PRESSURE SURGE TANK MAKE-UP PUMPS, 1 OPERATING
- 2 CIRCULATING WATER PRIMING PUMPS, 1 OPERATING
- 1 SERVICE AIR COMPRESSOR
- 2 ELEVATORS, 1 OPERATING
- 2 BATTERY CHARGERS, 2 OPERATING
- 1 TURBINE ROOM CRANE



LEGEND

———	STEAM
———	WATER
—o—o—	POWER
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR
TD	TERMINAL DIFFERENCE, DEGREES FAHR
DC	TERM. DIFF. OF DRAIN COOLER, DEGREES FAHR
KW	KILOWATTS
"Hg	PRESSURE, IN. OF MERCURY ABS
PSIA	PRESSURE, LB. PER SQ. INCH ABS
PSIG	PRESSURE, LB. PER SQ. INCH GAGE

TURBINE HEAT RATE = $\frac{3412.75(111,295+1515+1025)+976,870(970.4-59.7)+108,150(67.6-59.7)+1720(1123.0-59.7)}{111,295}$ = 11,525 BTU PER KWH

CONDENSER BACK PRESSURE "Hg	3RD POINT HEATER EXTRACTION FLOW LB	TURBINE EXHAUST FLOW LB	TURBINE EXHAUST ENTHALPY BTU/LB	GENERATION KW	NET STATION OUTPUT KW	TURBINE HEAT RATE BTU/KWH	STATION HEAT RATE BTU/KWH	CIRCULATING WATER TEMP 2 PUMPS F
4.0	73,230	1,012,780	1019.3	98,125	90,210	13,070	14,420	–
3.5	78,110	1,007,900	1010.9	100,470	92,555	12,765	14,055	–
3.0	81,870	1,002,140	1002.6	102,690	94,775	12,490	13,730	–
2.5	90,260	995,750	992.8	105,415	97,500	12,170	13,345	86.0
2.0	97,980	986,130	982.3	108,210	100,295	12,790	12,970	78.0
1.5	107,140	976,870	970.4	111,295	103,380	11,525	12,585	67.5
1.0	119,290	966,720	959.1	114,035	106,120	11,250	12,260	53.0
0.75	127,410	958,600	954.6	114,965	107,050	11,155	12,155	42.0

ISSUE	DESCRIPTION	CHKD	ASP	TDRS	APPD
5					
4					
3					
2					
1	ORIGINAL ISSUE				

HEAT BALANCE DIAGRAM-111 MW LOAD

POWER STATION

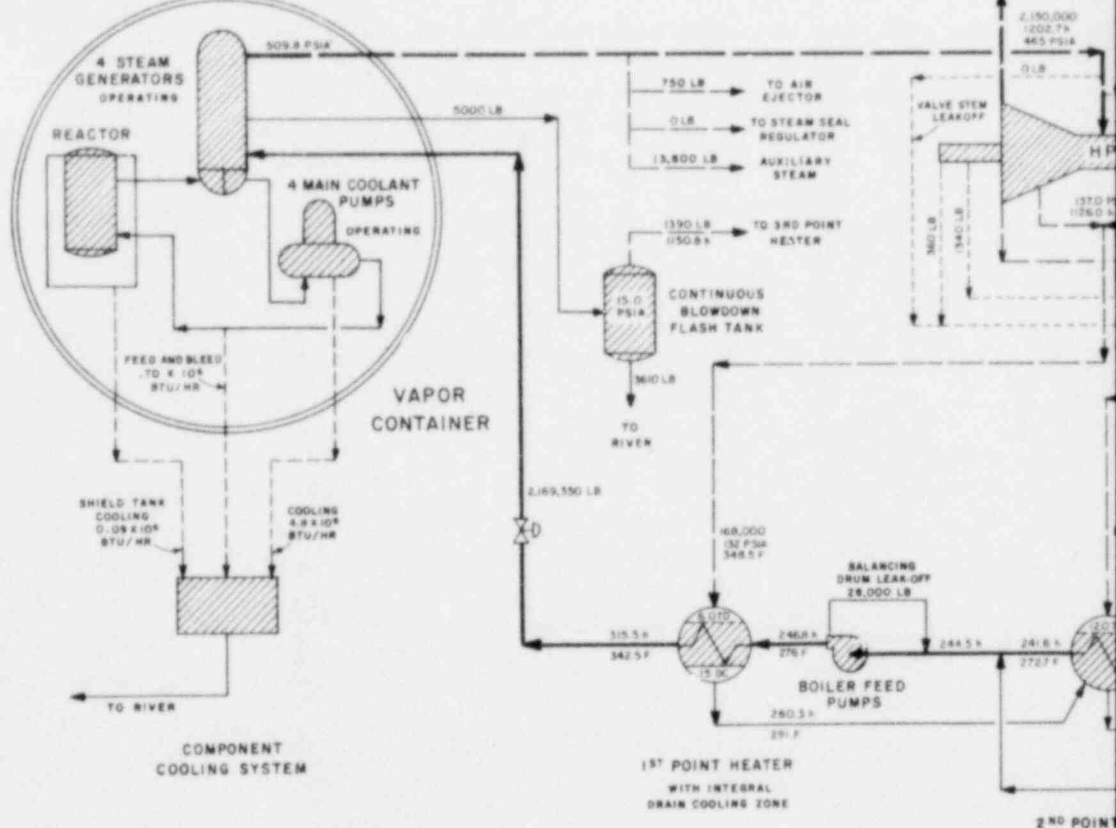
YANKEE ATOMIC ELECTRIC COMPANY

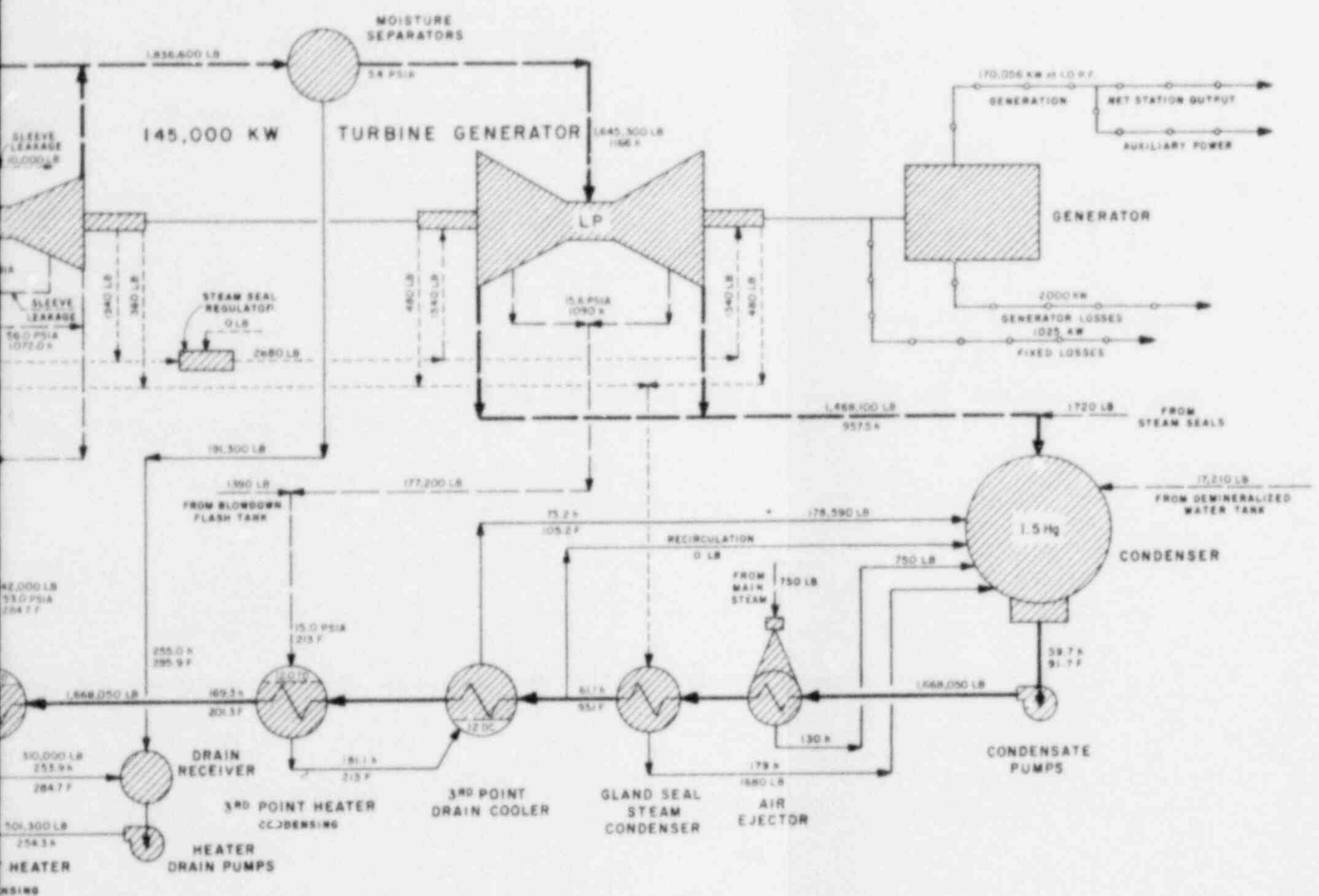
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699 FM-45E

9699 FM-45F


4 STEAM GENERATORS OPERATING
REACTOR
509.8 PSIA
5000 LB
4 MAIN COOLANT PUMPS OPERATING
FEED AND BLEED .70 X 10^6 BTU/HR
VAPOR CONTAINER
SHIELD TANK COOLING 0.09 X 10^6 BTU/HR
COOLING 4.8 X 10^6 BTU/HR
TO RIVER
COMPONENT COOLING SYSTEM
750 LB
TO AIR EJECTOR
0 LB
TO STEAM SEAL REGULATOR
13,800 LB
AUXILIARY STEAM
1390 LB
1150.8 h
TO 3RD POINT HEATER
15.0 PSIA
CONTINUOUS BLOWDOWN FLASH TANK
3610 LB
TO RIVER
2,169,550 LB
168,000
132 PSIA
348.5 F
BALANCING DRUM LEAK-OFF 28,000 LB
315.5 h
342.5 F
246.8 h
276 F
244.5 h
241.6 h
272.7 F
BOILER FEED PUMPS
260.5 h
291 F
1ST POINT HEATER
WITH INTEGRAL DRAIN COOLING ZONE
2,150,000
1202.7 h
465 PSIA
0 LB
VALVE STEM LEAKOFF
360 LB
1540 LB
HP
2ND POINT



LEGEND

— — —	STEAM
———	WATER
—o—o—	POWER
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR.
TD	TERMINAL DIFFERENCE, DEGREES FAHR.
DC	TERM. DIFF. OF DRAIN COOLER, DEGREES FAHR.
KW	KILOWATTS
"Hg	PRESSURE, IN. OF MERCURY ABS.
PSIA	PRESSURE, LB. PER SQ. INCH ABS.
PSIG	PRESSURE, LB. PER SQ. INCH GAGE.

PRELIMINARY

THIS HEAT BALANCE IS BASED ON APPROXIMATE DATA AND THE FLOWS ARE ONLY APPROXIMATELY BALANCED

NO.	DESCRIPTION	CHKD	REV	APPR	APP'D
5					
4					
3					
2					
1	ORIGINAL ISSUE				

HEAT BALANCE DIAGRAM-170 MW LOAD

POWER STATION

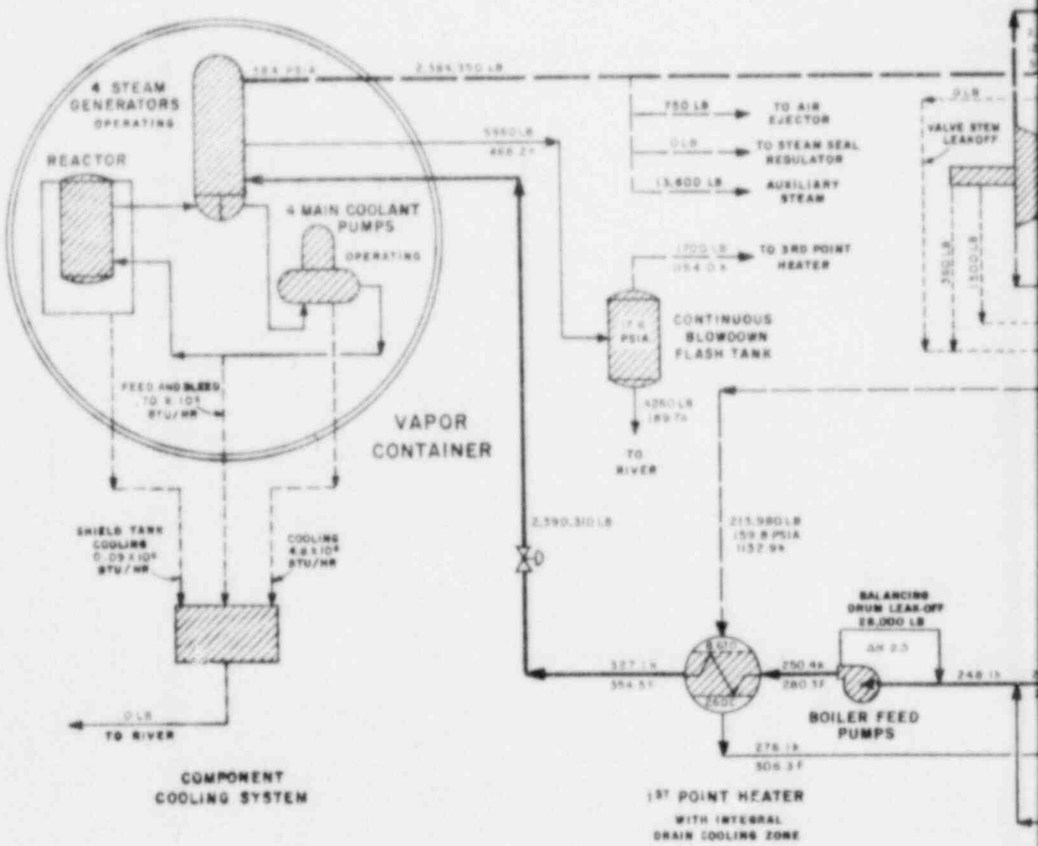
YANKEE ATOMIC ELECTRIC [redacted]

ROWE, MASS.

STONE & WEBSTER [redacted]

[redacted] 9699 FM-45F

9699 FM-45H



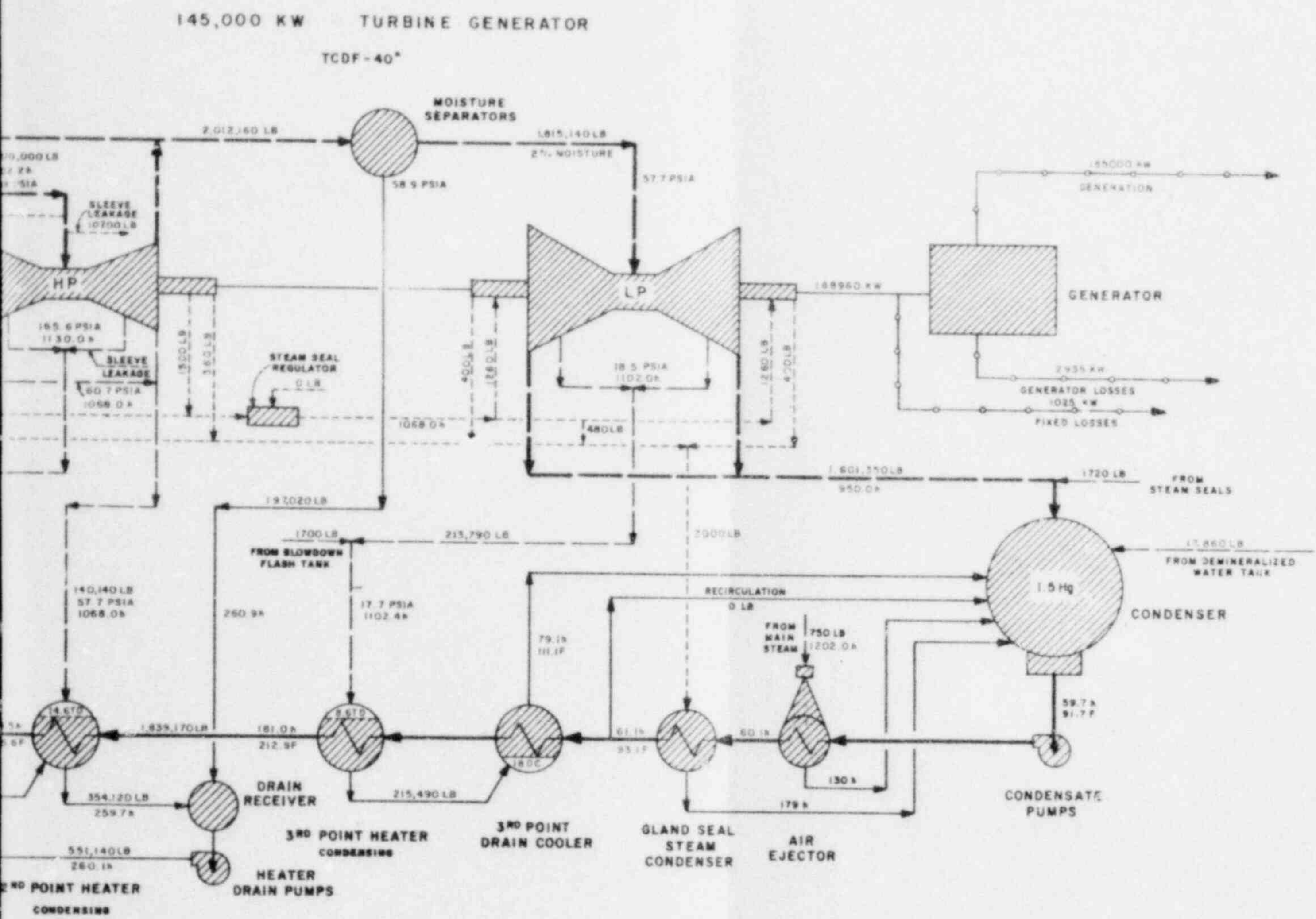
BASIS OF HEAT BALANCE CALCULATIONS

STEAM GENERATOR BLOWDOWN .25 % OF STEAM GENERATION
STEAM GENERATOR OUTLET PRESSURE AND THROTTLE PRESSURE TAKEN FROM CORRECTED OBSERVED DATA
EXTRACTION LINE PRESSURE DROPS CALCULATED AT 1,840,000 LB/HR THROTTLE FLOW AND EXPRESSED AS THE FOLLOWING PERCENTAGE OF THE ABSOLUTE PRESSURE AT THE TURBINE CONNECTION TO THE EXTRACTION LINE

LINE	1ST POINT	2ND POINT	3RD POINT
PERCENT	3.7	5.4	4.0

EXTRACTION PRESSURES SHOWN AT OR NEAR TURBINE ARE PRESSURES AT THE TURBINE CONNECTION TO THE EXTRACTION LINE
HEATER ENTRANCE PRESSURES ARE SHOWN OUTSIDE HEATER SYMBOLS
THE PERCENT PRESSURE DROP BETWEEN THE HIGH PRESSURE TURBINE EXHAUST AND LOW PRESSURE TURBINE INLET = 5.0%
THE PERCENT PRESSURE DROP FROM THE HIGH PRESSURE EXHAUST AND THE WATER OUTLET SIDE OF THE MOISTURE SEPARATOR = 3.0%
BASE HEAT BALANCE COMPUTED FOR 1.5" Hg BACK PRESSURE.

CALCULATIONS BASED ON OBSERVED PLANT CHARACTERISTICS AS OUTLINED IN STONE & WEBSTER REPORT, "MAXIMUM CAPABILITY-SECONDARY SYSTEM" AND TRANSMITTAL LETTER, BOTH NUMBERED YS-4543 AND DATED MARCH 23, 1963.



LEGEND

— — —	STEAM
———	WATER
—o—o—	POWER,
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR.
TD	TERMINAL DIFFERENCE, DEGREES FAHR.
DC	TERM. DIFF. OF DRAIN COOLER, DEGREES FAHR.
KW	KILOWATTS
"Hg	PRESSURE, IN. OF MERCURY ABS.
PSIA	PRESSURE, LB. PER SQ. INCH ABS.
PSIG	PRESSURE, LB. PER SQ. INCH GAGE.

$$\text{TURBINE HEAT RATE} = \frac{2,384,350\,(1202.2 - 327.1) + 5960\,(468.2 - 327.1)}{185,000} = 11,283 \text{ BTU PER KWH}$$

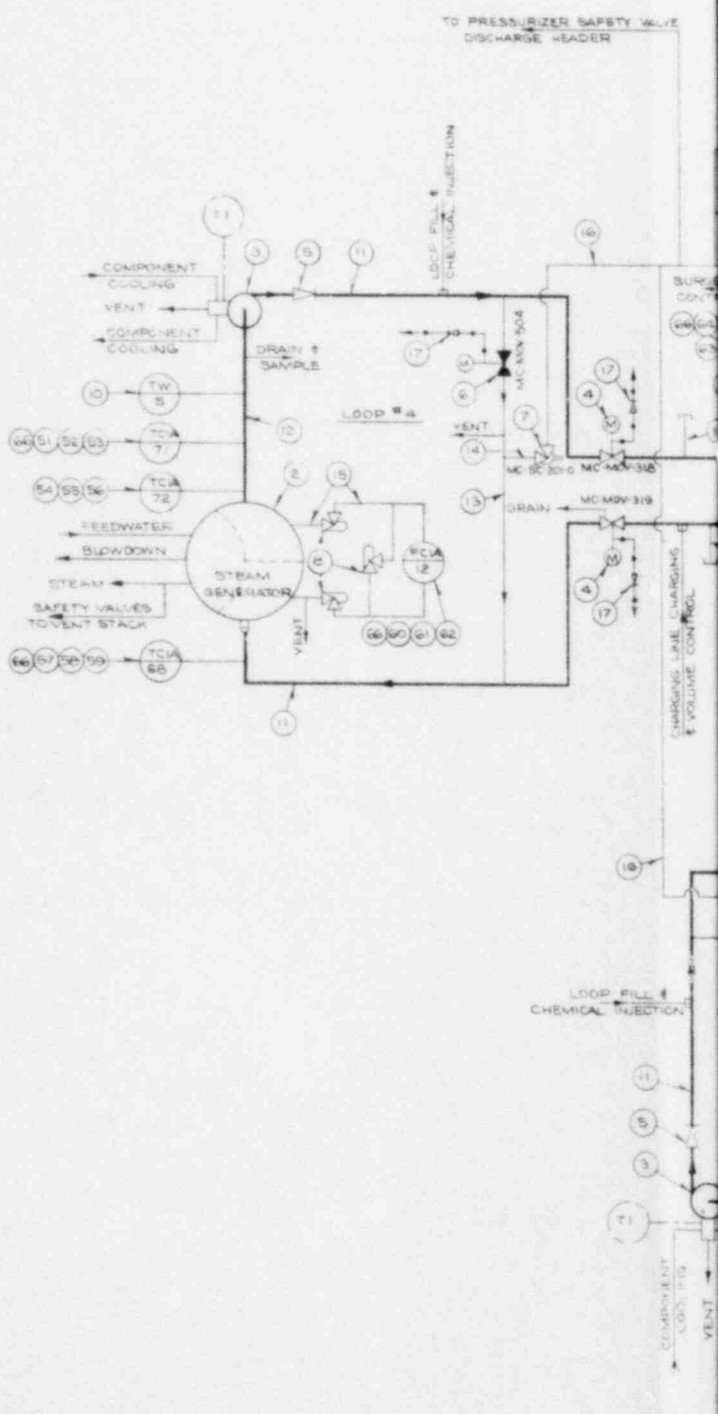
ISSUE	DESCRIPTION	CHKD.	SUP.	COOR.	APPR.
5					
4					
3					
2					
1	ORIGINAL ISSUE				

HEAT BALANCE DIAGRAM-185 MW LOAD

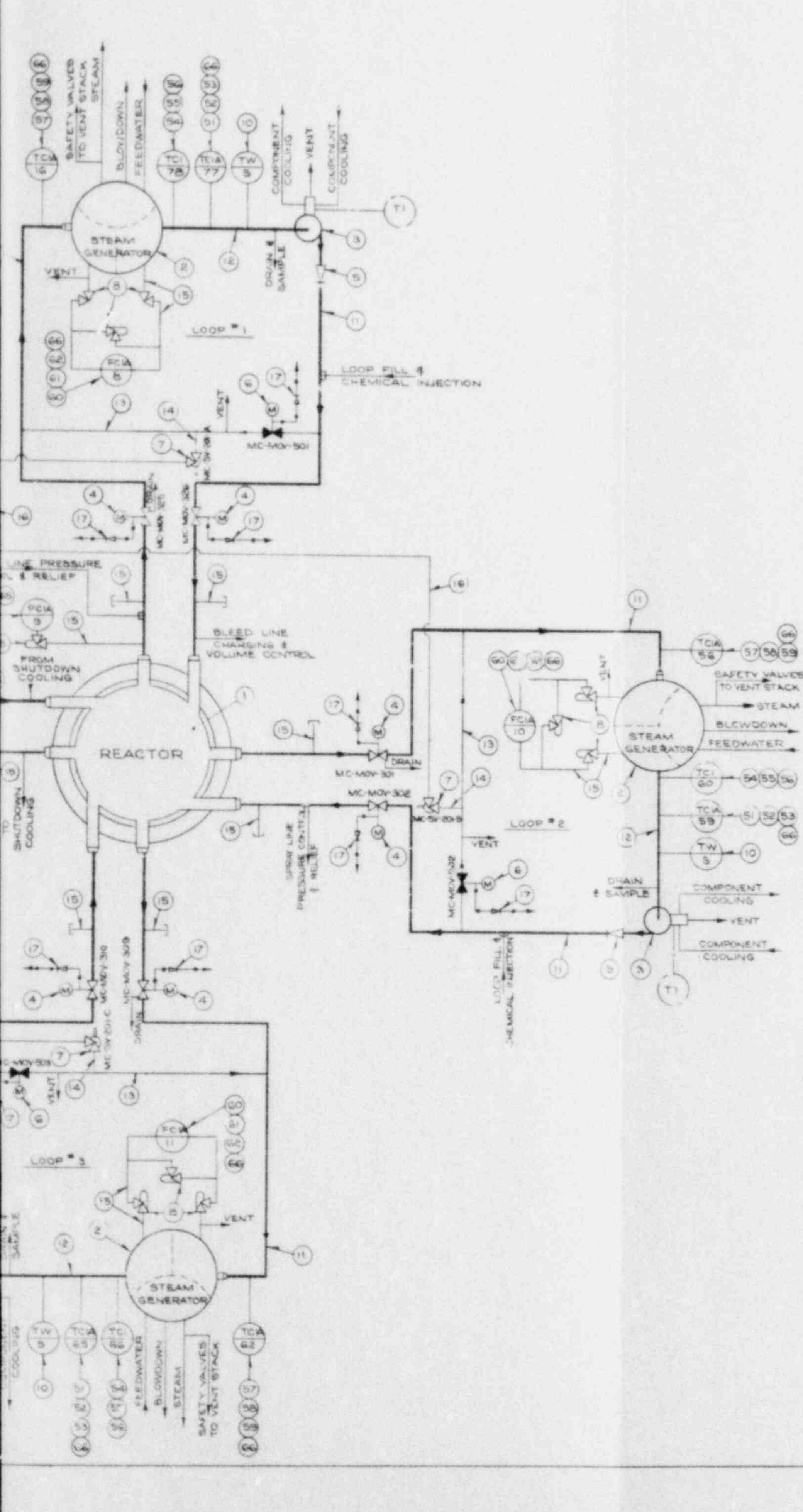
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699 FM-45H



TO PRESSURIZER SAFETY VALVE
DISCHARGE HEADER
LOOP FILL &
CHEMICAL INJECTION
COMPONENT
COOLING
VENT
COMPONENT
COOLING
DRAIN &
SAMPLE
LOOP #4
VENT
DRAIN
MC-MOV-504
MC-SC-201-D
MC-MOV-318
MC-MOV-319
FEEDWATER
BLOWDOWN
STEAM
SAFETY VALVES
TO VENT STACK
STEAM
GENERATOR
VENT
CHARGING LINE, CHARGING
& VOLUME CONTROL
LOOP FILL &
CHEMICAL INJECTION
COMPONENT
COOLING
VENT



TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT
MAIN COOLANT SYSTEM (MECH)
DWG 646J421 SUB /2#AB 87

SHEET No 1

NOTE	ITEM	MATERIAL & DESCRIPTION		SIZE	RATING	"E" SPECS	GROUP
	1	REACTOR VESSEL SST CLAD	CST		2500 LB @ 650°F	567135-C	1
	2	STEAM GENERATOR SST CLAD	CST	24×24	2500 LB @ 650°F	567120-C	4
	3	CIRCULATING PUMP	SST	24×24"	2500 LB @ 650°F	567121-D	4
	4	STOP VALVE - MOTOR OPERATED WITH STEM LEAK-OFF	SST	20"	2300 LB @ 550°F	567122-C	8
	5	CHECK VALVE	SST	24"×20"	2300 LB @ 550°F	567123-D	4
	6	GATE VALVE - MOTOR OPERATED WITH STEM LEAK-OFF	SST	5"	2500 LB @ 670°F		4
	7	RELIEF VALVE - BELLOWS SEAL	SST	1½"×2"		567124-D	4
	8	ANGLE VALVE - CAPPED	SST	¾"	2500 LB @ 670°F		13
	9						
	10	TEMP DETECTOR WELL (SPARE)					4
	11	PIPING - 1⁵⁄₁₆" WALL	SST	20"	2300 LB @ 550°F	596006	[illegible]
	12	PIPING - 2³⁄₁₆ WALL	SST	24"	2300 LB @ 550°F	596006	[illegible]
	13	PIPING SCH 160 S	SST	5"	2500 LB @ 670°F		[illegible]
	14	PIPING - SCH 160 S	SST	1½"	2500 LB @ 670°F		[illegible]
	15	PIPING - SCH 80 S	SST	¾"	2500 LB @ 670°F		[illegible]
	16	PIPING - SCH 10 S	SST	2"	150 LB		[illegible]
	17	BALL CHECK VALVE	CST	½"	600 LB		18

TITLE - YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT
MAIN COOLANT SYSTEM (I & C)
DWG 646J421 SUB 12#AB 87

SHEET NO 2

NOTE	ITEM	MATERIAL & DESCRIPTION	CODE NO.	GROUP NO. 1	2	3	4	5	6	7	8
	51	TEMPERATURE DETECTOR	MC-TD-77,59,65,71	1							
	52	TEMPERATURE CONTROLLER	MC-TC-77,59,65,71	1							
	53	TEMPERATURE INDICATOR	MC-TI-77,59,65,71	1							
	54	TEMPERATURE DETECTOR	MC-TD-78,60,66,72		1						
	55	TEMPERATURE CONTROLLER	MC-TC-78,60,66,72		1						
	56	TEMPERATURE INDICATOR	MC-TI-78,60,66,72		1						
	57	TEMPERATURE DETECTOR	MC-TD-16,56,62,68			1					
	58	TEMPERATURE CONTROLLER	MC-TC-16,56,62,68			1					
	59	TEMPERATURE INDICATOR	MC-TI-16,56,62,68			1					
	60	FLOW DETECTOR	MC-FD-8,10,11,12				1				
	61	FLOW CONTROLLER	MC-FC-8,10,11,12				1				
	62	FLOW INDICATOR	MC-FI-8,10,11,12				1				
	63	PRESSURE DETECTOR	MC-PD-9					1			
	64	PRESSURE CONTROLLER	MC-PC-9					1			
	65	PRESSURE INDICATOR	MC-PI-9					1			
	66	ANNUNCIATOR	MC-TA-16,77						7		
			MC-FA-8,10,11,12								
			PR-PA-6								

GROUP #6 E-SPEC 567201-B
GROUP #5 E-SPEC 567165-B
GROUP #4 E-SPEC 567166-B
GROUP #3 E-SPEC 567140-B
GROUP #2 E-SPEC 567164-B
GROUP #1 E-SPEC 567163-B

WESTINGHOUSE ELECTRIC CORPORATION

TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT - MAIN COOLANT SYSTEM (MECH & I C)

DIMENSIONS IN INCHES-SCALE N.T.S.

DFTN Weaver

CHKD

DIV. & PLANT LOCATION C.A.&A.

646-J-421

EAST PITTSBURGH, PA. U.S.A.

Design Data	Normal	Maximum
Duty, Btu/hr	4.1×10^6	15.75×10^6
Tube side temperature, operating		
Inlet F	500	500
Outle , F	188	200
Shell side temperature, operating		
Inlet, F	120	120
Outlet, F	440	428
Flow		
Tube side, lb/hr	12,500	50,000
Shell side, lb/hr	12,500	50,000
Design pressure		
Tube side, psi gage	2,500	
Shell side, psi gage	2,500	
Design temperature		
Tube side, F	650	
Shell side, F	650	

Pressure Reducing Orifices

Three stainless steel orifices connected in parallel in the bleed line fix the bleed flow rate in increments of roughly 25 gpm when the normal operating pressure drop exists across the orifices. The normal upstream and downstream pressures are 2,000 psi gage and 15 psi gage and 60 psi gage, respectively. The normal bleed temperature is 175 F but can reach a maximum of 250 F. Two of the orifices are designed for a flow of between 15 and 35 gpm and the third orifice for a flow of between 50 and 75 gpm. In order to facilitate removal of the orifices for cleaning or replacement, flange connections with provision for seal welding are provided.

Low Pressure Surge Tank

The low pressure surge tank receives the main coolant bleed and the discharge of primary plant safety and relief valves. It is a horizontal cylindrical stainless steel tank which has a volume of 750 cu ft. The normal water level in the tank, corresponding to a volume of 375 cu ft, is maintained by level control instrumentation. The pressure in the low pressure surge tank during normal operation is fixed by the saturation pressure of the water and the hydrogen atmosphere overpressure, which is maintained in the tank. The design pressure of the low pressure surge tank is 75 psi gage; the normal operating pressure is 15 psi gage.

Low Pressure Surge Tank Pump

This centrifugal pump has a capacity of 1,000 gpm when operating against a pressure of 78 psi. It recirculates water between the low pressure surge tank and the low pressure surge tank cooler during periods of high heat removal requirements. Since radioactive fluid is pumped, leakage from the pump is controlled by a double balanced mechanical seal. This unit is fully interchangeable and cross connected with the shutdown cooling pump.

Low Pressure Surge Tank Cooler

This shell and U-tube heat exchanger is designed not only to fulfill the requirements of low pressure surge tank cooling but also to serve as a back-up for the shutdown cooler. The component cooling system provides the cooling water to these coolers.

Design Data	Normal		Maximum
Duty, Btu/hr	1.0×10^6		4.0×10^6
Tube side temperature, operating			
Inlet, F	120		120
Outlet, F	100		112
Shell side temperature, operating			
Inlet, F	75		75
Outlet, F	85		83
Flow			
Tube side, gpm	100		1,000
Shell side, gpm	200		1,000
Design pressure			
Tube side, psi gage		425	
Shell side, psi gage		125	
Design temperature			
Tube side, F		370	
Shell side, F		150	

Low Pressure Surge Tank Make-up Pumps

Two small centrifugal pumps are provided for charging water from the primary water storage tank or the demineralized water storage tank into the primary plant through the low pressure surge tank or directly to the high pressure charging pump suction header. These pumps have a capacity of 100 gpm each when operating against a total dynamic head of 100 psi gage. Their design pressure is 200 psi gage. The pumps' suction and discharge piping is so arranged that the pumps may be operated singly or in parallel.

Instrumentation

Feed and Bleed Instrumentation - The level in the pressurizer is detected by two differential pressure level detectors having external uncompensated reference legs with condensing chambers. The narrow range level detector covers a range of 120 in. with the bottom tap located at approximately 40 in. from the bottom of the pressurizer. The changing level will cause a change in the electrical output of the differential transformer which is attached to the D/P cell. This output is sent to a magnetic amplifier controller which demodulates and amplifies the incoming signal. The controller has built-in manual compensation for setting the system for operation at the various saturation conditions that are present in the pressurizer. A high level on-off signal is sent to the annunciator panel. A low level on-off signal is sent to the annunciator panel and to the bleed valve controller, to close this valve, and to the heater control circuit, to turn off all the heaters. A linear signal is sent to a miniature indicator-recorder mounted on the control board to obtain a permanent record of level changes in the pressurizer. A linear signal is also sent to the charging pump speed control channel which varies the feed flow to the main loops to maintain a constant level in the pressurizer. The level controller also accomodates a narrow range signal from the wide range level channel which can be used if the narrow range detector becomes inoperative. A fail safe on-off signal is sent to the fail safe panel to indicate a failure in the instrumentation.

A level signal from the narrow range level channel of the pressurizer or a pressure signal from the main coolant system pressure channel is amplified by a magnetic amplifier. An electro-pneumatic transducer converts the output of the magnetic amplifier to a proportional pneumatic signal. Two pneumatic control stations, mounted on the control board, send a pneumatic signal, manual or automatic, to actuate the mechanism of the variable fluid coupling which in turn adjusts the speed of the two variable speed charging pumps. The system also allows for manual, automatic, or standby position of both the single fixed speed pump and the two variable speed pumps. There are two pressure switches in the proportional air line that are actuated by a high signal for one and a low signal for the other. These signals actuate corresponding alarms. The high pressure switch is used to energize the pump which is in the standby condition. A third pressure switch is used to close the bleed valve when the pressure corresponds to an extremely low level in the pressurizer. A fail safe signal is sent to the fail safe panel to indicate a failure in the instrumentation.

The wide range level detector covers a range of 340 in. with the bottom tap located approximately 21.5 in. from the bottom of the pressurizer. The wide range detector is similar to the narrow range detector except for the range of the instrument. The output of the detector is sent to a magnetic controller which demodulates and amplifies the incoming signal. The controller also has built-in manual compensation for setting the system for operation at the various saturation conditions. One output of the controller is a linear signal sent to an indicator on the control board. An adjustable high level scram signal is sent to the alarm and shutdown panel when the level reaches the scram set point. A narrow range signal, corresponding to the narrow range level detector span, is sent to the narrow range controller to be used in the event the narrow range detector becomes inoperative. A fail safe on-off signal is sent to the fail safe panel to indicate a failure in the instrumentation.

The two feed and bleed resistance type temperature sensing elements are connected to a vacuum tube controller through a two-position selector switch so that either feed or bleed temperature readings can be monitored depending on the position of the switch. The controller amplifies the incoming detector signal and transmits the amplified signal to a control board mounted indicator.

The low pressure surge tank resistance type temperature sensing element is connected to a vacuum tube controller that amplifies the signal and then sends it to a control board mounted indicator reading. An on-off signal is sent to the annunciator panel when the temperature reaches a preset value.

The flow and pressure indicators in the feed and bleed lines and the loop fill line, and the level indicator in the low pressure surge tank, all have a differential transformer giving an output which is demodulated and amplified by a vacuum tube controller. The output of the controller is sent to an indicator mounted on the control board.

The feed and bleed flow measurements are indicated separately on the control board and separate flow integrating units give the total flow to and from the main coolant system. For the bleed flow measurements the control board indicator has a reading from 0 to 150 gpm and a flow integrating unit gives the total flow from the main coolant system.

The low pressure surge tank pressure detector is of the Bourdon tube type with a differential transformer output to a vacuum tube controller and then to a control board indicator. An on-off signal is sent to the annunciator panel when the pressure reaches a preset value. An on-off signal is sent to the fail safe panel to indicate a failure in this instrumentation.

The level in the low pressure surge tank is detected by differential pressure detector with an external uncompensated reference leg and condensing chamber. The level in the reference leg is maintained by allowing water to continually flow into the condensing chamber. The output of the level detector signal is sent to a vacuum tube amplifier and to a control board indicator. An on-off signal is sent to the annunciator panel when the level reaches preset high and low values. An on-off signal is sent to the fail safe panel to indicate a failure in this instrumentation.

The pressure in an isolated loop is obtained from a pressure detector located in the loop fill line header. By opening or closing the appropriate valves in the loop fill lines any individual loop pressure can be obtained. The flexed element of the Bourdon tube type detector is contained in a secondary housing capable of withstanding the design pressure. The differential transformer output is sent to a magnetic amplifier and then to a control board indicator. An on-off signal is sent to the annunciator panel when the pressure reaches preset high and low values. An on-off signal is sent to the fail safe panel to indicate a failure in this instrumentation.

The pressure in the outlet header of the charging pumps is detected by a Bourdon tube type pressure detector with the flexed element being contained in a secondary housing capable of withstanding the design pressure. The differential transformer output is sent to a vacuum tube amplifier and then to a control board mounted indicator.

Auxiliary Instrumentation - In the line between the low pressure surge tank make-up pumps and the low pressure surge tank and between the low pressure surge tank make-up pumps and the charging pumps suction, are mounted local flow indicators with totalizers.

These flow totalizers are used to measure the quantity of water added to the main coolant system. This information is used to accurately determine the water balance of the main coolant system which is important during boron shim operation.

An automatic pressure control valve which relieves the pressure in the low pressure surge tank is actuated by a Bourdon tube type pneumatic pressure controller set to open on increasing pressure in the low pressure surge tank starting to open at 17 psi gage and to be fully open at 20 psi gage. Since the maximum flow rate through the valves is 10 scfm of pure hydrogen, a high pressure override is provided by a pressure switch actuating a three-way solenoid valve in the air loading line to the control valve to shut the control valve when the tank pressure reaches approximately 35 psi gage. In addition, a temperature controller also actuates the same three-way solenoid to override the action of the pressure controller when the temperature in the tank exceeds 180 F, which is the maximum allowable mixture temperature in the waste disposal system. The pressure control valve may be remote manually operated from the control room.

Instrumentation to control make-up water to the low pressure surge tank consists of the following: a differential level transmitter on the low pressure surge tank sends a pneumatic signal to a controller which operates a make-up valve on low level and a drain valve on high level; a Bourdon tube pressure controller operating through a relay and pressure switch opens the make-up valve and starts the low pressure surge tank make-up pumps to provide water for quenching safety valve discharge on steam pressure buildup in the low pressure surge tank. The make-up valve may be remote manually operated from the control room. When the temperature in the low pressure surge tank exceeds 180 F, a pressure switch in the loading line from a temperature controller actuates a three-way solenoid valve in the loading line to the tank drain control valve, preventing high temperature fluid discharging to the waste disposal system.

Local Bourdon tube type pressure indicators are mounted on the outlet header of the make-up pumps, the low pressure surge tank, and the outlet of the low pressure surge tank pump.

Functional Requirements

The following is a discussion of how, by employing the equipment presented above, the required charging and volume control system functions are accomplished.

Water Charg[illegible] to the Main Coolant System

During [illegible] filling and venting procedures, borated water from the safety injection [illegible] shield tank cavity water tank is pumped by the high pressure charging pumps into the main coolant system. When filling and venting the isolated main coolant loops the loop fill and chemical injection line is employed, while the feed line is used in filling and venting the reactor vessel and the pressure control and relief system. The feed line is connected to the hot leg of loop No. 4 of the main coolant system. The loop fill and chemical injection line is connected to the cold leg of each main coolant loop, upstream of the isolation valve, by means of a piping header system.

Changes in the steady state operating conditions of the main coolant system result in changes in the specific volume of the water in that system. This, in turn, affects the normal pressurizer vessel water level. When negative volume changes occur, a signal is sent from the pressurizer vessel instrumentation to the operating variable speed charging pump calling for an increase in feed flow until the normal water level is reestablished. Charging pump suction during normal main coolant system operating conditions is taken from purification system and/or the low pressure surge tank. Normal plant cool down operations also cause contraction of the water in the main coolant system. This results in a lowering pressurizer vessel water level and the signal to the high pressure charging pumps calling for an increase in feed flow to maintain the water level. During the plant cool down operations, the charging pump suction is taken from the safety injection and shield tank cavity water tank. This make-up water is charged by the high pressure charging pumps, through the feed and bleed heat exchanger, and then into the main coolant system.

In converse to the above, i.e. a positive volume change and a rising water level in the pressurizer vessel, a signal from that vessel calls for a reduction of the charging flow.

Any leakage from the main coolant system or the pressure control and relief system, as well as bleeding of main coolant for purification purposes, results in a lowering of the pressurizer vessel water level and, in turn, the signal calling for an increase in feed flow to maintain the water level.

During certain plant shutdown conditions, with the main coolant loops isolated from the reactor vessel, operation of the charging pumps is required to establish and/or to maintain a pressure in the isolated loops. In this case water is charged into the isolated loops via the loopfill and chemical injection line.

The three high pressure charging pumps in the charging and volume control system are connected to a common suction header and a common discharge header with appropriate valving employed to facilitate individual or simultaneous operation of two or three pumps. The arrangement is such that when charging pumps Nos. 1 and 2 are servicing the reactor vessel portion of the main coolant system, pump No. 3 may service the isolated loops. Also, all three pumps may service the same area. Isolation valves are installed in the pumps' suction and discharge piping, so that any pump may be isolated for repair and not affect the operation of the other pumps.

During normal plant operating conditions, the feed flow is balanced with the bleed flow by the variable speed high pressure charging pumps which receive signals from the pressurizer vessel instrumentation calling for maintenance of water level.

When an unbalance between the feed flow rate and the bleed flow rate occurs, the low pressure surge tank water level will rise or fall. During a falling water level condition, the low pressure surge tank water level instrumentation originates signals which start up the low pressure surge tank make-up pump(s). These pumps normally take suction from the primary storage water tank or alternatively from the demineralized water storage tank and discharge to the surge tank. When a rising water level condition exists, the low pressure surge tank instrumentation originates a signal which opens a valve in the purification system to drain the excess water to the waste holdup tank or the activity dilution decay tank.

Water Removal from the Main Coolant System

Water is removed from the main coolant system for purification, for draining to the drain collecting tank, or for disposal to the waste disposal system, as well as to maintain pressurizer vessel water level during plant heat up operations and during long time volume surges resulting from changes in main coolant system operating conditions.

Normally, all water bled from the main coolant system flows through the bleed line connected to the cold leg of loop No. 1. This bleed is cooled in passage through the feed and bleed heat exchanger before being reduced in pressure by the orifices. The cooled, low pressure bleed is then discharged to the low pressure surge tank through an underwater eductor. The bleed flow rate from the main coolant system is controlled by establishing flow through one or more of the orifices by opening the motor operated gate valves located at the discharge of each orifice. When a low water level condition exists in the pressurizer vessel, however, all bleed flow is stopped by closure of the diaphragm operated valve in the bleed line downstream of the orifices. Also, should the temperature of the bleed become excessive, an alarm will be sounded by a temperature sensing element located upstream of the low pressure surge tank connection.

During normal operation the temperature of the water in the low pressure surge tank is maintained within the desired limits by recirculating a constant flow of water through the low pressure surge tank cooler and the purification system by the purification cooling and drain pumps. The cooled and purified water is returned from the purification ion exchanger to the high pressure charging pump suction header for charging into the main coolant system with the excess flow being returned to the low pressure surge tank.

Boric Acid Addition and Removal for Control Purposes

In order to supply the necessary supplemental neutron absorbing capability, in excess of that possessed by the control rods, when shutting down the plant, sufficient boric acid is pumped into the main coolant system to establish a boron concentration of 950 ppm. Normal shutdown procedures call for predetermined quantity of 12% boric acid solution to be supplied by the chemical shutdown system to the suction header of the high pressure charging pumps for injection into the main coolant system via the feed line.

Boric acid is removed from the main coolant system by dilution and by the purification system. During normal plant start-up procedures, treated water from the primary storage water tank or the demineralized water storage tank is supplied by the low pressure make-up pumps to the suction header of the high pressure charging pumps. These pumps, in turn, charge the unborated water into the main coolant system, while water, containing decreasing concentrations of boric acid, is bled from the main coolant system via the bleed line. This bleed is discharged to the low pressure surge and subsequently dumped to the waste disposal system. During this operation, the charging pumps are controlled so as to maintain a constant water level in the pressurizer vessel. The dilution operation continues until the boric acid concentration in the main coolant system is reduced to 20 ppm. Thereafter, the boric acid is removed by passing the borated bleed through the purification system and returning the purified unborated water to the main coolant system.

Reduction of Main Coolant Activity by Dilution

When the reactor vessel head is to be removed following plant operation with some fuel cladding defects, the main coolant activity must be reduced by a bleed and feed dilution operation when shutting down the plant. This is necessary so that the activity of the shield tank cavity water, after it mixes with the diluted main coolant remaining in the isolated reactor, will give a sufficiently low dose rate to permit refueling and other operations on the charging floor.

While maintaining the main coolant system in a hot standby condition, the activity level is reduced during the normal shutdown procedure by charging purified make-up water from the primary water storage tank to the main coolant system with the high pressure charging pumps maintaining normal water level in the pressurizer. Diluted main coolant of decreasing activity level is bled at about 100 gpm from the main coolant system through the bleed line and low pressure surge tank and pumped from this tank to the waste disposal system. The dilution operation is continued until the gross activity level of the diluted main coolant in the bleed line is 0.58 microcurie per ml. Based on cladding defects in 1% of all fuel elements, the quantity of water required for this dilution operation is 69,000 gal if a constant 10 gpm purification rate is used, or 61,300 gal if the maximum purification rate of 100 gpm is maintained for one week prior to a normal plant shutdown. Since decay of the radioactivity continues during the additional time required for complete cold shutdown of the plant, the activity of the main coolant in the isolated reactor when the vessel head is removed will be 0.42 microcurie per ml.

Safety and Relief Valve Quenching

The safety valves on the pressurizer vessel as well as the relief valves on the safety injection line, feed line, shutdown cooling lines, main coolant loops and on the pressurizer vessel are all connected to a common header which discharges to the low pressure surge tank through an underwater eductor. Also, when the main coolant drain header is used as a bleed line, that header is connected to the low pressure surge tank via the safety valve header. As a result of the discharging of the safety valves into the low pressure surge tank and depending upon the conditions of the discharge, the temperature and pressure in the surge tank may increase.

In the event of excessive temperature in the low pressure surge tank, it will be necessary for the control room operator to manually start the low pressure surge tank cooling pump(s) after proper valving has been arranged locally. Temperature instrumentation will close the low pressure surge tank relief pressure control valve to prevent discharging high temperature steam to the primary drain collecting tank. The low pressure surge tank pumps are started and the level control valve is opened on high pressure in the low pressure surge tank to provide a cold water spray. In the event of pressure buildup in the low pressure surge tank caused by failure to quench the pressurizer safety valves discharge properly, a group of safety valves on the low pressure surge tank set at 75 psi gage will relieve the tank contents into the vapor container. The low pressure surge tank is normally maintained half full of water for the purpose of providing an adequate heat sink as well as providing a volume for an accumulator effect for steam formation.

The low pressure surge tank cooler and pump are so interconnected with the shutdown cooling pump and heat exchanger, that the corresponding equipment may be operated in parallel, if desired, and one item may serve as a back-up for the other.

Pressurizer Cooling and Decontamination

During the normal plant shutdown procedures after initial cooling and depressurization and after shutdown of the main coolant pumps, the rate of depressurization of the primary plant may be increased by operating the auxiliary spray on the pressurizer vessel. This auxiliary spray is connected to the feed line downstream of the feed and bleed heat exchanger. This arrangement permits the charging of water by the high pressure charging pumps into the top of the pressurizer vessel with resulting condensation of the steam bubble. The auxiliary spray flow is very small and is balanced with a small flow through the bleed line. This will heat up the spray water thereby reducing the thermal gradients in the pressurizer vessel.

To facilitate decontamination of the pressurizer vessel, a line must be provided at some future date between the loop fill and chemical injection line and the auxiliary spray line. The decontamination solution will then flow from the boric acid mixing and storage tank to charging pump No. 3 (which is valved off from the other pumps) through the loop fill and chemical injection line, to the line to the auxiliary pressurizer vessel spray. For flushing the pressurizer vessel after decontamination, treated water from the primary storage water tank or demineralized water storage tank is supplied to the high pressure charging pump by the low pressure make-up pumps and, in turn, through the same flow path as the decontamination solution.

To assure that no decontamination solution flows to the main coolant system from the pressurizer vessel, a small feed flow is established by either charging pump No. 1 or No. 2. This feed flow is bled off through the pressurizer vessel drain. This operation establishes a flow in the desired direction in the surge line; i.e. from the main coolant system to the pressurizer vessel.

Noncondensible Gas Removal

Since the low pressure surge tank is maintained at a lower pressure and temperature than the main coolant system, some of the gases which become dissolved in the main coolant come out of solution and accumulate in the low pressure surge tank. Periodically, the low pressure surge tank is blown down to the primary drain collecting tank in order to dispose of these gases.

Chemical Addition

In order to establish and maintain a low concentration of dissolved oxygen in the main coolant system, hydrogen and hydrazine are employed as scavengers. During subcritical plant operation, the scavenging of oxygen is accomplished by injecting a solution of hydrazine and water. This solution is supplied by the corrosion control system to the suction piping of each of the high pressure charging pumps which charge it into the main coolant system via the feed line.

During normal plant power operating conditions a hydrogen atmosphere at a pressure of 15 psi gage is maintained in the low pressure surge tank. There, the hydrogen under pressure and in contact with the water is dissolved in the water which is subsequently pumped into the main coolant system. In the presence of ionizing radiation in the core, the hydrogen combines with the oxygen in the main coolant.

Water Charging to the Auxiliary Systems and Equipment

The charging and volume control system facilitates charging of water from the demineralized water storage tank or the primary storage water tank to the following systems and equipment for the indicated purpose:

System or Equipment	Purpose
Chemical Shutdown System	Supply and for flushing of equipment and piping
Safety Injection System	Flushing of equipment and piping Make-up of boric acid solution
Ion Exchangers	Flushing of vessels and piping
Fuel Pit	Filling, make-up and pump priming
High Pressure Charging Pumps	Sealing
Primary Pumps Sealing Tank	Filling and make-up
Steam Generators, Secondary Side	Emergency loss of station power

Boric Acid Make-up to the Low Pressure Surge Tank During Chemical Shim Operation

To maintain stable boron concentrations in the main coolant system during operation with chemical shim, the boron concentration of the liquid in the low pressure surge tank must be controlled at the desired level. To accomplish this, both the low pressure surge tank make-up pump and boric acid transfer pump are started on a low pressure surge tank low level signal. The discharge line from each pump enters a common mixing section to insure admitting a uniform solution to the low pressure surge tank. The proper boron concentration of the low pressure surge tank make-up is provided by adjusting the metering or proportioning valves in the discharge lines from the boric acid transfer and low pressure surge tank make-up pumps. Totalizing flowmeters in each line provide a means for checking the setting of the metering valves.

204 CHEMICAL SHUTDOWN SYSTEM

Boric Acid Addition

General

The function of the chemical shutdown system is to provide a neutron absorbing boric acid solution to be injected into the main coolant system to complement the control rods. Boron is required in the coolant during certain periods of operation at power and also to give 5% Δ $k/_k$ shutdown with all 24 control rods fully inserted in the cold, clean core (See Section 103, CORE NUCLEAR DESIGN).

The chemical shutdown system consists of a mixing and storage tank, transfer pump, valves, piping, and instrumentation for pressure, temperature and water level control as shown on drawing No. 646-J-426.

A second, independent source of boric acid which is available to provide the necessary shutdown margin is the safety injection system. Borated water from the safety injection tank can be routed directly to the suction of the charging pumps. However, this system would not be used except in the event of a failure in the chemical shutdown system, and such a failure is very unlikely because this system is virtually duplicated within itself.

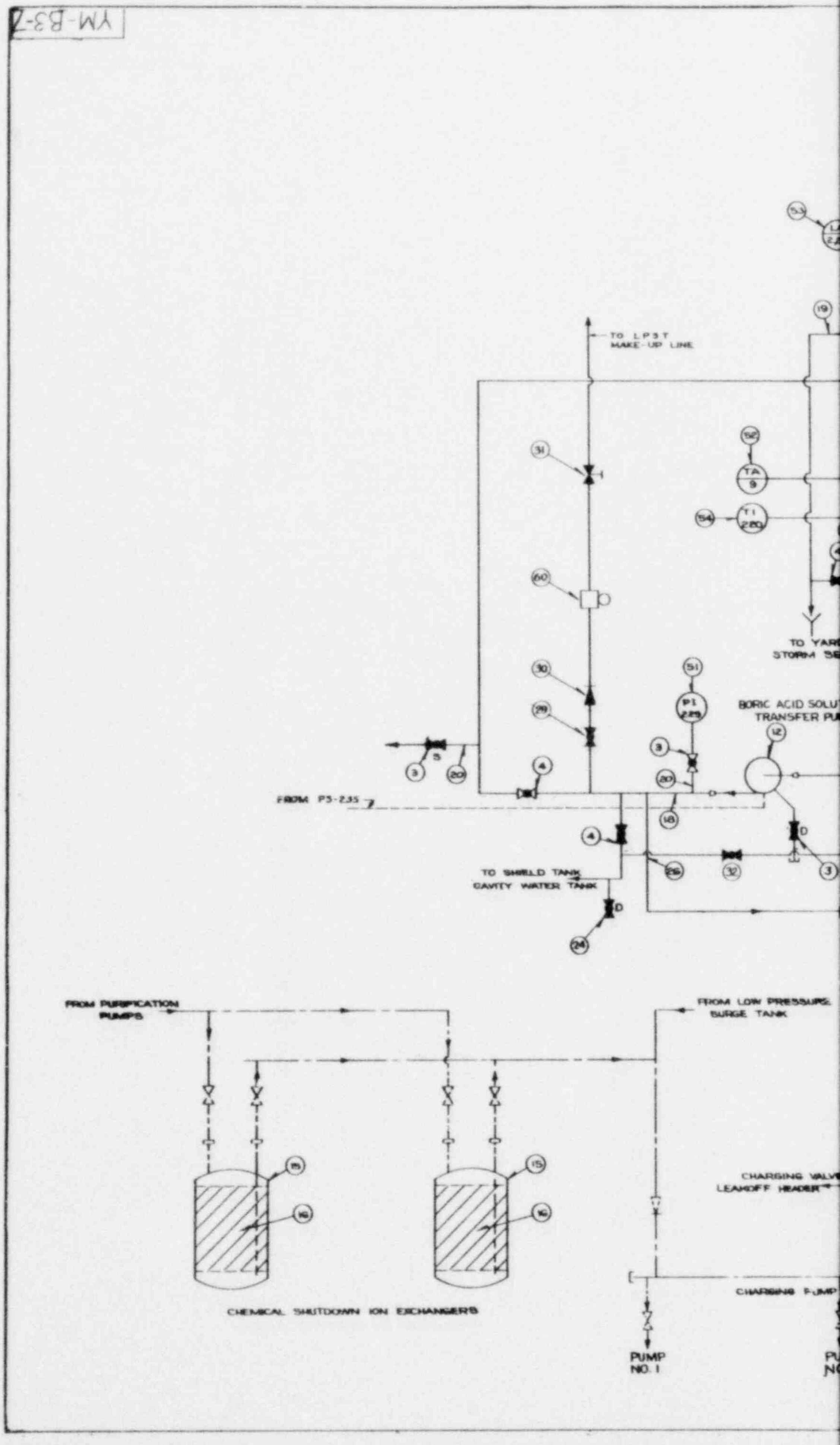
The system is sized to attain any desired concentration of boric acid in the main coolant. The actual boric acid concentration required for cold shutdown will be ascertained during initial critical tests. The boric acid is added to the main coolant in a 12 wt % solution and is injected by the charging pumps. Main coolant pump circulation assures that the injected solution is well distributed throughout the main coolant system. The operating procedure requires that the proper boric acid concentration be maintained throughout the shutdown period and that any previously isolated loop must contain borated water at the proper concentration before chemical shutdown is accomplished. This eliminates the possibility of subsequent change in boric acid concentration.

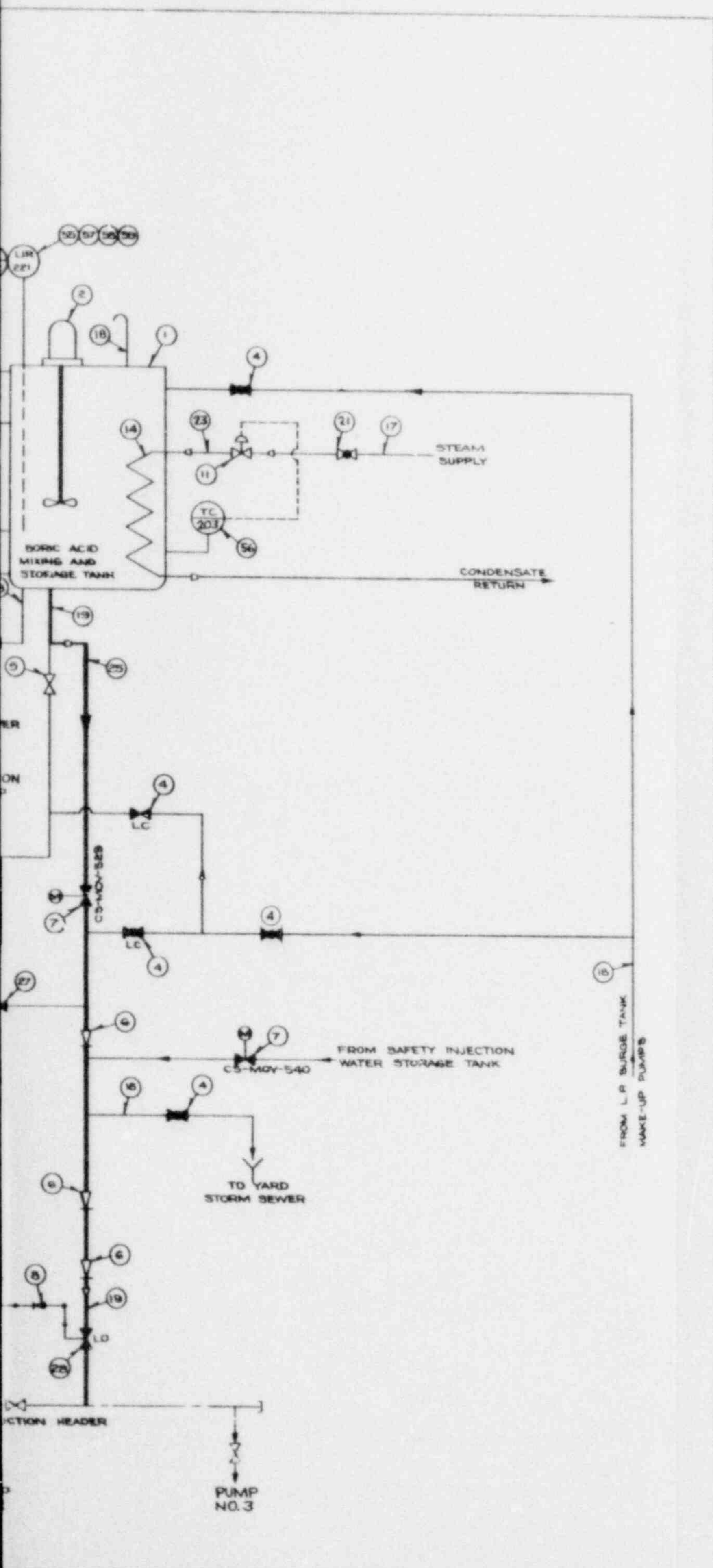
The entire injection operation can be carried out by remote control of the motor operated inlet valve between the mixing and storage tank and the charging pump suction header.

Boration of an isolated loop is accomplished by charging a precalculated volume of 12 wt % solution from the mixing tank into the isolated loop, while bleeding an equal volume of water from the loop through the drain to the waste disposal system.

Mixing and Storage Tank - The solution is prepared in a 3,000 gal mixing and storage tank by adding technical grade granular boric acid to demineralized water, heated to 150°F. A motor driven agitator is provided in the tank to assist initial mixing. Steam heating coils are also provided in the tank to maintain 12 wt % solution of boric acid completely soluble at 150°F by an automatic temperature controlled steam valve. A local temperature indicator and remote low temperature alarm are included to assure that the solution is maintained at 150°F.

Location of the mixing tank is such that a substantial positive suction head is provided from the tank to the charging pumps. The mixing and storage tank is vented to the atmosphere.


TO LPST
MAKE-UP LINE
TA 9
TI 280
TO YARD
STORM SE
PI 229
BORIC ACID SOLUT
TRANSFER PU
FROM PS-235
TO SHIELD TANK
CAVITY WATER TANK
FROM PURIFICATION
PUMPS
FROM LOW PRESSURE
SURGE TANK
CHARGING VALVE
LEAKOFF HEADER
CHARGING PUMP
CHEMICAL SHUTDOWN ION EXCHANGERS
PUMP
NO. 1



TITLE YANKEE ATOMIC ELECTRIC COMPANY
NUCLEAR POWER PLANT
CHEMICAL SHUTDOWN SYSTEM (MECH.)
DWG 646J426 SUB 8&7#7

SHEET NO. 1

NOTE	ITEM	MATERIAL & DESCRIPTION		SIZE	RATING	"E" SPEC	GROUP NO.
	1	BORIC ACID TANK	SST	3000 GAL			1
	2	AGITATOR					
	3	GLOBE VALVE	SST	1/2"	150 LB		7
	4	GLOBE VALVE	SST	2"	150 LB		7
	5	GATE VALVE	SST	3"	150 LB		2
	6	CHECK VALVE	SST	4"	150 LB		3
	7	GATE VALVE M.O. STEM LEAKOFF	SST	4"	300 LB @ 375°F		2
	8	BALL CHECK VALVE	SST	1/2"	600 LB		1
	11	CONTROL VALVE DIAPH OPER.		2 1/2"			1
	12	CENTRIFUGAL PUMP		2×1 1/2"	100 GPM @ 83 FT		1
	13	STEAM TRAP		2"			
	14	STEAM COIL HEATER		2"			
	15	ION EXCHANGER VESSEL		[illegible]	150 LB		2
A	16	RESIN		[illegible] CU FT			[illegible]
	17	PIPING SCH 80	CST	3"	150 LB		[illegible]
	18	PIPING SCH 10S	SST	2"	150 LB		[illegible]
	19	PIPING SCH 10S	SST	3"	*150 LB		[illegible]
	20	PIPING SCH 10S	SST	1/2"	150 LB		[illegible]
	21	GLOBE VALVE	BRONZE	3"	200 LB		1
	22	PIPING SCH 80	CST	1 1/2"	150 LB		[illegible]
	23	PIPING SCH 80	CST	2 1/2"	150 LB		[illegible]
	24	GLOBE VALVE	SST	3/4"	150 LB		1
	25	PIPING SCH 10S	SST	4"	150 LB		[illegible]
	26	PIPING SCH 10S	SST	2 1/2"	150 LB		[illegible]
	27	GATE VALVE	SST	2 1/2"	150 LB		1
	28	GATE VALVE-STEM LEAKOFF	SST	3"	300 LB @ 670°F		1
	29	GLOBE VALVE	SST	1 1/2"			
	30	CHECK VALVE	SST	1 1/2"			
	31	HAND METERING VALVE	SST	1 1/2"			
	32	GLOBE VALVE	SST	2"			

NOTES:
A B.O. FROM ROHM & HAAS * XE-78 OR EQUIV.

TITLE YANKEE ATOMIC ELECTRIC COMPANY
NUCLEAR POWER PLANT
CHEMICAL SHUTDOWN SYSTEM (I & C)
DWG 646J426 SUB 8&7#7

SHEET NO. 2

NOTE	ITEM	MATERIAL & DESCRIPTION	CODE NO.	GROUP NO. 1	2	3	4	5	6	7	8
	51	PRESSURE INDICATOR	CS-PI-229	1							
	52	TEMPERATURE ALARM	CS-TA-9			1					
	53	LEVEL ALARM	CS-LA-2,22					2			
	54	TEMPERATURE INDICATOR	CS-TI-220		1						
	55	LEVEL DETECTOR	CS-LD-221					1			
	56	TEMPERATURE CONTROLLER	CS-TC-203				1				
	57	LEVEL CONTROLLER	CS-LC-221					1			
	58	LEVEL INDICATOR	CS-LI-221					1			
	59	LEVEL RECORDER	CS-LR-221								
	60	FLOW METER									

GROUP #5 E-SPEC
GROUP #4 E-SPEC

GROUP #2 E-SPEC
GROUP #1 E-SPEC

REV	S.O. / D	CHANGE
3	S.O. YTR 16134; D 602400	WAS OLD DWG. REVISED & REDRAWN AS PER ENGRGS MARKED UP PRINT
4	S.O. YTR 16134; D 602400	CHANGED AS PER ENGINEERS MARKED PRINT
5	S.O. YTR 16134; D 602400	CHANGED AS PER ENGRGS MARKED UP PRINT
6	S.O. YTR 16134; D 602400; IT 28	(28) WAS ON VALVE
7	S.O. YTR 16134; D 602400	CHANGED AS PER MARKED ENGR PRINT THACKLEY 9-8-59
8		ADDED SOLUTION & DISCHARGE CONN. TO BORIC ACID TANK PUMP.

FLOW DIAGRAM YM-B3 8

WESTINGHOUSE ELECTRIC CORPORATION
TITLE YANKEE ATOMIC ELECTRIC COMPANY
POWER PLANT-CHEMICAL SHUTDOWN SYSTEM (MECH. & I&C)
DIMENSIONS IN INCHES SCALE NTC

646J426

A local level, recorder and indicator with remote high and low level alarms provide complete instrumentation to assist the operator in all phases of operation of the system.

Piping is arranged so that the line from the tank to the charging pump suction header may be flushed with demineralized water to the yard drain.

Transfer Pump - The 100 gpm transfer pump has three functions. The first is to transfer batches of 12 wt % boric acid solution from the mixing tank to the safety injection shield tank cavity water storage tank where it is diluted with demineralized water to a 1 wt % boric acid solution required for safety injection. The second function of the transfer pump is to periodically recirculate the 12 wt % solution to keep the concentration uniform throughout the mixing tank. A local pressure gage on the pump discharge provides convenient indication of pump performance. The third function is to provide borated make-up to the Low Pressure Surge Tank during chemical shim operation.

Boric Acid Removal

General - During reactor startup, the boric acid solution is removed from the main coolant system. In the initial phase, the boric acid concentration is reduced by dilution and recirculation for approximately 11 hr after which only 5% of the boric acid remains in the main coolant. The remaining boric acid is removed by ion exchange requiring approximately 9 hr so th t after a total of approximately 20 hr the main coolant system has no ap iable amount of boric acid remaining in solution. Ion exchange . ccomplished by bleeding the slightly borated main coolant to the low pressure surge tank and pumping it with the purification pumps through the chemical shutdown ion exchangers to the charging pumps which return the deborated water to the main coolant system.

Ion Exchangers - Two 30 cu. ft. ion exchange vessels are located in the ion exchange storage pit. Each vessel is charged with 20 cu. ft. of Rohm & Haas Anion Resin #XE-78 or equivalent. The ion exchange resin temperature is limited to a maximum of 140 F. Remote means for replacing and disposing of the exhausted ion exchanger are provided. In Section 205, PURIFICATION SYSTEM, the means of manipulating the ion exchangers is more fully described.

Isolation and operation of the radioactive portion of the chemical shutdown system is performed by means of manually operated valves with reach rods through concrete shielding.

All materials of the system in contact with the solution are Type 304 stainless steel. Tests over long periods of time have shown the boric acid corrosion rate of Type 304 stainless steel to be negligible.

All equipment is constructed and installed in accordance with the requirements of the latest edition of the ASME, Section VIII, Unfired Pressure Vessel Code.

Piping and valves are 150 lb class and meet the requirements of ASA B31.1, Code for Pressure Piping and ASA B16.5, Steel Pipe Flanges and Flanged Fittings, respectively.

205 PURIFICATION SYSTEM

General

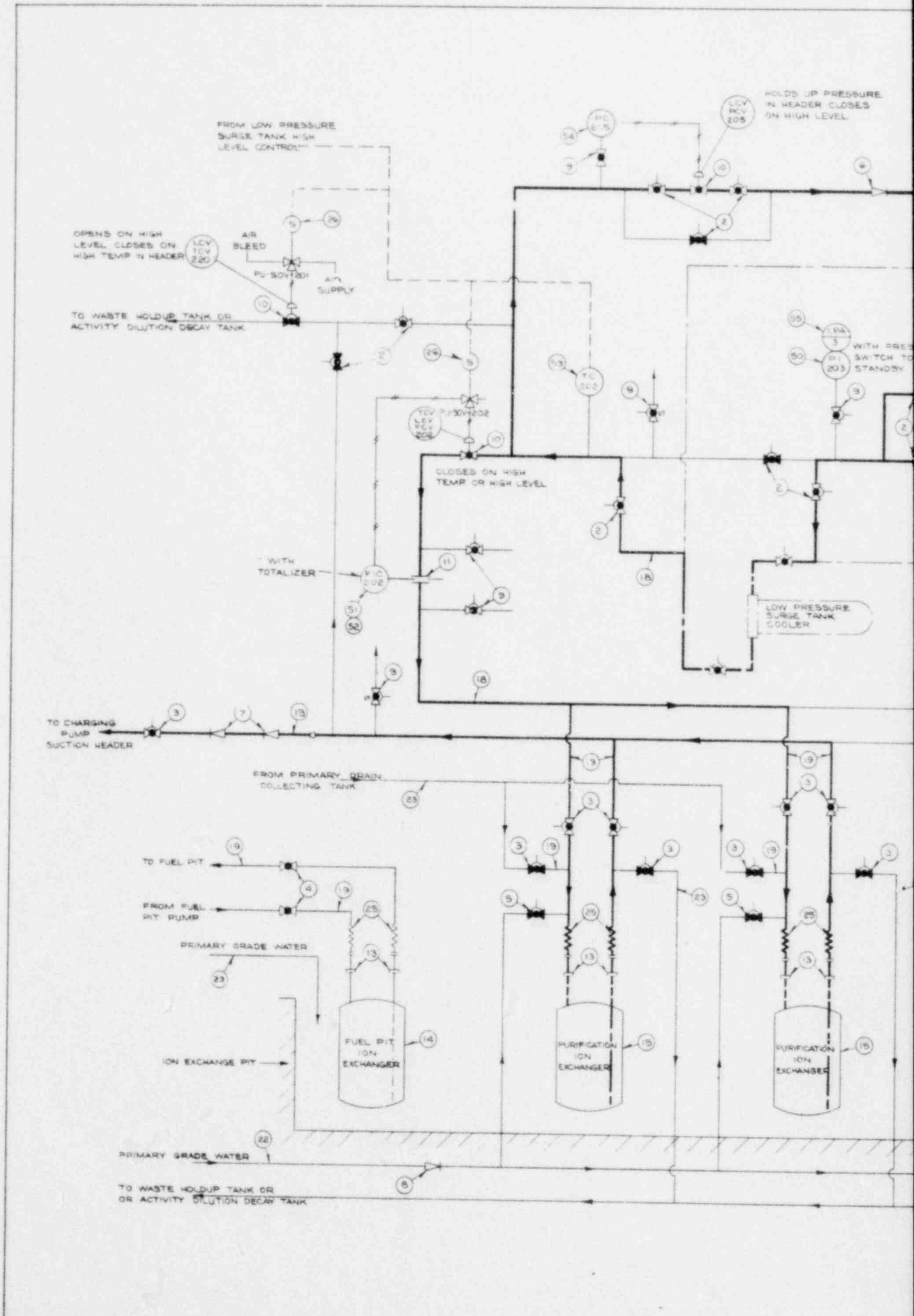
The function of the main coolant purification system is to remove impurities from the primary coolant. This is necessary in order to limit the level of induced radioactivity and to reduce fouling of h at transfer surfaces. Normally, the chief source of radioisotopes expected in the main coolant will be parent nuclides from Type 348 stainless steel. The impurity content, exclusive of chemical additives, is kept at 1 ppm or less, except during the plant initial operation period.

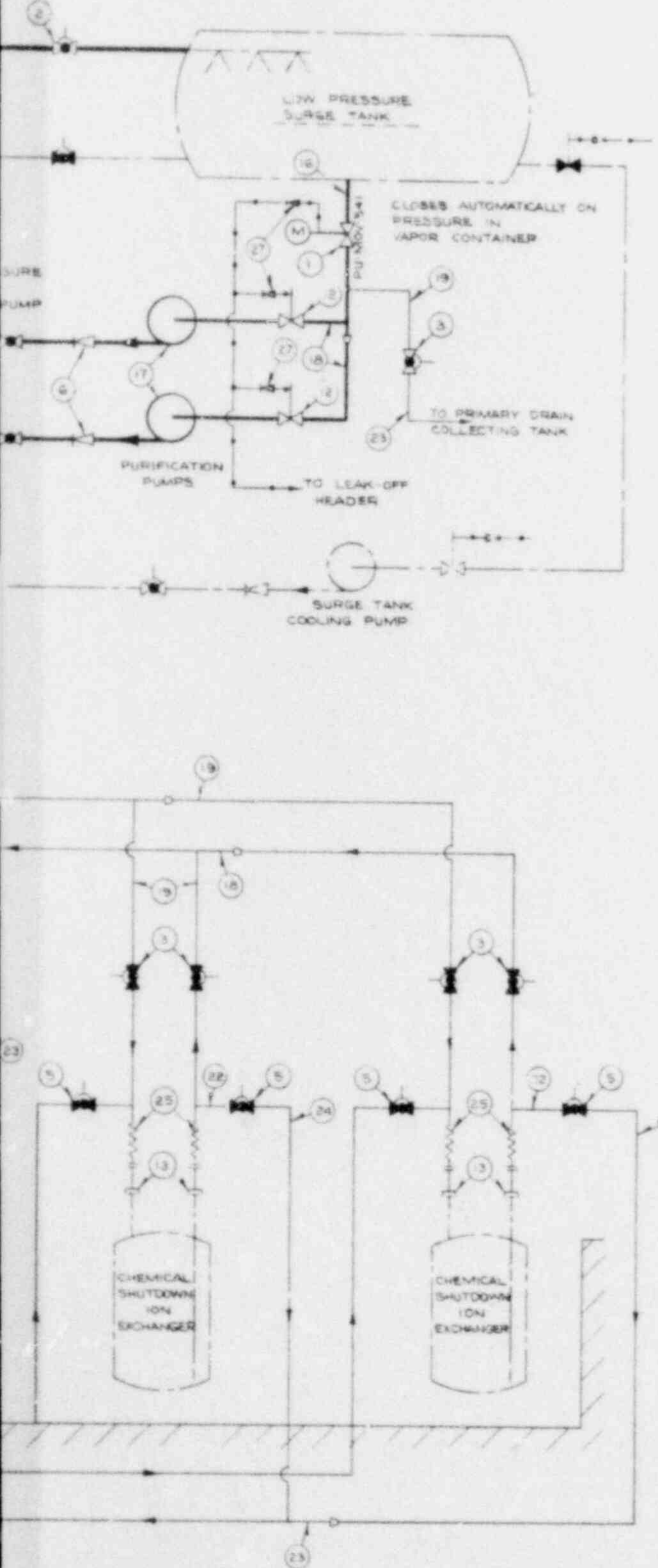
The system consists of two 100 gpm pumps in parallel, two ion exchange beds of mixed resin, and the necessary associated valves, pipe, fittings and instrumentation as shown on drawing No. 646-J-723.

The purification system operates at low temperature and pressure and is located outside the vapor container. Although access to the purification piping and equipment is not intended during operation, a spent ion exchanger can be replaced without interrupting the estimated normal purification flow of 10 gpm. The resin vessels are designed and stored for ease of handling; the portion of the purification-cooling-drain pumps flow which is sent to the ion exchanger passes through a pipe galley and shielded valve pit out into the ion exchangers, which are submerged in a water-filled pit. The reference height of water shielding is 10 ft above the top of the resin.

Normally, only a cooled, depressurized by-pass stream of main coolant will receive ion exchange treatment. However, piping is provided so that liquid in the primary drain collecting tank of the radioactive waste disposal system can be decontaminated by the purification ion exchangers, if it meets certain other chemical requirements. The liquid thus purified is returned to either the waste holdup or activity dilution decay tank in waste disposal for further treatment. In addition, the main coolant by-pass stream can be rejected to waste disposal after passing through the ion exchangers, if desired.

A by-pass stream (25 to 125 gpm in 25 gpm steps) is bled from the cold leg of one main coolant loop through the charging and volume control system variable flow orifices. The temperature is reduced to less than 240 F in the bleed portion of the regenerative heat exchanger, and a pressure reduction from 2,000 psi gage is accomplished at the orifices. The cooled, depressurized water is then pumped from a surge tank through a nonregenerative cooler into purification, normally at a temperature of 120 F, and returned to the suction side of the positive displacement pumps in the charging and volume control system. The purification system is arranged in parallel with the charging pump suction line from the surge tank and its flow is variable from 10 to 100 gpm by means of an automatic flow control valve. Thus, purification flow may be adjusted periodically during reactor operation to accomplish activity reduction or allow for increased pressure drop across the resin due to removal of insoluble solids. The system is protected by temperature and pressure controls to operate only at design conditions.


FROM LOW PRESSURE SURGE TANK HIGH LEVEL CONTROL
HOLDS UP PRESSURE IN HEADER CLOSES ON HIGH LEVEL
OPENS ON HIGH LEVEL CLOSES ON HIGH TEMP IN HEADER
AIR BLEED
AIR SUPPLY
TO WASTE HOLDUP TANK OR ACTIVITY DILUTION DECAY TANK
CLOSES ON HIGH TEMP OR HIGH LEVEL
WITH TOTALIZER
LOW PRESSURE SURGE TANK COOLER
TO CHARGING PUMP SUCTION HEADER
FROM PRIMARY DRAIN COLLECTING TANK
TO FUEL PIT
FROM FUEL PIT PUMP
PRIMARY GRADE WATER
ION EXCHANGE PIT
FUEL PIT ION EXCHANGER
PURIFICATION ION EXCHANGER
PURIFICATION ION EXCHANGER
PRIMARY GRADE WATER
TO WASTE HOLDUP TANK OR OR ACTIVITY DILUTION DECAY TANK



TITLE - YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT PURIFICATION SYSTEM (MECH)
DWG 646J723 SUB #2

SHEET NO 1

NOTE	ITEM	MATERIAL & DESCRIPTION		SIZE	RATING	"E" SPEC	GROUP NO
	1	GATE VALVE - MOTOR OPERATED STEM LEAK-OFF	SST	3"	300 LB @ 375°F		1
	2	GLOBE VALVE - BELLOWS SEAL	SST	2½"	300 LB @ 375°F		11
	3	GLOBE VALVE - BELLOWS SEAL	SST	2"	300 LB @ 375°F		3
	4	GLOBE VALVE		2"	150 LB		2
	5	GLOBE VALVE BELLOWS SEAL	SST	1"	300 LB @ 375°F		4
	6	CHECK VALVE SWING	SST	2½"	150 LB		3
	7	CHECK VALVE, LIFT	SST	2"	150 LB		2
	8	CHECK VALVE LIFT	SST	1"	150 LB		1
	9	GLOBE VALVE BELLOWS SEAL	SST	½"	300 LB @ 375°F		6
	10	DIAPHRAGM OPERATED VALVE BELLOWS SEALED	SST	2½"			3
A	11	METERING ORIFICE	SST	1 3/32			1
	12	GATE VALVE STEM LEAKOFF	SST	2½"	300 LB @ 375°F		2
	13	SPECIAL DISCONNECT COUPLING WITH PLUG SEAT -	SST	2"			0
	14	FUEL PIT ION EXCHANGER	SST	30 FT³	150 LB		1
	15	PURIFICATION ION EXCHANGER		30 FT³	150 LB		2
	16	PIPING SCH 10S	SST	3"	150 LB		[illegible]
	17	PURIFICATION COOLING DRAIN PUMPS	SST	2½×2½	100 GPM @ 225 FT		2
	18	PIPING SCH 10S	SST	2½"	150 LB		[illegible]
	19	PIPING SCH 10S	SST	2"	150 LB		[illegible]
B	20	RESIN - PURIFICATION		20 FT³			[illegible]
B	21	RESIN - FUEL PIT		20 FT³			[illegible]
	22	PIPING SCH 10S	SST		150 LB		[illegible]
	23	PIPING SCH 80	CST	2"	150 LB		[illegible]
	24	PIPING SCH 80	CST	1"	150 LB		[illegible]
	25	FLEX HOSE	SST	2"			10
	26	SOLENOID OPERATED VALVE					2
	27	BALL CHECK VALVE	CST	½"	600 LB		3

NOTES
ALL MATL'S 304 SST UNLESS OTHERWISE SPEC
A SIZED FOR 100' WATER HEAD & 10 GPM FLOW
B 80 FROM ROHM & HAAS #IE-150 OR EQUIV

TITLE - YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT PURIFICATION SYSTEM (I & C)
DWG 646J723 SUB #2

SHEET NO 2

NOTE	ITEM	MATERIAL & DESCRIPTION	CODE NO	GROUP NO 1	2	3	4	5	6	7	8
	50	PRESSURE INDICATOR	PU-PI-203	1							
	51	FLOW CONTROLLER	PU-FC-202		1						
	52	FLOW INDICATOR	PU-FI-202		1						
	53	TEMPERATURE CONTROLLER	PU-TC-202			1					
	54	PRESSURE CONTROLLER	PU-PC-205				1				
	55	ANNUNCIATOR	PU-LPA-3					1			

GROUP #5 E-SPEC
GROUP #4 E-SPEC
GROUP #3 E-SPEC
GROUP #2 E-SPEC
GROUP #1 E-SPEC 397251 B

33-3
X

WESTINGHOUSE ELECTRIC CORPORATION

TITLE - YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT - PURIFICATION SYSTEM (MECH & I&C)

DIMENSIONS IN INCHES - SCALE NTS

646J723

ATOMIC POWER DEPT.

Ion Exchangers

Design - The maximum rate of corrosion product removal allowed for is 20.5 lb each month. In addition, it is assumed that a maximum of 5 lb of uranium dioxide and associated fission products are leached uniformly throughout each year from fuel elements. These impurities, both soluble and insoluble, will be solids and gases.

The maximum allowable temperature for water entering the ion exchanger resin column is 140 F. Higher temperatures would cause some decomposition of the resin and a corresponding loss in capacity for impurities. For example, tests have shown that for 18 weeks exposure at 140 F, the resin capacity was reduced approximately 12%. For this reason, the normal purification inlet temperature is 120 F, or less.

A maximum flow loading of 10 gpm/sq ft of resin bed cross-section should not be exceeded for efficient operation. Since the maximum flow through one ion exchanger is 50 gpm, the diameter of each unit is fixed at 2 ft-6 in. The capacity of a new bed is 12 kilograins as $CaCO_3$ per cu ft of resin. Based on experimental results, the minimum lifetime for a 20 cu ft bed should be at least five months. The overall height of an ion exchanger is about 6 ft-6 in. to the top of the lifting lug.

Main coolant entering the ion exchanger is passed through a distributor ring above the resin level in the ion exchanger, so that no channeling through the resin is permitted. The water flows down through the resin and past a supported close welding pattern metallic filter orifice plate. A top-entering standpipe which passes through the resin, filter, and filter support plate returns purified water from the bottom of the ion exchanger to the charging pump suction line from the surge tank.

Pressure drops across a new resin and support filter have been estimated to total about 6 psi at 50 gpm. The resin may serve to filter out insoluble corrosion products as well as exchange with soluble impurities. Assuming 50% pluggage at the end of resin bed life, the pressure drop across the filter should be approximately 11 psi. To overcome these losses and all other system losses, the purification pumps are sized for a total dynamic head of 96.5 psi at 100 gpm.

Analyses of activity in the main coolant versus purification flow rate indicate a "point of diminishing returns" for flows above 70 gpm. Thus, the maximum system capability of 100 gpm is adequate, and the variable flow feature gives the advantage of less waste heat and lower pumping costs when low flows are allowable.

The equipment in the purification system is sized, constructed, and installed so that the requirements of the latest ASME, Section VIII, Unfired Pressure Vessel Code can be fulfilled. The piping in the purification system is sized, constructed, and installed so that the requirements of the ASA B31.1 - 1955, Code for Pressure Piping, Sections 1 and 6 can be fulfilled. Design pressure for all components is 150 psi gage. Reference design lifetime (except for the resin) is 140,000 hr.

As discussed earlier, the ion exchangers are submerged in a water-filled pit. They are disposable cartridge type units, so that when the resin is spent, the whole unit is disconnected and stored in the pit for an appropriate decay period before ultimate disposal. This method eliminates handling of loose radioactive resin, since the resin containing vessel is operated, removed from service, and stored while always submerged. Only when the unit is to be sent to ultimate disposal does it leave the pit. However, it will be loaded into a shipping coffin first and will meet established shipping regulations on activity external to the coffin when removed.

Before an exhausted ion exchanger is removed from service, it is flushed with pure water to waste disposal to remove contaminated water. The inlet and outlet nozzles at the top of the resin vessel are connected to vertical risers. Removable concrete slabs shield the inlet and outlet lines above the water surface. These slabs are removed and flexible connection flanges at the tops of the risers are broken. A special sealing plug, seated inside the nozzle at the top of the vessel, is then inserted through each riser by means of a long manipulating wrench. The riser is then unscrewed under water and a cored pipe plug screwed into the nozzle, above the sealing plug.

The ion exchanger vessels are supported by lugs on bearing plates in the pit, which are arranged in a rail-like fashion. Space for about five vessels is available in each of two rows. Initially, a minimum of two ion exchangers should be available. Since the inlet and outlet lines to each are separated by concrete shielding above the water level, one vessel can be isolated and removed from service while the other is in operation. The expended resin vessel is moved down the rail by a crane, away from the flexible connections, and stored for decay. A new vessel containing fresh resin with preassembled risers can then be lowered from above the pit into position and the connections to the flexible hose made.

Performance - The reference resin is nuclear grade H-OH saturation resin; Westinghouse PDS-11557-3. The manufacturer's value for capacity is 12 kilograins as $CaCO_3$ per cu ft of resin.

Decontamination factors obtained under laboratory conditions for the important corrosion products were:

Fe-273
Cr-180
Co-4000
Fe, Cr, Co-1188 (corrected for difference in specific activity of the elements in the feed mixture.)

Decontamination factors for mixed fission products average about 1,200.

Crud levels in the main coolant (nominal pH neutral) may be as great as 1 ppm based on Army Package Power Reactor experience. Actual exposed minus descaled weight changes have been determined to average about 30 mg/dm^2 for austenitic stainless steels in out-of-pile tests for the

Yankee reactor. This layer constitutes the majority of the corrosion product formed, which has been measured to form at a rate of less than 10 mg/dm^2/month in out-of-pile tests.

In addition to the soluble crud in the main coolant, insoluble corrosion products which probably exist as colloids and particulate matter will be picked up by the resin by a filtering action.

The life of the resin will be established mainly by gross decontamination factor. The decontamination factor based on degassed, 15 minute decay, inlet and outlet samples should normally exceed 100.

An increase in ion exchanger effluent water conductivity above the nominal value of approximately 2 μmho/cm^3 will also indicate resin exhaustion.

206 COMPONENT COOLING SYSTEM

General

The component cooling system is provided to dissipate waste heat from the various nuclear steam generator plant components. An intermediate fluid is used to ensure that any leakage of radioactive water through the cooled components may be under control.

The component cooling system is shown on drawing No. 646-J-424 and consists of two coolers, two circulating pumps, a surge tank, a chemical addition tank and associated piping, system and instrumentation piping, valves, fittings and instruments. This equipment is connected to two main piping headers which are located outside the vapor container. Independent lines, provided with isolation valves located outside the vapor container, are connected from the header to the various components inside the vapor container.

Each component cooling pump and cooler can accommodate full heat removal loads. For increased reliability of the system, each unit can be operated singly or in parallel and each pump and cooler can be cross connected.

The system is initially filled from the plant condensate supply and a corrosion inhibitor is immediately added to the fill water. During normal system operation, the chemical addition tank and associated piping are isolated.

To maintain the desired water level in the component cooling surge tank, level controls and alarms are provided in the water surge tank of the system. A valve in the feed line is operated by the surge tank controls.

The component coolant fluid is circulated by one or both pumps. A pressure switch, a pressure alarm, and pressure indicators are provided in the outlet of the pumps in order to check that the pressure remains within assigned limits. Check valves prevent backflow through the pumps.

A local temperature indicator in the common cooler inlet pipe is provided.

Temperature indicators, local and remote, a high temperature alarm, a flow meter, and a flow meter alarm are provided in the common cooler outlet pipe in order to check that the temperature and the flow of the component coolant remains within the assigned limits.

The component coolant flows from the common cooler outlet pipe into the main header from which seven branch lines, provided with check and stop valves, enter the vapor container. These lines connect with the four main coolant pumps, the neutron shield tank coolers, the sample cooler, and the neutron shield surge tank for fill and make-up only.

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Four other branch lines from the main header which is outside the vapor container provide cooling water for the fuel pit cooler, the low pressure surge tank cooler, the shutdown cooler, and for the Waste Disposal Building. Stop valves are provided in each of these lines.

Six return lines from the vapor container connect with the four main coolant pumps, the neutron shield tank coolers, and the sample cooler. All return lines are provided with temperature indicators and manually operated flow control valves. The cooling lines from the main coolant pumps are also provided with temperature alarms. A trip valve is provided in the common header of the six return lines to isolate the component cooling piping in the vapor container from the rest of the system in the event of a major rupture in the main coolant system.

The return lines from the shutdown cooler and the low pressure surge tank cooler are provided with temperature indicators. A control valve which regulates the flow from the heat exchanger is controlled by the temperature in the low pressure surge tank, which is maintained at approximately 120 F.

The return line from the fuel pit cooler is provided with a temperature indicator, a stop valve, and a manual flow control valve.

All the return lines connect to a common header which is provided with radiation monitoring and temperature indicators before entering the component cooling pumps inlet.

The four main coolant pump returns, the sample cooler return, and the shutdown and low pressure surge tank coolers are provided with safety valves discharging through a common line into the component cooling water surge tank. The safety valves in the return lines from the main coolant pumps are sized to handle the maximum flow occurring from a ruptured cooling coil in the pump.

The component cooling water surge tank is provided with a vent line discharging to the primary vent stack. In case the activity level indicated by the radiation monitoring unit in the pump inlets should be too high, a valve in the vent line shuts automatically in order to avoid any active vapor entering the stack. A safety valve discharging into the vapor container drain tank takes care of any excessive pressure in the component cooling water surge tank.

The system is provided with adequate drains discharging to the yard storm sewer or to the gravity drain tank if the water in the component cooling system becomes contaminated.

<u>Design</u>

The component cooling system is designed to remove heat from the various reactor plant components and to operate at a maximum design pressure of 110 psi gage and a maximum temperature of 150 F.

Material in contact with the component cooling is carbon steel except for the tubes and tube sheet of the heat exchangers and the pump internals. Stainless steel is not required since it is not possible, except through leakage, for component cooling water to enter the primary system, because these system are not cross connected.

The component cooling system is designed in accordance with the following codes:

Equipment - ASME - 1956 - Unfired Pressure Vessels, Section VIII

Piping - ASA B31.1 - 1955 - Code for Pressure Piping, Sections 1 and 6

Valves, Fittings - ASA B16.5 - 1957 - Standard for Steel Pipe Flanges and Flanged Fittings

The system design is based upon the following maximum heat requirements for each component:

Equipment	No. of Units	Unit Heat Removal Btu Per Hr	Total Heat Removal Btu Per Hr
Main Coolant Pumps	4	1.2×10^6	4.8×10^6
Neutron Shield Tank Coolers	8	$.011 \times 10^6$	$.090 \times 10^6$
Sample Cooler	1	0.5×10^6	0.5×10^6
Waste Disposal Building Connection	1	2.8×10^6	2.8×10^6
Shutdown Cooler	1	(16×10^6)*6.5×10^6	(16×10^6)*6.5×10^6
Low Pressure Surge Tank Cooler	1	4×10^6	4×10^6
Fuel Pit Cooler	1	5×10^6	5×10^6

*Only applicable for short periods of time.

The severest combination of simultaneous heat removal requirements gives the following design criteria for the component cooling coolers and pumps:

Conditions	Startup 60 F Cooling Water	Normal 60 F Cooling Water	Normal 81 F Cooling Water	Design 3 Hr After Shutdown
Total heat removal from system, Btu per hr	11.8×10^6	8.5×10^6	8.5×10^6	16×10^6
Total component cooling water required, gpm	2,000	1,050	2,000	2,000

Pumps

Two motor driven centrifugal circulating pumps are provided. The capacity of each pump is approximately 2,000 gpm, with a total dynamic head of 190 ft of water and a design discharge shutoff pressure of 110 psi gage.

The component cooling pumps can be operated singly or in parallel if required, and either pump can be isolated from the system for repairs without disturbing the operating pump. The pump power supply is designed to be highly reliable in order to provide dependable cooling to protect the serviced equipment from overheating. The main coolant pump, for example, must not be without component cooling water in the jacket for more than 3 min or, with water in the jackets, without circulation for more than 8 min. One component cooling pump is a spare and has an independent power supply. It is interlocked to the operating pump, so that a power failure to one pump will not affect the operation of the component cooling system.

Coolers

The two component coolers are of the shell and tube design and are provided to transfer heat from the component cooling water to the raw water. The tubes are made of admiralty metal. Each cooler is designed for the full cooling capacity reached during normal plant operation, i.e., 8.5×10^6 Btu per hr. Either cooler serves as a spare for the other, but each can be operated in parallel, if required. Either cooler can be isolated from the system for repairs.

Cooler design data are as follows:

Case	Normal 60 F Cooling Water Pond Water	Normal 81 F Cooling Water Cooling Water	Design 3 Hr After Shutdown
Duty, Bt[illegible]	8.5×10^6	8.5×10^6	16×10^6
Tube temperature, in out, F	91-75	100.5-92	96-80
Shell temperature, in out, F	60-74.2	81-87.8	60-72.8
Flows, gpm			
Tube side	1,050	2,000	2,000
Shell side	1,200	2,500	2,500

Surge Tank

A surge tank (4,000 gal) is used in the component cooling system to provide make-up water for the system, to accommodate the expansion and contraction of the water in the system as temperature changes, and to act as a receiver for the safety valves in the component cooling lines. The water level in the tank is maintained at approximately 2,500 gal by the level control valve on the condensate supply pipe.

The surge tank is equipped with a vent to the primary vent stack and with a safety valve which discharges into the vapor container drain tank.

Corrosion Control

For corrosion control, a small tank is provided in which potassium chromate is added, and then water is circulated through the tank to dissolve the chemical. During normal plant operation, the concentration of potassium chromate in the component cooling water is maintained between 300 and 500 ppm.

The neutron shield tank is filled from the component cooling system. The valve arrangement of the system provides a means of filling the neutron shield tank with water of the desired concentration of 300 to 500 ppm of potassium chromate.

Valves

There are no unusual required features for the valves in the component cooling system. They are manually operated gate and flow control valves.

Instrumentation

The location of the instruments used in the component cooling system is shown on drawing No. 646-J-424. The functions of these instruments are as follows:

Item	Function	Limits
Canned Motor Temperature Detector	Measures the outlet temperature of the componant cooling water from the pumps	Normal pressure - 100 psi gage Normal design pressure - 150 psi gage - temperature range 70-200 F
Local Pressure Detector	Measures (the outlet (pressure of	Normal pressure - 100 psi gage
Pressure Switch	Controls (the compon- (ent coolant	Max. design pressure - 150 psi gage
Low Pressure Alarm	Checks (water from (the pump	Maximum temp. - 150 F Pressure range - 0-150 psi gage

Item	Function	Limits
System Flow Meter	Measures (the outlet (flow of the (component (cooling water (from the heat	Max. temp. - 150 F Max. design pressure - 150 psi gage Flow range - 0-4,000 gpm
Low Flow Alarm	Checks (exchangers	
Radiation Monitor Unit	Measures the inlet activity of the component cooling water at the pump suction	Max. temp. - 150 F Max. design pressure - 150 psi gage Max. range - .01 to 10 r per hr
System Temperature Indicator	Measures (temperature (of the com-	Normal pressure - 100 psi gage
Temperature Switches	Control (ponent cool-	Max. design pressure - 150 psi gage
Temperature Alarm	Checks (ing water	Temp. range - 0-200 F

207 CORROSION CONTROL SYSTEM, PRIMARY PLANT

General

The function of the corrosion control system is to inject hydrazine or hydrogen into the main coolant for the purpose of reducing the dissolved oxygen concentration and maintaining it at a minimum value.

It is expected that the corrosion rate within the primary plant systems will be most subject to increase when the dissolved oxygen concentration increases in the main coolant. The two predominant means by which dissolved oxygen may be introduced into the main coolant are make-up water or contact with the atmosphere during a plant cold shutdown and radiolysis of coolant passing through an epithermal neutron flux in the reactor core. The former would be the probable source for an increase in dissolved oxygen content during a plant shutdown and subsequent startup period. Increase in dissolved oxygen by radiolysis would occur during the time the reactor is critical.

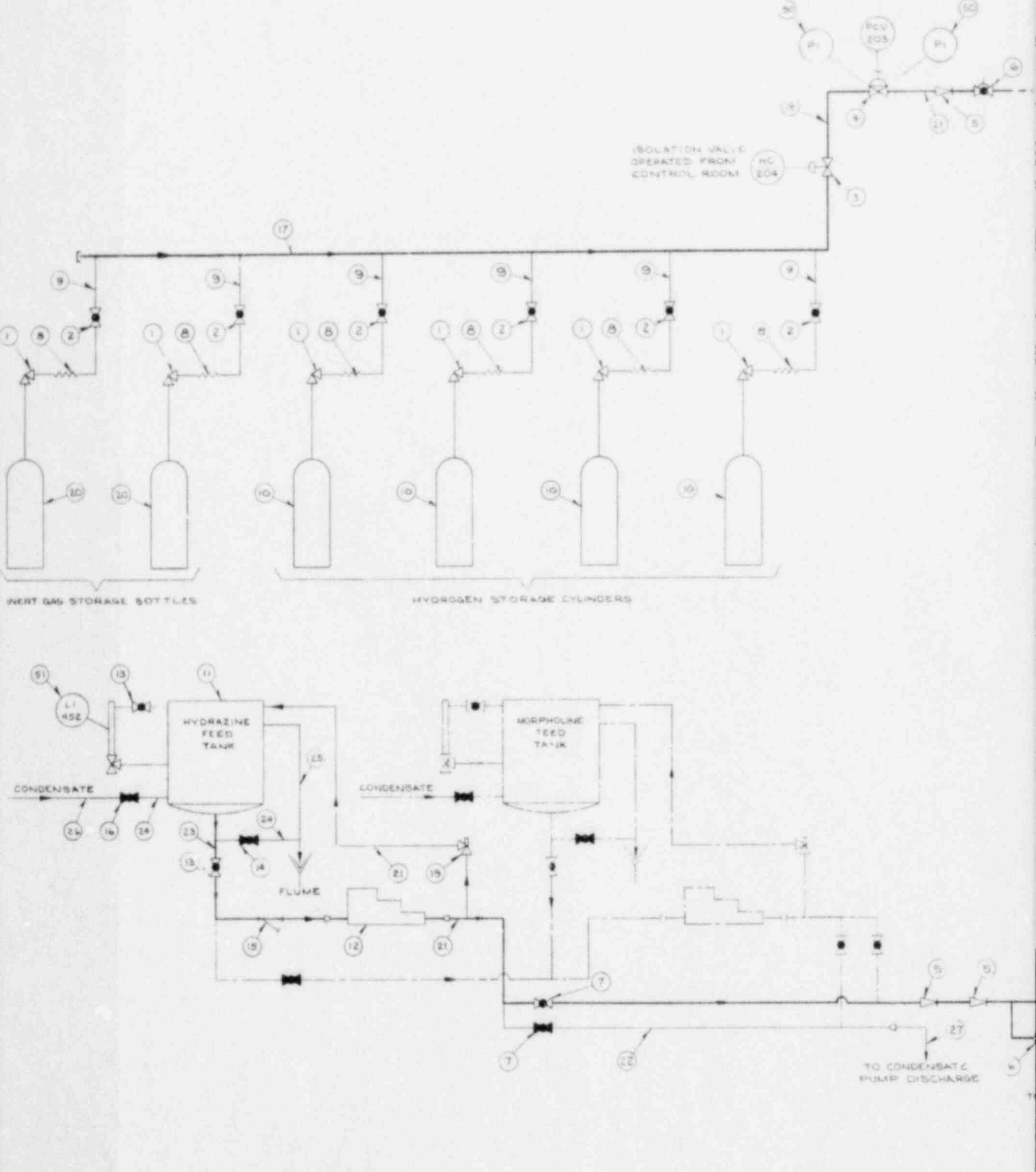
The concern over corrosion is not due primarily to mechanical consideration (reduction in wall thickness) but to induced radioactivity of the corrosion products, and therefore the radioactive contamination hazard.

The corrosion control system, as shown on drawing No. 646-J-431, consists of two sections, the hydrazine addition section and the hydrogen addition section, in order to provide means for lowering the oxygen concentration in the main coolant system during both plant startup and normal operating conditions; hydrazine during plant startup and hydrogen during reactor operation.

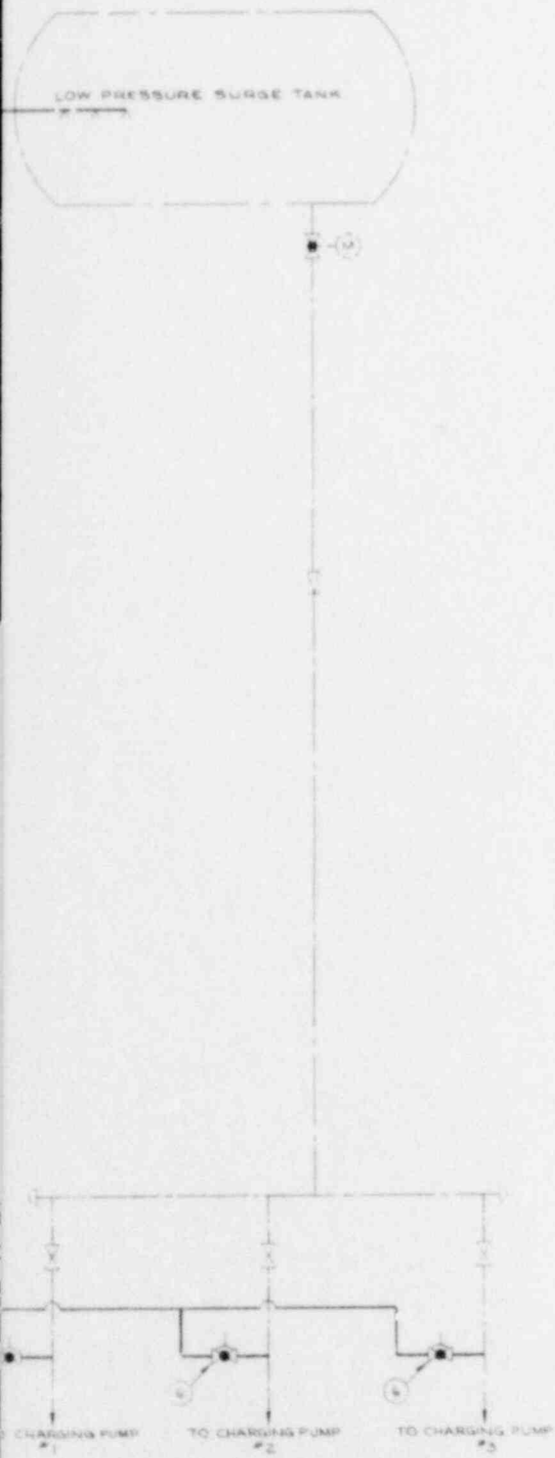
Hydrazine Addition

In order to minimize corrosion whenever the main coolant system is operated with the reactor subcritical, hydrazine is injected into the primary plant make-up water to reduce the dissolved oxygen concentration of the coolant. The facts that in the absence of radiation, introduction of hydrazine will not increase the dissolved or suspended solids in the primary coolant and facilities already exist for the use of hydrazine in the secondary system, point to the selection of hydrazine over other corrosion inhibitors. Theoretically, 1 lb of 100% hydrazine is capable of removing 1 lb of oxygen according to the reaction: $N_2H_4 + O_2 = 2H_2O + N_2$. At low temperature the reaction of the hydrazine may not be directly with the oxygen but rather with the surface iron. This iron then undergoes a surface reaction with the oxygen. Therefore, a higher quantity of hydrazine has to be injected. However, the handling of pure hydrazine presents safety hazards; for this reason, solutions of hydrazine in water are employed in the plant.

The hydrazine addition section consists of a feed tank, a feed pump and the charging line. As a spare, the morpholine equipment also used for the secondary plant, of the same size and of the same material as the hydrazine equipment, can be utilized.



PCV 203
PI
PI
ISOLATION VALVE OPERATED FROM CONTROL ROOM
HC 204
INERT GAS STORAGE BOTTLES
HYDROGEN STORAGE CYLINDERS
LI 452
HYDRAZINE FEED TANK
MORPHOLINE FEED TANK
CONDENSATE
CONDENSATE
FLUME
TO CONDENSATE PUMP DISCHARGE



TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT
CORROSION CONTROL SYSTEM (MECH)
DWG. 646J431 SUB 1 & 2

SHEET NO. 1

NOTE	ITEM	MATERIAL & DESCRIPTION	SIZE	RATING NUMBERS	"E" SPECS	QTY
A	1	ANGLE VALVE	1/2			6
	2	GLOBE VALVE	1/2	3000 LB		6
	3	DIAPHRAGM OPERATED VALVE	1/2"	3000 LB		1
	4	PRESS. REGULATOR VALVE (GAS)	1/2"	3000 LB		1
	5	CHECK VALVE SST.	1/2	150 LB		3
	6	GLOBE VALVE BLWS. SEAL SST.	1/2	300 LB		4
	7	GLOBE VALVE SST.	1/2	150 LB		2
	8	FLEX HOSE	1/4	3000 LB		4
	9	TUBING BRONZE	1/4"	2500 LB @ 610°F		[illegible]
	10	HYDROGEN STORAGE CYLINDERS	200 FT³			6
	11	HYDRAZINE FEED TANK SST.	58 GAL			1
	12	METERING PUMP SST.	1/2"-1/2"	.7 GPH @ 100 PSIG		1
	13	GLOBE VALVE SST.	3/4"	150 LB.		2
	14	GLOBE VALVE SST.	1"	150 LB.		1
	15	STRAINER SST.	3/4"			1
	16	GLOBE VALVE BRONZE	1"	200 LB.		1
	17	MANIFOLD (GAS) C.S.	1/2"	3000 LB.		1
	18	PIPING SCH 80 S SST.	1/2"	2500 LB @ 610°F		[illegible]
B	19	RELIEF VALVE	1/2"			1
	20	INERT GAS BOTTLES	200 FT³			2
	21	PIPING SCH 10 S SST.	1/2"	150 LB.		[illegible]
	22	PIPING SCH 80 CST.	1/2"	150 LB.		[illegible]
	23	PIPING SCH 10 S SST.	3/4"	150 LB.		[illegible]
	24	PIPING SCH 10 S SST.	1"	150 LB.		[illegible]
	25	PIPING SCH 10 S SST.	1 1/2"	150 LB.		[illegible]
	26	PIPING SCH 80 CST.	1"	150 LB.		[illegible]
	27	PIPING SCH 80 CST.	3/4"	150 LB.		[illegible]

NOTES:
A-PROVIDED ON HYDROGEN CYLINDERS AND INERT GAS BOTTLES
B-PROVIDED BY PUMP SUPPLIER

TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT
CORROSION CONTROL SYSTEM (I & C)
DWG. 646J431 SUB 1 & 2

SHEET NO 2
GROUP NO. 2

NOTE	ITEM	MATERIAL & DESCRIPTION	CODE NO.	1	2	3	4	5	6	7	8
1	50	PRESSURE INDICATOR		2							
2	51	LEVEL INDICATOR	CO-11482		1						

NOTE 1 - PART OF ITEM 4
NOTE 2 - 3-WAY VALVE PROVIDED BY LEVEL INDICATOR SUPPLIER

GROUP #2 E SPEC
GROUP #1 E SPEC

WESTINGHOUSE ELECTRIC CORPORATION
TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT - CORROSION CONTROL SYSTEM (MECH & I & C)
DIMENSIONS IN INCHES SCALE NTS
646J431
ATOMIC POWER DEPT PITTSBURGH, PA. U.S.A.

With the exception of a portion of the charging line, the hydrazine addition section is located within the water treatment room.

The hydrazine feed tank is equipped with a level sight glass, an overflow line and a drain line; both of which discharge into a flume. Condensate water is supplied through a tangential mixing connection at the bottom of the tank.

The hydrazine feed tank is charged with a 35 wt % solution of hydrazine in water that does not have either a flash or fire point. The feed tank may also be charged with a more dilute solution prepared from the 35 wt % solution. The capacity of the tank is 38 gallons.

The hydrazine solution flows from its feed tank to the suction of the feed pump. To prevent foreign matter from entering the feed pump, a strainer is provided on the pump suction. To protect the remainder of the system from overpressure, the pump is equipped with a safety valve on the discharge line. The hydrazine solution is discharged into the suction of each charging pump. This connection provides a direct path from the hydrazine feed tank to the operating charging pump and reduces the possibility of "hide-out". The charging pumps in turn feed the hydrazine solution into the main coolant system.

To ensure that a radioactive contamination problem does not occur from backflow of the primary coolant, the hydrazine feed line contains two check valves in series just upstream of its discharge points. In order to isolate the system from the primary plant, a globe type stop valve is provided in the charging line downstream of the metering pump.

Materials in contact with the hydrazine solution are Type 304 stainless steel or equivalent for corrosion resistance.

The need for hydrazine during plant startup is determined by analyzing the main coolant for dissolved oxygen.

Hydrogen Addition

When the reactor is critical, water passing through the core region will undergo radiolysis by the epithermal neutron flux. Since the products of water radiolysis are oxygen and hydrogen, this would create a dissolved oxygen buildup in the main coolant and might increase the corrosion rate through the primary system. Maintaining an excess of dissolved hydrogen will tend to reverse or prevent the radiolysis reaction and consequently maintain a low oxygen concentration. For this reason, hydrogen is used as the corrosion control agent during reactor operation.

The hydrogen residual is obtained by introducing the gas into the low pressure surge tank. The method employed consists of establishing a hydrogen overpressure in the vapor phase of the surge tank sufficient to maintain 25 to 50 cc (STP) of hydrogen per kilogram of water at equilibrium conditions. This requires that, with a normal operating temperature of 130°F in the surge tank, approximately 25 psia partial pressure of hydrogen be maintained in the vapor phase.

208 SAMPLING SYSTEM, PRIMARY PLANT

The function of the primary plant sampling system is to take samples of main coolant liquid and gases for chemical and radiochemical analyses. Sampling is a manual operation except for remotely controlled isolation valves in inaccessible areas. Local sampling of auxiliary systems is not described herein.

The primary plant sampling system, as shown on Drawing No. 646-J-429, is operated intermittently throughout the life of the plant to withdraw samples from the following systems and transport them to the sample room:

Main Coolant System, Pressurizer Drain and Bleed Line -- A common high pressure-high temperature sample cooler is used for all systems. The sample line for the main coolant system is used for all systems. The sample line for the main coolant system and pressurizer drain comes from the drain header. The bleed line sample point is ahead of the regenerative heat exchanger. A common line is used downstream of the high pressure sample cooler.

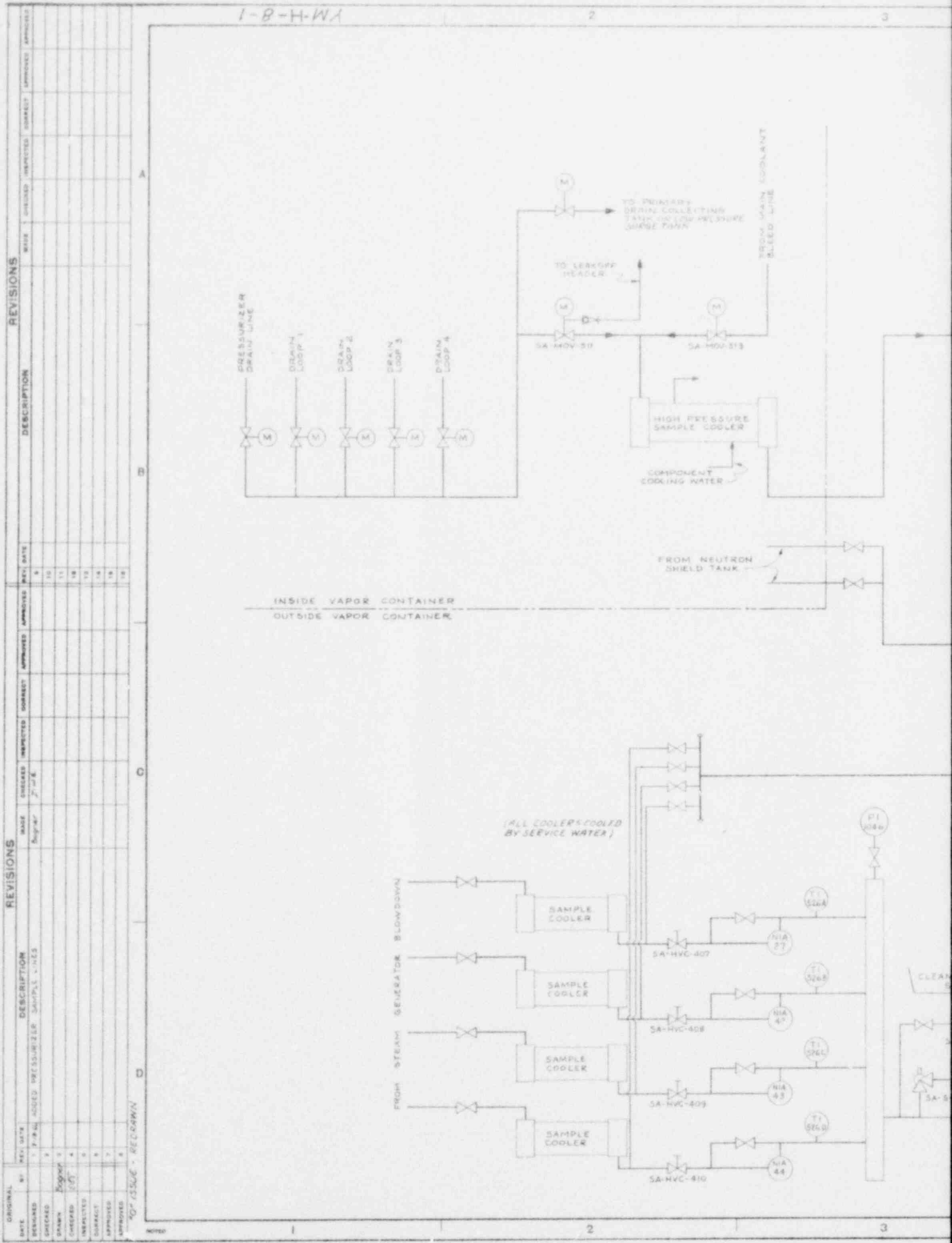
Shutdown Cooling System -- A low pressure sample line comes from the shutdown cooling system return line to the main coolant system.

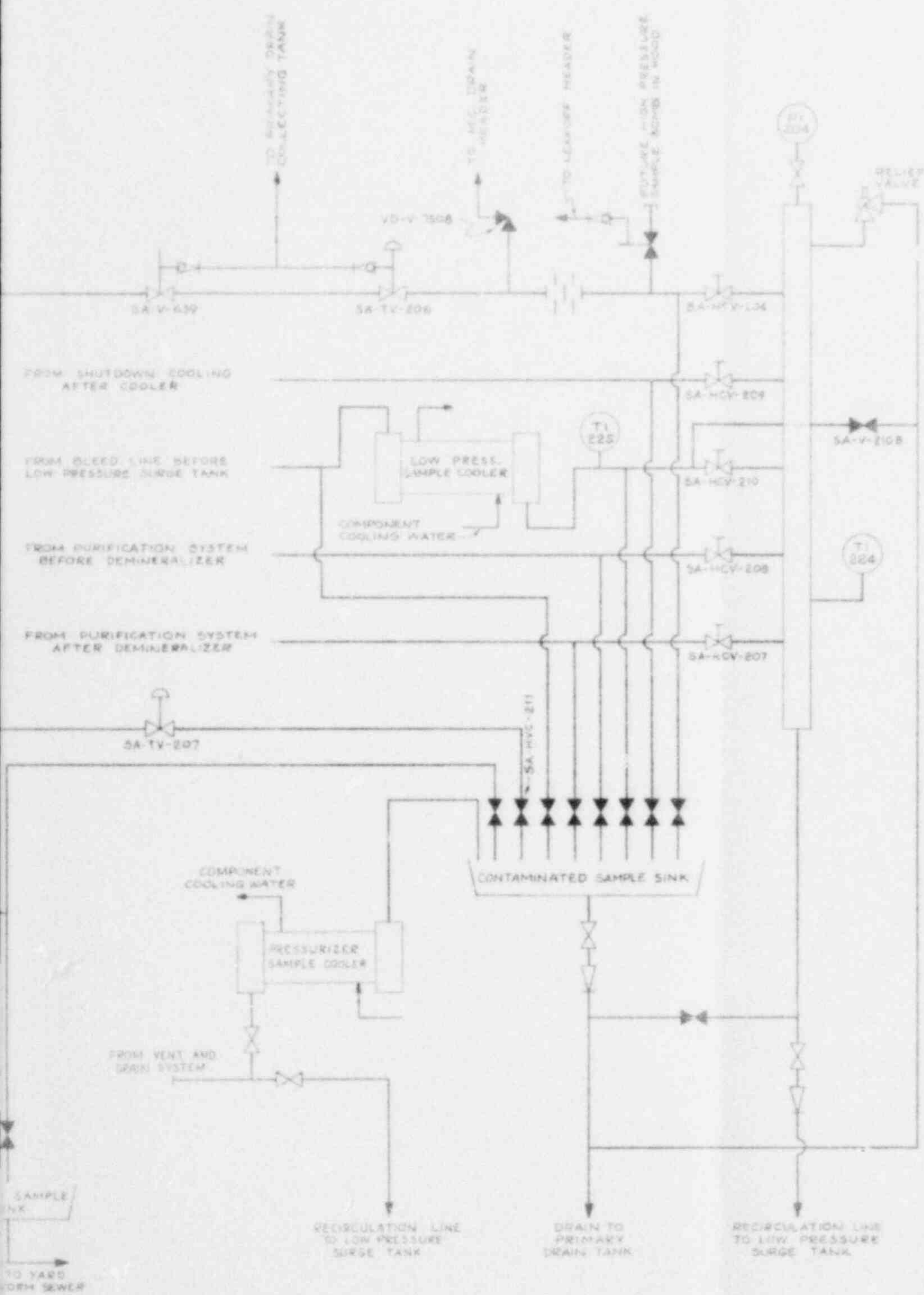
Charging Cooling System -- A low pressure sample line comes from the shutdown cooling system return line to the main coolant system.

Charging and Volume Control System -- A low pressure-low temperature sample line comes from the bleed line, between the pressure reduction point and the low pressure surge tank. This samples the same fluid as the bleed line sample, but samples after the regenerative heat exchanger and breakdown orifices and contains a low pressure-low temperature sample cooler.

Purification System and Chemical Shutdown System -- A low pressure-low temperature sample line comes from the ion exchange inlet header, which is common to both systems. A low pressure-low temperature sample line comes from the ion exchange outlet header, which is common to both systems.

Each of the five sample lines contain an isolation valve and slipstream sampling valve. The sample lines terminate in a header, which is equipped with local temperature and pressure indication, and a pressure relief valve discharging to the primary drain tank. This header normally discharges back to the low pressure surge tank to allow continuous sampling without system fluid loss, however, the discharge maybe valved to the waste disposal system.


REVISIONS
DESCRIPTION
ADDED PRESSURIZER SAMPLE LINES
"O" ISSUE - REDRAWN
TO PRIMARY DRAIN COLLECTING TANK OR LOW PRESSURE SURGE TANK
TO LEAKOFF HEADER
FROM MAIN COOLANT BLEED LINE
PRESSURIZER DRAIN LINE
DRAIN LOOP 1
DRAIN LOOP 2
DRAIN LOOP 3
DRAIN LOOP 4
SA-MOV-511
SA-MOV-513
HIGH PRESSURE SAMPLE COOLER
COMPONENT COOLING WATER
FROM NEUTRON SHIELD TANK
INSIDE VAPOR CONTAINER
OUTSIDE VAPOR CONTAINER
(ALL COOLERS COOLED BY SERVICE WATER)
FROM STEAM GENERATOR BLOWDOWN
SAMPLE COOLER
SAMPLE COOLER
SAMPLE COOLER
SAMPLE COOLER
SA-HVC-407
SA-HVC-408
SA-HVC-409
SA-HVC-410



THIS DWG SUPERSEDES WESTINGHOUSE ELECTRIC CORP. DWG. NO. 646J429

NEW ENGLAND POWER SERVICE COMPANY

BOSTON, MASS.

YANKEE ATOMIC ELECTRIC COMPANY

POWER STATION - ROWE, MASS.

FLOW DIAGRAM

SAMPLING SYSTEM

SCALE NONE — DATE DECEMBER 1965

YM-H-8-1

The sample room, located outside the vapor container in the Primary Auxiliary Equipment Building, contains a ventilation hood to vent radioactive gases to the primary vent stack, which might be released while a sample is being taken and a sample sink which discharges to the waste disposal system.

Two sample coolers, one located in the vapor container in the line for sampling high pressure-high temperature fluid and the other located in the sample room in the low pressure-low temperature line reduce main coolant sample temperature to about 100°F. A muffle orifice downstream of the high pressure-high temperature sample cooler reduces the pressure of main coolant samples to 30 psia.

One or more sample lines are allowed to flow into the sample header and recirculate back to the main coolant system via the low pressure surge tank until the flow in the line is representative of the point being sampled. A sample is then taken through the slipstream at the sample sink.

The design of the sampling system is based on the safety philosophy that no sample lines operating at high temperature and pressure containing radioactive fluids are allowed outside the vapor container. The high temperature-high pressure cooler is designed to reduce the main coolant sample temperature from 650°F to 200°F at a maximum flow of 3 gpm and at a design pressure of 2500 psia. The cooler is located within the vapor container and is cooled by component cooling water. A minimum line length of 50 feet assures adequate decay of N^{16} and O^{19} activity in the sample fluid at the design sampling rate.

The muffle orifice is designed to reduce the pressure of the main coolant samples from 2500 psia to 30 psia at 3 gpm. The individual sample lines terminate in the sample header which recirculates the fluid back to the system via the low pressure surge tank.

Sample lines from the neutron shield tank and the steam generator blowdown connections terminate in the sample room. Since the sample fluids differ from the main coolant system fluid in chemistry and radioactivity, they do not connect to the sample header.

Service water is supplied to the sample room to flush and clean the uncontaminated sample sink. All the drains from the contaminated sample sink are dumped to the primary drain collecting tank, and if secondary sample is contaminated it can be taken in contaminated sample sink.

All equipment is constructed of AISI 304 stainless steel and installed in accordance with the requirements of the 1956 edition of the ASME, Section VIII Unfired Pressure Vessel Code. Piping and valves meet requirements of ASA B31.1-1955 Code for Pressure Piping and ASA B16.5 Steel Pipe Flanges and Flanged Fittings, respectively.

209 RADIOACTIVE WASTE DISPOSAL SYSTEM

General

The waste disposal system receives, contains, adequately treats and safely disposes of all radioactive wastes other than certain separately handled low activity wastes which may come from the secondary plant. The basic processes used in this system are: natural decay of radioactive isotopes, filtration to remove most of the radioactive particulate matter, evaporation to concentrate radioactive constituents in a small volume of liquid waste to be solidified in concrete, incineration to concentrate activity in a reduced volume of solid wastes and dilution of low activity liquid and gaseous discharge. The waste disposal system consists of liquid and gas storage tanks, evaporator, incinerator, wet gas scrubber, pumps, compressors, heat exchangers, filters, instruments, piping and valves, all as shown on drawing No. 9699-RM-41F.

Although not a part of the waste disposal system, certain waste systems of the secondary plant are discussed in this section so that all waste handling methods are described in one place.

The potential sources of radioactive liquid and gaseous wastes to be processed by the waste disposal system are as follows:

Main Coolant System

Charging and Volume Control System

Purification System

Sampling System

Chemical Shutdown System

Vent and Drain System

Shutdown Cooling System

Vapor Container Drain Liquid

Safety Injection - Shield Tank Cavity System

Radioactive Laboratory, Decontamination Cubicle and Decontamination Pad Drain Liquids

Contaminated Laundry Drain Liquid (If on site laundry installed in future)

Contaminated Area Floor Drain Liquid

Steam Generator Drain Liquid

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During normal operation, no detectable leakage of main coolant through steam generator tubing to the secondary side of the steam generators is anticipated. It may be desirable, however, to operate the plant with a small amount of leakage as long as there is no hazard to the public. If such leakage should occur, it could provide a source of radioactive liquid and gaseous wastes in the form of the following:

Steam Generator Blowdown

Condenser Air Ejector Effluent

Radioactive wastes from the reactor plant, operating at steady state, appear as solids in suspension, solids in solution, gases in solution, and gases out of solution. If no fuel rod cladding defects occur, only activated corrosion products are piped to the waste disposal system or diluted and discharged to the environment for safe disposal. Plant operation, however, will continue with some fuel cladding defects, depending upon the adequacy of the primary plant shielding and the capacity of the disposal systems to handle and discharge these wastes safely.

Intermittently, other liquid wastes containing radioactive materials are handled by the system. These wastes include liquids from the radioactive laboratory and the decontamination cubicle and pad in the Service Building; drain liquids from various primary auxiliary systems not radioactive normally but which may, under certain conditions, become radioactive; drain liquids from the shield tank cavity system and spent fuel pit which occur only infrequently; and activity dilution liquid and boron dilution liquid comprising relatively large volumes of liquid at each complete plant shutdown and startup. When the plant is operated with some fuel cladding defects, the activity level in the main coolant must be reduced by charging make-up water to the main coolant system and discharging diluted main coolant to waste disposal as part of the plant shutdown operation. This is necessary so that the activity of the shield tank cavity water, after it mixes with the diluted main coolant remaining in the isolated reactor, will be sufficiently low to permit refueling operations. On the second and subsequent plant startups, the boron-containing water used in cold shutdown of the plant will be radioactive and must be disposed of safely. In addition, the system is designed to handle decontamination solutions if their use becomes necessary.

Adequate monitoring of the waste disposal systems is provided to assure safe operation, storage, drumming, and controlled release of all activity either to the environment or to approved waste disposal sites. Sufficient tank capacity is provided to permit suitable analysis of processed liquid wastes before a decision is made to treat and then reuse in the primary system or dilute and release to the environment.

The systems are designed to handle the total quantity of radioactive liquid, gaseous and solid wastes originating in the primary plant, secondary plant, and Service Building, based on primary plant operation

330 days per year, two complete shutdowns per year, and 15 days for inspection and maintenance during each shutdown. The total quantity of radioactivity entering the systems is based on 10 gpm purification rate and no steam generator leakage, and equilibrium fission product activity in the main coolant of 34.55 microcurie per ml resulting from cladding defects in 1% of the total number of fuel rods and a main coolant equilibrium corrosion product activity of 2.76 microcurie per ml. The equilibrium activity of each radioactive isotope in the main coolant is given in Section 106, REACTOR COOLANT CHEMISTRY. Some fraction of this activity may be safely disposed of under controlled conditions, as low activity steam generator blowdown and air ejector effluent if steam generator leakage should occur.

Steam generator blowdown and air ejector effluent will be controlled so that, after dilution at the plant site, the concentrations of activities from these sources will not exceed those specified in the current text of AEC Regulation 10CFR20 for unidentified mixtures of isotopes in unrestricted areas. If it becomes necessary, in order to stay within the AEC regulations for the release of radioactive isotopes, periodic isotopic analyses of these effluents may be performed so as to characterize the activities present.

The processed waste liquids, irrespective of activity level, are divided into two classifications: reactor plant effluents defined as radioactive liquids containing dissolved hydrogen and fission product gases; and radioactive liquids containing dissolved air. The gaseous wastes are subdivided into a mixture of hydrogen and fission product gases and air with undetectable activity. Solid wastes are combustible and noncumbustible. Each classification and type of waste requires a somewhat different treatment process. Hereafter, these wastes are described as "Processed" wastes. Possible wastes from steam generator blowdown and air ejector effluent are discussed separately.

Processed Liquid Wastes

The volume and activity of liquid wastes entering the waste disposal system that always require treatment, based on an assumption of cladding defects in 1% of all fuel rods, 10 gpm purification rate, and no steam generator leakage are as follows:

	Average Volume, Cu Ft per 6 Months	Average Gross Activity Microcurie per ml
Reactor Plant Effluents		
Main Coolant (No Boron)		
Normal operation	1,320	29.6
Shutdown (Activity dilution process)	9,210	11.12*

	Average Volume, Cu Ft per 6 Months	Average Gross Activity Microcurie per ml
Reactor Plant Effluents		
Main Coolant (With Boron)		
Shutdown (Drain loops and equipment)	2,165	0.574
Startup (Boron dilution process and coolant expansion)	8,7[illegible]3	0.003
Radioactive Liquids Containing Air		
Incinerator Roto-Clone drain liquid	120	0.030
Radioactive Laboratory sink, decontamination cubicle and pad drain liquid from Service Building	4,140	0.029
Total Volume	25,688 or 4,280 cu ft per month average	

Total Average Activity = 5.56 microcurie per ml

* The activity dilution liquid is passed through one of the purification ion exchangers giving an assumed decontamination factor of 10 for nonvolatile fission products and corrosion products.

The major volume of reactor plant effluents entering waste disposal consists of activity dilution liquid pumped from the low pressure surge tank to the activity dilution decay tank; boron dilution liquid pumped from the low pressure surge tank to the waste hold-up tank; and liquids from primary plant valve stem leak-offs and the main loop drains which flow by gravity to the primary drain collecting tank. These liquids are pumped batchwise to the waste hold-up tank. A filter unit is provided to remove most of the radioactive particulate matter before the liquids are discharged to waste disposal. Provisions are provided which will allow recirculation of the liquids through the filter either before they reach waste disposal or after the liquid is in the evaporator. Incorporated as part of the purification ion exchange system are provisions for passing boron-free waste liquids being discharged to waste disposal from the low pressure surge tank or the primary drain collecting tank through an ion exchange bed to remove nonvolatile fission and corrosion products on resin. These methods of operation will be used to remove part of the nonvolatile activity, if the extra decontamination factor is required when discharging activity dilution liquid to waste disposal, or if it proves to be more economical than evaporation and drumming.

The waste hold-up tank serves as a surge tank, and as soon as sufficient volume has accumulated for one evaporator batch, processing is started through the evaporator. Since the activity dilution liquid contains over 70% of all nonvolatile radioactivity discharged to waste disposal, it is stored separately from the other reactor effluents and decayed a total of 30 days to reduce the nonvolatile fission and corrosion product activity by a factor of 6.2 before further treatment. In addition, all liquids charged to the evaporator can be passed through a disposable filter unit which will reduce the nonvolatile fission and corrosion product activity by another factor of 10, which permits operating the evaporator at a higher concentration factor.

Liquid from either the waste hold-up tank or the activity dilution decay tank is charged continuously at 5 gpm through the disposable filter unit to the evaporator. The reboiler circulating pump takes suction from the liquid in the evaporator shell and pumps it into the reboiler. The effluent from the reboiler, consisting of steam and liquid, then flows into the cyclone separator where the liquid phase is separated and returned to the evaporator shell reservoir.

The steam from the cyclone separator passes into and up through the evaporator tower, and is condensed in the evaporator overhead condenser. The distillate is collected in a distillate accumulator before being pumped through the feed-distillate exchanger and a purifying unit to a test tank, where it is sampled for laboratory analysis. Based on the analysis, the distillate may be transferred to the primary water storage tank or discharged to the river after dilution.

The test tanks and the primary water storage tank are provided with floating roofs with seals at the tank wall to minimize diffusion of oxygen into the stored liquid, in order to maintain an oxygen content of less than 0.2 ppm. If an excess of primary make-up water occurs it will be discharged at a controlled rate to the main turbine condenser cooling water discharge line, resulting in sufficient dilution to satisfy AEC Regulations for "Unrestricted Area" concentrations.

The evaporator concentration factor is adjusted by monitoring the bottom of the evaporator to produce a bottoms liquid, which when mixed with cement and solidified in 55 gal steel drums and then stored to give a total of sixty days decay, meets all AEC and ICC Regulations for common carrier shipment of radioactive materials. These drums are shipped away without additional shielding for ultimate disposal in an approved manner, either on land or at sea.

Liquids containing dissolved air which are normally only slightly radioactive from nonvolatile constituents, such as floor drains from contaminated areas and other miscellaneous drains, are held in the monitored waste tanks for sampling and laboratory analysis. If, after dilution with the main condenser effluent cooling water, the monitored liquid meets the standards of public authorities, it is discharged at a controlled rate to the condenser discharge line. Monitored liquids and all other waste liquids containing air, which are expected or known to have a nonvolatile activity level too high to obtain adequate dilution with the quantity of main condenser water available, are transferred to the gravity drain tank. All liquid pumped or drained to the gravity drain tank is processed the same as the reactor effluents, but in separate batches to prevent the mixing of air with fission gases and hydrogen which could result in the possible formation of an explosive hydrogen-air mixture.

Processed liquid wastes from the waste disposal system will be discharged only if the activity contained therein, in combination with any activity being released from the steam generator blowdown, is within the maximum permissible concentration, after dilution, which is established in AEC Regulations, Part 20.

Although it is planned to have all contaminated clothing laundered under contract by a commercial laundry, all necessary facilities are provided for handling the waste liquids from an on site contaminated laundry. This will permit the installation and use of laundry equipment in the Service Building if this becomes necessary in the future.

The total volume of contaminated area floor drains and other miscellaneous drains can not be determined. However, it is expected that these liquids will consist of small and infrequent batches of low activity fluids.

Processed Gaseous Wastes

The processed gaseous wastes consist almost entirely of hydrogen and radioactive fission product gases which are dissolved in the liquid discharged to waste disposal, or which continuously leak through or are released intermittently to the primary drain collecting tank by the pressure control valve on the low pressure surge tank. Fission gases and hydrogen are collected from the distillate accumulator and from the vapor space of all reactor effluent liquid drain and hold-up tanks in a completely closed waste gas header system. This is compressed to a gas surge drum, which is bled back to the compressor suction to maintain a constant pressure on the waste gas header and a cushion to permit filling and emptying of tanks. Initially, this system will be filled with nitrogen and this atmosphere may be maintained indefinitely at the option of the operator.

The net gas make collects gradually in the waste gas surge drum and is removed once each month from the compressor discharge line and stored under pressure in one of the three gas decay drums for about 60 days to reduce the activity. The decayed gas discharged from a gas decay drum is passed through a deep bed particulate filter and then released at a carefully controlled rate to the suction side of either the Primary Auxiliary Building exhaust fan or the vapor container purge fan, each of which has a capacity of 15,000 cfm. The Primary Auxiliary Building exhaust fan is used normally; but if this fan becomes inoperative, the other fan may be used by changing the blanks in the suction and discharge ducts from one fan to the other. Interlocks are provided to shut off, automatically, the flow of waste disposal gas if the fan stops. The decayed gas and dilution air are thoroughly mixed during passage through the fan, after which the mixture is discharged to the atmosphere through the primary vent stack. The stack gases are continuously monitored. The processed gaseous waste equipment is designed and sized to accommodate the maximum expected activity emanating from the main coolant. Dilution is also provided so that all gaseous effluent accumulated during a period of continuous plant operation can be discharged at acceptable concentration during two-thirds of the hours in that period. This provides operating flexibility and allowance for equipment maintenance.

Nearly all the gaseous activity discharged from the waste disposal system to the stack is caused by 10.3 year krypton-85 isotope since, after 60 days' decay, the activity of the 5.3 day xenon-133 is very small. The maximum permissible concentration of either krypton-85 or xenon-133 in air as given in the Proposed Ammendment of AEC Regulations (10 CFR Part 20) is 1 x 10-5 microcurie per ml in a restricted area and 3 x 10-7 microcurie per ml in an unrestricted area.

For the purpose of analysis, two cases were evaluated. The first case covers operation of the waste disposal system without steam generator leakage, the expected normal case. The second case covers steam generator leakage without waste disposal system operation.

In the case of waste disposal plant operation alone, and when averaging concentrations over a period of one month or one year, the MPC calculated for continuous exposure in an unrestricted area may be increased by a factor of 1.5, since radioactive air is to be discharged only 20 out of every 30 days of plant operation. This gives a corrected MPC in the air discharged from the stack of 4.5×10^{-7} microcurie per ml for krypton-85 or for xenon-133.

Based on the intermittent discharge of a mixture of air and radioactive krypton-85 and xenon-133 to the suction of either the Primary Auxiliary Building exhaust fan or the vapor container purge fan, the volumes and activity levels of gaseous waste, assuming cladding defects in 1% of all fuel rods, are as follows:

Average volume of gaseous wastes, scf per month	206
Average gross activity of gaseous wastes:	
At zero decay, microcurie per ml	80.1
At 60 days' decay, microcurie per ml	4.31
Discharge rate of decayed gaseous wastes, scf per hr*	0.43
Air dilution volume, cfm	15,000
Average gross activity of air discharge from the stack, microcurie per ml	2.06×10^{-6}
Total activity discharged to the atmosphere, curie per month	25.2
Total volume of radioactive krypton 85 released, ml per month	16.2

The air discharged from the stack during a 20 day period has a gross activity level about one-fifth that permitted by the AEC Regulations for mixed identified isotopes in a restricted area. In order to satisfy the AEC proposed MPC of 4.5×10^{-7} microcurie per ml for discharge two-thirds of the total time in an unrestricted area, an additional dilution factor of about 4.6 is required. Since the decayed gas is being emitted at 26 fps, the dilution by entrainment above the stack gives the required dilution, with wind speeds less than 10 fps, without resorting to the atmospheric diffusion away from the source to produce the dilution. At wind speeds in excess of 10 fps, the turbulent atmosphere provides a dilution factor of 5 within 30 ft of the stack. The formulae in Section 301, METEOROLOGY, show that the expected maximum ground level concentration, with wind speeds of 10 fps, and an effective stack height of 150 ft, is of the order of 1/3,000th of the concentration at the top of the stack; i.e., a dilution factor of 3,000.

*Based on discharging decayed gas 20 days out of every 30 days of plant operation.

Air normally having undetectable activity from the stripper condenser, when stripping liquids containing air, is passed through a particulate filter and discharged to the waste disposal stack.

Combustible Solid Waste

Combustible solid wastes, such as removable floor covering, cloths used for decontamination, shoe coverings, and contaminated paper, are transported to the Waste Disposal Building in combustible fiber drums. The drums will be re-used until they become contaminated. This waste is burned in a specially designed incinerator, based on a U.S. Bureau of Mines recommendation, using free vortex flow of combustion air over the grate. Bottled gas is used as fuel to start and complete the combustion.

The flue gases from the incinerator are mixed with cool air and then passed through a combination wet gas scrubber and induced draft fan, in which essentially all particulate material 5 microns and larger and more than 70% of those particles one micron and larger is removed, and the gases are further cooled. The gas is then filtered through a glass wool packed deep bed filter for final cleanup and discharged to the atmosphere.

The incinerator is designed to burn about 80 lb per batch. After a complete charge is burned, the residue ash is dropped through the cone bottom into an open top 55-gal steel drum about one-half full of water. The drum is connected securely to the special head attached to the bottom of the cone, so that dust from the ash can not escape from the drum into the room. When the drum contains about 18 batches of ash, the two sprays inside the special head are operated to wet the ash thoroughly. Liquid is decanted from the settled ash, the drum lowered from the special head, and a standard clamp-on head installed. The number of batches of ash and the volume of liquid remaining in the drum are adjusted so that, after mixing with cement, the mixture solidifies. Drums containing the solidified mixture are ready for shipment and disposal by burial. Liquid drained from the wet gas scrubber, in excess of that remaining with the settled ash in the drums, is pumped to the gravity drain tank for further treatment.

Noncombustible Solid Waste

The noncombustible solid waste consists of cartridges from small filters, glass wool from large filters, and various items of contaminated equipment. The filter elements and small items of plant equipment are immobilized and shielded in concrete in 55-gal drums, ready for ultimate disposal in an approved manner. Large items of contaminated equipment which can not be decontaminated will be suitably shielded for temporary storage until arrangements can be made for permanent storage or burial at an AEC approved disposal area.

Steam Generator Leakage

As a result of careful design, fabrication and quality control, it is expected that the stainless steel steam generator tubes will be leak-free. However, the question of operating the Yankee Plant for prolonged periods of time with leaking steam generator tubes is evaluated.

The analysis of the leakage hazard is based on the split of volatile and nonvolatile main coolant activities given in Section 106 and maximum permissible concentrations (MPC's) of radioisotopes appearing in the current text of AEC Regulation 10, CFR Part 20. MPC's for isotopes not appearing in the current text are obtained from the proposed amendment to Part 20. Where the MPC for the soluble and insoluble forms of an isotope differ, the more restrictive form is assumed. No credit is taken for radioactive decay of nonvolatile isotopes during steam generator holdup.

Two general criteria for MPC's are used. One set of criteria for mixtures of unidentified isotopes is used as a basis for selecting set points for continuous radiation monitoring equipment. A second, less restrictive set of criteria may be used after periodic sampling and isotopic determinations of steam generator blowdown and air ejector effluent to permit maximum discharge rates consistent with 10 CFR Part 20.

The following MPC criteria are established to provide a basis for continuous monitoring.

a. For "unrestricted area" water-borne activity consisting of "unidentified beta or gamma emitters or any undetermined mixtures of beta or gamma emitters": 1×10^{-7} μc per ml at the circulating water discharge to Sherman Pond.

Steam generator blowdown monitor alarm set points will be established based on the availability of approximately 138,000 gpm of condenser circulating water for dilution purposes which will be assumed to contain no natural or fallout activity. This dilution is less than Sherman Pond inflow during 1941, the driest recorded year, which averaged over 200,000 gpm.

b. For "unrestricted area" air-borne activity consisting of "unidentified beta or gamma emitters or any undetermined mixtures of beta or gamma emitters": 1×10^{-9} μc per ml at the closest unrestricted area.

The air ejector effluent monitor alarm set point will be established based on the availability of approximately 15,000 cfm of primary auxiliary building exhaust fan or vapor container purge fan capacity for dilution purposes which will be assumed to contain no natural or fallout activity. In addition, a dilution factor of 1,000 will be assumed to be available from the top of the primary vent stack to the closest unrestricted area. Smoke tests performed under the most unfavorable meteorological conditions - that is, with a temperature inversion and light down-valley winds - indicate that a dilution factor of approximately 5,000 may be expected. These smoke tests are discussed on pages 301:3, 301:4, and 403:7.

Modified or characterized MPC's may be selected for use under controlled conditions based on periodic isotopic analyses of the waste effluent stream. These criteria have been established for the reference main coolant activity and their estimated magnitude given below:

a. For "unrestricted area" water-borne activity, with radio-iodine activity assumed to be controlling, the characterized MPC for steam generator blowdown is of the order of 7.9×10^{-6} uc per ml.

b. For "unrestricted area" air-borne activity, consisting primarily of noble gas radio-isotopes, the characterized MPC for the air ejector effluent is of the order of 2.5×10^{-7} μc per ml.

Equipment Capacities and Ratings

The capacities and ratings of equipment shown on drawing No. 9699-RM-41F which follows page 209:1 are:

Tanks	Net Operating Capacity
1 - Primary building sump tank (TK-24), gal	484
1 - Gravity drain tank (TK-27), gal	4,700
2 - Monitored waste tanks (TK-29-1, 2), gal each	1,370
1 - Primary drain collecting tank (TK-30), gal	7,500
1 - Waste hold-up tank (TK-31), gal	75,000
1 - Activity dilution decay tank (TK-32), gal	75,000
1 - Distillate accumulator (TK-33), gal	60*
2 - Test tanks (TK-34-1, 2), gal each	8,040
1 - Compressor K.O. drum (TK-35)	-
1 - Waste gas surge tank (TK-36), cu ft	4,160
3 - Gas decay drums (TK-37-1, 2, 3), cu ft each	60
1 - Primary water storage tank (TK-39), gal	135,000
1 - Dilute caustic storage tank (TK-40), gal	235
1 - Ash dewatering sump (TK-43), gal	100
1 - Cyclone Separator (TK-47), gal	110

Pumps	Design Gpm, Each
2 - Primary building sump tank pumps (P-24-1, 2)	75
2 - Gravity tank transfer pumps, (P-25-1, 2)	10
2 - Monitored tank transfer pumps (P-26-1, 2)	50
2 - Collecting tank transfer pumps (P-27-1, 2)	50
2 - Waste liquid transfer pumps (P-28-1, 2)	20
2 - Bottom pumps (P-29-1,2)	10
1 - Distillate pump (P-30)	10
1 - Test tank effluent pump (P-31)	20
1 - Ash dewatering sump pump (P-32)	10
1 - Reboiler circulating pump (P-55)	200

* 1/2 full of liquid.

Other Equipment	Design Rating, Each
2 - Waste gas compressors (C-3-1, 2) scfm	20
1 - Disposable filter unit, gpm	6
1 - Incinerator (M-1), lb per hr	40
1 - Roto-Clone (M-2), lb per hr	480
1 - Reboiler (E-15) gpm	6
1 - Evaporator shell (EV-1)	-

210 SHUTDOWN COOLING SYSTEM

General

The shutdown cooling system is provided to remove the heat generated by radioactive decay of fission products in the reactor core during extended shutdown periods. The reactor plant is cooled down after control rod insertion and before depressurization by discharging the steam from the steam generators through the turbine steam bypass to the main condenser. The shutdown cooling system is placed in service after the main coolant temperature has been reduced to approximately 330 F and the pressure to less than 300 psi gage. The shutdown cooling system then reduces the main coolant temperature to 140 F or less and operates continuously to maintain this temperature as long as is required by maintenance or refueling operations.

The shutdown cooling system consists of a heat exchanger, circulating pump, piping, valves, and instruments arranged in a low pressure auxiliary loop parallel with the main coolant loops, as shown on drawing 646-J-425. The shutdown cooling pump takes suction from the hot leg of the main coolant piping on the reactor side of the loop stop valves and recirculates radioactive main coolant water through the tube side of the shutdown cooler and back into the cold leg of the main coolant piping, also on the reactor side of the loop stop valves. The main coolant is contained in a closed system and reactor decay heat load is transferred through the shutdown cooler to the component cooling system which in turn is cooled by river water. This arrangement of providing the intermediate cooling medium of the component cooling system was selected in order to assure that any possible leakage of radioactive main coolant would not enter the river water.

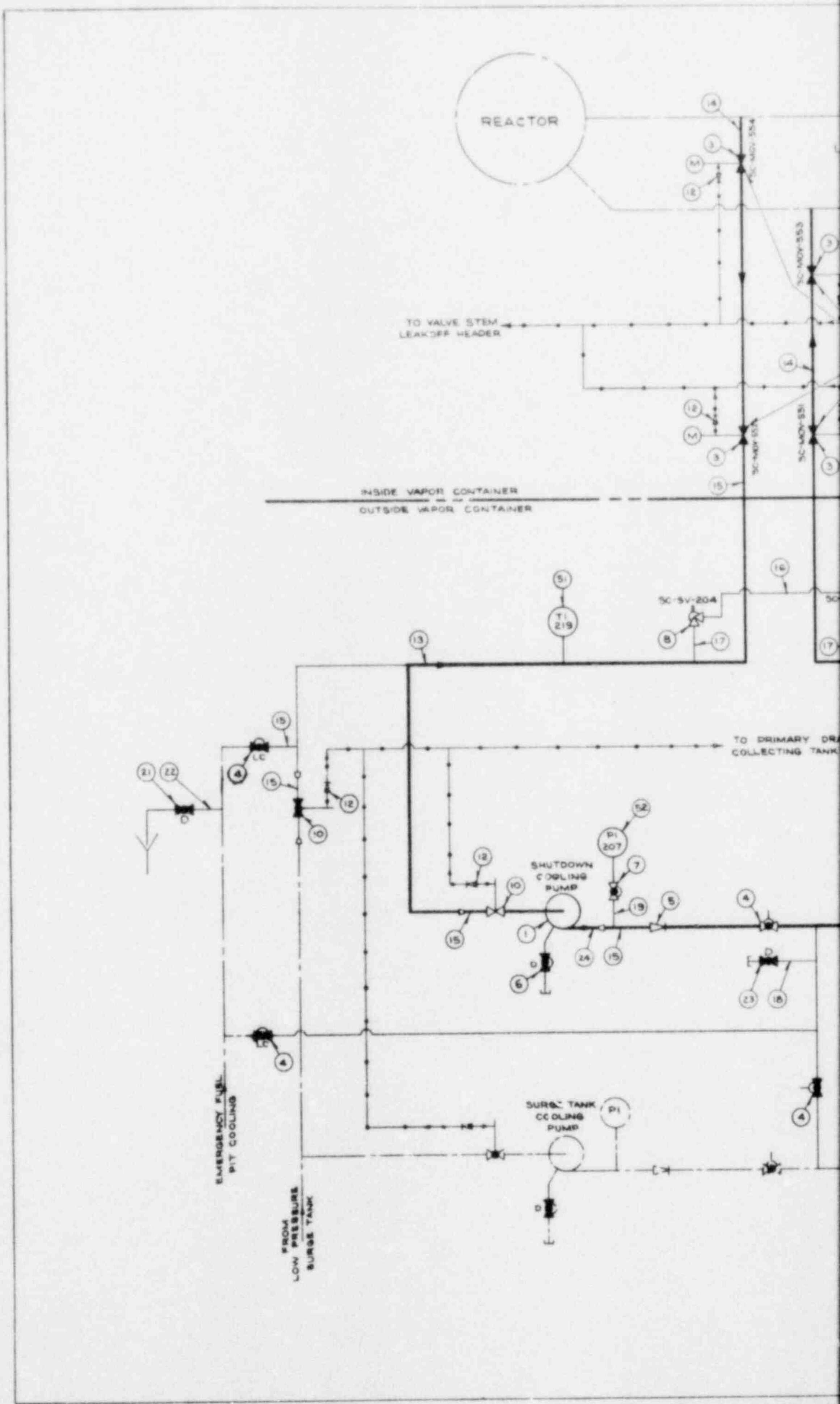
Complete backup of the system is provided by the low pressure surge tank pump and heat exchanger which are identical units connected in parallel. By employing double valving in the inlet and outlet lines to the main coolant piping, any required maintenance can be accomplished on the shutdown cooling system components while the reactor plant is pressurized and in full power operation.

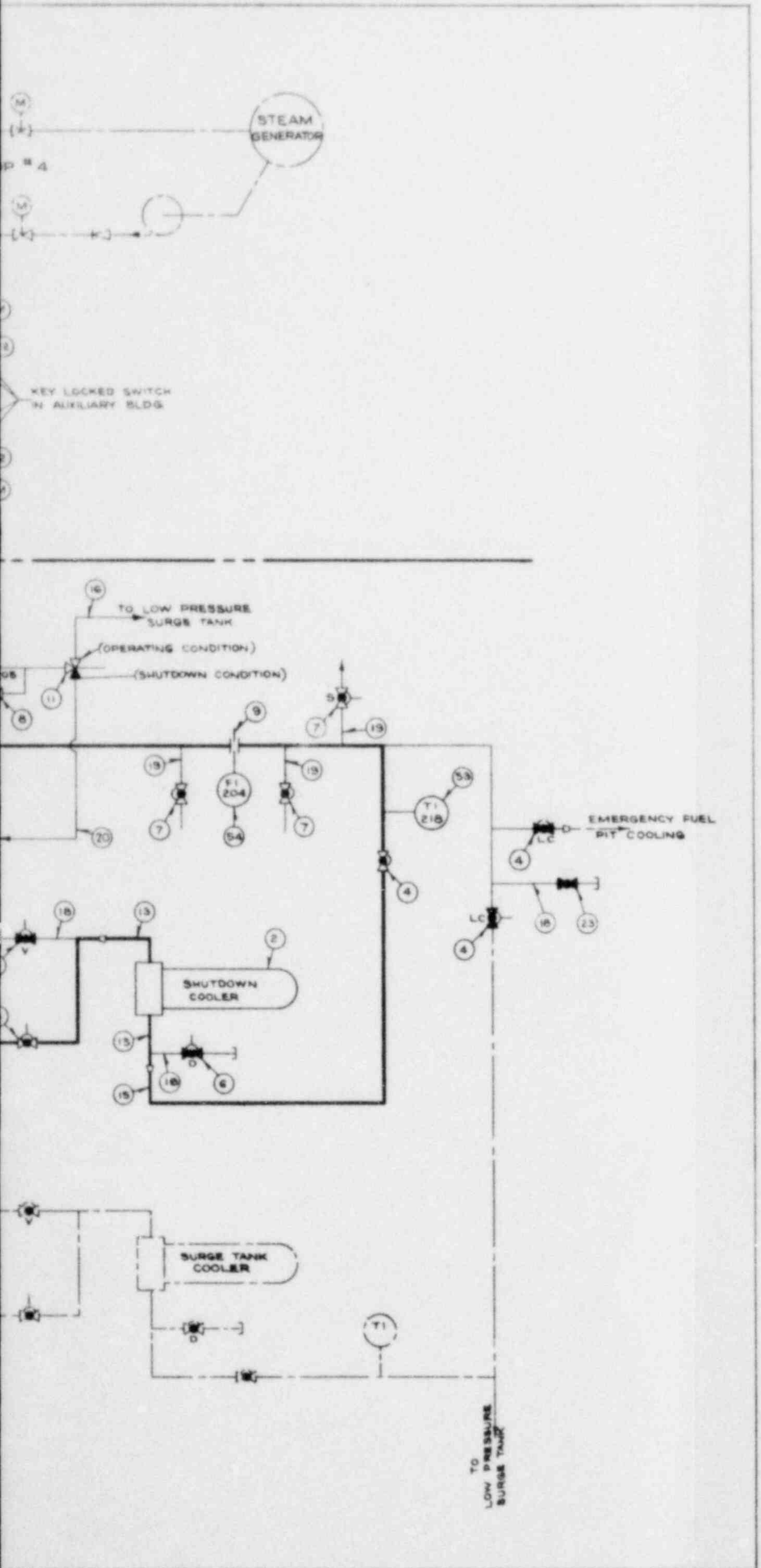
The shutdown cooling system is designed to remove the maximum expected decay heat from a core which has operated for an equivalent of 10,000 full power hours. Three hours after shutdown the expected decay heat is approximately 16,000,000 Btu per hour. The cooling system will also reduce the main coolant temperature at such a rate as to cool to 140 F in approximately 55 hours. Refer to curve on page 210:2 for decay heat as a function of time after shutdown.

The fluid to be handled by this system is radioactive and borated with a minimum equivalent of 950 ppm boron at ambient conditions. All leakage from the system is controlled.

Equipment

Actual sizing of units, based on capacity requirements is influenced by the condition that the low pressure surge tank cooler and pump are mutually interchangeable with the shutdown cooler and pump. The capacity requirements


REACTOR
SC-MOV-554
SC-MOV-553
SC-MOV-551
SC-MOV-552
TO VALVE STEM
LEAKOFF HEADER
INSIDE VAPOR CONTAINER
OUTSIDE VAPOR CONTAINER
SC-SV-204
TI
219
TO PRIMARY DRA
COLLECTING TANK
PI
207
SHUTDOWN
COOLING
PUMP
LC
EMERGENCY FUEL
PIT COOLING
FROM
LOW PRESSURE
SURGE TANK
SURGE TANK
COOLING
PUMP
PI



TITLE - YANKEE ATOMIC ELECT. COMPANY NUCLEAR POWER PLANT
SHUTDOWN COOLING SYSTEM (MECH)
DWG 646J425 SUB 3 # 5

SHEET NO 1

REV	ITEM	MATERIAL & DESCRIPTION		SIZE	RATING	"E" SPEC	GROUP
	1	CENTRIFUGAL PUMP	SST	6"x4"	1000 GPM @ 160 FT		
	2	HEAT EXCHANGER	SST	8"x6"	425 SQ FT		
	3	GATE VALVE MOTOR OPERATED STEM LEAKOFF	SST	6"	2500 LB @ 670°F		4
	4	GLOBE VALVE BELLOWS SEAL	SST	6"	300 LB @ 375°F		8
	5	CHECK VALVE	SST	6"	300 LB		1
	6	GLOBE VALVE BELLOWS SEAL	SST	3/4"	300 LB @ 375°F		3
	7	GLOBE VALVE BELLOWS SEAL	SST	1/2"	300 LB @ 375°F		4
	8	RELIEF VALVE BELLOWS SEAL	SST	1 1/2"x2"			1
	9	FLOW ORIFICE	SST	6"			1
	10	GATE VALVE - STEM LEAKOFF	SST	6"	300 LB		2
	11	THREE WAY VALVE - STEM LEAKOFF	SST	2"x2"x2"	150 LB		1
	12	BALL CHECK VALVE	CST	1/2"	600 LB		7
	13	PIPING SCH 40 S	SST	8"	300 LB		[illegible]
	14	PIPING SCH 160 S	SST	6"	2500 LB		[illegible]
	15	PIPING SCH 40 S	SST	6"	300 LB		[illegible]
	16	PIPING SCH 10 S	SST	2"	150 LB		[illegible]
	17	PIPING SCH 40 S	SST	1"	300 LB		[illegible]
	18	PIPING SCH 40 S	SST	3/4"	300 LB		[illegible]
	19	PIPING SCH 40 S	SST	1/2"	300 LB		[illegible]
	20	PIPING SCH 40	CST	2"	150 LB		[illegible]
	21	GLOBE VALVE	SST	3/4"	150 LB		1
	22	PIPING SCH 10 S	SST	3/4"	150 LB		[illegible]
	23	GLOBE VALVE	SST	1/2"	300 LB		2
	24	PIPING SCH 40 S	SST	4"	300 LB		[illegible]

TITLE - YANKEE ATOMIC ELECTRIC COMPANY NUCLEAR POWER PLANT
SHUTDOWN COOLING SYSTEM (I&C)
DWG 646J425 SUB 3 4 5

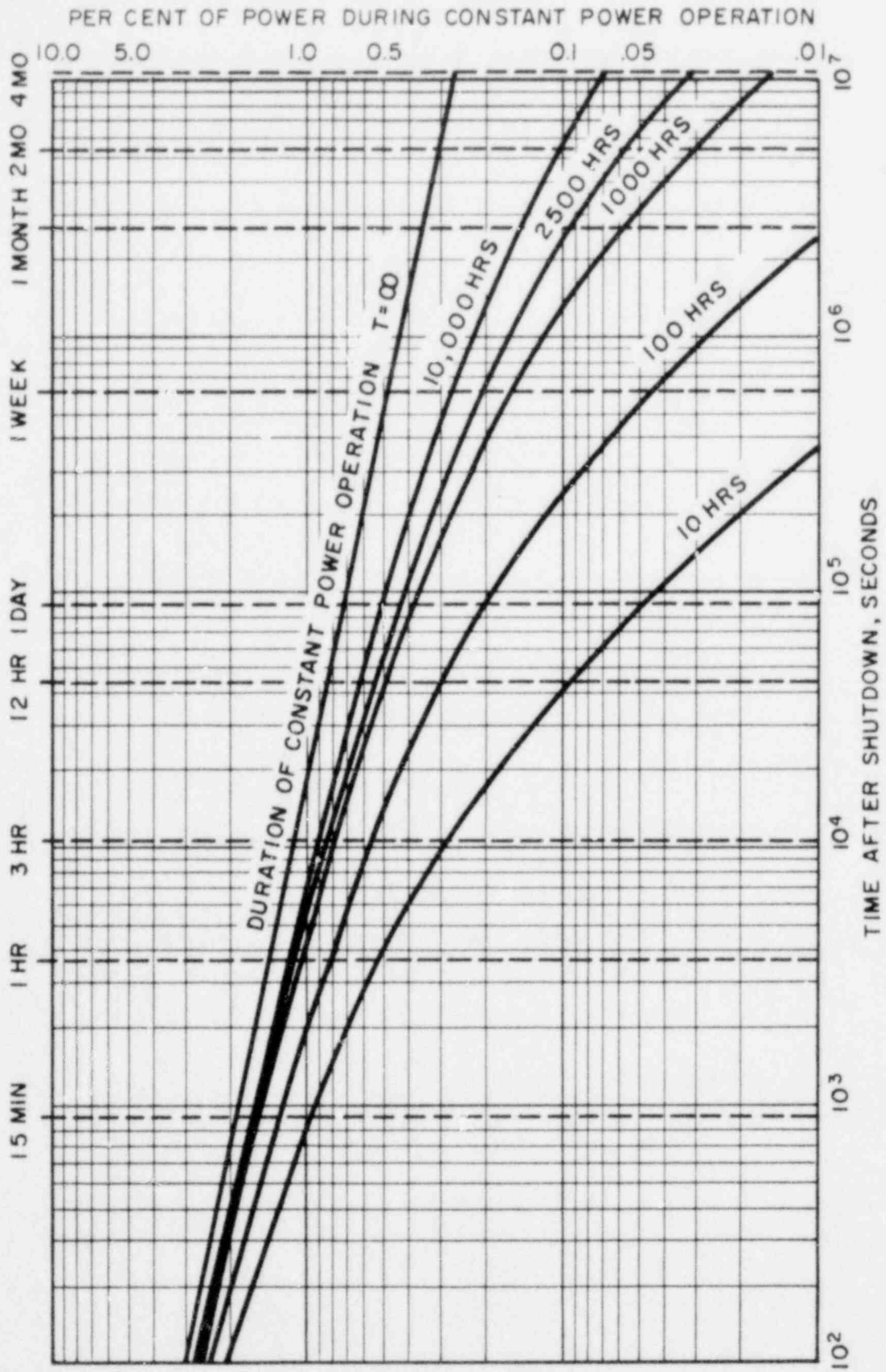
SHEET NO 2

REV	ITEM	MATERIAL & DESCRIPTION	CODE NO	GROUP NO. 1	2	3	4	5	6	7	8
	51	TEMPERATURE INDICATOR	SC-TI-219	1							
	52	PRESSURE INDICATOR	SC-PI-207		1						
	53	TEMPERATURE INDICATOR	SC-TI-218			1					
	54	FLOW INDICATOR	SC-FI-204				1				

GROUP # 4 E-SPEC
GROUP # 3 E-SPEC
GROUP # 2 E-SPEC
GROUP # 1 E-SPEC

50 D	YTR 16136 602400	3
IT	CHANGE	
	REVISED & RE-DRAWN AS PER ENGINEERS MARKED UP PRINT	
50 D	YTR 16136 602400	4
	CHANGED AS PER ENGINEERS MARKED PRINT	
50 D	YTR 16136 602400	5
	CHANGED AS PER MARKED ENGR PRINT	

WESTINGHOUSE ELECTRIC CORPORATION
TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT - SHUTDOWN COOLING SYSTEM
NTS MECH & I & C
646J425
ATOMIC POWER DEPT.



REACTOR DECAY HEAT, β AND γ ENERGY of the low pressure surge tank cooler are approximately the same; therefore, it is operationally and economically advantageous to use identical units. The design data to specify the shutdown cooler is partially based on the requirements of the low pressure surge tank cooler, as well as its own requirements.

Materials in contact with the cooled fluid are type 304 stainless steel or equivalent for corrosion resistance. Maximum system design conditions are set at 425 psi gage and 370 F.

Since it is required to start the shutdown cooling system with an inlet temperature of 330 F and a component coolant temperature of 80 F, the possibility of thermal shock has been considered. The heat exchanger in particular is designed in such a manner as to meet these requirements. The operating instruction for this system requires a warm up period prior to full operation.

The heat exchanger is of the shell and tube type, with 625 sq ft of surface and tube side channel flanges that have provision for external seal welding. The exchanger is designed, fabricated, and tested in accordance with the latest edition of the Standards of the Tubular Exchanger Manufacturer's Association and the latest edition of the ASME Code for Unfired Pressure Vessels.

The shutdown cooling pump is located approximately 60 ft below the elevation of the main coolant pipe from which the pump takes suction. This arrangement assures a positive suction head on the pump at all times since the system is required to operate when units of the main coolant system are open to the atmosphere during maintenance and refueling periods. A centrifugal type pump is provided with a capacity of 1,000 gpm at a total dynamic head of 180 ft. Since radioactive fluid is pumped, leakage from the pump is controlled by mechanical seals pressurized by demineralized water to a pressure in excess of the suction pressure, which prevents leakage of radioactive fluids to the atmosphere. The pump shaft stuffing box can also be solidly packed with injection and bleed-off connections, if later desired.

The entrance and exit piping connected to the main coolant system inside the vapor container up to and including the four motor operated isolation valves meet the requirements of the main coolant piping design of 2,300 psi gage and 550 F. The remainder of the piping outside the vapor container is schedule 40. Pipe size is selected at 6 in. allowing a velocity of approximately 11 fps. All piping in the system is designed and constructed in compliance with the ASA B31.1 - 1955 edition of Code for Pressure Piping, Sections 1 and 6.

The four motor operated isolation valves inside the vapor container are provided with stem seal lantern gland leak-off piping to control leakage and are key locked closed while the system is not in use. The manual valves outside the vapor continer are of the bellows sealed stem type for leak tightness, except pump suction valves which are provided with stem seal lantern leak-off connections in order to improve the pump suction head conditions. Relief valves are provided for system overpressure. All valves meet the requirements of the 1957 edition of ASA B16.5, Standard for Steel Pipe Flanges and Flanged Fittings.

Instrumentation consists of local temperature indication at the inlet and outlet of the system and local pressure indication at the pump discharge. Local flow indication is obtained by an orifice type flow indicator in the line just downstream from the heat exchanger.

211 VENT AND DRAIN SYSTEM, PRIMARY PLANT

General

The vent and drain system is designed to provide suitable facilities for discharging radioactive fluids to the waste disposal system during filling, draining, and flushing of the main coolant system, isolated loops or primary plant auxiliary systems and to provide a suitable means for venting air from the primary plant and its auxiliary systems.

The primary plant vent and drain system is shown on drawing No. 646-J-428. Essentially, the system consists of a high pressure drain header, a vent header, a valve stem leak-off header, and a vapor container drain tank.

Piping in this system is designed in accordance with ASA B31.1 - 1955 edition of Code for Pressure Piping.

High Pressure Drain Header

Drain lines from the following locations in the main coolant system and in the primary plant auxiliary systems are connected to the 2 in. high pressure header:

Four main coolant gate valves located at the steam generator inlet nozzle

Isolated loop drain between the steam generator outlet and the main coolant pump suction

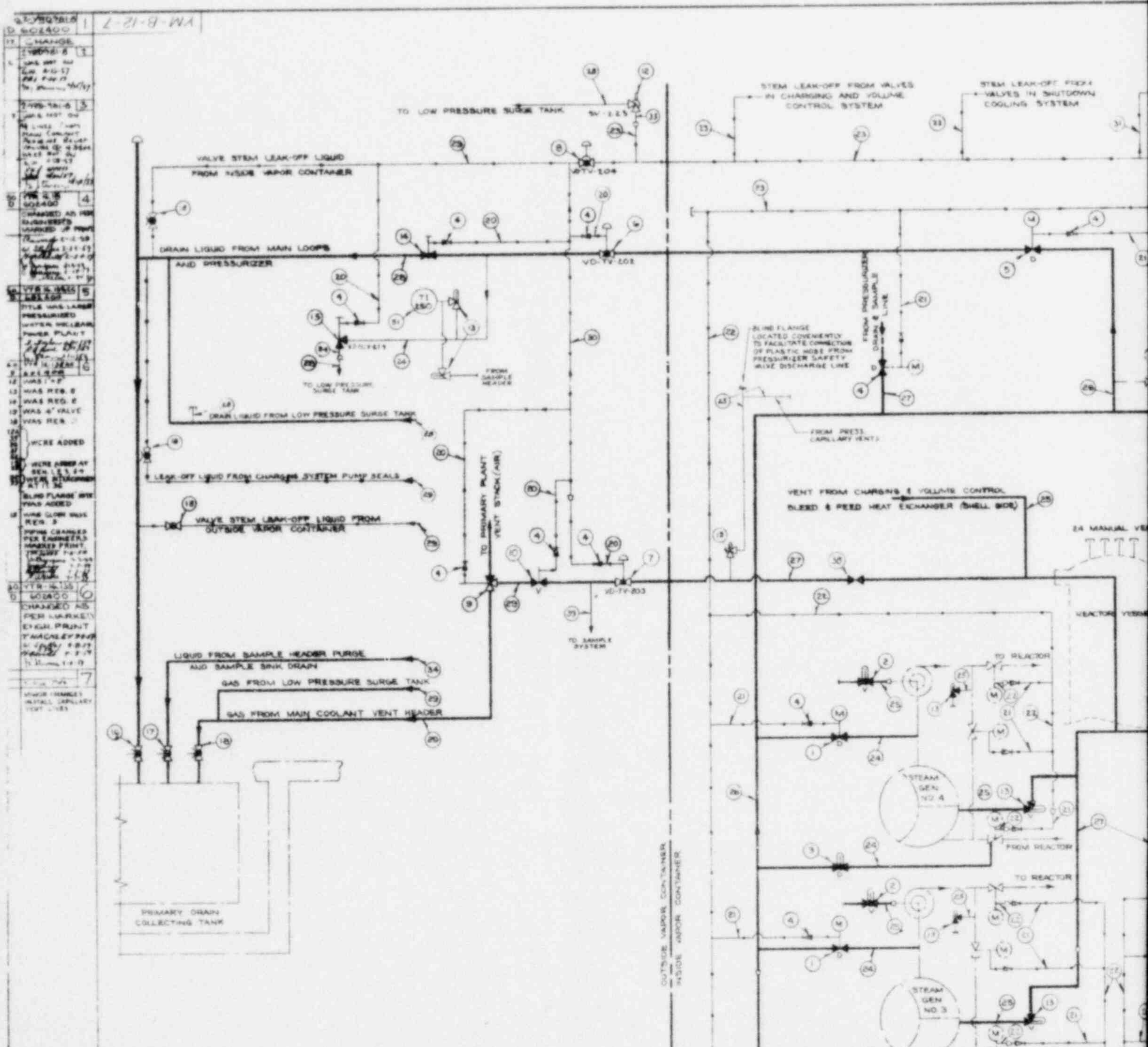
Pressurizer drain and sample line

Charging and volume control system feed and bleed heat exchanger

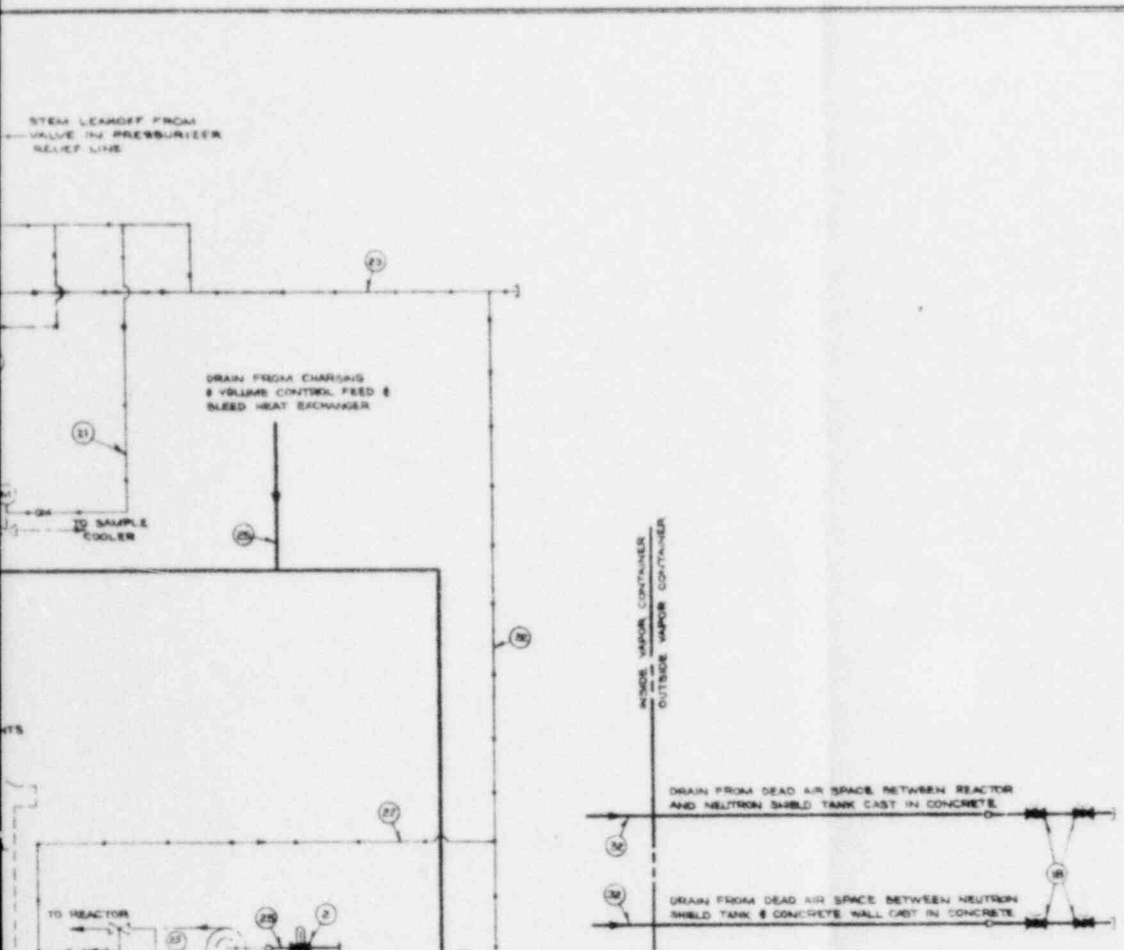
Liquids from the high pressure drain header discharge into the primary drain collecting tank.

The drain lines from the main coolant gate valves in the four 20 in. hot legs and from the 24 in. piping between the steam generator and the main coolant pumps are provided to drain an isolated main coolant loop. A capped stem globe valve is installed in the drain line from the main coolant gate valve, and a motor operated valve is installed in the drain line connected to the 24 in. piping between the steam generator and the suction of the main coolant pump. The motor operated valve provides a means for remotely removing borated water from an isolated loop by dilution process and also provides a means to sample the coolant from an isolated loop. A sample line with a motor operated valve is connected to the drain header.

The high pressure drain header connected to the primary drain collecting tank contains a motor operated valve inside the vapor container and a trip and manual stop valve outside the vapor container. The motor operated valve in the drain header is normally closed, thus providing two stop valves in series in this line from the main coolant system. The trip valve in the drain line outside the vapor container is provided as a safety precaution in the event of a main



YM-B-18-7
TO LOW PRESSURE SURGE TANK
VALVE STEM LEAK-OFF LIQUID FROM INSIDE VAPOR CONTAINER
DRAIN LIQUID FROM MAIN LOOPS AND PRESSURIZER
VD-TV-202
VD-TV-204
SV-225
TO LOW PRESSURE SURGE TANK
FROM SAMPLE HEADER
DRAIN LIQUID FROM LOW PRESSURE SURGE TANK
LEAK-OFF LIQUID FROM CHARGING SYSTEM PUMP SEALS
VALVE STEM LEAK-OFF LIQUID FROM OUTSIDE VAPOR CONTAINER
TO PRIMARY PLANT VENT STACK (AIR)
VD-TV-203
TO SAMPLE SYSTEM
LIQUID FROM SAMPLE HEADER PURGE AND SAMPLE SINK DRAIN
GAS FROM LOW PRESSURE SURGE TANK
GAS FROM MAIN COOLANT VENT HEADER
PRIMARY DRAIN COLLECTING TANK
OUTSIDE VAPOR CONTAINER
INSIDE VAPOR CONTAINER
STEM LEAK-OFF FROM VALVES IN CHARGING AND VOLUME CONTROL SYSTEM
STEM LEAK-OFF FROM VALVES IN SHUTDOWN COOLING SYSTEM
BLIND FLANGE LOCATED CONVENIENTLY TO FACILITATE CONNECTION OF PLASTIC HOSE FROM PRESSURIZER SAFETY VALVE DISCHARGE LINE
FROM PRESSURIZER DRAIN & SAMPLE LINE
FROM PRESS. CAPILLARY VENT
VENT FROM CHARGING & VOLUME CONTROL BLEED & FEED HEAT EXCHANGER (SHELL SIDE)
24 MANUAL VE
REACTOR VESSE
TO REACTOR
STEAM GEN NO. 4
FROM REACTOR
TO REACTOR
STEAM GEN NO. 3
FROM REACTOR



TITLE YANKEE ATOMIC ELECTRIC CO. POWER PLANT
VENT & DRAIN SYSTEM (MECH.)
DWG 646J428 SUB 4/67

SHEET NO. 1

#	MATERIAL & DESCRIPTION		SIZE	RATING	"E" SPEC	
1	GATE VALVE [illegible]	SST	1/2"	[illegible]		4
2	GLOBE VALVE CAPPED STEM	SST	3/4"	[illegible]		4
3	GLOBE VALVE CAPPED STEM	SST	1 1/2"	[illegible]		4
4	BALL CHECK VALVE	CST	3/4"	[illegible]		11
5	GATE VALVE [illegible]		2"	[illegible]		1
6	TRIP VALVE STEM LEAKOFF	SST	2"	[illegible]		1
7	TRIP VALVE STEM LEAKOFF	SST	1"	[illegible]		1
8	TRIP VALVE BELLOWS SEALED	SST	1"	[illegible] LB		1
9	THREE WAY VALVE	CST	1"	[illegible] LB		1
10	GATE VALVE STEM LEAKOFF	SST	1"	[illegible]		1
11	DIAPHRAGM SEALED VALVE	CST	[illegible]	[illegible] LB		1
12	RELIEF VALVE BELLOWS SEALED	SST	1/2"×1"			1
[illegible]	MANUAL CONTROL ANGLE VALVE	CST	2"×2"	[illegible]		1
13	ANGLE VALVE CAPPED STEM	SST	3/4"	[illegible]		12
14	MANUAL FLOW CONTROL VALVE	SST	2"	2500 LB AT 650°F		1
15	MANUAL CONTROL ANGLE VALVE		[illegible]	[illegible]		
16	DIAPHRAGM SEALED VALVE	CST	2"	150 LB		2
17	DIAPHRAGM SEALED VALVE	CST	1 1/2"	150 LB		1
18	DIAPHRAGM SEALED VALVE	CST	1"	150 LB		10
19	TRIP VALVE BELLOWS SEALED	CST	3"	150 LB		1
20	PIPING SCH 80	CST	1/2"	150 LB		[illegible]
21	PIPING SCH 80 S	SST	1/2"	300 LB		[illegible]
22	PIPING SCH 80 S	SST	3/4"	300 LB		[illegible]
23	PIPING SCH 80 S	SST	1"	300 LB		[illegible]
24	PIPING SCH 160 S	SST	1 1/2"	2500 LB AT 650°F		[illegible]
25	PIPING SCH 80 S	SST	3/4"	2500 LB AT 650°F		[illegible]
26	PIPING SCH 160 S	SST	2"	2500 LB AT 650°F		[illegible]
27	PIPING SCH 80 S	SST	1"	2500 LB AT 650°F		[illegible]
28	PIPING SCH 10 S	SST	2"	150 LB		[illegible]
29	PIPING SCH 80	CST	1"	150 LB		[illegible]
30	PIPING SCH 80	CST	3/4"	150 LB		[illegible]
31	PIPING SCH 80	CST	1/2"	150 LB		[illegible]
32	PIPING SCH 40	CST	3"	150 LB		[illegible]
33	PIPING SCH 40	CST	4"	150 LB		[illegible]
34	PIPING SCH 80	CST	1 1/2"	150 LB		[illegible]
35	PIPING SCH 40	SST	1 1/2"	300 LB		[illegible]
36	GATE VALVE BELLOWS SEALED	CST	3"	150 LB		1
37	GLOBE VALVE BELLOWS SEALED	CST	4"	150 LB		1

TITLE YANKEE ATOMIC ELECTRIC CO. POWER PLANT
VENT & DRAIN SYSTEM (I&C)
DWG 646J428 SUB 4/67

SHEET NO. 2

#	MATERIAL & DESCRIPTION	CODE NO.	GROUP NO. 1	2	3	4	5	6	7	8
31	PRESSURE INDICATOR	VD-PI-250	1							
32	LEVEL INDICATOR	VD-LI-203	1							

FLOW DIAGRAM YM B-12-7

WESTINGHOUSE ELECTRIC CORPORATION
TITLE YANKEE ATOMIC ELECTRIC COMPANY
POWER PLANT-VENT & DRAIN SYSTEM (MECH & I&C)
DRN. WILLS
646J428

coolant system rupture with a simultaneous drain line break. An increase in vapor container pressure will close this valve, thus preventing radioactive gases from discharging outside the vapor container. The vent header and the valve stem leak-off header also contain a trip valve in order to fulfill this safety requirement.

The drain line from the pressurizer is connected to the high pressure drain header. A motor operated valve is installed in this line. The pressurizer drain line facilitates drainage of the pressurizer and the reactor section of the main coolant system for the refueling operation.

A branch line with a hand operated control valve is connected to the drain header outside the vapor container. Liquid from this line discharges into the low pressure surge tank. This line and control valve are provided to discharge high pressure, high temperature water from the main coolant system in the event that the regenerative heat exchanger is isolated.

The piping for the high pressure 2 in. drain header is schedule 160S, Type 304 stainless steel. Maximum design conditions are 670 F and 2,500 psi gage.

Valve Stem Leak-off Header

The 1 in. valve stem leak-off header is provided to receive leakage from the lantern leak-off glands installed in high pressure valves containing radioactive fluid. Fluid from this header discharges into the primary drain collecting tank.

Piping for the 1 in. valve stem leak-off header is schedule 40S, Type 304 stainless steel inside the vapor container and schedule 80, carbon steel outside the vapor container.

Vent Header

The 1 in. vent header is provided to safely discharge gases from the various systems to the primary drain collecting tank or to the primary vent stack.

Vent lines from the inlet water chamber of the steam generator and from the feed and bleed heat exchanger discharge into the vent header. The vent lines from these components contain a capped stem globe valve. By operation of a three way valve, gases from the vent header may be discharged to the primary drain collecting tank or to the primary vent stack.

Venting at the following principal locations is done locally:

Main coolant pumps
Five inch main coolant by-pass line
Control rod mechanisms
Pressurizer

Manual capped stem globe valves are used for these vents except for the control rod mechanisms which have autoclave plug type vents.

The piping for the high pressure, 1 in. vent header, is schedule 80S, Type 304 stainless steel. Maximum design conditions are 670 F and 2,500 psi gage.

Vapor Container Drain Tank

Open drains from each of the five vapor container compartments, including the shipping hatch, are connected to a 3 in. header which discharges into the vapor container drain tank. The vapor container drain tank serves as a holdup tank, so that leakage from the open drains in the vapor container can be measured and monitored, thereby giving indication of the amount of leakage and possibly the source of leakage in the vapor container.

Miscellaneous

Two drains are also provided to detect and drain leakage from the void area between the reactor vessel and the neutron shield tank and the void area between the neutron shield tank and the concrete shielding wall. These drains penetrate the vapor container at a location directly beneath the reactor vessel.

In order to determine if water has leaked into the void areas, telltales are provided in the drains outside the vapor container.

212 SAFETY INJECTION SYSTEM

General

The functions of the safety injection system are to supply borated water automatically to the reactor vessel for cooling of the core in the unlikely event of a major loss of water accident and to supply borated water for flooding the shield tank cavity during refueling operations.

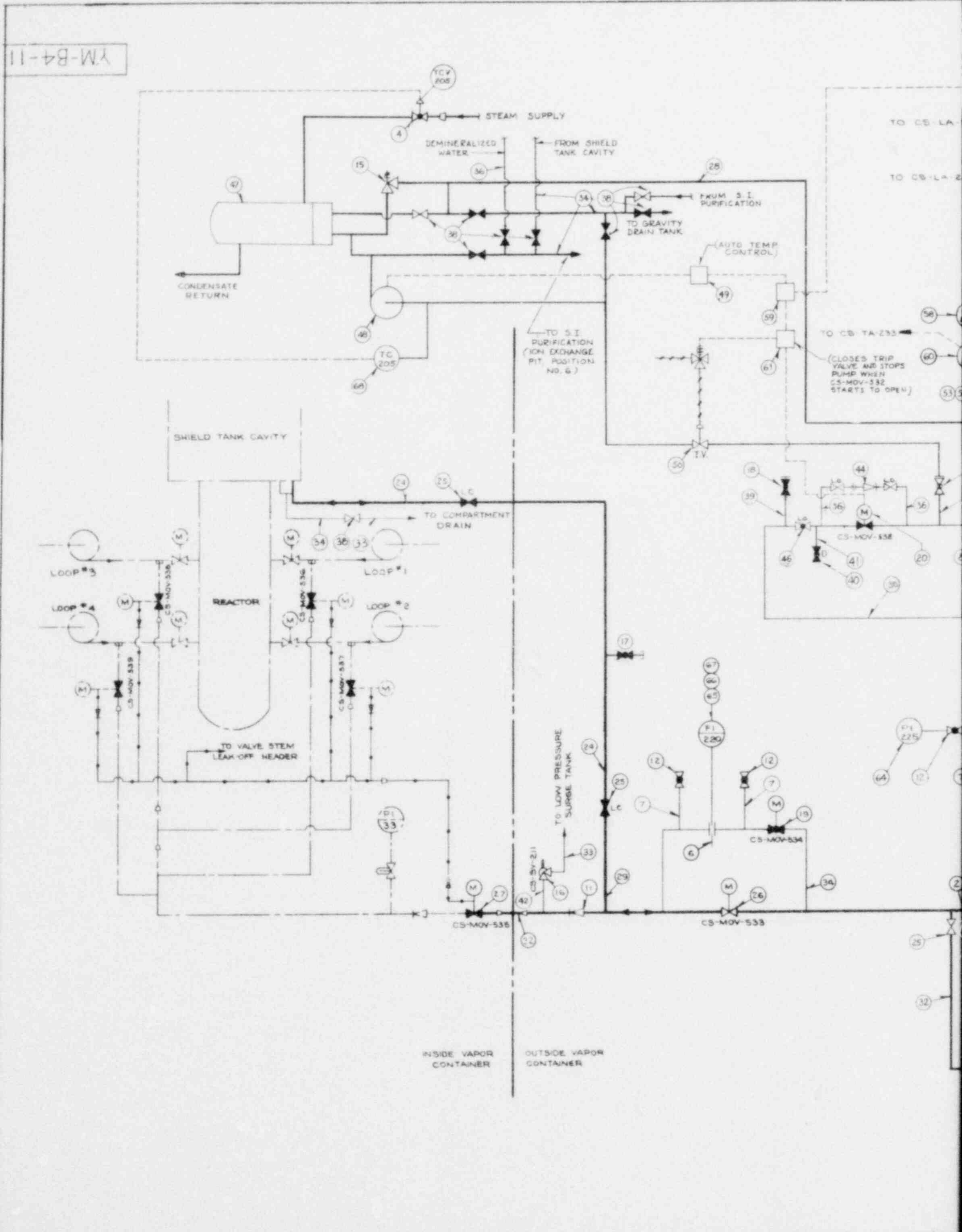
The system consists of a safety injection-shield tank cavity water storage tank, a high pressure and two low pressure dual purpose safety injection pumps, a 100 gpm circulation pump, an external shell and tube storage tank heater, an isolated purification loop and miscellaneous piping, valves and fittings as shown on drawing No. 646-J-644. Remotely operated pumps and valves permit control of this system from the control room.

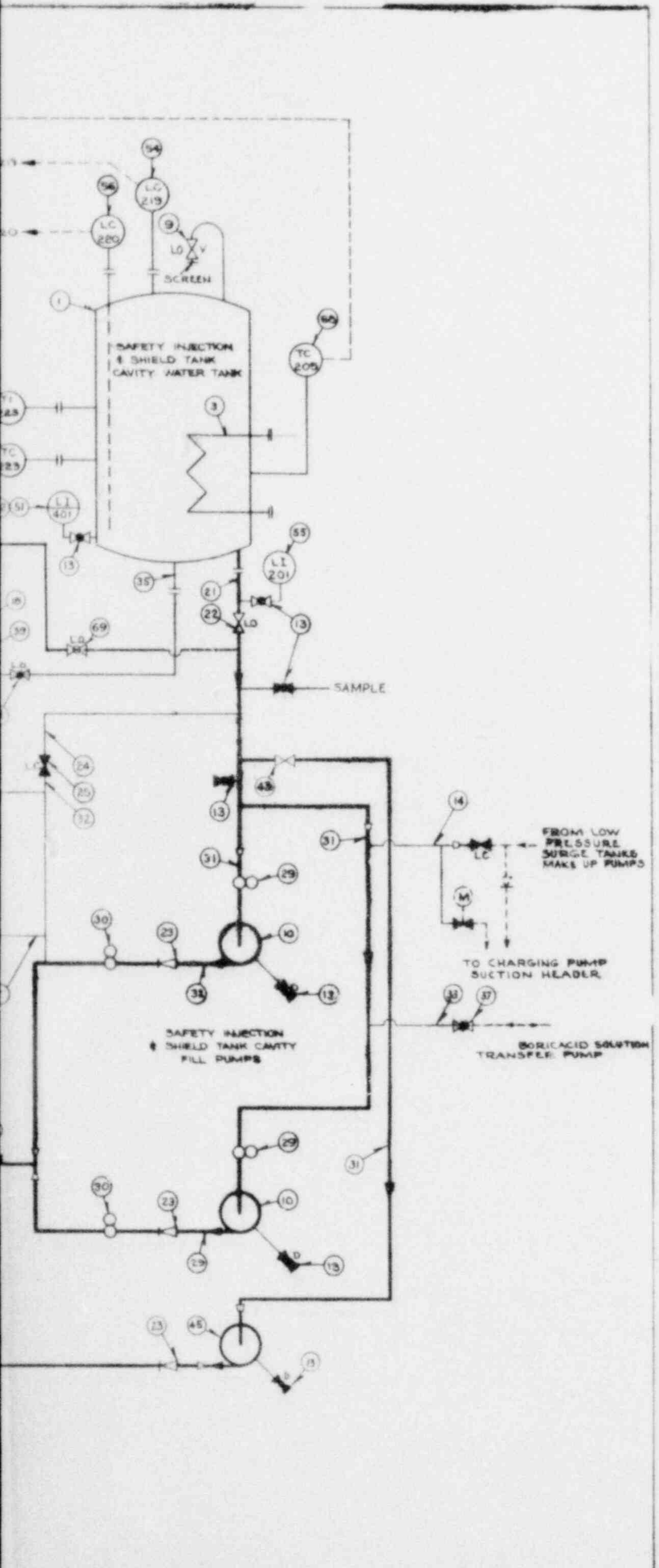
Safety injection is provided to each of the four main coolant loops outboard of the cold leg stop valve in order to cool the core following a main coolant system rupture of any size which can not be compensated for by the charging system pumps. This cooling is provided to prevent core meltdown due to decay heat.

Safety injection system operation is started automatically by a main coolant pressure signal set at 1000 psi gage. The high pressure safety injection pump and associated motor operated system valves operate simultaneously when the main coolant pressure drops to this set point. Since the high pressure pump has a shutoff pressure of approximately 770 psi gage, and since the allowable running time at shutoff condition is limited, pump protection is provided by means of a minimum flow bypass located in the safety injection recirculation line at the safety injection tank. The minimum flow bypass thus assures complete pump protection in the event system pressure decay from 1000 psi to 770 psi gage consumes a greater time than that specified for safe pump operation at shutoff. Further system pressure reduction results in the automatic starting of the two lower pressure safety injection pumps at approximately 300 psi gage.

Adequate missile protection is provided for the safety injection header, and the individual injection lines are divided compartmentally by reinforced concrete partitions. After the reactor vessel is filled to capacity following the rupture, the injection flow from one pump will be adjusted by control vlave, to replace the water in the reactor vessel that is boiled off into the vapor container by the release of decay heat according to E.I. No. 505B10, PRIMARY PLANT-TOTAL LOSS OF MAIN COOLANT COOLANT.

The system is sized for handling 117,000 gal. of demineralized water containing 1.0 wt % boric acid. This volume of water is sufficient for flooding the shield tank cavity to a level that will provide an adequate shield over the radioactive components in the shield tank cavity during refueling operations. One of the injection-fill pumps provides for mixing the stored boric acid solution and filling the shield cavity in approximately 1 hour. Provisions are made for pumping shield tank cavity water to the storage tank through a non-deborating ion exchange bed and/or filter for cleanup after refueling operations are completed. This purification loop is physically isolated from all other purification systems to prevent inadvertent interconnections. After completion of refueling operations, the water in the shield tank cavity can also flow by gravity directly to the waste disposal system or, by means of a bypass line around the safety injection pumps, back to the storage tank. The condition of the water will determine the path to be followed.


YM-B4-11
STEAM SUPPLY
DEMINERALIZED WATER
FROM SHIELD TANK CAVITY
FROM S.I. PURIFICATION
TO GRAVITY DRAIN TANK
CONDENSATE RETURN
AUTO TEMP CONTROL
TO S.I. PURIFICATION (ION EXCHANGE PIT, POSITION NO. 6)
TO CS-TA-233
(CLOSES TRIP VALVE AND STOPS PUMP WHEN CS-MOV-532 STARTS TO OPEN)
SHIELD TANK CAVITY
TO COMPARTMENT DRAIN
LOOP #3
LOOP #1
LOOP #4
LOOP #2
REACTOR
CS-MOV-538
TO VALVE STEM LEAK-OFF HEADER
TO LOW PRESSURE SURGE TANK
CS-MOV-534
CS-MOV-535
CS-MOV-533
CS-SV-211
INSIDE VAPOR CONTAINER
OUTSIDE VAPOR CONTAINER



TITLE - LARGE PRESSURIZED WATER NUCLEAR POWER PLANT — SHEET NO 1
SAFETY INJECTION SYSTEM (MECH.)
DWG. 646J644 SUB 2 & 4 6

NOTE	ITEM	MATERIAL & DESCRIPTION		SIZE	RATING	"E" SPEC	GROUP
	1	SAFETY INJ & SH CAVITY TANK	SST	25,000 GAL			1
	2	PIPING SCH 40S	SST	8"	300 LB		
	3	STEAM COIL HEATER		2"			1
	4	DIAPHRAGM OPER VALVE		2"			1
	5	PIPING SCH 40S		1/2"	[illegible] LB		
	6	METERING ORIFICE		2"	0-50 GPM		1
	7	PIPING SCH 40S	SST	1/2"	300 LB		
	8	GLOBE VALVE	SST	3"	300 LB		1
	9	GATE VALVE (FLANGED)	CST	3"	150 LB		1
	10	SAFETY INJ & SH. CAVITY PUMP		8 x 6"	1800 GPM @ 675 FT		2
	11	CHECK VALVE	SST	4"	300 LB		1
	12	GLOBE VALVE	SST	1/2"	600 LB		3
	13	GLOBE VALVE	SST	3/4"	150 LB		1
	14	PIPING SCH 10S	SST	4"	150 LB		
	15	RELIEF VALVE	SST	1 1/2 x 3"			
	16	SAFETY VALVE - BELLOWS SEAL	SST	1 1/2 x 2"			1
	17	GLOBE VALVE	SST	1"	600 LB		1
	18	GLOBE VALVE	SST	2 1/2"	150 LB		
	19	GLOBE VALVE MOTOR OPER	SST	2"	600 LB		
	20	GATE VALVE - MOTOR OPER	SST	3"	300 LB		
	21	PIPING SCH 40S	SST	10"	150 LB		
	22	GATE VALVE	SST	10"	150 LB		
	23	CHECK VALVE	SST	6"	300 LB		1
	24	PIPING SCH 40S	SST	6"	150 LB		
	25	GATE VALVE	SST	6"	300 LB		3
	26	GATE VALVE - MOTOR OPER	SST	8"	300 LB		
	27	GATE VALVE - MO. STM. LEAKOFF	SST	8"	2500 LB @ 370°F		
	28	PIPING SCH. 10S	SST	3	150 LB		
	29	SPECTACLE FLANGE	SST	8			2
	30	SPECTACLE FLANGE	SST	6			2
	31	PIPING SCH 40S	SST	8	150 LB		
	32	PIPING SCH 40S	SST	1/2"	300 LB		
	33	PIPING SCH 10S	SST	2"	150 LB		
	34	PIPING SCH 40S	SST	2	300 LB		
	35	PIPING SCH 40S	SST	3	300 LB		
	36	PIPING SCH 40S	SST	1"	300 LB		
	37	GLOBE VALVE	SST	2	150 LB		1

TITLE - LARGE PRESSURIZED WATER NUCLEAR POWER PLANT — SHEET NO 3
SAFETY INJECTION SYSTEM (I & C)
DWG. 646J644 SUB - 2 & 4 & 6

ITEM	MATERIAL & DESCRIPTION	CODE NO	GROUP NO
51	LEVEL DETECTOR	CS-LD-401	1
52	LEVEL CONTROLLER	CS-LC-401	1
53	LEVEL INDICATOR	CS-LI-401	1
54	LEVEL CONTROLLER	CS-LC-219	1
55	LEVEL INDICATOR	CS-LI-201	1
56	LEVEL CONTROLLER	CS-LC-220	1
58	TEMPERATURE INDICATOR	CS-TI-223	1
59	CONTROL SWITCH		
60	TEMPERATURE CONTROLLER	CS-TC-223	1
61	CONTROL SWITCH		
64	PRESSURE INDICATOR	CS-PI-225	1
65	FLOW DETECTOR	CS-FD-220	1
66	FLOW CONTROLLER	CS-FC-220	1
67	FLOW INDICATOR	CS-FI-220	1
68	TEMPERATURE CONTROLLER	CS-TC-205	1

SHEET NO 2 (CONT)

NOTE	ITEM	MATERIAL & DESCRIPTION		SIZE	RATING	"E" SPEC.	GROUP
	69	GLOBE VALVE	SST	3"	150 LB		

GROUP # 1 E SPEC
GROUP # 2 E SPEC
GROUP # 3 E SPEC
GROUP # 5 E SPEC
GROUP # 6 E SPEC
GROUP # 7 E SPEC
GROUP # 8 E SPEC

TITLE LARGE PRESSURIZED WATER NUCLEAR POWER PLANT — SHEET No 2
SAFETY INJECTION SYSTEM (MECH.)
DWG. 646J644 SUB. # 2 6

NOTE	ITEM	MATERIAL & DESCRIPTION		SIZE	RATING	E SPEC	GROUP REQ'D
	38	GATE VALVE	SST	2	150 LB		1
	39	PIPING SCH 40S	SST	2 1/2"	[illegible]		
	40	GLOBE VALVE	SST	3/4	[illegible]		
	41	PIPING SCH 40S	SST	[illegible]	[illegible]		
	42	PIPING SCH 40S	SST	[illegible]	300 LB		
	43	GATE VALVE	SST	8	150 LB		1
	44	[illegible] CHECK VALVE	SST	1/2	600 LB		
	45	SAFETY INJECTION PUMP		4 x 6"	70 GPM @ 1600 FT		1
	46	GLOBE VALVE		3"	900 LB		
	47	HEAT EXCHANGER			32 SQ FT		
	48	CIRC. PUMP			100 GPM		
	49	CONTROL RELAY					
	50	[illegible] VALVE					

FLOW DIAGRAM YM-B-4-11

WESTINGHOUSE ELECTRIC CORPORATION
TITLE YANKEE ATOMIC ELECTRIC COMPANY
POWER PLANT - SAFETY INJECTION SYSTEM (MECH & I & C)
DIMENSIONS IN INCHES SCALE NTS
646J644
ATOMIC POWER DEPT. PITTSBURGH PA. U.S.A.

REV	CHANGE
2	YTR 16134 D 602460 — REVISED AND REDRAWN. GK CASSADY W. Steffes 2-11-59
3	REVISED PER W. STEFFES MARKED PRINT DATED 5-25-59
4	YTR 16134 D 602460 — SHIELD CAVITY DRAIN WAS NOT ON; 38 WAS NOT ON; 39 WAS PART OF IT. 7; B/M SHEET 3 WAS SHEET 2. 7-24-59
5	YTR 16134 D 602460 — CHANGED AS PER MARKED ENGR PRINT
6	ADDED SAFETY INJECTION PUMP P-18-3 AND MINIMUM FLOW BY-PASS. DEV 5-23-62
7	INTERCHANGED LOCATION OF VALVES & ADDED MANUAL VALVE. JFK 4-30-63
8	RELOCATED DRAIN HOSE ITEM NO. 40. J.F.K. 12-11-63
9	RELOCATED S.I. TANK LEVEL DETECTOR. J.F.K. 10-13-64
10	ADDED PURIFICATION & HEATING LOOP. J.F.K. 6-18-65
11	AS INSTALLED CHANGES. ECT 12-23-65

Pump Power Supply and Control

The safety injection pumps are supplied with power from two independent 2,400 v buses, each bus supplied from its own station service power transformer from an independent 115 kv transmission line. Each safety injection pump is considered vital equipment although not normally operating and is one of the items not disconnected from the bus on loss of voltage on that bus as shown on drawing No. ESK 12659A. Transfer of the safety injection pump bus to a live bus is normally done manually, except for the emergency condition explained in E.I. No. 505D1, ELECTRICAL SYSTEM-LOSS OF 120 VOLT A-C VITAL BUS.

Special emergency safety injection control switches are provided on the nuclear section of the main control broard. These switches can be operated manually or placed in automatic. The automatic operation is initiated by conditions of low main coolant pressure (not less than 800 psi gage for the high pressure safety injection pump and valves and not less than 270 psi gage for the two low pressure safety injection pumps). The low main coolant pressure signals are obtained by bi-stable magamps located in the main coolant pressure instrument channel. An "auto by-pass" selector switch is located adjacent to the control switch; its function is that of permitting reset of the master relay following automatic safety injection so that the injection pumps and main injection system valves may be individually operated to control the rate of flow after initial injection. Blue indicating lights are also located adjacent to the main control switch; their function is to monitor the control power and the master relay coil curcuits when the "auto-manual" selector switch is in the auto position.

Selection of the "automatic" mode of control, by positioning the automatic-manual safety injection control switch, causes the safety injection system to perform the following operations without further control:

Opens CS-MOV-535 normally closed
Opens loop valves CS-MOV-536,537,538,539 normally closed
Opens CS-MOV-533 normally open (if closed)
Closes CS-MOV-532 normally closed (if open)
Starts safety injection pump P-18-3

At 300 psi gage main coolant pressure (on a pressure drop):

Starts safety injection pumps P-18-1 and P-18-2

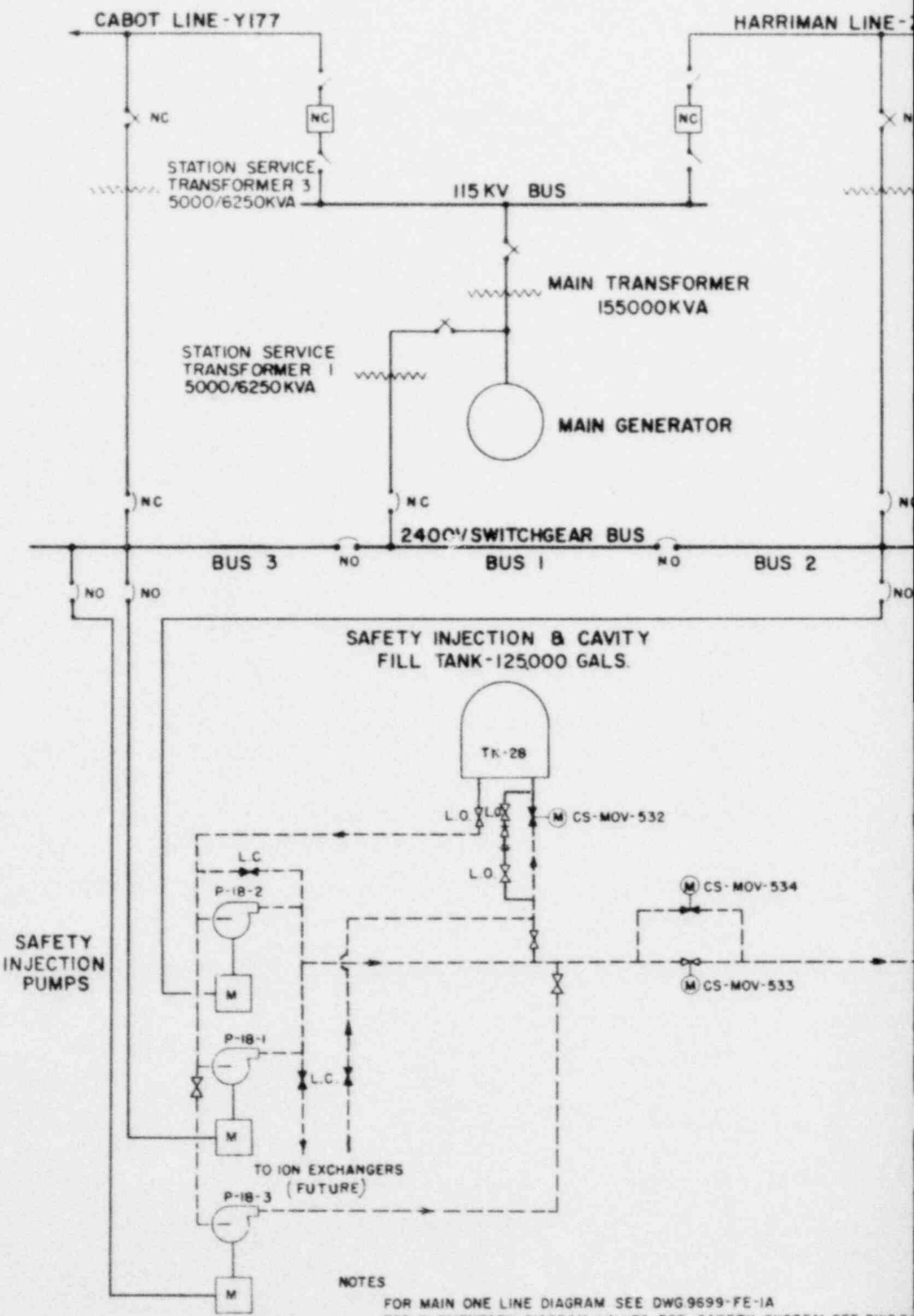
Light indication shows that the valves have operated as scheduled and the safety injection program is underway filling the main coolant system with boric acid solution. Locally controlled valves are furnished for shield tank cavity fill.

Safety injection system valve operators are supplied from the 480 v, 3-phase distribution cabinet with automatic throwover to alternate source upon failure of normal source.

Safety injection pumps are supplied at 2,400 v from vital line feeds as previously noted.

Light indication and control supply for safety injection pumps and automatic injection relay is from a 125 v d-c station battery.

A valve control panel is furnished where pump and valve operation can be individually operated or tested during maintenance operations.

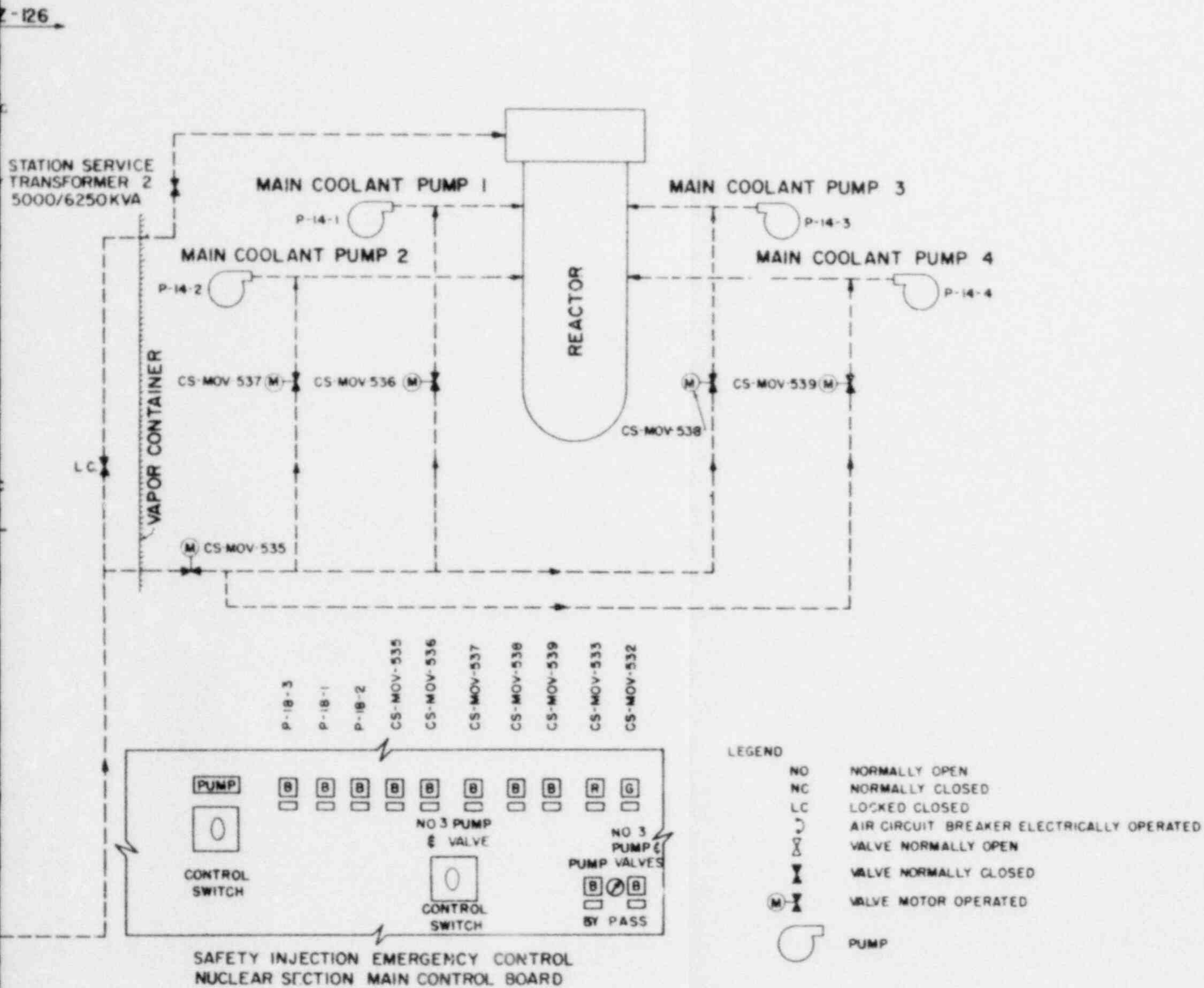


NOTES

FOR MAIN ONE LINE DIAGRAM SEE DWG.9699-FE-1A

FOR ELEMENTARY DIAGRAM-VALVES FOR SAFETY SYSTEM-SEE DWG.9

FOR ELEMENTARY DIAGRAM-2400V CIRCUITS SH 2-SEE DWG.9699-FE-3



POWER SUPPLY & CONTROL SAFETY INJECTION SYSTEM

POWER STATION

YANKEE ATOMIC ELECTRIC COMPANY

ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

1-26-59 ESK 12659A

REV 5-3-61

REV 6-23-61

REV 5-25-62

Safety Injection and Shield Tank Cavity Water Tank

The 125,000 gal. safety injection - shield tank cavity storage tank provides sufficient water to replace decay heat losses for approximately 200 hours after reactor shutdown. The tank is refilled, if it should be necessary, to continue borated water injection at rates less than 5 gpm for more than 200 hours. The vapor container is designed to hold 4,500,000 lbs., approximately 580,000 gals. of safety injection water. The tank is provided with an external shell and tube heat exchanger and 100 gpm circulation pump to maintain solution temperature above the freezing point. The tank solution will be pumped from a point on the recirculation line, through the tube side of the exchanger and return the heated solution to the safety injection pump suction line. The solution may also be pumped through the purification loop simultaneous to heating if cleanup is also desired. Steam is used on the shell side of the heat exchanger to supply the heat. Local and remote temperature and level indication and alarms are provided on this tank.

Safety Injection and Shield Tank Cavity Fill Pumps

In order to provide the required flow rate to the main coolant system, one high pressure safety injection pump with a capacity ranging from 900 gpm at 1600 ft. TDH to 1780 gpm at 475 ft. TDH operates initially. Subsequent to this, two low pressure safety injection pumps, each with a capacity of 1800 gpm at 475 ft. TDH, are started in order to increase the rate to 5380 GPM. Remote pressure indication is provided on the safety injection header and at the pump discharge. A bypass from the pump discharge header back to the tank is provided for recirculation, mixing to maintain uniform concentration in the tank, and to check pump operation. In addition, a minimum flow bypass is provided at the normally closed recirculation line valve in order to protect the high pressure safety injection pump during startup.

All materials of the system in contact with the fluid are Type 304 stainless steel or equivalent for corrosion resistance.

All piping and valves of this system inside the vapor container meet the requirements for main coolant piping design of 2300 psi gage at 550 F. Piping and valves outside the vapor container fall into the 600, 300 and 150 lb. class.

At periodic intervals in conjunction with routine maintenance, the system's pumps and motor operated valves are individually operated and checked. Complete system actuation tests can be carried out during shutdown periods with the reactor head removed.

213 REACTOR CONTROL SYSTEM

General

The reactor control system is provided to furnish dependable manual or semi-automatic control of the reactor, supply energy to and provide control switching for the 24 latch type control rod drive mechanisms, and provide two independent means for indicating control rod positions.

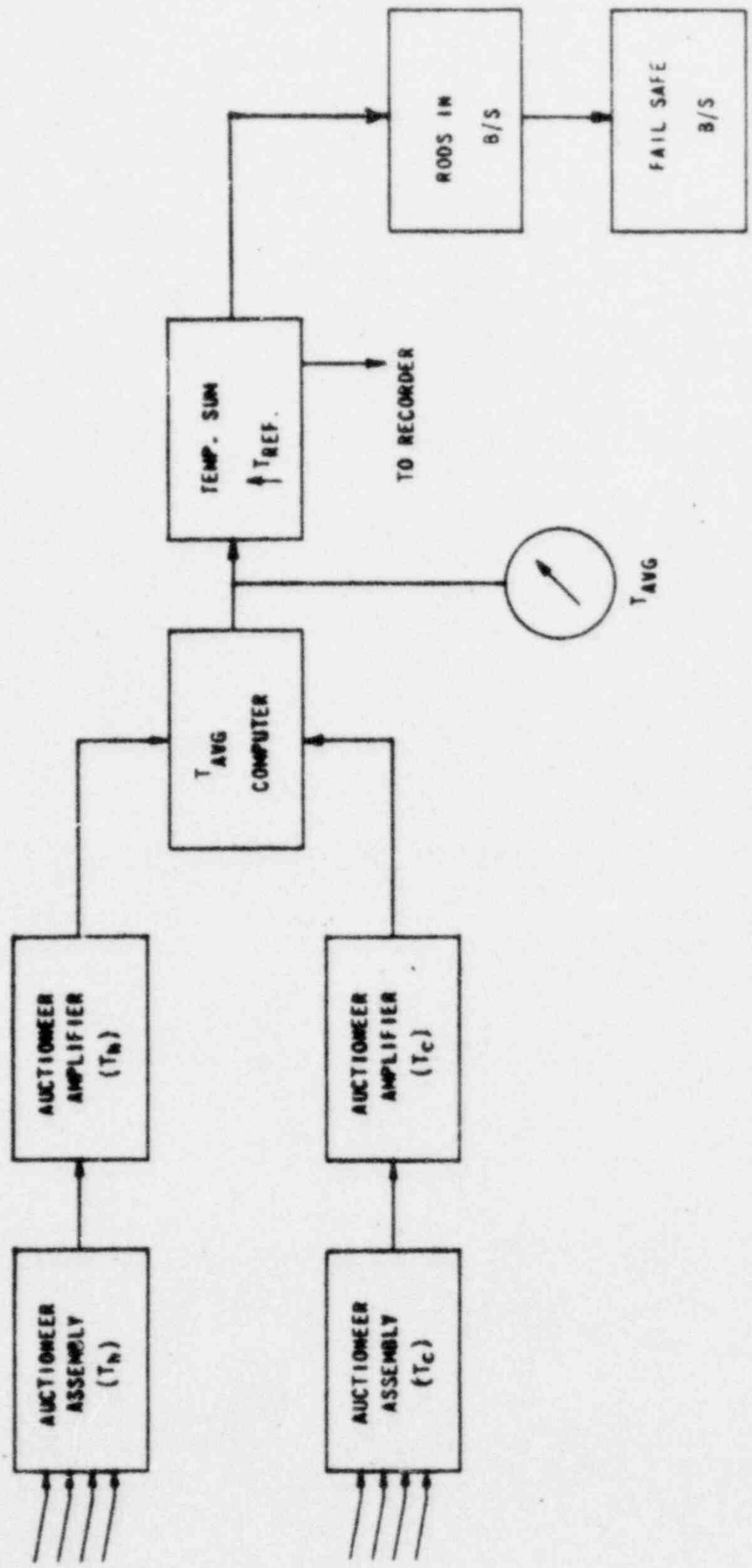
Reactor Servo Control

All of the equipment in the reactor servo control portion of the system is mounted on the nuclear control board. The principal equipment is as indicated in the figure on page 213:2, and consists of: a toggle switch for each of the four incoming main coolant loop hot leg temperature signals, an auctioneering assembly for selecting the highest main coolant loop hot leg temperature signal, a toggle switch for each of the four incoming main coolant loop cold leg temperature signals, an auctioneering assembly for selecting the highest main coolant loop cold leg temperature signal, an average temperature computer, an average temperature indicator, a temperature summing unit with a calibrated adjustable reference source, a rods-in bi-stable magnetic amplifier, and two fail-safe bi-stable magnetic amplifiers.

The reactor servo control part of the reactor control system is designed to provide dependable manual or semi-automatic control of the reactor. An essentially constant average temperature is maintained on a steady state basis. The system is capable of restoring system average temperature from a high main coolant temperature conditon resulting from a load reduction or transient. It is capable of initiating rods-in motion automatically at all power levels and provides a means for manually initiating rod motion at any power level.

As indicated in the figure on page 213:2, a temperature signal is received from the primary inlet side of each of the four main coolant loop steam generators. These are hot leg temperatures and designated as T_h. These input signals cover the range of 510°F to 560°F. Four toggle switches which are all normally closed are used to permit selection of any combination of these signals to enter the hot legs temperature (T_h) auctioneering unit. This unit which is made of static components for reliability, selects the highest T_h signal and transmits it to the T_h auctioneer amplifier where in turn it is amplified and transmitted to the average temperature (T_{avg}) computer.

Similarly, the outlet or cold leg temperatures of each of the four main coolant loop steam generators are transmitted to the cold legs temperature (T_c) auctioneering unit in the "Reactor Servo Control System". These signals cover the range of 485°F to 535°F. Here again, the highest value is selected, amplified and transmitted to the T_{avg} computer.



REACTOR SERVO CONTROL

The T_{avg} computer averages the auctioneered values of T_c and T_h and provides a signal to a control board mounted indicator. The T_{avg} signal is transmitted to a temperature summing unit where it is combined with the reference temperature signal. This combined signal is transmitted to a 10-point control board mounted recorder which provides an indication of the difference between T_{ref} and T_{avg}.

The T_{ref} signal is adjustable over a range of 497°F to 547°F, but is normally set at nominal T_{avg}. Local indication is provided for this reference temperature. Provision is also made to reduce the T_{ref} signal by an adjustable step in the range -3°F to -10°F. When the absolute difference between T_{ref} and T_{avg} exceeds a manually adjustable value of from 3° to 30°F, a bi-stable magnetic amplifier causes a normally energized relay to de-energize thus causing a "fail-safe" alarm to sound, notifying the operator of failure of T_{avg} or of T_{ref} due to some malfunction.

If the difference (T_{avg}-T_{ref}) exceeds +2°F (Trip-On) a bi-stable magnetic amplifier initiates rod motion "IN" and discontinues rod motion when the difference reduces to +1.5°F (Trip-Off). The Trip-On point is manually adjustable between +1° and +6°F, and the loop width (Trip-On minus Trip-Off) is adjustable from .5°F to 5°F.

Control Rod Drive Mechanisms - Design

The control rod drive mechanism is of the magnetic jack type using a positive latch engagement to hold and move the drive rod. The entire mechanical assembly is enclosed within the pressure housing which has been designed to conform with the ASME Boiler and Pressure Vessel Code, Section VIII Unfired Pressure Vessels. Operating and position indicating coils are outside and separate from the pressure housing.

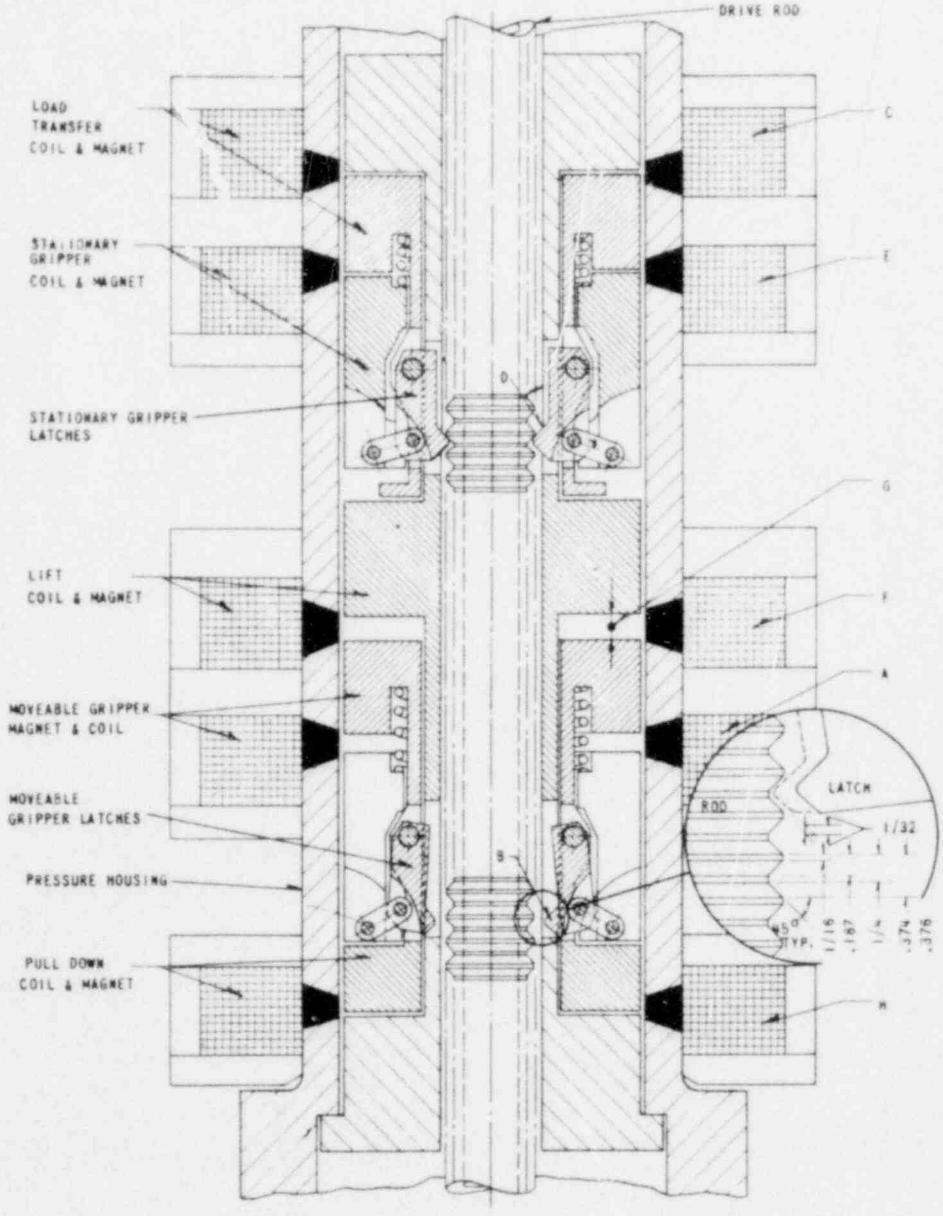
Overall arrangement of the mechanism is shown on page 101:11. The arrangement of the latches is shown on page 213:4.

The mechanisms have been designed to meet the following requirements:

1. Design pressure, psia	2,500
2. Design temperature, °F	500
3. Rod travel, in.	90
4. Lifting capacity, lb min	750
5. Rod speed, in./min.	10 in 3/8 in. steps

The following is a description of the operating sequence for a typical lift cycle:

At the start of the cycle as shown on page 213:4, the stationary gripper latches are engaged and are supporting the rod weight. The stationary gripper magnet coil and the load transfer magnet coil are energized.



MECHANISM SCHEMATIC DIAGRAM

MAGNETIC JACK LATCH TYPE CONTROL ROD DRIVE MECHANISM

2. The movable gripper magnet coil is then energized causing the movable gripper latches to engage the drive rod. A 1/32 in. clearance remains between the rod and the latches at this time.

3. The load transfer magnet coil is deenergized allowing the stationary gripper assembly and drive rod to drop until the load is transferred to the movable gripper latches. The stationary gripper assembly continues to drop until the latches are 1/32 in. clear of the drive rod.

4. The stationary gripper magnet coil is deenergized allowing the stationary gripper latches to disengage the drive rod.

5. The lift magnet coil is energized. This raises the movable gripper assembly and drive rod one step (3/8 in.).

6. The stationary gripper magnet coil is energized, causing the stationary gripper latches to engage the drive rod. Again, there is a 1/32 in. clearance between rod and latch.

7. The load transfer magnet coil is energized, raising the stationary gripper latches into contact with the drive rod. They continue to move upward, picking up the drive rod and unloading the movable gripper latches.

8. The movable gripper magnet coil is deenergized, allowing the movable gripper latches to disengage the drive rod.

9. The lift magnet coil is deenergized. The pull down magnet coil is energized to return the movable gripper assembly to its original position in preparation for the next stroke.

Lowering of the rod is accomplished by the reverse of the above procedure except that the lowering of the rod is accomplished by deenergizing the movable gripper magnet coil and allowing the assembly to drop by weight. The pull down magnet coil is not used during the lowering sequence.

Upon loss of power or in the event of a scram, all magnet coils are deenergized. The drive rod weight forces the latches outward allowing the rod to drop. The tooth angles of the latches and drive rod have been selected so that the latching system is not self-locking even with friction coefficients as high as 1.55. Springs have been provided in the gripper assemblies to speed up the unlatching stroke, but the ability of the mechanism to scram is not dependent upon these springs.

Control Rod Drive Mechanisms - Power Supply and Control

Equipment provided for the power supply and control for the rod drive mechanisms is shown on drawing No. 517F076. Of this equipment, the following are mounted within low voltage metal enclosed switchgear located in the plant switchgear room: two direct current breakers, one alternating current breaker, six motor driven cam switches with associated induction motor drives and speed reducers, three control switches, one alternating current undervoltage relay, 31•direct current contactors, six induction motor starters, one control transformer, one alternating current contactor, three alternating current control relays, seven direct current control relays and a complete set of internal wiring and bus work. The gear ratio used in the motor driven cam switch will be such as to limit the rate of travel of all control rods to a maximum of 6" per minute. In addition, three control switches, twenty-four disconnecting switches, two "Scram" push buttons and nine indicating lights are mounted on the nuclear section of the main control board located in the plant control room. An additional "Scram" push button is mounted on the turbine section of the main control board. Fusing for each individual mechanism coil is provided as shown on drawing No. 517-F-076 and is mounted in junction boxes located within the vapor container. Necessary wiring is provided between the various equipment locations and to the alternating current and direct current feeders.

The design of the power supply and control for the twenty-four rod drive mechanisms is based on the ability of the circuit to accomplish the following:

a. Supply energy to one or more rod drive mechanisms as well as to the associated control components.

b. Provide a means for selecting a particular mechanism group to be moved.

c. Provide both manual and semi-automatic control for performing "Rods In" and "Scramming" operations and manual control for performing "Rods Out" operation.

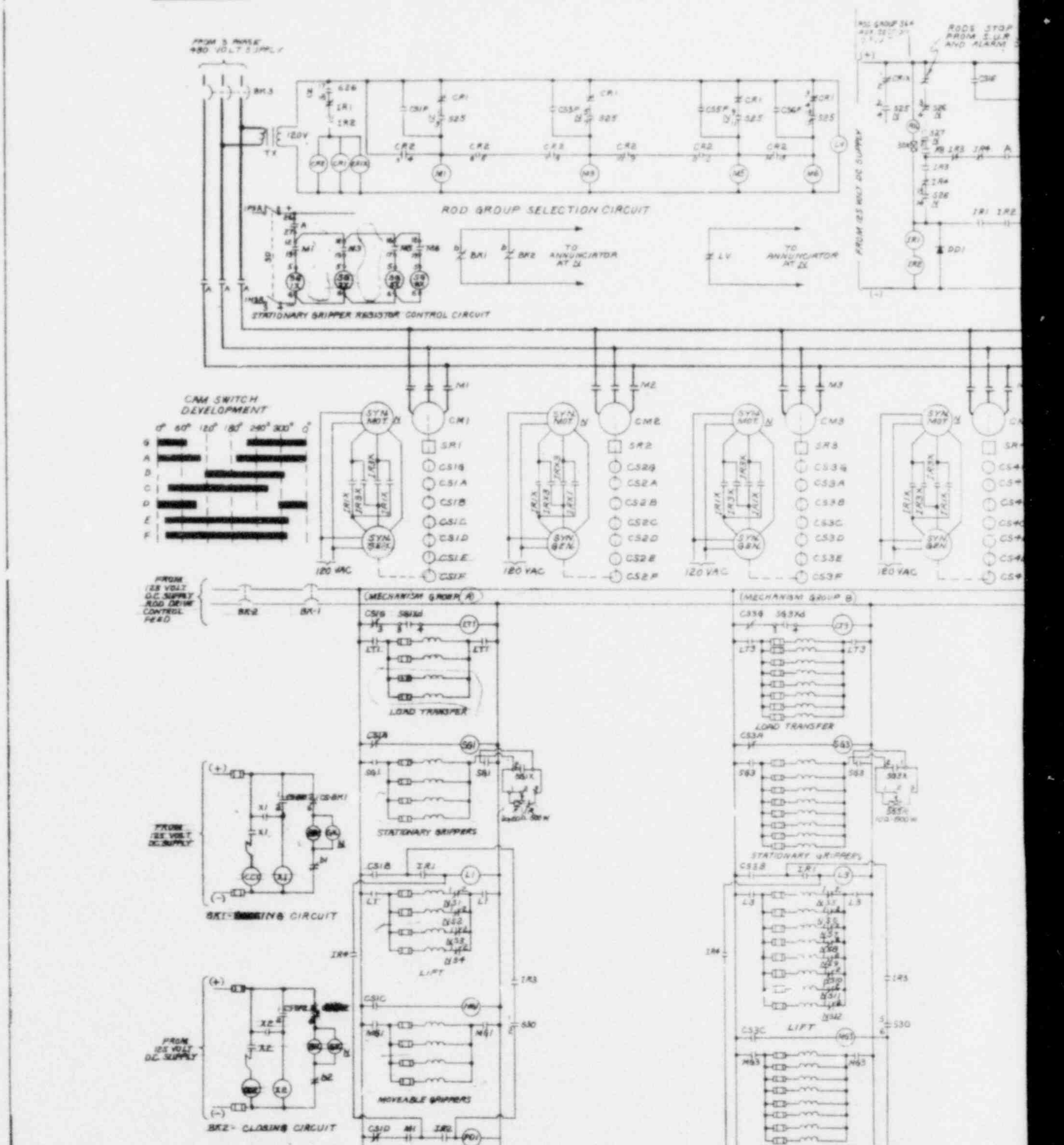
d. Provide a means for operating any group of rods with a fraction of its normal number of rods while the other rods of that group remain stationary.

e. Provide manual control for performing an "All Rods In" operation.

The latch type, magnetic jack,rod drive mechanism operates when its five functional coils, i.e. pull down, movable gripper, lift, load transfer, and stationary gripper, are energized in correct sequence for either raising or lowering the control rod. Energizing the same functional coils of more than one mechanism simultaneously allows these mechanisms to be controlled as a group. The twenty-four control rod mechanisms were initially grouped in the following manner: three groups (3,4,5 on page 103:13) of four mechanisms per group, two groups (1,2) of two mechanisms per group, and one group (6) of eight mechanisms.

For Core III, the eight-mechanism group (6) was operated as two groups of four mechanisms each. For Core IV, and subsequent cores, group (6) will again be operated as a single group of eight mechanisms. Groups 1 & 2 will be operated together as a single group of four mechanisms. For groups 3 & 4, two operating options will be maintained--3 & 4 can be operated individually as two groups of four mechanisms each, or 3 & 4 can be operated together as a single group of eight mechanisms. If these groups are operated individually, it will be done by alternate stepping of each group so as to maintain the programmed sequence. Individual operation will allow reactivity to be inserted at a slower rate than if all eight rods were moved simultaneously.

YE-BI-17 517F076

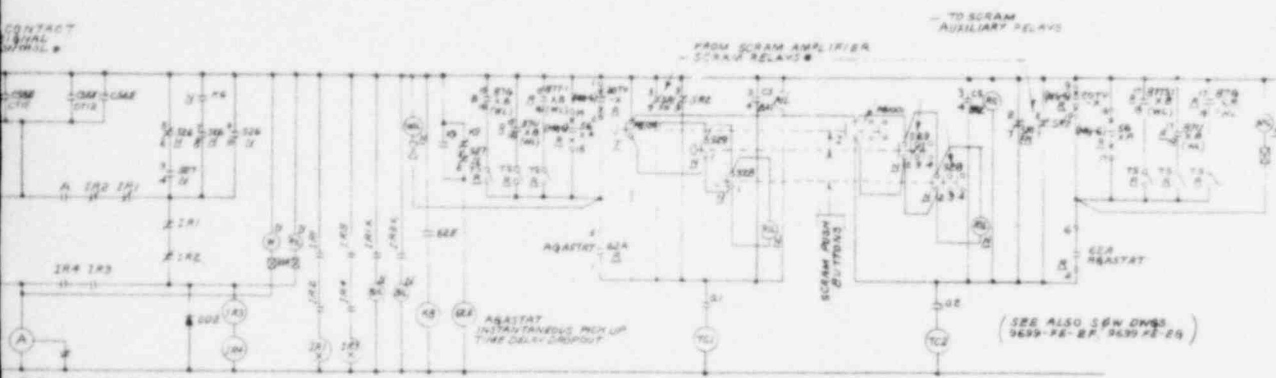


CONT.	POSITION			
	PULL	TRIP	OFF	CLOSE
1-2				X
3-4	X	X		
5-6		X	X	X

CS-BK1 & CS-BK2

NOTES:

1. N - EQUIPMENT LOCATED ON NUCLEAR SECTION OF MAIN CONTROL BOARD.
2. B - SEE N DRAWING 517F069 NUCLEAR INSTRUMENTATION BLOCK DIAGRAM.
3. ALL CIRCUITS ARE SHOWN DEENERGIZED
4. △ - 24 VOLT BULB WITH 2500 Ω RESISTOR.
5. T EQUIPMENT AT TURBINE SECTION MAIN CONTROL BOARD.
6. R EQUIPMENT AT REAR OF ELECT. & TURBINE SECTION - MAIN CONTROL BOARD.



ROD MOTION CONTROL CIRCUIT

(SEE ALSO S&W DWGS 9699-FE-2F, 9699-FE-2G)

CONT	POSITION	
	OPEN	CLOSE
1-2		X
3-4		X
5-6		X
7-8		X
9-10		X
11-12		X
13-14		X
15-16		X

S30

CONT	POSITION		
	AUTO.	MAN.	ALL IN
1-2	X		
3-4		X	
5-6		X	
7-8	X		
9-10			X
11-12	X	X	
13-14	X	X	
15-16	X	X	
17-18			X

S26

CONT	POSITION							
	OFF	GR. A	GR. B	GR. C	GR. D	SPARE	SPARE	SPARE
1-3		X						
2-4						X		
5-7			X					
6-8							X	
9-11				X				
[illegible]					X			
10-12								X

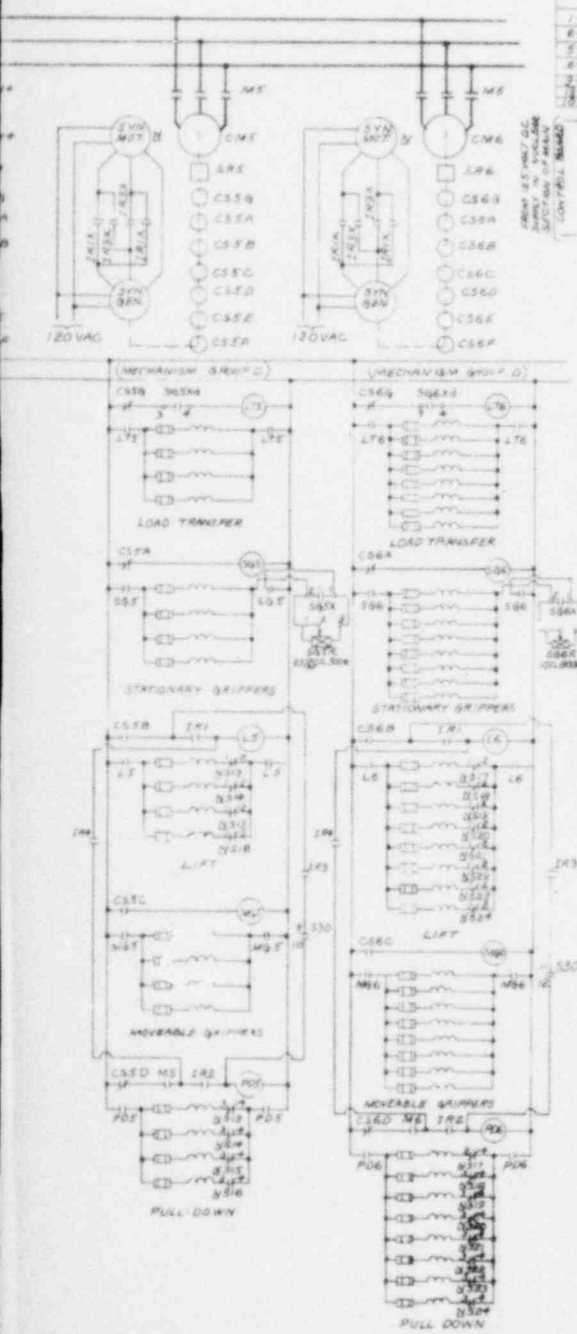
S25

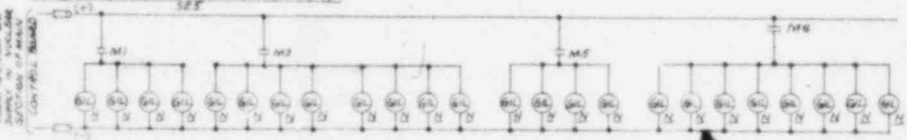
CONT.	POSITION		
	IN	OFF	OUT
1-2			X
3-4	X		
5-6		X	

S27

CONT.	POSITION	
	OPEN	CLOSE
1-2		X
3-4		X

S1 THRU S24



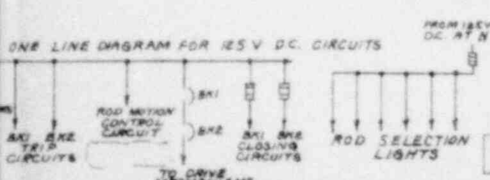


DEVICE CHART

DEVICE	FUNCTION	IDENTIFICATION
S1 THRU S24	LIFT COILS PULL DOWN COILS DISCONNECTING SWITCHES MAINTAINED CONTACT	SIMILAR TO W TYPE W STYLE #1539006
M1-M3-M5-M6	CAM MOTOR STARTERS	W TYPE N-130
S25	CAM MOTOR STARTER SELECTOR SWITCH-MAINTAINED CONTACT	W TYPE W
S26	"AUTOMATIC ALL RODS IN" CONTROL SWITCH-MAINTAINED CONTACT	W TYPE W
S27	RODS IN-RODS OUT CONTROL SWITCH, MOMENTARY CONTACT	W TYPE W
A	MAIN CONTROL CONTACTOR	W TYPE N-240
IR1X	AUXILARY RODS OUT INVERSION RELAY	MAGNETIC DEVICES
IR3X	AUXILARY RODS IN INVERSION RELAY	MAGNETIC DEVICES
SG1	STATIONARY GRIPPER COILS CONTROL CONTACTORS - GROUP A	W TYPE M-120-2H
SG5	STATIONARY GRIPPER COILS CONTROL CONTACTORS GROUP C	W TYPE M-120-2H
SG3-SG6	STATIONARY GRIPPER COILS CONTROL CONTACTORS GROUPS B&D	W TYPE M-220-2H
L1 L5	LIFT COILS CONTROL CONTACTORS GROUPS A&C	W TYPE MM-320-2H
L3-L6	LIFT COILS CONTROL CONTACTORS-GROUPS B&D	W TYPE MM-420-2H
H6	CONTACT OF RODS IN RELAY	
SG1R-5R	RESIS. FOR STATIONARY GRIPPER COILS-GROUPS A&C	25Ω 500W OHMITE
SG3R-6R	RESIS. FOR STATIONARY GRIPPER COILS-GROUPS B&D	10Ω 800W OHMITE
CR1	CONTROL RELAY-ROD GROUP SELECTOR CIRCUIT	W TYPE NH 6 POLE
CR2 CR1X	CONTROL RELAY-ROD GROUP SELECTOR CIRCUIT	W TYPE NH 6 POLE SG 2 POLE
CM1-3-5 & CM6	INDUCTION MOTOR DRIVES FOR CAM SWITCHES	
SA1-3-5&6	SPEED REDUCERS FOR CAM SWS.	
CS1A-CS3A CS5A&CS6A	CAM STAGES CONTROLLING SG1 SG3-SG5&SG6	
CS1B-CS3B CS5B-CS6B	CAM STAGES CONTROLLING L1-L3-L5 & L6.	
CS1C-CS3C CS5C-CS6C	CAM STAGES CONTROLLING MG1-MG3-MG5&MG6	
CS1D-CS3D CS5D-CS6D	CAM STAGES CONTROLLING PD1-PD3-PD5&PD6.	
CS1E-CS3E CS5E-CS6E	CAM STAGES CONTROLLING OPERATION OF CONTACTS IN ROD MOTOR CIRCUIT	
CS1F-CS3F CS5F-CS6F	CAM STAGES CONTROLLING OPERATION OF CONTACTS IN ROD GROUP SELECTION CIRCUIT.	
S30	PULL-DOWN COILS DISCONNECT SW.	W TYPE W
BIL	BLUE INDICATING LIGHT	W RECT. MINALITE
WIL	WHITE INDICATING LIGHT	W RECT. MINALITE
RIL	RED INDICATING LIGHT	W RECT. MINALITE
MG1&MG5	MOVEABLE GRIPPER COILS CONTROL CONTACTORS-GROUPS A&C	W TYPE M-120-2H
MG3&MG6	MOVEABLE GRIPPER COILS CONTROL CONTACTORS-GROUPS B&D	W TYPE M-220-2H

DEVICE	FUNCTION	IDENTIFICATION
GIL	GREEN INDICATING LIGHT	W RECT. MINALITE
AIL	AMBER INDICATING LIGHT	W RECT. MINALITE
TX	CONTROL TRANSFORMER	W TYPE EP
BK1	CIRCUIT BREAKER-DC	W TYPE DB-25
BK2	CIRCUIT BREAKER-DC	W TYPE DB-25
BK3	CIRCUIT BREAKER-AC	W TYPE AB 1st FRAME
CC1	CLOSING COIL FOR BK1	
CC2	CLOSING COIL FOR BK2	
TC1	TRIP COIL FOR BK1	
TC2	TRIP COIL FOR BK2	
X1	CONTROL RELAY BK1	
X2	CONTROL RELAY BK2	
CS1G-CS3G CS5G-CS6G	CAM STAGES CONTROLLING LT1-LT3-LT5 & LT6	
SG1X&5X	SHORTING CONTACTORS FOR RESISTORS SG1R&5R-GROUPS A&C	TYPE M 110-2H
SG3X&SG6X	SHORTING CONTACTORS FOR RESISTORS SG3R&6R-GROUPS B&D	TYPE M 210-2H
a1	BREAKER AUXILIARY CONTACT (BK1) CLOSES WHEN MAIN CONTACTS CLOSE, OPENS WHEN MAIN CONTACTS OPEN.	
K8	RODS OUT RESET RELAY	
a2	SAME AS ABOVE FOR BK2	
SG1Xa & 5Xa	AUX. FINGER ON SG1X&5X CONTACTOR	
b1	BREAKER AUXILIARY CONTACT (BK1) OPEN WHEN MAIN CONTACT CLOSE, CLOSED WHEN MAIN CONTACTS ARE OPEN.	
K9	485 MWT PERMISSIVE RELAY	
b2	SAME AS ABOVE FOR BK2	
62E	RODS OUT TIMING RELAY	
PD1&PD3	PULL DOWN COILS CONTROL CONTACTORS-GROUPS A&C	W TYPE M-220-2H
PD5&PD6	PULL DOWN COILS CONTROL CONTACTORS-GROUPS B&D	W TYPE MM-320-2H
CS-BK1	CONTROL SWITCH FOR BREAKER BK1	W TYPE W STYLE #1095923
CS-BK2	CONTROL SWITCH FOR BREAKER BK2	W TYPE W STYLE #1095920
LV	LOSS OF VOLTAGE RELAY	W TYPE CV-2
S28-S29	SCRAM PUSH BUTTONS	W TYPE HD MUSHROOM HEAD
IR1, IR2 IR3, IR4	INVERSION RELAYS	W TYPE AYK
SR1, SR2	SCRAM AMPLIFIER SCRAM RELAYS	
DD1, DD2	DISCHARGE DIODES	
LT1 & LT5	LOAD TRANSFER COILS CONTROL CONTACTORS-GROUPS A&C	W TYPE M-120-2H
LT3&LT6	LOAD TRANSFER COILS CONTROL CONTACTORS-GROUPS B&D	W TYPE M-220-2H

ONE LINE DIAGRAM FOR 125 V. D.C. CIRCUITS



DO NOT DESTORY- FILED AS PART OF FINAL HAZARDS SUMMARY REPORT

SEE SIMILAR DRWG YE-B-2 YANKEE ATOMIC ELECTRIC

YE-B1-17

WESTINGHOUSE ELECTRIC CORPORATION

TITLE LARGE PRESSURIZED WATER NUCLEAR POWER PLANT POWER SUPPLY & CONTROL FOR ROD DRIVE MECHANISM

DIMENSIONS IN INCHES-SCALE N.T.S.

517F076

DIVISION ATOMIC POWER PLANT LOCATION PGH. PA.

For any operation where only one group is to be moved or made available to be moved, the group is pre-selected manually with the group selector switch, S25. This switch, part of the rod group selection circuit, closes in any one of the induction motor starters.

Manual control of a pre-selected rod group is accomplished with the "Rods In - Rods Out" control switch, S27. This switch, part of the rod motion control circuit, permits the operator to energize either the "Rods Out" (IR1), (IR2) or "Rods In" (IR3), (IR4) inversion relays. The main control contactor (A) is then energized.

A pre-selected rod group can be placed on semi-automatic operation by moving the "Rods Operation Selector" switch, S26, to the automatic position. Should the K6 contacts, controlled by relays in the associated reactor servo control be operated, rod motion would be effected.

Auxiliary inversion relays (IR1X) and (IR3X) are provided to arrange the rod group position indicating circuits for either "Rods In" or "Rods Out" indication depending upon the respective signal.

At power levels of 150 MWe and above, a manual rods out reset circuit becomes effective requiring the "Rod Control Switch", S 27, to be returned to the de-energized or reset position before making each additional "Rods Out" step.

"All Rods In" motion is available at all times and takes precedence over any motion already in progress. This motion is accomplished by merely switching S26 to the "All Rods In" position.

Should it become necessary to operate any group with less than the normal number of rods, the pull down and lift coils of any mechanism which is to remain stationary can be disconnected. Switches S1 through S24 are provided for this purpose.

Removing all power to the mechanisms permits the control rods to drop. In order to scram, therefore, the trip coils on power supply breakers are energized. Manually, this is done by pressing either of the three "Scram" push buttons and automatically by closing the relay contacts which are operated from associated control and monitoring systems.

The sixth and seventh cams of each cam switch have their associated contacts in the rod motion control circuit and rod group selection circuit, respectively. This arrangement guarantees the return of the cam switch to such a position that energy is being supplied to the stationary gripper coils only.

Control Rod Coupling

Initial and alternate control rod drive shaft coupling arrangements may be seen by referring to the drawing on page 213:7B. Initial design of the control rod coupling provides for latching action upon a downward motion of the internal plunger.

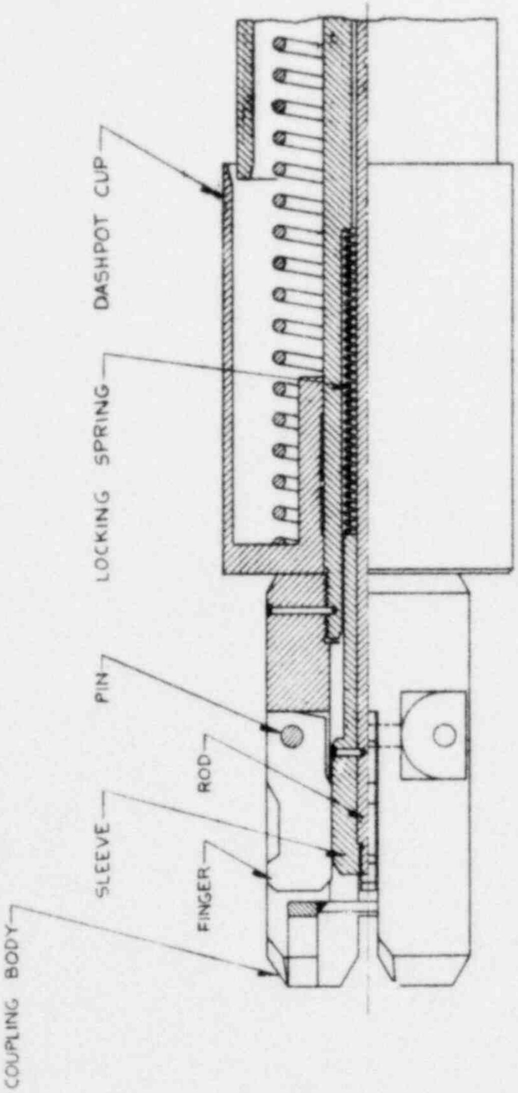
This causes the latch fingers to move out engaging the control rod absorber adapter section. Control rod absorber and drive shaft connection is maintained by the presence of the plunger in the space behind the latch fingers. Engaging surfaces of the plunger and fingers are parallel and therefore necessarily require small clearances for operation resulting in small finger-adapter axial backlash.

The alternate coupling design incorportates a wedge action latch finger-adapter fit and a provision for constant loading of the fit. The back edge of the latch fingers is tapered providing a surface for a spring loaded ball arrangement to replace the cylinderical plunger. The combination of the wedge fit and spring loading feature thus provides a constant coupling engaging force. The resulting zero clearance latch-adapter fit is thus maintained thereby minimizing corrosion and mechanical wear effects. Attached to the latch operating shaft and below the engaging ball is a small spring loaded plunger which initiates latch motion during the unlatching operation and also serves as a backup device in the event of ball loading spring failure.

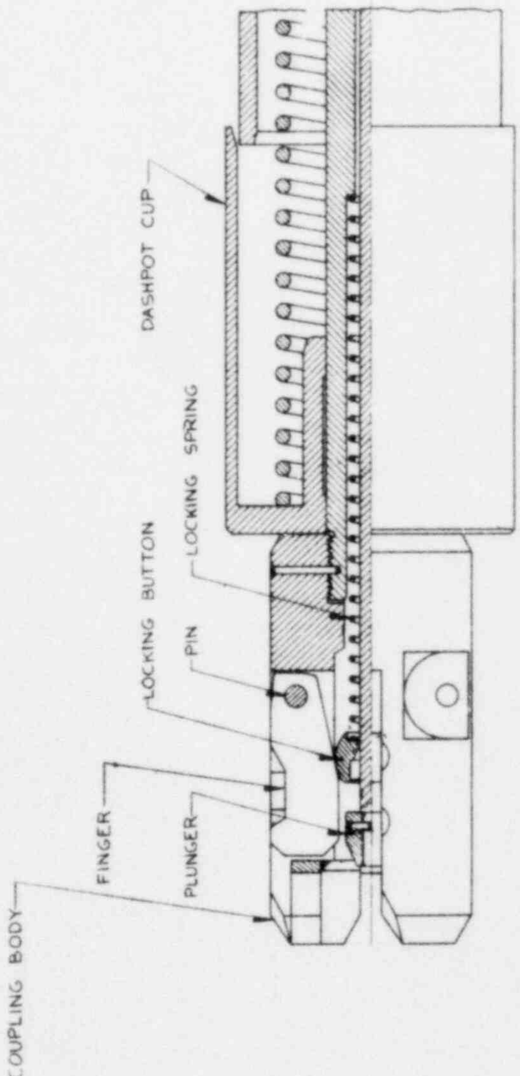
Control Rod Drive Mechanisms - Development Program

The AEC sponsored Research and Development Contract included a development and testing program to determine the feasibility of using magnetic jack latch type control rod drive mechanisms for the Yankee plant. As part of this program, a prototype unit having a reduced length of travel was constructed.*

*YAEC-155 - Design and Test of the Yankee Prototype Magnetic Jack Latch Type Mechanism - July 1959



INITIAL DESIGN



ALTERNATE DESIGN 2

CONTROL ROD COUPLING

In December 1958 the mechanism was first placed under test and was checked for mechanical function, scram delay time, and lift capacity. Coil current sequencing was optimized to produce maximum drive shaft velocity.

The mechanism with control rod weight loading was autoclave tested using primary plant water conditions. Maximum drive shaft velocity, mechanism function, and scram delay time were checked under these conditions. Air cooling requirements for the mechanism were determined, and an endurance test was also performed.

An 800 lb weight was lifted by the mechanism. The equipment specification for the control rod drive mechanism requires capability of lifting a 750 lb dry weight. The Yankee control rod and drive shaft assembly will weigh 400 lb.

Scram delay time in the test stand was found to average 150 milliseconds. The equipment specification call for 200 milliseconds.

Adjustment of sequencing of the various coil currents to produce smooth operation was carefully carried out.

The optimum sequencing of coil currents was reached by using "Visicord" recorder traces of the coil currents and adjusting the timing for energizing and deenergizing of these coils to produce smooth cycling of the latches. The maximum cycling speed at this point was approximately 16 cycles or steps per minute, each step being 3/8 in.

A modification was made which improved the cycling speed. It was found that by slotting all the magnet poles axially to reduce eddy currents, the cycling speed was increased to 30 steps (11.25 in.) per minute. Further adjustments have permitted as high as 35 steps per minute to be achieved.

For hot testing, the mechanism was put in an autoclave containing borated water at 500 F and 1,200 psi. Weights were added to the drive shaft to provide 400 lb (dry weight) for the mechanism to lift. With this attached weight, the mechanism operated smoothly at 30 steps per minute.

At approximately 260,000 cycles, two of the latch fingers fractured and jammed the mechanism. The unit was disassembled and the failure was determined to be the result of impact loading. Impact loading on the fingers increased after the magnet poles were slotted. The damping effect provided earlier by the water was largely lost due to the by-pass provided by this axial slotting. To improve this condition, magnet poles with slots that do not run the full length of the pole will be used. New latch fingers have been designed and tested which will feature more generous radii to reduce stress concentrations and improved facing design.

During the hot autoclave tests the mechanism was subjected to water having a crud accummulation exceeding 16 ppm. No stickiness of operation or other malfunction due to crud build up has been evidenced. Primary system water is expected to have 1 ppm of crud.

During the autoclave test, cooling air at 100 F was supplied by two fans capable of furnishing a total of 1,100 cfm. For determination of maximum plant air cooling requirements for 24 mechanisms, tests were conducted as follows:

2 fans running	Mechanism operating
1 fan running	Mechanism operating
1 fan running	Mechanism holding
0 fan running	Mechanism holding

Under these conditions, the various coil temperatures and the air flow were measured. This data was applied to maximum plant cooling requirements (eight mechanisms operating and 16 holding) using 400 F as the maximum allowable coil temperature for satisfactory coil life. A total of 9,600 cfm of cooling air at 100 F with a 20 F rise will be required.

Primary Rod Position Indication

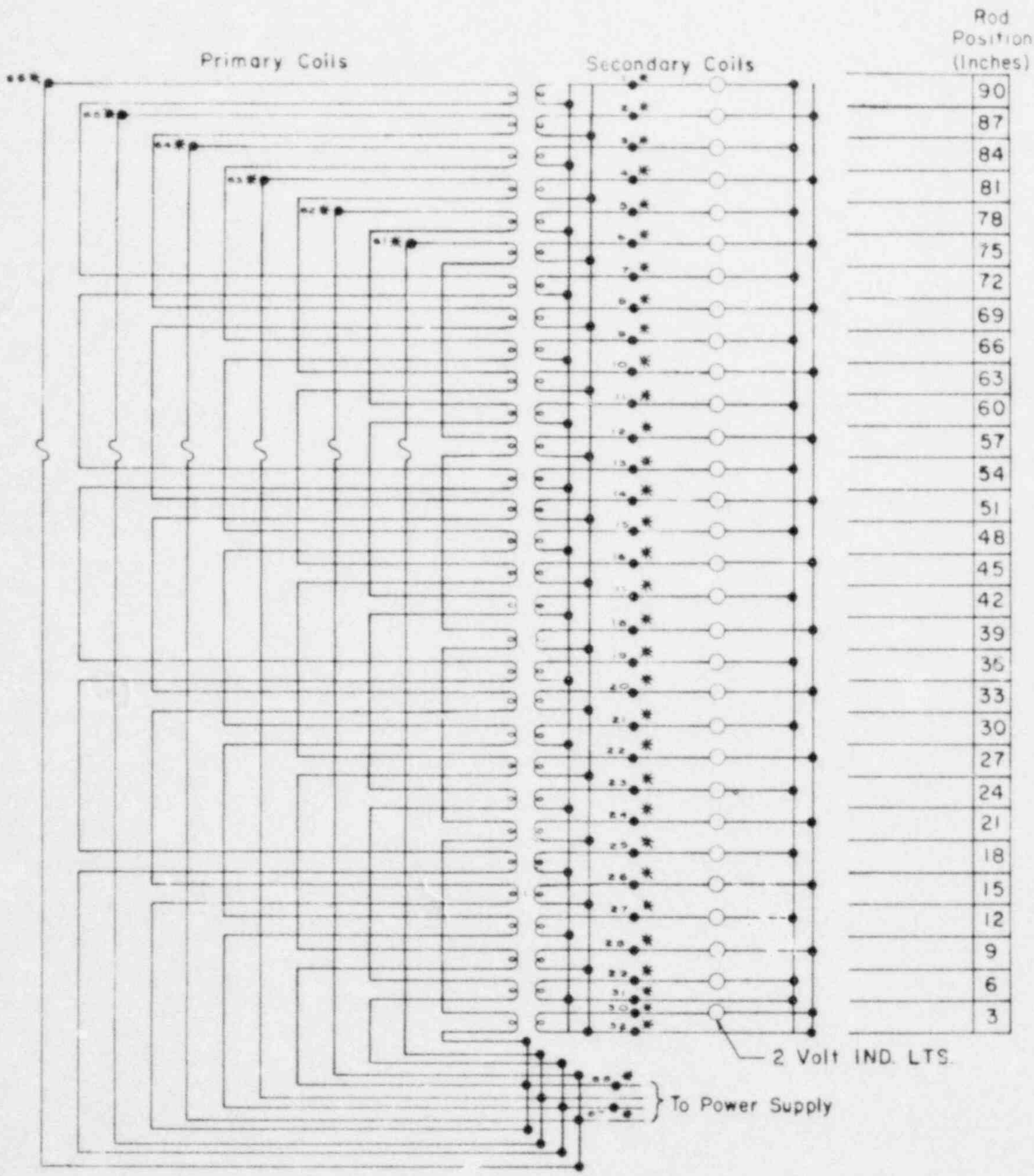
The primary rod position indicating scheme consists of 720 transformers which are mounted around the pressure housings of the control rod extensions. Six fuses per control rod are mounted in the vapor container. There are 720, 2-volt tungsten filament, incandescent bulbs. These bulbs are mounted in vertical columns on the front of the control board.

The primary rod position indication scheme is shown on page 213:10 This portion of the "Reactor Control System" consists of thirty 3 in. transformers per control rod. These are mechanically connected to facilitate handling. They are mounted around the pressure housing designed to contain the control rod drive shaft. The primary windings of five transformers, suitably staggered to avoid loss of any two consecutive transformers, are in series and are designed to maintain an essentially constant primary current. Each secondary winding has across it a 2-volt incandescent bulb. These bulbs are mounted in a vertical column behind a ground glass face plate on the control board. The individual bulb positions correspond to their respective transformer secondary position around the control rod drive shaft. As the control rod is withdrawn from the reactor, the increased permeability of each successive transformer increases the coupling between the primary and secondary winding enough to cause the bulbs to successively light and, in effect, give a positive column type indication of each individual control rod position. Twenty-four of these systems are included. The accuracy is sufficient for power plant operation, and is within ±3 in.

Secondary Rod Position Indication

The secondary rod position indicating scheme consists of six self-synchronous transmitters mounted on the control rod cam shaft extensions in the power supply for the control rod mechanisms and six self-synchronous receivers mounted on the control board. There are also six digital read-out indicators mounted on the control board with provision for manual reset.

The synchronous transmitters cause the similar control board unit to rotate in synchronism which cause motion of the digital read-out device. The unit counts the number of revolutions made by the cam shafts and gives an indication of each rod group position to an accuracy of ±1/8 in.



* Pin numbers are per Pyle National
ZZM-W-1520-13PV

ROD POSITION INDICATING SCHEME

214 NUCLEAR INSTRUMENTATION AND REACTOR PROTECTION SYSTEM

General

The function of the nuclear instrumentation and reactor protection system is to monitor the nuclear reactor flux from source to 150% of reactor designed full power output and to provide the necessary indications and controls for safe and efficient operation of the reactor. This equipment incorporates provisions for initiating a reactor and turbine shutdown in the event that conditions exist which may be hazardous for plant operation. Circuitry is also provided to by-pass several shutdown signals for startup operation. This system is shown schematically on drawings 517-F-069 and 9699-FE-2G.

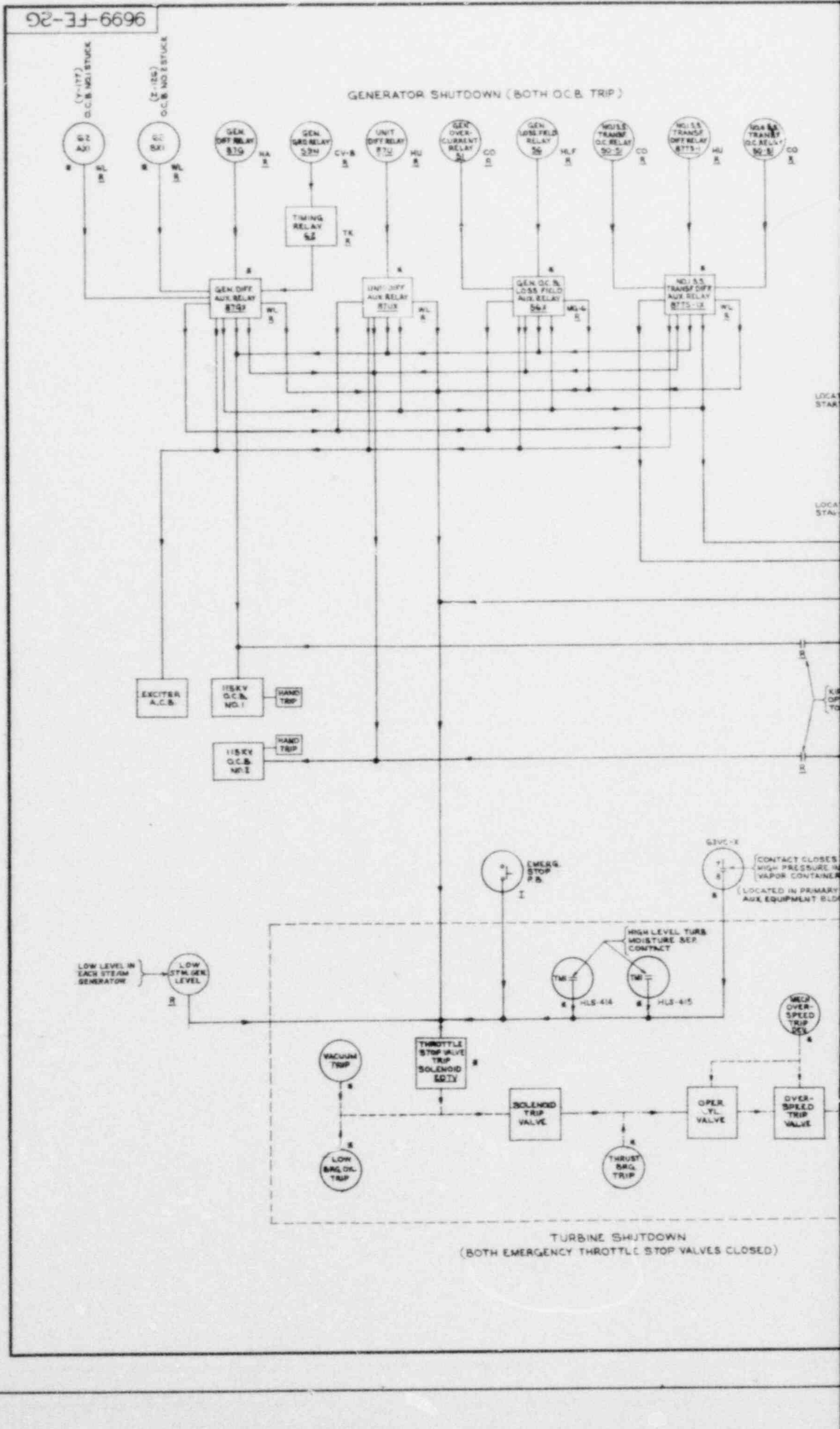
The nuclear instrumentation and reactor protection equipment contains eight nuclear information channels, two scram amplifiers, one alarm and scram panel, one auxiliary meter panel, two bistable panels, two meter and test panels, one intermediate range auxiliary panel, and one startup and power range auxiliary panel mounted in three cabinets located in the main control room. Also included as part of this equipment is the main control board mounted equipment consisting of one recorder, one signal jack board, two source level meters, two intermediate level meters, two startup rate meters, two startup rate selector switches, one source range scram cutout switch, one low power scram set switch, one alarm reset switch, six power level meters, two source range high voltage lights, one permissive relay signal light, one rods stop signal light, one low level scram set light, two manual scram buttons, six power range calibrating potentiometers, and one scram auxiliary relay.

The reactor scram signals which are initiated by the turbine generator protection equipment are connected through the permissive relay directly to the Rod Scram Air Circuit Breakers. The turbine generator protection equipment is discussed in detail in Section 233.

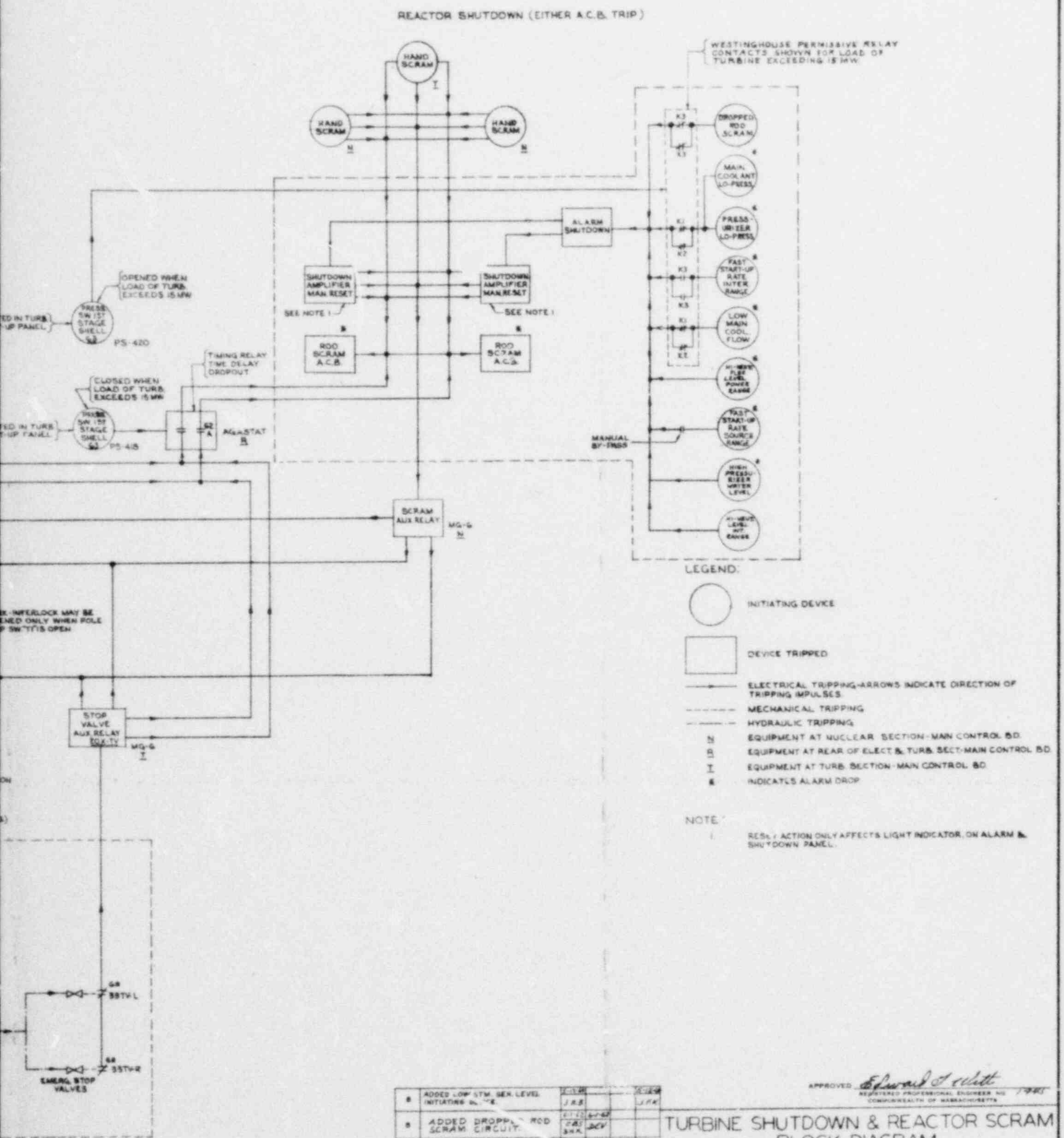
The eight nuclear information channels consist of two identical source ranges, two identical intermediate ranges, three identical power ranges and one special intermediate range. The source range and intermediate range are designated as the startup range.

The source range (channels No. 1 and No. 2) consists of two boron trifluoride (BF_3) proportional counters located in thimbles in the neutron shield tank. The nuclear instrumentation cabinet mounted equipment consists of two pulse integrators, two low voltage power supplies, two log microammeters, and two proportional counter power supplies.

The intermediate range (channels No. 3, No. 4, and No. 5) consists of three compensated ion chambers located in thimbles in the neutron shield tank. The nuclear instrumentation cabinet mounted equipment consists of two low voltage power supplies, two log microammeters, and three power range panels.



GENERATOR SHUTDOWN (BOTH O.C.B. TRIP)
GEN. DIFF RELAY 87G
GEN. GRD RELAY 59N
TIMING RELAY
UNIT DIFF RELAY 87U
GEN. OVER-CURRENT RELAY 51
GEN. LOSS FIELD RELAY
GEN. DIFF AUX. RELAY 87G1
UNIT DIFF AUX RELAY 87UX
GEN. O.C. & LOSS FIELD AUX. RELAY
EXCITER A.C.B.
115 KV O.C.B. NO. 1
115 KV O.C.B. NO. 2
HAND TRIP
EMERG. STOP P.B.
CONTACT CLOSES HIGH PRESSURE IN VAPOR CONTAINER
LOCATED IN PRIMARY AUX. EQUIPMENT BLDG.
HIGH LEVEL TURB. MOISTURE SEP. CONTACT
LOW LEVEL IN EACH STEAM GENERATOR
LOW STM. GEN. LEVEL
HLS-414
HLS-415
VACUUM TRIP
THROTTLE STOP VALVE TRIP SOLENOID
SOLENOID TRIP VALVE
OPER. CYL. VALVE
OVER-SPEED TRIP VALVE
LOW BRG. OIL TRIP
THRUST BRG. TRIP
TURBINE SHUTDOWN
(BOTH EMERGENCY THROTTLE STOP VALVES CLOSED)



REV. #	DESCRIPTION	CHKD.	INSP.	COOR.	APPR.
6	ADDED LOW STM. GEN. LEVEL INITIATING DEVICE	J.A.B.			J.F.K.
5	ADDED DROPPED ROD SCRAM CIRCUIT				
4	ADDED HI-NEUTRON LEVEL INTER-MEDIATE RANGE SCRAM CIRCUIT				
3	ADDED HIGH PRESSURIZER WATER LEVEL SCRAM CIRCUIT				
2	ADDED STUCK BREAKER TRIPPING, REVISED REACTOR SHUTDOWN TRIP, MINOR CHANGES				
1	ORIGINAL ISSUE				

APPROVED Edward J. [illegible] 1965

REGISTERED PROFESSIONAL ENGINEER NO. — COMMONWEALTH OF MASSACHUSETTS

TURBINE SHUTDOWN & REACTOR SCRAM BLOCK DIAGRAM

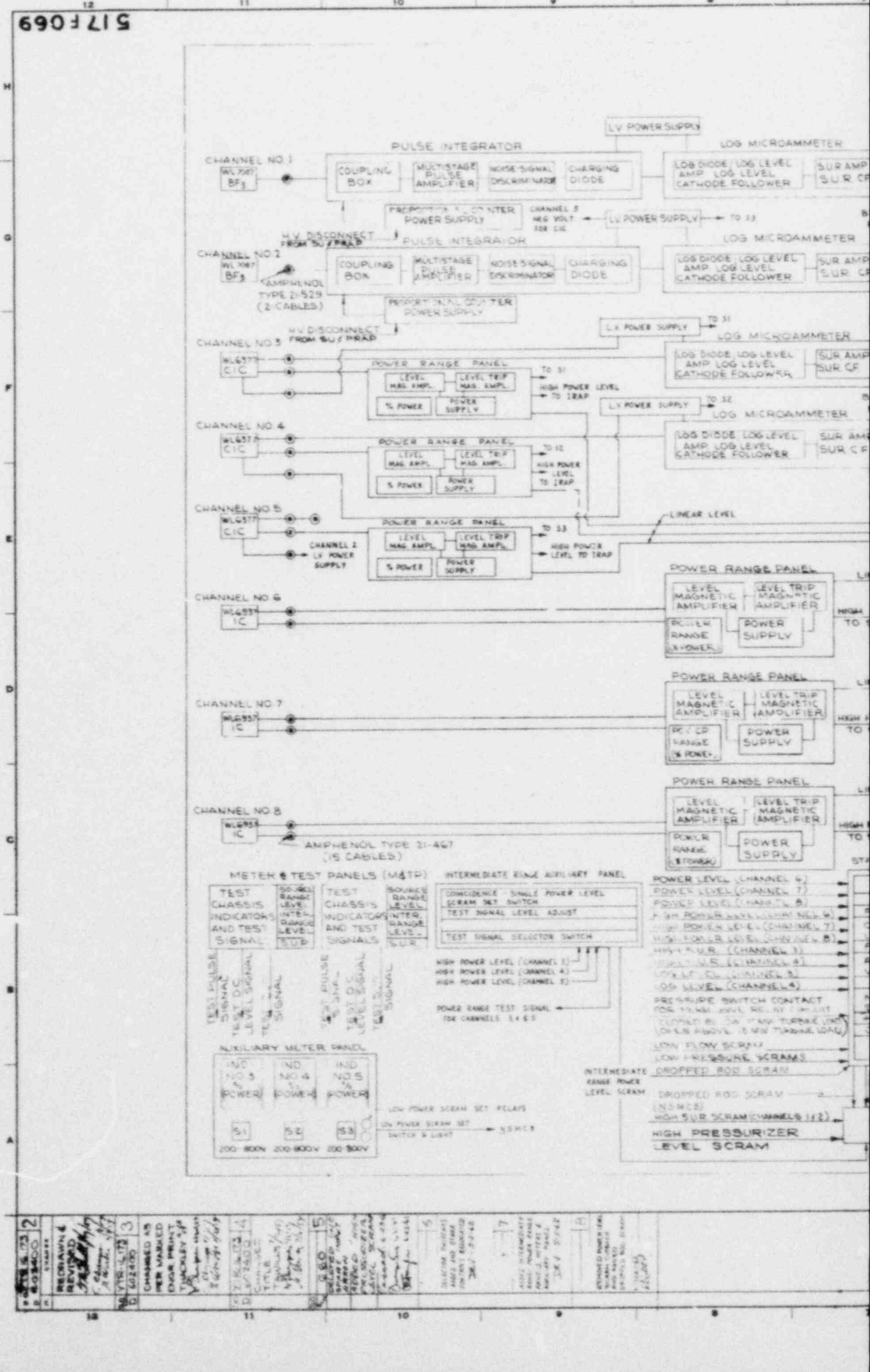
POWER STATION

YANKEE ATOMIC ELECTRIC COMPANY

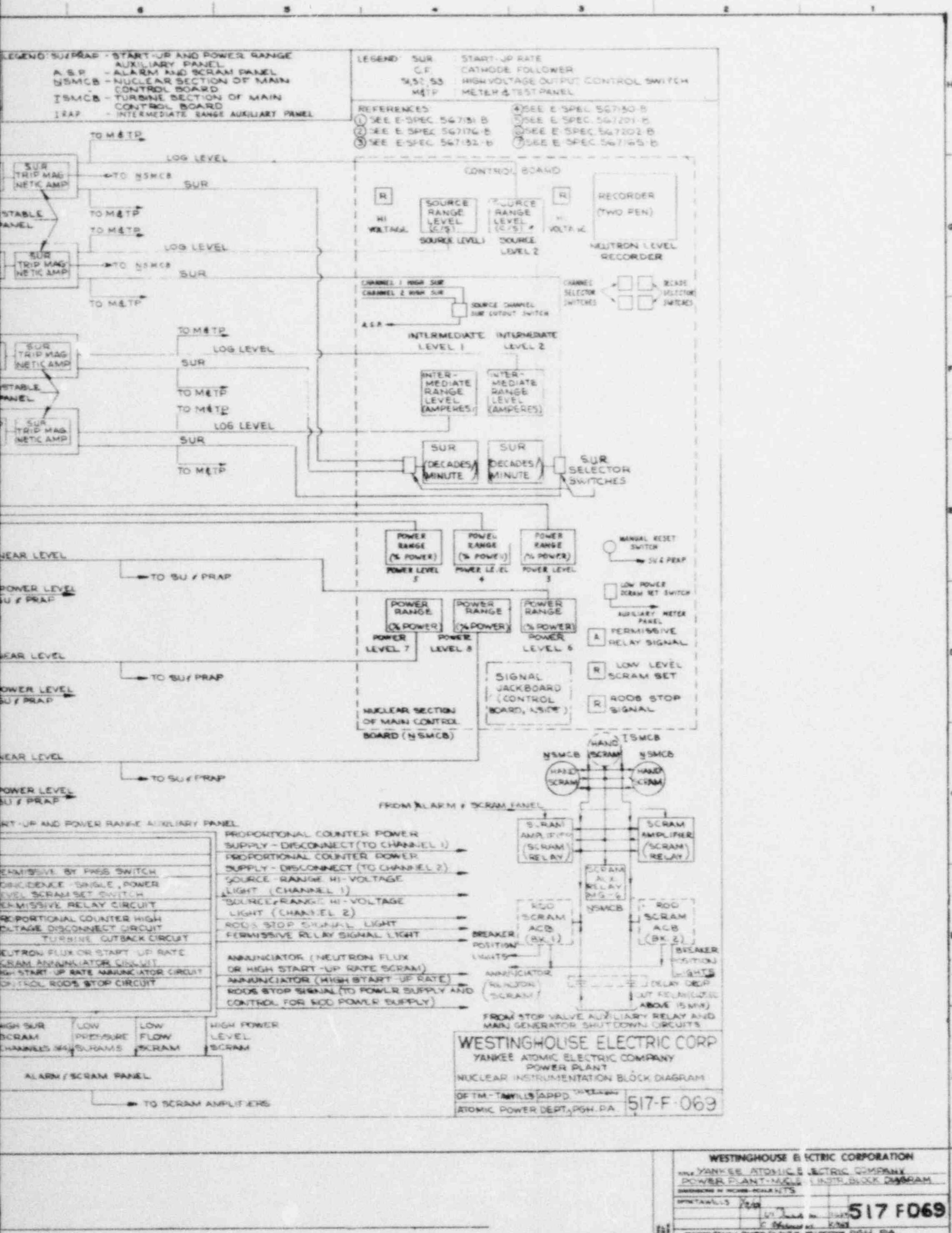
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FE-2G



517F069
PULSE INTEGRATOR
LV POWER SUPPLY
LOG MICROAMMETER
CHANNEL NO. 1
WL 7087 BF3
COUPLING BOX
MULTISTAGE PULSE AMPLIFIER
NOISE SIGNAL DISCRIMINATOR
CHARGING DIODE
LOG DIODE AMP LOG LEVEL CATHODE FOLLOWER
LOG LEVEL
SUR AMP
SUR CF
PROPORTIONAL COUNTER POWER SUPPLY
CHANNEL 5 NEG VOLT FOR CIC
H.V. DISCONNECT FROM SU / PRAP
CHANNEL NO. 2
AMPHENOL TYPE 21-529 (2 CABLES)
CHANNEL NO. 3
WL 6377 CIC
POWER RANGE PANEL
LEVEL MAG. AMPL.
LEVEL TRIP MAG. AMPL.
% POWER
POWER SUPPLY
TO S1
HIGH POWER LEVEL TO TRAP
CHANNEL NO. 4
TO S2
CHANNEL NO. 5
TO S3
CHANNEL 2 LV POWER SUPPLY
LINEAR LEVEL
CHANNEL NO. 6
WL 6937 IC
LEVEL MAGNETIC AMPLIFIER
LEVEL TRIP MAGNETIC AMPLIFIER
POWER RANGE % POWER
CHANNEL NO. 7
CHANNEL NO. 8
AMPHENOL TYPE 21-467 (15 CABLES)
METER & TEST PANELS (M&TP)
TEST CHASSIS INDICATORS AND TEST SIGNALS
SOURCE RANGE LEVEL
INTER RANGE LEVEL
SUR
TEST PULSE SIGNAL
TEST D.C. LEVEL SIGNAL
TEST SUR SIGNAL
INTERMEDIATE RANGE AUXILIARY PANEL
COINCIDENCE - SINGLE POWER LEVEL SCRAM SET SWITCH
TEST SIGNAL LEVEL ADJUST
TEST SIGNAL SELECTOR SWITCH
HIGH POWER LEVEL (CHANNEL 3)
HIGH POWER LEVEL (CHANNEL 4)
HIGH POWER LEVEL (CHANNEL 5)
POWER RANGE TEST SIGNAL FOR CHANNELS 3, 4 & 5
AUXILIARY METER PANEL
IND. NO. 3 % POWER
IND. NO. 4 % POWER
IND. NO. 5 % POWER
S1 S2 S3
200-800V
LOW POWER SCRAM SET RELAYS
LOW POWER SCRAM SET SWITCH & LIGHT
NSMCB
POWER LEVEL (CHANNEL 6)
POWER LEVEL (CHANNEL 7)
POWER LEVEL (CHANNEL 8)
HIGH POWER LEVEL (CHANNEL 6)
HIGH POWER LEVEL (CHANNEL 7)
HIGH POWER LEVEL (CHANNEL 8)
HIGH S.U.R. (CHANNEL 3)
HIGH S.U.R. (CHANNEL 4)
LOG LEVEL (CHANNEL 3)
LOG LEVEL (CHANNEL 4)
PRESSURE SWITCH CONTACT FOR
LOW FLOW SCRAM
LOW PRESSURE SCRAMS
DROPPED ROD SCRAM
INTERMEDIATE RANGE POWER LEVEL SCRAM
HIGH SUR SCRAM (CHANNELS 1 & 2)
HIGH PRESSURIZER LEVEL SCRAM
REDRAWN & REVISED
CHANGED AS PER MARKED DIGR PRINT
CHANGED TITLE



LEGEND: SU/PRAP - START-UP AND POWER RANGE AUXILIARY PANEL
A.S.P. - ALARM AND SCRAM PANEL
NSMCB - NUCLEAR SECTION OF MAIN CONTROL BOARD
TSMCB - TURBINE SECTION OF MAIN CONTROL BOARD
IRAP - INTERMEDIATE RANGE AUXILIARY PANEL
LEGEND: SUR : START-UP RATE
C.F. : CATHODE FOLLOWER
S1,S2,S3 : HIGH VOLTAGE OUTPUT CONTROL SWITCH
M&TP : METER & TEST PANEL
REFERENCES:
① SEE E-SPEC 567181-B
② SEE E-SPEC 567176-B
③ SEE E-SPEC 567182-B
④ SEE E-SPEC 567180-B
⑤ SEE E-SPEC 567201-B
⑥ SEE E-SPEC 567202-B
⑦ SEE E-SPEC 567165-B
TO M&TP
LOG LEVEL
SUR TRIP MAGNETIC AMP
TO NSMCB
SUR
STABLE PANEL
CONTROL BOARD
HI VOLTAGE
SOURCE RANGE LEVEL (C/S)
SOURCE LEVEL 1
SOURCE LEVEL 2
RECORDER (TWO PEN)
NEUTRON LEVEL RECORDER
CHANNEL 1 HIGH SUR
CHANNEL 2 HIGH SUR
SOURCE CHANNEL SUR CUTOUT SWITCH
A.S.P.
CHANNEL SELECTOR SWITCHES
DECADE SELECTOR SWITCHES
INTERMEDIATE LEVEL 1
INTERMEDIATE LEVEL 2
INTERMEDIATE RANGE LEVEL (AMPERES)
SUR (DECADES/MINUTE)
SUR SELECTOR SWITCHES
POWER RANGE (% POWER)
POWER LEVEL 5
POWER LEVEL 4
POWER LEVEL 3
POWER LEVEL 7
POWER LEVEL 8
POWER LEVEL 6
MANUAL RESET SWITCH
SU & PRAP
LOW POWER SCRAM SET SWITCH
AUXILIARY METER PANEL
A PERMISSIVE RELAY SIGNAL
R LOW LEVEL SCRAM SET
R RODS STOP SIGNAL
SIGNAL JACKBOARD (CONTROL BOARD, INSIDE)
NUCLEAR SECTION OF MAIN CONTROL BOARD (NSMCB)
LINEAR LEVEL
TO SU / PRAP
POWER LEVEL SU / PRAP
TSMCB
NSMCB
HAND SCRAM
FROM ALARM & SCRAM PANEL
SCRAM AMPLIFIER (SCRAM RELAY)
SCRAM AUX RELAY MG-6
ROD SCRAM ACB (BK 1)
ROD SCRAM ACB (BK 2)
BREAKER POSITION LIGHTS
ANNUNCIATOR (REACTOR SCRAM)
DELAY DROP OUT RELAY (CLOSE ABOVE 15 MW)
FROM STOP VALVE AUXILIARY RELAY AND MAIN GENERATOR SHUT DOWN CIRCUITS
START-UP AND POWER RANGE AUXILIARY PANEL
PERMISSIVE BY PASS SWITCH
COINCIDENCE - SINGLE, POWER LEVEL SCRAM SET SWITCH
PERMISSIVE RELAY CIRCUIT
PROPORTIONAL COUNTER HIGH VOLTAGE DISCONNECT CIRCUIT
TURBINE CUTBACK CIRCUIT
NEUTRON FLUX OR START-UP RATE SCRAM ANNUNCIATOR CIRCUIT
HIGH START-UP RATE ANNUNCIATOR CIRCUIT
CONTROL RODS STOP CIRCUIT
PROPORTIONAL COUNTER POWER SUPPLY - DISCONNECT (TO CHANNEL 1)
PROPORTIONAL COUNTER POWER SUPPLY - DISCONNECT (TO CHANNEL 2)
SOURCE - RANGE HI - VOLTAGE LIGHT (CHANNEL 1)
SOURCE RANGE HI - VOLTAGE LIGHT (CHANNEL 2)
RODS STOP SIGNAL LIGHT
PERMISSIVE RELAY SIGNAL LIGHT
ANNUNCIATOR (NEUTRON FLUX OR HIGH START-UP RATE SCRAM)
ANNUNCIATOR (HIGH START-UP RATE)
RODS STOP SIGNAL (TO POWER SUPPLY AND CONTROL FOR ROD POWER SUPPLY)
HIGH SUR SCRAM CHANNELS 3&4
LOW PRESSURE SCRAMS
LOW FLOW SCRAM
HIGH POWER LEVEL SCRAM
ALARM / SCRAM PANEL
TO SCRAM AMPLIFIERS
WESTINGHOUSE ELECTRIC CORP
YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT
NUCLEAR INSTRUMENTATION BLOCK DIAGRAM
ATOMIC POWER DEPT. PGH. PA.
517-F-069
WESTINGHOUSE ELECTRIC CORPORATION
YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT-NUCLEAR INSTR. BLOCK DIAGRAM
517 F069
PGH. PA.

The power range (channels No. 6, No. 7, and No. 8) consists of three uncompensated ion chambers located in thimbles in the neutron shield tank. The nuclear instrumentation cabinet mounted equipment consists of three power range panels.

The detector container assemblies for the intermediate range and power range detectors consist of three special large units to accommodate in each assembly one compensated ion chamber and one uncompensated ion chamber.

The detector container assemblies for the source range detectors are of molded polyethylene type to accommodate the BF_3 proportional counters.

The thimble flanges are made of carbon steel and will accommodate the detector cables through the flange by means of special cable seals.

The measurement of the reactor neutron flux is performed in the neutron shield tank surrounding the reactor vessel. The detectors in their container assemblies are lowered to the appropriate level in vertical thimbles that are welded to the neutron shield tank.

Three of these thimbles, spaced approximately 120 deg from one another, contain one intermediate and one power range ionization chamber. These chambers are located at different elevations, one above and the other below the center of the reactor. By observing the changes in relative flux readings, shown by these six chambers, it is anticipated that any tendency for the development of either axial or radial flux tilts may be detected. The BF_3 source range chambers are mounted in two separate thimbles in the neutron shield tank.

Source Range Nuclear Instrumentation

The source range detectors (channels No. 1 and No. 2) consist of BF_3 proportional counters. These counters have a sensitivity of approximately 4.5 counts/neutron/ cm^2/ second and cover a flux range of 2.5×10^{-1} to 2.5×10^4 nv, corresponding to detector output pulses of 1 count per second to 100,000 counts per second.

The signal output of the BF_3 counter consists of pulses which are proportional in number to the neutron and gamma flux present at the detector location. These pulses are fed over a triaxial cable to the panel unit in the control room, without the use of a preamplifier. The first panel unit (pulse integrator) amplifies the pulses, provides an adjustable discriminator which rejects the gamma pulses and pulses resulting from noise, and converts the neutron pulses to a direct current which is proportional to the reactor neutron flux.

The direct current signal from the pulse integrator is fed into a second panel unit (log microammeter). This circuit converts the linear input signal to an output which is proportional to the logarithm of the neutron flux level. An output is also provided which is proportional to the rate of change of the logarithm of the neutron flux level. The source level meter is calibrated from 1 count per second to 100,000 counts per second and the startup rate meter is calibrated from -1 decade per minute to +10 decades per minute.

The log level signal (counts per second) and the rate of change signal (decades per minute) are metered at the nuclear section of the main control board as well as at the nuclear instrumentation equipment. These signals are also available at the signal jack board for recording purposes and at the selector switches, both located at the nuclear section of the main control board.

Intermediate Range Nuclear Instrumentation

The intermediate range detectors (channels No. 3, No. 4, and No. 5) consist of compensated ionization chambers. These chambers have a neutron sensitivity of approximately 4×10^{-14} amperes/neutron/cm^2/second and a gamma sensitivity of 3×10^{-13} amperes/roentgen/hour. The compensated ionization chambers cover a flux range of 2.5×10^2 to 2.5×10^{10} nv.

The signal output of the compensated ionization chambers consists of a direct current which is proportional to the neutron flux present at the detector location. This signal is fed through a coaxial cable to the panel unit in the control room without the use of a preamplifier. This panel unit (log microammeter) converts the linear input signal to an output which is proportional to the logarithm of the neutron flux level. The intermediate level meter is calibrated from 10^{-11} amperes to 10^{-4} amperes. An output is also provided which is proportional to the rate of change of the logarithm of the neutron flux level.

The log level signal (amperes) and the rate of change signals (decades per minute) are metered at the nuclear section of the main control board as well as at the nuclear instrumentation equipment. These signals are also available at the signal jack board for recording purposes and at the selector switches, both located at the nuclear section of the main control board.

Power Range Nuclear Instrumentation

A linear meter and panel unit (power range panel) are connected in series on the high voltage supply to each of the compensated ionization chambers (channels No. 3, No. 4, and No. 5). The panel unit provides a linear level output signal (% power) which is metered at the nuclear section of the main control board as well as at the nuclear instrumentation equipment. A variable high voltage output from the panel unit is provided to allow for operation of the compensated ionization chamber in the high flux regions.

The power range detectors (channels No. 6, No. 7, and No. 8) consist of uncompensated ionization chambers. These chambers have a neutron sensitivity of 4.4×10^{-14} amperes/neutron/cm^2/second and a gamma sensitivity of 5×10^{-11} amperes/roentgen/hour. The uncompensated ionization chambers cover a flux range of 2.5×10^4 to 2.5×10^{10} nv.

The signal output of the uncompensated ionization chamber is a direct current which is proportional to the neutron flux present at the detector location. This signal is fed through a coaxial cable to the panel unit in the control room without the use of a preamplifier. This panel unit (power range panel) provides a linear level output signal.

The linear level signal (% power) is metered at the nuclear section of the main control board as well as at the nuclear instrumentation equipment. These power level meters are equipped with low adjust alarm contacts and are calibrated from 0% to 150%. These signal are also available at the signal jack board for recording purposes and at the selector switches, both located at the nuclear section of the main control board.

The adjustable low alarm meter contacts provide protection against loss of power supply to the power range channels. In addition, the low alarm contacts serve as the initiating scram device in the protection of the reactor core during the accidental drop of a control rod. A dropped control rod results in instantaneous flux depression and indication on power range meter(s). The closing of the contacts causes the scram amplifiers to trip, resulting in a reactor scram. Loss of voltage or signal to power range channels causes the meter(s) to drop to zero, also resulting in reactor scram. The meter contacts are set so that scram is initiated on a flux drop equivalent to 15% of the full power rating (540 MWt).

Intermediate Range Auxiliary Panel

The intermediate range auxiliary panel contains a coincidence-single scram switch for the three intermediate range power level scram signals, and a calibrating signal which is used to check out the three intermediate range panel units for normal operation.

Startup and Power Range Auxiliary Panel

The startup and power range auxiliary panel receives signals from the nuclear instrumentation and the process instrumentation equipment to provide the necessary signals for the appropriate annunciator circuits, the rods stop signal circuit and the permissive relay signal circuit. This panel also contains the permissive relay by-pass switch, and the power range coincidence single scram switch.

The high startup rate annunciator circuit is normally set to trip when the reactor startup rate reaches 1.1 decades per minute (adjustable between 0.5 and 5 decades per minute) and the rods stop circuit is set to trip at 1.5 decades per minute (adjustable between 0.5 and 5 decades per minute). These circuits are of the manual reset type and can be reset by operating the manual reset switch, which is located on the nuclear section of the main control board. The source range and intermediate range signals actuate the 1.1 decade per minute circuit, but only the intermediate range signals operate the 1.5 decades per minute circuit.

The startup rate scram is normally set to trip at 5.2 decades per minute and is adjustable from 3 to 10 decades per minute. The source range and intermediate range signals can actuate individual channel bistable magnetic amplifiers to initiate the scram.

In addition to these signals, there exists from each one of the log microammeter units in the intermediate range channels an automatic signal, which disconnects the high voltage from the BF_3 proportional counters when the reactor neutron flux is increasing between 5×10^4 and 10^5 nv and reconnects the high voltage on decreasing flux at approximately the same level. The information that this signal is initiated is obtained by the source range high voltage light mounted on the nuclear section of the main control board. The light is off when the high voltage is off. A manual switch disconnecting the BF_3 source range high voltage is also available at the nuclear instrumentation cabinets.

The coincidence feature makes it necessary for two out of six power range channels to initiate high neutron flux level signals in order to cause the scram amplifiers to trip. The high neutron flux level trip set point is adjustable for various reactor operation conditions. For reactor 100% full power operation, (i.e., 540 MWt), with four loops in service, the level trip set point is set at 108%. For reactor operation between 0 and 15% of full power, the level trip set point is manually adjusted to 35% of full power. A power range coincidence single switch is provided to allow for coincidence scram or any single channel scram. The low power scram set switch is located on the nuclear section of the main control board.

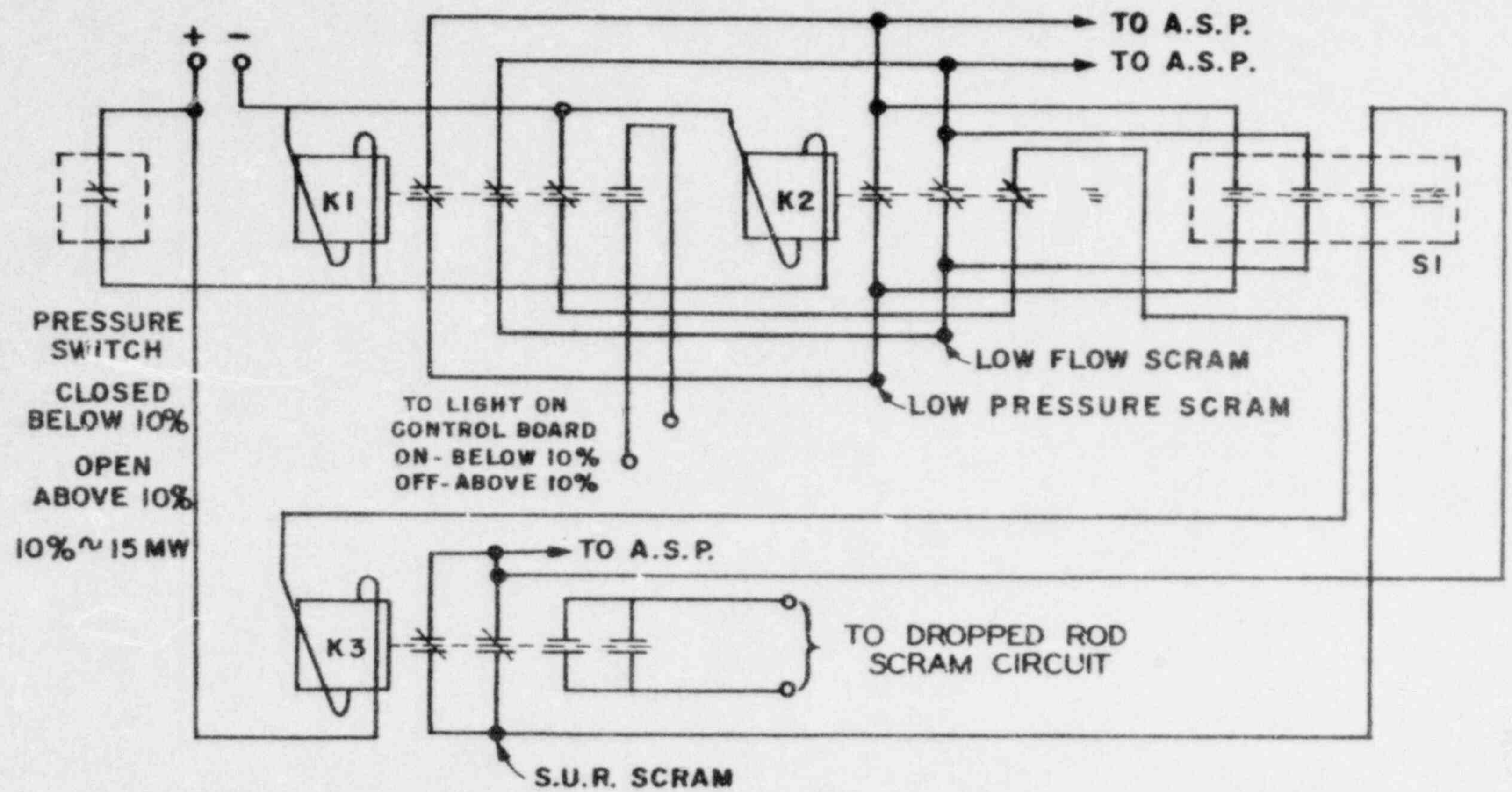
Signals not fed through the coincidence circuit but operating on the scram amplifiers through the alarm and scram panel are those initiated from low main coolant flow, low main coolant pressure, low pressurizer pressure, high pressurizer level, and high startup rate. Provision is made in the alarm and scram panel to accommodate two additional signals.

Two permissive relay circuits, similar to that shown on page 214:6, are provided which operate by pressure switches activated from the first stage turbine steam pressure. Operation of one circuit occurs at a turbine steam pressure equivalent to 15 MWe output. This circuitry provides for by-passing the low flow scram and low pressure scrams when the power is below 15 MWe. At 15 MWe and above, the low flow and low pressure scrams are reconnected, the startup rate scram is by-passed, and the system is available for automatic rods-in motion of the control rods. A permissive relay by-pass switch is available to connect the scram signals directly to the alarm and scram panel. The reactor scram signals which are initiated from the turbine generator protection equipment are by-passed below 15 MWe by this permissive relay circuit.

A second permissive relay circuit is activated at the 150 MWe power level, corresponding to 485 MWt, which provides for automatic cut-in of a manual rods out reset circuit and realignment of the low flow scram signals. At power levels of 150 MWe and above, the reset circuit requires the control switch to be returned to the neutral or reset position before making each

PERMISSIVE RELAY CIRCUIT

START-UP AND POWER RANGE AUXILIARY PANEL



LEGEND:

K1, K2, K3 = 4-POLE DOUBLE THROW RELAYS

S1 = 4-POLE DOUBLE THROW TOGGLE SWITCH

A.S.P. = ALARM AND SCRAM PANEL

S.U.R. = START-UP RATE

additional rods out step. Below 150 MWe output, the reset circuit becomes ineffective and thus a controlled but continuous rods out motion may be affected. The automatic realignment of the low flow scram signal at the 150 MWe power level consists of changing from initiating scram on low flow in two main coolant loops to initiating scram on low flow in one main coolant loop.

Alarm and Scram Panel

The seven scram signals, low pressurizer pressure, low main coolant pressure, low main coolant flow, high pressurizer level, high startup rate, and high neutron flux levels are connected to the magnetic amplifier alarm and scram panel that acts as the control center for indicating the individual signals that may have caused the scram and for operating the scram amplifiers directly.

Scram Amplifiers

The two magnetic scram amplifiers operate individual scram relays whose contacts are connected to the trip coil circuitry of the rod scram circuit breakers. The scram relays are energized at all times except when a scram signal is sent to the scram amplifiers. When the scram amplifier outputs are zero, the scram relays are de-energized and the contacts in the trip coil circuits close causing both breakers to open. The circuit is such that any one scram relay actuates both circuit breakers.

Meter and Test Panel

Two meter and test panels provide local indication at the nuclear instrumentation cabinets and the necessary calibrating signals to completely and accurately check out all the channels for normal operation and energizing conditions.

Auxiliary Meter Panel

The auxiliary meter panel contains three meters, calibrated from 0% to 150% of reactor power, used to detect the current through the compensated ionization chambers when the reactor is within power range. Each meter has a separate voltage adjustment to provide the required high voltage necessary for operating the compensated ionization chambers in the power range. The high voltage is obtained from the intermediate range (channels No.3, No.4 and No.5) power range panels. Connected across each meter are potentiometers which provide for the adjustment of meter indications.

Recorder

The recorder used with the nuclear instrumentation is a large, 2-pen, multi-speed instrument with two decade switching circuits. The speeds of the paper are 4 and 240 inches per hour. The decade switching allows for full scale deflection for one decade change in reactor flux. This recorder is mounted on the front of the nuclear section of the main control board.

Signal Jack Board and Selector Switches

The signal jack board and the selector switches, located at the nuclear section of the main control board, are the junction points for all signals available for recording from the nuclear instrumentation. Individual adjustments are provided at each jack point and two plugs are available which allow two signals to be recorded simultaneously.

Power Supply

The instrument bus power supply shall be 120 volts ± 3% and 60 cycles ± 1%.

Before starting, the nuclear instrumentation and reactor protection equipment shall be completely checked to insure that all channels are operating correctly, all set points are at their proper value, and all safety circuits are functioning properly.

215 RADIATION MONITORING SYSTEM

Operational Radiation Monitoring

General - The function of the operational radiation monitoring system is to detect, compute, and indicate the radiation level at selected locations inside and outside the vapor container. If these levels exceed predetermined values, alarms will be actuated. Radiation monitoring serves a dual purpose. The first is to warn of any radiation health hazard which might occur. The second is to give early warning of plant malfunction which might result in a health hazard or plant damage.

The operational radiation monitoring system is shown on drawing No. 548-D-638 and includes the following items.

Vapor Container Air Particle Detector - The vapor container air particle detector continuously samples and checks the air for the presence of particulate matter in the vapor container. The air is drawn through a section of moving filter paper upon which the particulate matter is collected. Directly behind the filter paper, at the point where collection occurs, is a scintillation counter. The complete air particle detector consists of two units: the air particle detector itself and a vacuum pump. These two units, mounted in a weatherproof enclosure for installation at the outside surface of the vapor container, can operate between -25 and +145 F and withstand an internal pressure of 45 psi. The output signal pulses from the scintillation counter are amplified by a preamplifier and fed to the computer indicator through a coaxial cable.

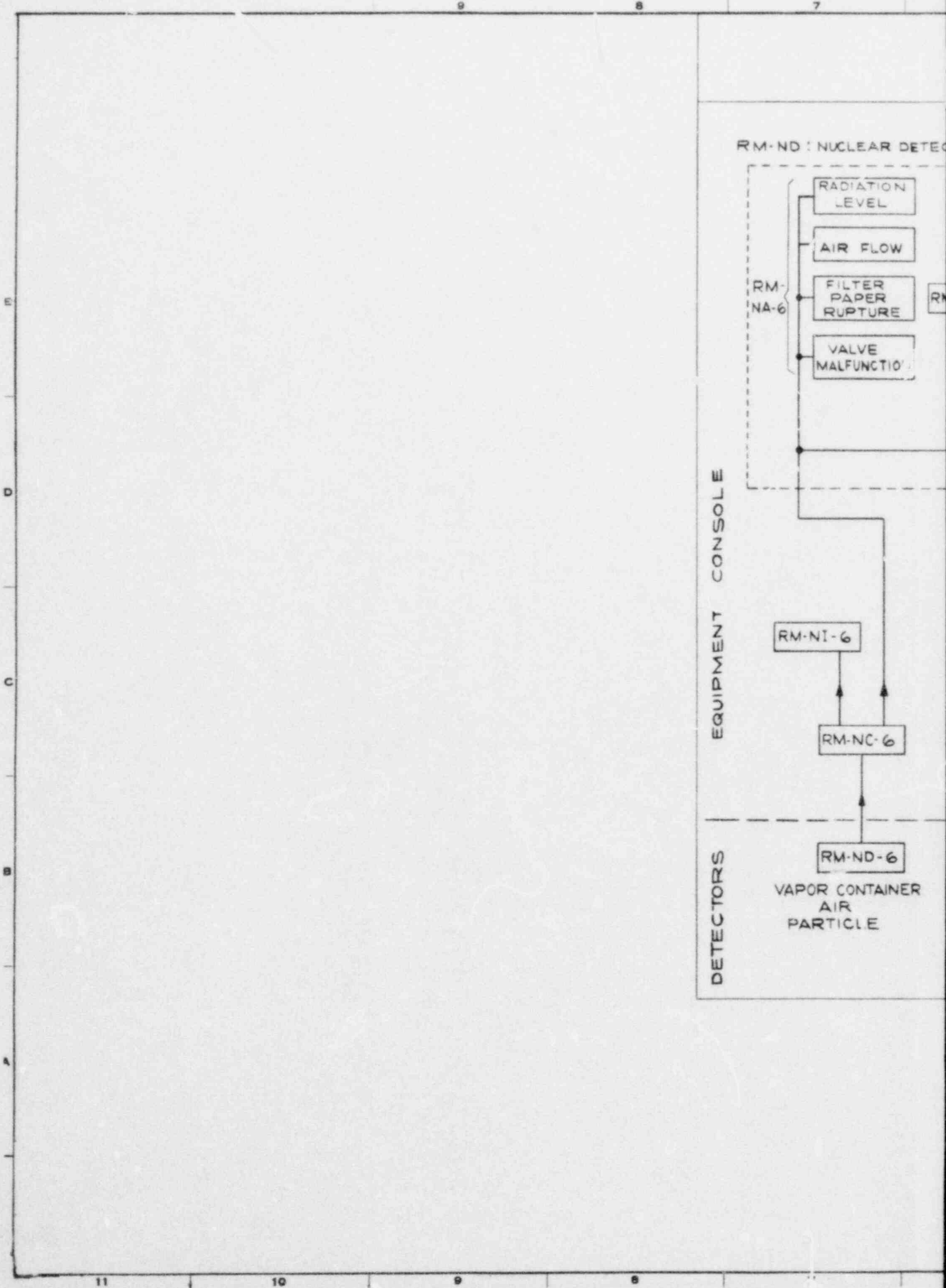
The computer-indicator mounted on the radiation monitoring equipment panel includes a discriminator, a pulse shaper amplifier, and a logarithmic count-rate integrator and meter amplifier. Provision is also made to operate a recorder.

The indicators include a background flasher, alarm lamp, and indicating meter.

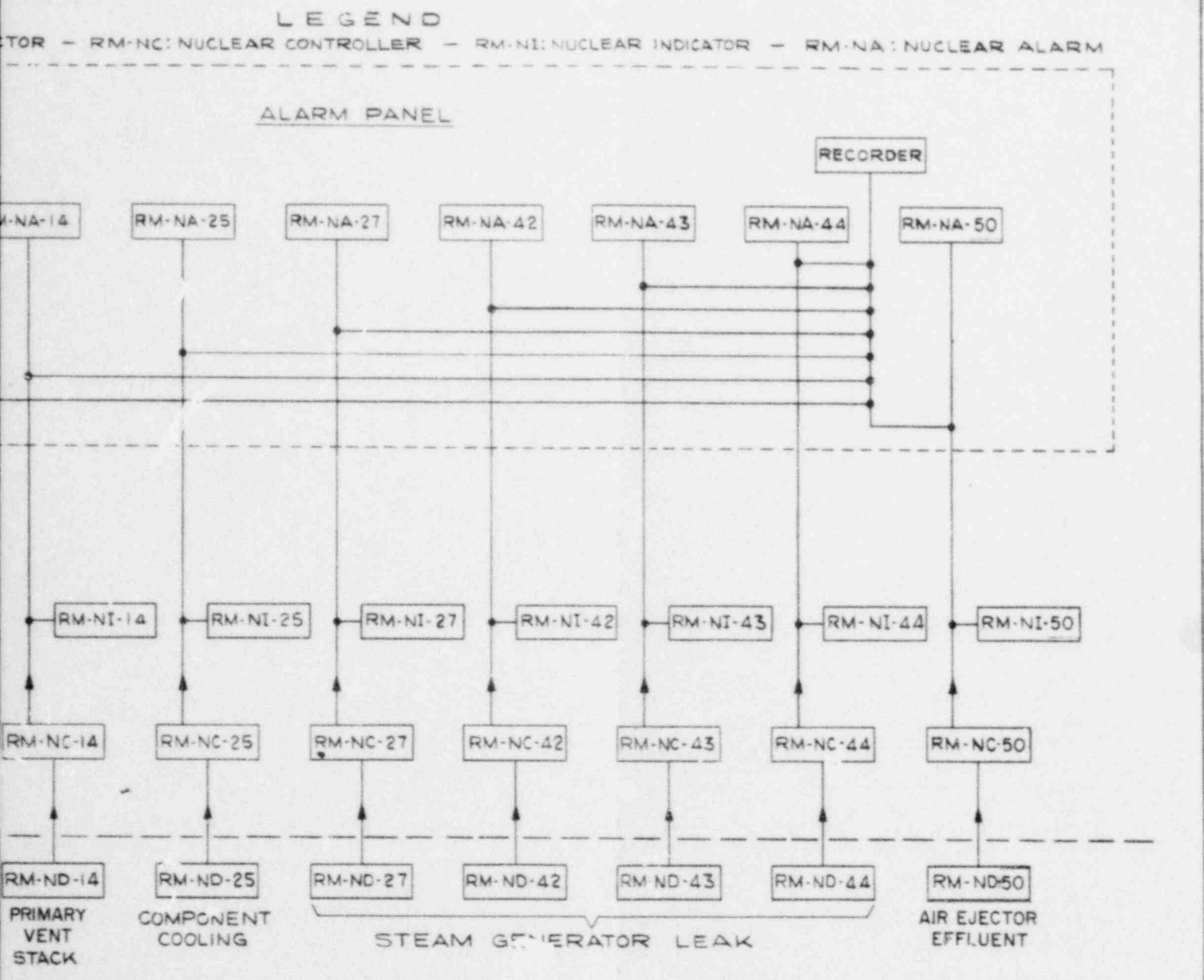
The computer-indicator has a range of 10 to 10,000 counts per second on a 3 decade log scale.

The air particle detector has a sensitivity of 10^{-9} to 10^{-6} microcurie per cubic centimeter of beta radioactive particulate detectable in less than 15 min with fixed filter, or 30 min with filter moving at 1 in. per hr. The detector head is enclosed in a lead housing and is completely surrounded by a shielding of approximately 2 in. of lead. A fast advance filter paper speed of 6 in. per min is provided, which makes it possible to clear the contaminated tape from the detecting area within a very short time. The filter paper supply is for 30 days at the normal speed of 1 in. per hr. Remote provision is made to allow the operator to select the desired speed of the tape drive mechanism.

A remote controlled calibration source is built into the detector. The source is moved in front of the detector head and a reading of 500 counts per second is obtained. The calibration source is a small piece of Radium DEF foil 10 mils thicks with a 22 year half life.



RM-ND : NUCLEAR DETEC
RADIATION LEVEL
AIR FLOW
FILTER PAPER RUPTURE
VALVE MALFUNCTIO
RM-NA-6
EQUIPMENT CONSOLE
RM-NI-6
RM-NC-6
RM-ND-6
VAPOR CONTAINER AIR PARTICLE
DETECTORS



REV. 2/24/60

WESTINGHOUSE ELECTRIC CORPORATION

TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT
OPERATIONAL RADIATION MONITORING SYSTEM

DIMENSIONS IN INCHES–SCALE

DFTM A.C.P 9-18-58

543D638

DIVISION ATOMIC POWER DEPT. PLANT LOCATION PITTSBURGH PA.

Alarms, both visible and audible, are also provided which operate when:

The air flow rate becomes either too high or too low.
The filter breaks or fails to advance in the normal manner.
The valve closure circuit is energized.

The alarms remain tripped until the alarm reset button on the panel front is actuated; the visual unit remains lit until normal conditions are restored.

Primary Vent Stack Discharge Detector - The primary vent stack discharge detector, mounted in the main plant stack, consists of four thin-walled, Geiger-Müller tubes, operated in parallel, used together with an impedance matching circuit and a suitable framework for placing the detector in the stack.

This framework consists of a steel panel to which is welded a pipe frame used to support four Geiger-Müller tubes inside the stack. The top telescopes into the two vertical members of the lower section and is spring loaded to keep the unit tight against the two supporting angles welded into the stack. The impedance matching circuit is housed in a small metal box located in the steel panel. A rubber gasket keeps the impedance matching circuit protected from the weather.

The stack detector is a high sensitivity beta-gamma detector, with a sensitivity range of 0.003 to 3 mr per hr, with a gamma energy response of 0.25 mev to 2.5 mev, and a beta energy response from 0.154 mev.

The computer-indicator, mounted on the radiation monitoring equipment panel, includes a pulse amplifier and a logarithmic count-rate integrator and meter amplifier.

The indicators include a background flasher, alarm lamp, and indicating meter.

The computer-indicator has a range of 1 to 1,000 counts per second on a 3 decade log scale. Provision is also made to operate a recorder and an alarm circuit with visible and audible indications. The alarm remains tripped until the alarm reset button on the panel front is actuated; the visual unit remains lit until normal conditions are restored.

Component Cooling Water Detector - The component cooling water detector is a single Geiger-Müller tube, together with an impedance matching circuit, housed in a weatherproof probe. The detector assembled in its housing is inserted in a thimble welded into the main return pipe upstream from the component cooling pump section block valves.

The component cooling water detector continuously measures the activity of the component cooling water. A high activity indication closes a solenoid operated trip valve in the vent line of the component cooling water surge tank.

The component cooling water detector is a medium sensitivity gamma detector, with a sensitivity of 0.01 to 10 mr per hr, and a gamma energy response of 0.25 mev to 2.0 mev. The detector operates in a temperature range of 40 F to 300 F.

The computer-indicator, mounted on the radiation monitoring equipment panel, includes a pulse amplifier and a logarithmic count-rate integrator and meter amplifier.

The indicators include a background flasher, alarm lamp, and indicating meter.

The computer-indicator has a range of 1 to 1,000 counts per second on a 3 decade log scale. Provision is also made to operate a recorder and an alarm circuit with visible and audible indications. The alarm remains tripped until the alarm reset button on the panel front is actuated; the visual unit remains lit until normal conditions are restored.

Four Steam Generator Leak Detectors - The four steam generator leak detectors, each a single Geiger-Müller tube together with impedance matching circuits, are housed in a weatherproof probe. Each detector and its housing is mounted in one of the four detector hold-up tanks ahead of the flash tank in the blowdown lines. The water of the continuous blowdown lines from the steam generators is fed into the hold-up tanks and the radioactivity of the samples is measured. The inlet is at the bottom and the outlet is near the top of the tank. A by-pass valve is provided which may be used to control the flow rate through the tank.

The steam generator leak detectors are medium sensitivity gamma detectors, with a sensitivity of 0.01 to 10 mr per hr and a gamma energy response of 0.25 mev to 2.0 mev. The detectors operate in a maximum temperature of 300 F.

The detector hold-up tanks are cooled to bring the water temperature down to a maximum of 250 F. A thimble with an inside diameter of 1.5 in. and closed at the bottom is welded into the tank to provide a means for mounting the detector well within the volume of water to be monitored.

The computer-indicator, mounted on the radiation monitoring equipment panel, includes a pulse amplifier and a logarithmic count-rate integrator and meter amplifier.

The computer-indicator has a range of 1 to 1,000 counts per second on a 3 decade log scale. Provision is also made to operate a recorder and an alarm circuit with visible and audible indications. The alarm remains tripped until the alarm reset button on the panel front is actuated; the visual unit remains lit until normal conditions are restored.

Air Ejector Effluent Detector - The air ejector effluent leak detector is a single Geiger-Muller tube, together with impedance matching circuit and is housed in a weatherproof probe. The detector and its housing is mounted in the air ejector effluent line to the primary auxiliary building exhaust fan suction.

The leak detector is a medium sensitivity beta-gamma detector, with a sensitivity range of .01 to 10 mr per hr, with a gamma energy response of 0.25 mev to 2.5 mev, and a beta energy response above 0.154 mev.

The computer-indicator, mounted on the radiation monitoring equipment panel, includes a pulse amplifier and a logarithmic count-rate integrator and meter amplifier.

The indicator includes a background flasher, alarm lamp, and indicating meter.

The computer-indicator has a range of 1 to 1,000 counts per second on a 3 decade log scale. Provision is also made to operate a recorder and an alarm circuit with visible and audible indications. The alarm remains tripped until the alarm reset button on the panel front is actuated; the visual unit remains lit until normal conditions are restored.

Radiation Monitoring Equipment Console - A radiation monitoring equipment console is located in the control room. A console consists of two cabinets providing mounting space for eight channels (computer-indicators), a relay unit and a calibration unit, a power distribution panel, a plate voltage and filament power supplies. Line regulators are also mounted in the cabinet.

The radiation monitoring equipment exclusive of the detectors is mounted in equipment racks. All equipment housed in the two cabinets, except for the power supplies, is mounted in pull-out drawers for easy access. A large removable door allows entry to the rear of each rack.

Site and Portable Radiation Detection Equipment

General - The site and portable radiation detection equipment includes the instrumentation required for providing the radiation level information necessary for the protection of plant personnel and for determining any increase in normal background activity of the plant site.

The details of the use of all the equipment listed are described in Section 507, RADIOLOGICAL HEALTH AND SAFETY.

Dosimeters and Film Badges - Personnel dosimetry and film badges are provided to measure integrated exposure on all personnel working in contaminated areas. The dosimeters are the direct reading type.

Hand and Foot Monitor - A hand and foot monitor is located adjacent to the entrance of the lunchroom. This unit monitors both hands and feet simultaneously. A preset time total count will be indicated for each hand and foot.

Portable Radiation Detectors - A total of ten portable radiation detectors are provided for radiation survey work.

Six of these detectors are battery operated, portable gun type survey meters for measurement of beta and gamma radiation. Each meter has a selection of three ranges 0-25, 0-250, and 0-2,500 mr per hr. In addition, two probes are provided for increasing the range of these instruments to 0-2.5, 0-25 and 0-250 r per hr. These probes can be plugged into any of these units and are used where high field intensities might be encountered.

Two detectors are portable battery operated Geiger-Müller survey meters for measuring alpha, beta, and gamma radiation of low and medium intensities. Each meter scale is direct reading in terms of mr per hr and counts per minute and is provided with a selection of three ranges 0.2, 2, and 20 mr per hr which correspond to 600, 6,000 and 60,000 counts per minute.

Two detectors are battery operated survey meters provided with two transistorized probes, one for alpha measurements and the other for neutron measurements. The neutron probe will detect both fast and thermal neutrons. The type detected depends on whether or not a paraffin-cadmium shield provided with the instrument is used.

Portable Air Samplers - Three portable air samplers are provided for collecting airborne dust on filter paper. The samplers are operated with fixed filters which are counted in the radiochemistry laboratory counting room. The units can be plugged into any 110 v, 60 cycle a-c receptacle and are designed to run unattended.

Electrically Operated Count-Rate Meters - Eight beta and gamma sensitive count-rate meters are provided for monitoring radiation in zones that are frequently or normally occupied.

These units are shelf-mounted with an indicating meter calibrated in counts per minute. Each unit is equipped such that when a preset level of radiation is exceeded, an audible and visual alarm will be automatically actuated. A shock mounted Geiger-Müller tube probe with a 6 ft extension cord is attached to each count-rate monitor. Each unit may be operated from any 120 v, 60 cycle, single phase receptacle.

The operating locations for these units are as follows:

Sampling Cubicle
Radiochemistry Laboratory
Decontamination Room
Contaminated Locker Room
Access to Potentially Contaminated Area
Control Room
Two Spares

Site Monitors - Two monitors for continuous measurement of air particulates are provided. One of these units is located approximately one-half mile below the plant, the other approximately four miles above the plant on the site of the Harriman hydroelectric station. These monitors employ the continuously moving filter paper principle with a continuous air flow through the filter of 10 cfm. The detector for these units is a 2.3 mg per sq cm end window counter.

This equipment will be employed in the post-operational radioactivity survey detailed in Section 305, ENVIRONMENTAL RADIOACTIVITY SURVEY.

216 VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS

General

The vapor container is a spherical steel envelope designed to contain all vapors, gases, liquids, and solid materials which may be the result of leakage from the primary system. The atmosphere control systems limit the vapor container temperature to a minimum of 50 F in the winter and 120 F during summer operation and will remove the airborne radioactivity during operation and after shutdown to facilitate refueling and maintenance operations. The systems are shown on drawing No. 517-F-417.

Ventilation to Outside Atmosphere

Some airborne activity may still be present in the container air after depressurizing the main coolant system. The purge system will exhaust and dilute the radioactive container air to the atmosphere within a reasonable time to allow personnel access to the vapor container. The purge system capacity is based on the radioactivity in the air of the vapor container at the time the main coolant system is depressurized. This system will dilute the container air until the concentration of airborne activity is reduced to tolerance levels as prescribed by the AEC Regulations (10 CFR Part 20).

The external purging system consists of a filter bank and heating coils in the duct work supplying outside air to the container and an exhaust fan rated at 15,000 cfm with duct work discharging to the atmosphere. Normally closed valves are provided at the container, to be opened only after the primary plant has been depressurized. Provisions are made for varying the proportions of exhaust air and dilution air by operating valves in order to control the activity of the purge air discharged to the atmosphere.

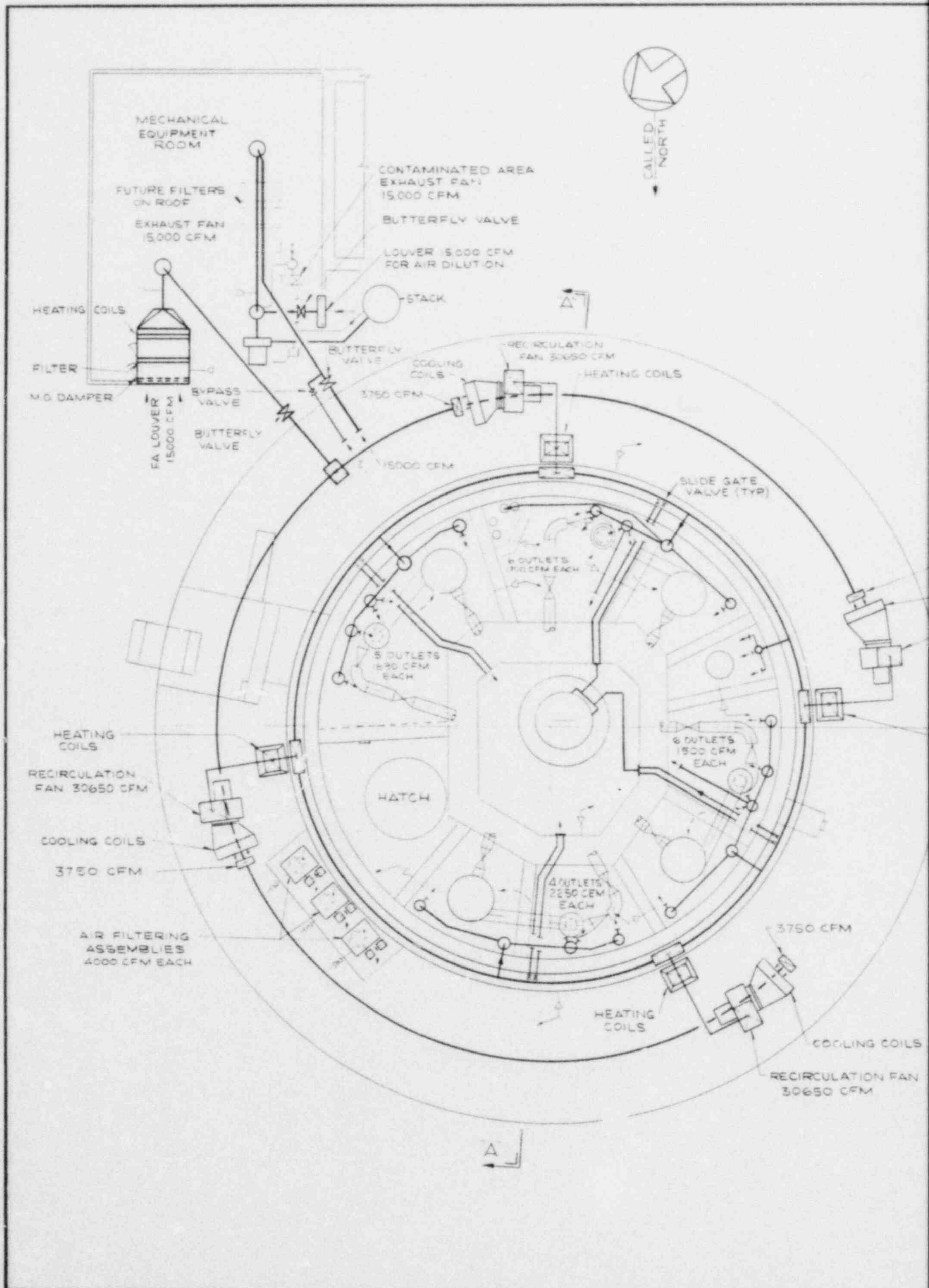
The outside air filters, heating coils, and exhaust fan as well as the dilution air valve are located in the mechanical equipment room of the Primary Auxiliary Building. The supply and exhaust air valves are located at the container.

Two valves, one 8 in. and one 30 in., are provided in the exhaust duct for control of the exhaust air rate. The air leaving the vapor container is discharged to the atmosphere through the primary vent stack located between the Primary Auxiliary Building and the vapor container.

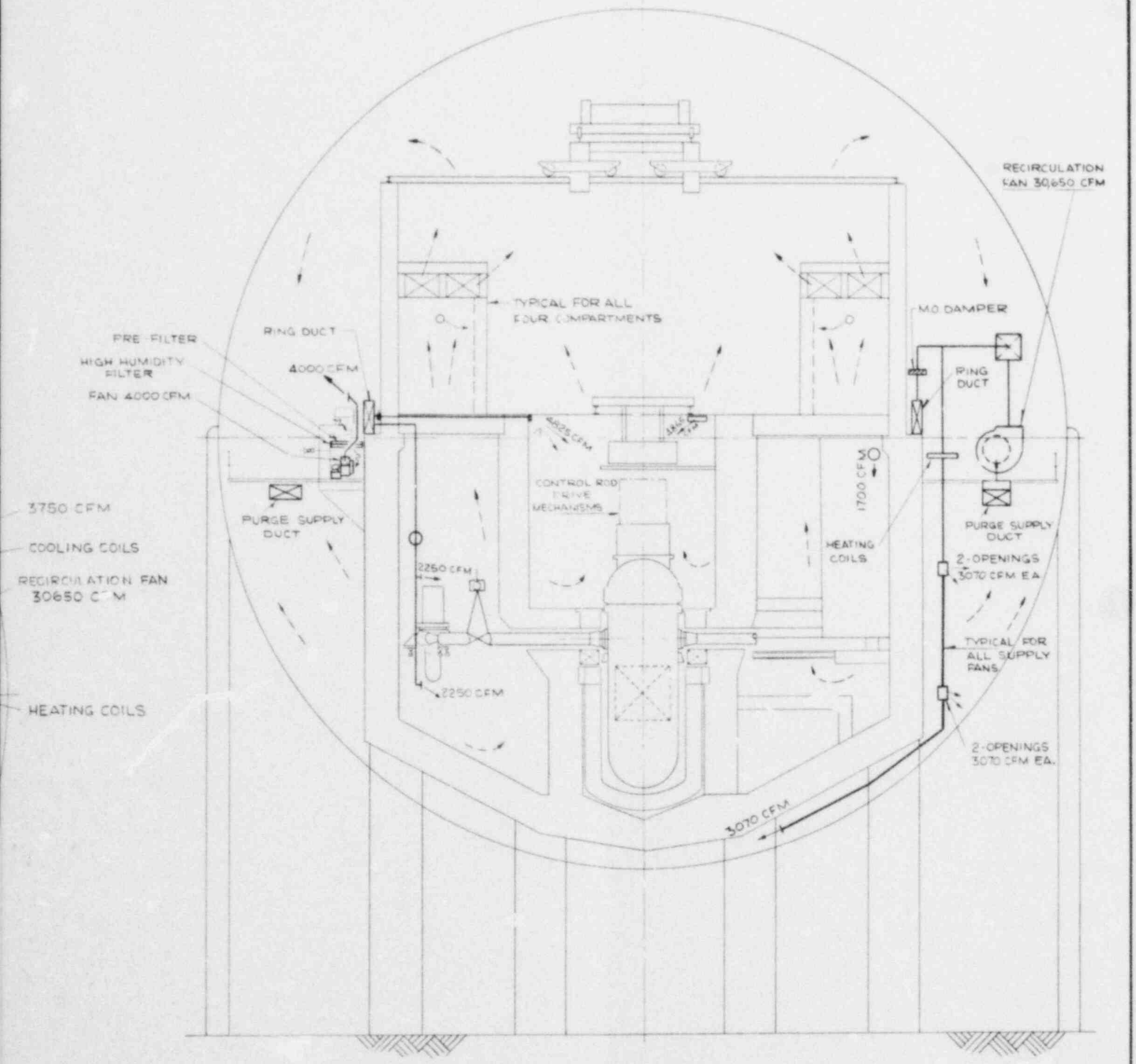
The components of the ventilation system are shown on drawing No. 517-F-417.

Recirculation, Heating and Cooling

Heat released during plant operation from hot insulated and uninsulated surfaces, together with solar radiation, contribute to the heat gain of the vapor container air. The vapor container is completely sealed from the natural atmosphere and no air, other than that which leaks from the container and is replaced by the leakage monitoring system, enters or leaves the container during operation. The ventilation system cooling units limit the air temperature inside the container to values which will prevent damage



MECHANICAL EQUIPMENT ROOM
FUTURE FILTERS ON ROOF
EXHAUST FAN 15,000 CFM
CONTAMINATED AREA EXHAUST FAN 15,000 CFM
BUTTERFLY VALVE
LOUVER 15,000 CFM FOR AIR DILUTION
STACK
CALLED NORTH
HEATING COILS
FILTER
M.O. DAMPER
FA LOUVER 15000 CFM
BYPASS VALVE
BUTTERFLY VALVE
BUTTERFLY VALVE
COOLING COILS
RECIRCULATION FAN 30650 CFM
HEATING COILS
3750 CFM
15000 CFM
SLIDE GATE VALVE (TYP)
6 OUTLETS 1500 CFM EACH
5 OUTLETS 1690 CFM EACH
HEATING COILS
RECIRCULATION FAN 30650 CFM
HATCH
6 OUTLETS 1500 CFM EACH
COOLING COILS
3750 CFM
4 OUTLETS 2250 CFM EACH
AIR FILTERING ASSEMBLIES 4000 CFM EACH
3750 CFM
HEATING COILS
COOLING COILS
RECIRCULATION FAN 30650 CFM
A
A



SECTION "AA"

WESTINGHOUSE ELECTRIC CORPORATION

TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT
VAPOR CONTAINER AIR COOLING AND VENTILATION SYSTEM

DIMENSIONS IN INCHES-SCALE

517F417

DIV. & PLANT LOCATION ATOMIC POWER DEPT PITTSBURGH, PA. U.S.A.

to instruments and electric wiring. During winter operation, heat is lost from the interior of the container through the shell to the atmosphere. To prevent freezing of water in the pipe lines, the heating units of the ventilation system provide warm air inside the container.

The internal cooling and heating system consists of four direct motor driven fans, four cooling coil assemblies, and four heating coil assemblies. Each fan supplies either cooled or uncooled air to a ring supply header through a dampered duct. For each fan, a branch duct upstream from the damper supplies cooled, uncooled or heated air to the space between the vapor container shell and the internal concrete shielding. Duct branches from the ring header serve the various compartments within the concrete shielding and the control rod drive mechanisms which require cooling during operation.

Fans are single width single inlet, NAFM Arrangement 4, nonoverloading wheels, overhung on extended shafts of constant speed motors. Each fan has a rating of 30,650 cfm.

Cooling coils are of the extended surface type with serpentine tubes. Each cooling coil assembly has three cooling coils. The air rate is 10,220 cfm STP air per coil.

Heating requirements are met by heating coils in the duct branches which supply air to the space between the container and the internal concrete. Heat is supplied to the coils by steam at 10 psi gage. There are two heating coils per assembly which have an air rate of 7,750 cfm per coil.

In order to permit isolation of faulty coils from outside the container, each coil assembly is provided with a separate supply and return line which penetrates the vapor container. Manually operated control and shutoff valves for steam and water are located outside the vapor container. Steam, condensate and water piping within the vapor container is carbon steel using welded construction throughout.

Heating requirements in the vapor container are based on a design outdoor dry bulb temperature of -10 F and a minimum dry bulb temperature of -25 F. Maximum heating requirements are experienced during winter shutdown, at which time the heat loss through the container shell is 5,170,000 Btu per hr. Heat loss to the atmosphere takes place only through the vapor container shell.

During normal cold weather operation, the heat released from equipment containing main coolant is sufficient to maintain temperatures within the shielded compartments above the minimum design value. Supplementary heat is required for the space between the container shell and the internal concrete shielding. The heating coils in the duct branches serving the space between the container shell and the internal shielding is of sufficient capacity to offset the heat losses and maintain a minimum bulk air temperature of 50 F in the vapor container during operation.

During normal hot weather operation, the bulk air temperature is limited to a maximum of 120 F in the compartments within the internal concrete shielding and 116 F in the space between the shell and the internal shielding. These temperatures are based on a total summer heat gain in the vapor container of 2,565,600 Btu per hr and cooling water available at 85 F.

Approximately 1.3 kw of heat is generated by the control rod mechanisms and conducted to the mechanism housing from the reactor vessel. Two ducts provide cool air to keep the mechanism coil temperature below 450 F.

Leakage Testing

Leakage of air from the vapor container is undesirable and is, therefore, held to a minimum. The function of the leakage monitoring system is to measure leakage over extended periods of time.

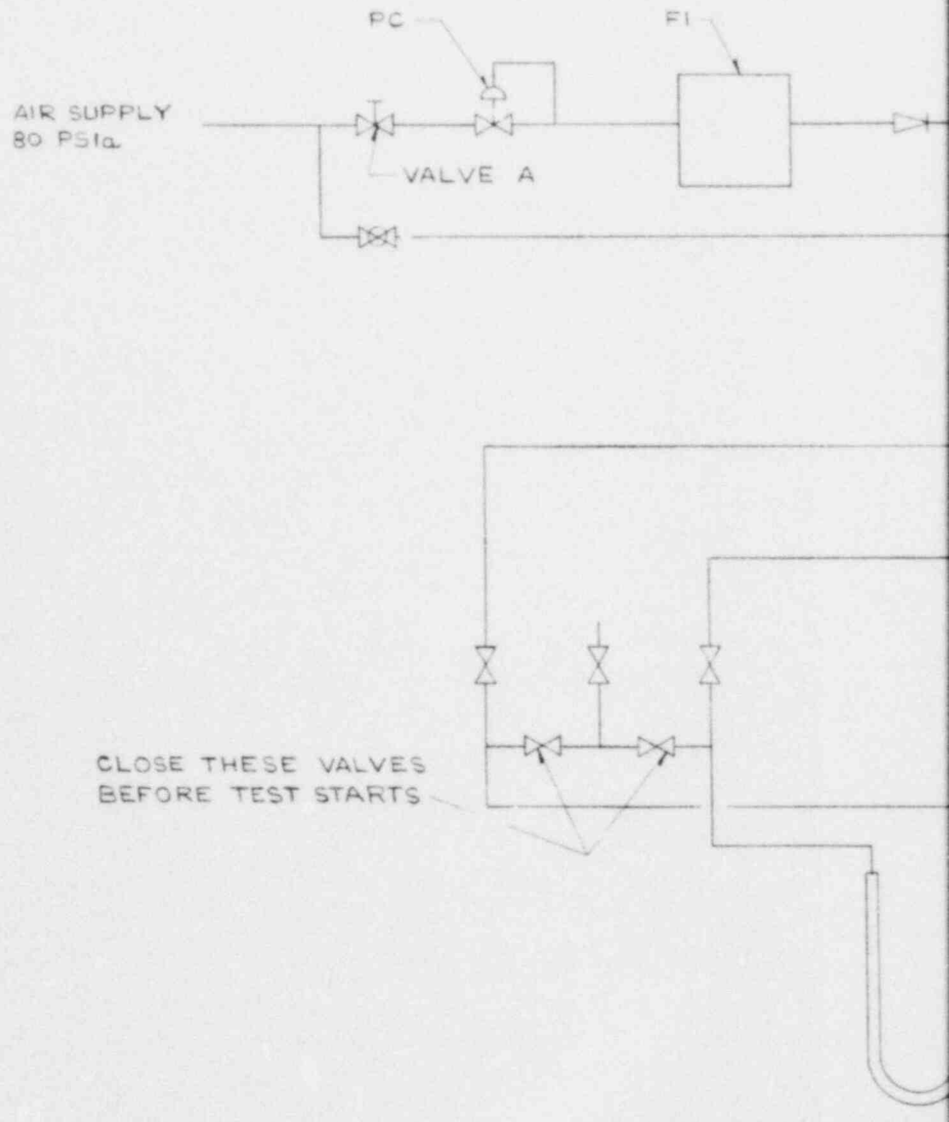
The system consists of two duplicate sets of tubing running throughout the vapor container. Eleven monitoring taps are located throughout the vapor container, four taps 90 deg apart between the sphere shell and the shield wall, one in each steam generator, pressurizer, and reactor compartment, and e above the charging floor. The taps on one tubing run are left open to the vapor container atmosphere, and the taps on the other tubing run terminate in small copper bulbs. This latter tubing system consists of a completely closed arrangement within the vapor container and is the reference system. A commercial U-tube manometer provided with a hairline and magnifying glass is used to measure any pressure differential between the open and closed tubing system. A standard household gas meter measures the amount of air required to equalize the vapor container pressure with that of the reference system.

The components of the leakage monitoring system are shown on drawing No. 549-D-295.

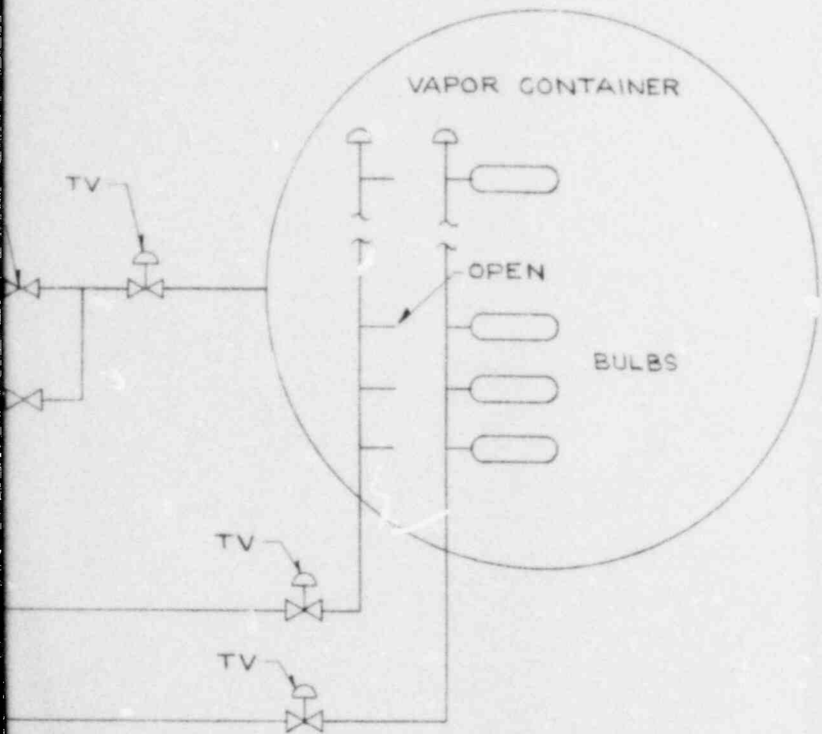
Vapor container leakage must be limited to values which can be tolerated in the event of a nuclear accident. Therefore, if the entire vapor container is pressurized to 15 psi gage, the leakage "allowed" is 70 standard cubic feet per day. Leakage is measured by equalizing the pressure in the reference (closed) tubing system and the vapor container. After equalizing pressures, the reference tubing system is valved off from the vapor container and the pressures in the two tubing systems will follow one another regardless of temperature change. Any leakage in the vapor container shell will be evidenced by a difference in pressure between the two systems and will be indicated on the U-tube manometer. A gas meter is used to meter the air required to equalize the two pressures. During plant operation, the vapor container will be slightly pressurized so that any leakage will be detected by this system.

Internal Air Filtration

Minor leakage of primary coolant may introduce radioactive solids, liquids, or gases to the vapor container air. A high efficiency internal air filtration facility, which is part of but not integral with the rest of



VAPOR CONTAINER LEAK



ITEM	EQUIPMENT
FI	GASMETER CAPACITY 570 SCFM MAX PRESS. 100 PSI
PC	REGULATOR
PTV	SECURITY VALVE
DPI	U TUBE MANOMETER
	ALL VALVES HAVE BELLOWS SEALED STEMS

MONITORING SYSTEM

WESTINGHOUSE ELECTRIC CORPORATION

TITLE YANKEE ATOMIC ELECTRIC COMPANY
VAPOR CONTAINER LEAKAGE MONITORING SYSTEM

DIMENSIONS IN INCHES—SCALE N.T.S.

DFTM 4/1/59

549D295

DIVISION ATOMIC POWER DEPT. PLANT LOCATION PGH., PA.

the ventilation system, removes activity from the container air during operation. It reduces the concentration of airborne activity after reactor shutdown to permit personnel access to the interior of the container.

The internal air filtering assemblies consist of three fan and filter combinations in concrete cubicles shielding one assembly from another, and all assemblies from personnel in the container. These assemblies have a 4,000 cfm capacity each when the filters are clean.

Each of the assemblies consist of one fan and one filter bank. The fans are single width, single inlet, NAFM Arrangement 4, nonoverloading wheels, overhung on extended shafts of constant speed motors.

The airborne activity filters are high humidity filters, having a particle count efficiency of not less than 99.95% on 0.3 micron particles, a resistance when clean of 1 in. of water at a face velocity of 250 fpm, and are constructed with fire resistant frames. Prefilters are provided at the internal air filtering assemblies to prevent premature overloading of the activity filters.

The air filtration system is designed to remove airborne activity resulting from minor leakage of main coolant into the vapor container. The activity in the main coolant is based on 1% of the fuel rods having minor defects and releasing fission products to the coolant in addition to activated corrosion products which are based on a corrosion rate of 10 mg per dm^2 per mo.

During plant operation, the internal air filtering assemblies limit the concentration of radioactivity, principly iodine, to a level which can be reduced to tolerance within a reasonable time after reactor shutdown and depressurization. This is accomplished by recirculating a minimum air rate of 6,300 cfm within the container using two fan and filter assemblies.

217 DECONTAMINATION SYSTEM

The function of the decontamination system is to remove radioactive fission and corrosion products from the internal surfaces of components, piping, and fittings of any isolated loop of the main coolant system and of the pressurizer.

The decontamination of the internal surfaces of the main coolant system can be accomplished by utilizing existing plant systems. These systems are shown schematically on drawing No. 646-J-616.

Decontamination, if it ever becomes necessary, will be performed only when the reactor is shutdown and the main coolant system is depressurized and cooled down.

A new combination of decontamination chemicals has been investigated by Westinghouse under the Yankee Research and Development Program and found to be exceptionally effective in laboratory tests. Two solutions are used with intermediate and final rinsing. The first solution is 3 wt % potassium permanganate and 10 wt % sodium hydroxide used at a temperature of 230 F for a reaction time of 90 min. The second solution is 10 wt % ammonium citrate used at a temperature of 210 F for a reaction time of 90 min.

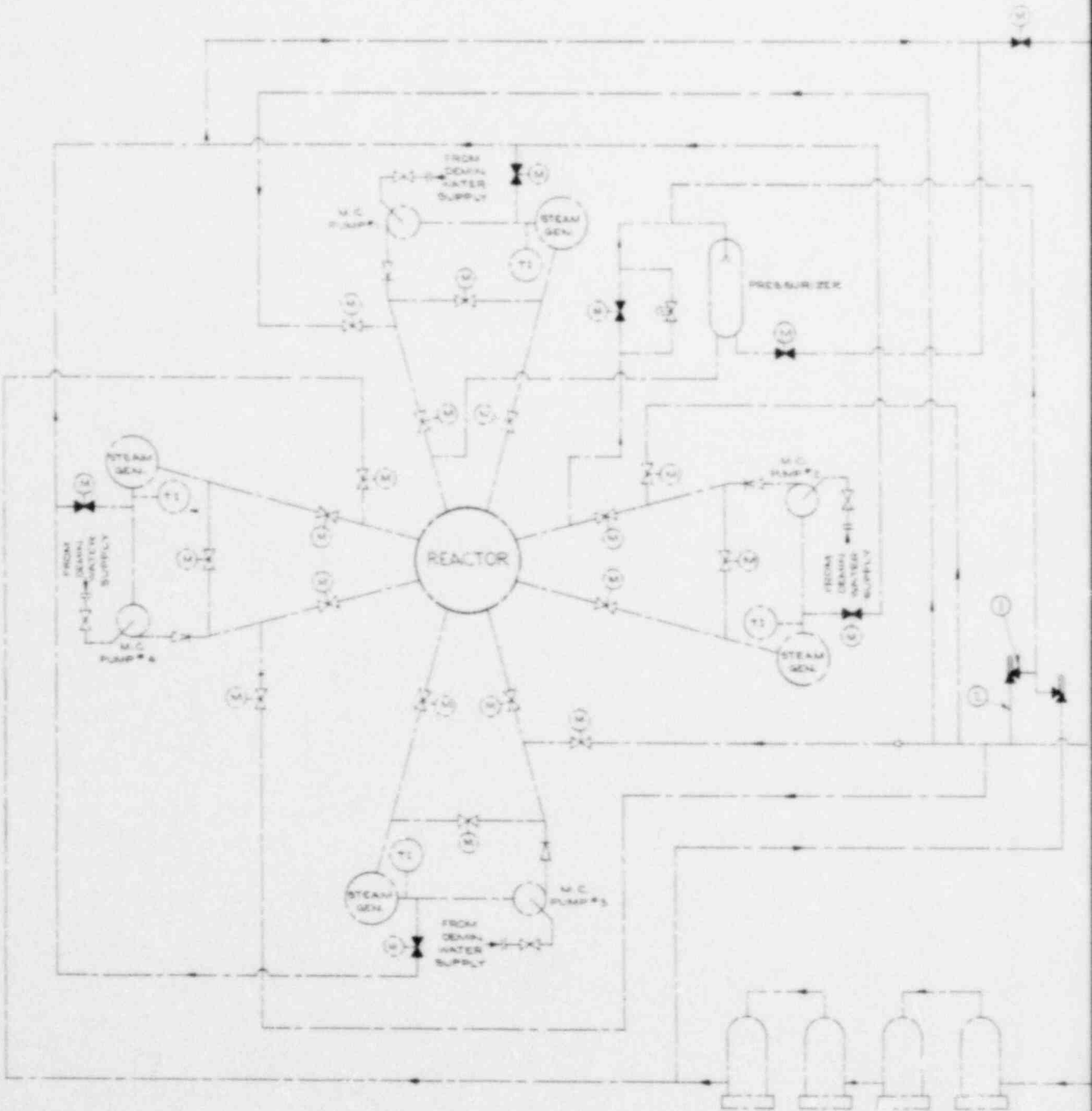
The materials of the main coolant loops and associated auxiliary systems have been tested with these solutions and no harmful effects have been discovered at the times and temperatures involved. In order to prevent any corrosion of the Graphitar 14 main coolant pump bearings, demineralized water will be introduced through the pump vents at a higher pressure than the decontamination solutions so as to provide an inflow of pure water and prevent the solutions from contacting the bearings.

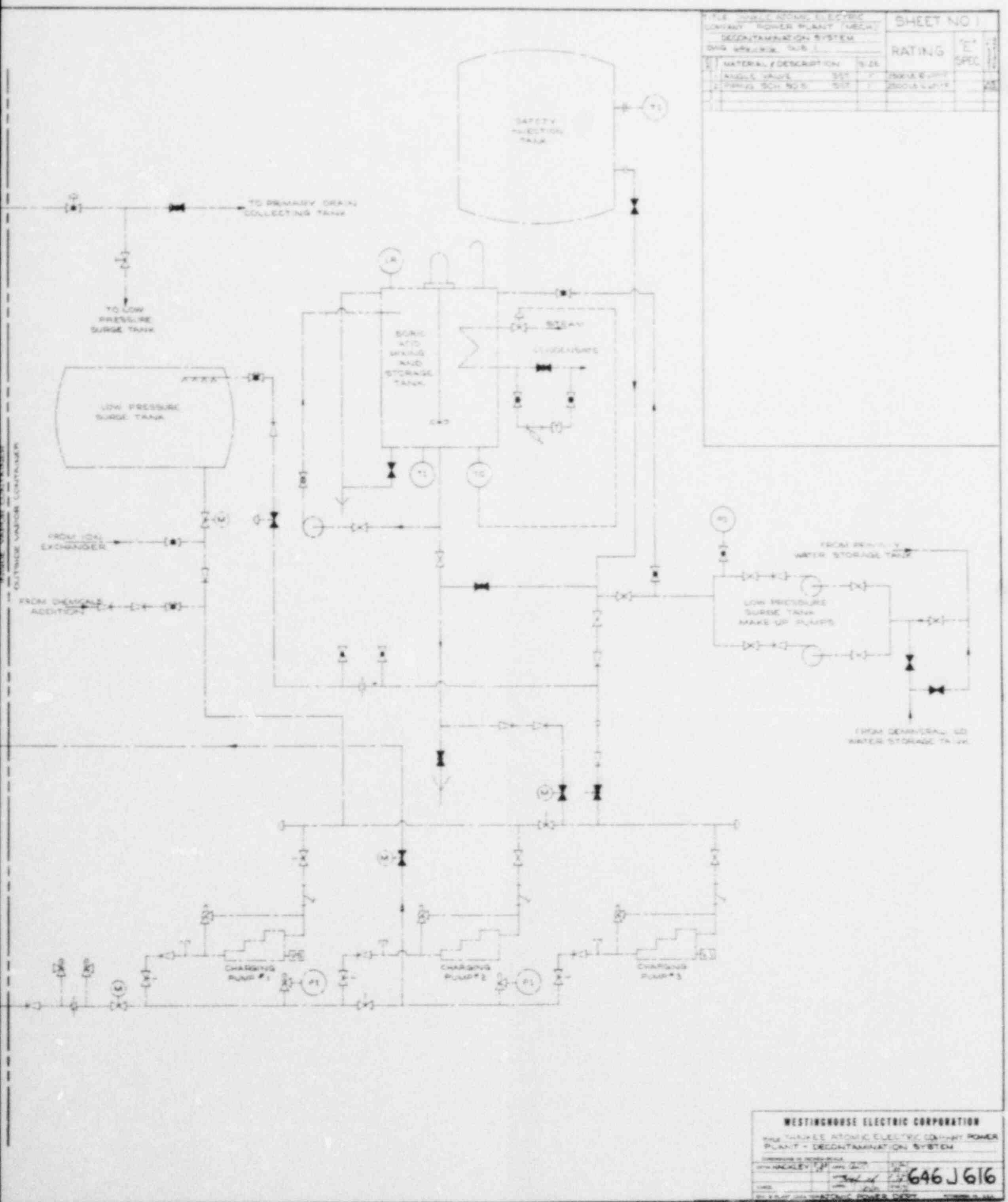
If decontamination of a loop is necessary, the loop is isolated by closing and locking the two main stop valves and is drained of primary grade borated water.

The loop is then refilled with the first decontamination solution. The solution is mixed in the boric acid mixing tank and introduced into the loop via the loop fill and chemical injection line. The loop is pressurized by the charging pump to permit circulation of the solution by means of the main coolant pump, via the by-pass line.

Water from the demineralized water storage tank is temporarily pumped to the vent of the main coolant pump and continuously drained to the primary drain collecting tank of the waste disposal system. To maintain the desired temperature of the solution, the heat generated in the loop by the main coolant pump is removed through the steam generator.

After the required reaction time the main coolant pump is stopped and the first decontamination solution is drained from the loop and discharged into the primary drain collecting tank. The loop is then refilled with demineralized water which is circulated in order to rinse the system. After having drained the rinse water, the loop is refilled with the second decontamination solution which is then circulated as in the first case.


REACTOR
STEAM GEN.
PRESSURIZER
M.C. PUMP #4
M.C. PUMP #3
FROM DEMIN WATER SUPPLY
FEED / BLEED HEAT EXCHANGER


TITLE YANKEE ATOMIC ELECTRIC
COMPANY POWER PLANT (MECH)
DECONTAMINATION SYSTEM
SHEET NO 1
RATING
"E" SPEC
MATERIAL & DESCRIPTION
SIZE
ANGLE VALVE
PIPING SCH 80 S
SAFETY INJECTION TANK
TO PRIMARY DRAIN COLLECTING TANK
TO LOW PRESSURE SURGE TANK
BORIC ACID MIXING AND STORAGE TANK
STEAM
CONDENSATE
LOW PRESSURE SURGE TANK
FROM ION EXCHANGER
FROM CHEMICALS ADDITION
INSIDE VAPOR CONTAINER
OUTSIDE VAPOR CONTAINER
FROM PRIMARY WATER STORAGE TANK
LOW PRESSURE SURGE TANK MAKE UP PUMPS
FROM DEMINERALIZED WATER STORAGE TANK
CHARGING PUMP #1
CHARGING PUMP #2
CHARGING PUMP #3
WESTINGHOUSE ELECTRIC CORPORATION
TITLE YANKEE ATOMIC ELECTRIC COMPANY POWER PLANT - DECONTAMINATION SYSTEM
DRN HACKLEY
ATOMIC POWER DEPT
646 J 616

After the required reaction time, the second solution is drained to the primary drain collecting tank and the loop is again rinsed with demineralized water until clean.

In the event that it is desired to decontaminate the pressurizer, the pressurizer is drained and a feed and bleed decontamination procedure is utilized. The decontamination solutions and rinse water are injected into the pressurizer via the spray nozzle, and drained to the primary drain collecting tank.

All solutions used in the decontamination processes are ultimately processed through the waste disposal system.

218 FUEL HANDLING SYSTEM

General

In order that the reactor may be fueled and refueled, as required, without hazard to personnel, means are provided for underwater removal of fuel assemblies from the reactor, for transferring the assemblies from within the vapor container to a water filled spent fuel storage pit located outside of the vapor container, for storing spent fuel assemblies underwater for a sufficient period of time to allow them to decay to a tolerable level, and for removing the loaded shipping containers from the spent fuel storage pit and placing them on a vehicle to be transported from the plant site.

New fuel assemblies are unloaded, removed from the shipping containers in the new fuel storage vault, and stored in racks. When the reactor is ready to be refueled the new fuel assemblies are moved from the fuel storage vault to the spent fuel storage pit, transferred to the interior of the vapor container, and installed in the reactor by reversing the core removal procedure.

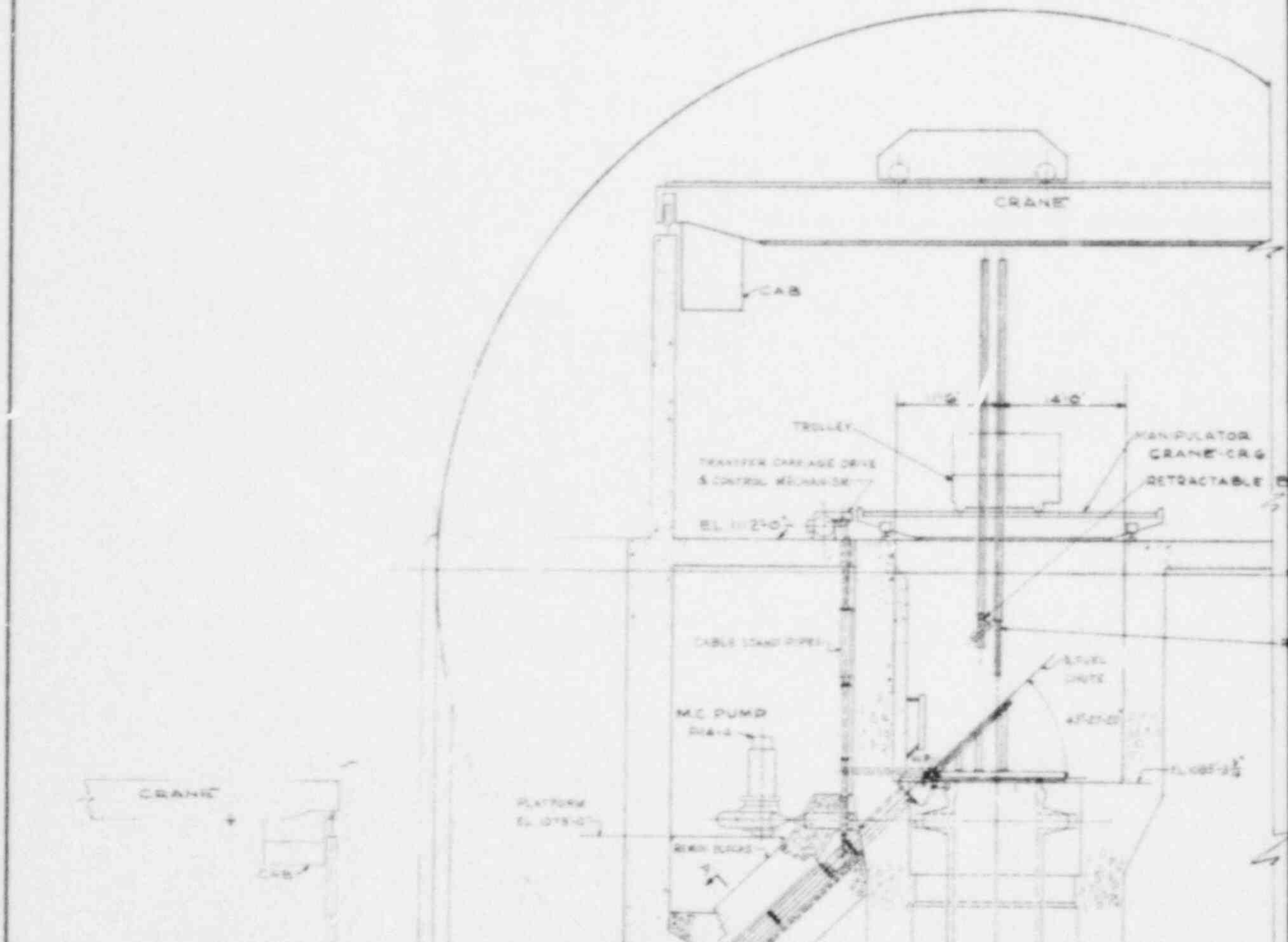
Spent control rods may be removed and new control rods installed by the same route as the fuel assemblies. The fuel handling system also removes and replaces all other reactor parts necessary to accomplish the refueling operation.

The fuel handling system consists of a new fuel storage vault, yard work area crane, fuel transfer pit, fuel transfer pit manipulator crane, laydown mechanism and grappling tool, fuel transfer chute and carriage, vapor container polar crane, shield tank cavity, shield tank cavity manipulator crane, laydown mechanism and universal handling tool, reactor vessel head handling device, reactor vessel internals handling device, and a variety of other special handling tools and fixtures. The overall arrangement of the fuel handling system is shown on drawing No. 9699-FM-19B.

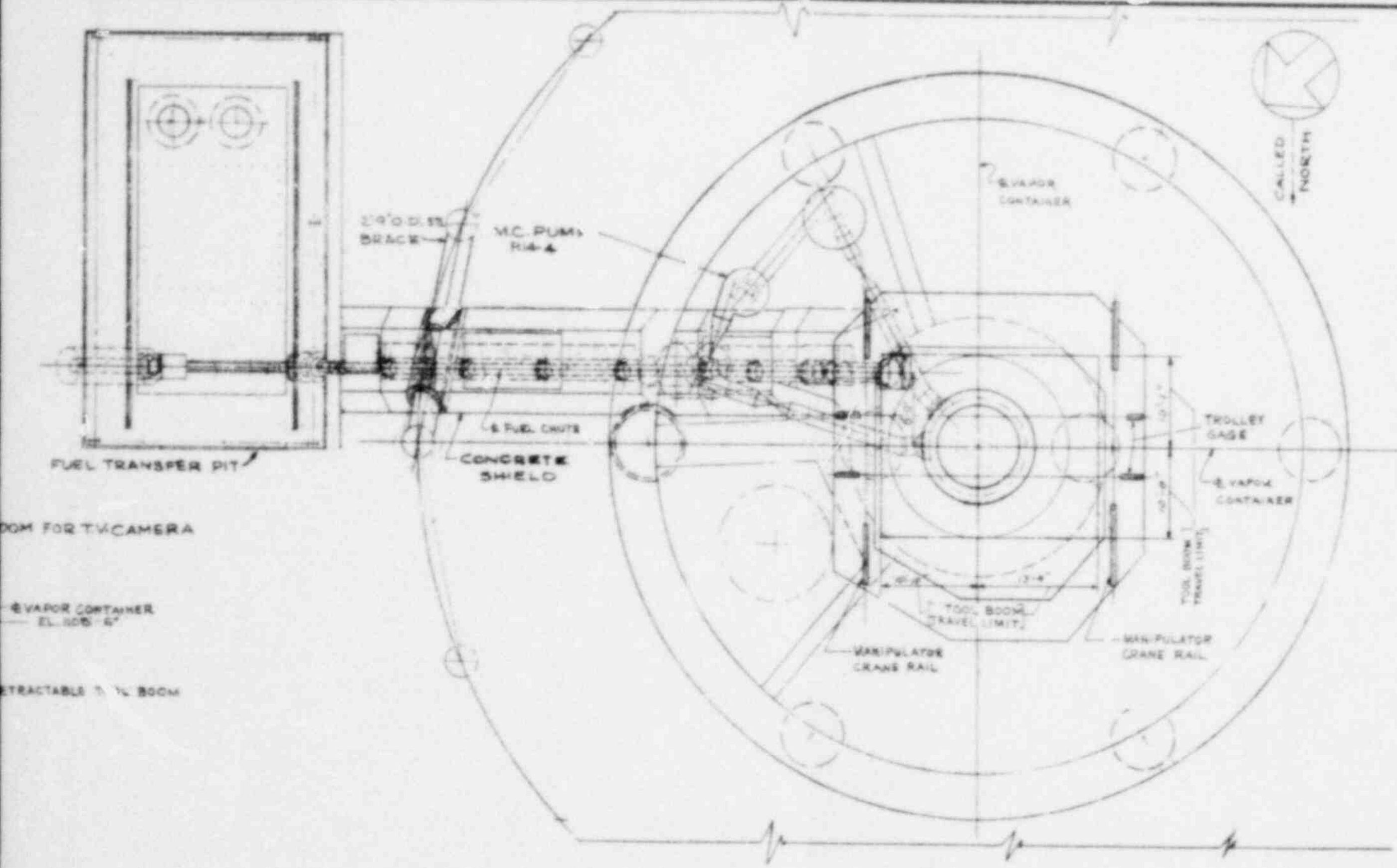
New Fuel Storage Vault

The reinforced concrete block new fuel storage vault located outside of the vapor container and adjacent to the fuel transfer pit is designed to receive and store 84 new fuel assemblies, 24 control rods, and 8 shim rods. A one ton monorail crane is employed to manipulate the above components inside the vault. A 14 ft high by 5 ft wide steel plate door located in the north wall is used for general access. The shipping containers are lowered into the vault through a hatchway in the roof into the northwest corner, where an intermediate wall rack is located. The racks, in which the assemblies are stored, are arranged in 4 parallel rows. The center to center distance between assemblies is 14 in., which gives a surface to surface spacing of 6.3 in. between assemblies. The spacing of the racks was so arranged, in order to avoid any chance of criticality. Calculations show that the k_{eff} of this arrangement would be approximately 0.8, with the vault flooded, which is an extremely remote possibility. The fuel vault arrangement is shown on drawing No. 9699-FM-21B.

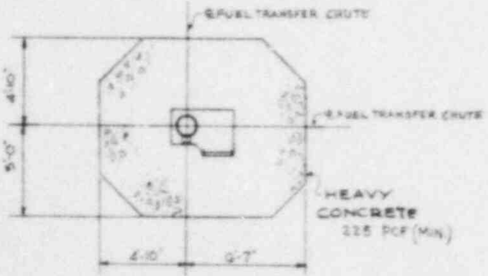
9699-FM-19B



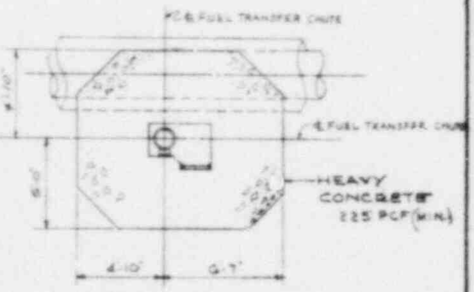
SECTIONAL ELEVATION
SCALE: 1/8"=1'-0"



PLAN
SCALE: 1/8"=1'-0"



SECT. AA
SCALE: 1/4"=1'-0"



SECT. CC
SCALE: 1/4"=1'-0"

REFERENCE DWGS:

ARRANGEMENT FUEL CHUTE & DETAILS FUEL TRANSFER PIT. DWG. 9699-FM-19F
ARR'G'T & DETAILS - FUEL CHUTE - VAPOR CONTAINER TO TRANSFER PIT. DWG. 9699-FM-19A
ARR'G'T & DETAILS - FUEL CHUTE VAPOR CONTAINER DWG. 9699-FM-19H.
FUEL TRANSFER PIT DWG. 9699-FM-21A.
FUEL TRANSFER CHUTE & PIPE SHIELDING DETAILS - SH. 1 DWG. 9699-FM-92A.

SUPERSEDES 9699-FM-19A

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER NO.
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5					
4					
3	GENERAL REVISION				
2	GENERAL REVISION				
1	ORIGINAL ISSUE				

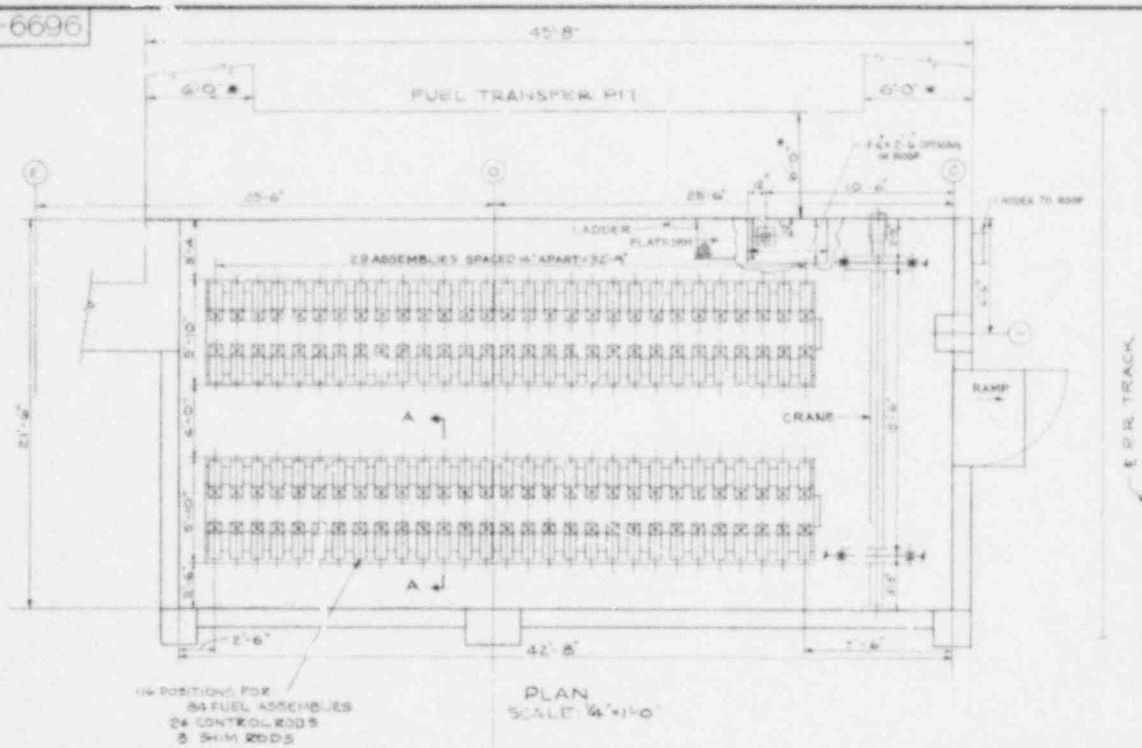
FUEL HANDLING ARRANGEMENT

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

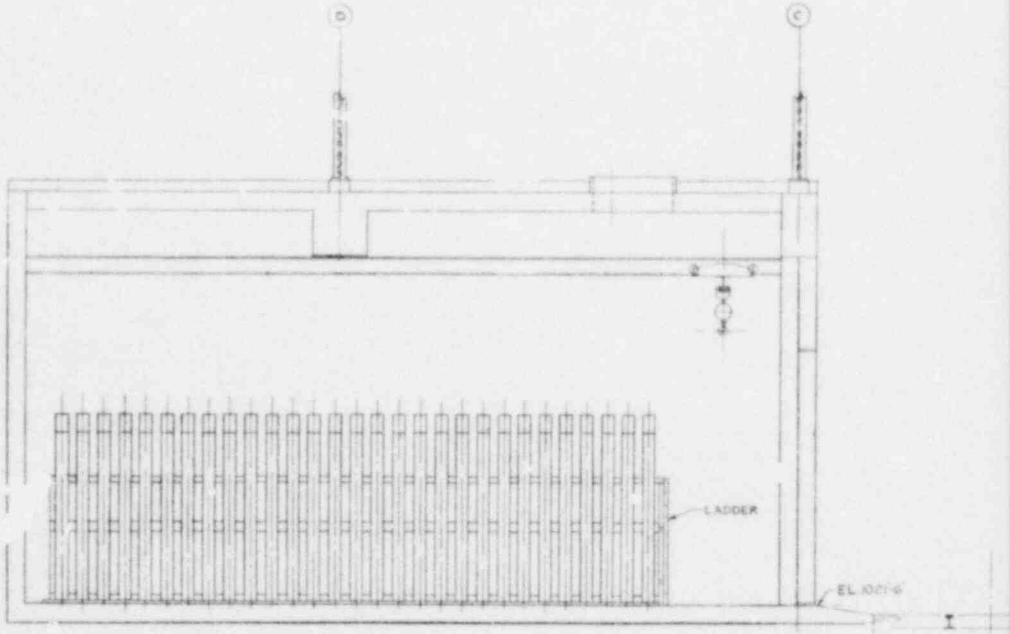
STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-19B

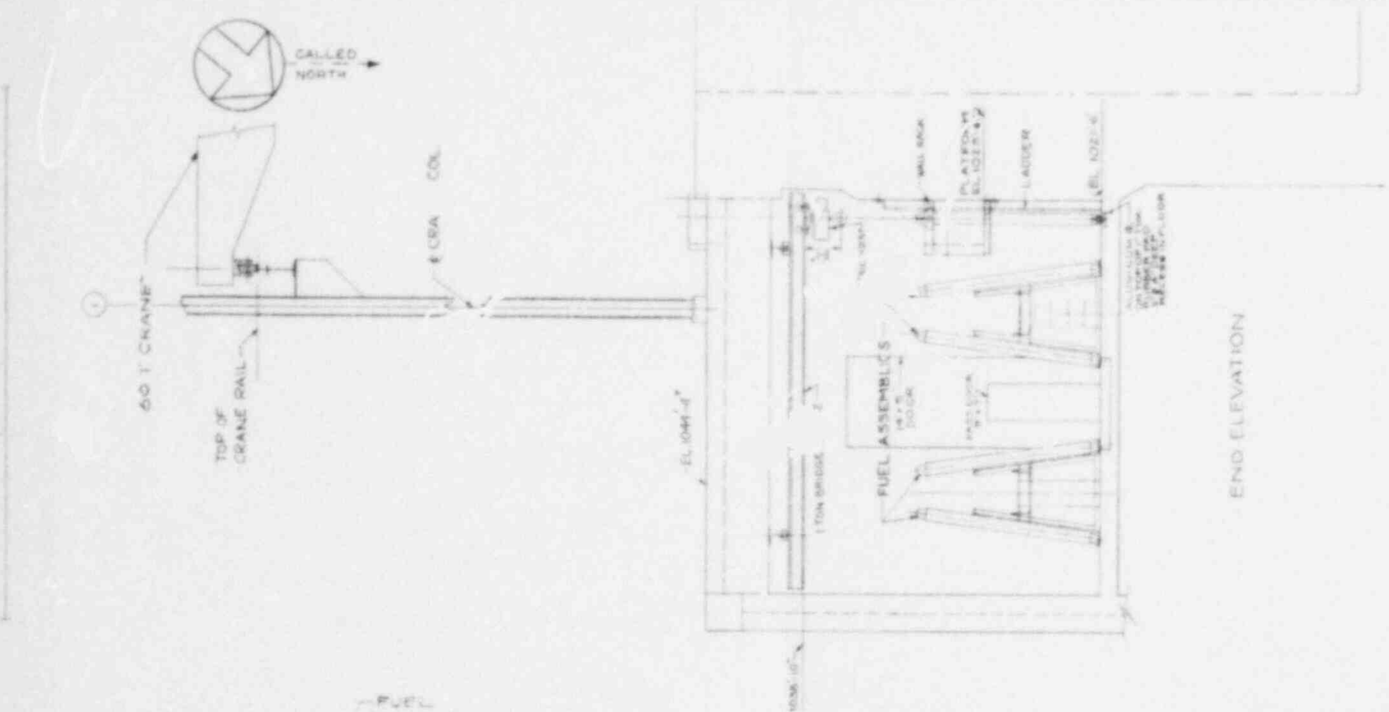
9699-FM-21B

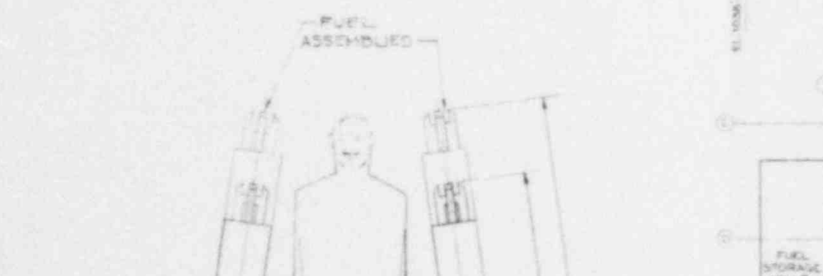


PLAN
SCALE: ¼"=1'-0"

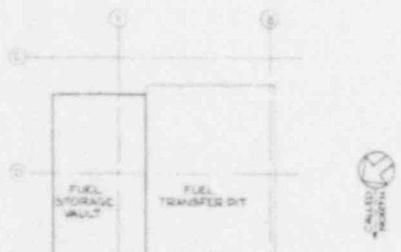


ELEVATION





SECTION A A
FOR FUEL ASSEMBLIES
SCALE 1"=1'-0"



KEY PLAN
SCALE 1/8"=1'-0"

NOTES:

* DIMENSION INDICATE MINIMUM SHIELDING REQUIREMENTS

USE FIREPROOF MATERIAL FOR RACKS IF AND WHERE APPLICABLE.

REFERENCES
FUEL TRANSFER PIT 9699-FM-21A
ARR'GT. ION EXCH & SPENT RESIN STOR. AREA 9699-FM-35B
DETAILS - FUEL STORAGE VAULT RACKS, DWG. NO. 9699-FS-24A

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER NO. 737
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5					
4	ADD'T. FUEL ASSEMBLY STEEL COLLARS, HATCHWAY SIZE AND CONCRETE SLAB, GRADE CHG'D. REFERENCE [illegible] HOLD REMOVED [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	GENERAL REVISION	[illegible]	[illegible]	[illegible]	[illegible]
2	ADD [illegible], NOTES & DIMENSIONS, GRADES CHG'D	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

FUEL STORAGE VAULT

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

SCALE: AS NOTED

DRAWING NUMBER 9699-FM-21B

Manually Operated Fuel Assembly Lifting Fixture

The fuel assembly lifting fixture is provided for grappling and lifting new fuel assemblies, guide tubes and plugs, control rods and followers, and shim rods in the new fuel storage vault. The steel fingers of this fixture are located by a spring loaded plunger which also acts as a load bearing member, and the action is such that the tool can not be disengaged when the weight of the item being handled is supported by the fixture. The tool is approximately 1 ft long.

Extended Fuel Assembly Lifting Fixture

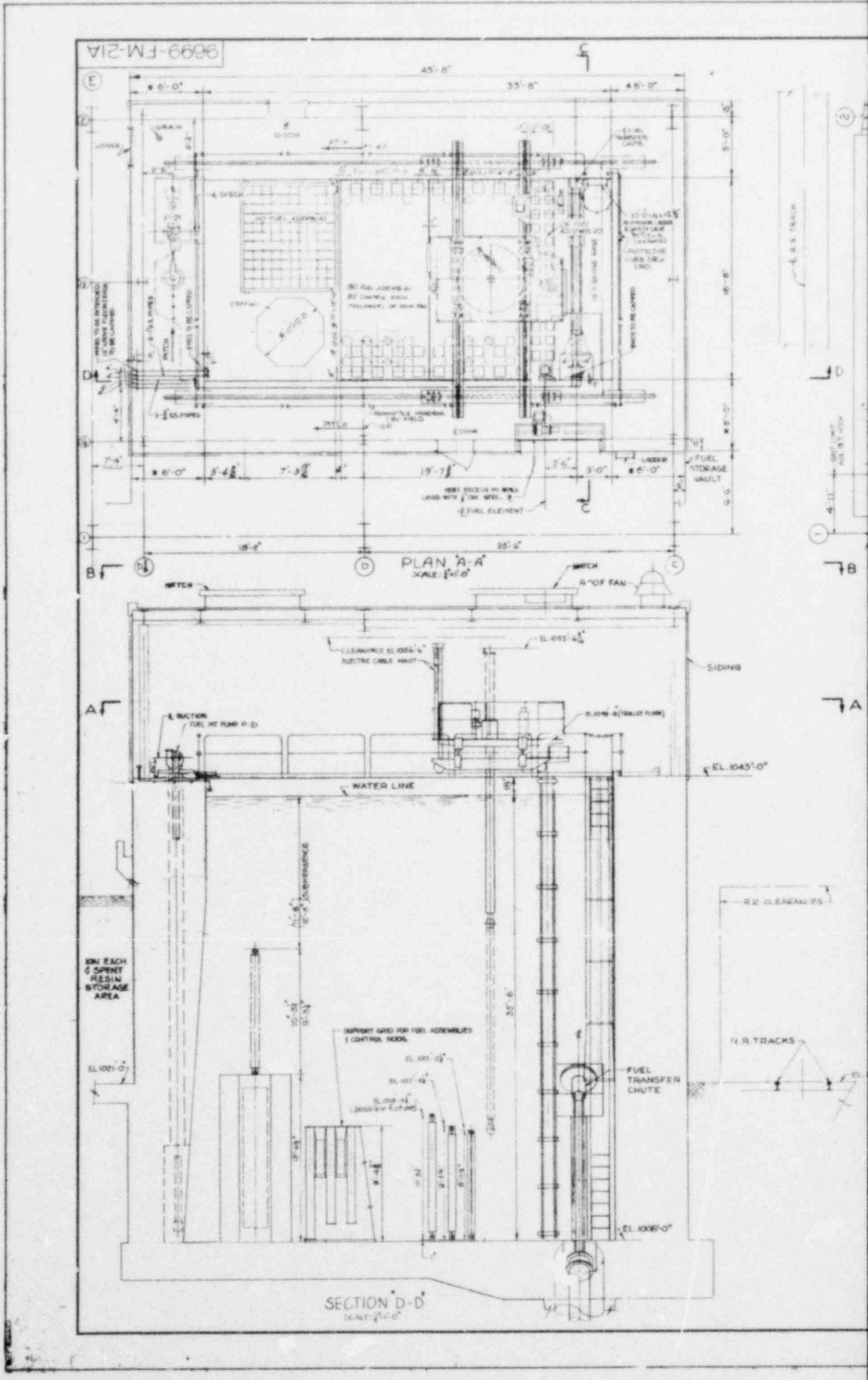
This fixture is a similar tool to the manually operated lifting fixture, and is used for handling the same items in the fuel transfer pit. It has a rigid extended shank provided with two operating handles so that the tool can be manually engaged and disengaged from the top and the bottom of the fixture. The tool length is approximately 11 ft-0 in.

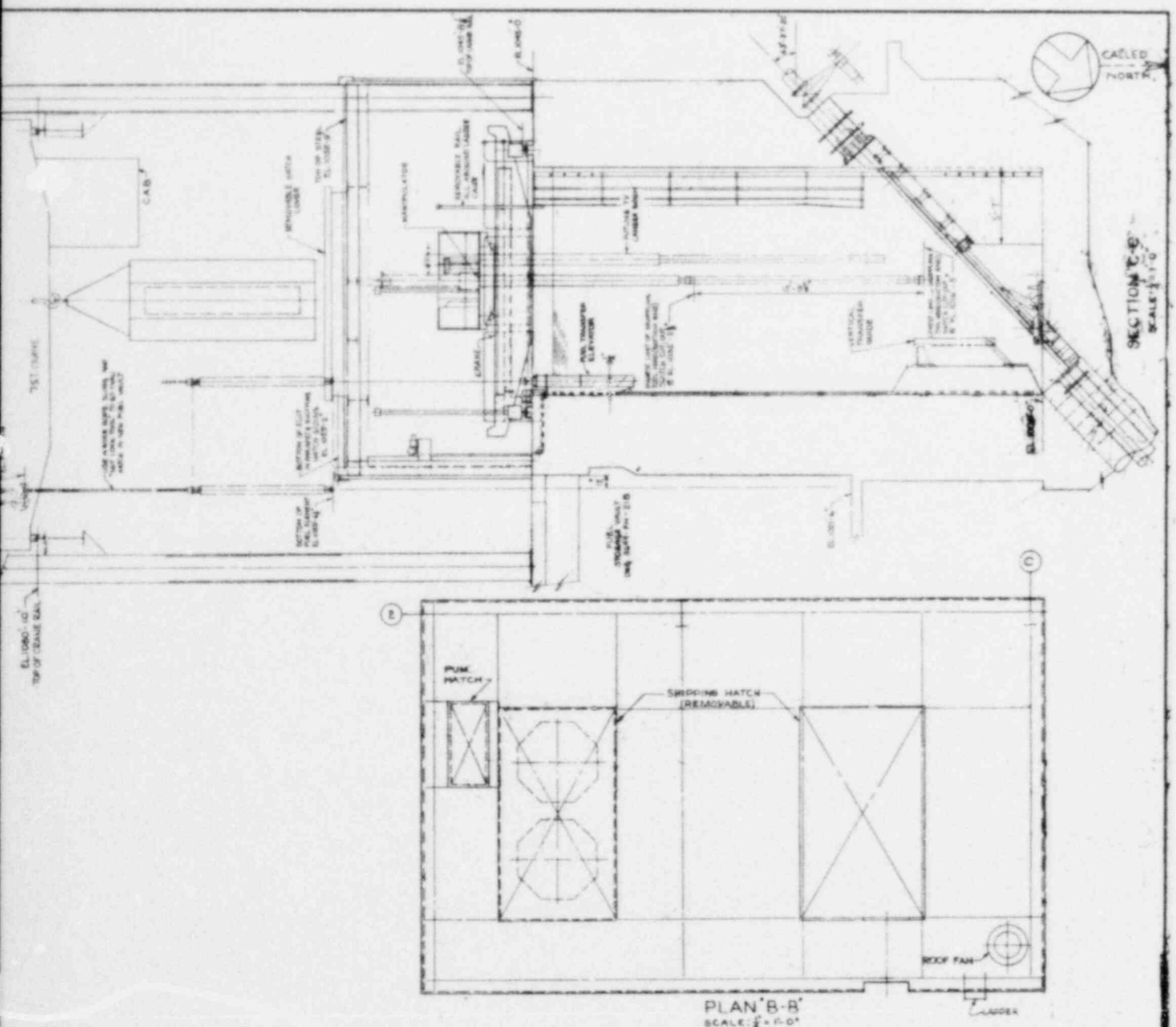
Yard Work Area Crane

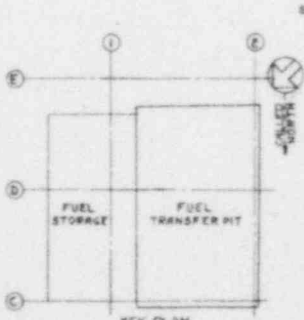
The yard work area crane spans the fuel storage vault, the fuel transfer pit, and the adjoining railroad spur track. The 60 ton main hook and the 12 ton auxiliary hook each have additional 25% overload capacity. The crane location enables transfer of: new fuel containers from the railroad to the fuel storage vault, new fuel assemblies from the fuel storage vault to the fuel transfer pit, and spent fuel shipping coffins from the fuel transfer pit to a railroad car. The lift of the crane is 68 ft-5 1/4 in., which enables it to raise items between El. 1,011'-0" and 1,079'-5 1/4".

Fuel Transfer Pit

The fuel transfer pit, outside of the vapor container, is designed to store fuel assemblies, control rods, control rod followers, and shim rods under water after removal from the reactor. In addition, the fuel transfer pit contains the equipment necessary to complete the functions of the fuel handling system outside the vapor container. The fuel transfer pit whose general arrangement is shown on drawing No. 9699-FM-21A, contains a manipulator crane, a grappling tool, laydown mechanism, and the lower portion of the tracks from the vapor container. The tracks are in an inclined position and are located at the lowest point of travel of the transfer carriage. After the transfer carriage has reached its lowest travel limit, the laydown mechanism raises it to a vertical position. New fuel assemblies can be placed into the vertically positioned carriage or spent fuel assemblies removed from it by means of the manipulator crane and the grappling tool. The laydown mechanism is actuated by a water hydraulic cylinder which raises a section of the rails containing the transfer carriage from their normal position to a vertical position. All of the operations within the reinforced concrete fuel transfer pit are performed in approximately 36 ft of demineralized water.


9699-FM-21A
45'-8"
33'-8"
FUEL STORAGE VAULT
LADDER
PLAN "A-A"
HATCH
ROOF FAN
SIDING
EL. 1045'-0"
WATER LINE
ION EXCH. & SPENT RESIN STORAGE AREA
EL. 1021'-0"
FUEL TRANSFER CHUTE
EL. 1008'-0"
R.R. CLEARANCES
R.R. TRACKS
SECTION "D-D"





NOTE:

*DIMENSIONS FOR MINIMUM SHIELDING REQUIREMENTS.
FUEL TRANSFER PIT TO BE LEFT UNLINED FOR PRESENT
Procure ladder from [illegible] Ladder Co., 92 Harvard St. [illegible] Mass.

REFERENCES

FUEL STORAGE VAULT 9699-FM-81B
ARRGT. ION EXCH. & SPENT RESIN STOR. AREA 9699-FM-35B
ARRGT. FUEL CHUTE & DETAILS FUEL TRANSFER PIT 9699-FM-21F
NEW FUEL TRANSFER ELEVATOR - FUEL TRANSFER PIT - DWG. 9699-FM-71A
SUPPORT GRID FOR FUEL ASSEMBLIES & CONTROL RODS - FUEL TRANSFER PIT - DWG. 9699-FM-64A

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER NO. 538
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	INSP.	COORD.	APPR.	ISSUE	DESCRIPTION	CHKD.	INSP.	COORD.	APPR.
11	[illegible]										
10	Added rack for 26 additional fuel assemblies					5	[illegible]				
9	[illegible]					4	GENERAL REVISION				
8	AS BUILT CHANGES					3	CHKD. DWG. & GRADES. ADDED HOLD. MINOR CHGE. MANIPULATOR. LOWERED.				
7	[illegible]					2	CHKD. COFFIN, ADDED DWGS. & PIT [illegible] ADDED & SUB ASSEMBS. NOTES & [illegible]				
6	[illegible]					1	ORIGINAL ISSUE				

FUEL TRANSFER PIT

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-21A

The fuel transfer pit contains three fuel storage racks with respective capacities of 110, 80 and 26 fuel assemblies. The 80 and 26 assembly racks are fabricated of 6061-T6 aluminum and employ distance between assemblies to prevent criticality. The center to center distance between fuel assemblies is 19 1/2 inches in the 80 element rack and 13 3/4 inches in the 26 element rack. With unirradiated, 4.1% enriched uranium fuel stored in the 26 element rack, K_{eff} has been calculated to be 0.725.

The 110 element rack is also fabricated of 6061-T6 aluminum and provides for storage of fuel in an oblong array with a center to center spacing of 8.78" x 9.5". The active portion of each assembly is enclosed in a boral sheath for reactivity control. The boral is made up of 35 weight per cent B_4C in an aluminum matrix, clad with aluminum on all sides. K_{eff} has been ca lated to be 0.835 with unirradiated, 4.1% enriched uranium fuel stored in this rack.

For all three racks, K_{eff} has been calculated to be less than 0.88 for y fuel likely to be used in the Yankee reactor.

The design of the racks allows insertion of fuel assemblies only in the prescribed storage channels in the racks.

The fuel transfer pit is provided with a cooling and purification system. This removes the decay heat given off by the spent fuel assemblies in storage and prevents the buildup of radioactivity and boric acid in the fuel pit water. The 500 gpm fuel transfer pit cooling pump circulates the water between the pit and a heat exchanger maintaining the water temperature under 130°F. The water is also circulated by the same pump through a 20 cu. ft. ion exchanger. The fuel transfer pit cooling pump may also be used to unwater the fuel transfer pit.

Fuel Transfer Pit Manipulator Crane

The crane is composed of a trolley mounted on a bridge which in turn rides along rails set in concrete at the top of the fuel transfer pit. A rotating turret is mounted on the trolley. The turret supports a rigid tool boom which cannot rotate relative to the turret. The stainless steel tool boom is provided with a grappling tool which will engage the top end of a fuel assembly, control rod or control rod follower. The boom is raised and lowered by means of a rack attached to the boom, meshing with the pinion gear output of a motor driven gear mechanism.

In order that the crane operator can accurately position the tool boom over the laydown mechanism in its vertical position, positive stops are placed on each of the main crane rails. The crane is visually indexed by scales and pointers to enable the operator to position the boom accurately over the storage racks.

A height indicator is used to indicate the height of the tool boom. The indicator consists of a mechanically driven revolution counter, arranged so that indicating dials are visual to the operator. The crane bridge and trolley motors are alternating current wound rotor type, operated with drum controllers (440v, 3 phase, 60 cycles). The tool boom hoist motor is a direct current motor supplied by a motor generator set driven by a 440v a-c motor and is operated by drum controllers. The capacity of manipulator crane is 6000 lb. The maximum vertical boom travel is 16 ft - 10 in.

Grappling Tool

The grappling tool is designed to pick up a fuel assembly, control rod or a control rod follower, and operates by extending latching fingers within the nozzle head of the item being raised. The tool is pneumatically operated and manually controlled with positive locking in both the open and closed positions. An interlock is provided that will prevent upward motion if the tool head is not completely latched or unlatched.

Fuel Transfer Chute and Carriage

An inclined chute is provided for transportation of the fuel assemblies and control rods between the fuel transfer pit and the shield tank cavity. The chute consists of several sections of 12 in. ID stainless steel pipe flanged together, a motor operated lower lock valve, and a swinging plate upper lock valve at the top of the chute near the bottom of the shield tank cavity. The chute and its joints are watertight under the static water pressures involved. A solid plate flange serves as a water and gas tight closure in order to maintain the integrity of the vapor container during reactor operation. The plate flange is located at the fuel chute joint just outside the vapor container. It consists of 2 plates of identical thickness, one plate totally solid, the other containing a circular cutout of slightly large diameter than the 12 in. ID of the fuel chute. During reactor operation, the solid plate is located between the gasketed fuel chute flanges. When the refueling operation is to start, the solid plate is replaced by the cutout plate. The solid plate is replaced before power operation begins.

Rails placed in the fuel chute support the transfer carriage and extend the length of the chute except where discontinuous at the lower lock valve and the upper lock valve. The transfer carriage consists of a multi-wheeled trolley and an attached receptacle which is designed to contain a fuel assembly or a control rod or follower. The wheel arrangement provides accurate alignment of the carriage during its operation. The carriage is provided with a clevis type joint which allows the receptacle end to be elevated to a vertical position by means of the laydown mechanism in each pit. The transfer carriage moves by gravity in the down direction and its travel is controlled by a pair of stainless steel wire cables. These cables are also used in drawing the carriage in its upward direction at a maximum speed of 100 fpm. Both cables are wound up on a suitable winch, which is located on the charging floor above the reactor.

The winch assembly is provided with a direct current motor powered from the 125 v d-c line. It has sufficient power to provide a hoisting speed of 100 fpm in the upward direction. The winch is provided with an automatic brake which fails safe in the event of a power failure. The winch is controlled by the shield tank cavity crane operator during the entire travel of the transfer carriage.

When the transfer carriage is moving in the upward direction it opens the upper lock valve upon contact. The valve is closed by a spring after the passage of the carriage in the downward direction. The movable plate is provided with a replacable neoprene "O" ring for sealing purposes so that the allowable leakage does not exceed 2 gal per hr under a head of 25 ft of water.

The lower lock valve is a standard stainless steel gate valve which remains in the closed position until the carriage reaches a point in the chute above the valve. The operator of the shield tank cavity crane manually controls the operation of this valve. Indicating lights on the operator's console designate the open, closed, or intermediate position of the valve.

To minimize the loss of borated water from the shield tank cavity to the fuel storage pit during refueling operations, a system of external piping is provided to partially dewater the chute before the transfer carriage passes through the lower lock valve. The boric acid solution is removed from the fuel chute down to a level approximately equal to the level of the water in the fuel transfer pit. The water removed is then returned to the shield tank cavity. The spent fuel assembly is submerged throughout this procedure.

Shield Tank Cavity

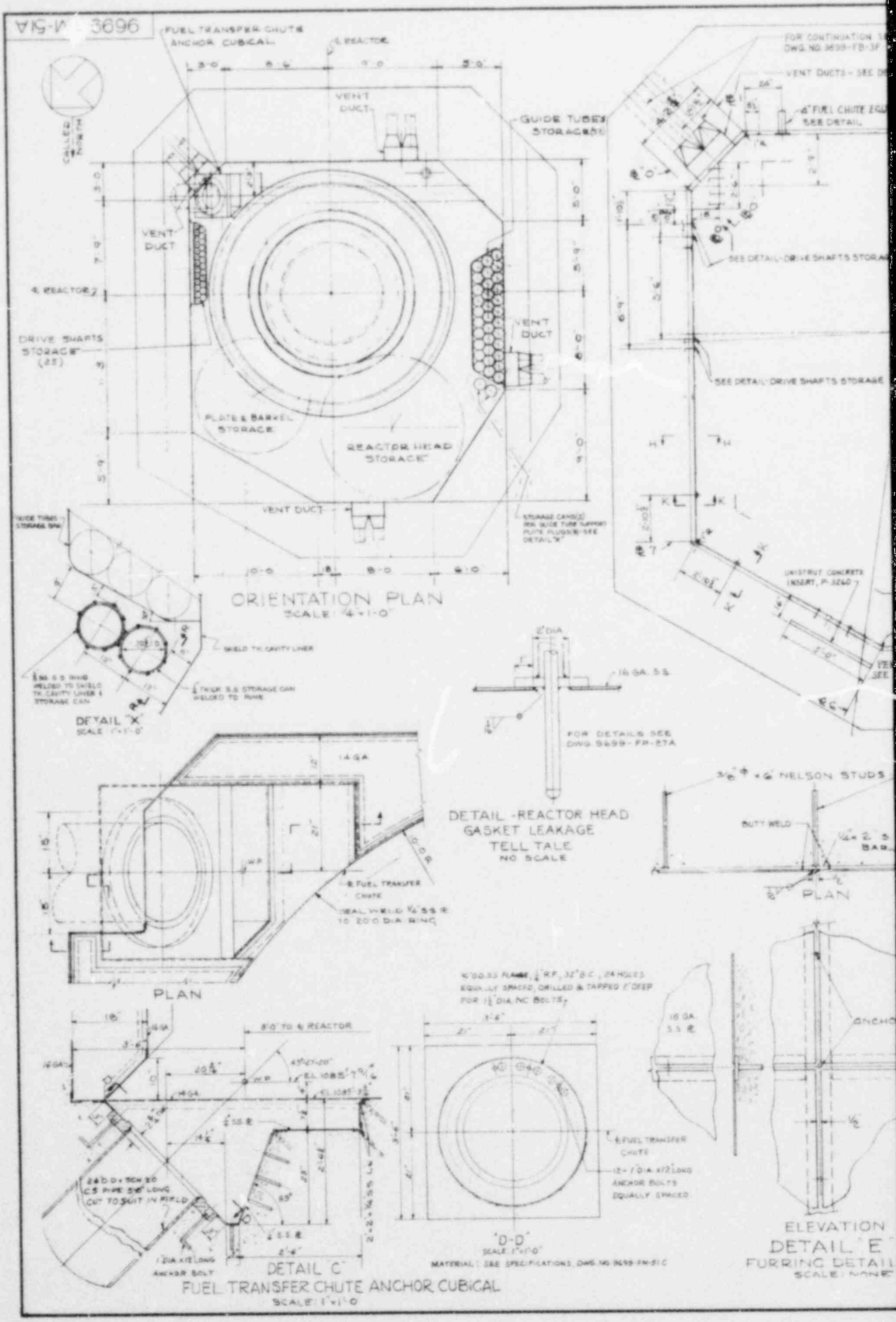
The shield tank cavity above the reactor vessel is a reinforced concrete, stainless steel lined container which can be filled with approximately 25 ft of borated water. It is provided for the purpose of permitting fuel assemblies and control rods to be handled underwater as they are withdrawn from the core by means of the fuel handling system manipulator crane and the universal handling tool. It is also a storage area for the reactor vessel head and its handling fixture, and various other reactor internals and their handling fixtures. The general arrangement is shown on drawing No. 9699-FM-51A.

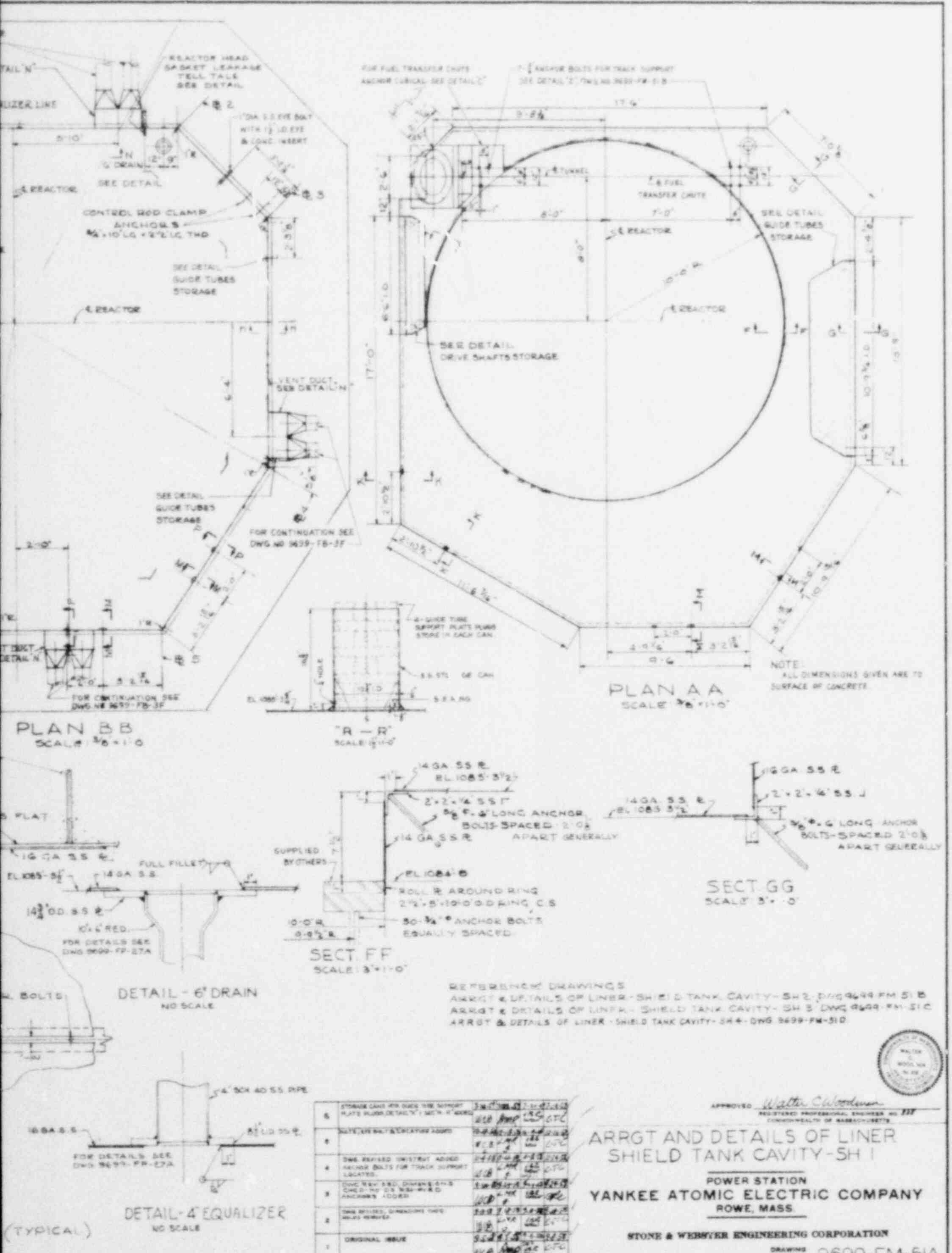
The shield tank cavity provides for a minimum 13 ft water shield over the top of the withdrawn fuel assembly and 8 ft minimum water shield over the top of the withdrawn control rods. This water coverage is necessary to limit the radiation at the surface of the refueling water to a level of 2 mr per hr.

Shield Tank Cavity Manipulator Crane

The crane is used with the pneumatically operated universal handling tool to handle fuel assemblies, control rod absorbers and followers, control rod drive shafts, and control rod guide tubes and plugs. The crane incorporates a rotating turret mounted on the trolley. The turret supports a rigid tool boom which may be rotated relative to this turret. A device is provided which will maintain the tool boom in any fixed position with respect to asimuthal rotation and simultaneously allow the turret to rotate freely around it. Pin locks are also incorporated which will provide positive locking in the north-south and east-west axis and at the 45 deg positions between.

The crane is visually indexed by means of scales and pointers to enable the operator to bring the handling tool close to the center line of any fuel assembly or control rod in the reactor core. The scales also enable the operator to position a fuel assembly in the locating fixture prior to insertion in the about-to-be elevated carriage. A load cell is provided which measures the tension load in the boom during withdrawal of the fuel assembly from the core. The cell is equipped with an adjustable cutout to limit the load being lifted to 5,000 lb. The maximum capacity of the crane is 6,000 lb. The control console is located on the trolley. Directly operated manual air control valves are provided on the console to allow the operator to perform the various latching and unlatching operations required by the universal handling tool. The bridge, trolley and boom are driven by 125 v d-c motors which provide smooth variable speed up to a maximum running speed of 20 fpm. The maximum vertical boom travel is 30 ft.


AIS-W-3696
FUEL TRANSFER CHUTE ANCHOR CUBICAL
VENT DUCT
GUIDE TUBES STORAGE
DRIVE SHAFTS STORAGE (25)
PLATE & BARREL STORAGE
REACTOR HEAD STORAGE
ORIENTATION PLAN
SCALE: 1/4"=1'-0"
DETAIL "X"
DETAIL - REACTOR HEAD GASKET LEAKAGE TELL TALE
NO SCALE
FOR DETAILS SEE DWG. 9699-FP-27A
16 GA. S.S.
SEE DETAIL-DRIVE SHAFTS STORAGE
UNISTRUT CONCRETE INSERT, P-3260
NELSON STUDS
BUTT WELD
PLAN
DETAIL "C"
"D-D"
MATERIAL: SEE SPECIFICATIONS, DWG. NO. 9699-FM-51C
ANCHOR BOLTS EQUALLY SPACED
ELEVATION
DETAIL "E"
FURRING DETAIL
SCALE: NONE
FUEL TRANSFER CHUTE ANCHOR CUBICAL
SCALE: 1"=1'-0"



REFERENCE DRAWINGS
ARRGT & DETAILS OF LINER - SHIELD TANK CAVITY - SH 2 - DWG 9699-FM-51B
ARRGT & DETAILS OF LINER - SHIELD TANK CAVITY - SH 3 - DWG 9699-FM-51C
ARRGT & DETAILS OF LINER - SHIELD TANK CAVITY - SH 4 - DWG 9699-FM-51D

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER NO. 737
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	GSP	CORR.	APPR.
6	STORAGE CANS FOR GUIDE TUBE SUPPORT PLATE PLUGS, DETAIL "R" & SECT. "R" ADDED				
5	BOLTS, EYE BOLT & LOCATION ADDED				
4	DWG REVISED. UNISTRUT ADDED. ANCHOR BOLTS FOR TRACK SUPPORT LOCATED.				
3	DWG REVISED. DIMENSIONS CHECKED. ANCHORS ADDED				
2	DWG REVISED. DIMENSIONS CHKD. HOLES REMOVED				
1	ORIGINAL ISSUE				

ARRGT AND DETAILS OF LINER
SHIELD TANK CAVITY - SH 1

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-51A

A second rigid boom mounted in the rotating turret is located precisely three fuel assembly pitches laterally from the tool boom measured on the square. This boom is equipped with a television camera and is capable of being raised, lowered and rotated 60 deg relative to the turret. The normal position of the camera is face down but it can be raised to a position a few degrees above horizontal. In the vertically downward position, the camera case runs up against a fixed stop and in this way its position is always reproducible at the bottom end of its movement.

The crane operating console contains all of the controls, television picture tube, and all indicating devices required to control all the fuel handling operations in the shield tank cavity, the fuel chute, and up to the point when the transfer carriage reaches the lowest limit of travel in the fuel transfer pit. Operation in the fuel transfer pit past this point is controlled by the operator in fuel transfer pit through the control console located on the pit manipulator crane trolley.

In addition, the crane is capable of removing a control rod assembly from the reactor core, inserting it into a retainer provided in the wall of the cavity, applying a torque to uncouple the top absorber section from the bottom follower section, and inserting the top section in the fuel element locating fixture. It is also capable of coupling together the two control rod sections by applying a reverse torque. The turret assembly incorporates an adjustable 2 direction torque limiting device which limits the torque which can be applied to the control rod during the coupling and uncoupling operations.

Universal Handling Tool

The universal handling tool is designed to manipulate the fuel assemblies, the control absorbers and followers, the control rod drive shafts, the guide tubes, and guide tube hole plugs. It is actuated by pneumatic cylinders of the spring return type. The fingers which grip the component being handled are locked when the cylinder pistons are in the spring returned position and the air is used only for the release of the fingers. The air supply lines inside the vapor container furnish air at 80 psi for the tool operation. The control system originates at the cavity crane console and controls the air to the cylinders by direct manually operated valves. A 3 way solenoid operated valve is provided to assure that sufficient air pressure is available at each set of cylinders.

The handling tool has a splined section at the top which prevents the operator from lowering the tool beyond the positioning level, and thus applying a vertical axial load to the tool and boom assembly. The action of the spline allows the tool to ride up 2 5/8 in. into the boom. The spline travel operates an interlock which interrupts the boom drive in its down direction. A pilot light is provided to indicate this condition. A tool pressure interlock interrupts the air supply to the operating cylinders whenever the tool is supporting the weight of the component. Pilot lights are provided to show the loaded and unloaded condition of the tool.

A universal joint is provided in the upper tool section to allow some freedom of movement in alignment during coupling, lifting, lowering or discharging operations. The tool is 6 ft long and is designed for a maximum static load of 5,000 lb.

Vapor Container Polar Crane

The polar crane is designed primarily to lift the various pieces of equipment which comprise the main coolant system within the vapor container. During the refueling operations, the polar crane removes and replaces the control rod shield and supports, control rod drive ventilation duct work, the reactor vessel head, guide tube hold-down and support plates, the upper core support barrel and upper core support plate. The crane consists of a bridge riding on a 75 ft diam crane rail and a common trolley containing 2 hooks. Each hook has a 75 ton capacity with 25% overload and can operate at maximum speeds of 5 fpm at 75 ton capacity or 15 fpm maximum speed when the load is 20 tons or less. The maximum trolley speed is 40 fpm and the bridge 60 fpm. Each hoist is driven by a compound wound direct current motor to allow for better control and the dual speed.

Reactor Vessel Head Lifting Device

This device is designed to remove the reactor pressure vessel head remotely. It consists of welded and bolted structural steel members with suitably mounted and located lugs which enable the polar crane operator to lift the attached head and device and place it on the cavity floor, for storing during the refueling operation. The head is guided by 4 guide studs screwed into stud bolt holes, so that the vessel head is guided in a level manner while being raised above the control rod drive shafts. The device is designed to lift the vessel head load of approximately 50 tons.

Plate and Barrel Handling Device

This device is designed to remove the reactor vessel core plates and barrels remotely. The base plate of this device is a weldment having the shape of a circular ring. Air operated latching pins are mounted on this ring to engage and lift the internals. Each plate and barrel has 3 lifting lugs spaced to match the location of the latch pins on the fixture. Four lugs cantilevered radially outward from the ring carry guide bushings which engage the 4 reactor vessel guide studs. The device is carried by a three legged sling suspended from the main polar crane. Each leg of the sling has a turnbuckle arrangement to permit levelling the device in the field. The air line to the locking mechanism is carried up one leg of the sling to the manipulator crane.

219 MAIN AND AUXILIARY STEAM SYSTEM

Main Steam

The main steam system, shown diagrammatically on drawing No. 9699-FM-3A, conducts steam in a 14 in., Schedule 80, carbon steel pipe from each of the four steam generators within the vapor container of the primary plant through a conventional angle type nonreturn valve into a common 24 in., Schedule 60, carbon steel pipe; thence by two 18 in., Schedule 60, carbon steel pipes to the throttle valves of the turbine. The design pressure of this system is 1,035 psi gage at 550°F. A steam flow nozzle is in the 14 in. line from each steam generator downstream from the nonreturn valve to measure output of each unit.

The main steam piping has been designed to have the minimum economical pressure drop between the outlet of the steam generators and the turbine throttle, in order to have available at least 450 psi gage steam pressure at the throttle valves of the turbine for full load (145,000 kw) operation. It will operate satisfactorily under maximum turbine capability conditions when steam generator output will be about 2,400,000 lb per hr of steam.

Two 2½ by 6 safety valves are on each of the four 14 in. main steam lines, just ahead (vapor container side) of the main steam nonreturn valves. The discharge connections of these safety valves are enlarged to 12 in. branch lines entering a 24 in. vent line to the secondary stack, fabricated steel 36 in. diam and 110 ft high, for discharge to atmosphere. One safety valve in each line is set to open at 935 psi gage and the other at 985 psi gage. The total relieving capacity of these eight valves is 860,000 lb per hr.

With the addition of boron to the main coolant at power, the moderator temperature coefficient is reduced. This raises the inherent steaming capacity of the system, and more safety valve capacity is required by the ASME code. Four additional valves will be added during the second refueling, one to each 14" main steam line. This will raise the total relieving capacity at the design pressure to 3,240,000 lbs/hour, which is well above the requirements of Core III, and is expected to be sufficient for any operating condition likely to be encountered during the life of the plant.

The safety valves are capable of preventing overpressure in the steam generator shells by relieving the steam generated by the nuclear core at steam blowing pressure and temperature in the following cases:

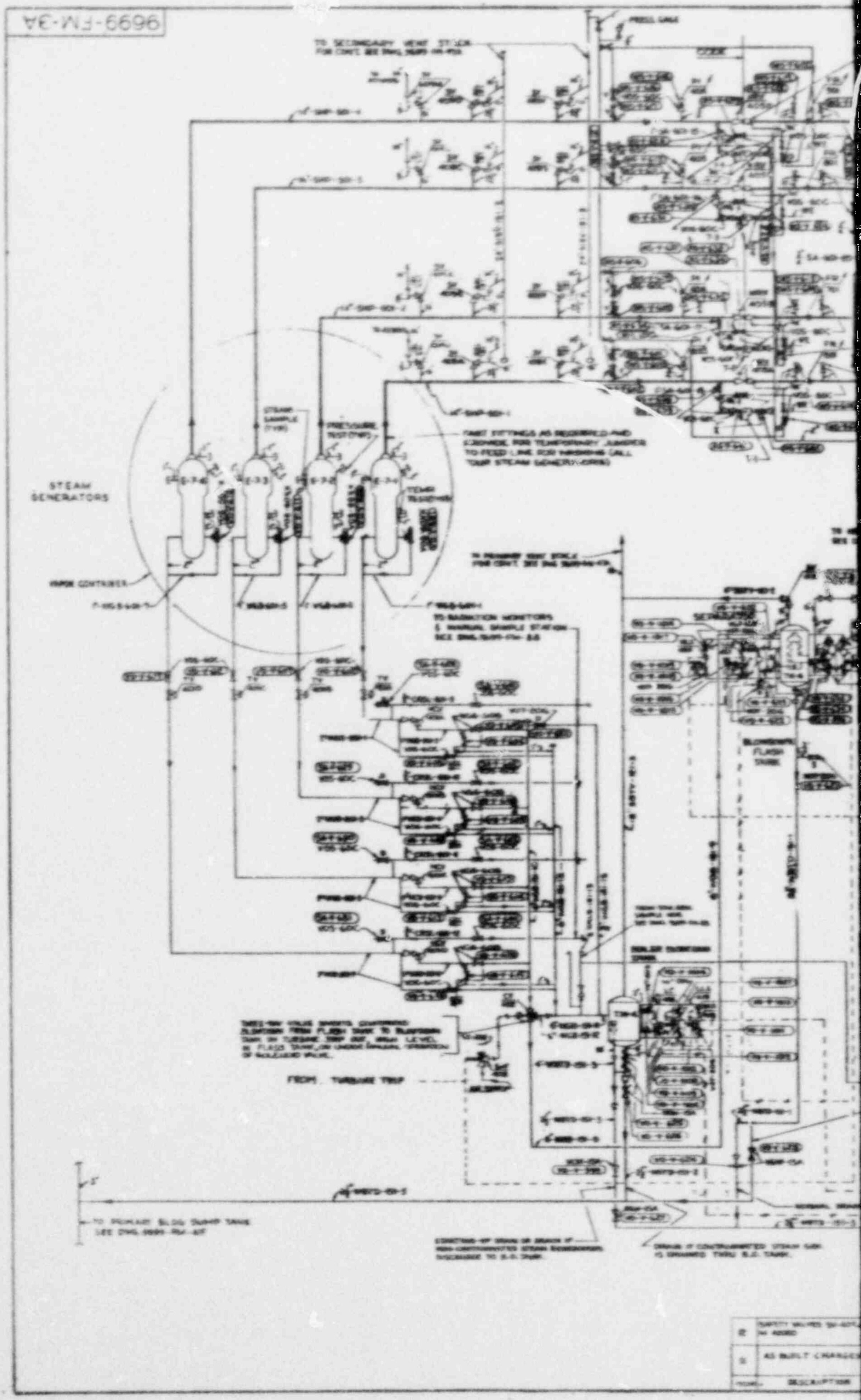
Turbine throttle trip without reactor scram or control rod insertion

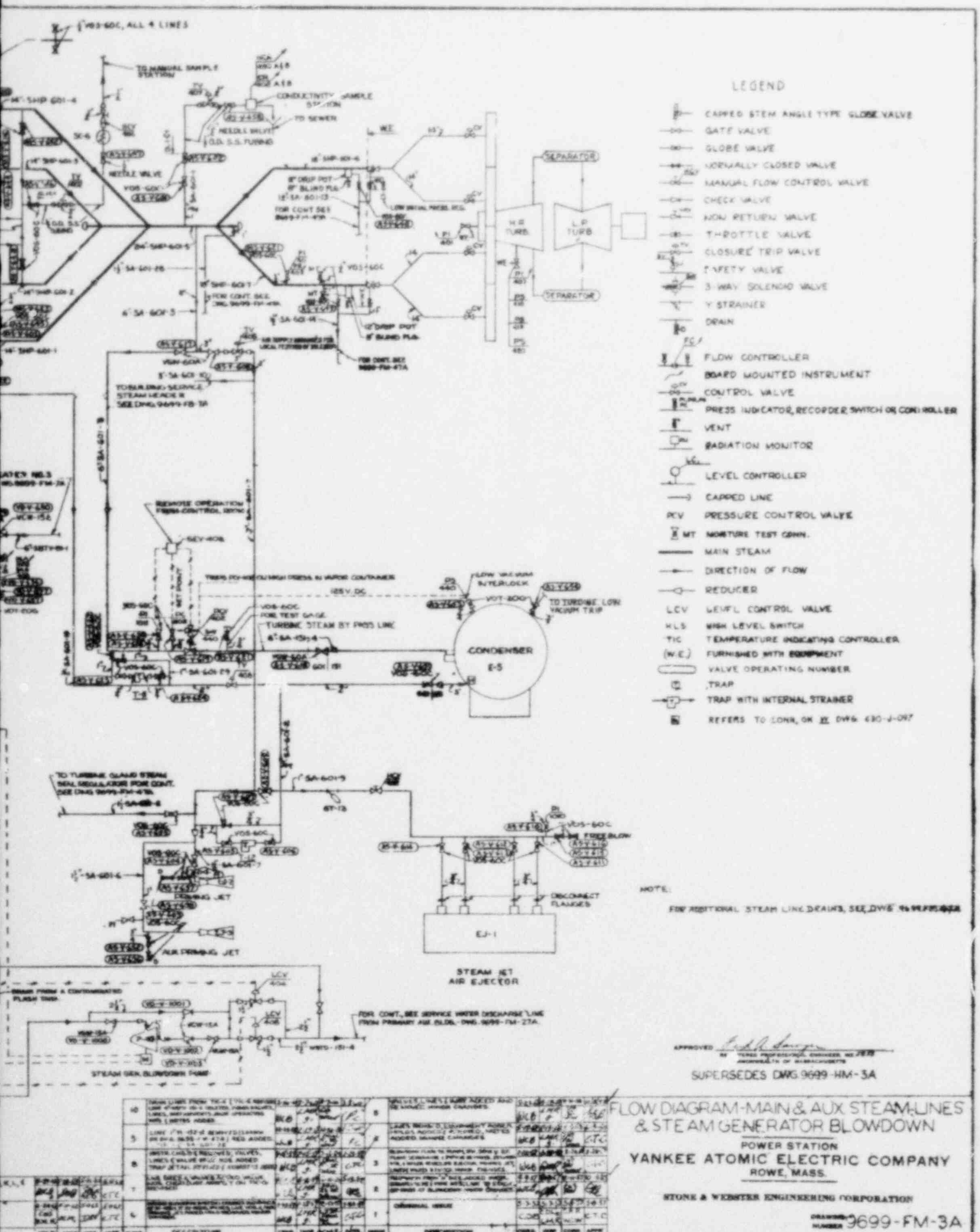
Failure or loss of steam condenser vacuum or turbine steam by-pass line during hot standby or shutdown of the main coolant system

Trapped drains from above the seat of each nonreturn valve and from a 12 in. drip pot on the 18 in. lines just before the turbine throttle valves flow to the condenser. One of these drip pots also receives drains from the 24 in. section of the main steam line.

Auxiliary Steam

Auxiliary steam piping, shown on the flow diagram drawing No. 9699-FM-3A, comprises two branch lines from the main steam piping: one to the air ejector unit priming jets and building heating system and one to the condenser which provides means for by-passing the turbine through the steam by-pass line when necessary.


9699-FM-3A
STEAM GENERATORS
FROM TURBINE TRIP
AS BUILT CHANGES
DESCRIPTION


LEGEND
CAPPED STEM ANGLE TYPE GLOBE VALVE
GATE VALVE
GLOBE VALVE
NORMALLY CLOSED VALVE
MANUAL FLOW CONTROL VALVE
CHECK VALVE
NON RETURN VALVE
THROTTLE VALVE
CLOSURE TRIP VALVE
SAFETY VALVE
3-WAY SOLENOID VALVE
Y STRAINER
DRAIN
FLOW CONTROLLER
BOARD MOUNTED INSTRUMENT
CONTROL VALVE
PRESS INDICATOR, RECORDER, SWITCH OR CONTROLLER
VENT
RADIATION MONITOR
LEVEL CONTROLLER
CAPPED LINE
PCV PRESSURE CONTROL VALVE
MT MOISTURE TEST CONN.
MAIN STEAM
DIRECTION OF FLOW
REDUCER
LCV LEVEL CONTROL VALVE
HLS HIGH LEVEL SWITCH
TIC TEMPERATURE INDICATING CONTROLLER
(W.E.) FURNISHED WITH EQUIPMENT
VALVE OPERATING NUMBER
TRAP
TRAP WITH INTERNAL STRAINER
REFERS TO CONN. ON W DWG 630-J-097
TO MANUAL SAMPLE STATION
CONDUCTIVITY SAMPLE STATION
TO SEWER
NEEDLE VALVE
SEPARATOR
H.P. TURB.
L.P. TURB.
CONDENSER E-5
LOW VACUUM INTERLOCK
TO TURBINE LOW VACUUM TRIP
REMOTE OPERATION FROM CONTROL ROOM
TURBINE STEAM BY PASS LINE
TO BUILDING SERVICE STEAM HEADER
STEAM JET AIR EJECTOR
EJ-1
DISCONNECT FLANGES
PRIMING JET
AIR PRIMING JET
STEAM GEN. BLOWDOWN PUMP
FOR CONT. SEE SERVICE WATER DISCHARGE LINE FROM PRIMARY AUX. BLDG. DWG. 9699-FM-27A.
NOTE:
FOR ADDITIONAL STEAM LINE DRAINS, SEE DWG 9699-FM-
APPROVED
SUPERSEDES DWG. 9699-HM-3A
FLOW DIAGRAM-MAIN & AUX. STEAM LINES & STEAM GENERATOR BLOWDOWN
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NUMBER 9699-FM-3A
DESCRIPTION
ORIGINAL ISSUE

On a large loss of water accident in the main coolant system, when normal pressure in the vapor container is exceeded, a trip valve in the branch line to the building heating system and condenser auxiliaries and the turbine steam by-pass control valve in the other branch line will close automatically.

Trapped drains from the steam lines to the priming jet and from the steam dump line are piped to the condenser.

Extraction Steam

Steam from extraction openings in the turbine casing is piped to the closed feed-water heaters through lines appearing on drawing No. 9699-FM-7A, Flow Diagram - Extraction Steam, Feed-water Heater Vent & Drain Lines, included under Section 220. The first point (high pressure) heater is supplied with steam from the high pressure section of the turbine. The second point (intermediate pressure) heater is supplied with steam from the exhaust of the high pressure section of the turbine ahead of the moisture separators. The third point (low pressure) heater is supplied with steam from the low pressure section of the turbine by piping connections leading from the turbine casing out through the condenser neck, also by steam flashed from steam generator blowdown.

The first point (high pressure) heater shell is vented through an orifice to the shell of the second point heater, or, by opening a normally closed valve in a branch line, the vent connection is opened to the condenser. Similarly the second point (intermediate pressure) heater is normally vented to the shell of the third point heater but can also be vented to the condenser. The third point (low pressure) heater is vented to the condenser.

Shell safety valves of all three heaters and the drain cooler discharge to the secondary plant vent stack.

Boiler Blowdown

Each steam generator is provided with a blowdown connection for shell solids concentration control. The blowdown may be continuous or intermittent as operating conditions require. The bottom of the steam generator shell is also provided with a drain connection which discharges into the blowdown line.

Each blowdown line includes, in addition to the necessary shutoff valves, a manually operated needle type flow control valve, HCV-401, for blowdown flow adjustment. A blowdown slip stream is taken under steam generator shell pressure from a point ahead of each flow control valve to a continuous radiation monitoring and sampling station.

Normally, blowdown from all four steam generators passes to blowdown flash tank TK-6. The flashed vapor is discharged to the turbine third point extraction line, while the unflashed liquid drain by gravity or is pumped under level control to the service cooling water line leaving the component cooling water heat exchangers. A seal is maintained in the flash tank by level control valve LCV-404 in the drain line at an elevation so that the flash tank will normally drain properly when subatmospheric pressure prevails in the turbine.

The steam generator blowoff piping is arranged so that any or all steam generators can discharge to either blowdown flash tank TK-6 or to separate blowdown tank TK-4. Shut down steam generators are normally drained into TK-4. If steam generators are blown down during the starting-up period, TK-4 is used. If blowdown water entering TK-6 becomes radioactively contaminated from a leaking steam generator to an excessive activity level, the faulty steam generator blowdown is diverted from TK-6 to TK-4, which is connected to the primary building drain tank.

The steam generator blowdown header preceding the blowdown tank is provided with an automatic 3-way diversion valve, CV-402. On high level in the blowdown flash tank or on turbine generator trip out, this valve automatically diverts the blowdown from the flash tank to the blowdown tank. The 3-way valve is provided with a manual relatching solenoid valve and an automatic reset switch. The solenoid is energized to operate the valve, and when tripped, the reset switch opens to deenergize the solenoid. The latch is manually reset in order to return the valve from the position to discharge into TK-4 to that to discharge into TK-6. Thus, having diverted the blowdown flow to the blowdown tank on turbine generator shutdown, the valve remains in this deenergized position during any long period of shutdown and until after the turbine generator has been restarted, at which time the valve is relatched, closing the reset switch and returning the flow to the blowdown flash tank.

Normally, both the blowdown and blowdown flash tanks discharge ultimately to the main condenser circulating water outlet and Sherman Pond. If either becomes excessively radioactively contaminated under unusual operating conditions, the liquid is diverted from either tank to the primary drain collecting sump, from which it can be pumped to the waste disposal system for processing. However, the capacity of the waste disposal plant to process all liquid wastes is limited to approximately 5 gpm.

The normal full load blowdown rate from four steam generators with 150 concentrations is approximately 12,500 lb per hr. The design basis is 25,000 lb per hr for four steam generators, to allow for occasional higher blowdown rates when it is desired to reduce concentration.

The blowdown flash tank is provided with a moisture separator in order to reduce to a minimum the discharge of solids entrained with moisture into the turbine. The moisture separator will produce a minimum of 98% purity with a 4,000 lb per hr vapor flow.

220 CONDENSATE AND FEED WATER SYSTEM

General

The condensate and feed water system store the condensate produced in the surface condenser, turbine moisture separators, shell sides of feed-water heaters, and trapped piping drains and conduct this condensate by means of condensate pumps, heater drain pumps, and boiler feed pumps through the channel sides of closed feed-water heaters to the steam generators in the primary plant.

The condensate and boiler feed piping systems are designed to handle the flow of condensate from all sources under conditions of maximum expected throttle flow of 2,000,000 lb per hr (157 mw load). The condensate pumps are designed to meet the same requirements, and their capacity of 1,600 gpm and TDH of 460 ft include design margins of approximately 10% in capacity and 20% in head over that required for the 145 mw rated load of the plant.

This system may be considered in sections as follows:

Condensate system

- Condenser make-up and draw-off
- Condensate pumps and discharge piping
- Heater drains
- Heater drain pumps

Feed water system

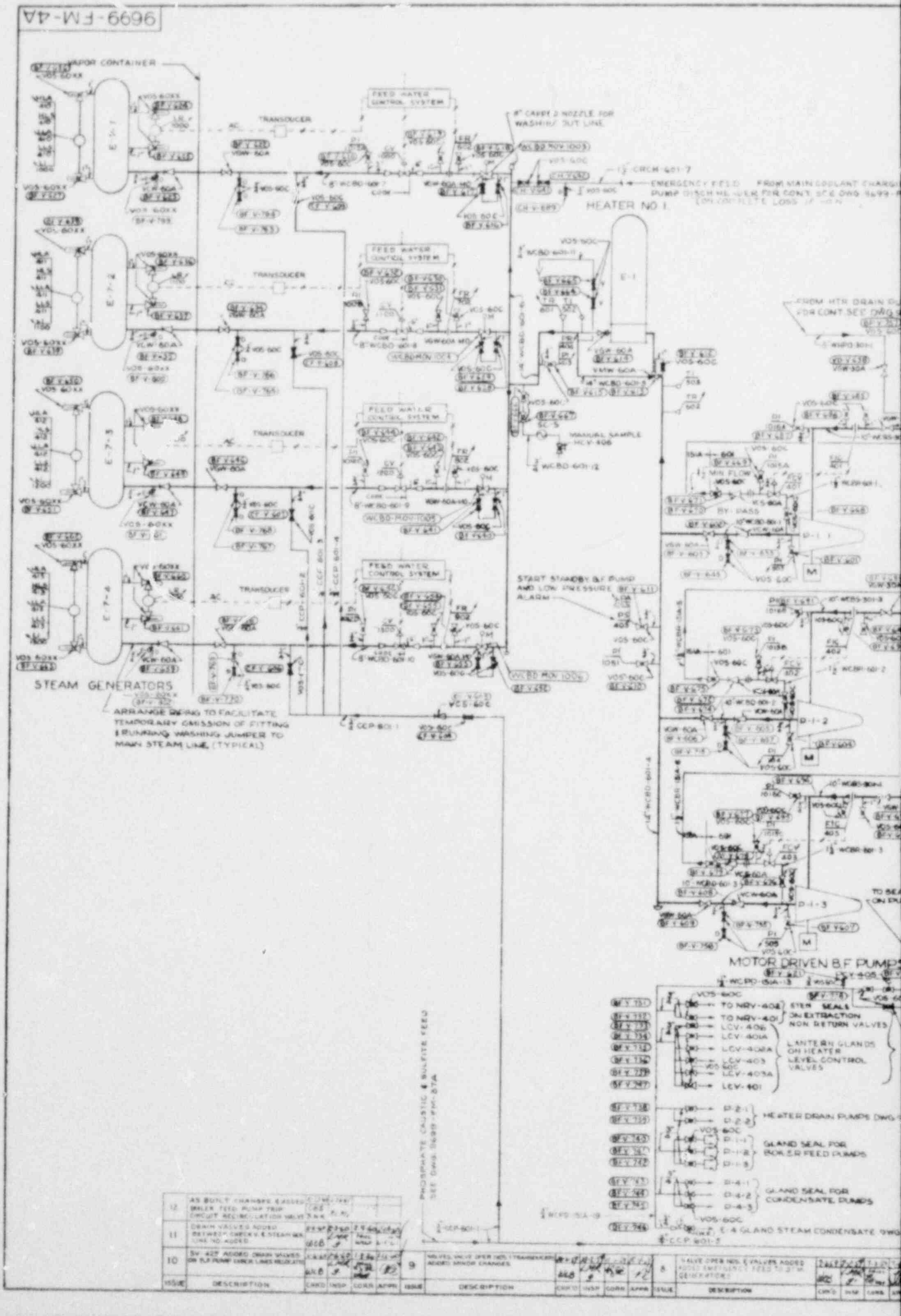
- Boiler feed pumps and discharge piping
- Boiler feed pump recirculation control
- Feed water control system

Condensate System

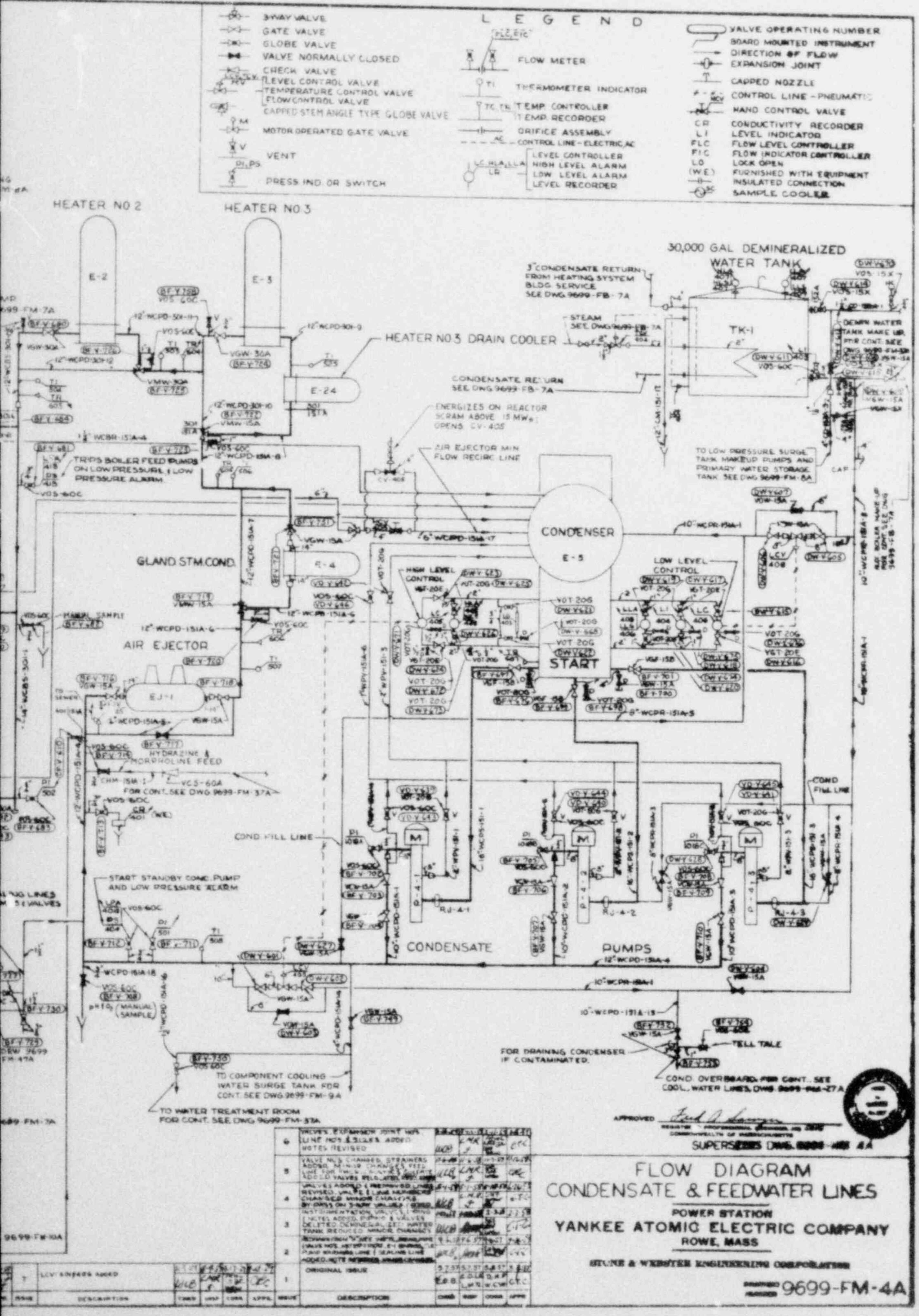
This system is shown diagrammatically on drawings Nos. 9699-FM-4A and 9699-FM-7A.

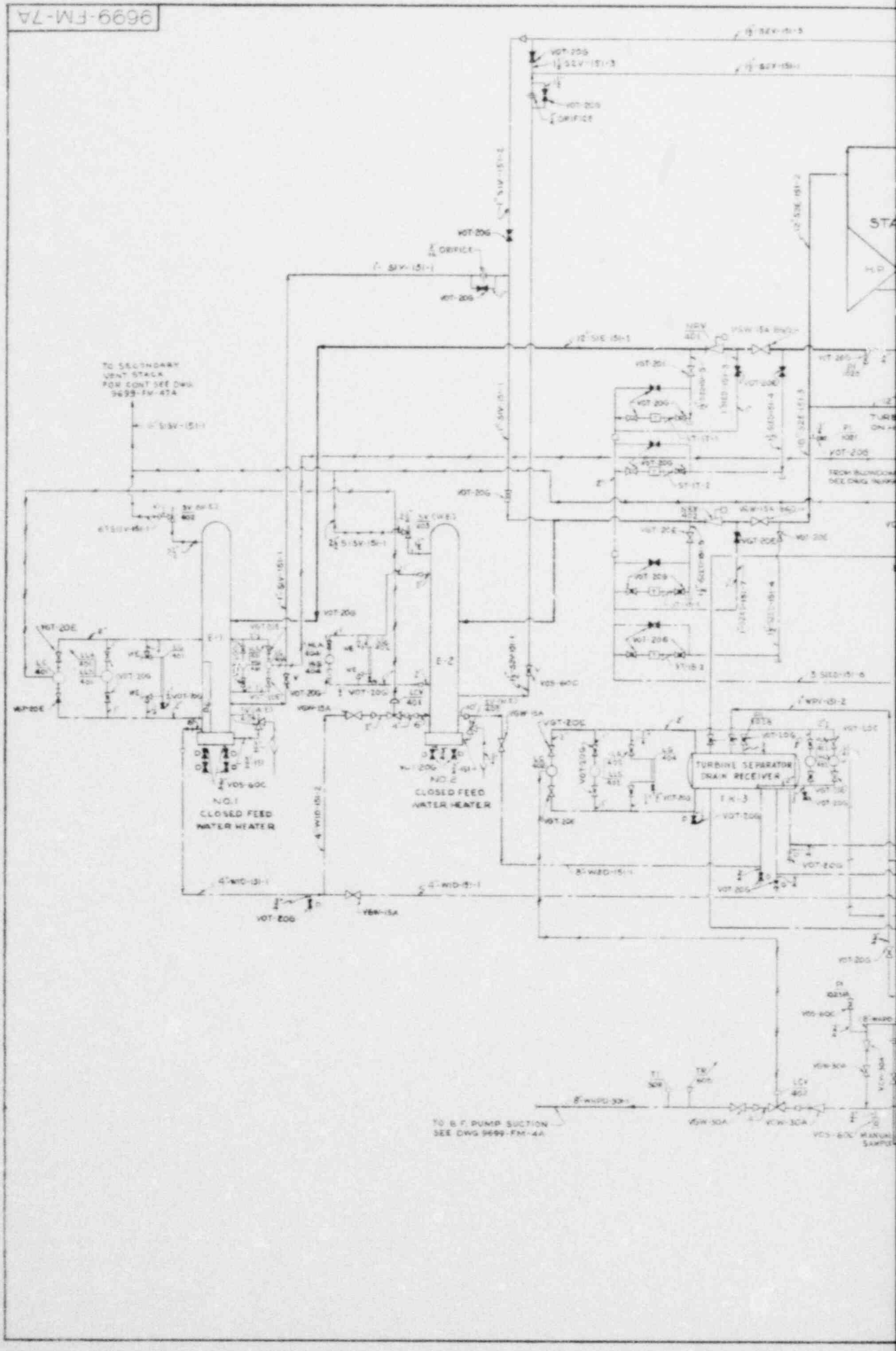
Condenser Make-up and Draw-off - The maximum allowable storage capacity of the condenser hot well is 15,000 gal (approximately 5 min supply). With normal operating water levels the storage capacity is about 10,000 gal (3 min supply). On high water level in the condenser, controller LC-405 actuates draw-off valve LCV-405 to discharge condensate from the condensate pump discharge to the 30,000 gal demineralized water tank. On low hot well level, controller LC-406 actuates make-up valve LCV-406 permitting water to flow into the condenser from the demineralized water tank.

Condensate Pumps and Discharge Piping - Three 1,600 gpm, vertical centrifugal, pit type pumps take suction by individual 16 in. lines from the bottom of the condenser hot well and discharge through the air ejector, gland steam condenser, third point heater drain cooler, third point heater, and second point heater to the suction header of the boiler feed pumps. Manually operated 3-way by-pass valves are provided in the 12 in. condensate line to permit by-passing the gland steam condenser, the third point heater and drain cooler, or the second point heater.

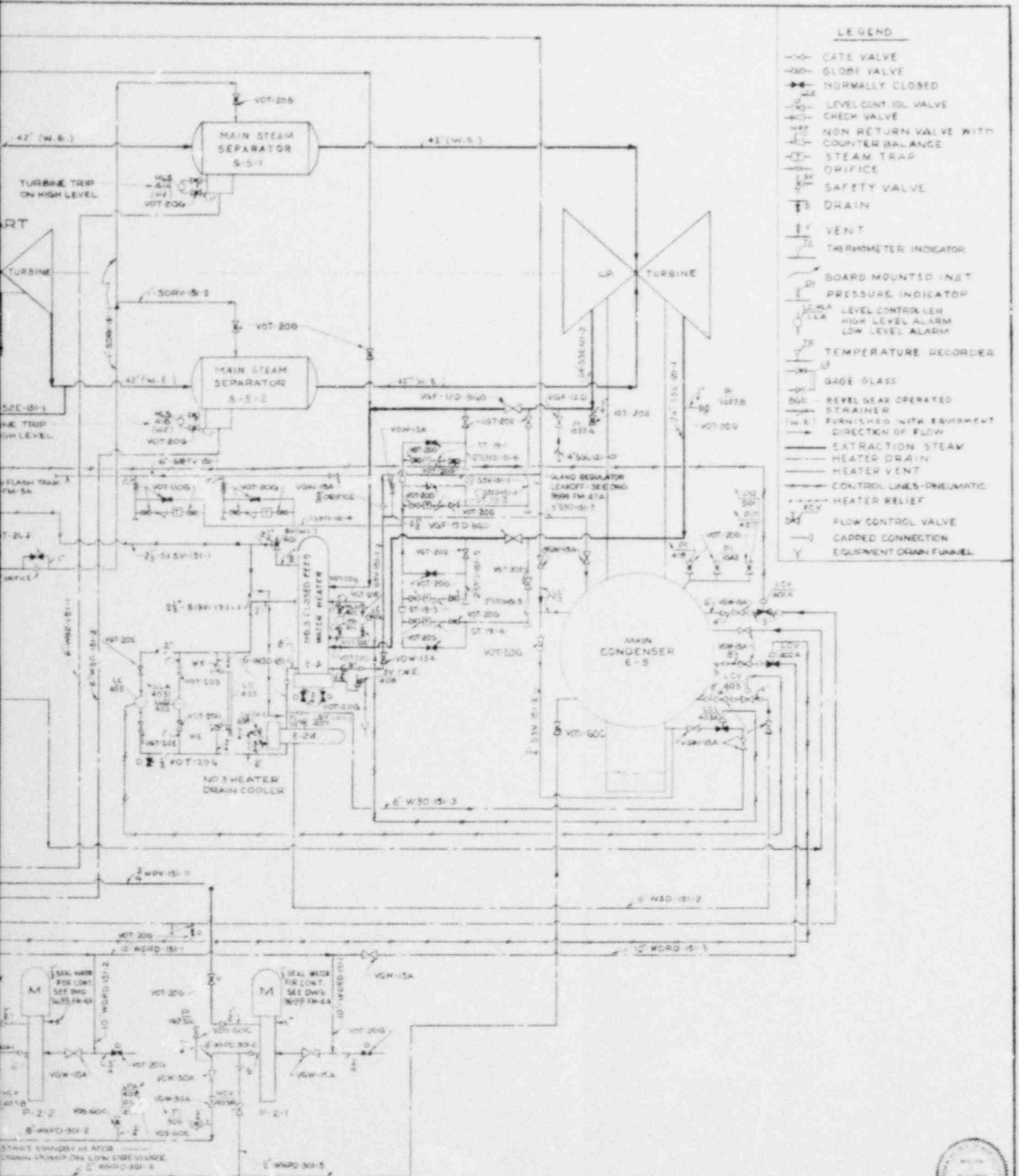


9699-FM-4A
VAPOR CONTAINER
E-7-1
E-7-2
E-7-3
E-7-4
STEAM GENERATORS
TRANSDUCER
FEED WATER CONTROL SYSTEM
8" CARRY 2 NOZZLE FOR WASHING OUT LINE
EMERGENCY FEED FROM MAIN COOLANT CHARGING PUMP DISCHARGE
HEATER NO 1
E-1
MANUAL SAMPLE HCV-406
START STANDBY B.F. PUMP AND LOW PRESSURE ALARM
ARRANGE PIPING TO FACILITATE TEMPORARY OMISSION OF FITTING & RUNNING WASHING JUMPER TO MAIN STEAM LINE (TYPICAL)
FROM HTR DRAIN
MIN FLOW
BY-PASS
P-1-1
P-1-2
P-1-3
MOTOR DRIVEN B.F PUMPS
TO NRV-402
TO NRV-401
STEM SEALS ON EXTRACTION NON RETURN VALVES
LCV-406
LCV-401A
LCV-402A
LCV-403
LCV-403A
LCV-401
LANTERN GLANDS ON HEATER LEVEL CONTROL VALVES
P-2-1
P-2-2
HEATER DRAIN PUMPS
GLAND SEAL FOR BOILER FEED PUMPS
P-4-1
P-4-2
P-4-3
GLAND SEAL FOR CONDENSATE PUMPS
E-4 GLAND STEAM CONDENSATE
PHOSPHATE CAUSTIC & SULFITE FEED SEE DWG 9699-FM-87A
ISSUE
DESCRIPTION
CHK'D
INSP
CORR
APPR


LEGEND
3-WAY VALVE
GATE VALVE
GLOBE VALVE
VALVE NORMALLY CLOSED
CHECK VALVE
LEVEL CONTROL VALVE
TEMPERATURE CONTROL VALVE
FLOW CONTROL VALVE
CAPPED STEM ANGLE TYPE GLOBE VALVE
MOTOR OPERATED GATE VALVE
VENT
PRESS. IND. OR SWITCH
FLOW METER
THERMOMETER INDICATOR
TEMP. CONTROLLER
TEMP. RECORDER
ORIFICE ASSEMBLY
CONTROL LINE - ELECTRIC, AC
LEVEL CONTROLLER
HIGH LEVEL ALARM
LOW LEVEL ALARM
LEVEL RECORDER
VALVE OPERATING NUMBER
BOARD MOUNTED INSTRUMENT
DIRECTION OF FLOW
EXPANSION JOINT
CAPPED NOZZLE
CONTROL LINE - PNEUMATIC
HAND CONTROL VALVE
CR CONDUCTIVITY RECORDER
LI LEVEL INDICATOR
FLC FLOW LEVEL CONTROLLER
FIC FLOW INDICATOR CONTROLLER
LO LOCK OPEN
(W.E.) FURNISHED WITH EQUIPMENT
INSULATED CONNECTION
SAMPLE COOLER
HEATER NO 2
HEATER NO 3
E-2
E-3
HEATER NO 3 DRAIN COOLER
E-24
30,000 GAL DEMINERALIZED WATER TANK
TK-1
3" CONDENSATE RETURN FROM HEATING SYSTEM BLDG. SERVICE SEE DWG. 9699-FB-7A
STEAM SEE DWG. 9699-FB-7A
CONDENSATE RETURN SEE DWG. 9699-FB-7A
ENERGIZES ON REACTOR SCRAM ABOVE 15 MW OPENS CV-405
AIR EJECTOR MIN FLOW RECIRC LINE
TRIPS BOILER FEED PUMPS ON LOW PRESSURE & LOW PRESSURE ALARM
TO LOW PRESSURE SURGE TANK MAKEUP PUMPS AND PRIMARY WATER STORAGE TANK. SEE DWG 9699-FM-8A
CONDENSER
E-5
START
GLAND STM. COND.
E-4
HIGH LEVEL CONTROL
LOW LEVEL CONTROL
AIR EJECTOR
EJ-1
HYDRAZINE & MORPHOLINE FEED
FOR CONT. SEE DWG. 9699-FM-37A
COND. FILL LINE
START STANDBY COND. PUMP AND LOW PRESSURE ALARM
CONDENSATE PUMPS
P-4-1
P-4-2
P-4-3
COND FILL LINE
FOR DRAINING CONDENSER IF CONTAMINATED.
TELL TALE
TO COMPONENT COOLING WATER SURGE TANK FOR CONT. SEE DWG 9699-FM-9A
TO WATER TREATMENT ROOM FOR CONT. SEE DWG. 9699-FM-37A
COND. OVERBOARD. FOR CONT. SEE COOL. WATER LINES DWG 9699-FM-27A
APPROVED
SUPERSEDES DWG.
FLOW DIAGRAM
CONDENSATE & FEEDWATER LINES
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS
STONE & WEBSTER ENGINEERING CORPORATION
9699-FM-4A
ORIGINAL ISSUE
ISSUE
DESCRIPTION



NO.1
CLOSED FEED
WATER HEATER
NO.2
CLOSED FEED
WATER HEATER
TURBINE SEPARATOR
DRAIN RECEIVER
TO SECONDARY
VENT STACK
FOR CONT SEE DWG
9699-FM-47A
TO B.F. PUMP SUCTION
SEE DWG 9699-FM-4A


LEGEND
GATE VALVE
GLOBE VALVE
NORMALLY CLOSED
LEVEL CONTROL VALVE
CHECK VALVE
NON RETURN VALVE WITH COUNTER BALANCE
STEAM TRAP
ORIFICE
SAFETY VALVE
DRAIN
VENT
THERMOMETER INDICATOR
BOARD MOUNTED INST.
PRESSURE INDICATOR
LEVEL CONTROLLER
HIGH LEVEL ALARM
LOW LEVEL ALARM
TEMPERATURE RECORDER
GAGE GLASS
BEVEL GEAR OPERATED
STRAINER
FURNISHED WITH EQUIPMENT
DIRECTION OF FLOW
EXTRACTION STEAM
HEATER DRAIN
HEATER VENT
CONTROL LINES-PNEUMATIC
HEATER RELIEF
FLOW CONTROL VALVE
CAPPED CONNECTION
EQUIPMENT DRAIN FUNNEL
MAIN STEAM SEPARATOR S-5-1
MAIN STEAM SEPARATOR S-5-2
TURBINE TRIP ON HIGH LEVEL
L.P. TURBINE
MAIN CONDENSER E-5
NO. 5 CLOSED FEED WATER HEATER
NO. 5 HEATER DRAIN COOLER
E-24
GLAND REGULATOR LEAKOFF - SEE DWG. 9699-FM-47A
P-2-2
P-2-1
HEATER DRAIN PUMPS
START STANDBY HEATER DRAIN PUMP ON LOW PRESSURE
SUPERSEDES DWG. 9699-HM-7A
APPROVED
FLOW DIAG. EXTRACTION STEAM F.W. HEATER VENT & DRAIN LINES
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NUMBER 9699-FM-7A
ORIGINAL ISSUE

In order to maintain suitable vacuum in the gland leak-off condenser and air ejector at light loads, condensate is recirculated under normal control back to the condenser hot well in amounts up to 800 gpm.

The 250 hp condensate pump motors are controlled by 2,400 v air circuit breakers having 125 v d-c control and located in the 2,400 v station service switchgear. Operation of the circuit breakers is controlled from the turbine panel of the main control board, turbine section. The switches may be set in "Close", "Auto", or "Trip" positions with red, green, and amber lights to indicate running, stopped, and overload trip, respectively. No local controls are provided at the pumps. When the control switch is in the "Auto" position, the pump is on standby and will be started automatically on low pressure in the condensate pump discharge header. This action is initiated by pressure switch PS-404 set to close at approximately 175 psi gage which will cause a standby pump to start and annunciate that a low discharge pressure has occurred. Once started, the standby pump continues to run until the control switch is turned to the "Trip" position or relay action trips the circuit breaker.

When the control switch is in the "Close" position, the pump starts irrespective of discharge header pressure and, as in the case of "Auto" operation, will continue to run until the control switch is turned to the "Trip" position or relay action trips the circuit breaker. Normally, one or two pumps run continuously with the third pump on standby (control switch in "Auto" position) to operate as described in the previous paragraph.

<u>Heater Drains</u> - The first point closed feed-water heater drains normally flow to the shell of the second point heater but on high level in the heater shell flow to the condenser. The normal condensate level in the first point heater is maintained by level control LC-401 actuating valve LCV-401 at the drain inlet to the second point heater to ensure that the integral drain cooler is full of water at all operating conditions. On high level in the first point heater, level controller LC-401A actuates valve LCV-401A at the condenser permitting first point heater drains to flow directly to the condenser. A gage glass and high and low water level alarms are provided.

The second point heater drains flow by gravity to the turbine separator drain receiver. On the second point heater shell are a gage glass and high level alarm.

There are also discharged to the drain receiver approximately 170,000 lb per hr of drains from the moisture separators in the main steam crossover pipes between the high pressure and low pressure cylinders of the turbine. Since the drain receiver shell is vented to the separators, gravity flow of drains from the second point heater will be influenced by the slight excess pressure of the separators above the pressure of the second point heater. Drain pipes from the separators and the second point heater are designed oversize to operate partially full of water.

Drains from the drain receiver are normally pumped by heater drain pumps to the boiler feed pump suction header. Normal water level is maintained by controller LC-402 actuating valve LCV-402 in the drain pump discharge line. On high water level, controller LC-402A actuates control valve LCV-402A permitting the drains to by-pass the pumps and flow directly to the condenser. Float switches for pump starting and high and low level alarms and gage glass are on the drain receiver.

On the sump of each moisture separator is a level switch HLS-414 and HLS-415, respectively, to trip the turbine and sound alarm on high water level in the separator.

Drains from the third point heater normally flow through a separate horizontal drain cooler to the condenser through control valve LCV-403 which is actuated by controller LC-403. On high water level in the third point heater, controller LC-403A actuates valve LCV-403A permitting drains from the third point heater to by-pass the drain cooler and flow directly to the condenser.

The heater drain piping is also designed to handle the flow of condensate at the 2,000,000 lb per hr throttle flow condition. Normal level control valves in the system are also designed for this rating. This includes valves LCV-401, 402, and 403. The high level control valves which control emergency flow to the condenser and the emergency lines also are sized for normal flow plus the flow from one ruptured tube in the heater in question. Included in this category are LCV-401A, 402A, and 403A.

Heater tube sides are provided with a relief valve to protect against a closed-off water side with shell side heat leakage. Heater shell sides are provided with relief valves having capacity to relieve the flow from one ruptured tube (one open end, .9 orifice factor) with the differential pressure taken as the tube side shell side design pressure.

Heater Drain Pumps - Two full-size, 961 gpm, vertical turbine, pit type pumps take suction from the turbine separator moisture receiver mentioned in the previous section and discharge through a common header to the boiler feed suction header.

The total dynamic head of each heater drain pump is designed to be sufficient to discharge the drains when all three condensate pumps operate simultaneously.

The heater drain pump motors are controlled by 440 v air circuit breakers having 125 v d-c control and located in the 440 v station service switchgear. The breakers are controlled by 3-position switches marked "Close-Auto-Trip", locally mounted at the pumps. Red indicating lights are illuminated when the pumps are running. In the event of overload causing motor tripout, an annunciator alarm is initiated and an amber light is illuminated. Green lights indicate pumps not running.

Placing its switch in the "Close" position starts a pump.

Placing its switch in the "Auto" position starts a heater drain pump when heater drain pump discharge header pressure is below approximately 150 psi gage (PS-408) or when there is high level (HLS-402) in the turbine separator drain receiver. At normal high loads in the plant, one heater drain pump is required in service and the control switch for this pump will normally be in the "Close" position. The switch for the standby heater drain pump will normally be in the "Auto" position.

With the preceding switch settings, in the event of a drop in heater drain pump discharge header pressure to a pressure approximately 35 psi below normal discharge pressure, the standby heater drain pump will start automatically. With the preceding switch settings, in the event of a high level in the turbine separator drain receiver, approximately 7 1/2 in. above normal average level in the drain receiver, the standby heater drain pump will start automatically. In such cases, the standby heater drain pump will continue to run until shut down manually.

With falling level in the turbine separator drain receiver, low level switch LLS-402 will trip any running heater drain pumps out of service (at a level approximately 6 in. below normal average level) and the pump operating with its switch set at the "Close" position will be locked out of service and can only be restarted by momentary operation of the control switch to either the "Trip" or "Auto" positions. The heater drain pump operating with its switch in the "Auto" position will not be locked out of service and will be restarted automatically when the level in the turbine separator drain receiver is restored above the low level lockout by the low pressure switch in the pump discharge header.

Turning the control switch of the pump locked out of service from the "Close" position to the "Auto" position will release the lockout, but the pump will not start unless the level in the turbine separator drain receiver is at or above the high level or pressure in the discharge header is below normal. Tripout of a heater drain pump due to overload will lock the pump out of service until the control switch is momentarily turned to the "Trip" position.

Each pump has a recirculation line from the pump discharge to the condenser to maintain a minimum flow of 80 gpm when normal flow is insufficient to prevent the pump from overheating. A manual control valve and breakdown orifice are in each recirculation line. It is expected that the recirculation line will always be open. If adjusted to recirculate 80 gpm near pump shutoff, the recirculation line will handle about 53 gpm at the pump design point.

Feed Water System

This system is shown diagrammatically on drawing No. 9699-FM-4A, Flow Diagram - Condensate and Feed Water Lines, mentioned earlier in this section.

Boiler Feed Pumps and Discharge Piping - Three [illegible],160 gpm horizontal centrifugal pumps take suction through individual 10 in. lines from a 14 in. header and discharge similarly to a 14 in. main through the first point heater to the steam generators. A manually operated 3-way by-pass valve is provided to permit by-passing the first point heater. After passing through the first point heater, the 14 in. main branches into four 8 in. lines, one to each steam generator. In each branch is a motor operated gate valve, flowmeter, and feed water regulating valve. The gate valves are operated from the control room and are provided with 1 in. manually operated by-passes to be used during startup of the steam generators to maintain water level.

The 700 hp boiler feed pump motors with a service factor of 125% are controlled by 2,400 v air circuit breakers having 125 v d-c control and located in the 2,400 v station service switchgear. Operation of the circuit breakers is controlled from the boiler feed panel of the main control board, turbine section, by 3-position switches with "Close", "Auto", or "Trip" positions and with red, green, and amber lights to indicate running, stopped, and overload trip, respectively. No local controls are provided at the pumps for the main pump drives.

Normally, one or two pumps will run continuously (control switch in "Close" position) with the third pump as a standby (switch in "Auto" position) at power levels of 150 MWe and below. At power levels above 150 MWe conditions may require operation of the third pump in order to meet required steam flows while maintaining proper water levels. When a control switch is in the "Auto" position, the pump will be started automatically on low pressure in the pump discharge header due to increase in demand or failure of a running pump (action initiated by pressure switch PS-405 set at approximately 500 psi gage), provided there is sufficient pressure in the suction header to ensure that the feed water will not flash in the pump suction, as determined by pressure switch PS-415, set at approximately 95 psi gage. In the event of low suction header pressure, all boiler feed pumps are shut down (action initiated by PS-415) and prevented from restarting until pressure is restored. In the event of reactor scram above 15 MWe, all boiler feed pumps are shutdown.

Any pump started either manually when the switch is in "Close" position or automatically when the switch is in "Auto" position will continue to run until the control switch is turned to the "Trip" position or shut down automatically due to low suction pressure or overload relay action. If shutdown should occur due to loss of suction header pressure, pumps with switches in the "Auto" position would resume operation automatically when pressure is restored. If the pump control switch were in the "Close" position when shut down due to low suction header pressure, the switch must be turned to either "Auto" or "Trip" positions momentarily to reset the controlling relay. For overload or undervoltage shutdown, the control switch must be turned momentarily to the "Trip" position to reset the lockout relay.

Each pump has a shaft-driven lubricating oil pump and a motor-driven auxiliary lubricating oil pump. The auxiliary pump provides lubrication for startup and starts automatically on falling pressure at 5 psi gage and stops at 13 psi gage rising pressure. Starting of the main pump is not interlocked with the lubrication system. Although it is not necessary that the auxiliary lubricating system be operated prior to starting the main pump, except after long shutdown periods, the locally mounted push button for the auxiliary oil pump should be left in the "On" position, except when the pump is taken out of service. When the pump is returned to service, the push button should be returned to "On" and the auxiliary oil system should be checked.

The boiler feed pumps are designed to handle the total feed water required at 2,000,000 lb per hr throttle flow. Their capacity of 2,160 gpm and 1,280 TDH include design margins of approximately 9% in capacity and 20% in head over the 145 mw rated load requirements.

Due to the steam generator characteristic of rising pressure with decreasing load, the boiler feed pumps have been designed with a higher shutoff head than would be required in conventional steam plants. The normal expected no-load pressure in the steam generator is 785 psi gage (future core T_{avg}-518F), with the possibility of an additional 250 psi gage if the main steam pressure attains the steam generator shell design pressure of 1,035 psi gage following a loss of load condition. The boiler feed pumps have been designed to meet this latter condition with a shutoff head of 2,110 ft. which includes 50 psi drop across feed water control valves.

Boiler Feed Pump Recirculation Control - The boiler feed pump recirculation control system is shown on drawing No.B-5030493 and maintains a minimum flow of 33,750 lb per hr through each pump by measuring the pump suction flow and positioning an air-operated regulating valve in the recirculation line from each pump discharge.

The proportional band adjustment of the pneumatic relay adjusts the differential gap required by the system to prevent cycling, and the system provides open-closed control of each valve.

Feed Water Control System - The 3-element feed water control system provided for each of the four steam generators is shown on drawing No.E-5030434 and maintains water level by positioning the air-operated regulating valve in the feed line to each generator.

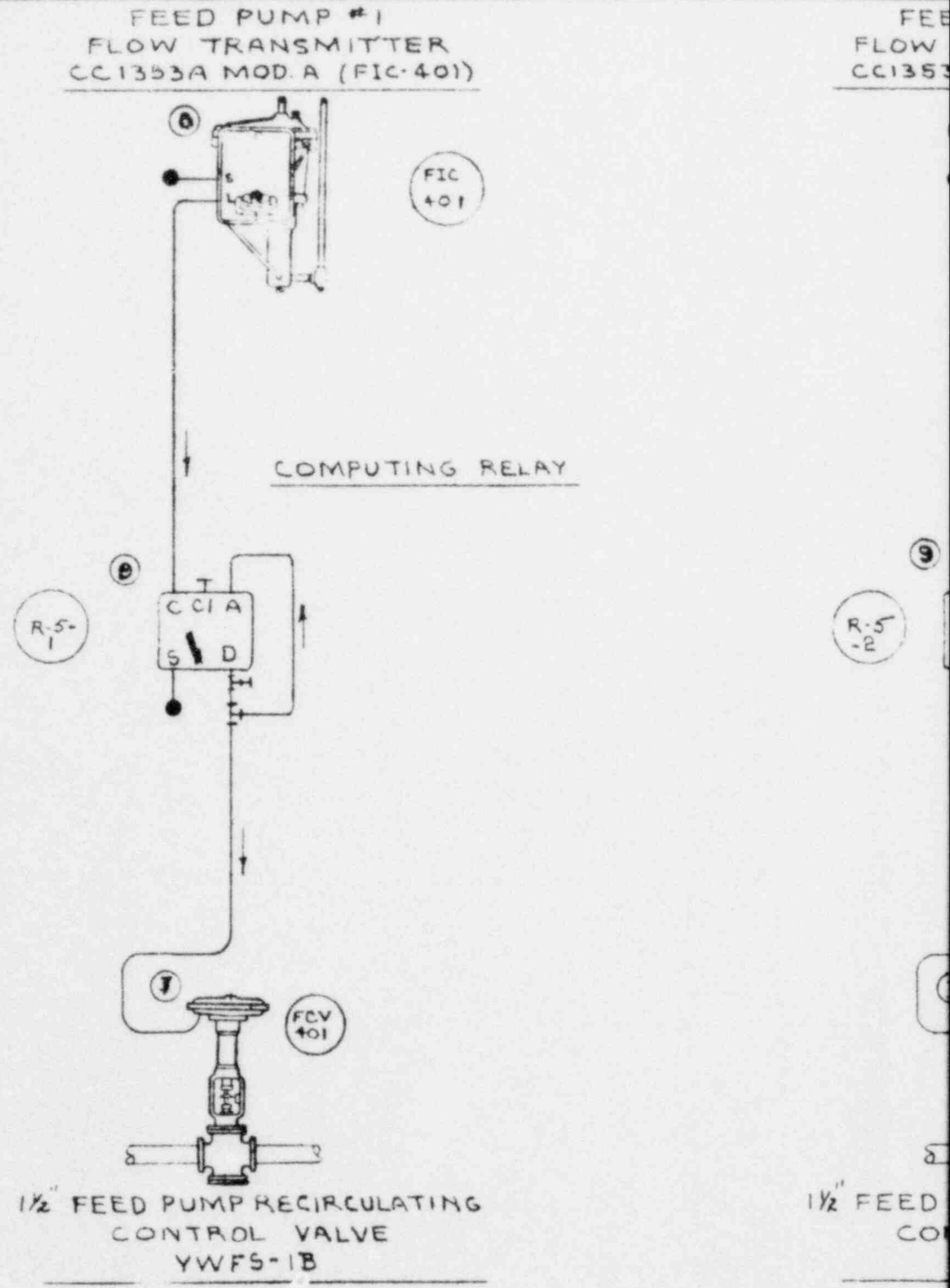
The water flow to each generator is controlled primarily from steam flow-water flow ratio with readjustment from water level in the generator.

A remote manual-automatic selector valve with remote set point adjustment of the generator water level is provided on the turbine section of the main control board for each feed water regulating valve. The set point adjustment is accomplished indirectly by adjustment of the steam flow-water flow ratio relay. Since pressure in the steam generators and steam lines varies from 755 psi gage at zero load to 450 psi at rated load, water level and steam flow measurements are pressure compensated.

Each steam generator has both a wide and narrow range level transmitter. The wide range units transmit both to level indicators adjacent to the regulating valves to aid the operators when manual valve operation is desired and to indicators on the front of the turbine section of the main control board. The narrow range level transmitters function as part of the control system and transmit both to indicators adjacent to the regulating valve and to strip chart recorders on the front of the turbine section of the main control board. The narrow range level signal also initiates a turbine throttle valve trip in the event of a coincident low water level in each of the four steam generators. On the rear of the main control board is an instrument for each steam generator to record and integrate steam flow and water flow and also one 4-pen instrument to record total steam flow, total feed water flow, steam header pressure, and feed water pressure.

Pressure switches in the air loading lines from the wide range level transmitters annunciate high and low steam generator water level.

In the event of reactor scram above 15 MW electric, a circuit is provided to trip each of the three boiler feed pumps and establish recirculation flow of condensate from the air ejector to the main condenser. This is accomplished by the turbine first stage pressure switch closing at pressures equivalent to 15 MW electric or higher and a tripout of either of the scram breakers. Such action causes appropriate relaying to function thereby tripping the pumps and opening the recirculation valve.



— FEED PUMP MINIMUM FLOW RECIR

— FOR —

—YANKEE ATOMIC ELECTRIC CO

— STONE & WEBSTER - ENGR'S

— JOB # 1183B —

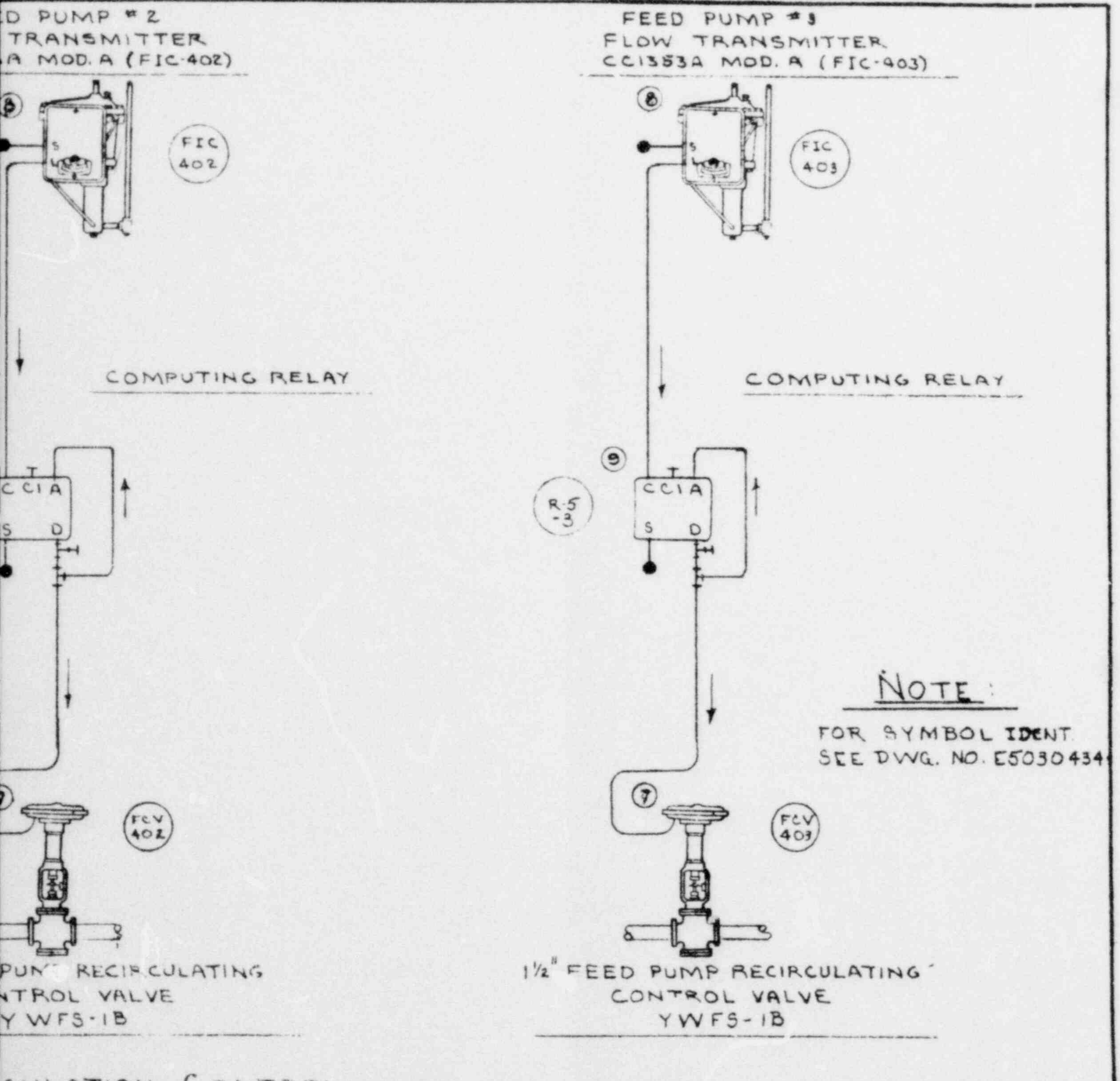
LEGEND - INSTRUMENT LOCATION

(7) LOCALLY MOUNTED

(8) LOCATED ON BOILER FEED PUMP GAGE RACK

(9) LOCALLY MOUNTED ON VALVE

FORM ED 21-357



CULATION CONTROL —

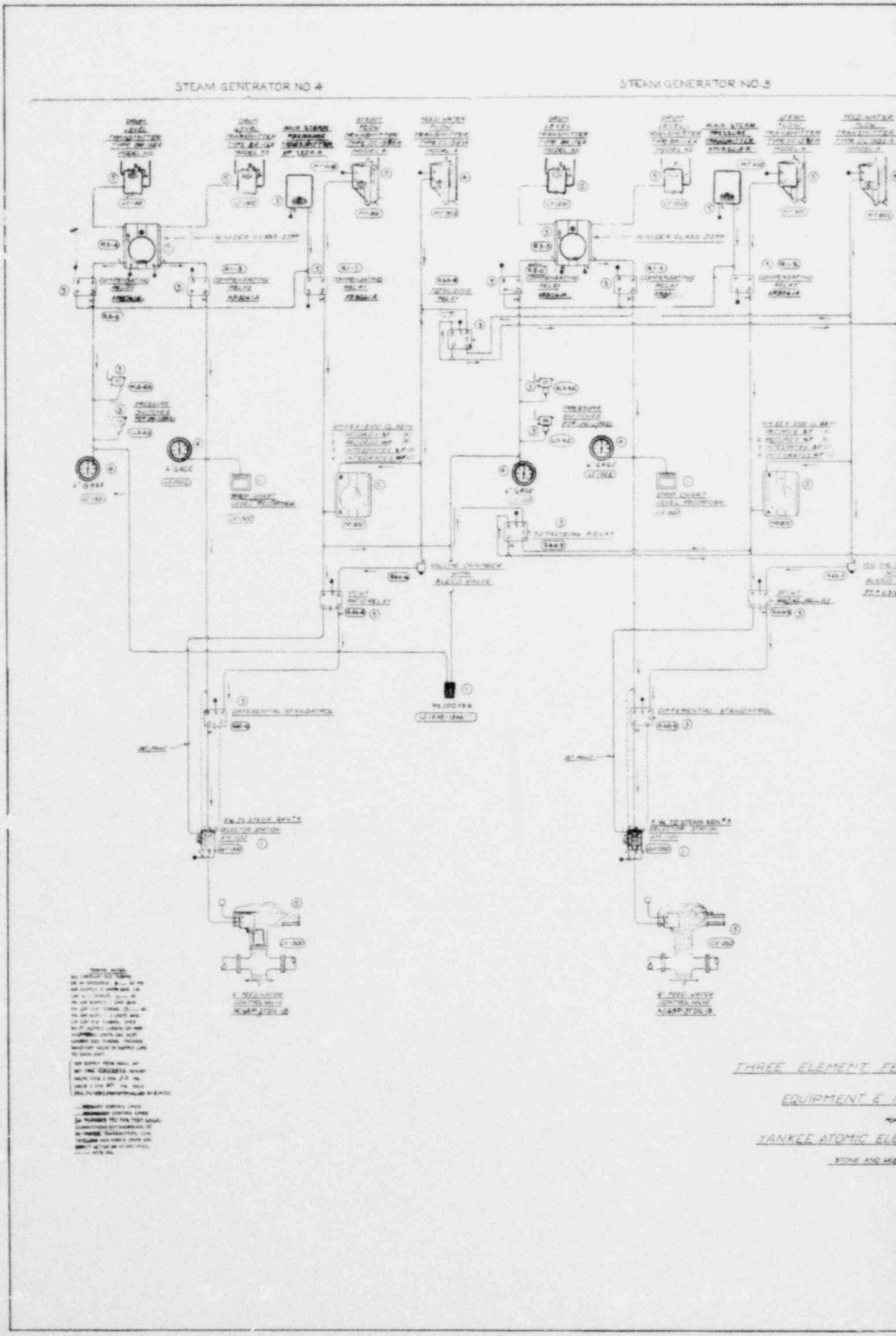
MPANY —

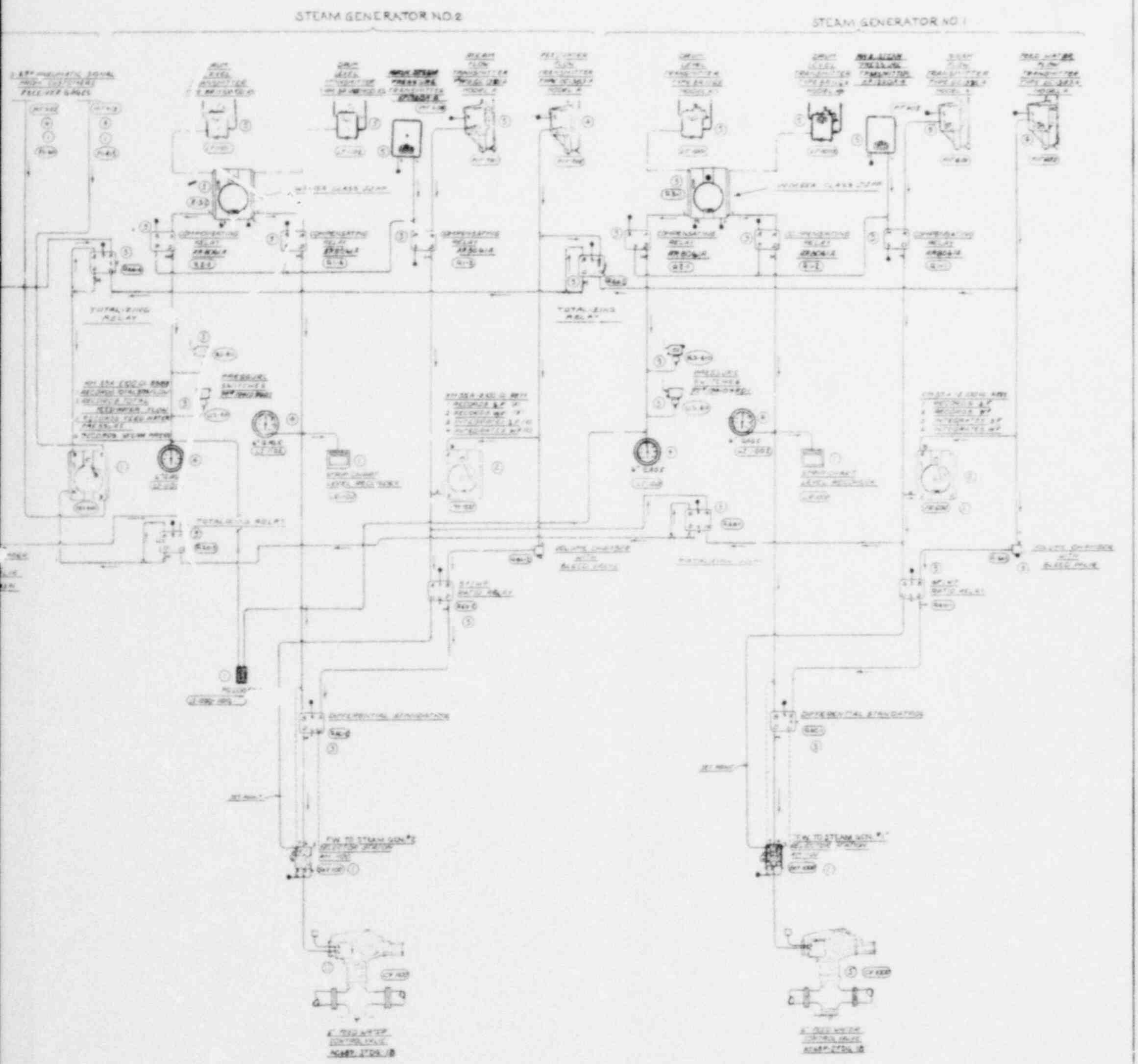
REV	DATE	CHANGE	APVD
D	3/7/59	REVISED ITEM NO'S	
C	1/6/59	ADDED INST LEGEND	
B	12/10/58	ADDED NOTE & SYMBOLS & CORRECTED FCV-403 IN	

BAILEY METER CO.
CLEVELAND, OHIO

DATE 4-24-58 | DWN T.D.M. | CHKD | APVD

B5030493-D


STEAM GENERATOR NO.4
STEAM GENERATOR NO.3
COMPENSATING RELAY
TOTALIZING RELAY
PRESSURE SWITCHES
4" GAGE
STRIP CHART LEVEL RECORDER
VOLUME CHAMBER WITH BLEED VALVE
SPLIT RATIO RELAY
DIFFERENTIAL STANDATROL
THREE ELEMENT FEE
EQUIPMENT & IN
FOR
YANKEE ATOMIC ELEC



LEGEND INSTRUMENT LOCATION

1 - FRONT PANEL MAIN CONTROL BOARD
2 - REAR PANEL MAIN CONTROL BOARD
3 - BELOW MAIN CONTROL BOARD
4 - FEEDWATER CONTROL GAGE RACK
5 - LOCALLY MOUNTED
6 - TURBINE START-UP PANEL

D WATER CONTROL

STRUMENTS

TRIC COMPANY

JOB 1858

BAILEY METER CO.

6-8-38

E-5030454-2

221 CIRCULATING WATER SYSTEM

General

The circulating water system provides cooling water for the main condenser of the secondary plant. This system is illustrated on drawings Nos. 9699-FM-10A and 9699-FM-38F, attached. The intake provides a common inlet for Sherman Pond water to the circulating water, service water, and fire pumps. Warm service water from the various cooling systems is returned to the circulating water discharge piping in the turbine room basement for return to the pond.

In addition to numerous grades of structures included in this description, the following elevations are included for general reference in connection with this system:

	Ft
General ground at plant	1,022
Circulating water pump inlet	982
Minimum operating level in pond	988
Low normal in pond	992
Average in pond	998
High normal in pond	1,002
High normal in pond (future)	1,008
Extreme high in pond	1,009
Sherman Dam	1,014
Extreme high in pond (future)	1,018
Sherman Dam (future)	1,025
Top of condenser water box	1,035.5

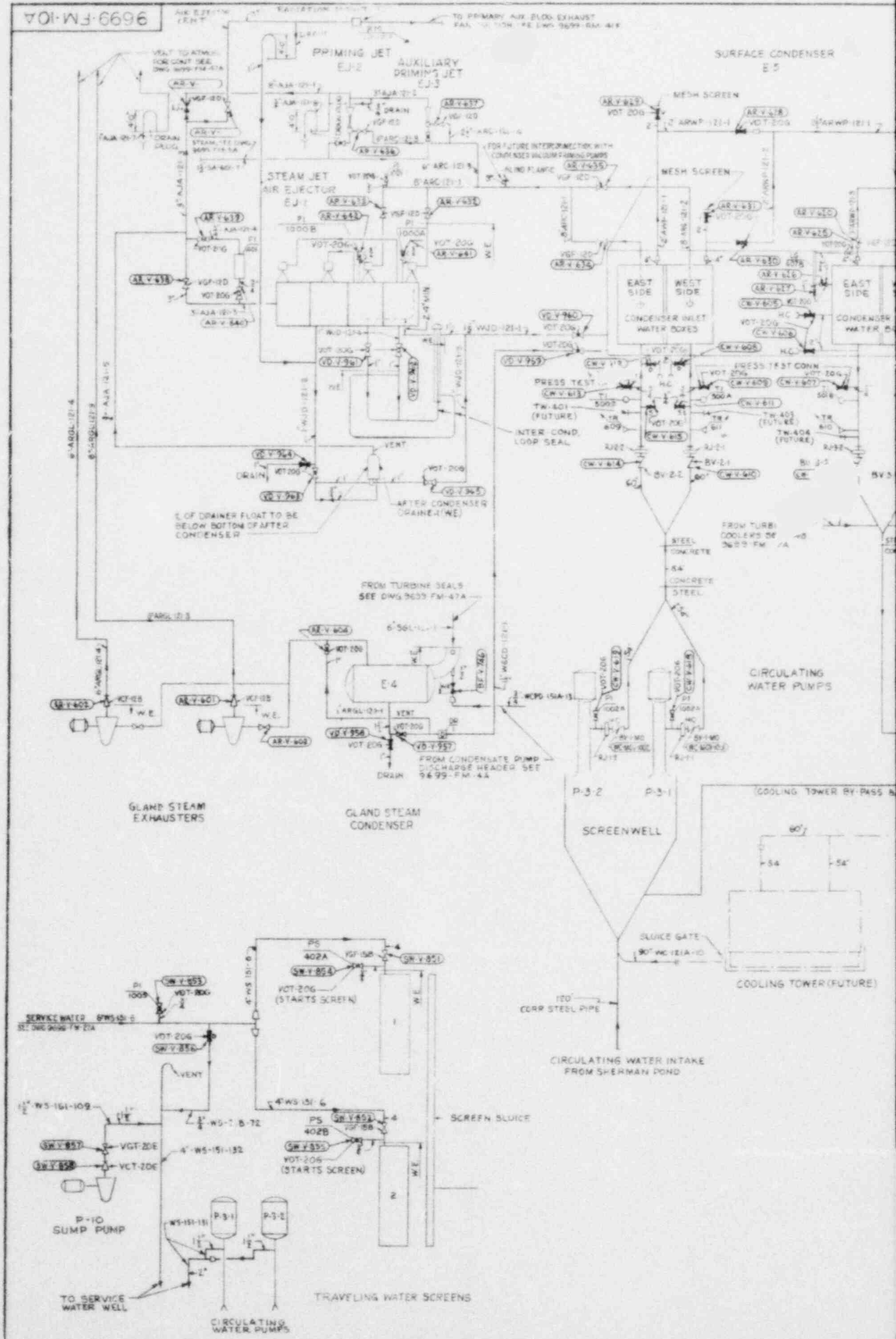
These elevations are based on New England Power Company datum which is 105.66 ft above mean sea level (U.S.G.S. datum).

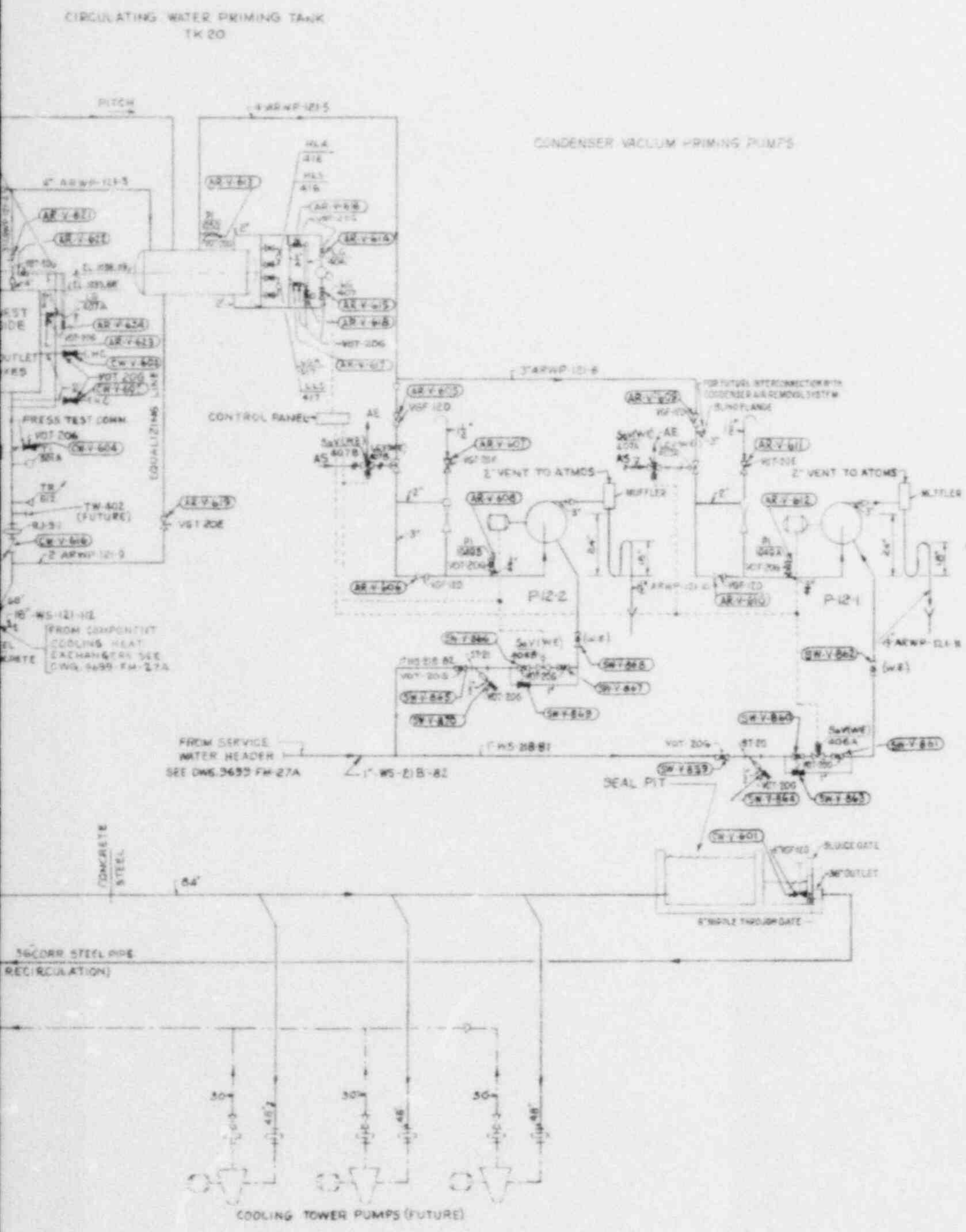
Intake and Pump House

The circulating water intake is located approximately 180 ft out from the shore of Sherman Pond with invert El. 925'. Entering through a vortex-eliminating intake, water is drawn through 120 in. corrugated steel pipe to the entrance of the concrete screen well (invert El. 976'-8"). The screen well has a divided inlet channel, in each side of which is one traveling water screen and one circulating water pump.

Pump House Structure

The screen well and pump house substructures are constructed of reinforced concrete. The pump house is a steel-framed building with concrete block walls. Hatches are provided in the roof to facilitate installation and removal of equipment, including the circulating water pumps. The circulating water pumps, service water pumps, fire pump and its pressure maintenance system are all installed on a floor at El. 1,000'.


9699-FM-10A
TO PRIMARY AUX. BLDG. EXHAUST
PRIMING JET
EJ-2
AUXILIARY
PRIMING JET
EJ-3
SURFACE CONDENSER
E-5
MESH SCREEN
STEAM JET
AIR EJECTOR
EJ-1
FOR FUTURE INTERCONNECTION WITH CONDENSER VACUUM PRIMING PUMPS
BLIND FLANGE
EAST SIDE
WEST SIDE
CONDENSER INLET WATER BOXES
PRESS TEST CONN
PRESS TEST
TW-401 (FUTURE)
TW-403 (FUTURE)
TW-404 (FUTURE)
INTER-COND. LOOP SEAL
VENT
DRAIN
AFTER CONDENSER DRAINER (WE)
℄ OF DRAINER FLOAT TO BE BELOW BOTTOM OF AFTER CONDENSER
STEEL
CONCRETE
FROM TURBINE SEALS SEE DWG. 9699-FM-47A
E-4
CIRCULATING WATER PUMPS
FROM CONDENSATE PUMP DISCHARGE HEADER SEE 9699-FM-4A
P-3-2
P-3-1
COOLING TOWER BY-PASS
GLAND STEAM EXHAUSTERS
GLAND STEAM CONDENSER
SCREENWELL
SLUICE GATE
COOLING TOWER (FUTURE)
120" CORR STEEL PIPE
CIRCULATING WATER INTAKE FROM SHERMAN POND
SERVICE WATER
VOT-206 (STARTS SCREEN)
VENT
SCREEN SLUICE
P-10 SUMP PUMP
TO SERVICE WATER WELL
TRAVELING WATER SCREENS
CIRCULATING WATER PUMPS



LEGEND

- CHECK VALVE
- GATE VALVE
- GLOBE VALVE
- VALVE NORMALLY CLOSED
- DIAPHRAGM OPERATED VALVE
- BUTTERFLY VALVE
- BUTTERFLY VALVE M.O.
- STRAINER
- EXPANSION JOINT
- DRAINER
- SAMPLE CONNECTION
- DRAIN
- VENT
- TEMPERATURE INDICATOR
- TEMPERATURE RECORDER
- PRESSURE INDICATOR (OR SWITCH)
- BOARD MOUNTED INSTRUMENT
- CAPPED LINE
- HOSE CONNECTION
- SIGHT FLOW FUNNEL
- RESTRICTION ORIFICE
- REDUCER
- DIRECTION OF FLOW
- LC LEVEL CONTROLLER
- THERMOMETER WELL
- ORIFICE
- SOLENOID OPERATED VALVE
- LCV LEVEL CONTROL VALVE
- S SAMPLE CONNECTION
- BLIND FLANGE
- (W.E.) FURNISHED WITH EQUIPMENT
- CONTROL LINES - ELECTRICAL
- CONTROL LINES - PNEUMATIC
- FUTURE
- THREE WAY SOLENOID OPERATED VALVE
- A.S. AIR SUPPLY
- A.E. AIR EXHAUST

SUPERSEDES DWG. 9699-HM-10A

ISSUE	DESCRIPTION	CHKD	INSP	CORR	APPR
7	LINES AT STEAM JET AIR EJECTOR ... DIM. INSTRUMENTS ... ADDED	[illegible]			
6	LINE SIZES & VALVE NOS./CHG'D AT AIR OFFTAKE - VALVE OPERATING NOS. & PUMPS P-10, P-11 & P-12 ADDED	[illegible]	[illegible]	[illegible]	[illegible]
5	INSTRUMENT CHANGES ... ARRGT OF VENTS TO ATMOS REVISED	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	SAMPLE ... REMOVED AIR EJECTOR DRAINS REVISED ... SCREEN WASH ... REVISED	[illegible]	[illegible]	[illegible]	[illegible]
2	REDRAWN FROM H SIZE. GENERAL REVISION	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

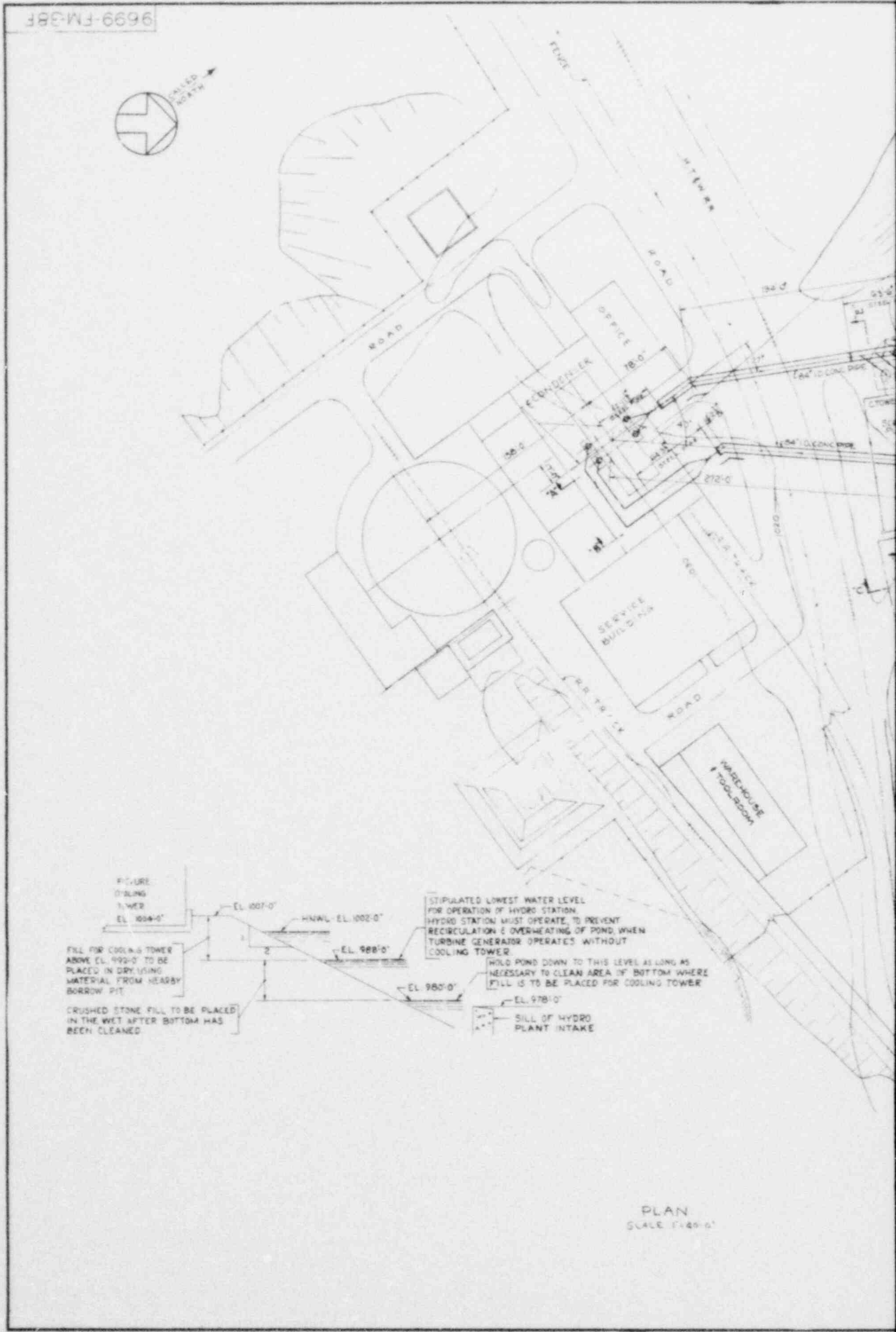
APPROVED [signature]
REGISTERED PROFESSIONAL ENGINEER NO. [illegible]
COMMONWEALTH OF MASSACHUSETTS

FLOW DIAGRAM - CIRCULATING WATER, SCREEN WASH & AIR OFFTAKE LINES

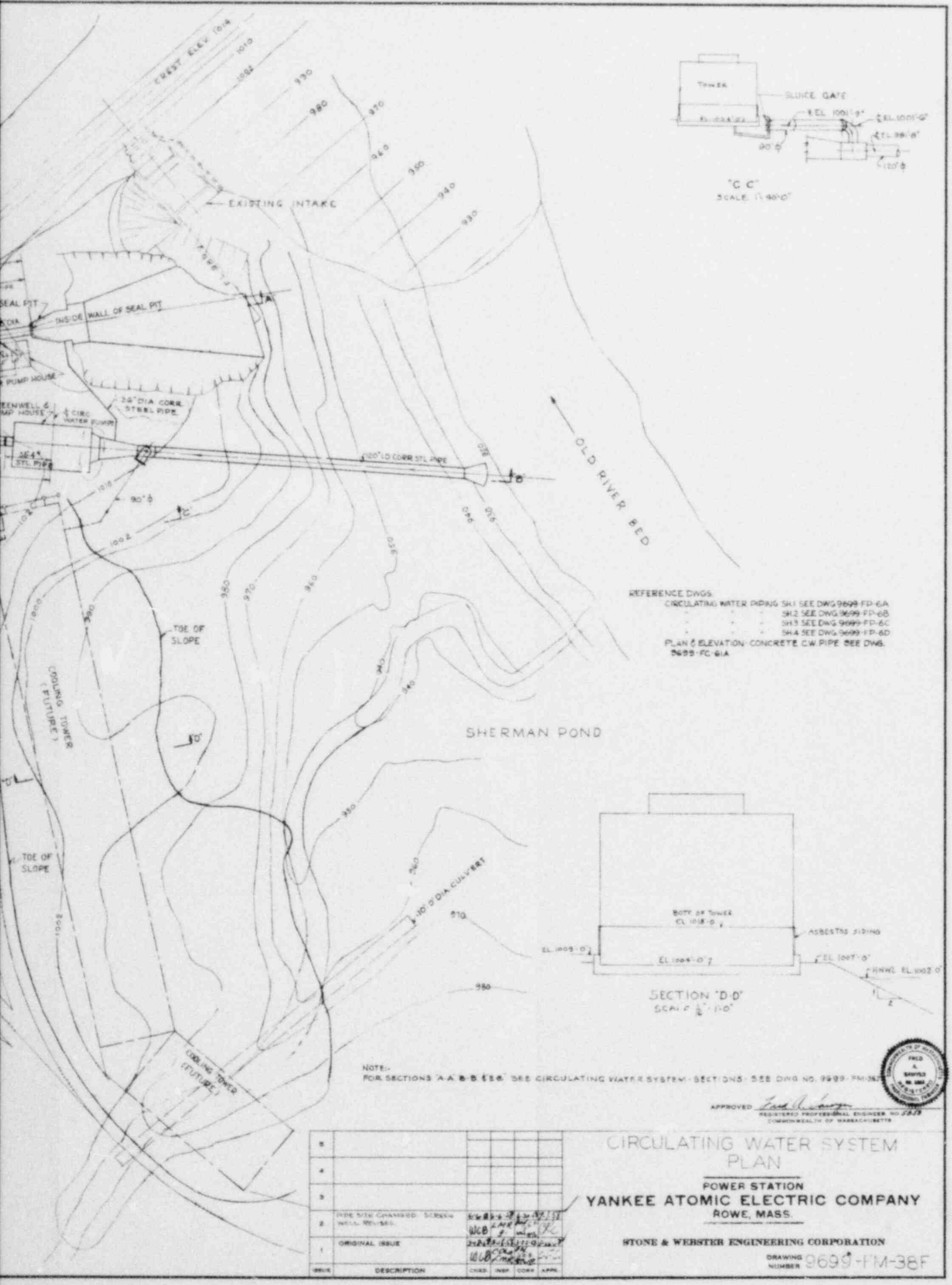
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-10A



PLAN
SCALE 1"=40'-0"


CREST ELEV 1014
EXISTING INTAKE
SEAL PIT
INSIDE WALL OF SEAL PIT
PUMP HOUSE
24" DIA CORR STEEL PIPE
120" I.D CORR STL PIPE
OLD RIVER BED
TOE OF SLOPE
COOLING TOWER (FUTURE)
SHERMAN POND
10'-0" DIA CULVERT
TOWER
SLUICE GATE
"C-C"
REFERENCE DWGS.
CIRCULATING WATER PIPING SH.1 SEE DWG 9699-FP-6A
SH.2 SEE DWG 9699-FP-6B
SH.3 SEE DWG 9699-FP-6C
SH.4 SEE DWG 9699-FP-6D
PLAN & ELEVATION CONCRETE C.W. PIPE SEE DWG. 9699-FC-61A
BOTT OF TOWER EL 1018-0
ASBESTOS SIDING
SECTION "D-D"
NOTE:-
FOR SECTIONS "A-A" "B-B" & "E-E" SEE CIRCULATING WATER SYSTEM - SECTIONS - SEE DWG NO. 9699-FM-38
APPROVED
REGISTERED PROFESSIONAL ENGINEER
COMMONWEALTH OF MASSACHUSETTS
PIPE SIZE CHANGED SCREEN WELL REVISED
ORIGINAL ISSUE
ISSUE
DESCRIPTION
CIRCULATING WATER SYSTEM
PLAN
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NUMBER 9699-FM-38F

A platform at El. 1,007'-0" permits access to the circulating water pump coupling and gland packing. The motor control center for all, except circulating water and fire pumps, is located on a balcony at El. 1,019'-0". This balcony also provides access to the traveling screen operating mechanism which is installed out-of-doors at the same elevation.

Ground grade of the land side of the pump house is at El. 1,014'-0".

Traveling Water Screens

The two traveling water screens are arranged for continuous operation and continuous flushing under local manual control. The screen wash nozzles are supplied with water from the service water pump discharge header, through a basket strainer, to a shutoff valve on each screen wash header. Operation of the driving motors is controlled by a pressure switch in each screen wash header, downstream from the shutoff valve. To operate the screens, the shutoff valves are manually opened, permitting water to pass to the screen wash nozzles. When the pressure in each header reaches the preset value (approximately 50 psi gage), the screen driving motors of both screens will start automatically.

Push button stations at the screen driving motors permit manual operation for maintenance as well as instantaneous stopping. Normal procedure for stopping each screen is to close its shutoff valve, thereby reducing pressure in the wash line below the setting of the pressure switch and causing automatic stopping of the motor.

Screen driving motors are provided with thermal overload protection and the screens are protected from overload by break-pin sprocket driving hubs.

Each screen has a capacity of 89,000 gpm of water with the pond surface at El. 992' and a submergence of 14 ft-7 in. Stop log slots are provided before each traveling screen, and a set of logs provided for each.

Circulating Water Pumps

Directly beyond the traveling screens in each circulating water inlet is a vertical, motor driven, mixed flow, circulating water pump. These pumps are expected to operate continuously, except during maintenance periods. When two pumps are operating in parallel, their capacity is 69,100 gpm each at 28.5 ft TDH. During periods of low load operation, one pump will deliver 85,000 gpm with a 19 ft TDH.

The 250 hp circulating water pump motors are fed by 2,400 v air circuit breakers having 125 v d-c control and located in the 2,400 v station service switchgear. Operation of the circuit breakers is manually controlled from the turbine panel of the main control board, turbine section. The control switches have "Close" and "Trip" positions with red, green, and amber indicating lights to denote pump running, stopped, or overload trip, respectively.

Each pump is supplied with bearing lubricating water from the service water system through an all metal edge-filtration type filter.

A concrete wall separates the circulating water pump inlets from the service and fire pump suction well at the rear of the pump house. A 3 ft by 5 ft sluice gate, manually operated from the pump house floor (El. 1,000'-0") and normally open, permits water to flow from each circulating water pump inlet chamber to the service water pump suction well. To unwater a screen and circulating pump for maintenance, stop logs are inserted ahead of the screen in question and the sluice gate in that half of the screen well closed.

Piping System

The circulating water pumps discharge through rubber expansion joints and motor operated butterfly valves to a common 84 in. concrete pipe which conducts the circulating water to the turbine room basement. These motor operated valves on the pump discharge lines are arranged to close automatically when pump power supply is shut off. Since this is a base load plant, the pumps are driven by constant speed motors.

The common pump discharge pipe divides in the turbine room basement and the flow continues through 60 in. steel pipes encased in concrete below floor level to flanged connections (above floor El. 1,022'-8") beneath the inlet water boxes of the condenser. Final connection to the condenser is made through rubber expansion joints and manually operated butterfly valves.

Divided water box construction permits one pump and one side of the condenser only to operate for brief periods during condenser cleaning operations. It is planned to clean the tubes by rubber plugging and brushing. A chlorination system is not installed for treatment of the water for bacterial slime. A condenser backwash arrangement is not provided.

Discharge Seal Pit

Circulating water from the outlet water boxes passes through butterfly valves and rubber expansion joints into 60 in. steel piping beneath the condenser floor level, then through a common 84 in. concrete underground pipe to a concrete seal pit into which it is discharged over a weir whose crest is at 1,002 ft-0 in. but is designed for adjustment to higher levels by addition of stop logs. These can be installed and removed with the aid of a mobile crane which can be brought to the inshore side of the pit. From the seal pit, circulating water is returned to the pond.

The circulating water system has been designed to take the coldest water available in Sherman Pond, circulate through the condenser and return the water to the pond near the Sherman hydroelectric plant intake, to ensure that warmed discharge water passes at once downstream.

Future Cooling Tower

Early in the development of the project, it became apparent that during a prolonged dry period and under certain possible conditions of hydroelectric power operation of the Deerfield River system, circulation of Sherman Pond water through the condenser could produce higher temperature downstream than could be tolerated. When and if this condition develops, installation of a cooling tower will augment the cooling effect of Sherman Pond and the Deerfield River and provide the means of maintaining the pond outlet temperature at a satisfactory level. A final selection of cooling tower size and flow has not been made.

For future cooling tower operation three 48 in. steel connections have been provided in the circulating water discharge piping, just before the seal pit, for suction connections on future cooling tower pumps.

There is also a 90 in. steel vertical connection in the top of the circulating water inlet channel to receive the future cooling tower returns. All these connections are closed by blank steel plates until such time as a cooling tower may be found necessary.

In addition, a 36 in. diam underground steel pipe connects the seal pit with the screen well inlet to permit recirculation of a portion of the circulating water during future cooling tower operation. Flow through this pipe is controlled by a sluice gate in the seal pit.

<u>Circulating Water Vacuum Priming System</u>

The vacuum priming or air collecting system removes air from the top of the condenser inlet and discharge water boxes. The circulating water pumps have a sufficiently high discharge head near pump shutoff to fill the piping with water, so that the priming system is not required to prime the complete system initially.

The vacuum priming or air collecting tank is connected to the top of the condenser water boxes and to the condenser circulating water discharge piping and is located with its horizontal center line about 5 1/2 in. above the top of the water boxes. The inlet water box can be vented to atmosphere and is normally isolated from the priming tank; therefore, water level in the tank is normally indicative of the water level in the discharge water box. Two motor driven, water sealed, rotary type vacuum pumps with air jets take suction from the tank and discharge through silencers to atmosphere. Each pump with air jet has a capacity of 100 cfm at 2 in. Hg abs and, with the air jet by-passed, has a capacity of 150 cfm at 4 in. Hg abs. The solenoid valve actuated, diaphragm operated check valve in the suction to each pump and the solenoid valve in the sealing water supply to each pump are electrically interlocked with the motor starting circuit to open when the pump is running and to close when the pump is stopped.

The 15 hp pump motors are controlled by magnetic starters in 440 v motor control center No. 2. Operation of the starters is controlled by locally mounted, 3-position switches with "Close", "Auto", and "Trip" positions. Normally, one switch will be in the "Auto" position and this pump will be automatically started and stopped by level switch LC-407 on the priming tank to maintain water level above the height of the condenser tubes. The other pump control switch will normally also be in the "Auto" position and this pump will be automatically started and stopped by a second set of contacts on LC-407, if the normally operating pump does not maintain a minimum water level in the tank. Gage glasses on each side of the condenser discharge water box assist in adjusting the set points of level switch LC-407 and are used intermittently to check water box water level.

The absolute pressure at the top of the condenser discharge water box will vary from about 2 in. to 6 in. Hg abs, depending upon water temperature, height of the discharge weir, barometric pressure, number of circulating water pumps in operation, and the water level of Sherman Pond. With the use of the wet type vacuum tank, the pumps automatically maitain whatever pressure is required to hold the syphon in the circulating water system. It is possible that the pumps will be able to operate with the jets by-passed much of the time when the minimum pressure required is above 4 in. Hg abs.

222 WATER SUPPLY SYSTEMS

Service Water

The service water system provides Sherman Pond water for cooling systems throughout the plant, supply for the water treating plant, and for washing the traveling water screens.

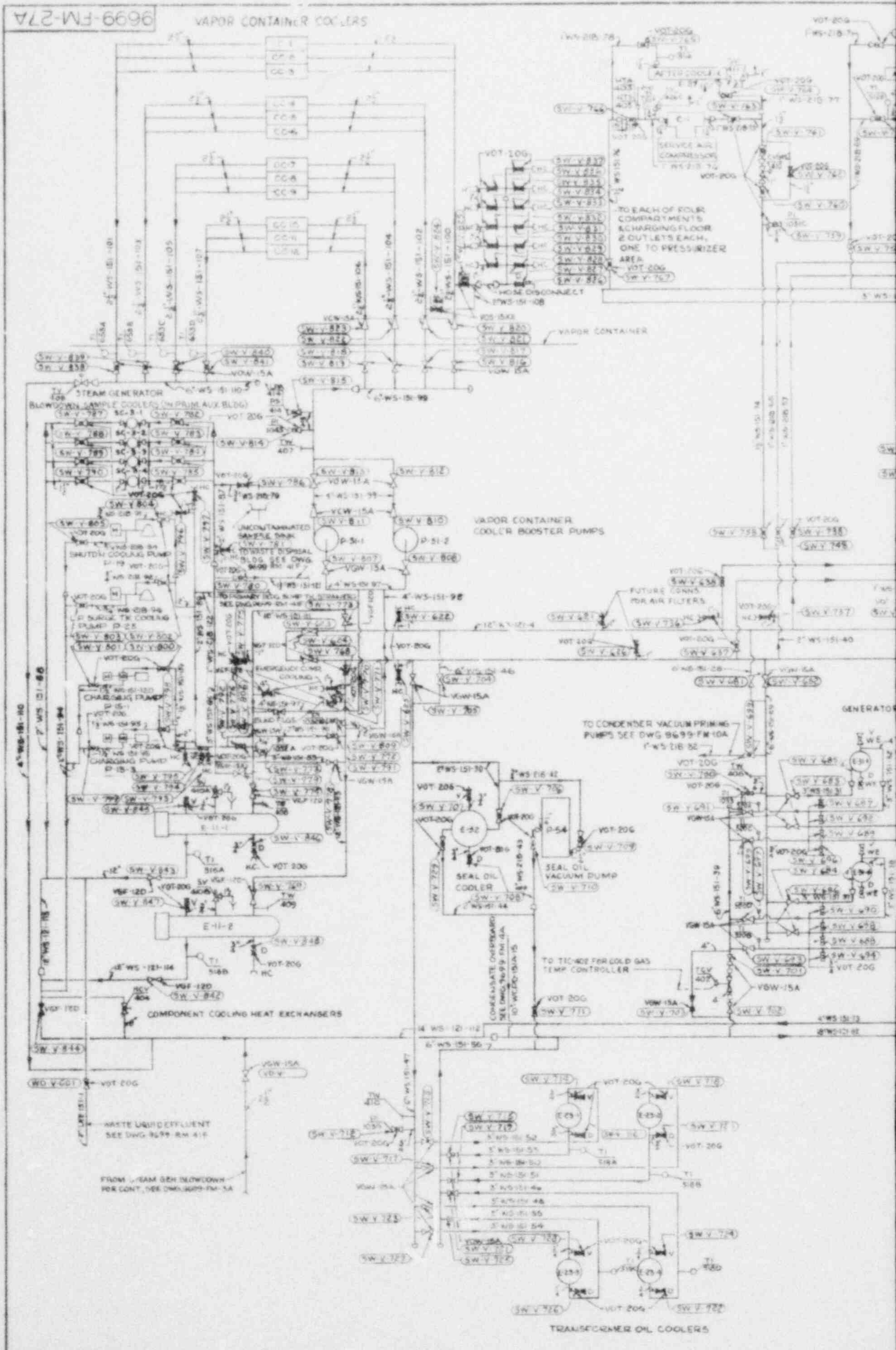
The service water system is illustrated by drawing No. 9699-FM-27A. Three 2,500 gpm vertical deep well type pumps obtain suction from a common intake well in the Circulating Water Pump House. The pumps discharge to a common 12 in. header which is continued as a service water supply loop, two 12 in. lines running parallel, to the southern corner of the turbine room basement, and supplying branch lines to the following systems in the amounts shown for service water temperatures of 85 F (design)* and 60 F (normal):

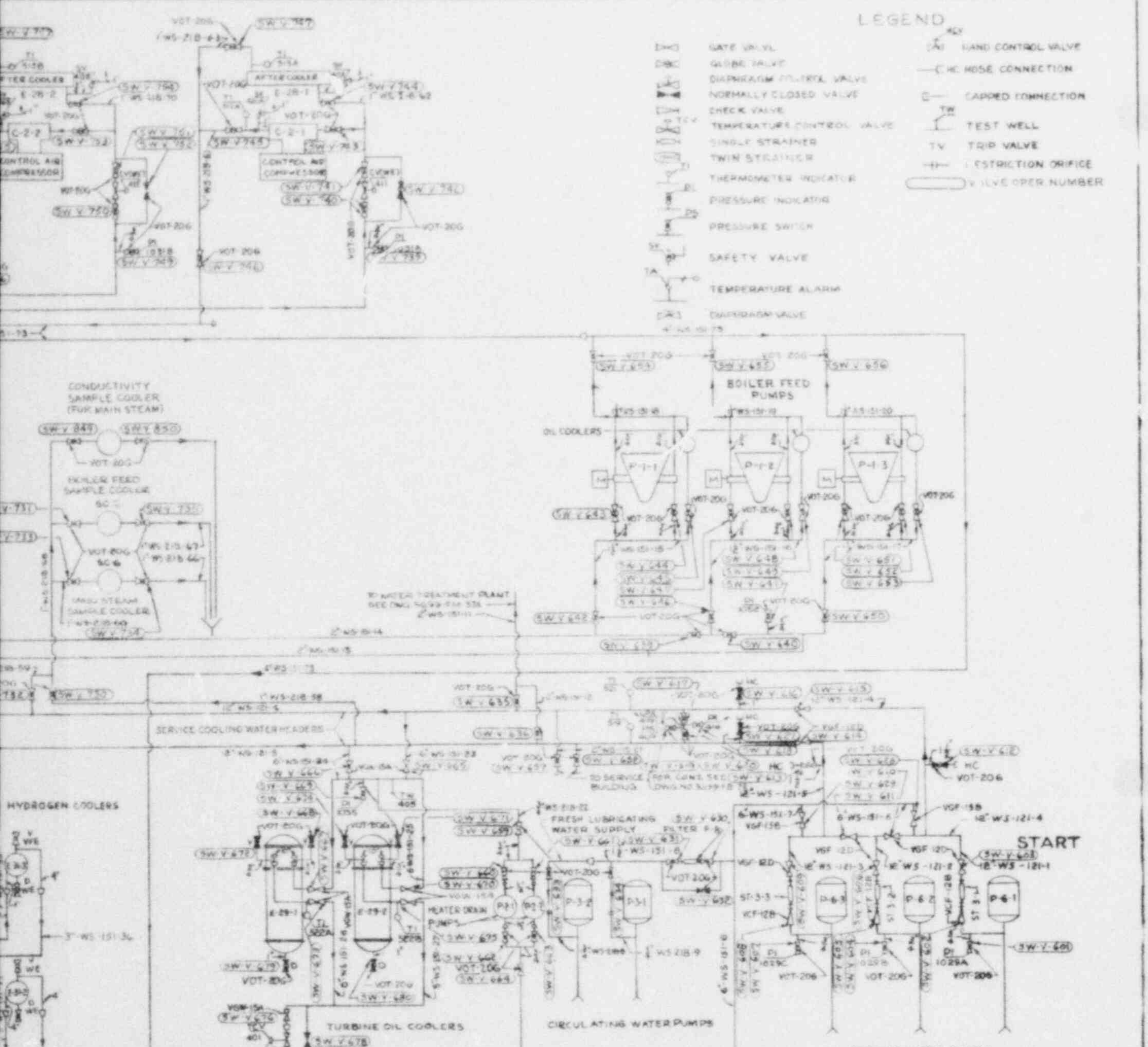
	Flow, Gpm	
	85 F	60 F
Secondary Plant		
Traveling water screen washing	500	500
Water treating plant	100	100
Turbine oil cooling	410	410+
Generator hydrogen cooling	270	270+
Main transformer cooling	400**	400**
Miscellaneous secondary services, including air compressor cooling, boiler feed pump cooling, heater drain pump cooling, circulating water vacuum priming pump sealing, sample coolers in turbine area and hose connections	100	100
Total, Secondary Plant	1,780	1,780

*The design condition of 85 F may be required in the future if and when a cooling tower becomes necessary (Section 221, CIRCULATING WATER SYSTEM). Due to manufacturers' standard procedure of specifying cooling water requirements, some of the tabulated flows are based on other temperatures.

**Maximum temperature 77 F.

+Minimum flow to obtain turbulence.


9699-FM-27A
VAPOR CONTAINER COOLERS
VAPOR CONTAINER
TO EACH OF FOUR COMPARTMENTS & CHARGING FLOOR 2 OUTLETS EACH, ONE TO PRESSURIZER AREA
HOSE DISCONNECT
SERVICE AIR COMPRESSOR
STEAM GENERATOR BLOWDOWN SAMPLE COOLERS (IN PRIM. AUX BLDG)
VAPOR CONTAINER COOLER BOOSTER PUMPS
UNCONTAMINATED SAMPLE SINK
CHARGING PUMP
FUTURE CONNS FOR AIR FILTERS
GENERATOR
TO CONDENSER VACUUM PRIMING PUMPS SEE DWG 9699-FM-10A
SEAL OIL COOLER
SEAL OIL VACUUM PUMP
TO TIC-402 FOR COLD GAS TEMP CONTROLLER
COMPONENT COOLING HEAT EXCHANGERS
WASTE LIQUID EFFLUENT SEE DWG 9699-FM-41F
TRANSFORMER OIL COOLERS



ISSUE	DESCRIPTION	DWG	[illegible]	[illegible]	[illegible]
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7	[illegible]	WCB	[illegible]	[illegible]	GPC
6	[illegible]	WLB	[illegible]	[illegible]	[illegible]

ISSUE	DESCRIPTION	DWG	[illegible]	CHK	[illegible]
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2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	WOB	[illegible]	[illegible]	[illegible]

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER NO. [illegible]
COMMONWEALTH OF MASSACHUSETTS

FLOW DIAGRAM COOLING WATER LINES

POWER STATION

YANKEE ATOMIC ELECTRIC COMPANY

ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-27A

Two 12 in. extensions running in parallel and each controlled by a shutoff valve at the branch from the 12 in. loop carry service water to the Primary Auxiliary Building to supply.

	Flow, Gpm	
	85 F	60 F
Primary Plant		
Component cooling - normal operation	2,500++	1,200++
Vapor container coolers	300	300
Sample coolers in primary plant	180	180
Miscellaneous primary plant services, including charging pump cooling, low pressure surge tank pump cooling, shutdown cooling pump cooling, waste disposal building and hose connections	60	60
Total, Primary Plant	3,040	1,740
Grand Total, Secondary and Primary Plants	4,820	3,520

++The component cooling flow requirements listed in this tabulation are exceeded during certain times of primary plant operation.

During primary plant startup when the maximum bleed flow rate from the main coolant system is 100 gpm, a service water flow of 2,500 gpm with 60 F cooling water is required through the operating component cooling heat exchanger. A flow rate of 2,500 gpm of 60 F cooling water is also required following a plant shutdown when the shutdown cooler is put in operation. This same flow is required at any time when the main coolant system water chemistry requires operating the purification system at its maximum capacity of 100 gpm. There is adequate capacity in the service water pumps to meet these special operating conditions.

During future cooling tower operation with 85 F cooling water, it may be necessary to operate in parallel combinations of standby heat exchangers and pumping equipment during startup, shutdown, and maximum purification operation of the primary plant.

The service water system has been designed to provide sufficient cooling water for all equipment listed under all foreseeable operating conditions.

Based on two pump operations at 5,000 gpm combined rating, the tabulated cooling water requirements result in 42% over capacity initially and 4% over capacity with cooling tower operation.

Normally, two pumps will be in operation with one pump on standby. If the pressure in the discharge header falls below a preset value, the standby pump will start and simultaneously an alarm will be given at the control board. The pressure switch, PS-409, initiating this standby operation, is located in the turbine room and is set at approximately 50 psi gage.

Controls for the service water pumps are located on the nuclear auxiliary panel of the main control board, turbine section. The switches may be set in "Close", "Auto", or "Trip" positions with provision for "Pull-out" in the trip position.

Potable Water

Potable water is supplied from a well located south of the power plant by a submersible type pump having a nominal capacity of 810 gal per hr at a head of 88 ft at the discharge nozzle. Underground distribution of potable water is through copper and cast iron pipe. A 10,000 gal tank, located on the hillside west of the power plant, provides storage for use during peak periods and serves to maintain a relatively constant pressure on the potable water system. The tank is insulated and is provided with an electric heater to prevent freezing in cold weather.

The potable water system serves water closets, lavatories, wash fountains, showers, sinks, and drinking water coolers throughout the plant and is designed for a daily station population of approximately 75 persons, with some reserve capacity.

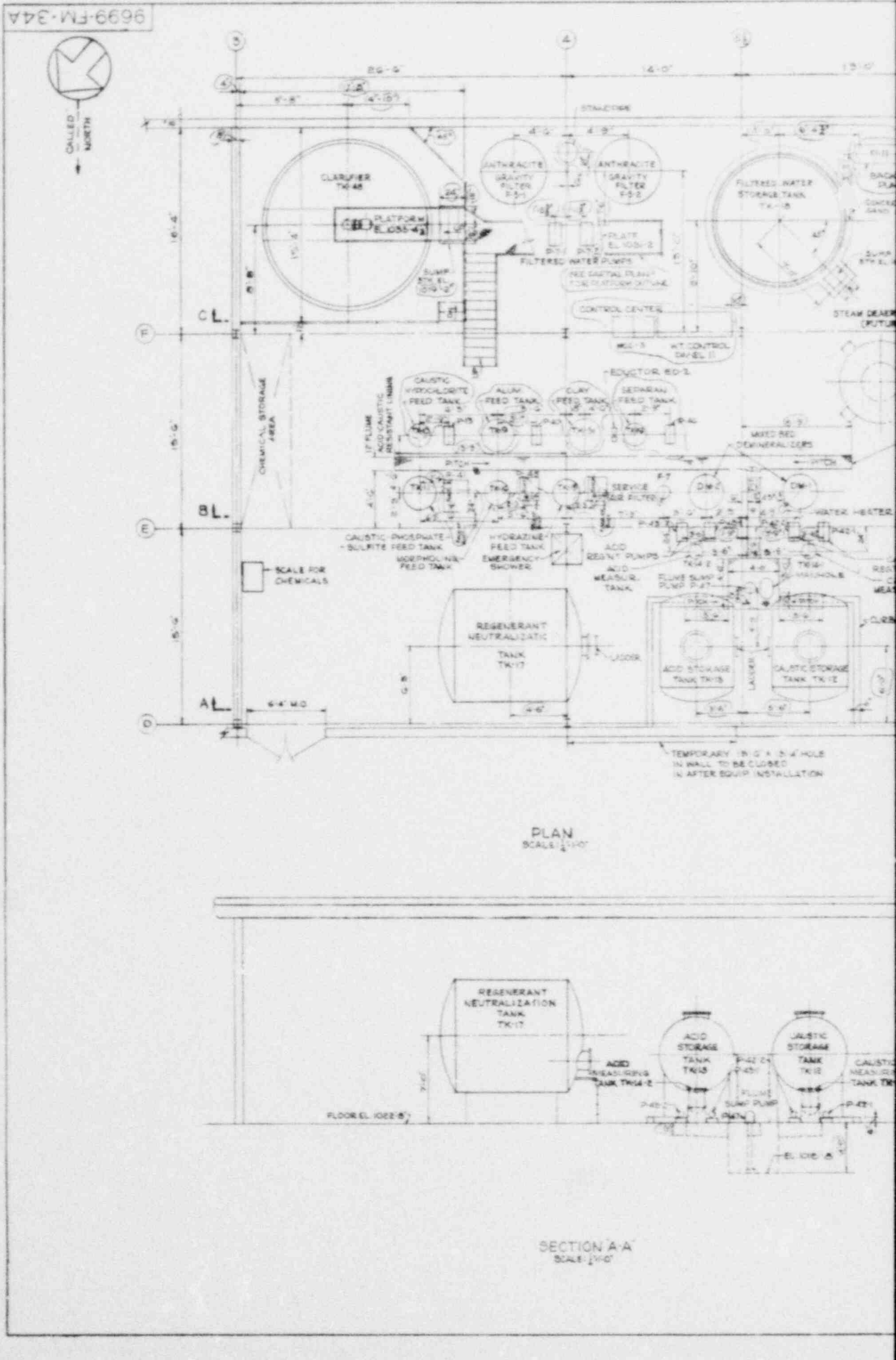
Treated Water

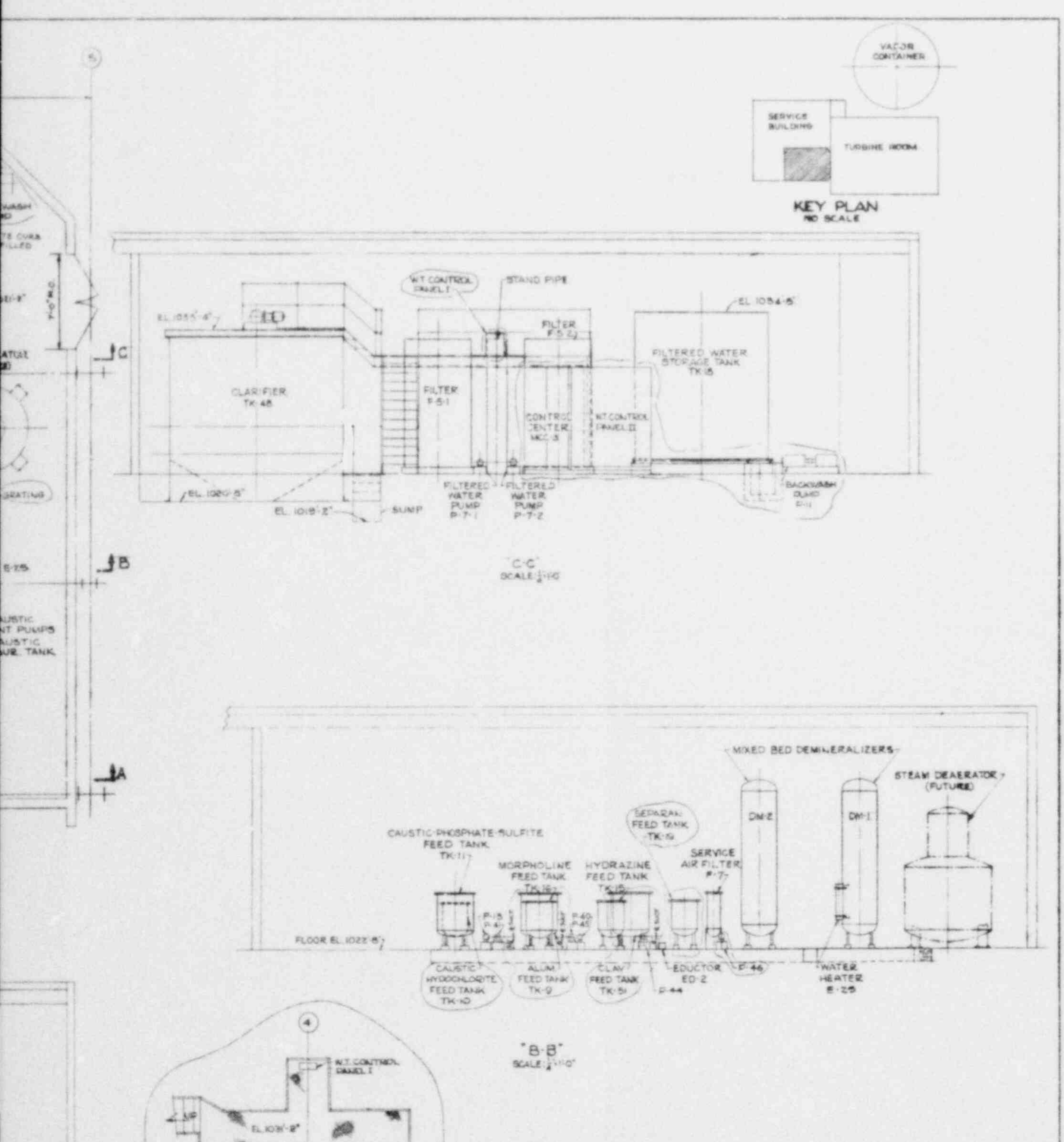
The water treatment plant provides demineralized water for primary and secondary plant make-up and equipment for conditioning primary plant main coolant and secondary plant boiler feed.

The treated water system is shown on drawings Nos. 9699-FM-34A and 9699-FM-37A. The system consists of equipment for clarifying, filtering, and demineralizing Sherman Pond water and for mixing and pumping water conditioning chemicals to the primary and secondary plants. Ion exchange resin regeneration and filter backwash equipment and demineralized water storage tankage is also provided.

The demineralized water system, including ion exchange resin regeneration, is designed to operate automatically with manual initiation. Filter backwashing and chemical addition to the primary and secondary plants are under manual control.

The water treatment plant is sized to provide 40 gpm of demineralized water on a continuous basis and 80 gpm maximum, based on the average chemical analyses of Sherman Pond water obtained over a one year period. The 30,000 gal demineralized water storage tank is sized to handle all anticipated transient demands of the secondary plant.


9699-FM-34A
CALLED NORTH
CLARIFIER TK-48
PLATFORM EL.1035-4½
ANTHRACITE GRAVITY FILTER F-5-1
ANTHRACITE GRAVITY FILTER F-5-2
FILTERED WATER STORAGE TANK TK-18
FILTERED WATER PUMPS
CONTROL CENTER
EDUCTOR ED-2
CAUSTIC HYPOCHLORITE FEED TANK
ALUM FEED TANK
CLAY FEED TANK
SEPARAN FEED TANK
MIXED BED DEMINERALIZERS
CHEMICAL STORAGE AREA
SERVICE AIR FILTER
WATER HEATER
CAUSTIC-PHOSPHATE-SULFITE FEED TANK
MORPHOLINE FEED TANK
HYDRAZINE FEED TANK
EMERGENCY SHOWER
ACID REGNT PUMPS
ACID MEASUR. TANK
SCALE FOR CHEMICALS
REGENERANT NEUTRALIZATIC TANK TK-17
LADDER
ACID STORAGE TANK TK-13
CAUSTIC STORAGE TANK TK-12
TEMPORARY HOLE IN WALL TO BE CLOSED IN AFTER EQUIP. INSTALLATION
PLAN
REGENERANT NEUTRALIZATION TANK TK-17
ACID MEASURING TANK TK-14-2
ACID STORAGE TANK TK-13
CAUSTIC STORAGE TANK TK-12
FLUME SUMP PUMP
FLOOR EL. 1022-8
SECTION 'A-A'



APPROVED *Walter C. Woodman*
REGISTERED PROFESSIONAL ENGINEER NO. 237
COMMONWEALTH OF MASSACHUSETTS

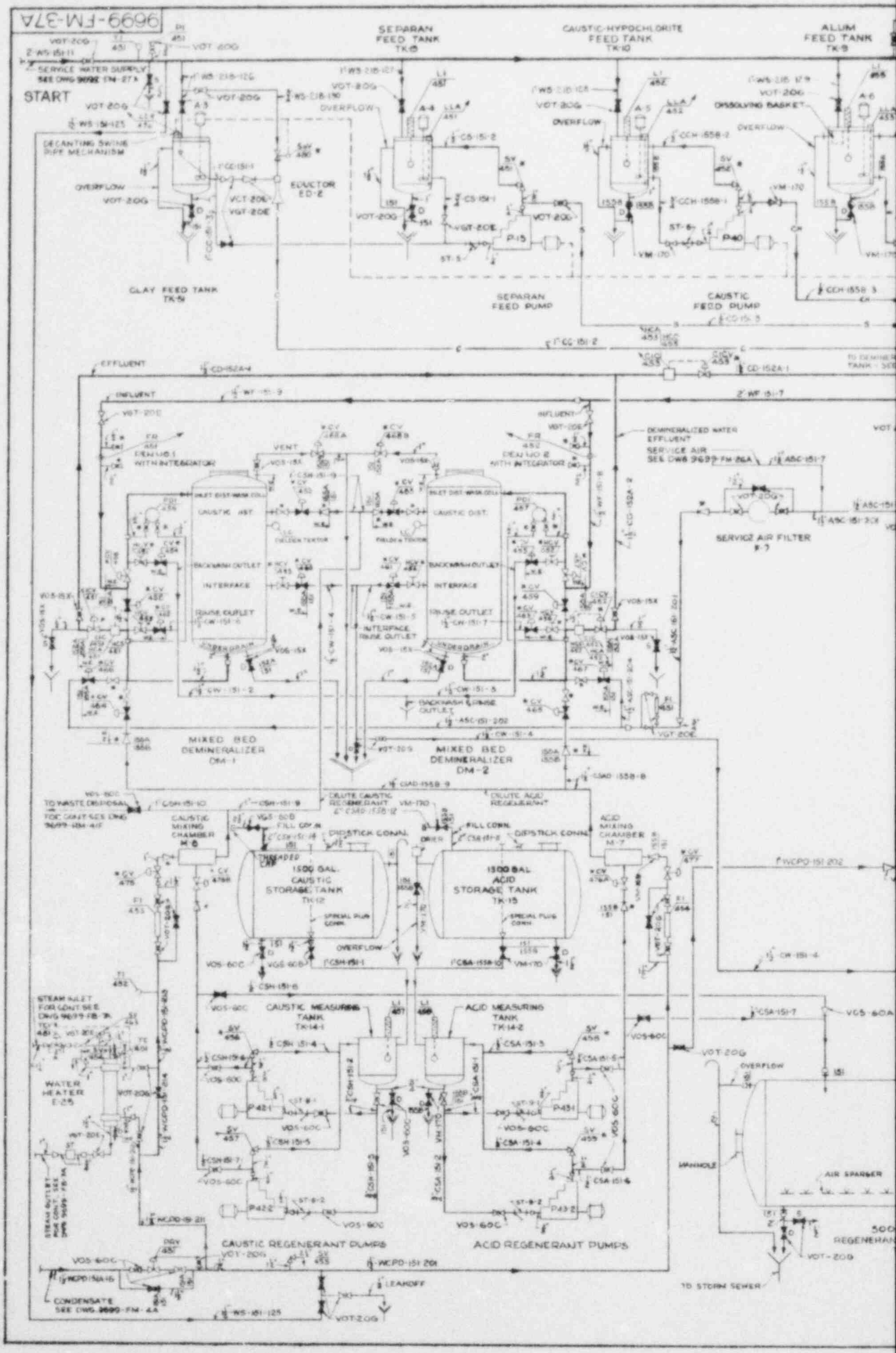
ISSUE	DESCRIPTION	CHKD	INSP	COOR	APPR
5					
4	[illegible] W.T. CONTROL PANEL I [illegible] CURB & SUMP ADDED FOR TK-18 [illegible]				
3	[illegible] STAIRS [illegible]				
2	GENERAL REVISION				
1	ORIGINAL ISSUE				

MACHINE LOCATION PLAN
WATER TREATMENT ROOM

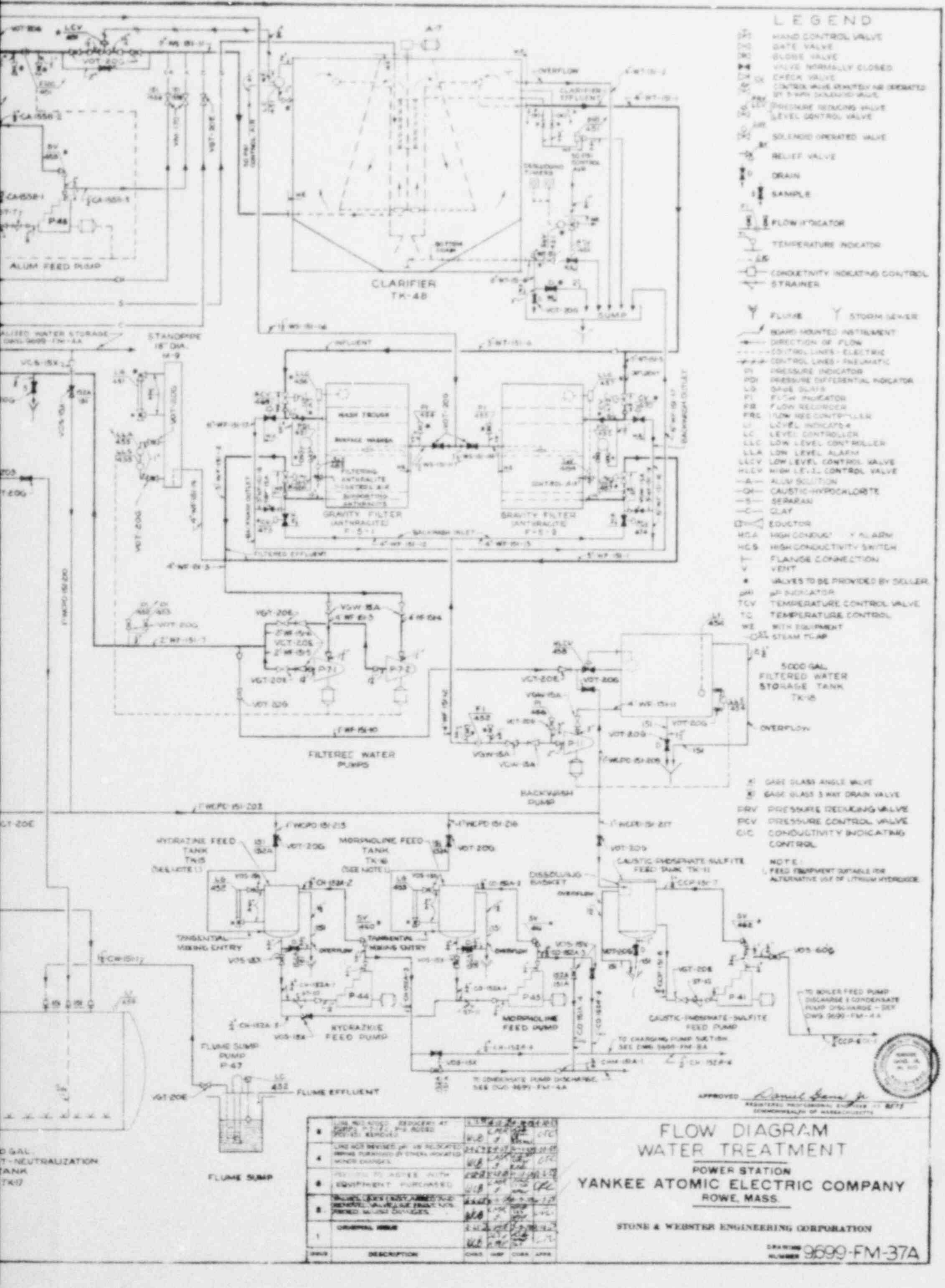
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-34A



9699-FM-37A
START
SEPARAN FEED TANK TK-8
CAUSTIC-HYPOCHLORITE FEED TANK TK-10
ALUM FEED TANK TK-9
SERVICE WATER SUPPLY SEE DWG 9699-FM-27A
DECANTING SWING PIPE MECHANISM
OVERFLOW
EDUCTOR ED-2
CLAY FEED TANK TK-51
SEPARAN FEED PUMP
CAUSTIC FEED PUMP
DISSOLVING BASKET
EFFLUENT
INFLUENT
VENT
DEMINERALIZED WATER EFFLUENT
SERVICE AIR SEE DWG 9699-FM-26A
SERVICE AIR FILTER F-7
CAUSTIC DIST.
BACKWASH OUTLET
INTERFACE
RINSE OUTLET
UNDERDRAIN
INTERFACE RINSE OUTLET
BACKWASH & RINSE OUTLET
MIXED BED DEMINERALIZER DM-1
MIXED BED DEMINERALIZER DM-2
TO WASTE DISPOSAL FOR CONT SEE DWG 9699-FM-41F
DILUTE CAUSTIC REGENERANT
DILUTE ACID REGENERANT
CAUSTIC MIXING CHAMBER M-6
ACID MIXING CHAMBER M-7
FILL CONN.
DIPSTICK CONN.
DRIER
1500 GAL. CAUSTIC STORAGE TANK TK-12
1500 GAL. ACID STORAGE TANK TK-13
SPECIAL PLUG CONN.
CAUSTIC MEASURING TANK TK-14-1
ACID MEASURING TANK TK-14-2
STEAM INLET FOR CONT SEE DWG 9699-FB-7A
WATER HEATER E-25
STEAM OUTLET FOR CONT SEE DWG 9699-FB-7A
CAUSTIC REGENERANT PUMPS
ACID REGENERANT PUMPS
LEAKOFF
CONDENSATE SEE DWG 9699-FM-4A
MANHOLE
AIR SPARGER
TO STORM SEWER



LEGEND
HAND CONTROL VALVE
GATE VALVE
GLOBE VALVE
VALVE NORMALLY CLOSED
CHECK VALVE
PRESSURE REDUCING VALVE
LEVEL CONTROL VALVE
SOLENOID OPERATED VALVE
RELIEF VALVE
DRAIN
SAMPLE
FLOW INDICATOR
TEMPERATURE INDICATOR
CONDUCTIVITY INDICATING CONTROL
STRAINER
FLUME
STORM SEWER
BOARD MOUNTED INSTRUMENT
DIRECTION OF FLOW
CONTROL LINES - ELECTRIC
CONTROL LINES - PNEUMATIC
PI PRESSURE INDICATOR
PDI PRESSURE DIFFERENTIAL INDICATOR
LG GAGE GLASS
FI FLOW INDICATOR
FR FLOW RECORDER
LI LEVEL INDICATOR
LC LEVEL CONTROLLER
LLC LOW LEVEL CONTROLLER
LLA LOW LEVEL ALARM
LLCV LOW LEVEL CONTROL VALVE
HLCV HIGH LEVEL CONTROL VALVE
—A— ALUM SOLUTION
—CH— CAUSTIC-HYPOCHLORITE
—S— SEPARAN
—C— CLAY
EDUCTOR
HCS HIGH CONDUCTIVITY SWITCH
FLANGE CONNECTION
V VENT
• VALVES TO BE PROVIDED BY SELLER
TCV TEMPERATURE CONTROL VALVE
TC TEMPERATURE CONTROL
WE WITH EQUIPMENT
STEAM TRAP
GAGE GLASS ANGLE VALVE
GAGE GLASS 3 WAY DRAIN VALVE
PRV PRESSURE REDUCING VALVE
PCV PRESSURE CONTROL VALVE
CIC CONDUCTIVITY INDICATING CONTROL
NOTE:
1. FEED EQUIPMENT SUITABLE FOR ALTERNATIVE USE OF LITHIUM HYDROXIDE.
CLARIFIER TK-48
OVERFLOW
CLARIFIER EFFLUENT
SUMP
ALUM FEED PUMP
STANDPIPE 18" DIA.
INFLUENT
WASH TROUGH
GRAVITY FILTER (ANTHRACITE) F-5-1
GRAVITY FILTER (ANTHRACITE) F-5-2
BACKWASH INLET
FILTERED EFFLUENT
BACKWASH OUTLET
FILTERED WATER PUMPS
5000 GAL. FILTERED WATER STORAGE TANK TK-18
OVERFLOW
BACKWASH PUMP
HYDRAZINE FEED TANK TK15 (SEE NOTE 1)
MORPHOLINE FEED TANK TK16 (SEE NOTE 1)
CAUSTIC-PHOSPHATE-SULFITE FEED TANK TK-11
DISSOLVING BASKET
TANGENTIAL MIXING ENTRY
OVERFLOW
HYDRAZINE FEED PUMP
MORPHOLINE FEED PUMP
CAUSTIC-PHOSPHATE-SULFITE FEED PUMP
P-44
P-45
P-41
TO BOILER FEED PUMP DISCHARGE & CONDENSATE PUMP DISCHARGE - SEE DWG. 9699-FM-4A
TO CHARGING PUMP SUCTION SEE DWG. 9699-FM-3A
TO CONDENSATE PUMP DISCHARGE, SEE DWG. 9699-FM-4A
FLUME SUMP PUMP P-47
FLUME EFFLUENT
FLUME SUMP
TANK TK17
APPROVED
REGISTERED PROFESSIONAL ENGINEER
COMMONWEALTH OF MASSACHUSETTS
ORIGINAL ISSUE
REVISED TO AGREE WITH EQUIPMENT PURCHASED
DESCRIPTION
FLOW DIAGRAM
WATER TREATMENT
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NUMBER 9699-FM-37A

Chemical addition equipment is provided to flocculate Sherman Pond feed water in order to reduce color and suspended matter, thereby enhancing ion exchange resin life. The design basis for chemical addition is as follows:

Chemical	Dosage, ppm
Clay, as required	40
Filter alum	20-40
Caustic soda	6-12
Sodium hypochlorite, as required	1
Dow Separan 2610	0.6

The clarifier is sized to provide 2.15 hr detention time at the maximum flow rate of 80 gpm, with an overflow rate not to exceed 0.75 gpm per sq ft at the plane of separation between solids and clarified water. Automatic clarifier desludging is provided.

Because of the fine nature of the floc formed, two gravity filters with anthracite beds are provided, each designed for a capacity of 40 gpm with a filtration rate of 2.0 gpm per sq ft. Filter backwashing is controlled manually from a locally mounted control panel.

Two mixed bed ion exchange units are provided, constructed in accordance with the ASME Code for Unfired Pressure Vessels and for 100 psi design. Each unit is designed for an average capacity of 40 gpm at 7.5 gpm per sq ft. Cutoff at the end of a service run is taken as 2.0 micromhos per centimeter cube, with chlorides in the demineralized water not to exceed 0.2 ppm. Each ion exchange unit is loaded with 13 cu ft of cationic exchange resin, Amberlite IR-122, with a total exchange capacity of 121 kg as $CaCO_3$, and 18 cu ft of anionic exchange resin, Amberlite IRA-400, with a total exchange capacity of 147 kg as $CaCO_3$. The ion exchange resin regenerating equipment is initiated manually but automatically controlled from a local control panel.

Chemical addition equipment is provided to add hydrazine and/or lithium hydroxide to the charging pump suction of the primary plant main coolant system to reduce main coolant oxygen content during plant startup to less than 0.1 ppm and/or adjust main coolant pH to 9.5-10.5 if it becomes desirable. The same equipment can be used to add hydrazine and/or morpholine to the condensate pump discharge in the secondary plant to remove residual oxygen in the condensate as discharged from the deaerating condenser hot well and/or adjust pH to (9-10). Additional equipment is available to add miscellaneous chemicals to either the boiler feed or condensate pump discharge to further adjust secondary plant water chemistry. All chemical addition is under manual control and may be either on a batch or continuous feed basis.

223 VENT AND DRAIN SYSTEM

The secondary plant vents and drains are shown on the following drawings:

9699-FM-3A, Flow Diagram - Main & Auxiliary Steam Lines and Steam Generator Blowdown, included with Section 219

9699-FM-7A, Flow Diagram - Extraction Steam, Feed-Water Heater Vent & Drain Lines, included with Section 220

9699-FM-10A, Flow Diagram - Circulating Water, Screen Wash & Air Offtake Lines, included with Section 221

9699-FM-36A, Flow Diagram - Lubricating Oil System, included with Section 225

9699-FM-47A, Flow Diagram - Gland Steam Leak-off Lines & Vents to Stacks, included with Section 223.

Vents

General - The vents from the main steam, condensate and feed water systems are independent of vents for other systems or services.

All miscellaneous atmospheric vents are extended above the height of the turbine roof parapet.

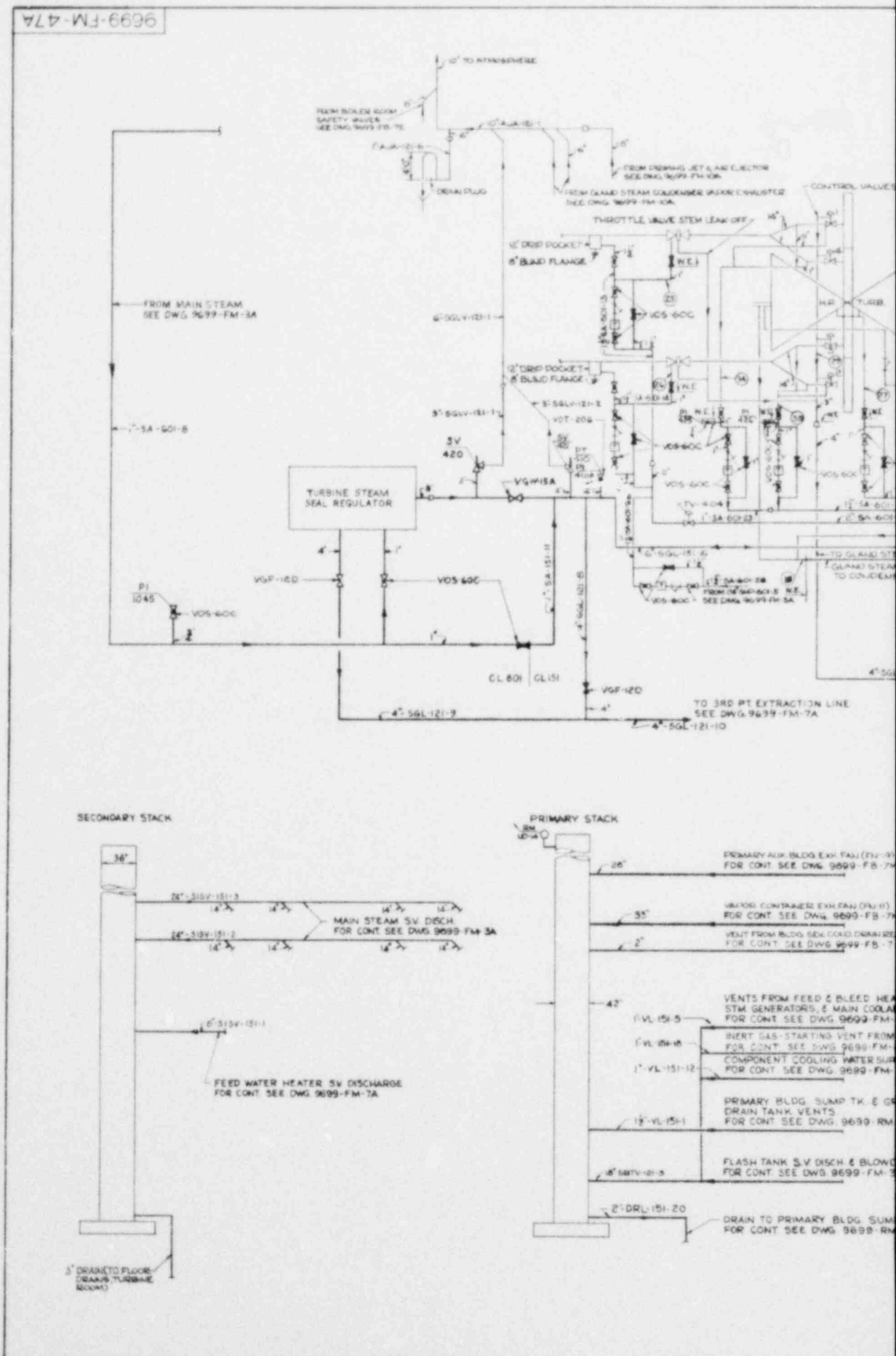
Safety Valve Discharges - The steam generator safety valves located on the main steam lines outside the vapor container discharge to the secondary stack, a 36 in. diam, 110 ft high, self-supporting, fabricated steel stack located adjacent to the south wall of the Turbine Building and braced from the equator of the vapor container.

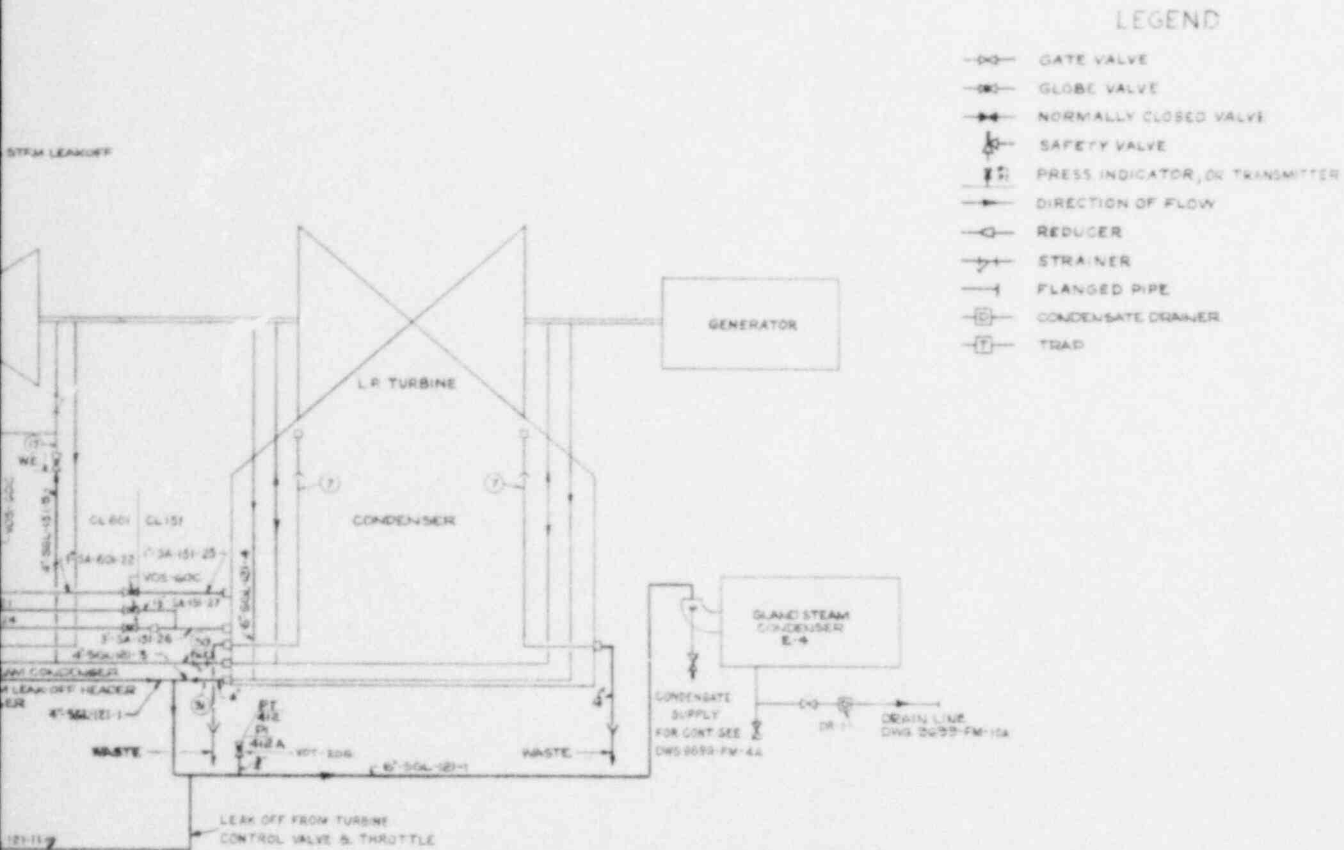
The feed-water heater and drain cooler shell side safety valves discharge to the secondary stack.

The safety valves on the turbine gland steam supply header discharge to the 10 in. condenser priming ejector discharge which runs up along the south side of the "G" line wall to about El. 110' above the roof parapet and hereafter referred to as the secondary plant vent.

The heating boiler safety valves also discharge to atmosphere through this secondary plant vent.

Feed-Water Heater Shell Vents - The shells of the first and second point closed feed-water heaters are normally vented to the next lower pressure heater to dispose of noncondensable gases, and the third point heater is vented to the condenser. The first and second point heaters may also be vented directly to the condenser under manual control, if required. Orifices in the vent lines from each heater limit the flow through the lines. The heater shell vents are also mentioned under Section 219.


9699-FM-47A
10" TO ATMOSPHERE
FROM BOILER ROOM SAFETY VALVES SEE DWG. 9699-FB-7E
DRAIN PLUG
FROM PRIMING JET & AIR EJECTOR SEE DWG. 9699-FM-10A
FROM GLAND STEAM CONDENSER VAPOR EXHAUSTER SEE DWG. 9699-FM-10A
CONTROL VALVES
THROTTLE VALVE STEM LEAK OFF
12" DRIP POCKET
8" BLIND FLANGE
H.P. TURB.
FROM MAIN STEAM SEE DWG. 9699-FM-3A
1"-SA-601-8
TURBINE STEAM SEAL REGULATOR
VGF-12D
VOS-60C
PI 1045
CL 801
CL 151
TO 3RD PT. EXTRACTION LINE SEE DWG. 9699-FM-7A
4"-SGL-121-9
4"-SGL-121-10
SECONDARY STACK
36"
MAIN STEAM S.V. DISCH. FOR CONT. SEE DWG. 9699-FM-3A
FEED WATER HEATER S.V. DISCHARGE FOR CONT. SEE DWG. 9699-FM-7A
3" DRAIN TO FLOOR DRAINS, TURBINE ROOM
PRIMARY STACK
VAPOR CONTAINER EXH. FAN (FN-11) FOR CONT. SEE DWG. 9699-FB-7
VENTS FROM FEED & BLEED HEA... STM. GENERATORS, & MAIN COOLA... FOR CONT. SEE DWG. 9699-FM-
COMPONENT COOLING WATER SUR... FOR CONT. SEE DWG. 9699-FM-
PRIMARY BLDG. SUMP TK. & ... DRAIN TANK VENTS FOR CONT. SEE DWG. 9699-RM
FLASH TANK S.V. DISCH. & BLOW... FOR CONT. SEE DWG. 9699-FM-
2"-DRL-151-20
DRAIN TO PRIMARY BLDG. SUM... FOR CONT. SEE DWG. 9699-RM



REFER WESTINGHOUSE DWG 652-J-591

ITEM	SIZE	CONNECTIONS	DISPOSITION OR SOURCE
17	4" B.W.	SEALING STEAM TO H.P. TURBINE GLANDS	FROM STM SEAL REGULATOR
18	4" B.W.	GLAND STEAM LEAK-OFF FROM H.P. TURBINE	TO G.S. CONDENSER
25	1" S.W.	DRAIN FROM THROTTLE VALVE (L.H.)	TO MAIN CONDENSER
26	1" S.W.	DRAIN FROM THROTTLE VALVE (R.H.)	TO MAIN CONDENSER
27	1" S.W.	DRAIN FROM IMPULSE CHAMBER	TO MAIN CONDENSER
29	3" B.W.	L.P. LEAK-OFF FROM CONTROL VALVE & THROTTLE VALVE STEMS	TO G.S. CONDENSER
30	6" B.W.	SEALING STEAM TO L.P. TURBINE GLANDS	FROM STM SEAL REGULATOR
31	4" B.W.	GLAND STEAM LEAK-OFF FROM L.P. TURBINE	TO G.S. CONDENSER
33	1" S.W.	DRAINS FROM STM. INLET PIPES (R.H.)	TO MAIN CONDENSER
34	1" S.W.	DRAINS FROM STM. INLET PIPES (L.H.)	TO MAIN CONDENSER

REFER WESTINGHOUSE DWG 652-J-170 & 172

7	2-1/2" S.W.	SLOP DRAINS (WASTE OIL & WATER)	TO WASTE

NOTE:
PIPING THROUGH CONDENSER NECK FURNISHED BY WESTINGHOUSE.

APPROVED
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COMMONWEALTH OF MASSACHUSETTS

5					
4					
3	LINE NO. 4"-SGL-121-1, PI-425 & PI-426 ADDED				
2					
1	ORIGINAL ISSUE				
GROUP	DESCRIPTION	CHKD	PREP	COORD	APPR

FLOW DIAGRAM-GLAND STEAM LEAK-OFF LINES & VENTS TO STACKS

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-47A

Condenser Air Removal and Miscellaneous Steam Vapor Vents - The 2-stage, twin element condenser air ejector unit discharges to the suction of the vapor container purge fan or primary auxiliary building exhaust fan and thence to the primary vent stack. The condenser priming jet and auxiliary jet ejectors discharge to atmosphere through the 10 in. secondary plant vent.

The two gland steam condenser exhausters also discharge to the secondary plant vent.

Miscellaneous Oil, Hydrogen and Carbon Dioxide Vents - The turbine lubricating oil tank and vapor extractor are vented to atmosphere through a 3 in. line, which runs up along the south side of the "G" line wall.

The turbine generator loop seal tank and vapor extractor are vented to atmosphere through a 4 in. line, which runs up along the inside of the west wall of the turbine room and through the roof.

On the west wall of the turbine room are two additional vent pipes. A 1 1/2 in. line vents the generator seal oil unit to atmosphere and hydrogen or carbon dioxide is purged from the 160,000 kva generator to atmosphere through a 2 in. vent.

Drains

General - Secondary plant piping and feed-water heaters are, in most cases, drained to the condenser. However, drains from vent pipes handling oil vapors from the oil centrifuge and oil transfer pump go to the waste oil sump, and drains from steam and air vapor vents, together with miscellaneous equipment drains, go to floor drainage system.

Closed Feed-Water Heaters - The closed feed-water heater shell drains are described under Section 220.

Piping Drains - In the main steam lines, the above seat drains of the four 14 in. nonreturn valves, the drains from the 12 in. drip pots on each 18 in. line at the turbine throttle, the above seat throttle valve drains, the above seat drains of the two upper turbine control valves, and the turbine inlet piping drains are trapped to the condenser.

Drains from the auxiliary steam lines to the condenser air ejector unit and from the turbine steam by-pass line are trapped to the condenser, as well as the drains from the extraction steam lines.

Circulating Water Pump Gland Discharge - The discharge or leakage from the circulating pump glands drains by gravity to a sump in the pump house floor which is emptied by an 8 gpm sump pump discharging into the suction well vent pipe. With the pump gland packing correctly adjusted, the leakage from the gland should be negligible.

Steam Generator Blowdown - The steam generator blowdown system is described under Section 219.

224 COMPRESSED AIR SYSTEMS

The station service and control air systems are shown on drawing No. 9699-FM-26A.

Control Air System

Two 120 scfm, 600 rpm control air compressors with V-belt drive and 25 hp motors provide air at 100 psi gage to the instrument and control air systems. Because of the isolated nature of this single turbine generator unit station, each compressor has sufficient capacity to meet the station requirements. The vertical, single stage, double acting, reciprocating, water-cooled compressors are of the nonlubricated carbon ring type and are installed with aftercoolers, air receivers, and intake filters. Each compressor motor is controlled by a magnetic starter supplied from a different source of power to increase reliability. The starter for one compressor is located in motor control center No. 2 and the starter for the other in motor control center No. 1. A local control switch with "Off-Hand-Auto" positions actuates the starter for each compressor. In "Hand" position, the compressor runs continuously with the compressor valves loading and unloading automatically to maintain receiver pressure. In "Auto" position, the compressor motor is started and stopped automatically to maintain receiver pressure. If, with this type of control, the on-off cycle is repeated more than six to seven times per hour, the control switch should be switched to "Hand". Diaphragm control valves regulate cooling water flow to the aftercoolers and compressors. The valve for each compressor is opened and closed from an air signal in compressor loading line as the compressor is loaded and unloaded.

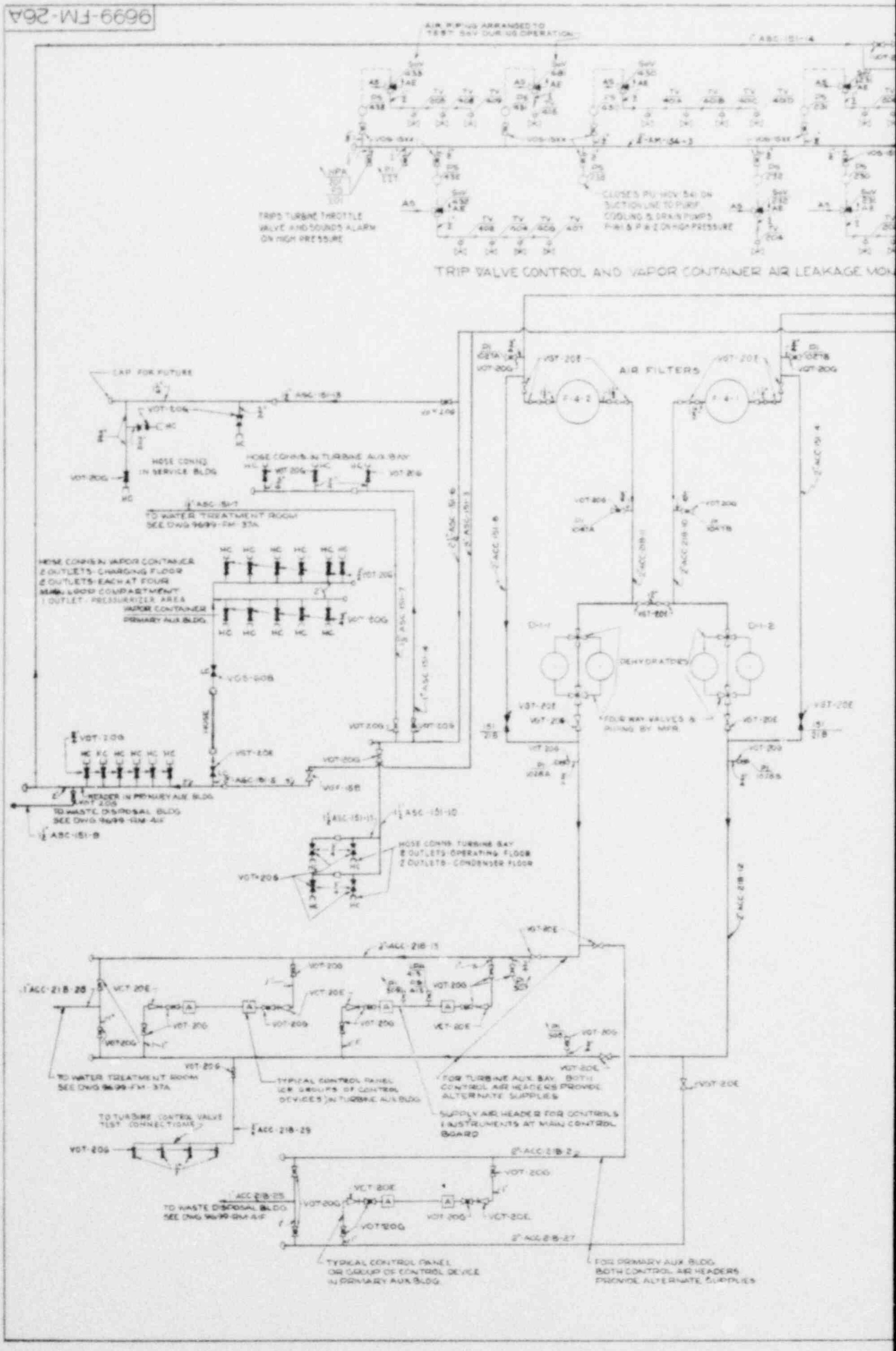
The discharge from each control air receiver supplies one header of a double header piping system which runs throughout the station. The two headers are cross-connected at the receivers in the turbine area and in the Primary Auxiliary Building. Air from each header is supplied through reducing valves, as required, to each instrument or control air supply manifold in the turbine area and Primary Auxiliary Building.

Before passing into the distribution system, air from each receiver goes through a filter unit and dual tower dehydrating unit. The 100 scfm filter units have moisture traps and disposable filter cartridges. With inlet air temperature of 70-90 F, each 100 scfm dual tower dehydrator reduces the dew point of the air to minus 50 F. The silica gel desiccant is dried electrically under full automatic control. Regeneration is on an adjustable time basis and may be required about every 6 hr.

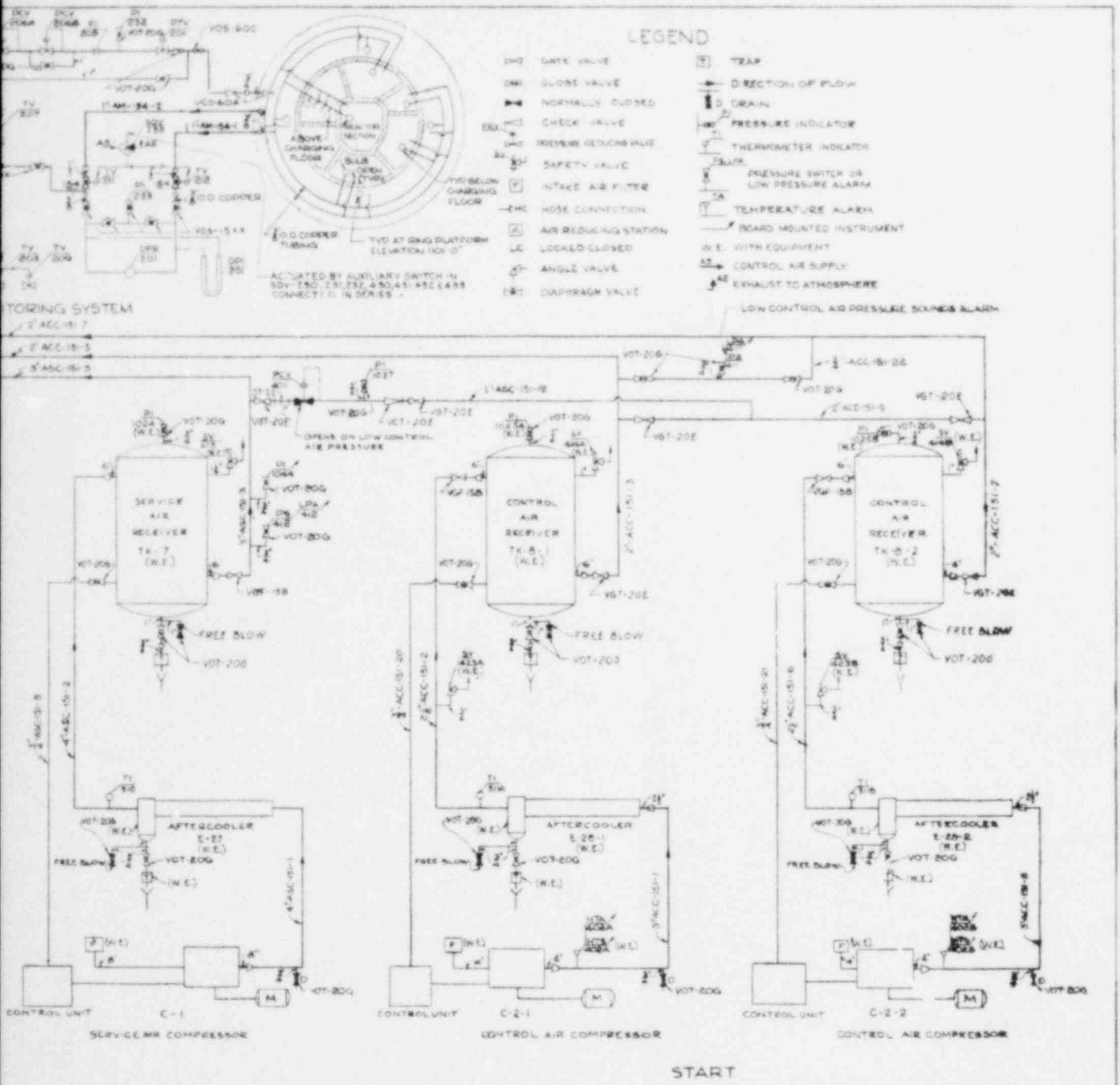
The control air header low pressure alarm is set at 65 psi gage.

Service Air System

One 514 scfm service air compressor with V-belt drive and 100 hp motor provides service air to the station at 100 psi gage. The vertical, single stage, double acting, reciprocating, water-cooled compressor is of the lubricated type and is installed with intake filter, aftercooler, and air receiver. The 100 hp, 440 v motor is controlled by an air circuit breaker with 125 v d-c control in the 440 v switchgear. Operation of the circuit breaker



9699-FM-26A
AIR PIPING ARRANGED TO TEST SAV DURING OPERATION
TRIPS TURBINE THROTTLE VALVE AND SOUNDS ALARM ON HIGH PRESSURE
CLOSES PU-HOV-541 ON SUCTION LINE TO PURIF. COOLING & DRAIN PUMPS P-1 & P-2 ON HIGH PRESSURE
TRIP VALVE CONTROL AND VAPOR CONTAINER AIR LEAKAGE MON
AIR FILTERS
CAP FOR FUTURE
HOSE CONNS IN SERVICE BLDG
HOSE CONNS IN TURBINE AUX BAY
TO WATER TREATMENT ROOM SEE DWG 9699-FM-37A
HOSE CONNS IN VAPOR CONTAINER 2 OUTLETS-CHARGING FLOOR 2 OUTLETS-EACH AT FOUR MAIN LOOP COMPARTMENT AREA 1 OUTLET-PRESSURIZER AREA
VAPOR CONTAINER
PRIMARY AUX BLDG
DEHYDRATORS
FOUR WAY VALVES & PIPING BY MFR.
HEADER IN PRIMARY AUX BLDG
TO WASTE DISPOSAL BLDG SEE DWG 9699-FM-41
HOSE CONNS TURBINE BAY 2 OUTLETS-OPERATING FLOOR 2 OUTLETS-CONDENSER FLOOR
TO WATER TREATMENT ROOM SEE DWG 9699-FM-37A
TYPICAL CONTROL PANEL (OR GROUPS OF CONTROL DEVICES) IN TURBINE AUX BLDG
FOR TURBINE AUX BAY. BOTH CONTROL AIR HEADERS PROVIDE ALTERNATE SUPPLIES
SUPPLY AIR HEADER FOR CONTROLS & INSTRUMENTS AT MAIN CONTROL BOARD
TO TURBINE CONTROL VALVE TEST CONNECTIONS
TO WASTE DISPOSAL BLDG SEE DWG 9699-FM-41
TYPICAL CONTROL PANEL OR GROUP OF CONTROL DEVICE IN PRIMARY AUX BLDG
FOR PRIMARY AUX BLDG BOTH CONTROL AIR HEADERS PROVIDE ALTERNATE SUPPLIES



APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION
6	PS-158 & HC ADDED, STRAINER ST-22 ADDED, INSTR'S ADDED
5	[illegible]
4	AIR FILTER PIPING REVISED, TEST CONNECTIONS ADDED, TURBINE CONTROL VALVE LINES CHANGED ADDED
3	VALVES (A.E. MONITORING SYSTEM) ADDED, INST. NOS. & LINE SIZES CHANGED, REVISED, MINOR CHANGES
2	ADDED INSTR. [illegible] VALVES [illegible] REMOVED AFTERCOOLER [illegible] & MINOR CHANGES
1	ORIGINAL ISSUE

FLOW DIAGRAM
COMPRESSED AIR LINES

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699 FM-26A

is controlled from a locally mounted 3-position switch. The type of automatic control for this compressor duplicates that provided for the control air compressors. A diaphragm control valve regulates cooling water flow to the aftercooler and compressor. The valve is opened and closed from an air signal in the compressor loading line as the compressor is loaded and unloaded.

The discharge from the service air receiver supplies a single header piping system which runs throughout the station. This system is interconnected with and serves as standby for the control air system when control air pressure decreases to 60 psi gage.

225 LUBRICATING OIL SYSTEM

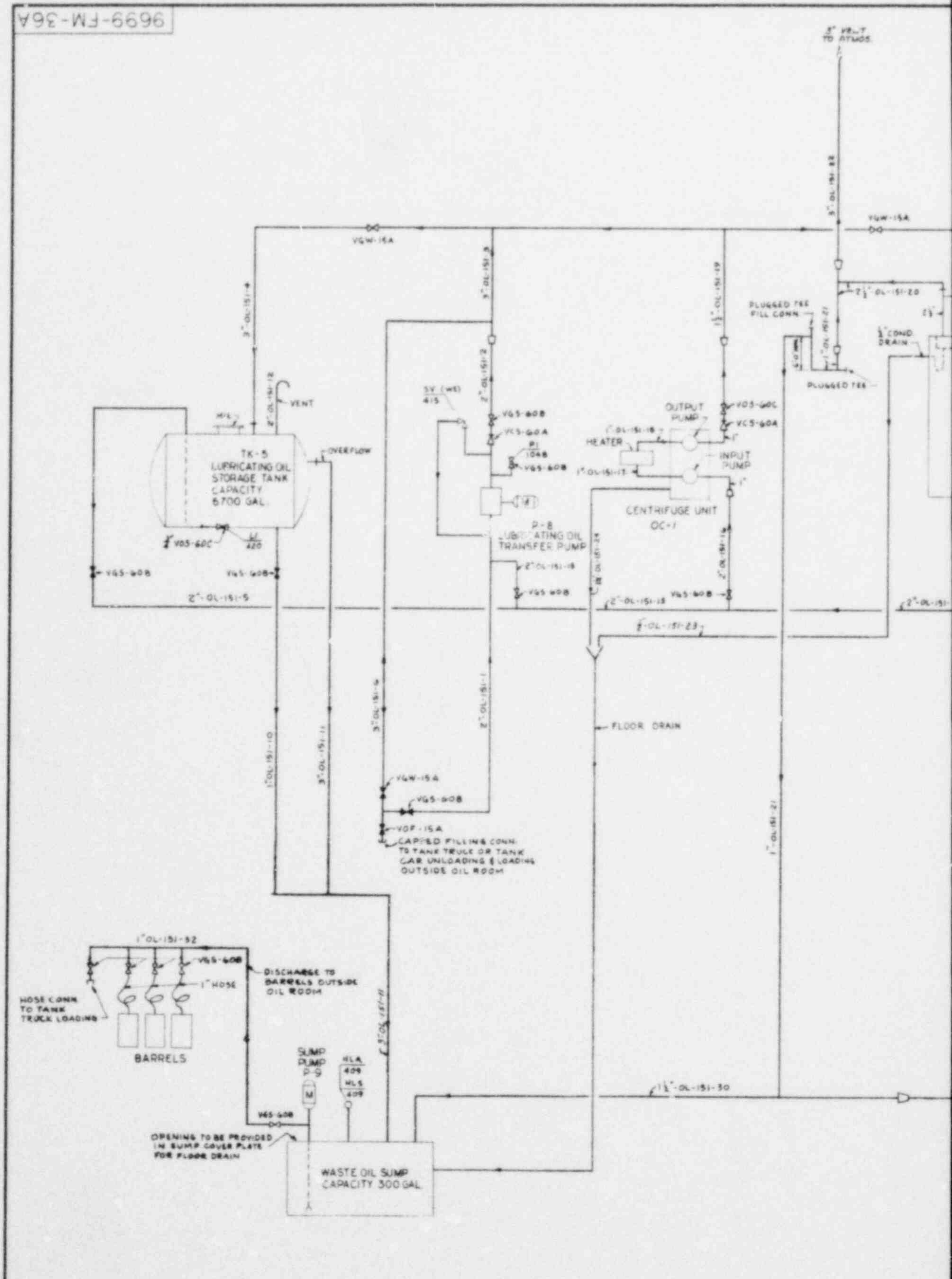
The lubricating oil system is shown on drawing 9699-FM-36A and provides the means for conditioning the turbine oil and for filling and draining the 4,500 gal turbine lubricating oil tank.

The 450 gal per hr lubricating oil centrifuge OC-1, located on the basement floor adjacent to the turbine oil tank, continuously clarifies a portion of the turbine lubricating oil and is sized to condition the contents of the turbine oil tank in about 10 hours. The centrifuge has inlet and discharge pumps which, together with the centrifuge itself, are driven by a common 2 hp, 440 v motor controlled by a magnetic starter with push button mounted on the unit. An 18 kw thermostatically controlled heater with an adjustable set point automatically maintains a minimum temperature of oil to the centrifuge at about 120-130 F.

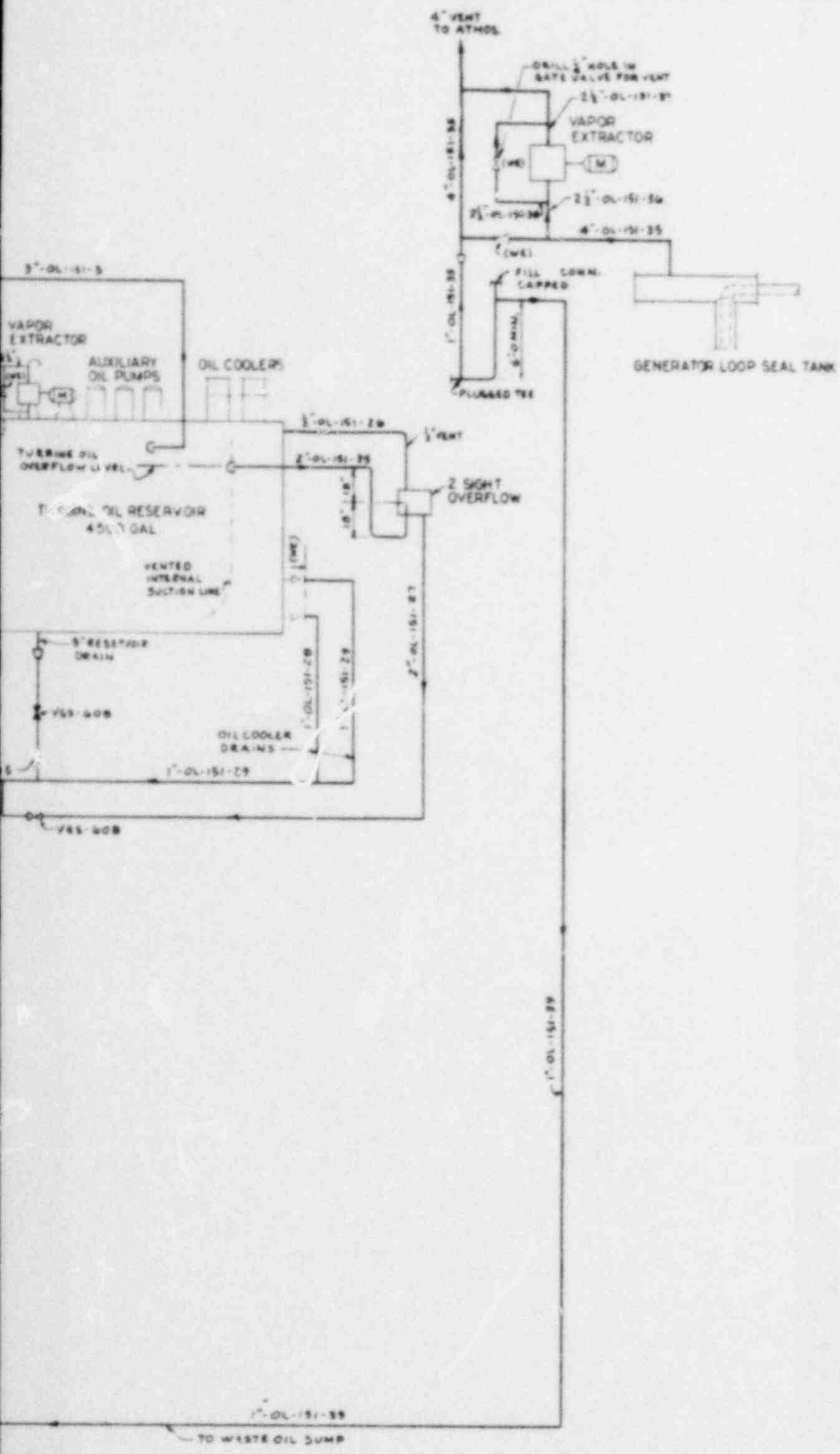
The lubricating oil room at El. 1022'-8" is of fireproof construction with automatic water spray fire protection and houses the 6,700 gal oil storage tank transfer pump and waste oil sump pump. The positive displacement type transfer pump has a capacity of 50 gpm with a total dynamic head of 25 psi gage.

The 5 hp, 440 v pump motor is controlled by a magnetic starter in motor control center No. 2 and has a locally mounted push button station. The pump is arranged to transfer oil in either direction between the oil loading point north of the oil room and the storage tank or the turbine oil tank. The pump can also transfer oil in either direction between the storage tank and turbine oil tank.

The 300 gal waste oil sump in the oil room receives drains from the oil storage tank, centrifuge and miscellaneous oil vent line drains. The 10 gpm sump pump discharges into barrels outside the north wall of the oil room. The 1/2 hp, 440 v sump pump motor is controlled by a magnetic starter located in motor control center No. 2 and actuated by a float switch or local selector switch.



9699-FM-36A
3" VENT TO ATMOS.
VGW-15A
3"-OL-151-4
3"-OL-151-3
2"-OL-151-12
VENT
TK-5
LUBRICATING OIL
STORAGE TANK
CAPACITY
6700 GAL.
OVERFLOW
VGS-60C
VGS-60B
2"-OL-151-5
2"-OL-151-2
VGS-60B
VCS-60A
P-8
LUBRICATING OIL
TRANSFER PUMP
2"-OL-151-18
OUTPUT PUMP
INPUT PUMP
HEATER
CENTRIFUGE UNIT
OC-1
VGS-60C
VCS-60A
PLUGGED TEE FILL CONN.
PLUGGED TEE
2"-OL-151-13
FLOOR DRAIN
3"-OL-151-6
2"-OL-151-1
1"-OL-151-10
3"-OL-151-11
VGW-15A
VGS-60B
VOF-15A
CAPPED FILLING CONN.
TO TANK TRUCK OR TANK
CAR UNLOADING & LOADING
OUTSIDE OIL ROOM
1"-OL-151-32
VGS-60B
DISCHARGE TO
BARRELS OUTSIDE
OIL ROOM
1" HOSE
HOSE CONN.
TO TANK
TRUCK LOADING
BARRELS
SUMP PUMP
P-9
1 1/2"-OL-151-30
1"-OL-151-21
OPENING TO BE PROVIDED
IN SUMP COVER PLATE
FOR FLOOR DRAIN
WASTE OIL SUMP
CAPACITY 300 GAL.



LEGEND

	GLOBE VALVE
	GATE VALVE
	VALVE NORMALLY LOCKED CLOSED
	CHECK VALVE
	REDUCER
	DIRECTION OF FLOW
	HOSE CONNECTION
	CAPPED CONN
	ORIFICE PLATE
SV	SAFETY VALVE
LI, HLS, HLA	LEVEL INDICATOR, HIGH LEVEL SWITCH, HIGH LEVEL ALARM
(WE)	FURNISHED WITH EQUIPMENT

APPROVED ____ REGISTERED PROFESSIONAL ENGINEER, COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5					
4					
3					
2	LINE 1"-OL-151-27 REMOVED				
1	ORIGINAL ISSUE				

FLOW DIAGRAM
LUBRICATING OIL SYSTEM

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-36A

226 ELECTRICAL SYSTEM

General

The electrical system includes the equipment necessary to generate electric power and deliver it to the 115 kv transmission system and also the facilities for providing the power necessary to drive auxiliary equipment within the plant itself. It has been designed to ensure that sufficient coolant flow is maintained to keep the thermal rise in the core within safe limits when electrical disturbances cause a partial loss of the electrical system. In order to provide complete safety to the reactor during a total loss of the electrical system for a prolonged period, an engine driven power source is provided to maintain service to vital equipment.

One line diagrams indicating the main electrical connection for the plant are shown on drawings Nos. 9699-FE-1B, 1C, 1D, 1G, and 9699-RE-1F.

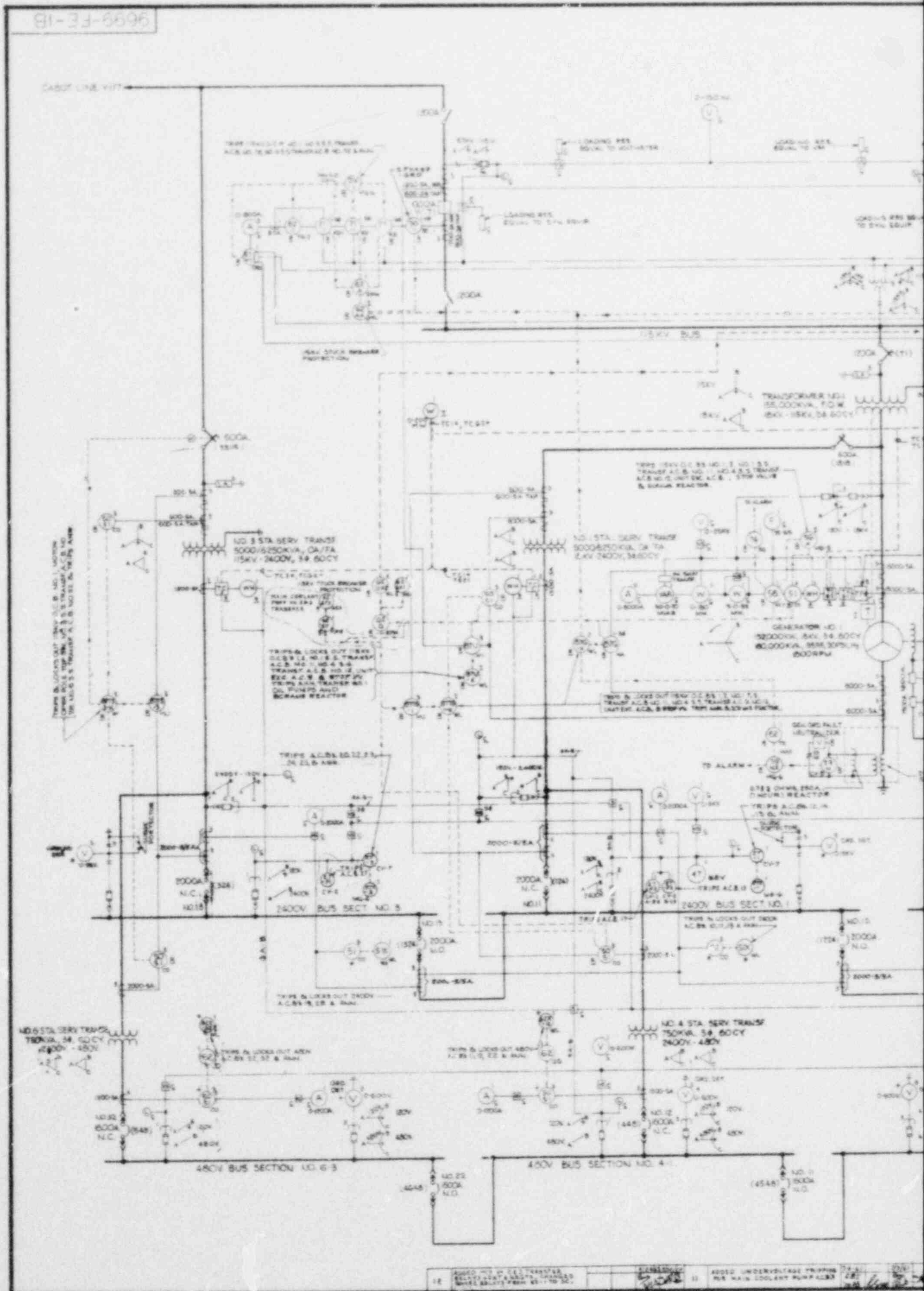
Generation and Transmission

The generator, a conventionally cooled unit, is rated 160 mva, .95 pf, 30 psi H_2, 3 phase, 60 cycles, 18 kv and operates at 1,800 rpm. The main exciter, rated 400 kw, 375 v is direct connected to the unit and the excitation is controlled automatically through the use of static type voltage regulating equipment or manually.

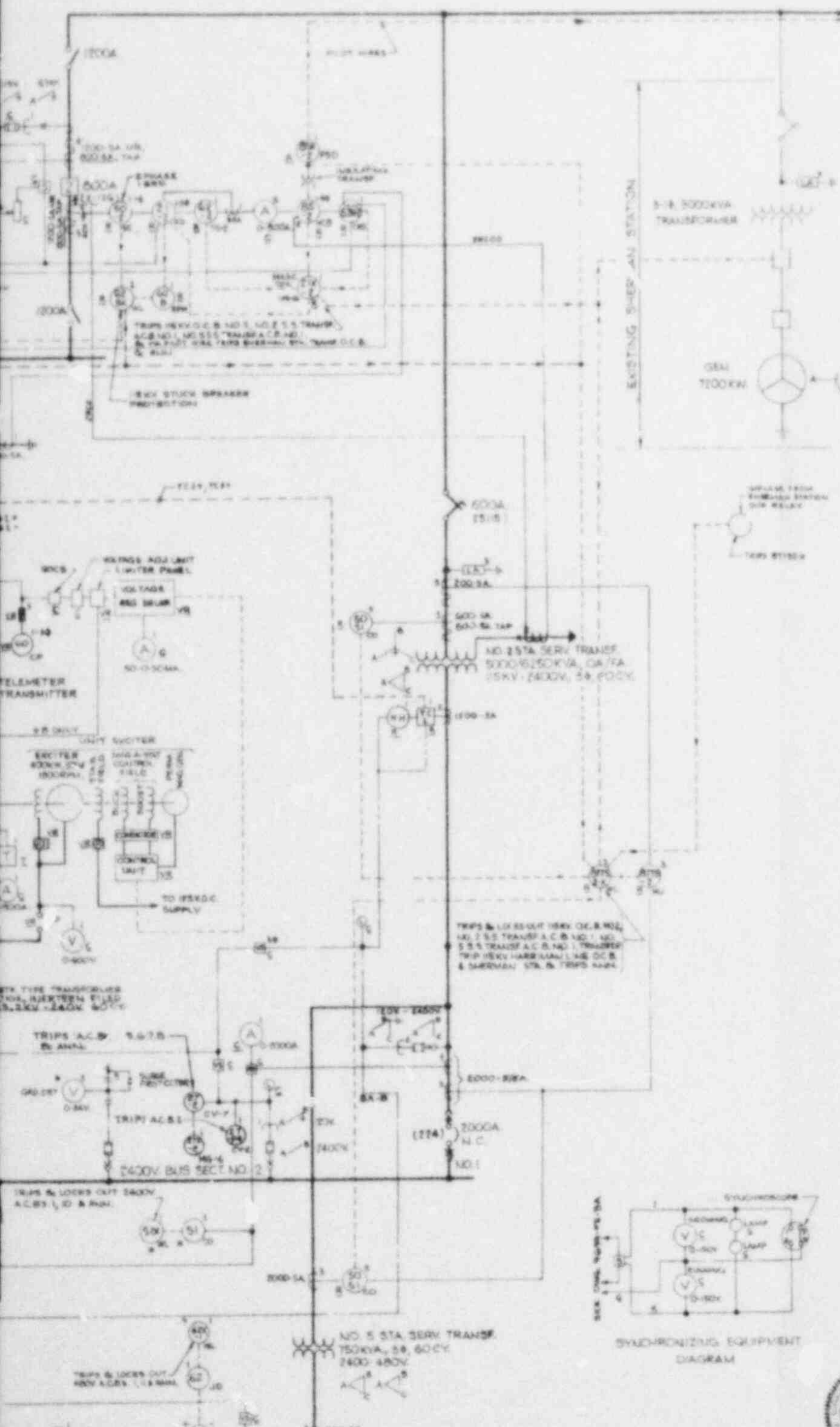
The generator line terminals are connected to the outdoor 18 kv aluminum channel bus by 5,500 amp, 23 kv, isolated phase type, copper conductor in cylindrical aluminum enclosures. The neutral bus is connected to a ground fault neutralizer which limits the ground current through the unit to a low value and minimizes damage t the unit during a ground fault.

No. 1 transformer is forced oi. ater cooled unit and is rated 155 mva, 115/18 kv, 3 phase, 60 cycles. I connected by overhead aluminum line to the 115 kv switchyard. The latter ins two 800 amp, 3-pole oil circuit breakers of 1,500 mva interrupting cap which provide the connection to the two transmission lines. A complemen 115 kv, 1,200 amp, gang operated, disconnecting switches are furnished for ally isolating various pieces of equipment and the lines during maintenance op ations.

These two 115 kv lines, owned by New England Powe mpany connect the plant output into the New England interconnection in the following manner. Line Z-126 runs in a northerly direction and connects to the 115 kv bus at the Harriman Station of New England Power Company. Line Y-177 runs in an easterly direction and connects to the 115 kv bus at Cabot Station of Western Massachusetts Electric Company. Normal operation is with both of these lines in service and, in this way, they furnish a firm station power supply with maximum reliability. The major portion of the transmission network for New England is shown on page 226:2.



CABOT LINE
115KV BUS
TRANSFORMER NO.1
2400V BUS SECT. NO. 3
2400V BUS SECT. NO. 1
NO.3 STA. SERV. TRANSF.
NO.1 STA. SERV. TRANSF.
NO.4 STA. SERV. TRANSF.
750KVA, 3Φ, 60CY
2400V - 480V
GENERATOR NO.1
1800RPM
TO ALARM
480V BUS SECTION NO. 6-3
480V BUS SECTION NO. 4-1



LEGEND:

- OIL CIRCUIT BREAKER - ELECTRICALLY OPERATED.
- AIR CIRCUIT BREAKER - ELECTRICALLY OPERATED.
- DISCONNECTING SWITCH.
- POLE TOP SWITCH - MOTOR OPERATED.
- DISCONNECT DEVICE FOR DRAWOUT CIRCUIT BREAKER.
- FUSE.
- LIGHTNING ARRESTER.
- SHUNT.
- CURRENT TRANSFORMER - NUMERAL INDICATES QUANTITY.
- CURRENT TRANSFORMER - BUSHING TYPE.
- POTENTIAL TRANSFORMER.
- CAPACITOR.
- BUSHING TYPE POTENTIAL DEVICE.
- RECORDING METER; T-TEMPERATURE, V-VOLT.
- INDICATING METER; A-AMMETER, F-FREQUENCY METER, T-TEMPERATURE INDICATOR, V-VOLTMETER, VAR-VARMETER, W-WATTMETER, WH-WATTHOUR METER, MW-MEGAWATT.
- RELAY OR OPERATING COIL; NUMERAL INDICATES DEVICE NUMBER.
- INDICATING LAMP.
- SWITCH; AS-AMMETER SWITCH, S-SYNCHRONIZING SWITCH, WS-WATTMETER SWITCH, VS-VOLTMETER SWITCH.
- RHEOSTAT - ELECTRICALLY OPERATED.
- RHEOSTAT - MANUALLY OPERATED.
- VOLTAGE DIVIDER CAPACITOR.
- EQUIPMENT LOCATED AT ELECTRICAL SECTION - MAIN CONT. BD.
- EQUIPMENT LOCATED AT REAR OF ELEC. & TURB. SECT. MAIN CONT. BD.
- EQUIPMENT LOCATED AT VOLTAGE REG. CUBICLE.
- EQUIPMENT LOCATED AT 2400V. SWITCHGEAR.
- EQUIPMENT LOCATED AT 480V. SWITCHGEAR.
- EQUIPMENT LOCATED AT TURBINE SECTION - MAIN CONT. BD.
- THERMAL CONVERTER [illegible]

DEVICE NUMBERS:

- 21 IMPEDANCE RELAY
- 27 UNDERVOLTAGE RELAY
- 74 ALARM RELAY
- 50 OVERCURRENT RELAY - INSTANTANEOUS
- 51 OVERCURRENT RELAY - TIME DELAY
- 56 LOSS OF FIELD RELAY
- 59N GROUND OVERVOLTAGE RELAY
- 61 PHASE BALANCE CURRENT RELAY
- 62 TIME DELAY RELAY
- 67N DIRECTIONAL GROUND RELAY
- 87 DIFFERENTIAL CURRENT RELAY; G-GENERATOR, U-UNIT, TS-STATION SERVICE TRANSFORMER.
- 85 PILOT WIRE RELAY
- X AUXILIARY DEVICE
- 60 VOLTAGE BALANCE RELAY
- 47 POSITIVE PHASE SEQUENCE UNDERVOLTAGE RELAY

NOTES:

1. FOR 2400V ONE LINE DIAGRAM, SEE DWG. 9699-FE-1C.
2. FOR 480V ONE LINE DIAGRAM - SH.1, SEE DWG. 9699-FE-1D
3. FOR 480V ONE LINE DIAGRAM - SH.2, SEE DWG. 9699-FE-1P
4. FOR 480V ONE LINE DIAGRAM - SH.3, SEE DWG. 9699-FE-1Q

APPROVED [signature]
REGISTERED PROFESSIONAL ENGINEER NO. 1175
COMMONWEALTH OF MASSACHUSETTS

THIS DRAWING SUPERSEDES DWG 9699-FE-1A

Issue	Description	Chkd.	Insp.	Corr.	Appr.
10	ADDED NET STA. OUTPUT INDICATION	[illegible]	[illegible]	[illegible]	[illegible]
9	AS BUILT CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
8	ADDED AUX. FOR LINE FAULTS & STA. SERV. OVERLOAD	[illegible]	[illegible]	[illegible]	[illegible]
7	ADDED TELEMETER TRANSMITTER, REVISED TRANSFER TRIPPING TO SHERMAN & MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
6	ADDED RECORDING VOLTMETER, AUX. RE. FOR GEN. GND. FAULT DET., REVISED SYN. EQUIP. DIAGRAM & MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
5	ADDED POSITIVE PHASE SEQUENCE UNDERVOLTAGE RELAY, REMOVED CARRIER BD. & MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
4	ADDED 2400V BUS [illegible] RELAYS, [illegible] RELAY, REV. 550 [illegible] & MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
3	GENERAL REVISION	[illegible]	[illegible]	[illegible]	[illegible]
2	GENERAL REVISION	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

SCHEMATIC DIAGRAM - METERS, RELAYS & SYNCHRONIZING

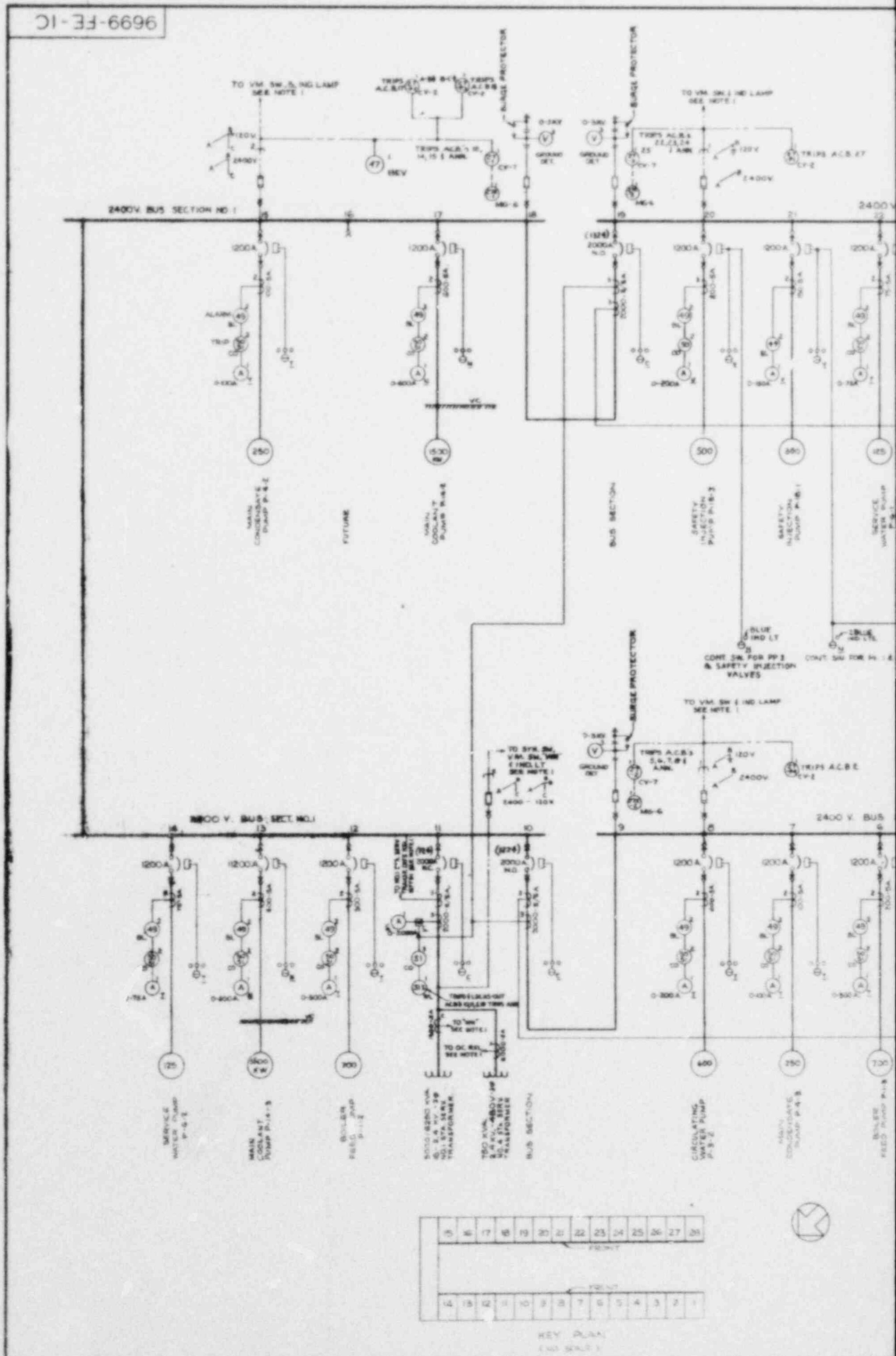
POWER STATION

YANKEE ATOMIC ELECTRIC COMPANY

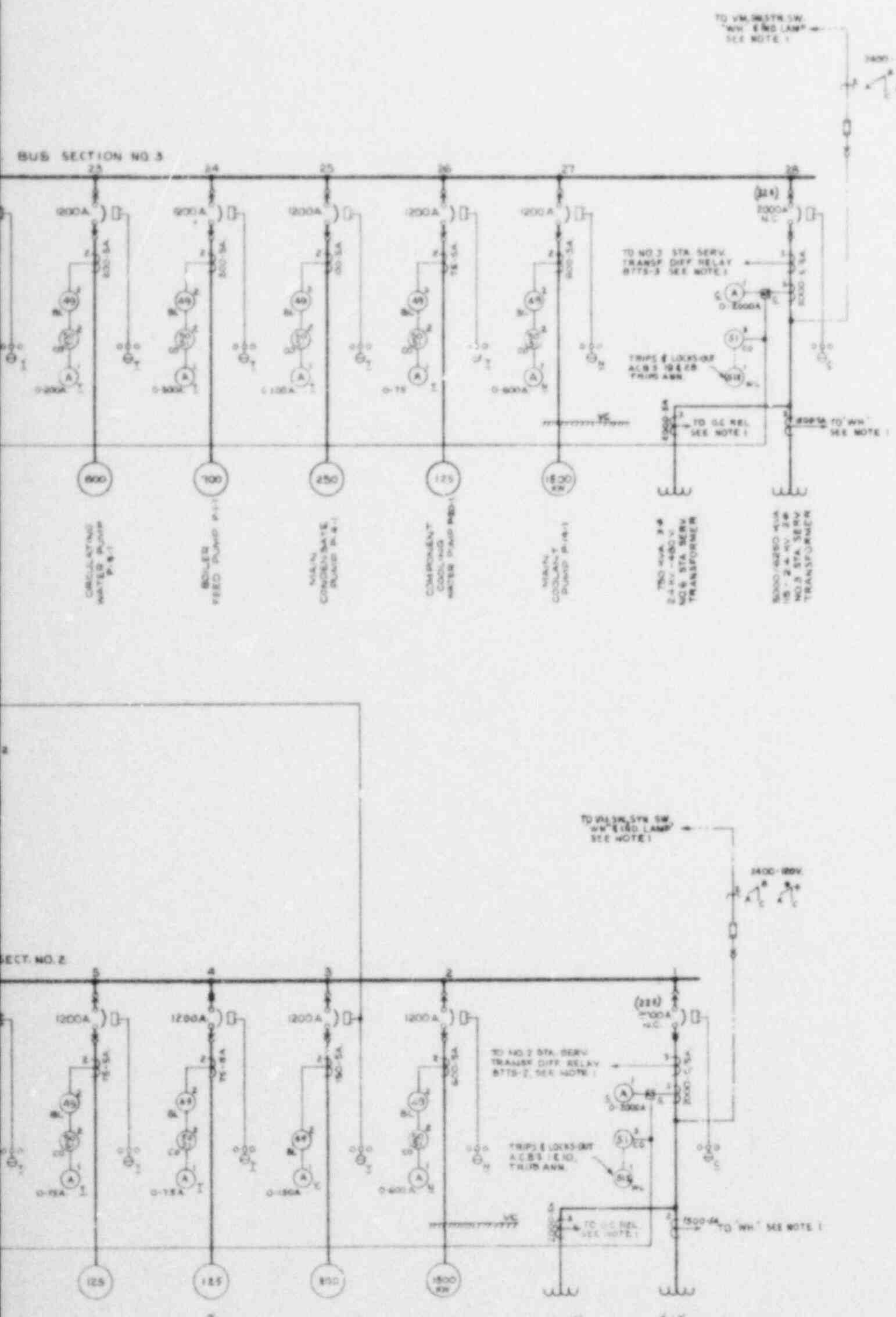
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FE-1B



9699-FE-1C
2400V. BUS SECTION NO. 1
2400 V. BUS SECT. NO. 1
2400 V. BUS
SURGE PROTECTOR
TO VM. SW. & IND. LAMP SEE NOTE 1
GROUND DET.
TRIPS A.C.B. 27
MAIN CONDENSATE PUMP P-4-2
FUTURE
MAIN COOLANT PUMP P-1-2
BUS SECTION
SAFETY INJECTION PUMP P-18-2
SAFETY INJECTION PUMP P-18-1
SERVICE WATER PUMP
BLUE IND. LT.
CONT. SW. FOR PP 2 & SAFETY INJECTION VALVES
SERVICE WATER PUMP P-6-2
MAIN COOLANT PUMP P-1-3
BOILER FEED PUMP P-1-2
BUS SECTION
CIRCULATING WATER PUMP P-3-2
MAIN CONDENSATE PUMP P-4-3
BOILER FEED PUMP P-1-3
KEY PLAN
FRONT



LEGEND:

- AIR CIRCUIT BREAKER, ELECTRICALLY OPERATED
- DISCONNECT DEVICE: CLOSED WITH BREAKER IN OPER POS.
- CURRENT TRANSFORMER, NUMERAL INDICATES QUANTITY
- POTENTIAL TRANSFORMER, NUMERAL INDICATES QUANTITY
- FUSE
- (27) RELAY OR OPERATING COIL, NUMERAL INDICATES DEVICE NUMBERS
- (175) INDUCTION MOTOR, NUMERAL INDICATES HP-RATING
- AS AMMETER SWITCH, VS - VOLTMETER SWITCH
- (A) AMMETER, V - VOLTMETER, WH - WATTHOUR METER
- CONTROL SWITCH WITH RED, AMBER AND GREEN INDICATING LIGHTS
- VOLTAGE DIVIDER CAPACITOR

- X EQUIPMENT LOCATED AT VALVE CONTROL PANEL
- E EQUIPMENT LOCATED AT ELEC. SECT. - MAIN CONTROL
- T EQUIPMENT LOCATED AT TURB. SECT. - MAIN CONTROL
- N EQUIPMENT LOCATED AT NUCLEAR PANEL (BY [illegible])
- D EQUIPMENT LOCATED AT WASTE DISPOSAL BLDG.
- VC STOP JOINT AT VAPOR CONTAINER

DEVICE NUMBERS:

- 27 VOLTAGE RELAY
- 49 THERMAL RELAY
- 50 OVERCURRENT RELAY, INSTANTANEOUS
- 51 OVERCURRENT RELAY, TIME DELAY
- 47 POSITIVE PHASE SEQUENCE UNDERVOLTAGE RELAY

NOTES:

1. FOR SCHEMATIC DIAGRAM - METERS, RELAYS & SYNCHRONIZING SEE DWG. 9699-FE-18.
2. A CONTROL SW. WITH RED AND GREEN INDICATING LIGHTS IS MOUNTED ON EACH A.C.B. CUBICLE. THIS SWITCH OPERATES A.C.B. ONLY, WHEN BREAKER IS IN TEST POSITION.

ISSUE	DESCRIPTION	CHKD	INSP	COORD	APPR
10	ISSUED FOR [illegible] REMOVED WASTE DISP. [illegible] TRANSF. [illegible] & MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
9	ADDED UNDERVOLTAGE RELAYS FOR MAIN COOLANT PUMP A.C.B. TRIPPING	[illegible]	[illegible]	[illegible]	[illegible]
8	ADDED SURGE PROTECTOR TO VOLTAGE DIVIDERS & MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
7	ADDED POSITIVE PHASE SEQUENCE UNDERVOLTAGE RELAYS & [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	ADDED BUS UNDERVOLTAGE RELAYS, RELOCATED BUS PT'S & MINOR CHANGES	QT	[illegible]	[illegible]	[illegible]
5	REMOVED AUTO. TRANSFER RELAYS, REVISED MOTOR SIZES.	QT	[illegible]	[illegible]	[illegible]
4	GENERAL REVISION, SEE YANKEE LETTER YY617.	QT	[illegible]	[illegible]	CW
3	REMOVED SPARE EXC. REVISED CKTS. 1, 11 & 28 & MINOR CHANGES.	QT	[illegible]	[illegible]	[illegible]
2	REVISED STA. SERV. TRANSF'S. [illegible] MINOR CHANGES	QT	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	QT	[illegible]	[illegible]	[illegible]

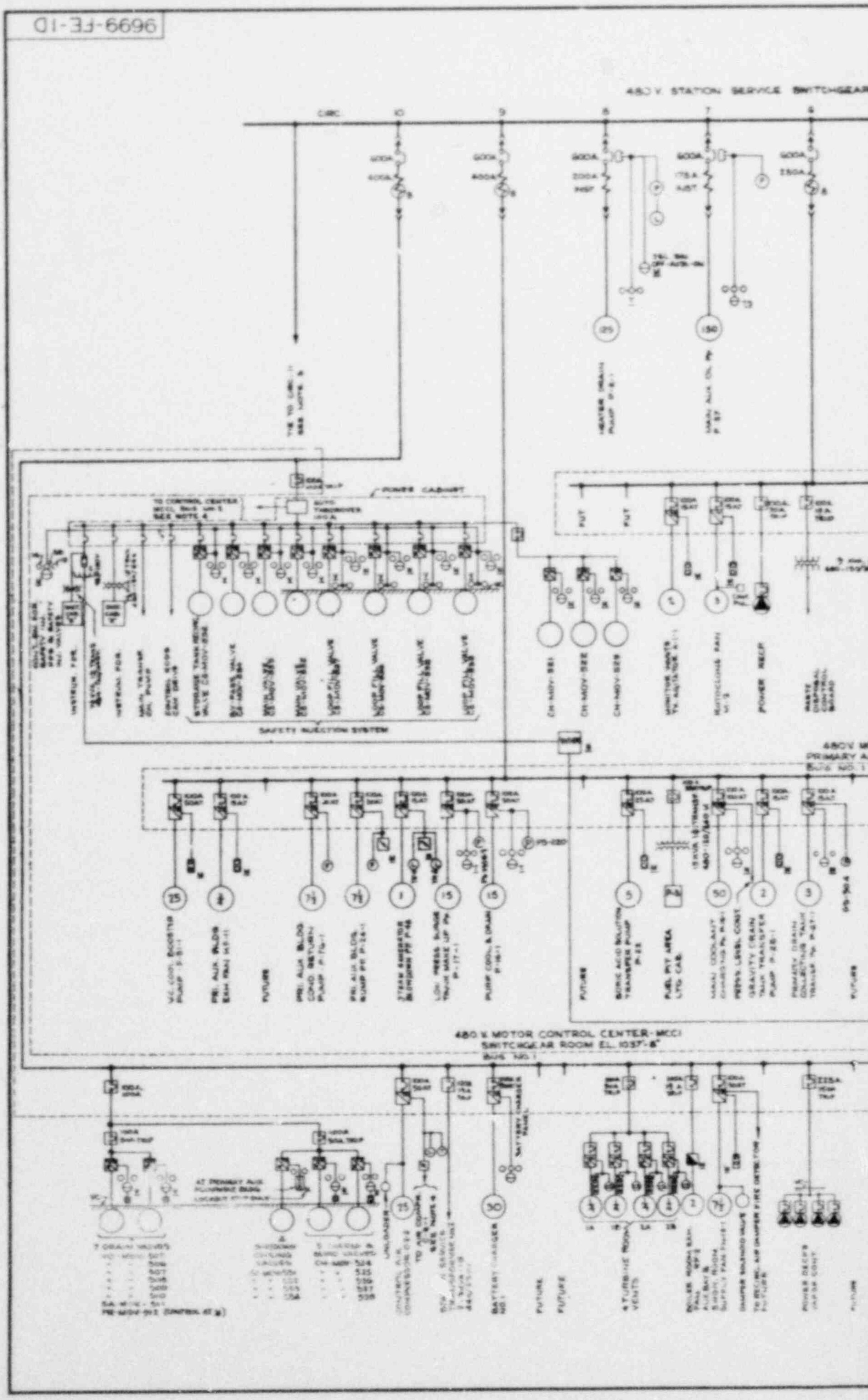
APPROVED *Edward T. [illegible]*
REGISTERED PROFESSIONAL ENGINEER NO. [illegible]
COMMONWEALTH OF MASSACHUSETTS

2400V ONE LINE DIAGRAM

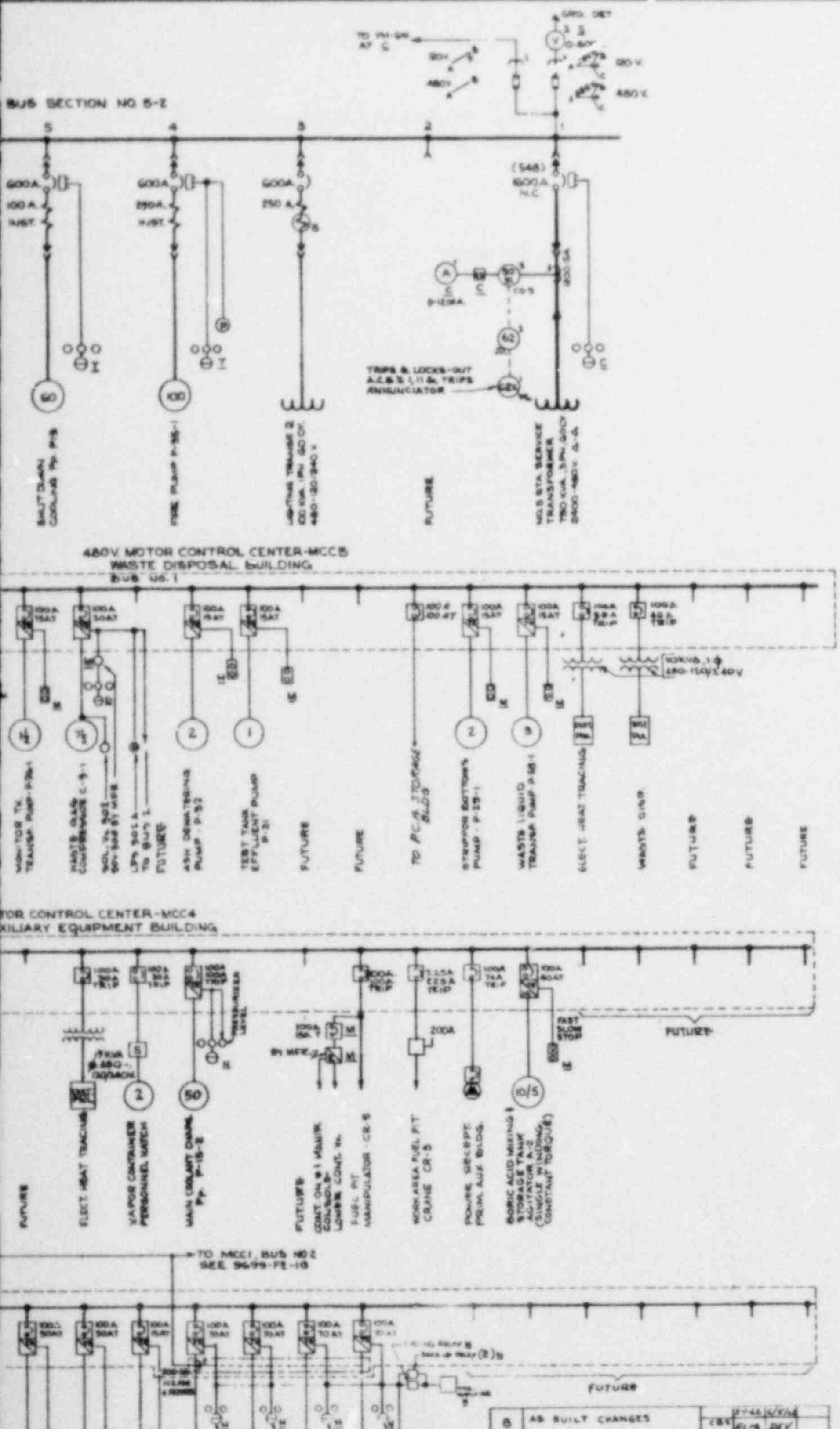
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FE-1C



9699-FE-1D
480 V STATION SERVICE SWITCHGEAR
480 V MOTOR CONTROL CENTER-MCC1
SWITCHGEAR ROOM EL. 1037'-8"
BUS NO. 1
POWER CABINET
SAFETY INJECTION SYSTEM
480V MO
PRIMARY AU
BUS NO. 1
HEATER DRAIN PUMP P-8-1
FUTURE



LEGEND

- FUSED DISC. SW., 100 AMPS
- UNFUSED DISC. SW., 100 AMPS
- SPECIAL CONTROL
- MANUAL STARTER
- SYNCHRONIZING LAMP
- AIR CIRCUIT BREAKER, MANUALLY OPERATED, 3 P.S.T., 600V. 600A. FRAME WITH 175 A. INVERSE TIME MAGNETIC OVERCURRENT TRIP ATTACHMENT (80-160% ADJ.) AND A SELECTIVE SHORT TIME (2 TO 30 SEC.) OVERCURRENT TRIP DEVICE AT APPROX. 5-12 TIMES THE OVERCURRENT COIL RATING
- VOLTMETER
- VOLTMETER SWITCH
- AIR CIRCUIT BREAKER, ELECTRICALLY OPERATED, 3 P.S.T. 600V. 600 A. FRAME WITH 150 A. INVERSE TIME MAGNETIC OVERCURRENT TRIP ATTACHMENT (80-160% ADJ.) AND AN ADJUSTABLE INSTANTANEOUS MAGNETIC TRIP ATTACHMENT SET FOR APPROX. 5-12 TIMES THE OVERCURRENT COIL RATING
- SYNCHRONIZING SWITCH
- AIR CIRCUIT BREAKER, ELECTRICALLY OPERATED 3 P.S.T. 600V. 1600A. FRAME
- DISCONNECTING DEVICE
- CURRENT TRANSFORMER, 1200-5A. NUMERAL 3 INDICATES QUANTITY
- POTENTIAL TRANSFORMER, 480-120 V. NUMERAL 3 INDICATES QUANTITY
- FUSE
- INDUCTION MOTOR - NUMERAL INDICATES HORSE POWER RATING
- COMBINATION CIRCUIT BREAKER & POWER RECEPTACLE, 3φ, 480V. 100A. FRAME, 50A. TRIP, 60A. RECEPT.
- OVERCURRENT RELAY - TIME DELAY
- AMMETER
- AMMETER SWITCH
- AIR CIRCUIT BREAKER, 3 P.S.T., 600V., 100A.
- COMBINATION A.C.B. & MAGNETIC CONTACTOR WITH THERMAL OVERLOAD RELAY
- MAGNETIC CONTACTOR: R - REVERSING, TR - CONTROL TRANSF. 480-120 V., 2S - 2 SPEED
- CONTROL SWITCH WITH RED, AMBER & GREEN INDICATING LIGHTS
- PUSH BUTTON STATION "START" "STOP" MOMENTARY CONTACT
- PUSH BUTTON STATION "START" "STOP" MAINTAINING CONTACT
- EQUIPMENT LOCATED AT 100KW EMERGENCY GENERATOR
- PUSH BUTTON STATION "OPEN-STOP-CLOSE" MOMENTARY CONTACT. "K" DENOTES KEY OPERATED.
- F-FLOAT SWITCH, P-PRESS. SW., T-THERMOSTAT, LS-LIMIT SW. & L-LEVEL SW.
- SELECTOR SWITCH - HAND-OFF-AUTO
- STOP JOINT AT VAPOR CONTAINER.
- EQUIPMENT LOCATED AT ELEC. SECT.-MAIN CONTROL BOARD
- EQUIPMENT LOCATED AT TURB. SECT.-MAIN CONTROL BOARD
- EQUIPMENT LOCATED AT TURBINE START UP PANEL
- EQUIPMENT LOCATED NEAR MOTOR.
- EQUIPMENT LOCATED AT NUCLEAR SECT.-MAIN CONTROL BOARD
- EQUIPMENT LOCATED AT VALVE CONTROL PANEL
- EQUIPMENT LOCATED AT 480V SWITCHGEAR.
- EQUIPMENT LOCATED ON WASTE DISPOSAL BOARD

NOTES

1. FOR SCHEMATIC DIAGRAM - METERS, RELAYS & SYN. SEE DWG. 9699-FE-1B
2. FOR 2400V. ONE LINE DIAGRAM, SEE DWG. 9699-FE-1C
3. FOR 480V. ONE LINE DIAGRAM-SH.2, SEE DWG. 9699-FE-1F
4. FOR 480 V. ONE LINE DIAGRAM-SH.3, SEE DWG. 9699-FE-1G
5. FOR ARRANGEMENT CONTROL CENTERS, SEE DWG. 9699-FE-50A
6. SWITCHGEAR CONTROL DEVICES OPERABLE ONLY WHEN THE BREAKER IS IN THE TEST POSITION, SHALL BE FURNISHED FOR ELECTRICALLY OPERATED BREAKERS AS FOLLOWS;
   (1) CONTROL SWITCH WITH RED, AMBER & GREEN INDICATING LIGHTS FOR 1600A. TRANSFORMER FEEDER BREAKERS.
   (2) CONTROL SWITCH WITH RED & GREEN INDICATING LIGHTS FOR 1600A. BUS TIE BREAKERS.
   (3) "CLOSE"-"TRIP" PUSHBUTTON STATIONS FOR 600A. MOTOR FEEDER BREAKERS.

ISSUE	DESCRIPTION	DRAWN	CHKD	W.S.P.	APPR.
10	ISSUED FOR LD 10600-73 ADDED P-15-2 TO BUS 1 MCC1 ADDED VALVES CH-MOV-321, CH-MOV-327 & CH-MOV-329 TO AUTO T.O. SYSTEM	[illegible]	[illegible]	[illegible]	[illegible]
9	ADDED A.C.B. TO MOTOR CONTROL CENTER MCC5 7-32-81	DRC	REM	R.M.	[illegible]

ISSUE	DESCRIPTION	CHKD	INSP.	CORR.	APPR.
8	AS BUILT CHANGES	CBY	RLM	DEV	
7	ADDED TO LEGEND	[illegible]	[illegible]	[illegible]	[illegible]
6	ADDED FRAME RATING & TRIP SETTING OF A.C.B'S. MINOR CHANGES	[illegible]	[illegible]	WR	[illegible]
5	ADDED STARTER IN MCC4 FOR PUMP P-46 & WATTHOUR METER FOR PRESSURIZER HEATERS MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
4	GENERAL REVISIONS	[illegible]	HAT	[illegible]	[illegible]
3	GENERAL REVISIONS	JHF	[illegible]	[illegible]	[illegible]
2	GENERAL REVISIONS	JKK	[illegible]	[illegible]	
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

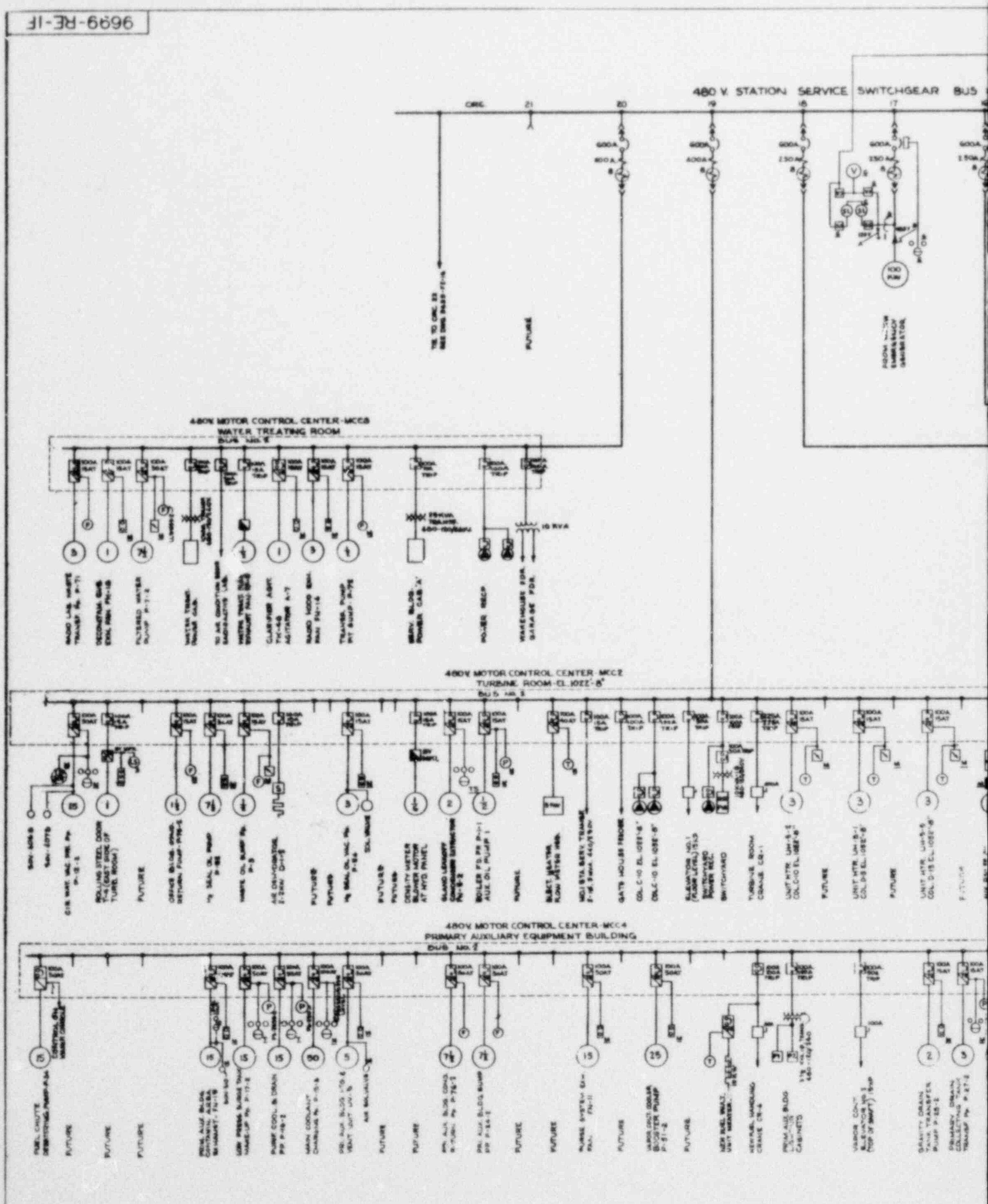
APPROVED [signature]
REGISTERED PROFESSIONAL ENGINEER NO. [illegible]
COMMONWEALTH OF MASSACHUSETTS

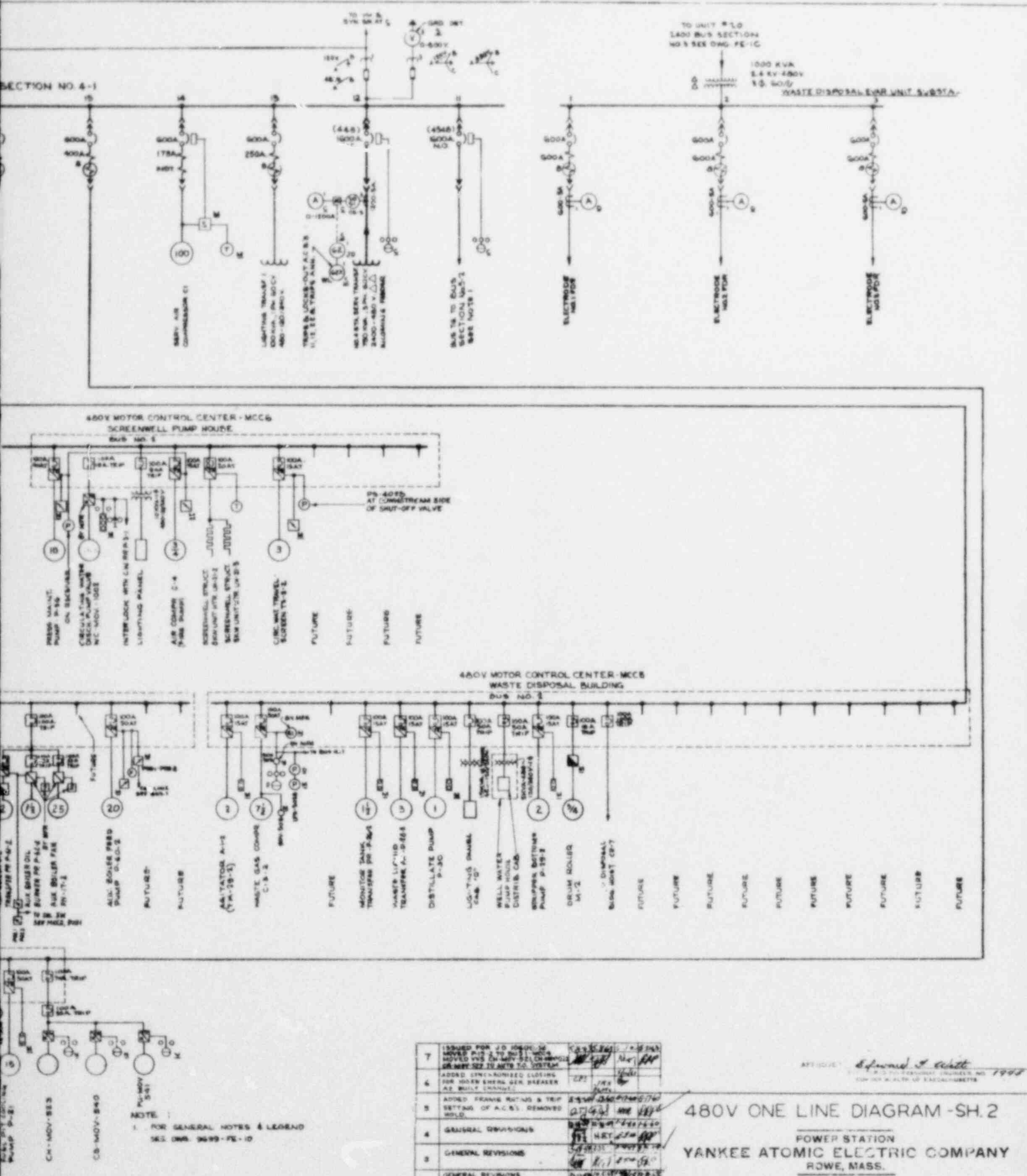
480V. ONE LINE DIAGRAM - SH.1

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FE-1D


480 V. STATION SERVICE SWITCHGEAR BUS
480V MOTOR CONTROL CENTER-MCC8
WATER TREATING ROOM
480V MOTOR CONTROL CENTER-MCC2
TURBINE ROOM-EL.1022'-8"
480V MOTOR CONTROL CENTER-MCC4
PRIMARY AUXILIARY EQUIPMENT BUILDING



ISSUE	DESCRIPTION	CHKD.	INSP.	COOR.	APPR.
7	ISSUED FOR J.O. ... MOVED ... TO ... SYSTEM				
6	ADDED SYNCHRONIZED CLOSING FOR 1000 KW EMERG GEN. BREAKER AS BUILT CHANGES				
5	ADDED FRAME RATING & TRIP SETTING OF A.C.B'S. REMOVED HOLD.				
4	GENERAL REVISIONS				
3	GENERAL REVISIONS				
2	GENERAL REVISIONS				
1	ORIGINAL ISSUE				

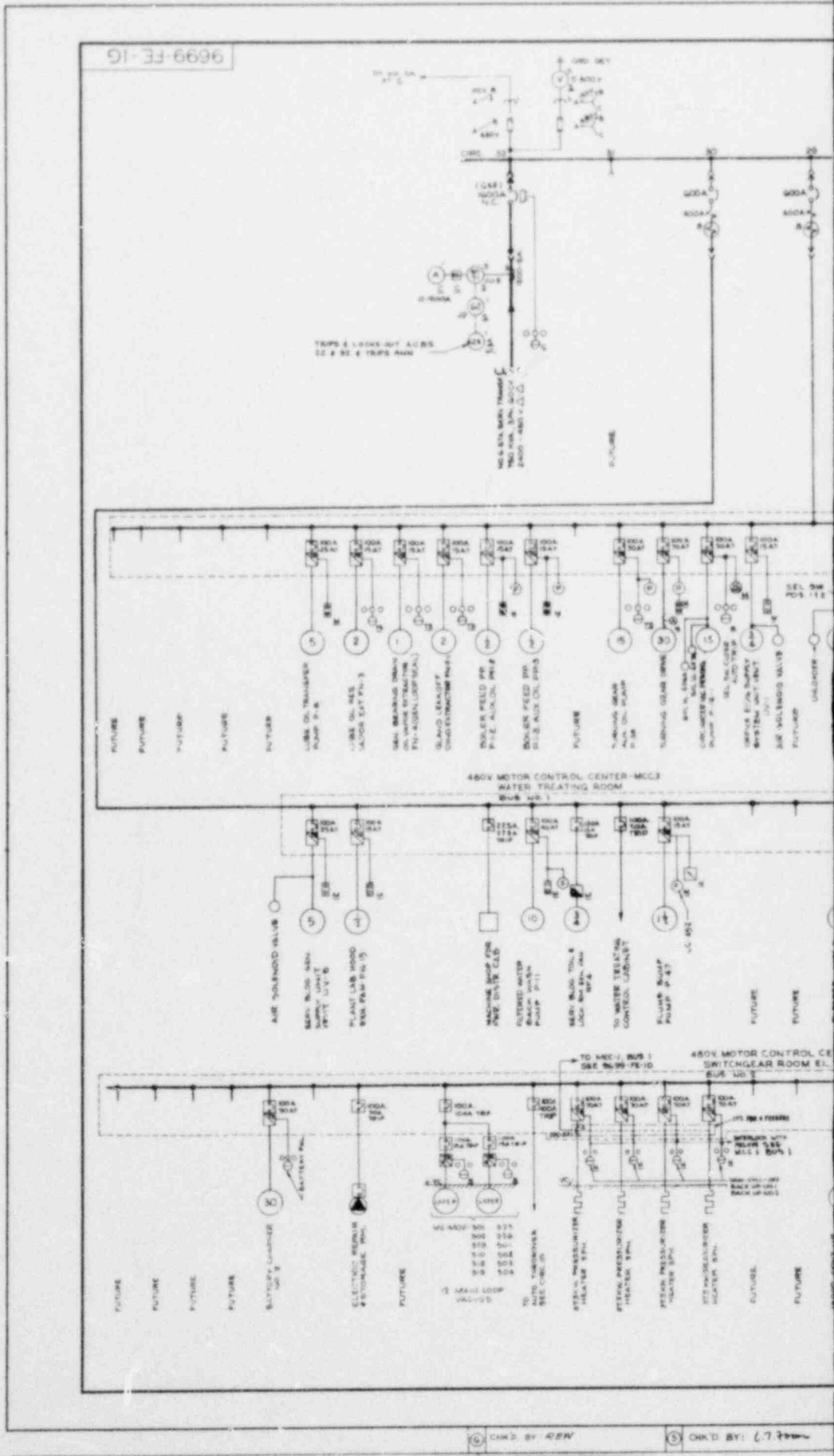
APPROVED: Edward F. Abbott

480V ONE LINE DIAGRAM - SH. 2

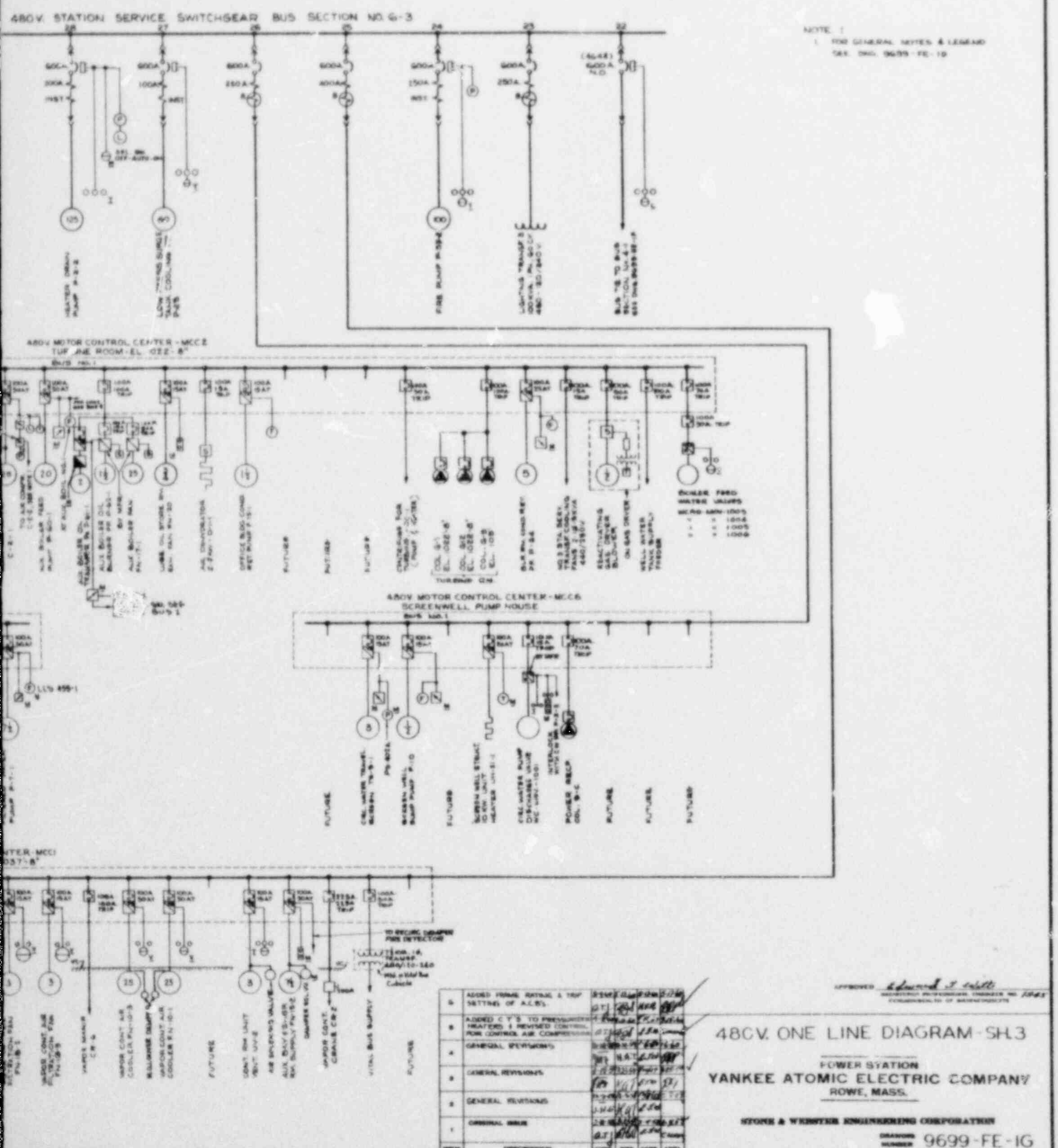
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-RE-1F



9699-FE-1G
480V MOTOR CONTROL CENTER-MCC3
WATER TREATING ROOM
480V MOTOR CONTROL CE
SWITCHGEAR ROOM EL
TRIPS & LOCKS-OUT A.C.B.S
FUTURE
LUBE OIL TRANSFER PUMP P-8
BOILER FEED PP
TURNING GEAR DRIVE
AIR SOLENOID VALVE
FLUME PUMP P-47
TO WATER TREATING CONTROL CABINET
FILTERED WATER BACK WASH PUMP P-11
MACHINE SHOP FOR PWR DISTR CAB
BATTERY CHARGER
ELECTRIC REPAIR & STORAGE PNL
TO MCC-1, BUS 1 SEE 9699-FE-10
CHK'D. BY: REW
CHK'D. BY:



6	ADDED FRAME RATINGS & TRIP SETTINGS OF A.C.B.'s				
5	ADDED C.T.'S TO PRESSURIZER HEATERS & REVISED CONTROL FOR CONTROL AIR COMPRESSORS				
4	GENERAL REVISIONS				
3	GENERAL REVISIONS				
2	GENERAL REVISIONS				
1	ORIGINAL ISSUE				
ISSUE	DESCRIPTION				

480V. ONE LINE DIAGRAM - SH.3

POWER STATION

YANKEE ATOMIC ELECTRIC COMPANY

ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

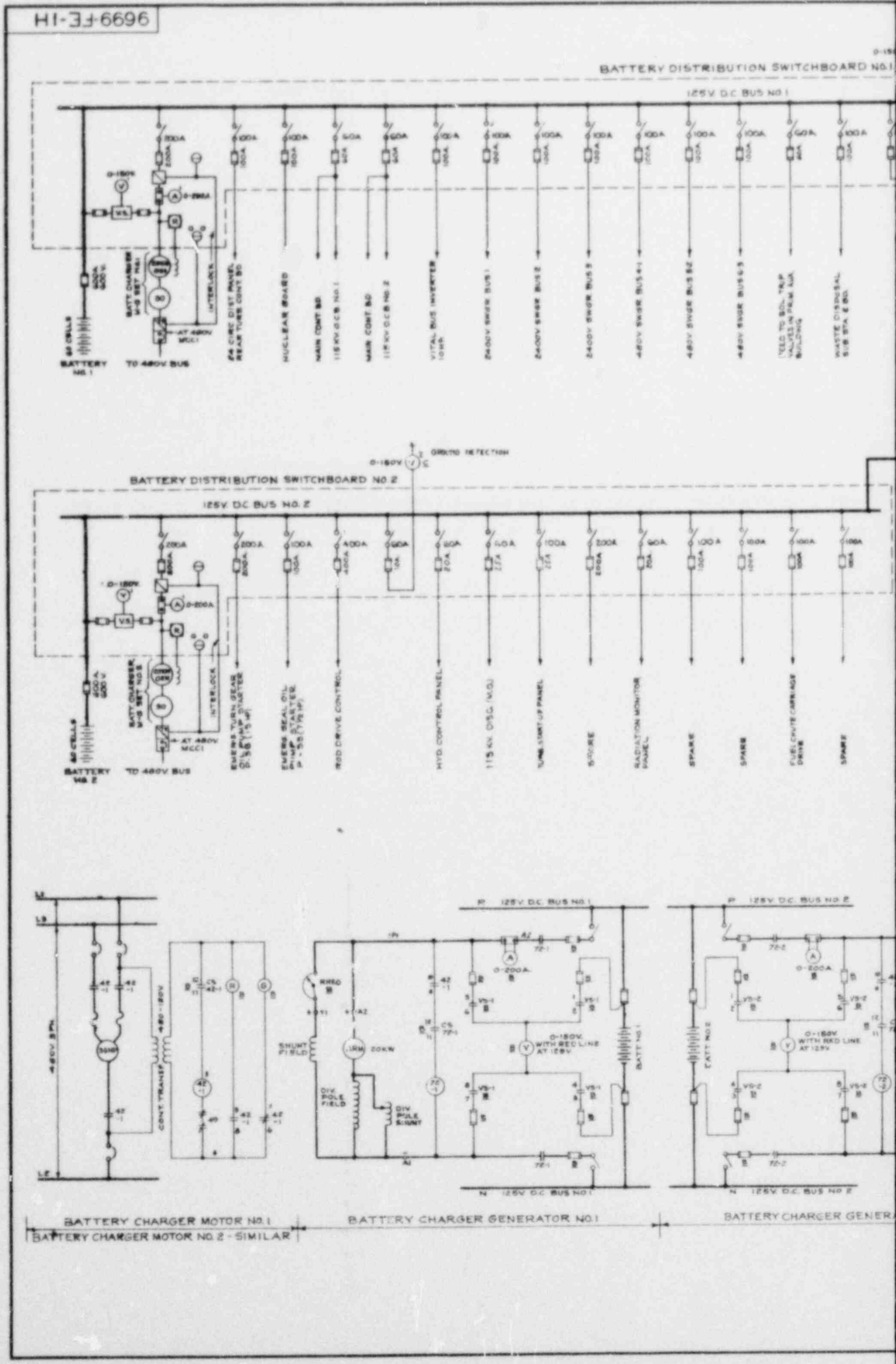
DRAWING NUMBER 9699-FE-1G

Designed by

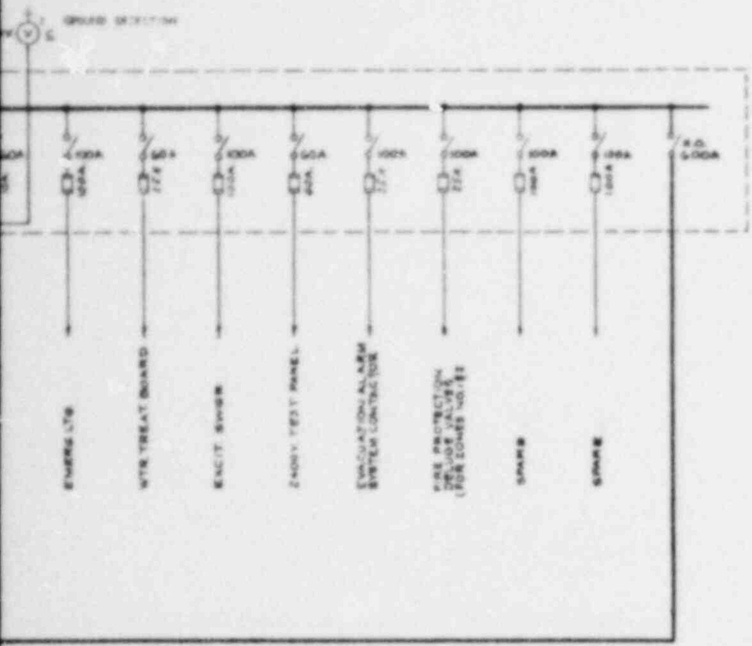
Dwn. Chk'd by

Drawn by

Chk'd by



BATTERY DISTRIBUTION SWITCHBOARD NO.1
125V. D.C. BUS NO.1
BATTERY NO.1
TO 480V BUS
INTERLOCK
NUCLEAR BOARD
MAIN CONT BD
VITAL BUS INVERTER
2400V SWGR BUS 1
2400V SWGR BUS 2
2400V SWGR BUS 3
480V SWGR BUS 4-1
480V SWGR BUS 5-2
480V SWGR BUS 6-3
WASTE DISPOSAL SUB STA. & BD.
GROUND DETECTION
BATTERY DISTRIBUTION SWITCHBOARD NO.2
125V. D.C. BUS NO.2
BATTERY NO.2
ROD DRIVE CONTROL
HYD. CONTROL PANEL
115 KV. DISC. (M.O.)
RADIATION MONITOR PANEL
SPARE
FUEL CHUTE CARRIAGE DRIVE
P 125V. D.C. BUS NO.1
N 125V. D.C. BUS NO.1
P 125V. D.C. BUS NO.2
N 125V. D.C. BUS NO.2
SHUNT FIELD
DIV. POLE FIELD
DIV. POLE SHUNT
CONT. TRANSF.
BATTERY CHARGER MOTOR NO.1
BATTERY CHARGER MOTOR NO.2 - SIMILAR
BATTERY CHARGER GENERATOR NO.1
BATTERY CHARGER GENERA



LEGEND:

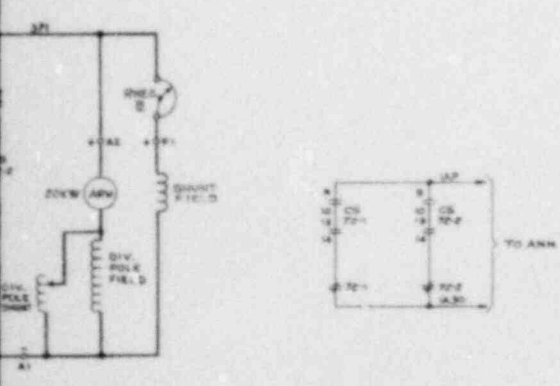
- AIR CIRCUIT BREAKER
- DISCONNECT SWITCH
- FUSE - ALL FUSES TO BE TIME LAG
- CONTACT, CLOSED WHEN DEVICE IS DE-ENERGIZED OR IN NON-OPERATED POSITION
- CONTACT CLOSED WHEN DEVICE IS ENERGIZED OR IN OPERATED POSITION
- SHUNT 200A, 50MV
- A.C. COMBINATION A.C.B. & MAGNETIC CONTACTOR WITH T.O.P. TB CONTROL TRANSFORMER 480-120V
- MAGNETIC CONTACTOR
- VOLTMETER SWITCH
- MOTOR - NUMERALS INDICATE H.P. RATING
- METER - A-AMMETER, V-VOLTMETER
- INDICATING LIGHT - R-RED, G-GREEN
- MANUAL RHEOSTAT
- CONTROL SWITCH WITH RED & GREEN INDICATING LIGHTS
- RELAY OR OPERATING COIL - NUMERAL INDICATES DEVICE NUMBER.
- CS CONTROL SWITCH
- C EQUIP LOCATED AT MAIN CONT. BD. ELECT. SECT
- B EQUIP LOCATED AT BATTERY DIST. SWBD.

DEVICE NUMBERS:

- 42 A.C. CONTACTOR
- 49 THERMAL OVERLOAD DEVICE
- 72 D.C. CONTACTOR

NOTES:

1. FOR SCHEMATIC DIAG. METERS, RELAYS & SYNCHRONIZING, SEE DWG. 9699-FE-1B.
2. FOR 480V ONE LINE DIAG. SHEETS 1, 2 & 3, SEE DWG. 9699-FE-1D, 1F & 1G.



VS-1, 2

CONT	POSITION		
	GEN	OFF	BATT
1-2			X
3-4			X
5-6	X		
7-8	X		

VOLTMETER
OFF
GEN BATT
BATT GEN
OFF
FV

VOLTMETER SWITCH
WEST. CO. TYPE "W"
SIMILAR TO STYLE
1254744

42-1, 42-2, 72-1 & 72-2

CONT	POSITION				
	PULL	TRIP	OFF AFTER TRIP	OFF AFTER CLOSE	CLOSE
1-2					X
3-4	X	X			
5-6		X	X	X	X
7-8			X	X	
9-10			X	X	
11-12				X	X
13-14				X	X

CONTACTOR CONTROL
OFF CLOSE
PULL
FV

SPRING RETURN TO "OFF"
PULL TO LOCK
WEST. CO. TYPE "W"
STYLE 1646902

THIS DRAWING SUPERSEDES DWG 9699-FE-1E

APPROVED Edward J. Witt
REGISTERED PROFESSIONAL ENGINEER NO. 7967
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD	INSP	CORR	APPR
5	ADDED CIRCUIT FOR FIRE PROTECTION DELUGE VVS	[illegible]	[illegible]	[illegible]	[illegible]
4	REVISED VOLTMETER SW.	[illegible]	H.E.T.	[illegible]	[illegible]
3	REVISED VOLTMETER SW. ADDED EVACUATION ALARM SOL. TRIP VVS & RADIATION MONITOR PNL. CIRCUITS & MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
2	ADDED FDR. FOR FUEL CHUTE CAMS. REVISED GEN. ANN. CKT. & MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

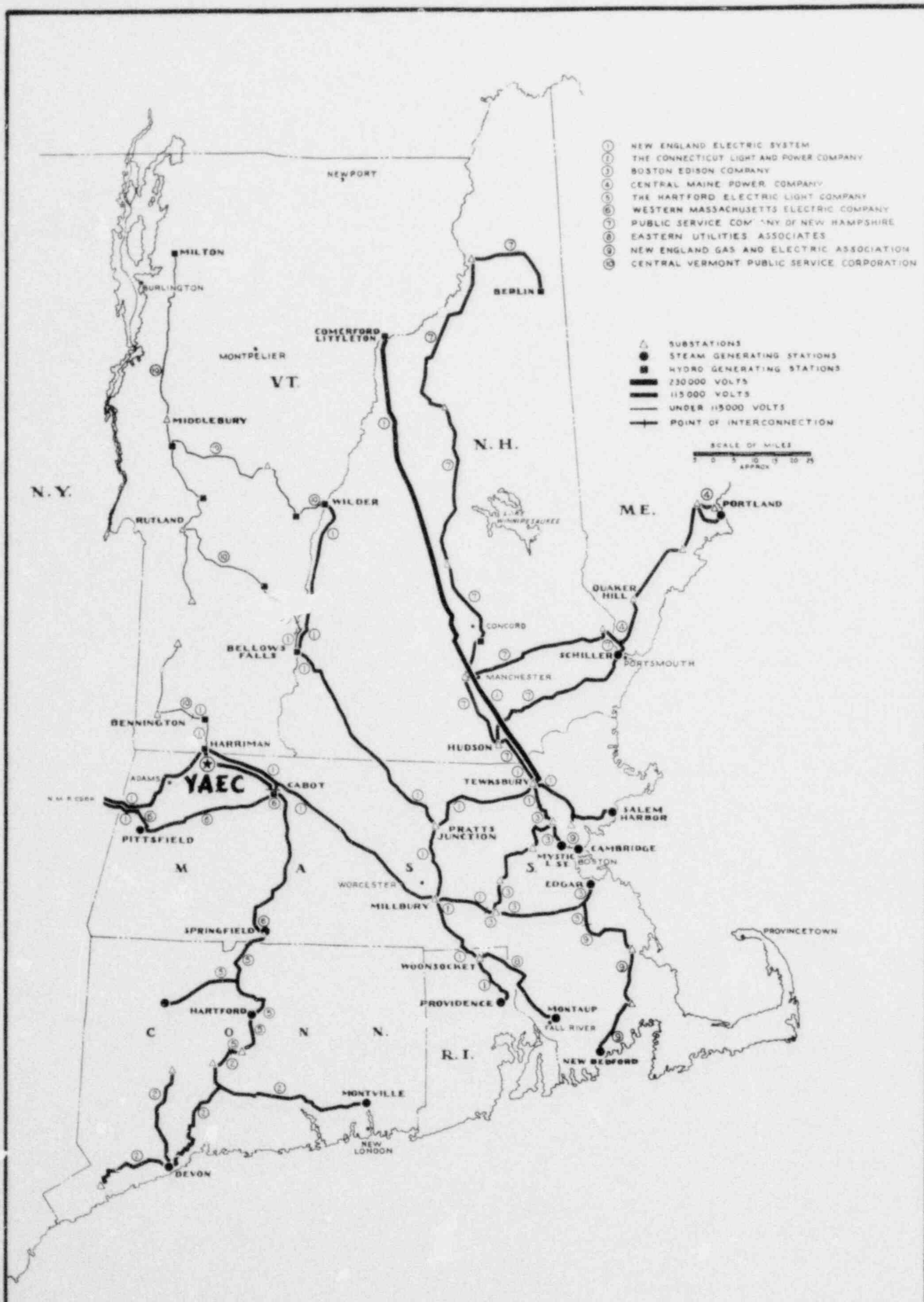
AS BUILT CHANGES

125V D.C. ONE LINE DIAGRAM

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FE-1H



TRANSMISSION LINE INTERCONNECTIONS WITH MEMBER COMPANIES

Station Service

Station service power is supplied through three forced air-cooled transformer units. Two are of equal rating, 5.0/6.25 mva, 115/2.4 kv, 3 phase, 60 cycles and are connected one each to the 115 kv lines; while the third 5.0/625 mva, 18/2.4 kv, 3 phase, 60 cycles is connected to the outdoor section of the generator bus. Each of these units normally supplies one section of the 2,400 and 480 v bus, the latter through a 750 kva, 2,400/480 v, 3 phase, 60 cycles self-cooled transformer.

The 2,400 v indoor metalclad switchgear is equipped with 150 mva interrupting capacity air circuit breakers and consists of three sections of bus, normally operated independently, with the two bus tie breakers open. Care has been taken in assignment of loads, so that the main station auxiliaries are divided between the three sections with the main coolant pumps located one each on bus sections No. 2 and No. 3 and two on bus section No.1. The latter bus is fed from the generator. This arrangement for the main coolant pumps was made so that, in the event of turbine trip, at least 50% of normal main coolant flow will be maintained for 30 to 60 sec from the inertia of the generator directly without switching or from bus sections No.2 or No.3 by manual transfer.

The safety injection system pump motors are connected to bus sections Nos. 2 and 3. Therefore, loss of the turbine generator due to mechanical or electrical faults or reactor scram does not affect the electrical supply to these units.

The 480 v indoor metalclad switchgear consists of three sections of bus, normally operated independently, with the two bus tie breakers open. Again the loading arrangement for each bus provides maximum reliability of operation of the plant by assuring to alternate pieces of equipment separate sources of supply from different bus sections. However, for single items of equipment which are vital to the normal and safe operation of the plant, a firm 480 v, 3 phase source is supplied by providing automatic throwover facilities between two 480 v feeders connected to different bus sections. The equipment which is supplied by this source is the valve operators for the safety injection systems, the control rod selection and programming controls, No. 1 main transformer oil pump motors and essential 120 v a-c instrumentation, exclusive of those supplied from the 120 v a-c vital bus. This supply also serves as an emergency source for the 120 v a-c vital bus, but must be switched into service manually.

For nuclear, pressurizer, main coolant and various primary process instrumentation which is vital for control and supervision during all phases of plant operation, a separate 120 v, single bus, employs a synchronous inverter set which consists of a 10 hp, 125 v, shunt wound direct current motor directly connected to a 5 kw, 120 v, single phase, 60 cycles generator. The inverter is designed to operate continuously from the 125 v station battery and is supplied with voltage regulating equipment which controls the excitation of the generator and motor, so as to limit the alternating current voltage and frequency variations to plus or minus 3 and 1%, respectively.

Two 125 v, 60 cell, lead acid batteries are furnished for the direct current requirements in the station. Battery No. 1 has an 8 hr rated capacity of 547 ampere hours, and supplies the breaker control circuits, the protective relay trip coils, the vital bus inverter, equipment control lights, and the station emergency lighting. Battery No. 2 has an 8 hr rated capacity of 704 ampere hours and supplies the turbine emergency auxiliary pumps and the reactor control rod drive mechanisms. Each battery is supplied with a motor-generator set which maintains it automatically at the proper charge level. Each set consists of a 30 hp, 440 v, 3 phase, 60 cycles, induction motor directly connected to a 20 kw, 90/140 v, shunt wound diverter pole direct current generator. Normally, the two direct current busses are isolated from each other, but a manually operated bus tie switch is provided in order to allow for maintenance of the battery or charging equipment and to facilitate operation of the direct current system during loss of any portion of the source equipment.

An engine driven alternating current generator rated 75 kw, 480 v, 3 phase, 60 cycles is provided as an emergency power source in the event a complete loss of station power occurs. This unit is sized to provide power to operate the pressurizer heaters, a charging pump for the primary and secondary systems, and essential 120 v a-c instrumentation and controls exclusive of those supplied from the 120 v a-c vital bus and to maintain a station battery for essential nuclear instrumentation.

Control and Protection

Centralized control for the reactor and primary plant auxiliaries, the turbine and secondary plant auxiliaries, the generator, the station power supply, and the transmission line switching is provided on the main control board. All necessary supervisory instrumentation is included at the same control board. This allows operating personnel to have complete control of the plant and information concerning its performance at all times.

The electrical system is provided with conventional relay protective equipment. It is designed so that when any portion of the electrical system experiences trouble of more than a transient nature, the item causing this will be immediately detected by this equipment and will be quickly isolated by automatic relay and circuit breaker action from the rest of the system. Annunciation is provided in conjunction with all relay operations to inform operating personnel of the nature of the trouble and allow them to undertake corrective measures.

The generator is provided with differential, ground, overcurrent and loss of field relaying which will remove the unit from service, thereby preventing or limiting the damage incurred by the unit. The 115 kv bus, transformer No. 1, and generator are included in a unit differential relay system which protects primarily the bus and transformer. The station service transformer No. 1 is provided with differential and overcurrent relaying which will remove this unit and the generator from service. Operation of any of these protective devices for the generator, transformers or bus will scram the reactor, when turbine load is 15 mw or above, disconnect the generator from the two 115 kv lines and deenergize the 2,400 v bus No. 1 and the 480 v bus No. 4-1. The two main coolant pumps on bus No. 1 will thereby become inoperative unless manually reenergized by transfer to either bus No. 2 or No. 3. However, main coolant flow is maintained by two pumps on busses No. 2 and No. 3.

The 115 kv lines are provided with relaying which supervises the total length of each line. In the event of a line fault, the relaying clears the line from the plant, thereby deenergizing the associated 2,400 and 480 v bus sections. Similarly, station service transformers No. 2 and No. 3 are provided with differential and overcurrent relaying which, when initiated, causes the same condition to occur. Reactor output is still maintained, but at a reduced level, since one main coolant pump will be inoperative unless manually reenergized by transfer to bus No. 1 according to Section 213, REACTOR CONTROL SYSTEM.

The supply to each 2,400 v bus section is provided with overcurrent relaying which, when initiated, will deenergize only the bus section affected. A fault of long duration on bus No. 2 or No. 3 will cause the reactor power level to be reduced; but in the case of bus No. 1, since two main coolant pumps will be deenergized causing a low flow condition, the reactor will be scrammed. This, in turn, will shut down the turbine generator; but main coolant flow will be maintained by the two pumps on bus No. 2 and No. 3. Further, each of the 2,400 v feeders supplying the main coolant pump motors is provided with overcurrent and thermal overload protection. The former automatically deenergizes the unit in trouble causing a reduction in reactor power level, while the latter alerts the operator that manual corrective action must be undertaken. Also, each bus section is provided with undervoltage relaying which sheds all nonvital load on the bus when it is deenergized. This is essentially a precautionary measure to limit the amount of load to be energized on a bus transfer. Vital components of load are the main coolant pump motors, the component cooling water pump motors, and the safety injection pump motors. Service water pumps, although of a vital nature, are deenergized by undervoltage relay action. However, since three units are employed, one on each bus, with automatic starting facilities, it is assured that at least one unit will be in operation at all times when required.

In addition, the 2,400 volt feeders supplying the main coolant pumps are provided with separate undervoltage protection having an appreciably longer time delay (10 sec vs 3 sec at zero voltage) than the undervoltage protection for other feeders on the three 2,400 v bus sections. The longer time delay is necessary to insure that the pumps will not be tripped during an automatic bus section transfer operation described below. Undervoltage tripping is provided on the main coolant pump circuits to automatically prevent restarting a pump by reenergizing a bus section after an interruption in power supply of some duration. Once open, a pump breaker cannot be closed and the pump started without first completing an interlock circuit by closing the cold leg stop valve and opening the 5" by-pass valve in the affected loop. This arrangement effectively prevents returning to service a loop which may have cooled down during an interruption in power supply to the main coolant pump.

The supply to each 480 v bus section is provided with overcurrent relaying which, when initiated, will deenergize the bus section affected. A slight reduction in plant output may result depending on the auxiliaries affected.

Thus, for any single particular fault on the electrical system, the protective system is designed to ensure maximum safety in the operation of the reactor. In addition, although simultaneous occurrence of two electrical faults is very infrequent, the electrical protective system was extended to include the control action necessary to restrict the thermal transient in the core due to the loss of greater than 50% main coolant flow. The combinations of simultaneous conditions which have been compensated for by stuck-breaker relaying are a 115 kv line fault combined with an inoperative associated line breaker or a 115 kv or 18 kv bus or equipment fault combined with an inoperative 115 kv line breaker. In either case, three main coolant pump motors are deenergized which would result in less than the 50% main coolant flow according to Section 403, MECHANICAL ACCIDENTS - LOSS OF COOLANT FLOW. Therefore, within 30 cycles from initiation of the stuck-breaker relaying, the faulted equipment and line or bus is isolated, the turbine generator is shut down, the reactor is scrammed, and the two main coolant pump motors on bus No. 1 are automatically transferred to the one 2,400 v bus which is energized, thereby limiting the thermal transient in the core. Other improbable conditions such as an improper operating procedure resulting in clearing the generator from the 115 kv lines, a simultaneous fault on each 115 kv line, or the station being separated from the transmission system would not cause an immediate cessation of main coolant flow, since in all these cases at least two pumps would be operating from the generator inertia for 30 to 60 sec. It is also conceivable, but highly improbable, that a severe weather condition could strike the 115 kv switchyard and cause a complete loss of the station power supply for a long period. If any of the last three cases occur and power cannot be restored from the 115 kv lines within 3 hrs, the emergency engine driven generator will be utilized to provide power for sufficient charging water to the primary plant, for boiler feed water to the secondary plant, and for essential 120 v a-c instrumentation and controls, exclusive of those supplied from the 120 v a-c vital bus and to maintain a station battery in a fully charged condition.

One other area, in the electrical system, of possible concern to safety of the reactor is the effect that faults on the transmission system might have on the voltage level of the bus to which the main coolant pump motors are connected and the subsequent effect on the main coolant flow. A fault study, dated April, 1959, has been prepared by New England Power Service Company, indicating the voltage values which would exist for various conditions. It is evident from these data that in all cases 50% of normal main coolant flow will be maintained while the transient condition exists.

With the use of boron at power specified for Core III, the power supplies to three key valves associated with the chemical shutdown system will be relocated to the autothrowover facilities between bus sections No. 2 and No. 3. Also the power supply to No. 2 charging pump will be transferred to bus section No. 1. These changes will improve the reliability of the boron injection system.

227 HEATING SYSTEMS

General

Space heating is provided by several systems using steam and hot water as the heating medium. Steam is used also for heating of domestic hot water, outdoor storage tanks, boric acid mixing tank and for decontamination hose streams. These systems are shown diagrammatically on drawings Nos. 9699-FB-7A and 9699-FB-7B.

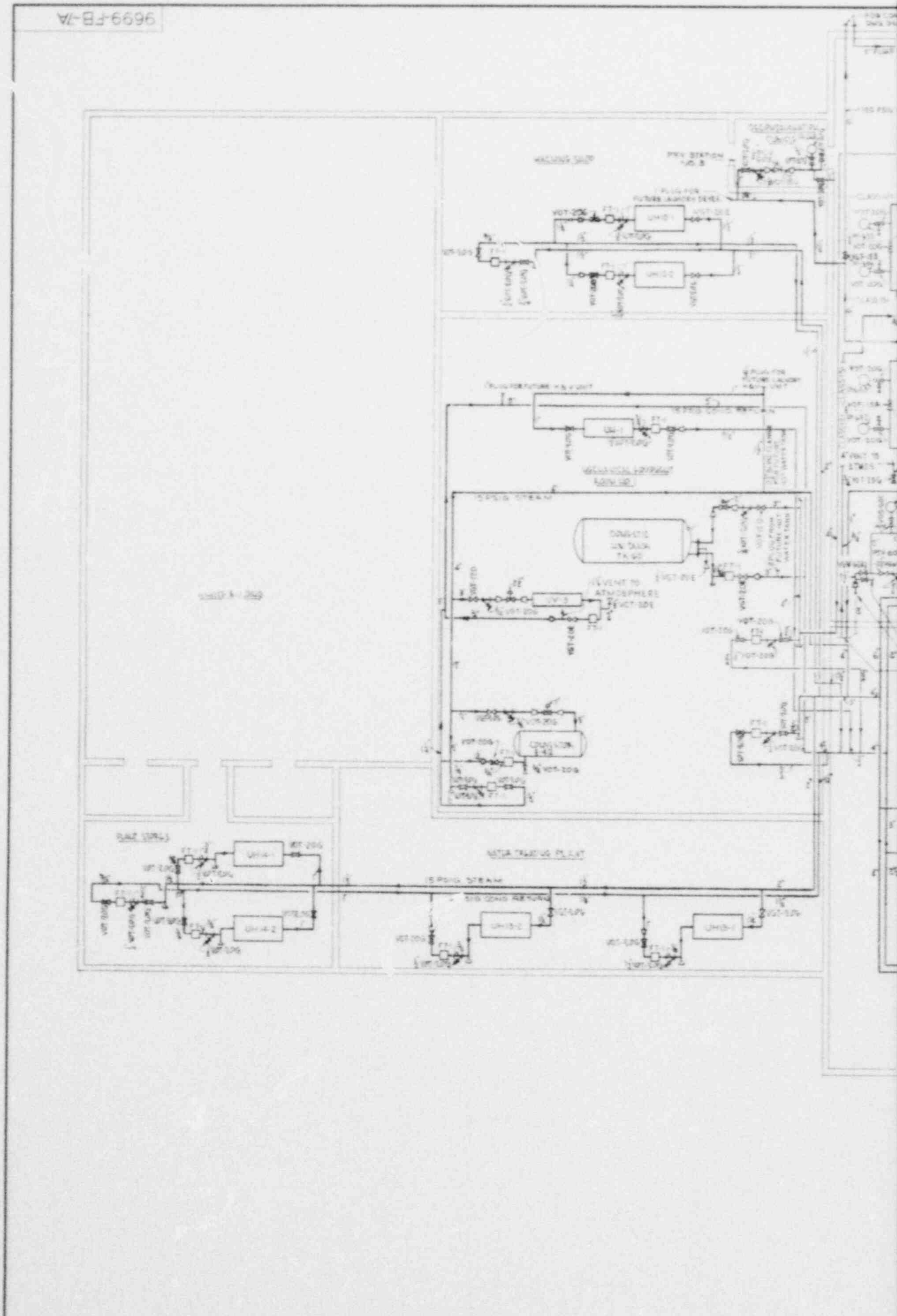
Steam Heating System

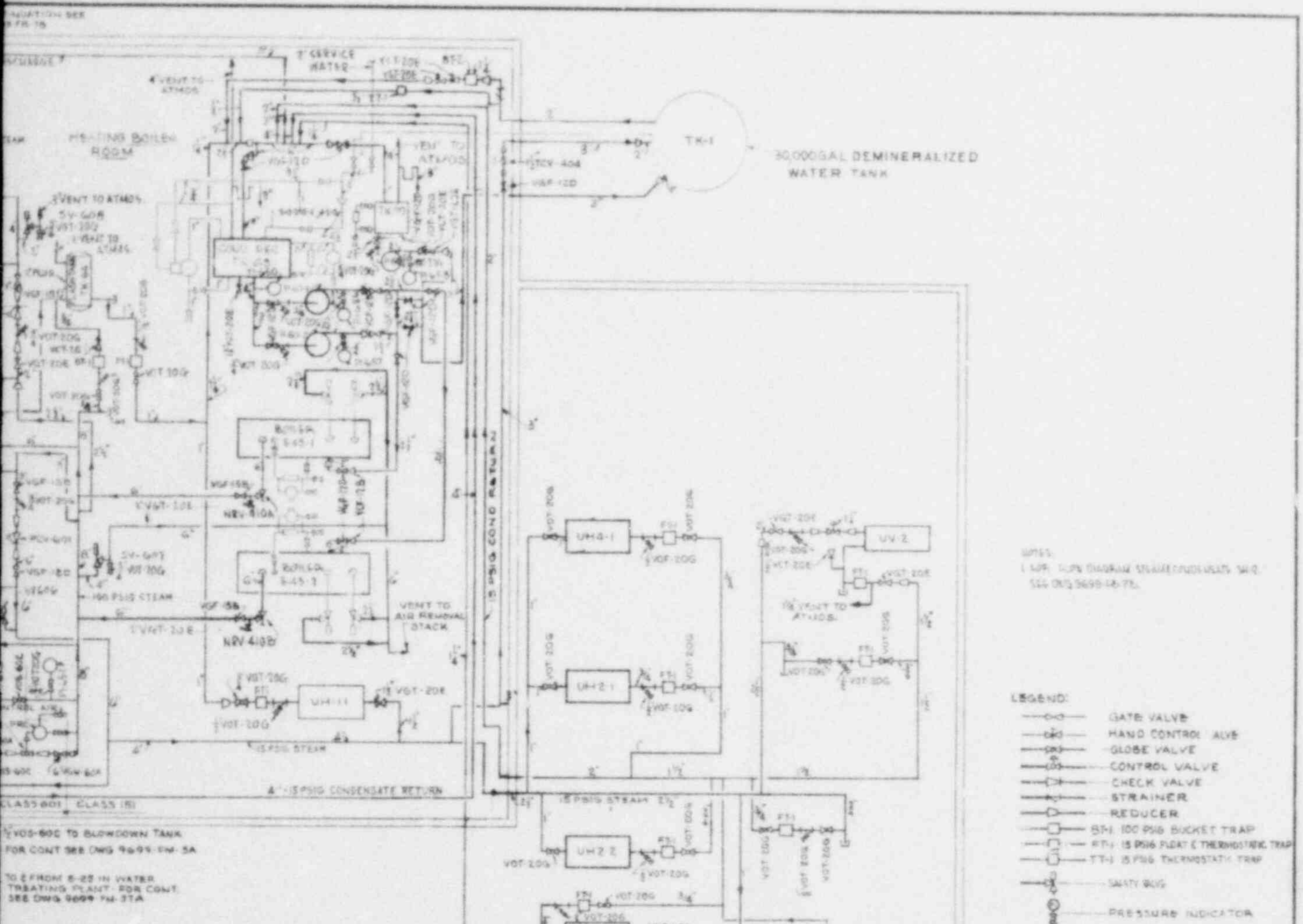
The steam heating system originates with a valved connection to the steam piping of the secondary plant and includes a pressure reducing valve which, during normal reactor plant operation, delivers steam at 100 psi gage to a heating steam distribution header. During periods when no steam is available from the main steam generators, two light oil-fired auxiliary steam generators supply the 100 psi gage heating steam header.

Steam at 100 psi gage is reduced to 15 psi gage through two reducing stations in the heating boiler room, one serving the domestic hot water heater and one serving the plant heating systems. A 100 psi gage main also serves two reducing stations in the Primary Auxiliary Building, one of which reduces the pressure to 30 psi gage for tank farm and space heating service in the Waste Disposal Plant and for process heating requirements in the Primary Auxiliary Building. The second reducing station in the Primary Auxiliary Building provides steam at 15 psi gage for ventilation air and space heating for this structure and the Spent Fuel Pit Enclosure as well as for the vapor container heating and purge systems. A small reducing station provides steam at 30 psi gage for steam hoses used for cleaning and provisions are made to furnish 100 psi gage steam for a future laundry drying tumbler.

Steam at 15 psi gage serves the unit heaters and unit ventilators in the turbine generator portion of the plant including those in the Service and Office buildings as well as two hot water heating system heat exchangers, one for the Service Building and one for the Office Building.

Condensate from heating steam in the tank farm, Waste Disposal Plant, Primary Auxiliary Building, Spent Fuel Pit Enclosure, and from the vapor container heating and purge systems is collected in the receiver of a twin pump condensate return unit located in the Primary Auxiliary Building. Condensate from the hot water heating system heat exchanger and unit ventilator serving the Office Building is collected in a single pump condensate return unit located at the condenser floor level adjoining the Office Building. The discharg[illegible] these pumps as well as all condensate which drains by gravity from [illegible]ment in the Turbine Generator Building and Service Building areas [illegible]llected in one of two receivers located in the heating boiler room. During nuclear steam generator operation, condensate is pumped from one of these receivers to the demineralized water storage tank. When the auxiliary steam generators are operative, condensate is pumped from the second receiver to these generators by auxiliary boiler feed pumps. Provisions are made to permit the use of the auxiliary boiler feed pumps to return condensate to the demineralized water storage tank in the event of pump failure.

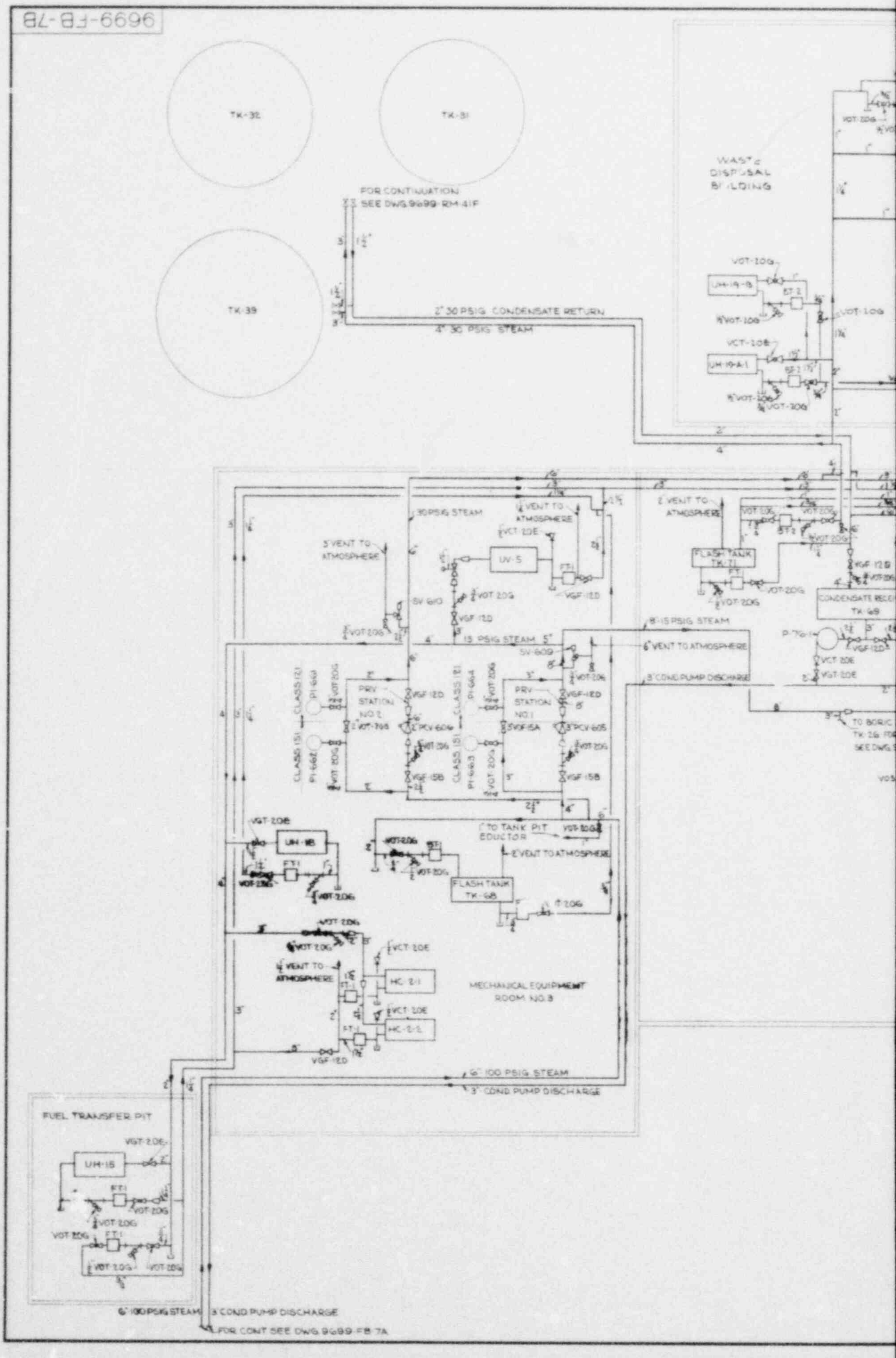

9699-FB-7A
15 PSIG STEAM
VENT TO ATMOSPHERE

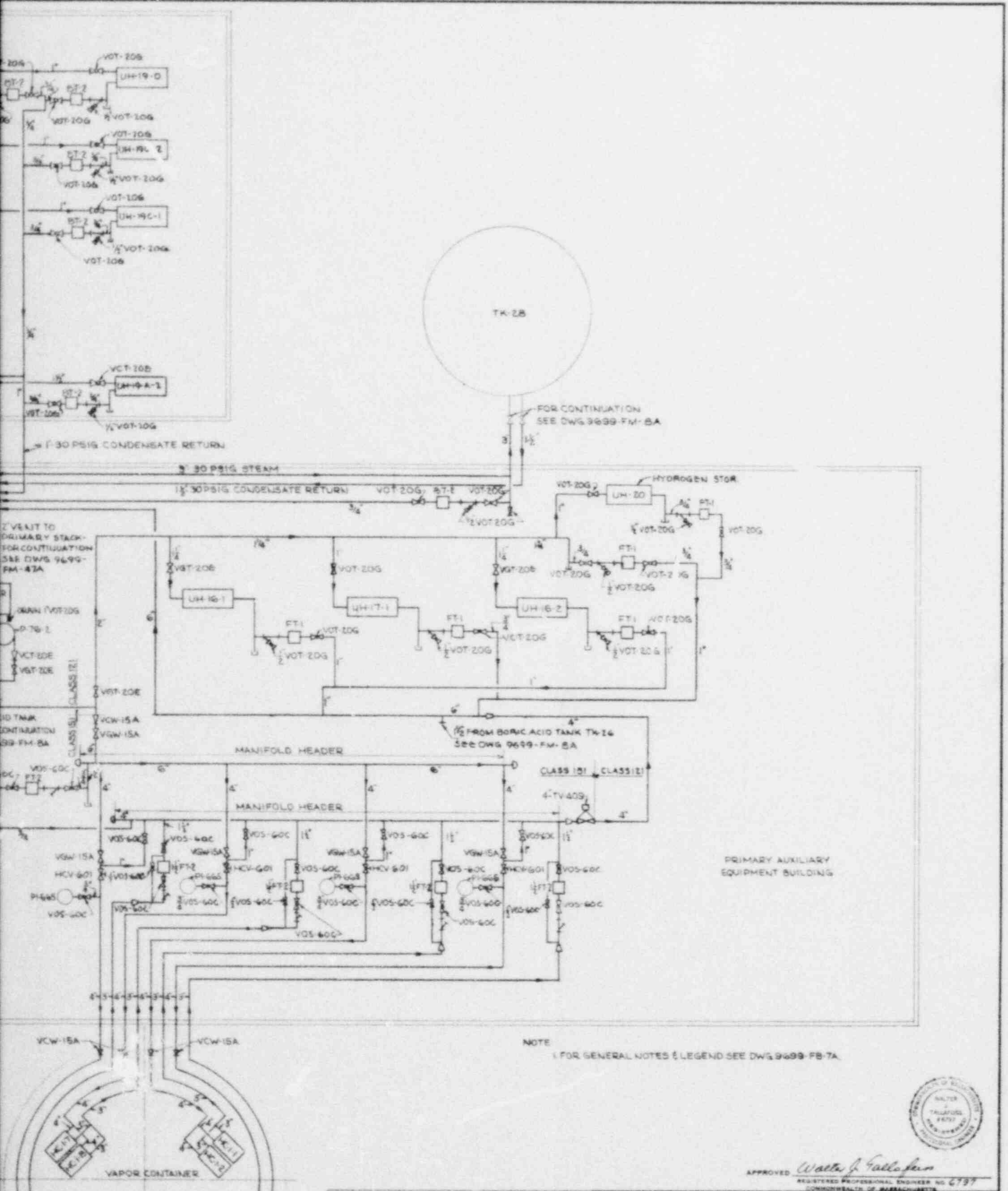


APPROVED Walter J. Gallagher
REGISTERED PROFESSIONAL ENGINEER NO. 6797
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD	INSP	CORR	APPR
5					
4					
3					
2	PIPING FOR HTR E-25 RELOCATED PIPE SIZES AND VALVE NO'S CHANGED				
1	ORIGINAL ISSUE				

FLOW DIAGRAM
STEAM & CONDENSATE SH-1
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NUMBER 9699-FB-7A


9699-FB-7B
TK-32
TK-31
TK-39
FOR CONTINUATION SEE DWG.9699-RM-41F
2" 30 PSIG CONDENSATE RETURN
4" 30 PSIG STEAM
WASTE DISPOSAL BUILDING
UH-19-B
UH-19-A-1
FLASH TANK TK-72
CONDENSATE RECEIVER TK-69
30 PSIG STEAM
3" VENT TO ATMOSPHERE
UV-5
SV-610
15 PSIG STEAM
SV-609
6" VENT TO ATMOSPHERE
8" 15 PSIG STEAM
3" COND PUMP DISCHARGE
PRV STATION NO.2
PRV STATION NO.1
PCV-606
PCV-605
2" TO TANK PIT EDUCTOR
2" VENT TO ATMOSPHERE
FLASH TANK TK-68
UH-18
HC-2-1
HC-2-2
MECHANICAL EQUIPMENT ROOM NO.3
6" 100 PSIG STEAM
3" COND PUMP DISCHARGE
FUEL TRANSFER PIT
UH-15
6" 100 PSIG STEAM
3" COND PUMP DISCHARGE
FOR CONT SEE DWG.9699-FB-7A



APPROVED Walter J. Gallagher
REGISTERED PROFESSIONAL ENGINEER NO. 6797
COMMONWEALTH OF MASSACHUSETTS

5					
4					
3	VALVES REMOVED & PIPING CHGD.				
2	UNIT HTR UH-20 ADDED, PIPING AND VALVE SIZES CHANGED & ADDED				
1	ORIGINAL ISSUE				
	DESCRIPTION	CHKD.	INSP.	CONS.	APPR.

FLOW DIAGRAM
STEAM & CONDENSATE SH 2

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

NO SCALE

DRAWING NUMBER 9699-FB-7B

Hot Water Heating Systems

Two hot water heating systems are provided to serve finned pipe radiation along exterior walls in normally occupied areas. One system serves various spaces in the Service Building and the other system serves the Office Building. Each system consists of a steam to water heat exchanger, expansion tank, circulator, finned pipe radiators and enclosures, reversed return piping system, valves and accessories. The design of the system is based on 180 F supply water temperature and 160 F return water temperature. The supply water temperature is controlled automatically by an outdoor temperature compensated controller which actuates the steam valve serving the steam to water heat exchanger.

228 VENTILATION SYSTEMS

General

The ventilation system for the Turbine Generator, Service and Office Buildings are shown on drawings Nos. 9699-FB-3A, 3B and 3E. In these areas the ventilation systems provide heat removal, space heating, odor or fume control and hood exhaust as required in the particular location.

In the Primary Auxiliary and Waste Disposal Buildings, the ventilation systems provide space heating in cold weather, heat removal in the summer, and dilution of possible hydrogen leakage in certain equipment compartments during operation and maintenance periods. Ventilation systems for heat removal are provided also for the mechanical equipment rooms and the Fuel Transfer Pit House.

Turbine and Condenser Rooms

The air rate required to maintain the design temperature in these spaces is provided by natural means, using window and door openings at the lower level for supply and continuous ventilators on the turbine room roof for exhaust. Air flow is occasioned by the stack effect resulting from the difference in elevation between supply and exhaust openings and the heat added to the air. The average stack height is approximately 50 ft and the design difference between supply and exhaust air temperature is 20 F.

The design ventilation air rate for the turbine and condenser rooms is 1.5 cfm per kw of turbine generator rating, a value which is based on equipment heat release and the design air temperature rise.

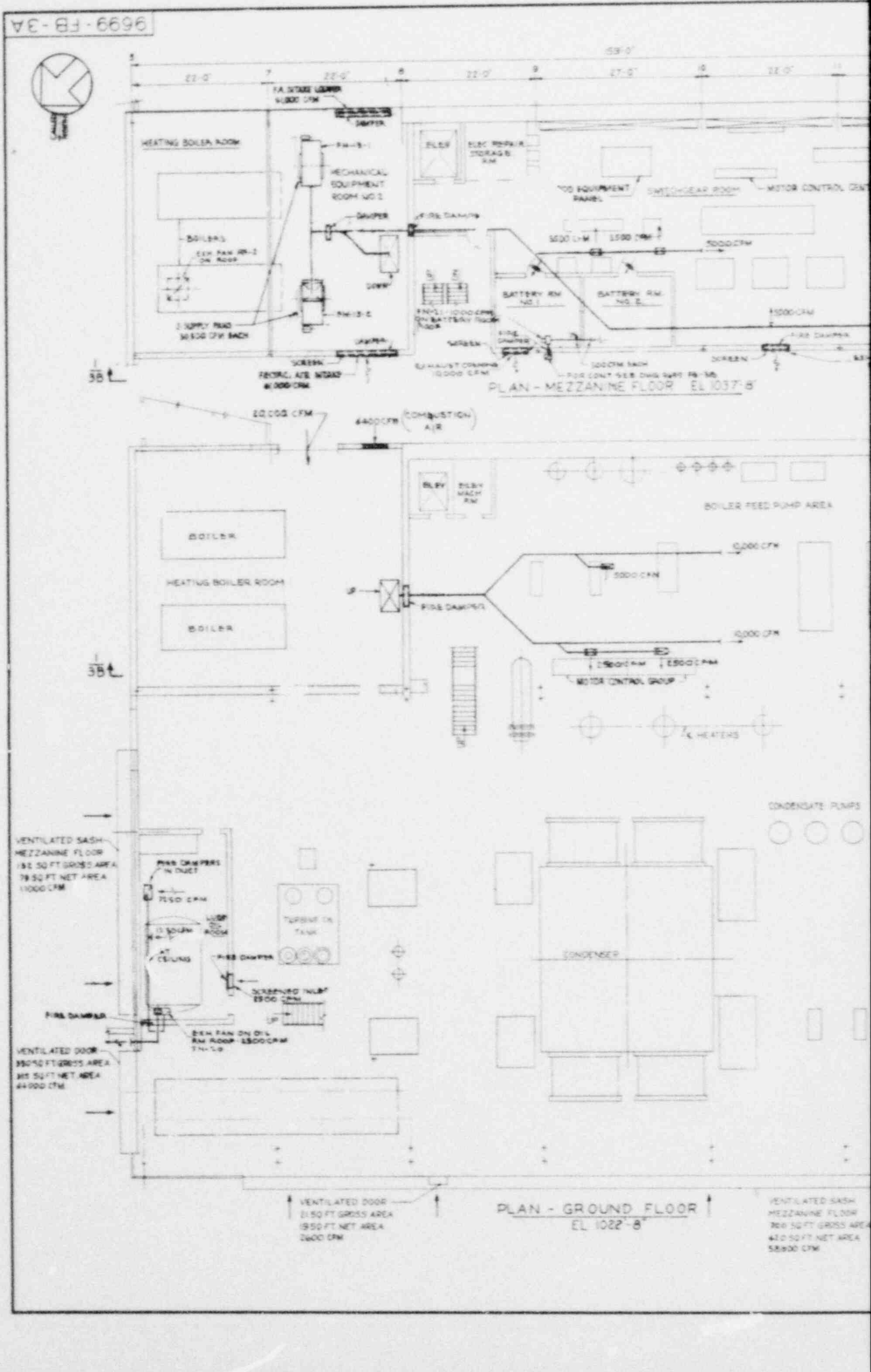
Air relieved to the turbine and condenser rooms from the pump, switchgear and control rooms is also exhausted through the ventilators on the turbine room roof.

Approximately 60% of the air entering the turbine and condenser rooms by natural means enters below the operating floor level and the balance through windows above the operating floor level.

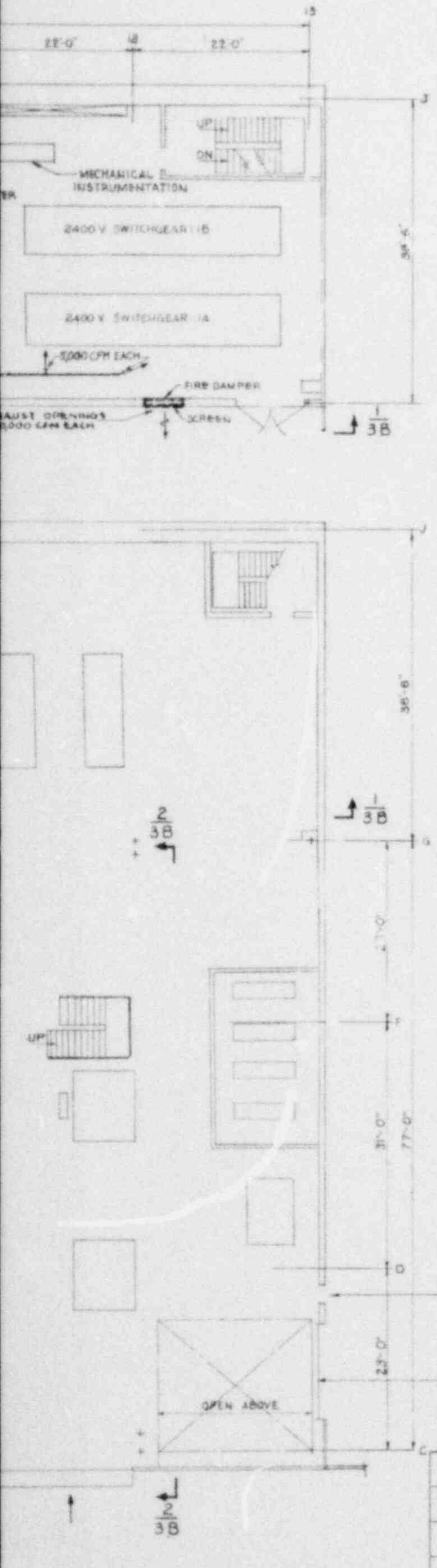
Openings in the operating floor for stairs, equipment removal, and around heaters and piping relieve air from the condenser room to the turbine room.

Lubricating Oil Storage Room

The exhaust system for the lubricating oil storage room consists of a centrifugal fan unit located above the oil storage room ceiling with suction duct work exhausting from high and low levels in the oil room and a discharge duct exhausting to outdoors. Air is drawn into the oil room from the condenser room through a screened opening. Fire dampers are provided for ventilation openings.



HEATING BOILER ROOM
MECHANICAL EQUIPMENT ROOM NO. 2
BOILERS
DAMPER
FIRE DAMPER
SCREEN
SWITCHGEAR ROOM
BATTERY RM. NO. 1
BATTERY RM. NO. 2
PLAN - MEZZANINE FLOOR EL 1037'-8"
20,000 CFM
4400 CFM (COMBUSTION AIR)
BOILER FEED PUMP AREA
BOILER
HEATING BOILER ROOM
BOILER
FIRE DAMPER
10,000 CFM
5000 CFM
MOTOR CONTROL GROUP
HEATERS
CONDENSATE PUMPS
VENTILATED SASH
MEZZANINE FLOOR
TURBINE OIL TANK
CONDENSER
FIRE DAMPER
VENTILATED DOOR
PLAN - GROUND FLOOR
EL 1022'-8"
VENTILATED SASH
MEZZANINE FLOOR



LEGEND:

- SUPPLY AIR
- AIR MOVEMENT
- EXHAUST & RECIRC AIR
- 1/3B: SECTION NO. / DWG WHERE SHOWN
- GRILLE OR REGISTER
- DOOR LOUVER

NOTES:
FOR VENTILATION ARRG'T - OPERATING FLOOR SEE DWG 9699-FB-3B

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5					
4					
3					
2	FAN NUMBERS, FANS & DUCTWORK CHGD - EXHAUST OPG'S ADDED - FAN REMOVED	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

VENTILATION ARRG'T - GROUND & MEZZANINE FLOORS

POWER STATION

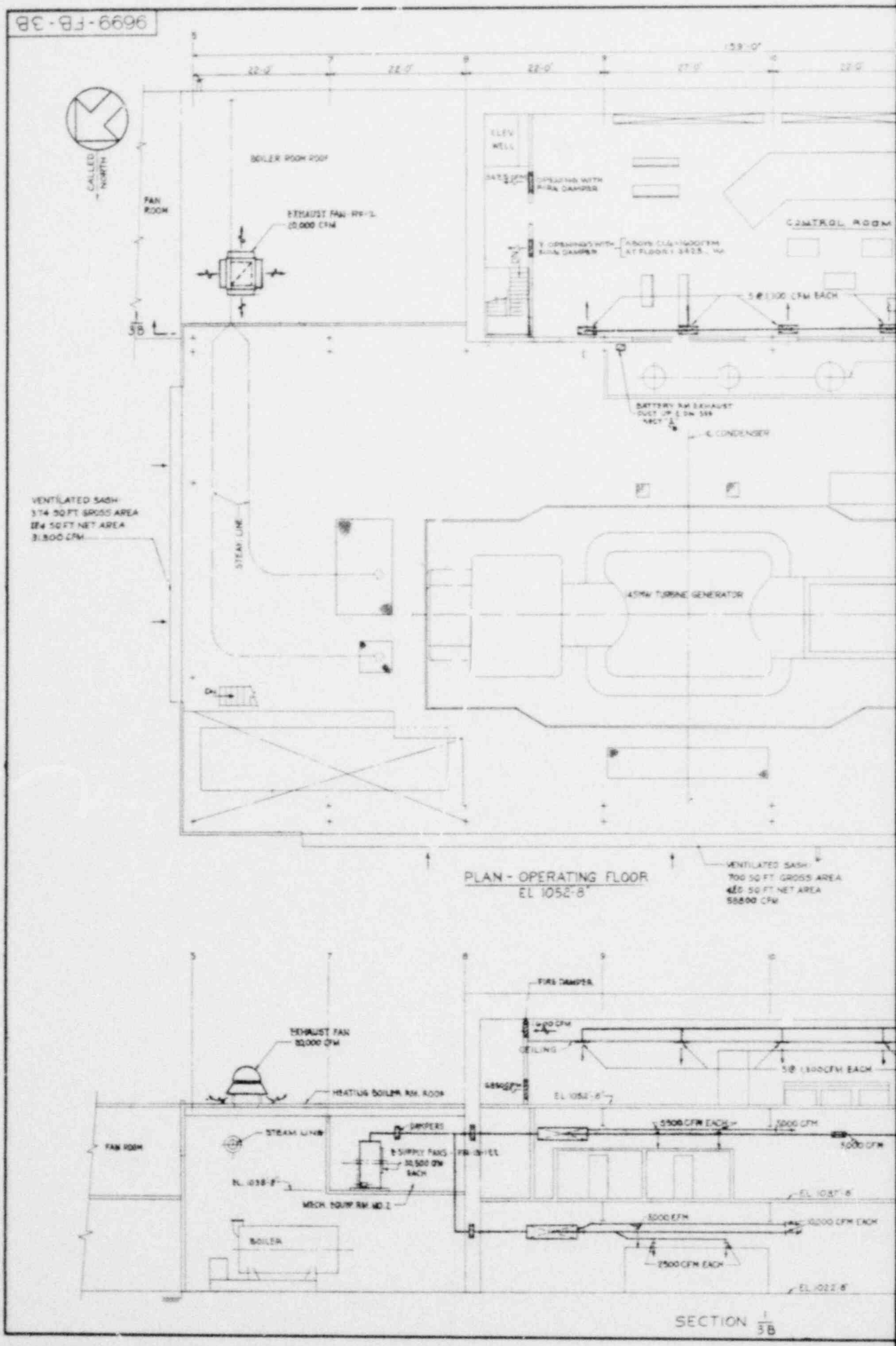
YANKEE ATOMIC ELECTRIC COMPANY

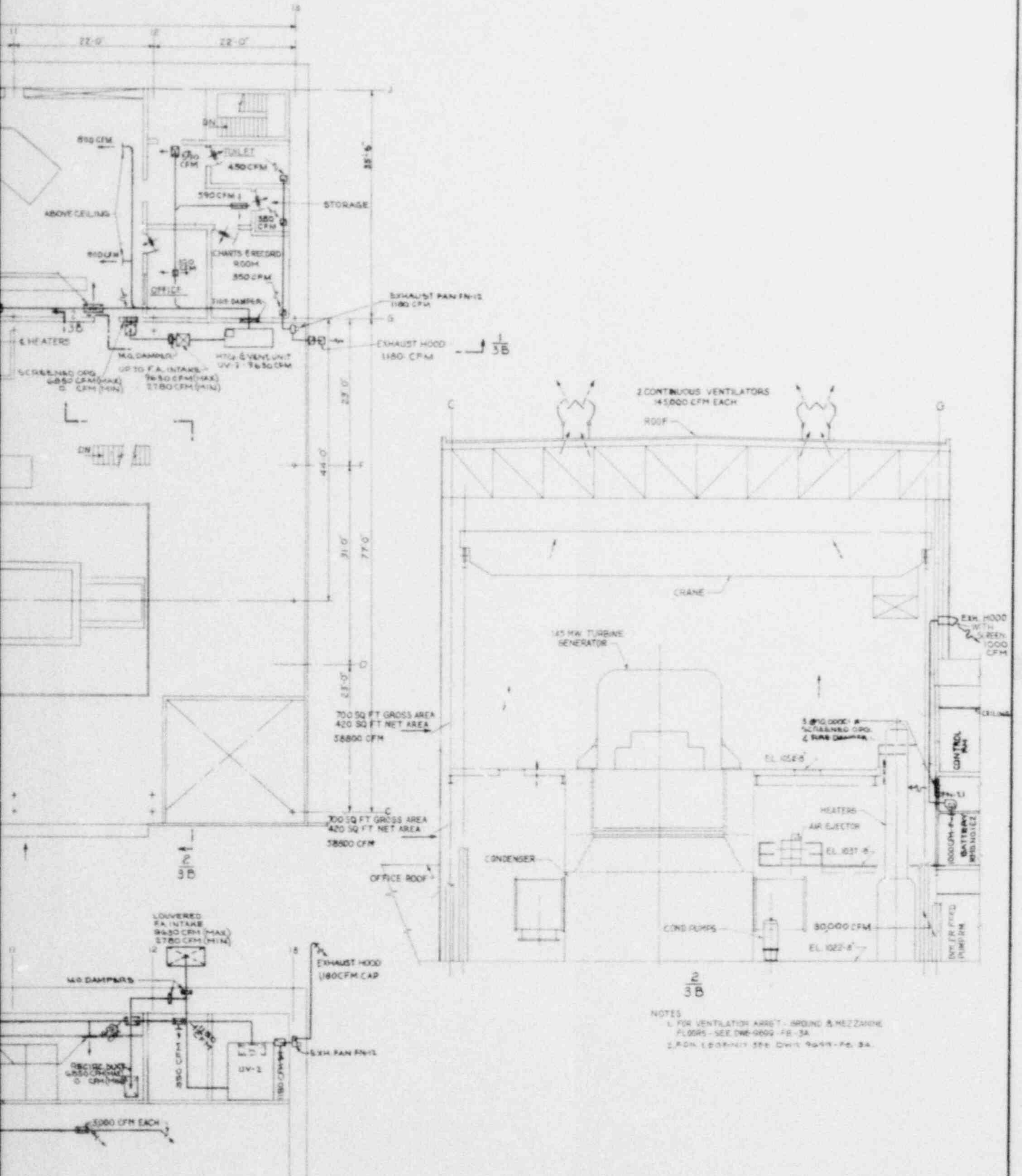
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

SCALE 1/8"=1'-0"

DRAWING NUMBER 9699-FB-3A


9699-FB-3B
CALLED NORTH
FAN ROOM
BOILER ROOM ROOF
EXHAUST FAN RF-2
10,000 CFM
ELEV WELL
OPENING WITH FIRE DAMPER
2 OPENINGS WITH FIRE DAMPER
CONTROL ROOM
5 @ 1,300 CFM EACH
BATTERY RM EXHAUST
℄ CONDENSER
VENTILATED SASH
374 SQ FT GROSS AREA
224 SQ FT NET AREA
31,800 CFM
STEAM LINE
45MW TURBINE GENERATOR
PLAN - OPERATING FLOOR
EL 1052-8"
VENTILATED SASH
700 SQ FT GROSS AREA
420 SQ FT NET AREA
58800 CFM
FIRE DAMPER
EXHAUST FAN
10,000 CFM
CEILING
5 @ 1,300 CFM EACH
HEATING BOILER RM ROOF
EL 1052-8"
FAN ROOM
STEAM LINE
DAMPERS
2 SUPPLY FANS
10,500 CFM EACH
5500 CFM EACH
5000 CFM
EL 1038-8"
MECH. EQUIP RM NO. 2
EL 1037-8
3000 CFM
10,200 CFM EACH
BOILER
2500 CFM EACH
EL 1022-8"
SECTION 1/3B



ISSUE	DESCRIPTION	CHKD	INSP	COOR	APP
5					
4					
3					
2	CFM QUANTITIES, DUCTWORK & FAN NOS. CHANGED - FAN & GRILLES REMOVED	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

VENTILATION ARRGT - OPERATING FLOOR & SECTIONS

POWER STATION

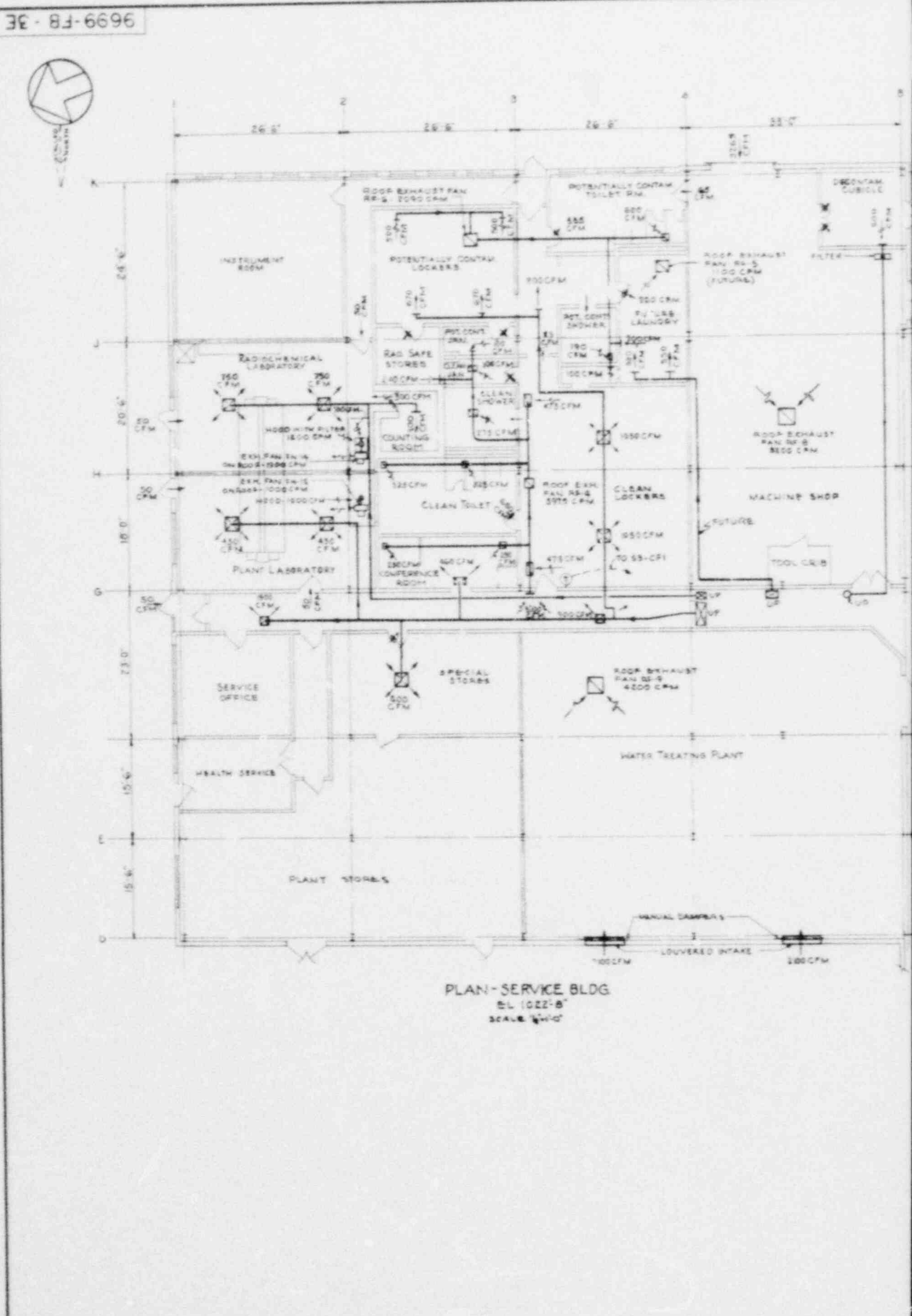
YANKEE ATOMIC ELECTRIC COMPANY

ROWE, MASS.

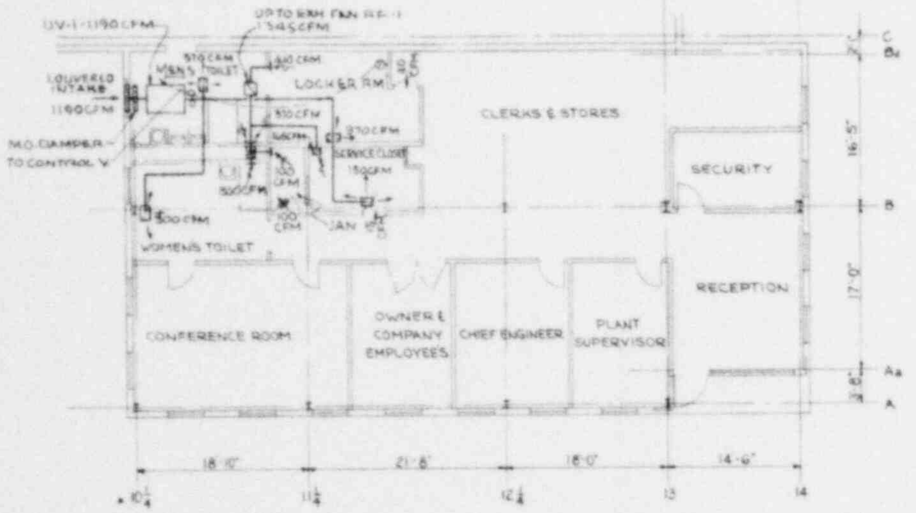
STONE & WEBSTER ENGINEERING CORPORATION

SCALE 1/8" = 1'-0"

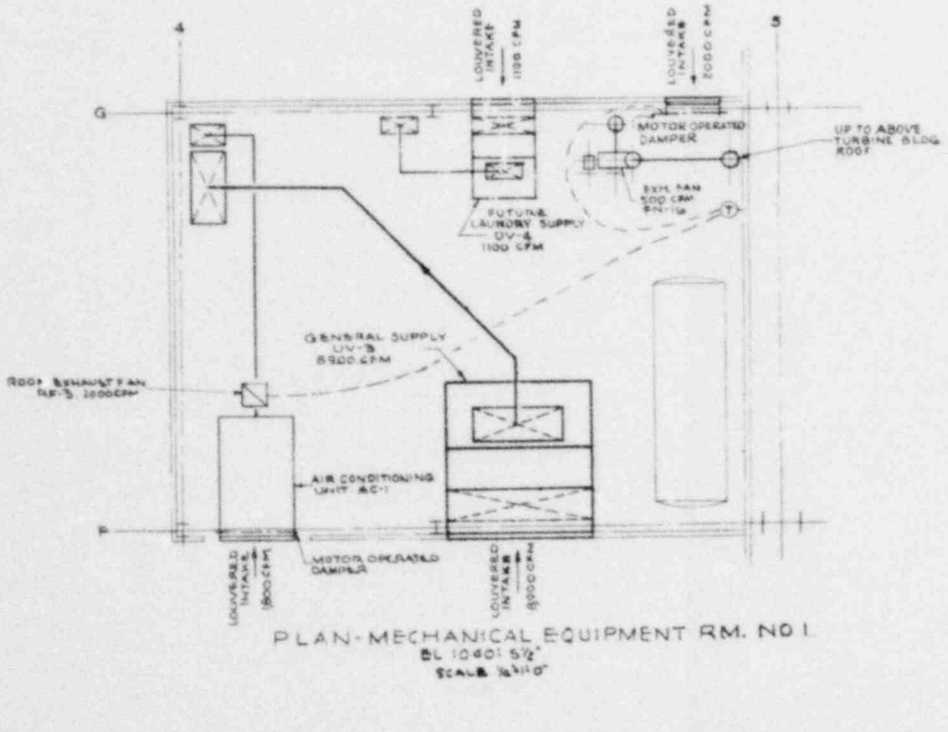
DRAWING NUMBER 9699 - FB - 3B



PLAN - SERVICE BLDG.
EL 1022'-8"



PLAN - OFFICE BLDG.
EL 1022'-6"
SCALE 1/8"=1'-0"



PLAN - MECHANICAL EQUIPMENT RM. NO. 1
EL 1040'-5½"
SCALE 1/4"=1'-0"

LEGEND
- SUPPLY AIR
- EXHAUST AIR
- DOOR LOUVER
- SUPPLY AIR DIFFUSER
- EXHAUST AIR REGISTER
- THERMOSTAT
- DUCTSTAT

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5					
4					
3					
2	AIR QUANTITIES, DUCTWORK & FAN NOS. CHANGED AIR CONDITIONING UNIT ADDED	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

VENTILATION ARRANGEMENT
OFFICE & SERVICE BUILDINGS
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FB-3E

Pump and Switchgear Rooms

Air for the pump and switchgear rooms is supplied by a common system consisting of two centrifugal fans, with supply duct work and recirculation provisions. Fans are located in a fan room, which functions as a plenum, drawing air from outdoors through louvers. Provisions are made to recirculate all or a portion of the ventilation air in order to permit adjustment of supply air temperatures without resorting to steam heating.

Provisions are made to operate one or both fans, and dampers are provided in the duct work at each fan to prevent recirculation through the idle fan.

Control Room Area

Air for the office and control, chart and toilet rooms is supplied through a unit ventilator which is fitted with outside air louvers, filters and mixing box. Connecting duct work distributes the air to the various spaces where final distribution is made through ceiling diffusers. Provision is made for recirculation of air from the control room and office to minimize steam consumption during the winter.

Air is exhausted from the toilet, chart and record rooms, using make-up air from the vestibule which is supplied by the unit ventilator through duct work.

The space above the suspended control room ceiling is ventilated in order to decrease the heat gain to the space below the ceiling. This permits the use of a lesser air quantity in the occupied space and minimizes drafts.

Service Building

Two supply systems are provided for the Service Building. One system consisting of a unit ventilator supplies ventilation air and heat for the plant laboratory, corridors, conference and special stores rooms.

The other system consisting of an air conditioning unit supplies conditioned air to the radiochemical laboratory and counting room to maintain a temperature and humidity controlled atmosphere in these areas where delicate instruments are in constant use.

Several exhaust systems are provided. One serves the clean toilet, shower and locker rooms, conference room and janitor's closets, another serves the potentially contaminated toilet room, shower room and locker room.

Each of the laboratory fume hoods is provided with an exhaust fan. The fume hood in the radiochemical laboratory includes a pre and after filter assembly to remove 99 plus per cent of particles which might be radioactive.

The decontamination cubicle is exhausted by a separate system which includes pre and after filters to remove possible radioactive particles prior to discharge to atmosphere.

Roof exhaust fans are provided for summer heat removal for the machine shop and water treating plant. Outdoor air for ventilation of the machine shop is drawn through open windows and doors and for the water treatment plant through louvered openings in the exterior wall.

Summer ventilation for plant stores, service office and contaminated instrument room is by natural means through open windows.

The unit ventilator and air conditioning equipment for the supply air are located in mechanical equipment room No. 1 above the Service Building roof. This room also houses the decontamination cubicle exhaust fan as well as water heating equipment, hot water heating system heat exchanger, expansion tank and circulators. The mechanical equipment room is exhausted in the summer by a thermostatically controlled roof exhaust fan, interlocked with a motor operated damper associated with a louvered air intake in the exterior wall.

Office Building

With the exception of the toilet and locker rooms and the janitor's closet, ventilation of spaces in the Office Building is by natural means through windows.

A unit ventilator serves the toilet and locker rooms. Air is exhausted from these spaces by a system connected to a fan located above the roof.

Primary Auxiliary Building

In the radioactivity clean portion of the Primary Auxiliary Building a roof type exhaust fan provides summer ventilation with supply air entering through open windows and doors.

Ventilation, heat removal, heating and dilution of possible hydrogen leakage in certain equipment compartments during operation and maintenance periods for the potentially contaminated portion of the Primary Auxiliary Building are provided by a supply system and an exhaust system. Filtered outdoor air, heated when required, is furnished by a supply unit ventilator located in mechanical equipment room No. 3 and is distributed by ducts to the potentially contaminated area. Air is exhausted from each of the shielded compartments through ducts connected to an exhaust fan located in the mechanical equipment room which discharges to the primary vent stack. Provisions are made to permit the use of the vapor container purge fan for Primary Auxiliary Building exhaust in the event the Primary Auxiliary Building exhaust fan becomes inoperative.

The mechanical equipment room is ventilated by the systems serving the potentially contaminated areas of the building.

Waste Disposal Building

Roof type exhaust fans for summer heat removal and dilution of possible hydrogen leakage during operation and maintenance periods are provided for the waste gas compressor room, waste disposal gas stripper compartment, and the area occupied by the incinerator. Make-up air is heated in the winter by unit heaters.

Fuel Transfer Pit House

Ventilation for the Fuel Transfer Pit House is provided by a roof type exhaust fan, with outdoor air entering the structure through a dampered and louvered wall opening.

229 FIRE PROTECTION SYSTEM

General

Fire protection is provided for exterior areas by yard hydrants. Interior protection in selected areasis provided by hose stations and, where a potential oil fire hazard may exist, by fixed piping systems with spray nozzles and sprinkler heads. Portable extinguishers of various types supplement piped facilities.

Fire Pumps and Source of Water

Two electric motor driven vertical turbine type fire pumps, located in the intake structure, take water from Sherman Pond. Each pump has a nominal capacity of 1,000 gpm at 125 psi gage. Both pumps discharge to the underground piping system which serves the yard hydrants and the interior fire protection systems.

A 75 gpm vertical turbine pressure maintenance pump, small air compressor and hydropneumatic tank with pressure and level controls located in the intake structure are arranged to maintain pressure on the yard fire lines automatically.

Electric power for the fire pumps is supplied through two buses, one of which is always energized. One pump is connected to one bus and the other pump is connected to the second bus.

Yard Fire Protection

Fire protection in the yard is provided by hydrants connected to an underground yard piping loop by valved branches. Hose houses contain standard hose house equipment. The hose house near the outdoor transformers contains, in addition, a water spray nozzle to combat an oil fire. Valved branches from the underground yard main serve the interior systems.

Sectionalizing valves in the yard piping loop are provided to permit partial pipe line isolation without interruption of service to the entire system during maintenance, repair or future extension of the facilities.

Interior Hose Station Protection

Fire hose stations are provided for interior areas of the plant, except within the vapor container, Waste Disposal Building, Primary Auxiliary Building and radioactivity laboratory, which are areas either inaccessible normally, or where the use of a fire hose stream might result in spread of radioactive contamination.

Hose reels with 50 ft of noncollapsible rubber hose and fixed spray nozzles with shutoff valve suitable for extinguishment of oil and electrical fires are provided at the operating and condenser floor levels of the turbine generator area. In the office and service buildings, hose stations consist of hose racks with rubber lined cotton hose and combination solid stream and spray nozzles.

Turbine Oil Tank, Seal Oil Unit, Turbine Oil Piping

A system of water spray fire protection is provided for protection of the turbine oil tank, seal oil unit, and turbine oil piping. This system is zoned and operable manually from dual valve stations located at a distance from the protected equipment and in areas shielded from potential fires.

Lubricating Oil Room

A system of automatic spray sprinkler heads is provided for protection of the central lubricating oil room.

Portable Extinguishers

Portable fire extinguishers of various types are distributed within the plant for extinguishment of small fires.

230 REACTOR VESSEL

General

The reactor vessel assembly is provided in a pressurized water reactor plant to contain the nuclear core, to direct pressurized coolant water through the core, and to facilitate the control and replacement of the core.

The reactor vessel assembly as shown on page 230:2 consists of a reactor vessel, a removable reactor vessel head, and various internal plates and barrels. The reactor vessel with the head is approximately 31 ft-6 in. overall height by 9 ft-1 in. internal diameter.

During operation, the main coolant water enters the reactor vessel assembly through four inlet nozzles, flows down through the annuli between the vessel wall, thermal shield, and core barrel, experiences a temperature rise as it passes up through the core, and leaves the reactor vessel assembly through four outlet nozzles. All of the internals hang from the support ledge near the top of the reactor vessel flange and are held in place by the reactor vessel head which presses down on the core hold down ring. The core is held between the two core support plates and the guide tubes are held between the two guide tube plates. Control rods are moved into and out of the core by control rod drive mechanisms mounted on the reactor vessel head.

The reactor vessel is a welded assembly of the following parts:

The hemispherical bottom head of the reactor vessel is formed of SA-302, Grade B, carbon steel plate of 3 7/8 in. minimum thickness and is clad on the inside with a sheet of Type 304 stainless steel of .109 in. thickness.

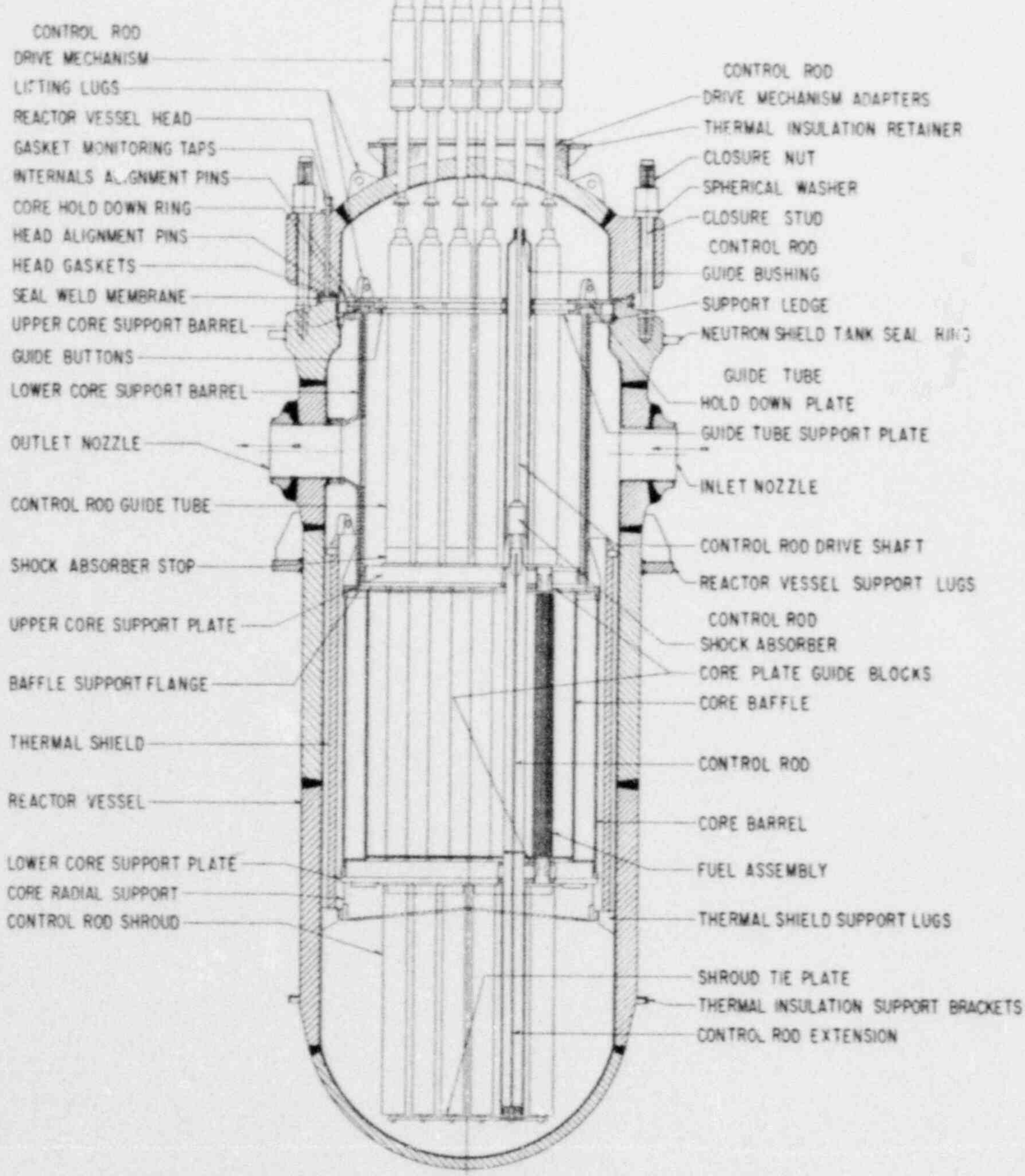
The cylindrical shell section of the reactor vessel is made up of two rolled courses of SA-302, Grade B, carbon steel plate of 7 7/8 in. minimum thickness and is clad on the inside with sheets of Type 304 stainless steel of .109 in. thickness. Each rolled course has a longitudinal weld seam and the two courses are joined together by a circumferential weld seam.

Twenty equally spaced brackets for supporting the thermal insulation are welded to the outside of the lower shell section.

Eight equally spaced clad feet for supporting the thermal shield are welded to the inside of the lower shell section.

Twenty-eight equally spaced lugs for supporting the reactor vessel are welded to the outside of the upper shell section.

The cylindrical upper shell section of the reactor vessel is made up of three formed segments of SA-302, Grade B, carbon steel plate of 9 5/8 in. minimum thickness and is clad on the inside with Type 308L stainless steel weld deposited to a thickness of 1/4 in. The three formed segments are joined together by three longitudinal weld seams.



REACTOR VESSEL ASSEMBLY

Four main coolant inlet nozzles and four main coolant outlet nozzles are welded to the upper shell section. The inlet and outlet nozzles alternate around the vessel at 45 deg intervals and are all at the same level. The nozzles are hollow forgings of SA-182 carbon steel, modified to the requirements of SA-302, Grade B, carbon steel and are clad on the inside with Type 308L stainless steel weld deposited to a thickness of 1/4 in. Stainless steel is weld deposited to the end of each nozzle to facilitate welding to the main coolant piping.

The bolting flange of the reactor vessel is an SA-105, Grade 2, carbon steel forging clad on the inside and top with Type 308L stainless steel weld deposited to a thickness of 1/4 in.

A support ledge for the internals is machined on the inside of the bolting flange near the top.

A machined ring is welded to the outside of the bolting flange to facilitate a seal between the reactor vessel and the neutron shield tank.

Two gasket grooves are machined into the top of the bolting flange.

The reactor vessel head is a welded assembly of the following parts:

The center disc of the reactor vessel head is approximately hemispherical in shape and is formed of SA-302, Grade B, carbon steel plate of 7 in. minimum thickness and is clad on the inside with a sheet of Type 304 stainless steel of .109 in. thickness.

Thirty-two adapters for supporting control rod drive mechanisms are welded to the center disc. Each adapter is made up of a Type 304 stainless steel top and a co-extruded tube which, in turn, is made up of an SA-106, Grade C, carbon steel tube clad on the inside with Type 304 stainless steel.

Three equally spaced lifting lugs are welded to the center disc.

A combination thermal insulation retainer and support for the control rod drive mechanisms cooling ducts is welded to the center disc.

The bolting flange of the reactor vessel head is an SA-105, Grade 2, carbon steel forging clad on the inside and bottom with Type 308L stainless steel weld deposited to a thickness of 1/4 in.

Two gasket monitoring taps penetrate the bolting flange and exit at the top.

The reactor vessel head is held to the reactor vessel by 52 closure studs with nuts and spherical washers. The 5-1/4 in. diameter closure studs are made of SA-193, Grade B16, carbon steel and the closure nuts are made of SA-194, Grade 2HB, carbon steel. Each set of spherical washers consists of two halves: a lower half with a concave upper surface and an upper half with a convex lower surface. The washers are made of special nitrided alloy.

The closure joint between the reactor vessel head and the reactor vessel is sealed by two self-energizing stainless steel O-ring gaskets. The two gasket monitoring taps monitor the leakage past both the inner and outer O-ring gaskets. A backup provision for sealing is provided in the form of a seal weld membrane. Operating experience will show whether seal welding of the seal weld membrane is required.

The internals, made of Type 304 stainless steel, consist of the following parts:

A 3 in. thick cylindrical thermal shield

A lower core support assembly consisting of the lower core support barrel, head alignment pins, internals alignment pins, core barrel, core baffle, lower core support plate, core radial support, core plate guide blocks, control rod shrouds, and shroud tie plate

Four secondary core support assemblies, each consisting of a support pad and strap, rigidly clamped to the thermal shield

An upper core support assembly consisting of the upper core support barrel, lifting lugs, upper core support plate, core plate guide blocks, and shock absorber stops

A guide tube support assembly consisting of the guide tube support plate, lifting lugs, and guide buttons

A guide tube hold down assembly consisting of the guide tube hold down plate, lifting lugs, and core hold down ring

Twenty-four control rod guide tubes and eight guide tube plate plugs

Design

The reactor vessel and head is designed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels, 1956 Edition and latest Addenda, and Code Case No. 1234.

The nominal design pressure is 2,500 psi gage and the design temperature is 650 F. The reactor vessel and head will be given a hydrostatic test at 3,750 psi gage. The minimum hydrostatic test temperature is 90 F and the maximum is 200 F.

The maximum heating and cooling rates are 50 F per hr. In heating up, the vessel must be held in the 150 F to 250 F range until an iso-thermal condition is obtained.

The thermal shield is designed to limit thermal stress in the reactor vessel shell during full power operation by absorbing radiation emanating from the core. It is made of four 90° sections bolted together at their lapped joints. Joint clamp assemblies have been added to reinforce the bolted joints and assure that the thermal shield remains intact even though all bolts in any joint should fail. The figure on page 230:10 shows details of a joint clamp assembly.

The closure studs have center holes to permit them to be elongated by the use of stud heaters and they also have extra threaded length to permit them to be elongated by the use of stud tensioners. The center holes are also designed to receive the rods required so that stud elongation measurements can be obtained by special dial-indicating gages.

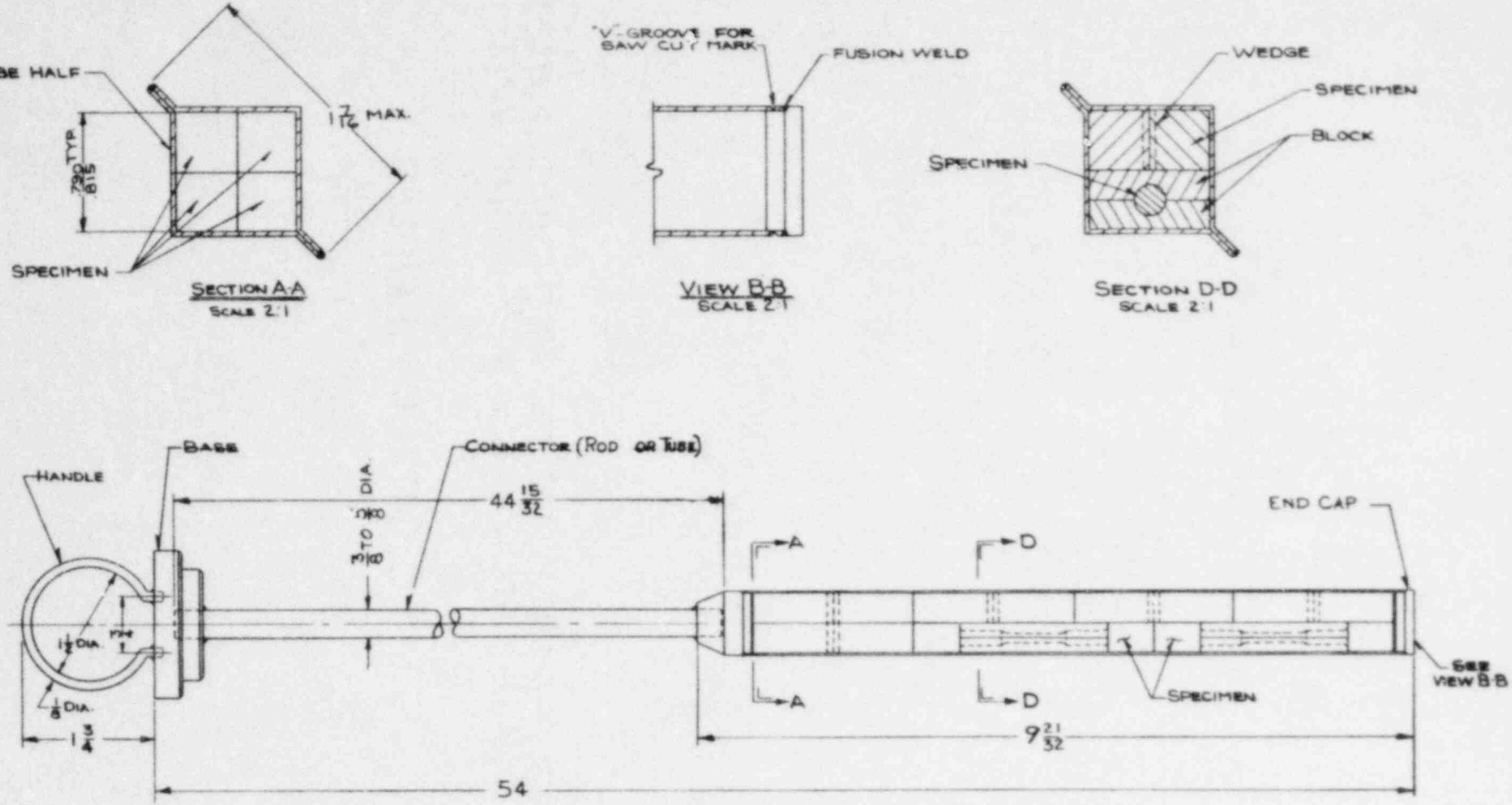
Radiation Samples

Provision is made for the installation of radiation test samples of reactor vessel material within the reactor vessel. The installation of up to 12 special tube assemblies containing encapsulated specimens is for the purpose of determining long and short term effects of neutron bombardment on the physical properties of the reactor vessel material.

Eight holes are provided in the upper flange of the core baffle, which permit specimen assemblies to hang beside the core, just inside the core barrel. Type A special tube assemblies are inserted in these holes. Each tube assembly seats in its respective hole, and is held captive by the upper core support plate pressing against the handle of the specimen assembly. The approximate position of the Type A assemblies may be seen by referring to page 230:8.

In addition to the above eight positions, four guide channels, attached to the outer surface of the thermal shield, are provided so that specimens may be located between the thermal shield and the reactor vessel. Type B special tube assemblies fit into these guides and are supported at the upper end by fitting into holes provided in the flange of the lower core support barrel, while the lower end rests in the guide channels attached to the thermal shield. The specimen assemblies are held captive by the upper core support barrel during operation. The location of these assemblies is also shown on page 230:8. Removal and insertion of the specimens is accomplished by a special lifting tool which screws into a threaded hole in each specimen assembly.

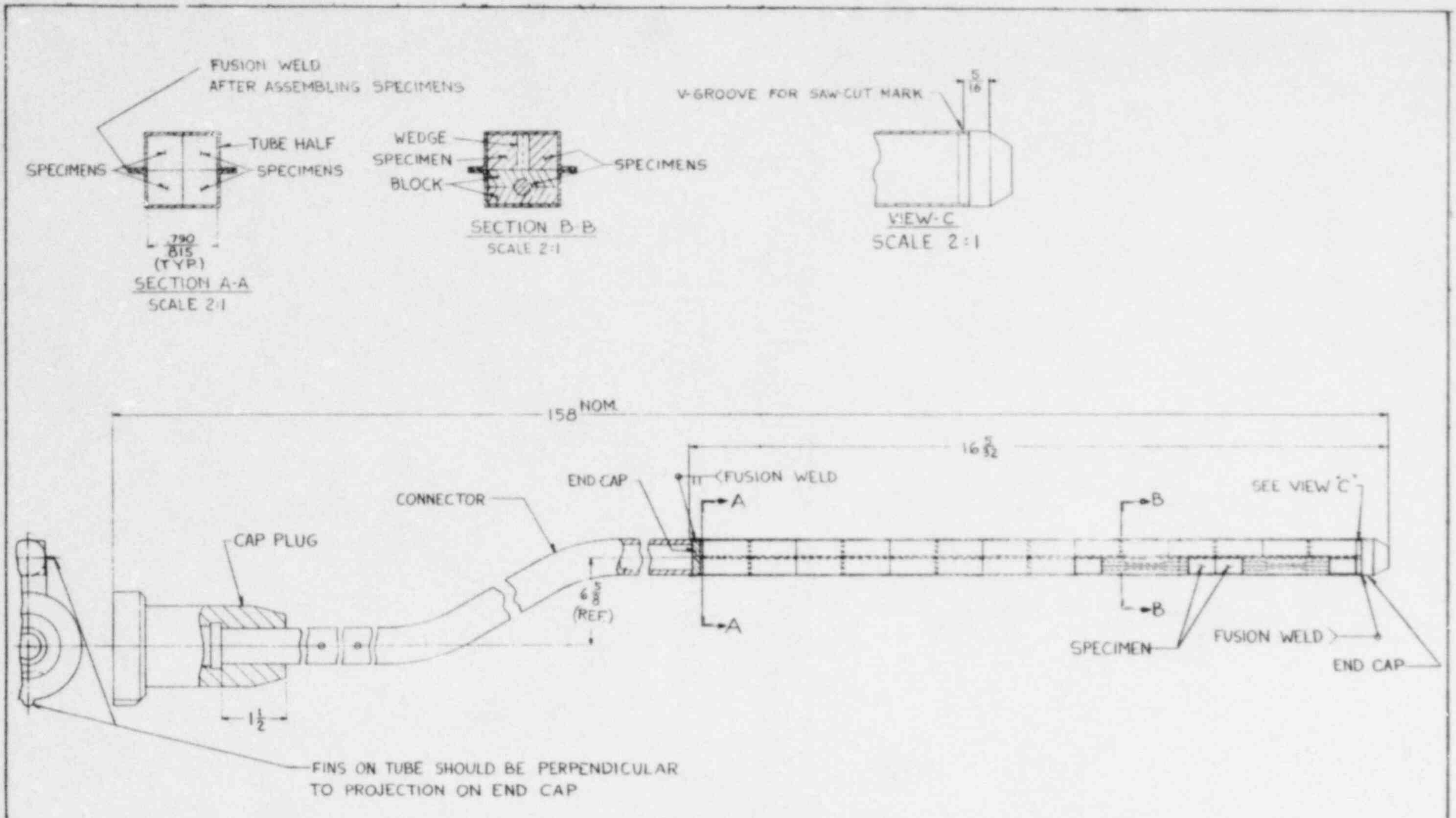
The vessel material specimens consist of ASTM-A-302B steel, machined from actual Yankee vessel shell plate and United States Steel ASTM-A-302B reference material.



IRRADIATION TEST SPECIMEN (TYPE A)

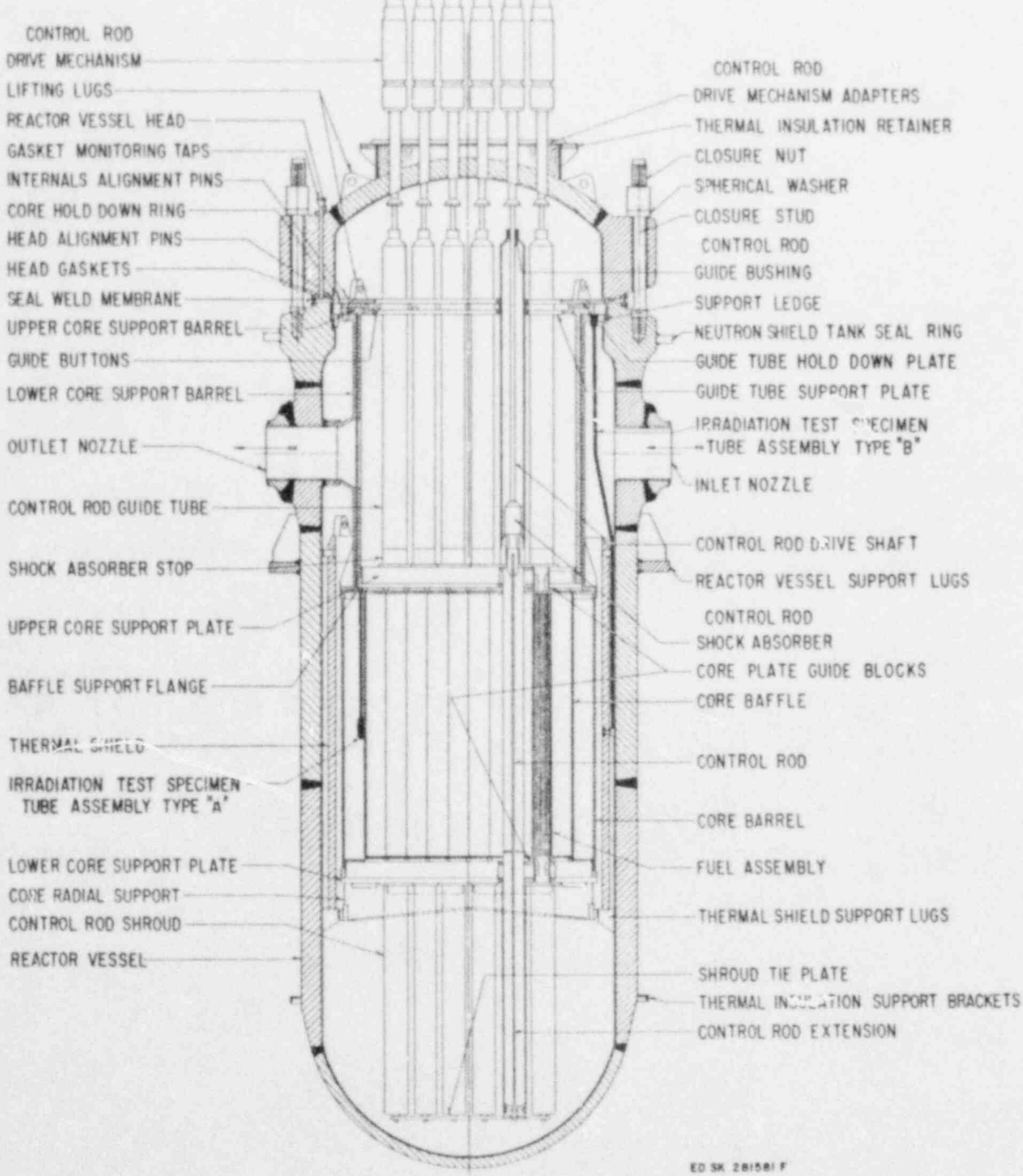
230-6
2/2/62

1919



IRRADIATION TEST SPECIMEN (TYPE B)

Fig. 2.30.8
12/6/61

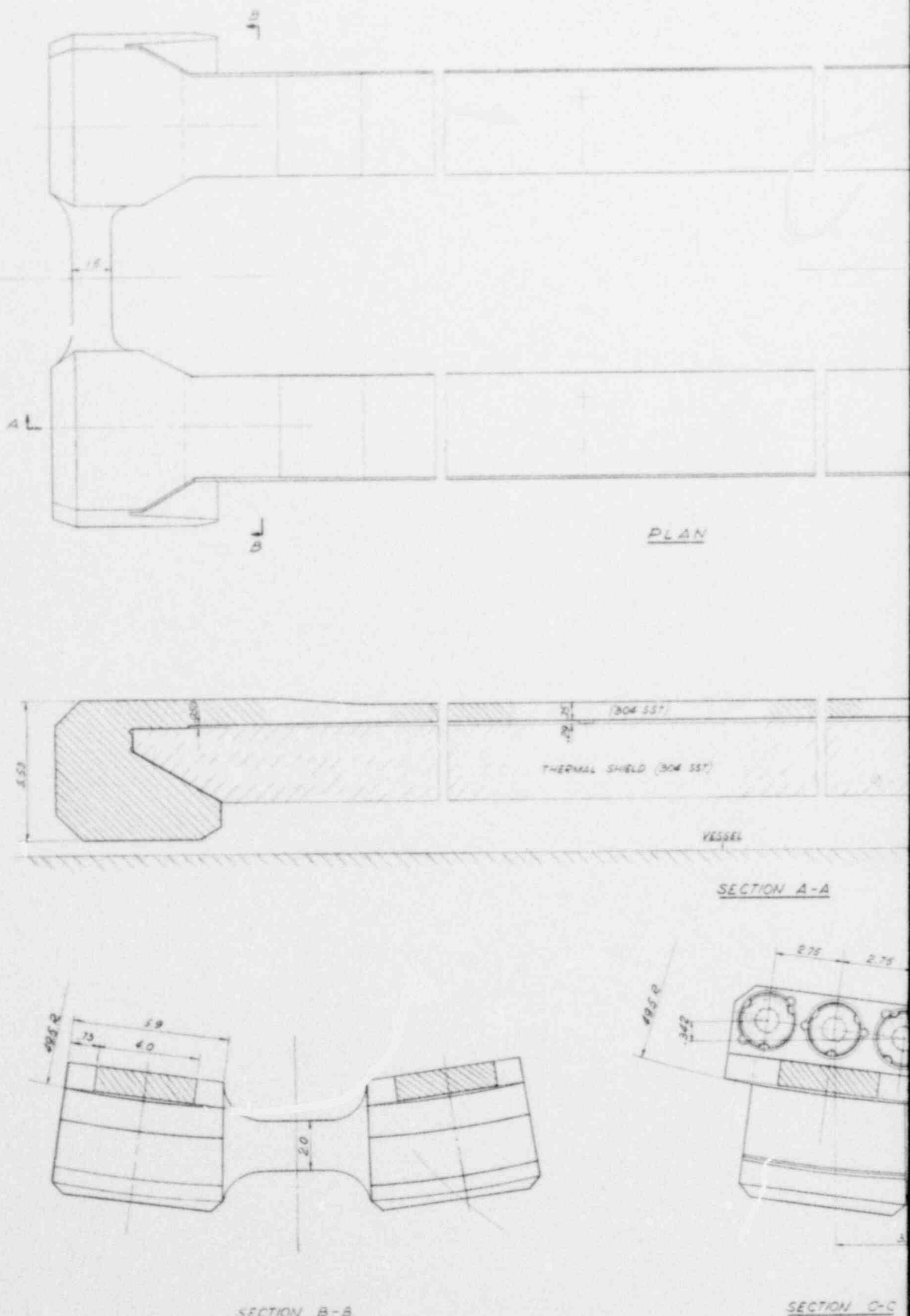


REACTOR NOMENCLATURE

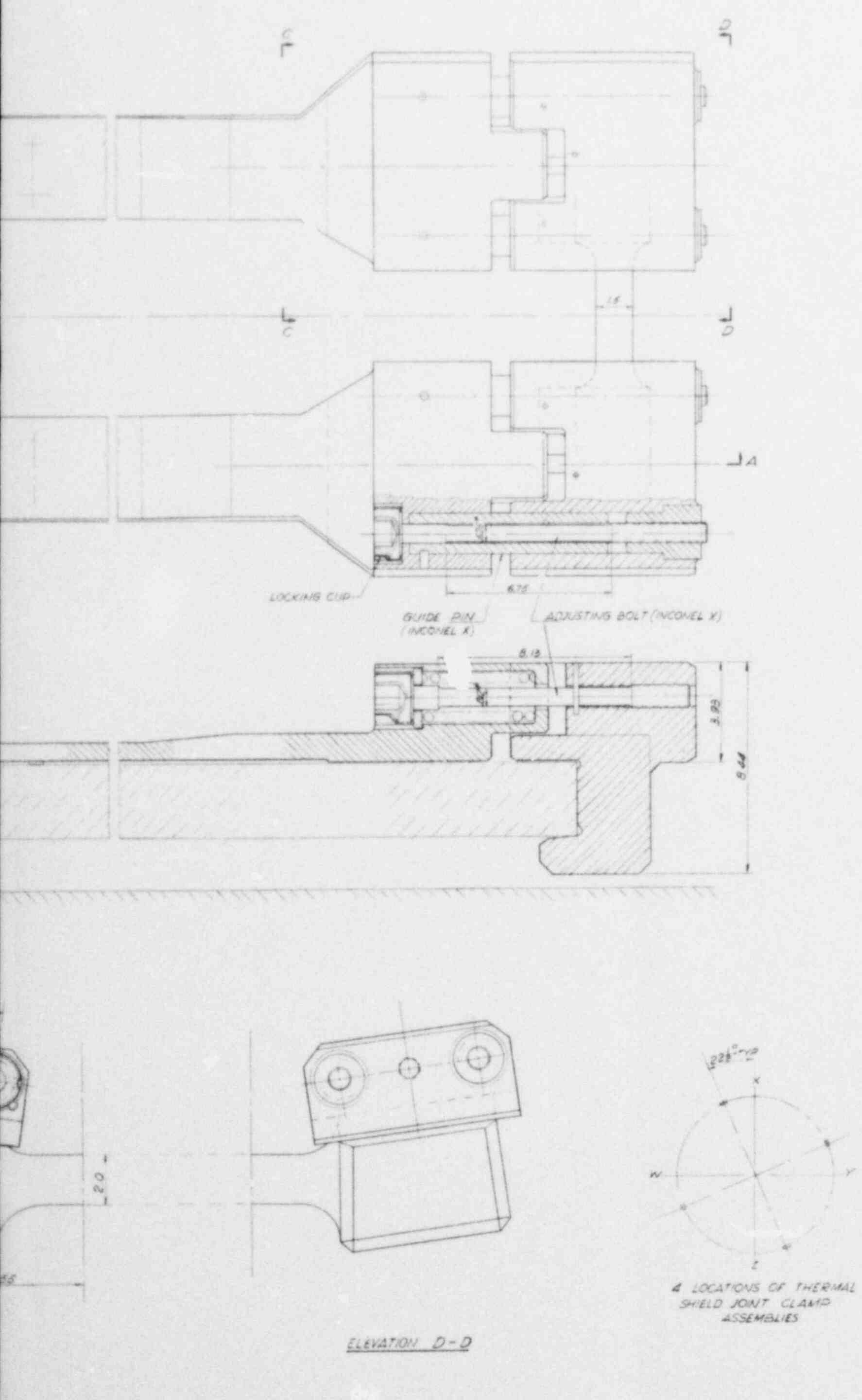
Type A assemblies each contain twelve specimens. Ten are Charpy V-notch impact specimens and two are tensile specimens. Seven of the ten impact specimens are Yankee material samples, the remaining three being U.S. Steel reference material. The two tensile specimens are both machined from Yankee vessel material. Details of the Type A Specimen Tube Assemblies may be found on page 230:6.

The Type B assemblies (page 230:7) each contain twenty-four specimens. Twenty-two of these are Charpy V-notch impact specimens and two are tensile specimens. Eighteen of the twenty-two impact specimens are machined from Yankee vessel material with the remaining four being the U. S. Steel reference material. As in Type A assemblies, both tensile specimens are machined from Yankee vessel material.

Positioned within the support tube of selected Type A and Type B specimen assemblies are capsule type neutron detectors which yield data valuable in the evaluation of specimen neutron exposures. Detector materials of varying threshold energy values, such as nickel, iron, cadmium or cobalt, are encapsulated in a stainless steel tube to form a detector unit.



B
A
1.5
PLAN
5.52
(304 SST)
THERMAL SHIELD (304 SST)
VESSEL
SECTION A-A
49.5 R
5.9
1.3
4.0
2.0
SECTION B-B
2.75
2.75
SECTION C-C



JOINT CLAMP ASSEMBLY

231 VAPOR CONTAINMENT

General

The vapor container is a steel envelope which surrounds the main coolant equipment loops and encloses all pressurized parts of the main coolant system. It prevents the release of radioactivity to the atmosphere in the unlikely event of an accident resulting from a rupture and release of fluid from the main coolant system within the containment vessel.

When the reactor is critical or when the main coolant system is pressurized with nuclear fuel in place, the vapor container is closed and pressure-tight. Under these conditions access openings are closed with gasketed doors, pipe lines not required for operation are closed with tight shutoff valves, and the fuel chute is blanked off with a bolted and gasketed closure.

The vapor container, when closed, is maintained at a pressure level slightly higher than atmospheric for continuous leakage indication.

The layout of the vapor container and the interior structure is shown on drawing No. 9699-FM-1C.

The vapor container is a steel spherical shell, 125 ft in diameter and with a minimum wall thickness of 7/8 in. The spherical shape is selected since it uses a minimum of material for a given volume and internal pressure. The spherical shape permits the most accurate determination of secondary stress and facilitates the design of the necessary penetrations.

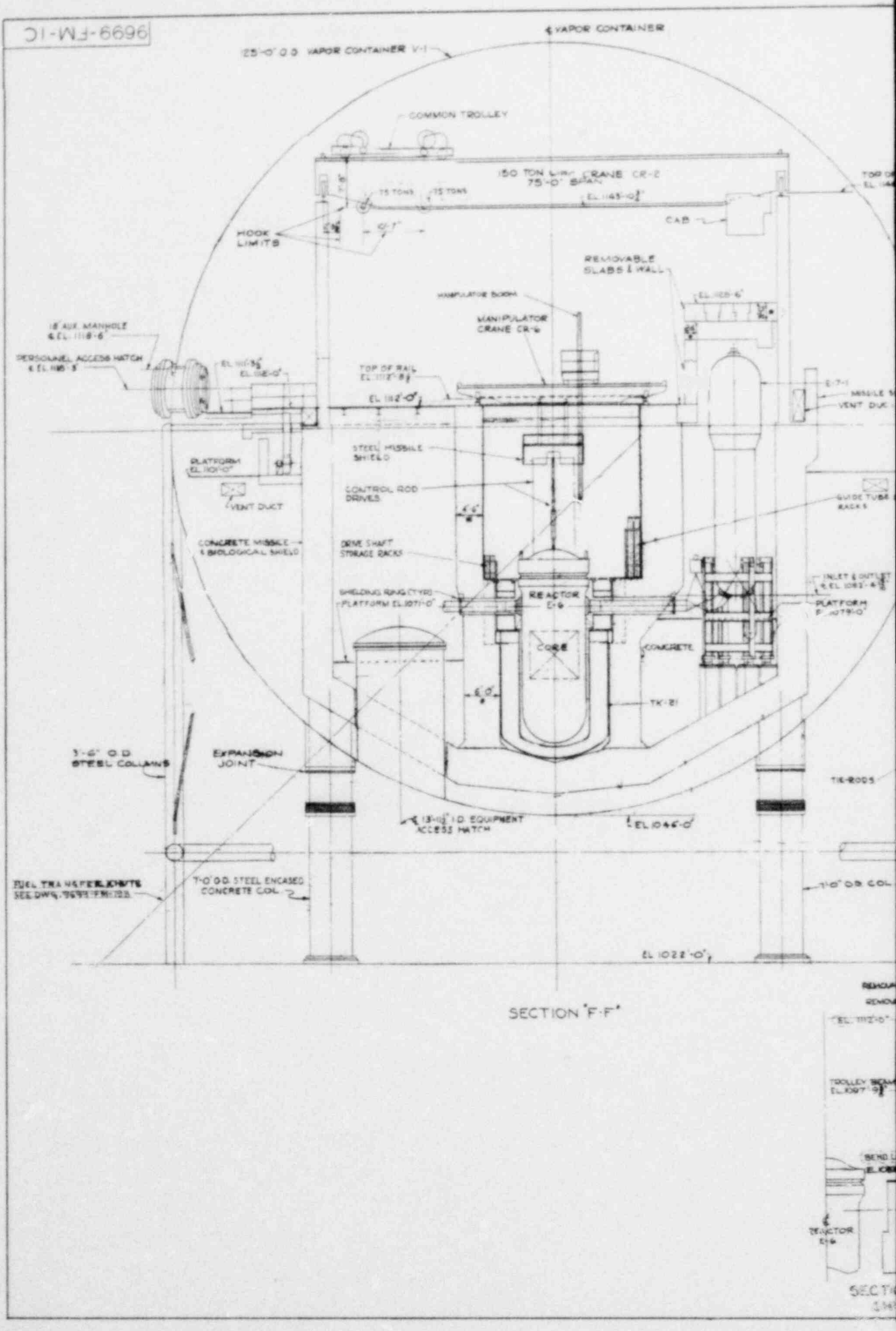
The spherical vessel is supported on braced steel columns.

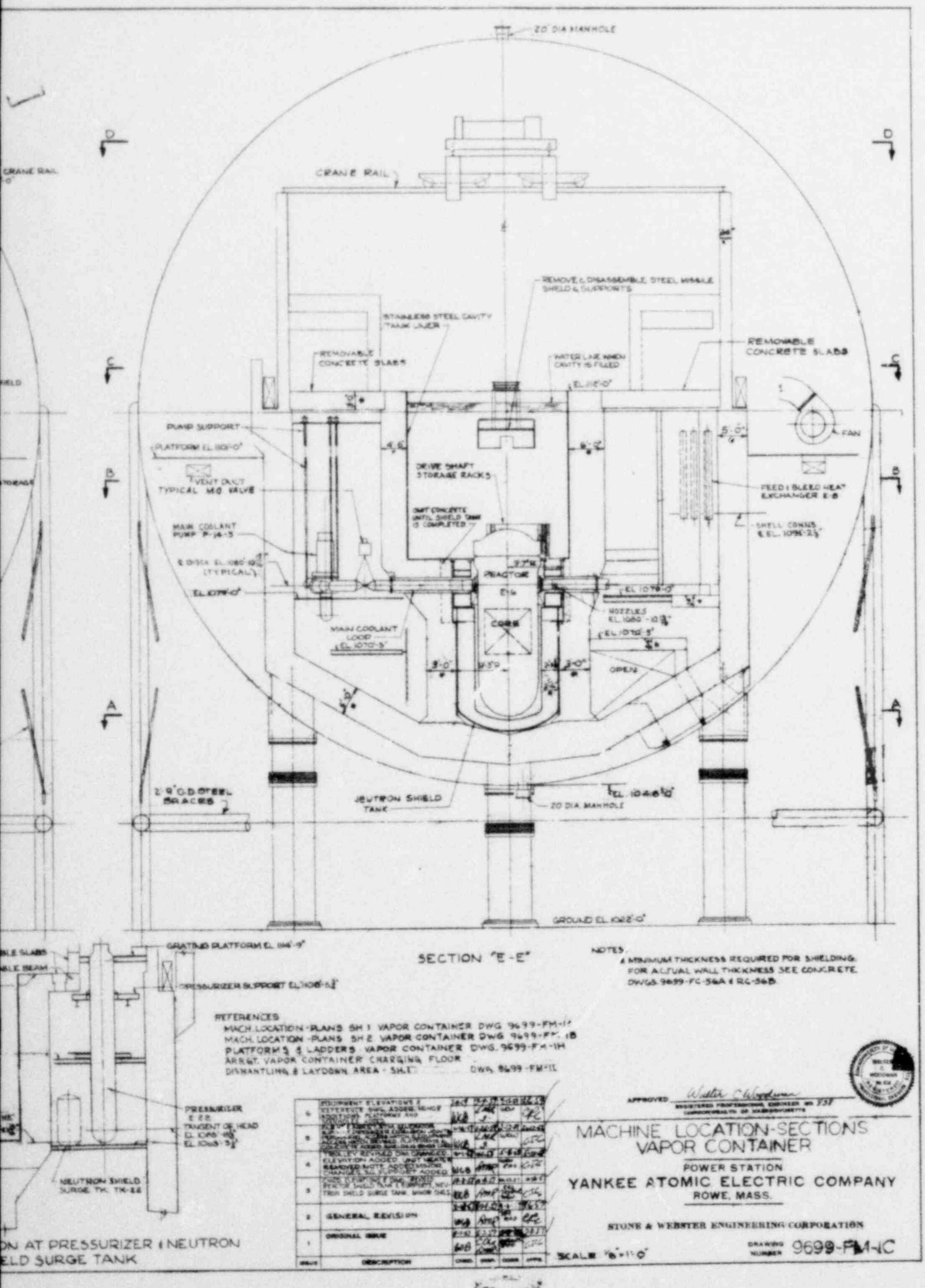
Piping Penetrations and Access Openings

Pipe lines penetrating the vapor container, which are used only when the plant is not in operation, are provided with valves located outside the vapor container. These valves are closed whenever the reactor is critical or when the main coolant system is pressurized with nuclear fuel in place. Incoming pipe lines, used for operation of the plant, are provided with two check valves, one inside and one outside the vapor container. The external check valve is, in some cases, located at an item of equipment or a closed auxiliary vessel. Outgoing lines, used for operation of the plant, are each provided with a closure trip valve arranged to close automatically on pressure rise in the container of 5 psi.

Piping penetrations are shown on drawings Nos. 9699-FV-1X and 1Y.

The personnel access opening is at the charging floor level just above the vessel equator. The opening consists of tubular shell penetration with 6 ft-8 in. head room and with a steel plate door at each end, one inside and one outside the vessel. This arrangement permits entrance to and egress from the vessel with the primary plant at pressure without ever completely opening the vessel to atmosphere. Door closures are hydraulically operated, with provision for manual jacking. A small auxiliary bolted and gasketed


9699-FM-1C
℄ VAPOR CONTAINER
125'-0" O.D. VAPOR CONTAINER V-1
COMMON TROLLEY
150 TON LIFT CRANE CR-2
75'-0" SPAN
75 TONS
75 TONS
HOOK LIMITS
CAB
REMOVABLE SLABS & WALL
MANIPULATOR BOOM
MANIPULATOR CRANE CR-6
18" AUX. MANHOLE
PERSONNEL ACCESS HATCH
TOP OF RAIL
PLATFORM
VENT DUCT
STEEL MISSILE SHIELD
CONTROL ROD DRIVES
CONCRETE MISSILE & BIOLOGICAL SHIELD
DRIVE SHAFT STORAGE RACKS
REACTOR E-6
CORE
CONCRETE
TK-21
3'-6" O.D. STEEL COLUMNS
EXPANSION JOINT
I.D. EQUIPMENT ACCESS HATCH
EL 1046'-0"
FUEL TRANSFER LIMITS
7'-0" O.D. STEEL ENCASED CONCRETE COL.
EL 1022'-0"
SECTION "F-F"


20" DIA MANHOLE
CRANE RAIL
REMOVE & DISASSEMBLE STEEL MISSILE SHIELD & SUPPORTS
STAINLESS STEEL CAVITY TANK LINER
REMOVABLE CONCRETE SLABS
WATER LINE WHEN CAVITY IS FILLED
EL. 1115'-0"
REMOVABLE CONCRETE SLABS
FAN
PUMP SUPPORT
PLATFORM EL. 1101'-0"
VENT DUCT
TYPICAL M.O. VALVE
DRIVE SHAFT STORAGE RACKS
OMIT CONCRETE UNTIL SHIELD TANK IS COMPLETED
FEED & BLEED HEAT EXCHANGER E-8
SHELL CONNS. ℄ EL. 1096'-2½"
MAIN COOLANT PUMP P-14-3
(TYPICAL)
EL. 1079'-0"
REACTOR
CORE
EL. 1079'-0"
NOZZLES
MAIN COOLANT LOOP
EL. 1070'-5"
EL. 1070'-5"
OPEN
2'-9" O.D. STEEL BRACES
NEUTRON SHIELD TANK
20" DIA. MANHOLE
EL. 1046'-0"
GROUND EL. 1022'-0"
GRATING PLATFORM EL. 1114'-9"
PRESSURIZER SUPPORT EL. 1108'-6¼"
PRESSURIZER
NEUTRON SHIELD SURGE TK. TK-22
...ON AT PRESSURIZER & NEUTRON
...ELD SURGE TANK
SECTION "E-E"
NOTES
⁑ MINIMUM THICKNESS REQUIRED FOR SHIELDING. FOR ACTUAL WALL THICKNESS SEE CONCRETE DWGS. 9699-FC-56A & FC-56B.
REFERENCES
MACH. LOCATION - PLANS SH 1 VAPOR CONTAINER DWG 9699-FM-1A
MACH. LOCATION - PLANS SH 2 VAPOR CONTAINER DWG 9699-FM-1B
PLATFORMS & LADDERS - VAPOR CONTAINER DWG. 9699-FM-1H
ARRGT. VAPOR CONTAINER CHARGING FLOOR
DISMANTLING & LAYDOWN AREA - SH. 1 DWG. 9699-FM-1L
GENERAL REVISION
ORIGINAL ISSUE
DESCRIPTION
APPROVED
MACHINE LOCATION - SECTIONS
VAPOR CONTAINER
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
SCALE ⅛" = 1'-0"
DRAWING NUMBER 9699-FM-1C

XI-AJ-6696

WELD THIS CAP TO PIPE AFTER ALL STRESS RELIEVING HAS BEEN PERFORMED. TYPICAL FOR ALL DOUBLE CAPPED CONNECTIONS ON THIS DRAWING

BUILDING SERVICE PIPES

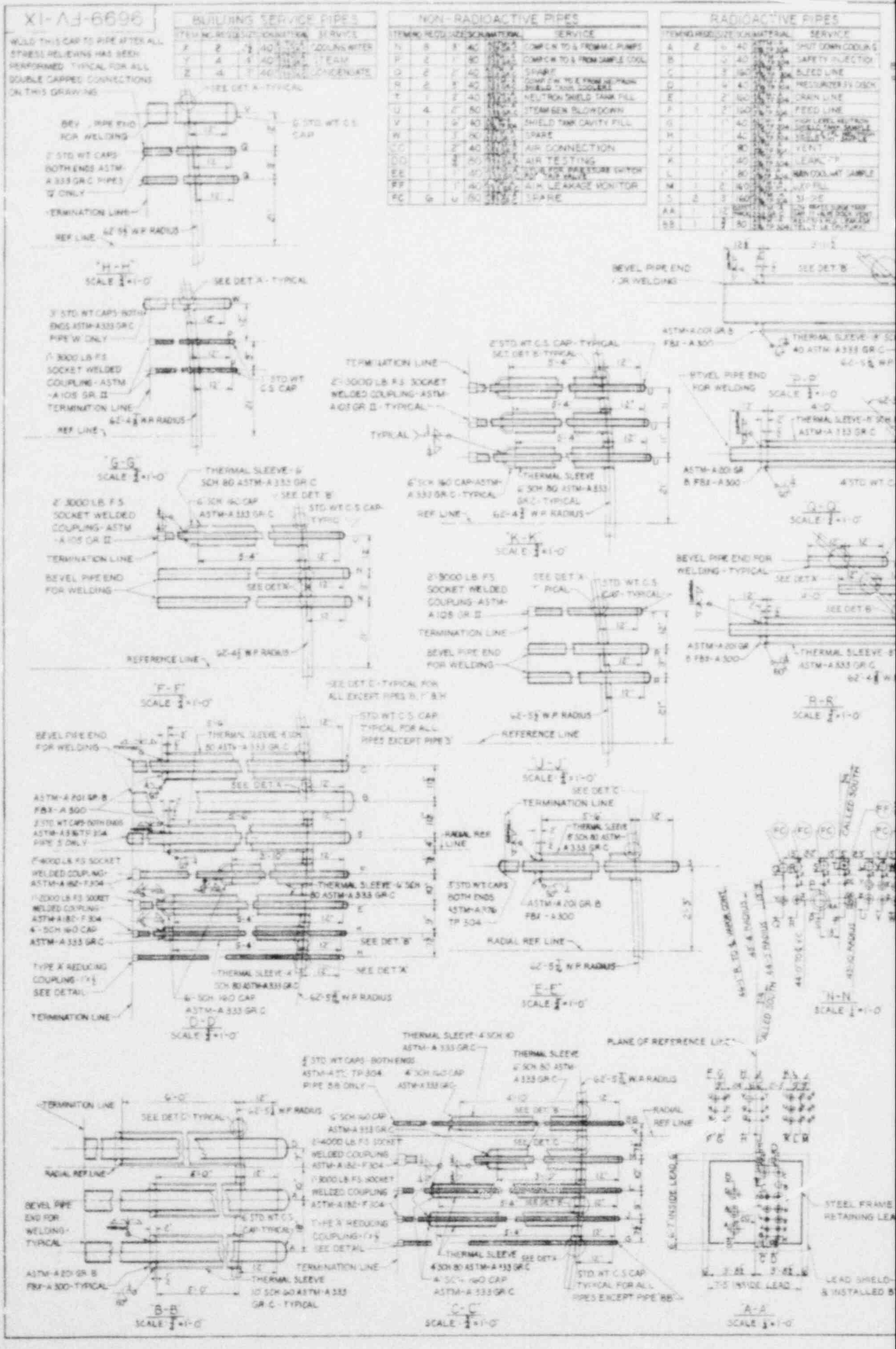
ITEM	NO. REQD	SIZE	SCH	MATERIAL	SERVICE
X	2	1/2	40	[illegible]	COOLING WATER
Y	4	1"	40	[illegible]	STEAM
Z	4	1"	40	[illegible]	CONDENSATE

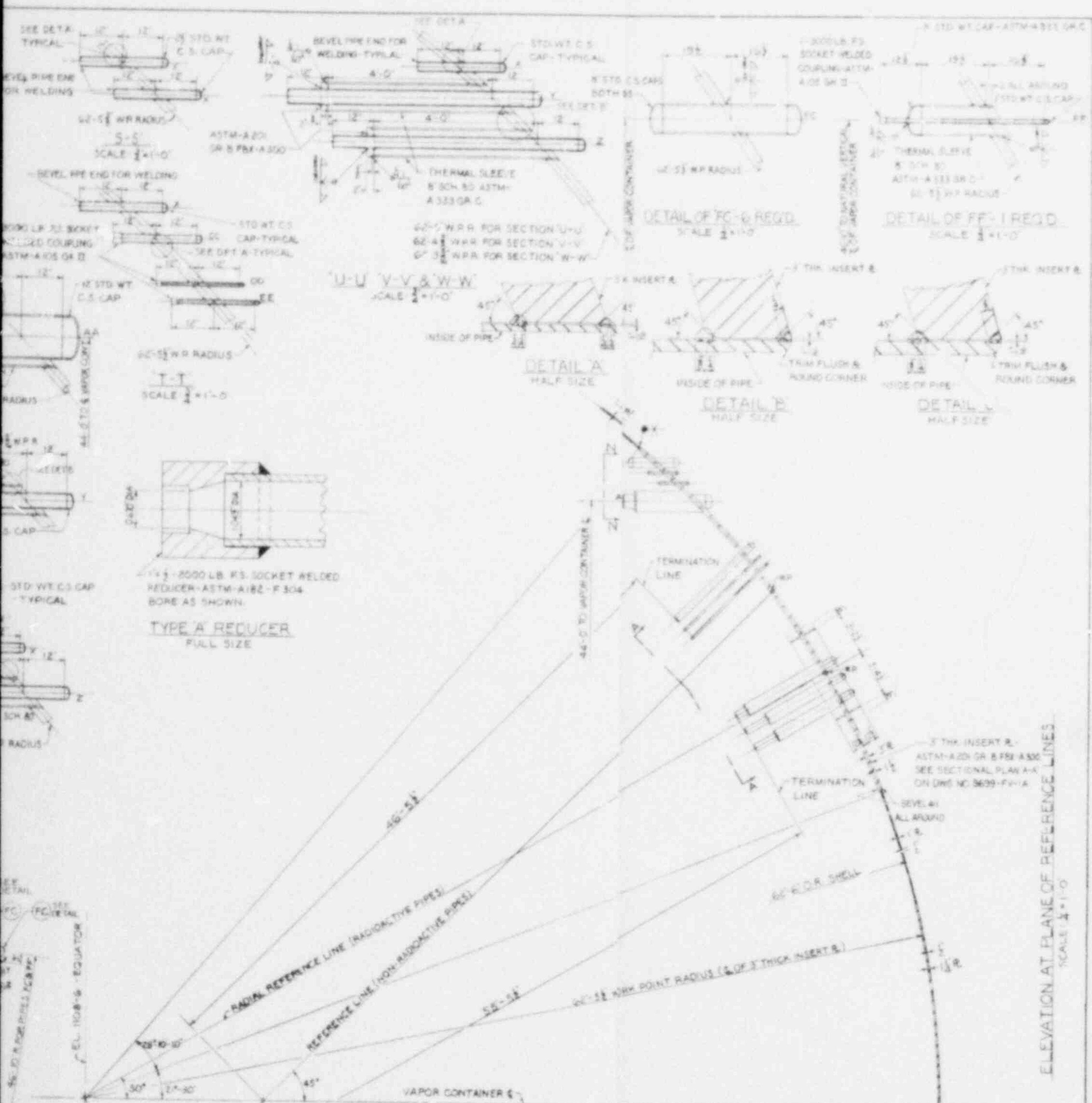
NON-RADIOACTIVE PIPES

ITEM	NO. REQD	SIZE	SCH	MATERIAL	SERVICE
N	8	1"	40	[illegible]	COMP. C.W. TO & FROM M.C. PUMPS
P	2	1"	80	[illegible]	COMP. C.W. TO & FROM SAMPLE COOL
Q	2	2"	40	[illegible]	SPARE
R	2	1"	40	[illegible]	COMP. C.W. TO & FROM NEUTRON SHIELD TANK COOLERS
T	1	2"	40	[illegible]	NEUTRON SHIELD TANK FILL
U	4	2"	80	[illegible]	STEAM GEN. BLOWDOWN
V	1	6"	40	[illegible]	SHIELD TANK CAVITY FILL
W	1	3"	80	[illegible]	SPARE
CC	1	2"	40	[illegible]	AIR CONNECTION
DD	1	3/4"	80	[illegible]	AIR TESTING
EE	1	1"	40	[illegible]	[illegible] FOR PRESSURE SWITCH [illegible]
FF	1	1"	40	[illegible]	AIR LEAKAGE MONITOR
FC	6	4"	80	[illegible]	SPARE

RADIOACTIVE PIPES

ITEM	NO. REQD	SIZE	SCH	MATERIAL	SERVICE
A	2	6"	40	[illegible]	SHUT DOWN COOLING
B		6"	40	[illegible]	SAFETY INJECTION
C	1	3"	160	[illegible]	BLEED LINE
D	1	4"	40	[illegible]	PRESSURIZER S.V. DISCH.
E	1	2"	160	[illegible]	DRAIN LINE
F	1	2"	160	[illegible]	FEED LINE
G	1	1"	40	[illegible]	HIGH LEVEL NEUTRON SHIELD TANK SAMPLE
H	1		40	[illegible]	[illegible] SAMPLE
J	1	1"	80	[illegible]	VENT
K	1		40	[illegible]	LEAK-OFF
L	1	1"	80	[illegible]	MAIN COOLANT SAMPLE
M	1	2	160	[illegible]	[illegible] FILL
S	2	3	160	[illegible]	SPARE
AA	1	12	[illegible]	[illegible]	[illegible]
BB	1	3/4	80	[illegible]	[illegible]





NOTES -

3" THK. INSERT ℞ TO BE STRESS RELIEVED AFTER ALL PENETRATIONS HAVE BEEN INSTALLED.

ALL WELDING INVOLVING A STAINLESS STEEL PART MUST BE PERFORMED WITH A STAINLESS STEEL ELECTRODE.

REFERENCE DRAWINGS -

FOR VAPOR CONTAINER, SEE DWG. NO. 9699-FV-1A.

FOR DETAILS OF VAPOR CONTAINER PIPING PENETRATIONS - SH. 2, SEE DWG. NO. 9699-FV-1Y.

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER, NO. 3??
COMMONWEALTH OF MASSACHUSETTS

SUPERSEDES DWG. NOS. 9699-FV-1P, 1Q & 1R

ISSUE	DESCRIPTION	CHKD.	DISP.	CONS.	APPR.
5					
4					
3					
2	GENERAL REVISION	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE ISSUED FOR CONSTRUCTION	[illegible]	[illegible]	[illegible]	[illegible]

DETAILS OF VAPOR CONTAINER PIPING PENETRATIONS - SH. 1

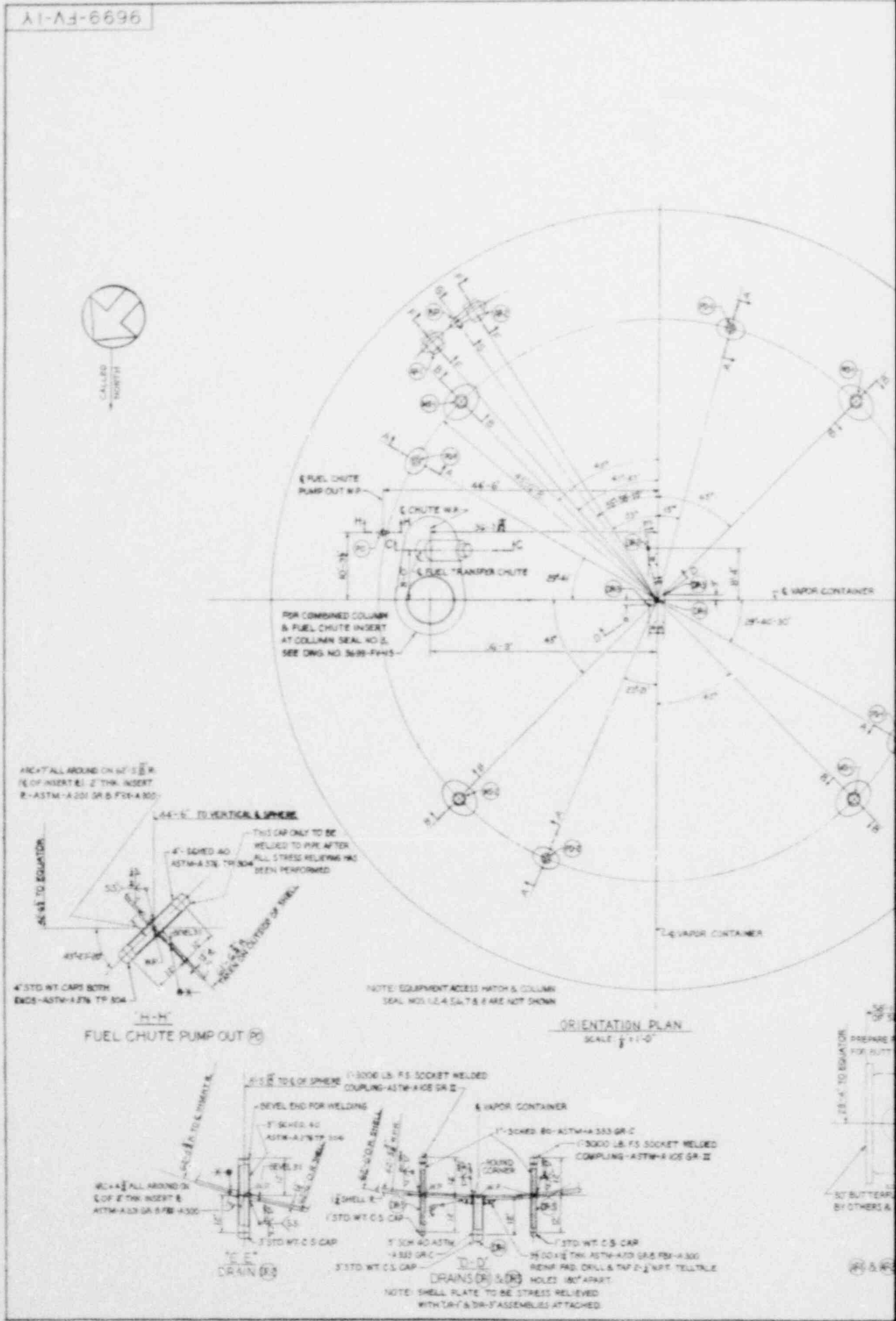
POWER STATION

YANKEE ATOMIC ELECTRIC COMPANY

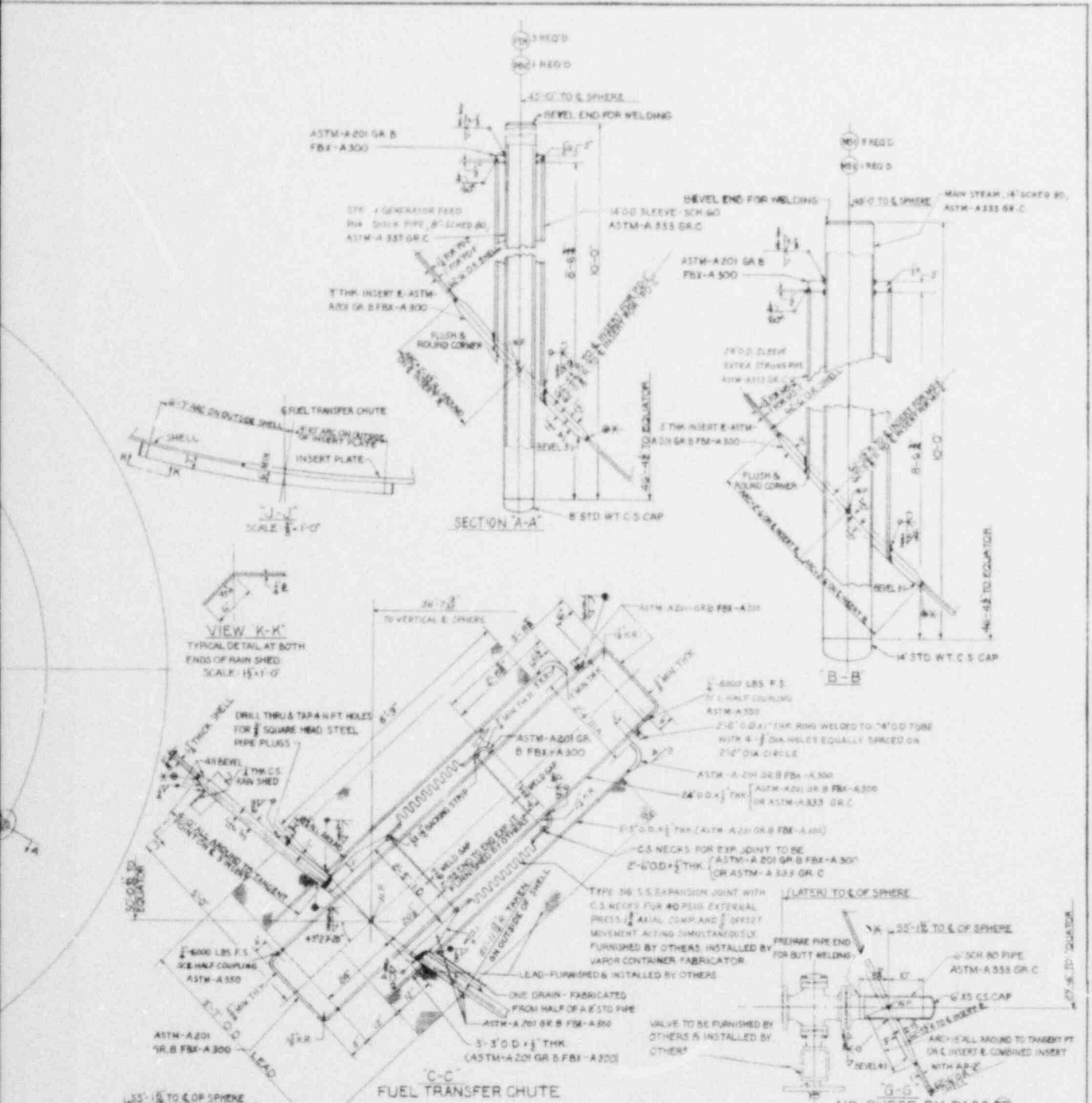
ROWE, MASS.

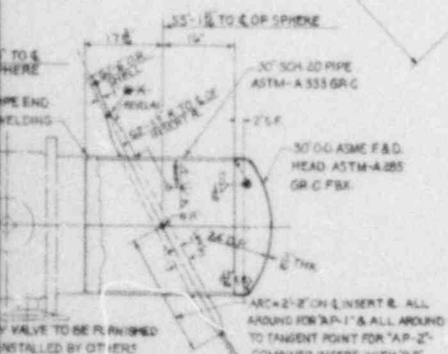
STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FV-1X



9699-FV-1Y
CALLED NORTH
℄ FUEL CHUTE PUMP OUT W.P.
℄ CHUTE W.P.
℄ FUEL TRANSFER CHUTE
℄ VAPOR CONTAINER
FOR COMBINED COLUMN & FUEL CHUTE INSERT AT COLUMN SEAL NO. 3, SEE DWG. NO. 3699-FV-15
NOTE: EQUIPMENT ACCESS HATCH & COLUMN SEAL NOS. 1, 2, 4, 5, 6, 7 & 8 ARE NOT SHOWN
ORIENTATION PLAN
"H-H"
FUEL CHUTE PUMP OUT
4" STD. WT. CAPS BOTH ENDS-ASTM-A 376 TP 304
THIS CAP ONLY TO BE WELDED TO PIPE AFTER ALL STRESS RELIEVING HAS BEEN PERFORMED
44'-6" TO VERTICAL ℄ SPHERE
TO EQUATOR
"C-C"
DRAIN
"D-D"
DRAINS
℄ VAPOR CONTAINER
BEVEL END FOR WELDING
1"-3000 LB. F.S. SOCKET WELDED COUPLING-ASTM-A 105 GR. II
3" STD. WT. C.S. CAP
1" STD. WT. C.S. CAP
NOTE: SHELL PLATE TO BE STRESS RELIEVED WITH "DR-1" & "DR-3" ASSEMBLIES ATTACHED.





NOTE:-
SCALE - 3/4" = 1'-0" EXCEPT AS NOTED

REFERENCE DRAWINGS:-
FOR VAPOR CONTAINER, SEE DWG. NO. 9699-FV-1A
FOR DETAILS OF VAPOR CONTAINER PIPING PENETRATIONS - SH.1, SEE DWG. NO. 9699-FV-1X

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER NO.
COMMONWEALTH OF MASSACHUSETTS

SUPERSEDES DWG. NOS. 9699-FV-1P, 1Q & 1R

NO.	DESCRIPTION	CHKD.	SUP.	COORD.	APPD.
5					
4					
3					
2	GENERAL REVISION				
1	ORIGINAL ISSUE ISSUED FOR CONSTRUCTION				

DETAILS OF VAPOR CONTAINER
PIPING PENETRATIONS - SH. 2

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FV-1Y

manhole cover may be removed to provide access to the interior of the vessel if the normal door closures should fail to function. This auxiliary manhole is not opened unless the primary plant has been depresurrized.

The personnel access opening is reached by a 4,000 lb combined passenger and freight elevator and by a flight of stairs.

An additional bolted and gasketed manhole is provided in the lower part of the vapor container below the concrete bowl section. This allows access to the space between the concrete bowl and the vapor container shell primarily for construction purposes. No operational use of this manhole is planned.

A 13 ft-11 1/2 in. ID equipment access opening is located in the lower part of the vessel for handling large items of equipment. The equipment hatch is opened only occasionally after initial leak tests and only when the primary plant is depressurized. The opening is provided with a flanged, bolted and gasketed cover which is removed from within by the overhead crane.

All large, heavy equipment, valves and pipe and many of the smaller components are handled by a polar crane inside the vessel. Rotation, traverse and the two 75 ton hoists are motorized.

Electrical Penetrations

Electrical power and control leads throuth the steel vapor container from the primary plant to the control bay of the secondary plant are provided with gastight fittings. Electrical penetrations are made through steel pipe penetrations welded into the vapor container with bolted and gasketed flanged ends. An electrical penetration cartridge with matching flange is drilled and tapped to receive sealing fittings for one or several conductors.

Electrical penetrations are shown on drawing No. 9699-FE-29C.

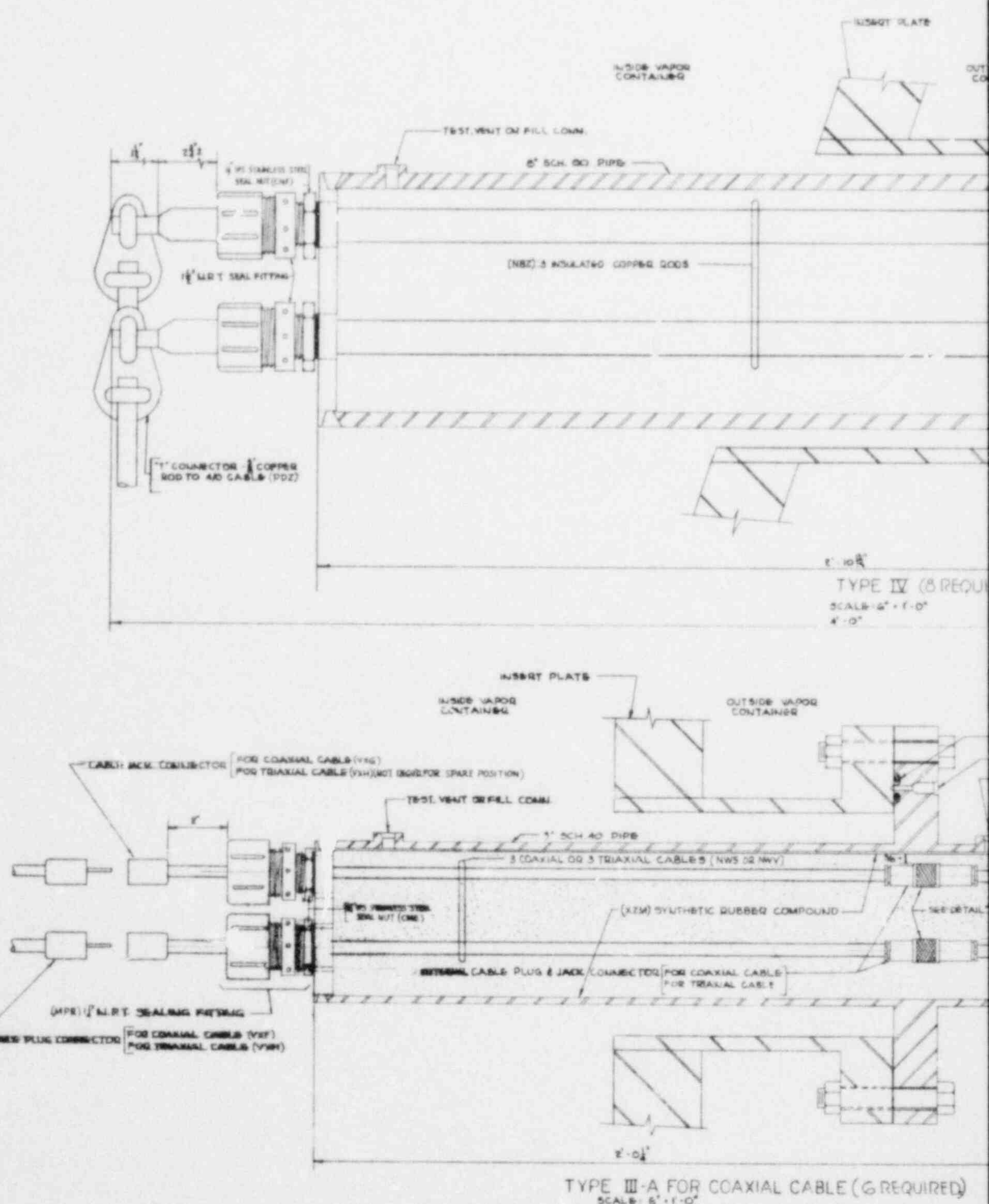
For 2,400 v conductors, a solid copper rod with 5 kv Buna insulation is used for the conductor through the penetration. The solid copper rod serves to stop any leakage through the cable stranding. A Sonolastic (pourable synthetic rubber sealing) compound is used in the seal in addition to the high temperature rubber seal furnished with the gland seal. After completion of the cartridge assembly by shop bench methods, the assembly is cured and tested.

Mineral insulated cable (MI) is used for power and control penetrations under 600 v except for coaxial cables.

A cartridge of similar construction to the 2,400 v cartridge is used, except the gland seal closely fitting the cable is potted with Sonolastic sealing compound.

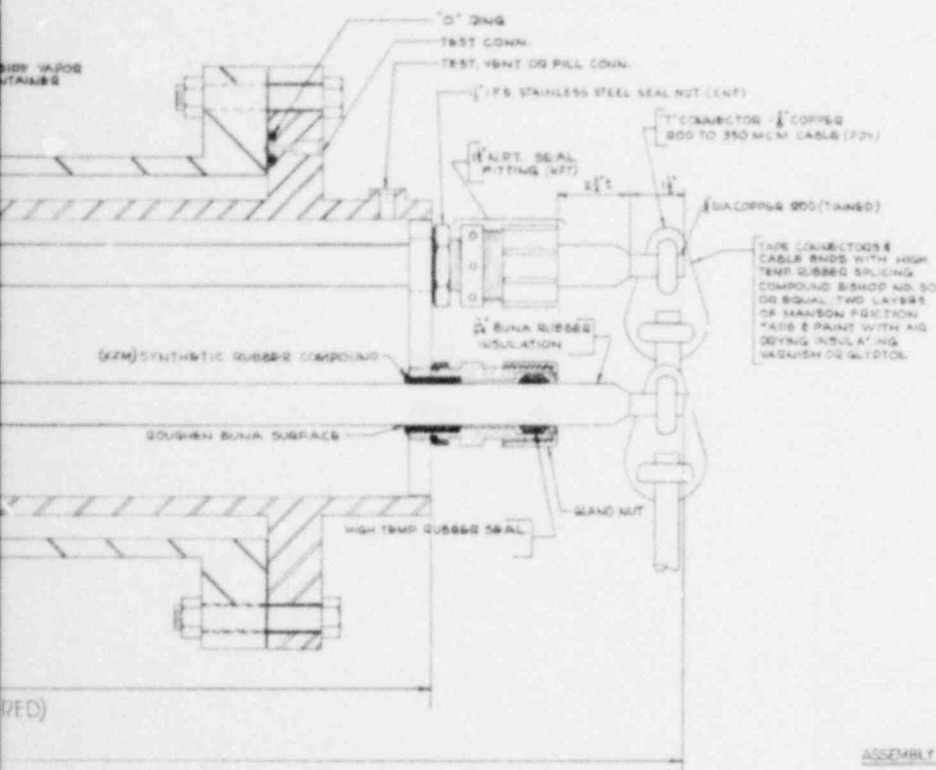
Coaxial cables pass through vapor container penetrations in a cartridge similar to those used for power and control cables, except a solid connector is inserted in the coaxial strands to prevent air passage.

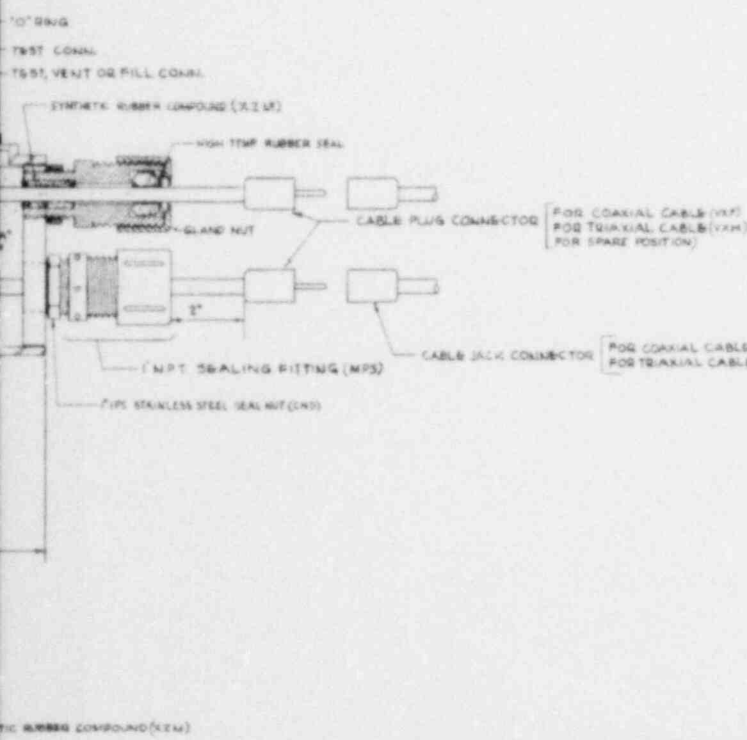
9699-FE-290



TYPE III-A FOR COAXIAL CABLE (6 REQUIRED)
SCALE: 6" = 1'-0"
TYPE III-B FOR TRIAXIAL CABLE (2 REQUIRED)

DETAIL "A"
SCALE: 6" = 1'-0"





BILL OF MATERIAL

ITEM	DESCRIPTION	QUANTITY	REMARKS
MPS	SEAL FITTING 1" NPT & HIGH TEMP RUBBER SEALING BUSHING	24	
MPT	SEAL FITTING BRASS BODY WITH 1½" STAND MALE THREAD & HIGH TEMP COMPRESSIBLE RUBBER SEAL GASKET INSIDE DIA OF RUBBER SEAL GASKET TO BE 1.25" BODY OF FITTING TO BE DRILLED WITH 6 RADIAL HOLES OF PROPER DEPTH & DIA FOR USE WITH PIN SPANNER WRENCH	48	
NBZ	⅝" DIA TINNED COPPER ROD INSULATED WITH 1/16" BUNA RUBBER INSULATION 4'-0" LONG	24	CUT TO LENGTH BY FIELD
NWJ	COAXIAL CABLE-NOISE FREE, POLYETHYLENE INSULATED, COPPER SHIELD VINYL JACKET OD .405" APP	77 FT	
NWY	TRIAXIAL CABLE MILITARY No. RG TRIAXIAL I/O POLYETHYLENE INSULATED COPPER SHIELDS VINYL JACKET OD .490"	24 FT	
PDY	"T" CONNECTOR, SOLDERLESS TYPE FOR ⅝" DIA TINNED COPPER ROD RUN TO 350 MCM 37 STRAND COPPER CABLE TAP	24	
PDZ	"T" CONNECTOR, SOLDERLESS TYPE FOR ⅝" DIA TINNED COPPER ROD RUN TO 4/0 19 STRAND COPPER CABLE TAP	24	
VXP	SERIES "N" COAXIAL CABLE PLUG CONNECTOR FOR 21-487 CABLE	54	
VXG	SERIES "N" COAXIAL CABLE JACK CONNECTOR FOR 21-487 CABLE	54	
VXH	TRIAXIAL CABLE PLUG CONNECTORS FOR RG 1/U TRIAXIAL CABLE (AMPHENOL 21-579)	14	
VXJ	TRIAXIAL CABLE JACK CONNECTOR WITH JACK ASSEMBLY TO MATCH ABOVE PLUG CONNECTOR	14	
XZM	HIGH TEMP POURABLE SYNTHETIC RUBBER SEALING COMPOUND	16 GAL	[illegible]
CNG	1" IPS STAINLESS STEEL SEAL NUT	24	
CNF	1½" IPS STAINLESS STEEL SEAL NUT	48	
CNE	1¼" IPS STAINLESS STEEL SEAL NUT	24	
MPR	SEAL FITTING 1¼" NPT & HIGH TEMP RUBBER SEAL BUSHING	24	

ASSEMBLY INSTRUCTIONS FOR TYPE IV ELECTRICAL CARTRIDGE WIRING

1. WITHDRAW CARTRIDGE FROM BLISTER & REMOVE PLUGS (SEE TO 9699-FE-29D).
2. CUT INSULATED COPPER ROD TO PROPER LENGTH. REMOVE 1⅞" OF BUNA RUBBER INSULATION AT EACH END OF ROD. ROUGHEN & PENCIL INSULATION AS PER DWG.
3. INSTALL "TRUE SEAL" FITTING ON "OUTSIDE END" SEAL FITTING. SLIDE THIS ASSEMBLY ONTO INSULATED COPPER ROD TO ITS [illegible] POSITION. TIGHTEN GLAND NUT TO 15 FT-LBS. TORQUE. HANG COPPER ROD IN VERTICAL POSITION WITH SEAL FITTING TOWARD BOTTOM. FILL BASE OF SEAL FITTING WITH SYNTHETIC RUBBER COMPOUND AND ALLOW TO SET UNTIL THOROUGHLY CURED (HEATING TO 100°F. MAXIMUM MAY BE APPLIED TO ACCELERATE CURING)
4. INSERT ABOVE ASSEMBLY INTO CARTRIDGE FROM "OUTSIDE END". TIGHTEN ALL THREADED CONNECTIONS TO 35 FT-LB. TORQUE.
5. INSTALL STAINLESS STEEL SEAL NUT ON "INSIDE END" SEAL FITTING. SLIDE THIS ASSEMBLY ONTO INSULATED COPPER ROD. TIGHTEN SEAL FITTING BODY IN CARTRIDGE END PLATE THREADED HOLE. TIGHTEN GLAND NUT TO 15 FT-LB TORQUE & THEN TIGHTEN STAINLESS STEEL SEAL NUT TO 35 FT-LB. TORQUE.
6. TEST FOR LEAKS WITH HALOGEN LEAK DETECTOR (SEE DESCRIPTION LEAK TESTS)
7. RETURN CARTRIDGE TO ORIGINAL POSITION IN BLISTER & BOLT.
8. TEST FOR FLANGE LEAKAGE (SEE DESCRIPTION LEAK TESTS)
9. ATTACH "T" CONNECTORS TO COPPER RODS.
10. ATTACH APPROPRIATE CABLES TO "T" CONNECTORS.

ASSEMBLY INSTRUCTIONS FOR TYPE III A & III B ELECTRICAL CARTRIDGE WIRING

1. WITHDRAW CARTRIDGE FROM BLISTER & REMOVE PLUGS (SEE TO 9699-FE-29D)
2. ASSEMBLE COAXIAL CABLE AND INTERNAL CABLE PLUG & JACK CONNECTOR. FOR TRIAXIAL: ASSEMBLE TRIAXIAL CABLE AND INTERNAL CABLE PLUG & JACK CONNECTOR WITH SYNTHETIC RUBBER COMPOUND (XZM) IN SPACE BETWEEN PLUG & JACK. ALLOW TO SET UNTIL THOROUGHLY CURED.
3. INSERT ABOVE ASSEMBLY INTO CARTRIDGE FROM "INSIDE END" AND TIGHTEN THREADED CONNECTION TO 35 FT-LB. TORQUE.
4. PUT TRUE SEAL FITTING ON "OUTSIDE END" SEALING FITTING. PUT STAINLESS STEEL SEAL NUT ON "INSIDE END" SEALING FITTING.
5. SLIDE "OUTSIDE END" AND "INSIDE END" SEALING FITTINGS ONTO CABLE AND THEN TIGHTEN GLAND NUTS TO 15 FT-LB TORQUE. TIGHTEN THREADED CONNECTION TO 35 FT-LB TORQUE.
6. ATTACH CABLE JACK AND CABLE PLUG CONNECTORS TO CABLE PER DWG.
7. FILL CARTRIDGE WITH SYNTHETIC RUBBER COMPOUND TO COMPLETELY COVER PLUG & JACK CONNECTORS AND ALLOW TO SET UNTIL THOROUGHLY CURED. (HEATING MAY BE APPLIED TO 100°F MAXIMUM TO ACCELERATE CURING.)
8. TEST FOR LEAKS WITH HALOGEN LEAK DETECTOR (SEE DESCRIPTION LEAK TESTS)
9. RETURN CARTRIDGE TO ORIGINAL POSITION IN BLISTER & BOLT.
10. TEST FOR FLANGE LEAKAGE (SEE DESCRIPTION LEAK TESTS)

APPROVED *Edward I. Witt*
REGISTERED PROFESSIONAL ENGINEER NO. 1[illegible]
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	INSP.	COORD.	APPR.
5					
4					
3					
2	REVISED B/M, ASSEMBLY INSTRUCTIONS & ADDED DETAIL "A" MINOR CHANGES	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

ELECTRICAL PENETRATIONS - SH. 3

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FE-29C

Thermocouple cables are magnesium oxide insulated with an overall cold drawn steel sheath. A gland seal with metallic seal ring and potting compound around the cable is tapped into the end flanges of the electrical cartridge similar to the 600 v type of fitting.

Internal Structure

Associated with the outer steel vapor container is an inner reinforced concrete structure which supports the main coolant loop equipment, attenuates radiation from the main coolant loop to a tolerable level outside the vapor container, and acts as a stop for objects possessing kinetic energy.

The pressurized equipment within the vapor container is surrounded by a reinforced concrete cylinder, the bottom of which approximates a segment of a sphere. Concrete wall thickness is 4.5 to 6 ft. Ordinary concrete is used having a density of 150 lb per cu ft, except for a small area around the fuel discharge chute where concrete having a density of 225 lb per cu ft is required because of the limited space available.

The concrete structure is supported on eight steel encased concrete columns which penetrate the spherical container. These penetrations are sealed with stainless steel expansion joints. The joints are welded and completely sealed to the steel shells of the concrete column. The column shells are seal welded to the column base plates. They were built and tested as parts of the steel shell of the vapor container before being filled with concrete. This construction permits the spherical vessel and the internal concrete structure to make small movements independent of each other when temperature changes occur.

The concrete cylinder is separated into compartments by concrete walls, one for each loop and one for the pressurizer, to facilitate access to individual units at times of high activity level as well as to minimize the extent of a disturbance. The access opening is segregated by battered concrete walls.

The operating compartments are covered by a 3 ft thick charging floor, with removable slab covers to provide crane access to equipment in the main coolant loops below. Spiral stairs provide the principal access from the charging to the operating level and minor stairs and ladders give access to other levels.

Design Features

The vapor container is designed, built and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII (Unfired Pressure Vessels), and Code Case No. 1226, and the code stamp is applied. The vapor container is not provided with a relief valve, in accordance with special ruling, Case No. 1235, which states:

> "It is the opinion of the Committee that, since it is intended that these vessels be designed and built to safely contain all the lethal radioactive substances that may be released in case of a maximum credible accident affecting the reactor vessel or primary coolant circuit or both, and because of the hazardous character of the materials, which might be released, pressure relief devices are not required."

The stress permitted by the Code in the specified plate is 15,000 psi. The Code further specifies that the design stress shall be reduced by a factor of 0.9 when employing welded seams with 100% radiographic inspection. The resulting design stress is 13,500 psi.

The design pressure of the vapor container is 31.5 psi gage, corresponding to a membrane stress of 13,500 psi in a 125 ft diam sphere with a minimum plate thickness of 7/8 in.

The calculated internal pressure in the event of a major loss of water accident is 33.8 psi gage, which is called 34.5 psi gage for design purposes. This latter pressure includes the 10% overpressure permitted by the Code under paragraph UG-125(c), which states "All unfired pressure vessels other than unfired steam boilers shall be protected by pressure relieving devices that will prevent the pressure from rising more than 10% above the maximum allowable working pressure, except when the excess pressure is caused by exposure to fire or other unexpected source of heat." A 10% increase in the design pressure of 31.5 psi gage results in an allowable pressure of 34.5 psi gage which corresponds to the internal pressure developed in a major loss of water accident.

The plate material is ASTM Specification A-300, Class A-201, Grade B, firebox quality, a carbon-silicon steel of suitable quality for forming and welding in pressure vessel service. The tensile strength is 60,000-72,000 psi with a minimum yield point of 32,000 psi. The atmospheric temperature outside the uninsulated sphere occasionally approaches -25 F, so that the shell metal temperatures may be close to the freezing point during operation. Specification A-300 material is employed for its superior impact value at low temperature, equivalent to 15 ft-lb at -50 F.

All penetrations of the sphere are reinforced to the full strength value of the metal removed. All shell seams are completely radiographed, as well as all welds in the penetrations wherever possible. All welds not amenable to radiographic examination are subjected to a magnetic particle inspection at every pass.

All high temperature piping entering or leaving the spherical shell is isolated from the shell by means of a steel thermal sleeve which connects the pipe and shell. The space between the pipe and sleeve is filled with heat insulation. These expansion joints eliminate the necessity of heavily reinforcing the spherical shell to contain the forces and moments resulting from pipe expansions.

The internal concrete structure consists of two concentric cylinders of 3,000 psi compressive strength reinforced concrete. These cylinders are tied together with six reinforced concrete radial walls so located as to provide an isolation compartment for each main coolant loop, for the pressurizer, and for an access way from the equipment hatch into the structure. The compartment radial concrete walls have several ports to limit the differential pressure across the concrete walls to a value of 6 psi at the time of a major loss of coolant accident. The battered concrete walls at the equipment access opening are designed for 8 psi.

The inner concrete wall serves as the support for the reactor vessel, the water-filled neutron shield tank surrounding the reactor vessel, and as a shield tank cavity above the vessel. The shield tank cavity, which is water-filled when handling fuel, is lined with a stainless steel membrane to assure complete watertightness.

When not otherwise metal covered, the surface of the concrete is protected with a smooth, hard finish paint to prevent absorption of contaminated vapor and to assist in decontamination.

Vapor Container Tests

After the vapor container has been erected and all welding, radiographing, and magna-fluxing have been completed, including manhole closures and shell penetrations, the vapor container is completely closed and subjected to field acceptance tests, including air pressure tests and a leakage rate test.

Air Pressure Tests - The vessel is air pressured to 5 psi gage and all welded seams given a bubble test to determine gross leakage. After all indicated leaks have been repaired by depressuring and chipping out and rewelding, the vessel is then air pressured by first slowly raising the pressure to 20 psi gage and then increasing the pressure by 4 psi increments until 40 psi gage is reached and held at this pressure for a minimum of 1 hr in the manner prescribed by the ASME Code for Unfired Pressure Vessels. The vessel is bubble tested again after reducing the pressure to 31.5 psi gage. At this time, the gasketed joints at both the equipment and the personnel access hatches are also bubble tested. In the event that any leaks are discovered, the vessel is depressured, the leaks repaired, and the bubble test repeated, except that a soapsuds test is made of the repaired area only.

Air Leakage Rate Test - See O.I. No. 504Q, VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS.

Final evaluation of the vapor container is based on a leakage rate test. The vapor container is pressurized with air to 15 psi gage, and the leakage is recorded over a period of several days. The test pressure corresponds to the average pressure anticipated within the vapor container during a 24 hr period following a major loss of coolant accident.

The leakage measuring system consists of two duplicate sets of tubing running throughout the vapor container with taps at each of 11 representative locations. The taps on one tubing run are left open to the vapor container atmosphere, and the taps on the other tubing run each terminate in a large bulb of brass pipe capped. This latter tubing system consists of a completely closed arrangement within the vapor container which is leak tested and made absolutely tight. The entire vapor container is pressured to 15 psi gage, and the pressure is equalized between the closed tubing system and the vapor container. The closed tubing system is then valved off from the vapor container and from the open system, and the pressures in the two tubing systems will follow one another, regardless of temperature change. Any leak in the vapor container shell will be evidenced by a difference in pressure between the two systems. A standard gas meter is used to meter the air required to equalize the two pressures. The volume of air thus measured by this gas meter and required to bring the differential pressure between the two pressure measuring systems to zero is the amount of leakage. The closed tubing system acts to compensate for temperature change directly and allows the test to be run at any pressure, and the sensitivity in standard cubic feet or air loss is constant.

If the leakage rate should be less than 0.1 wt % of the contained air during any 24 hr interval, corresponding to 70 cu ft per hr (STP), the vapor container is considered to be essentially leak-tight.

Freon Leak Test (Optional) - The preliminary Hazards Summary Report included a Freon leak test as a regular vapor container tightness test. Due to the advances in vapor container leakage testing since, this test is retained on an optional basis only.

If the vessel should fail to meet the requirements of the air leakage rate test, a Freon gas test may be used to determine the areas of leakage. This test is performed as follows:

> After injecting Freon-12 to a 1% by volume concentration, the vessel is then air pressured to 15 psi gage. All the welded seams, penetration welded joints and gasketed closures of the vessel are then hand-probed from the outside at a rate of 0.5 ips, with a halogen type leak detector device. When leakage in exce. of about .00012 cu ft per hr of air occurs, which is equivalent to about 5 oz per year of Freon-12, an audible alarm sounds, indicating a leak within the sensitivity of the instrument. Any such leaks detected are repaired and the area tested again.

Final Air Leakage Rate Test (Optional) - If the vessel fails to meet the requirements of the air leakage rate test, and resort is made to supplementary Freon leak test, subsequent to repair, a final air leakage rate test is performed.

Leakage Indication During Operation - See O.I. No. 504Q, VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS.

In order to evaluate quantitatively the leakage rate from the vapor container during operation and to guard against the chance for gross leakage through improper closure after opening the vapor container, the vessel will be monitored by the same system described under air leakage rate test. Any leakage will be determined by the metered quantity of air which must be admitted to permit equalizing the pressure between the closed and open pressure measuring system.

Leakage Tests On Electrical Penetrations - Tests on prototype electrical penetrations have been conducted to ensure their integrity during thermal excursions from -40 F to 250 F.

232 RADIATION SHIELDING

General

The radiation shielding is divided into five categories according to function: the neutron shield tank, the primary shield, the secondary shield, the fuel handling shield, and auxiliary shielding. The arrangement of shielding is shown on drawings Nos. 9699-FM-1A and 1C which is included in Section 231.

The shielding thicknesses are designed for full rated reactor heat output of 485 mw. The basis for the various shield thicknesses is determined by the expected time of exposure and the source strength of the shielded component. At working stations, during full power operation, 0.75 mr per hr is the dose criterion. For intermittently manned ground level areas during full power operation a maximum dose of 2 mr per hr has been established. During refueling operations the average dose rate is 2 mr per hr, with instantaneous dose rates of 16 mr per hr during spent fuel transit through the fuel chute. The dose rate criteria in the control room during release of volatile fission products into the vapor container which would follow the hypothetical accident according to Section 403, HAZARDS FROM REACTOR ACCIDENTS are less than 1 r in the first hour and less than 10 r in the first 24 hr.

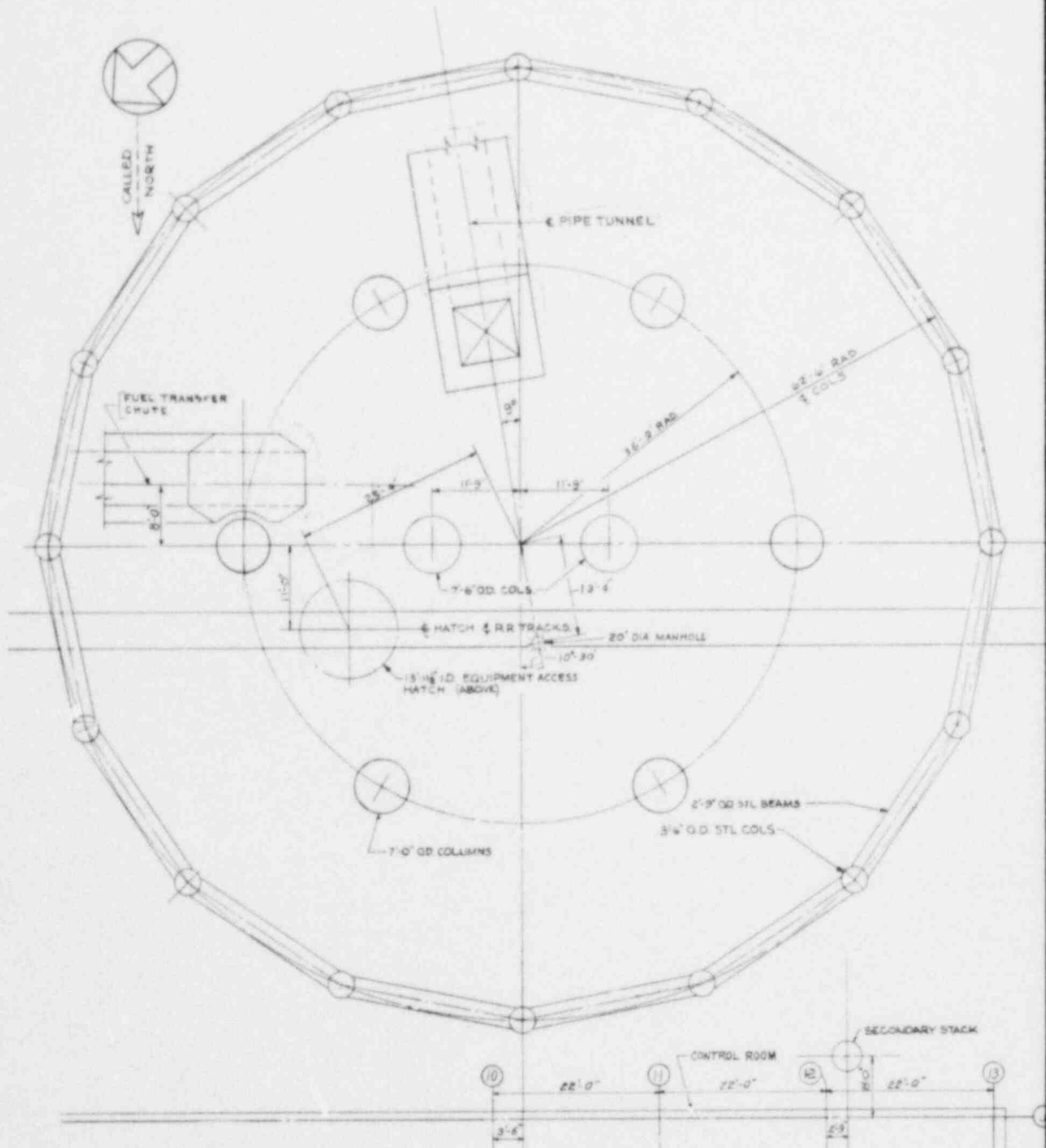
Neutron Shield Tank

The neutron shield tank is an annular, water-filled tank surrounding the reactor vessel in the radial direction. It is designed to prevent neutron activation of the plant components within the vapor container and to prevent overheating or dehydration of the primary concrete shield immediately surrounding it. The annular dimension of the tank is 36 in. The water in the tank will attenuate the neutron flux to approximately 5×10^3 thermal neutrons per cm^2 sec and 1×10^3 fast neutrons per cm^2 sec.

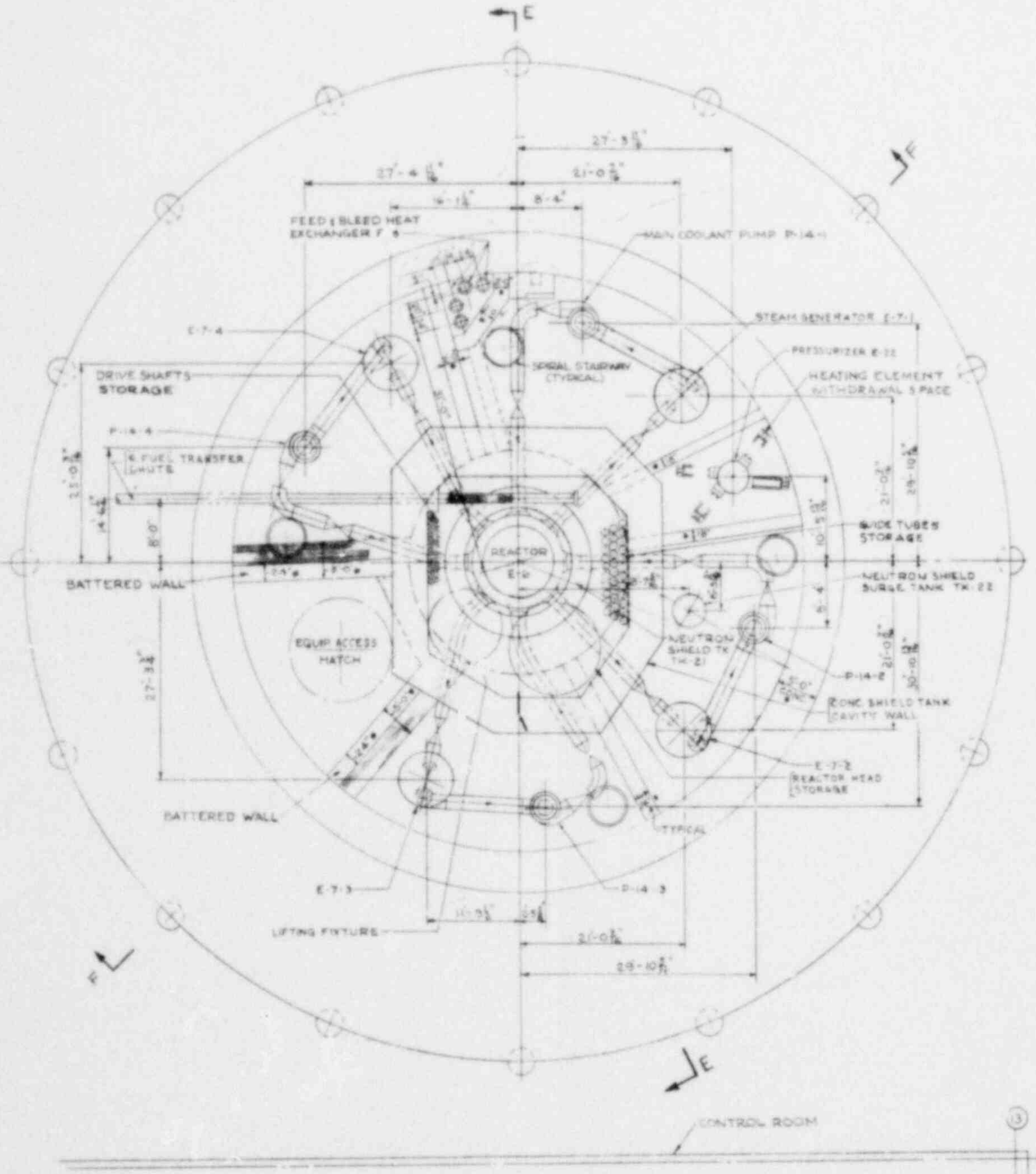
Primary Shield

The primary shield is a reinforced concrete structure immediately adjacent to and surrounding the exterior of the neutron shield tank. This shield, together with the neutron shield tank, serves to attenuate radiation from the core to the level of the radiation emanating from the main coolant system. The bottom portion of the shield is 5 ft. thick and is an integral part of the main structural concrete support for the reactor vessel. The lower cylindrical section is 5 ft thick and extends to a height just below the reactor vessel flange surface. The upper portion is 4.5 ft thick and extends from the top of the lower cylindrical section to the charging floor above the reactor. The upper portion forms the shield tank cavity which is flooded during the refueling operation to shield against radiation during withdrawal of fuel assemblies and control rods. Extra shield thickness is provided in the main structural concrete support near the vapor container equipment hatch to compensate for the opening which the hatch necessitates.

9699-FM-1A



PLAN "A-A"



PLAN 'B-B'

SCALE 1/8"=1'-0"

NOTES:
* MINIMUM THICKNESS REQUIRED FOR SHIELDING
FOR ACTUAL WALL THICKNESS SEE CONCRETE
DWGS 9699-FC-56A & FC-56B.

REFERENCES
MACHINE LOCATION - PLANS SH NO 2 VAPOR CONTAINER DWG 9699-FM-1B
MACHINE LOCATION - SECTIONS - VAPOR CONTAINER DWG 9699-FM-1C
PLATFORMS & LADDERS - VAPOR CONTAINER DWG 9699-FM-1H
ARRGT. VAPOR CONTAINER CHARGING FLOOR
DISMANTLING & LAY DOWN AREA - SH 1 DWG 9699-FM-1L

APPROVED Walter C. Woodman
REGISTERED PROFESSIONAL ENGINEER NO. 787
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5	FUEL TRANSFER CHUTE, PIPE TUNNEL DIMENSIONS & REFERENCE DWG ADDED, EQUIPMENT RELOCATED, MANHOLE ADDED	[illegible]	[illegible]	[illegible]	[illegible]
4	FEED & BLEED HEAT EXCHANGER REVISED, DWG ADDED & REMOVED, HOLD REMOVED, UP ENDER REMOVED, MINOR CHGS.	[illegible]	[illegible]	[illegible]	[illegible]
3	EQUIPMENT RELOCATED F & B HEAT EXCHANGER & NEUTRON SHIELD SURGE TANK ADDED, UNIT HEATER REMOVED, SHIELDING CHGD.	[illegible]	[illegible]	[illegible]	[illegible]
2	SHIELD TK CAVITY WALLS, MAIN COOLANT PIPING & PRESS. REVISED, CHG'D. FOR [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

MACHINE LOCATION PLANS SH NO. 1
VAPOR CONTAINER

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

SCALE: 1/8"=1'-0"

DRAWING NUMBER 9699-FM-1A

Secondary Shield

The secondary shield surrounds the entire reactor plant within the vapor container and reduces the radiation from the reactor plant to tolerable levels outside the vapor container. The bottom portion of the shield is an integral part of the main structural support for the reactor plant. The lower cylindrical side portion of the shield is 5 ft thick and extends from the main support structure to the charging floor above the reactor vessel. The charging floor above the steam generator compartments also serve as a radiation shield. The upper portion of the cylindrical secondary shield is 2 ft thick and supports the polar crane.

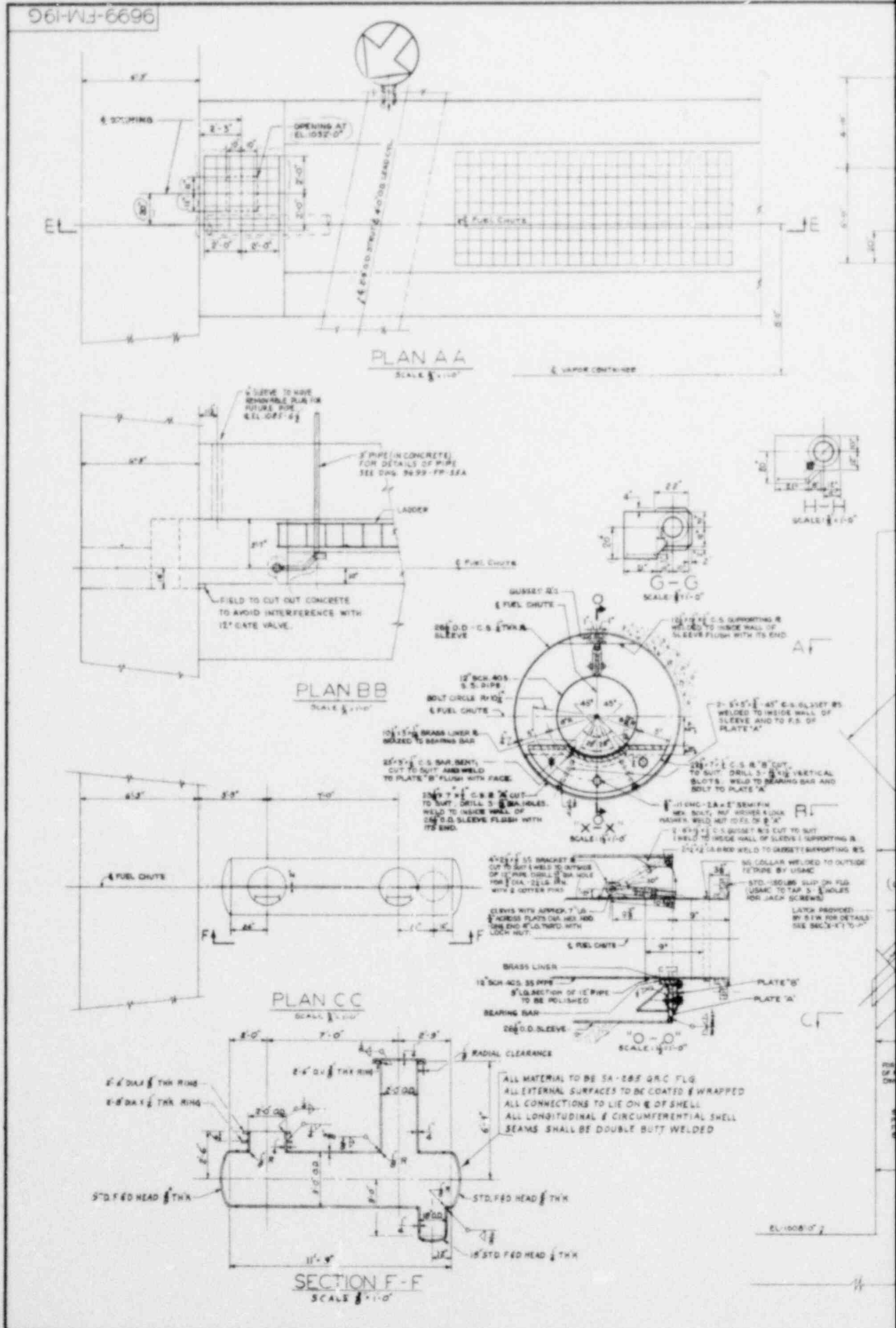
Within the secondary shield, additional shielding is provided between the steam generators, the equipment hatch, and the pressurizer. These shield partitions are designed to reduce radiation from adjacent compartments during shutdown and equipment maintenance. The partitions extend from the main structural support to the charging floor above the compartments. A battered wall on each side of the equipment hatch shields the area outside the vapor container, below the hatch, from radiation emanating from the steam generator compartments on each side of the hatch. Near the base, the battered wall is 5 ft thick and, at the top, the shield thickness is 2 ft. Steam generator compartments are separated by 2 ft thick concrete partitions which extend to the charging floor. These partitions limit the radiation dose in any one compartment to the radiation emanating from equipment in that compartment only. The pressurizer compartment is separated from the steam generator compartments by 1.5 ft of concrete.

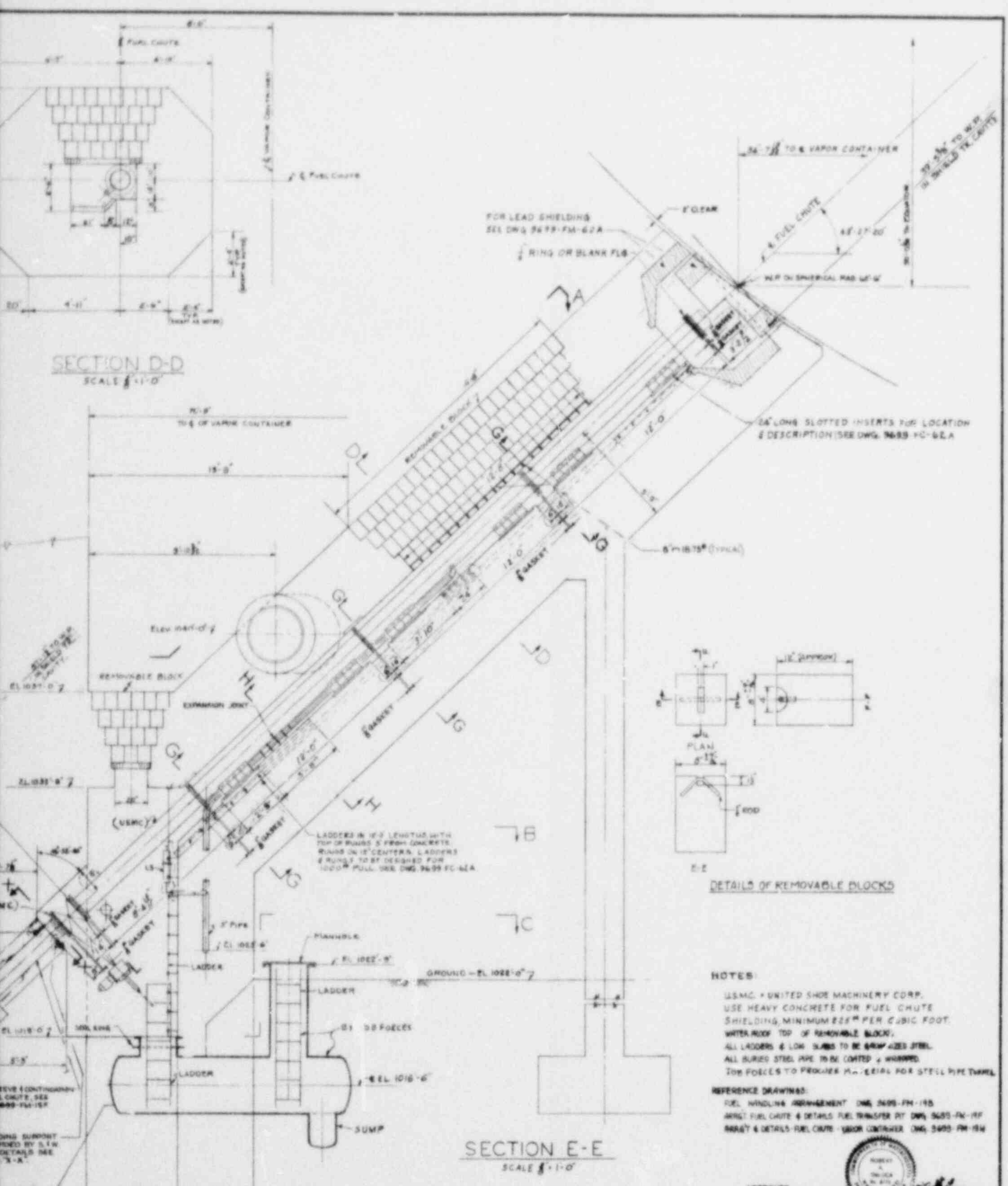
Fuel Handling Shield

The fuel handling shield facilitates the removal and transfer of spent fuel assemblies and control rods from the reactor vessel to the spent fuel transfer pit. It is designed to attenuate radiation from spent fuel, control rods, and reactor vessel internals to tolerable radiation levels. The arrangement is shown on drawing No. 9699-FM-19G.

The shield tank cavity which is formed by the upper portion of the secondary shield is flooded during refueling operations to provide a temporary water shield above the components being withdrawn from the reactor vessel. The water height during refueling is approximately 25 ft above the reactor vessel flange. This height assures that 13 ft of water will be above a withdrawn fuel assembly and 8 ft of water will be above the withdrawn control rod. The spent fuel assemblies and control rods are remotely lowered out of the vapor container through the spent fuel chute and placed in the spent fuel transfer pit. Concrete and lead completely shield the spent fuel chute. The concrete shield is 4 ft of "heavy" concrete. Where space limitations prohibit the use of concrete, 14 in. of lead is used. The shielding is designed to protect personnel from radiation during the time a spent fuel assembly is passing through the main concrete support, the vapor container, and the spent fuel chute.

Since the spent fuel transfer pit is partially above ground, the concrete walls are designed to shield personnel from radiation emanating radially from the spent fuel assemblies and control rods during storage. The


PLAN A A
PLAN BB
PLAN CC
SECTION F-F
G-G
H-H
"X-X"
"O-O"
FUEL CHUTE
LADDER
FIELD TO CUT OUT CONCRETE TO AVOID INTERFERENCE WITH 12" GATE VALVE.
BRASS LINER
BEARING BAR
PLATE "B"
PLATE "A"
RADIAL CLEARANCE
ALL MATERIAL TO BE SA-285 GR.C FLG
ALL EXTERNAL SURFACES TO BE COATED & WRAPPED
ALL CONNECTIONS TO LIE ON ℄ OF SHELL
ALL LONGITUDINAL & CIRCUMFERENTIAL SHELL SEAMS SHALL BE DOUBLE BUTT WELDED
STD. F&D HEAD
VAPOR CONTAINER



NOTES:

USMC = UNITED SHOE MACHINERY CORP.
USE HEAVY CONCRETE FOR FUEL CHUTE SHIELDING, MINIMUM 225# PER CUBIC FOOT.
WATERPROOF TOP OF REMOVABLE BLOCKS.
ALL LADDERS & LOW SLABS TO BE GALVANIZED STEEL.
ALL BURIED STEEL PIPE TO BE COATED & WRAPPED.
TOB FORCES TO PROVIDE MATERIAL FOR STEEL PIPE TUNNEL.

REFERENCE DRAWINGS:

FUEL HANDLING ARRANGEMENT DWG. 9699-FM-19B
ARRG'T FUEL CHUTE & DETAILS FUEL TRANSFER PIT DWG. 9699-FM-19F
ARRG'T & DETAILS-FUEL CHUTE - VAPOR CONTAINER DWG. 9699-FM-19H

APPROVED
REGISTERED PROFESSIONAL ENGINEER
COMMONWEALTH OF MASSACHUSETTS

ISSUE	DESCRIPTION	CHKD.	INSP.	COOR.	APPR.
5					
4					
3	[illegible]	WCB	AMR	[illegible]	GTC
2	DIMENSIONS CHANGED, ADDED & DELETED. INSERTS ADDED. NOTES ADDED & DELETED. HOLD ADDED [illegible]	WCB	AMR	[illegible]	GTC
1	ORIGINAL ISSUE	WCB	AMR	[illegible]	GPC

ARRG'T & DETAILS - FUEL CHUTE - VAPOR CONTAINER TO TRANSFER PIT

POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 9699-FM-19G

sections of the wall which are above grade are 6 ft thick. Water in the spent fuel transfer pit protects personnel who are above the fuel assemblies and control rods during handling operations. The water depth is 35.5 ft above the transfer pit floor which assures that sufficient water will always be above the fuel assemblies and control rods during storage and handling.

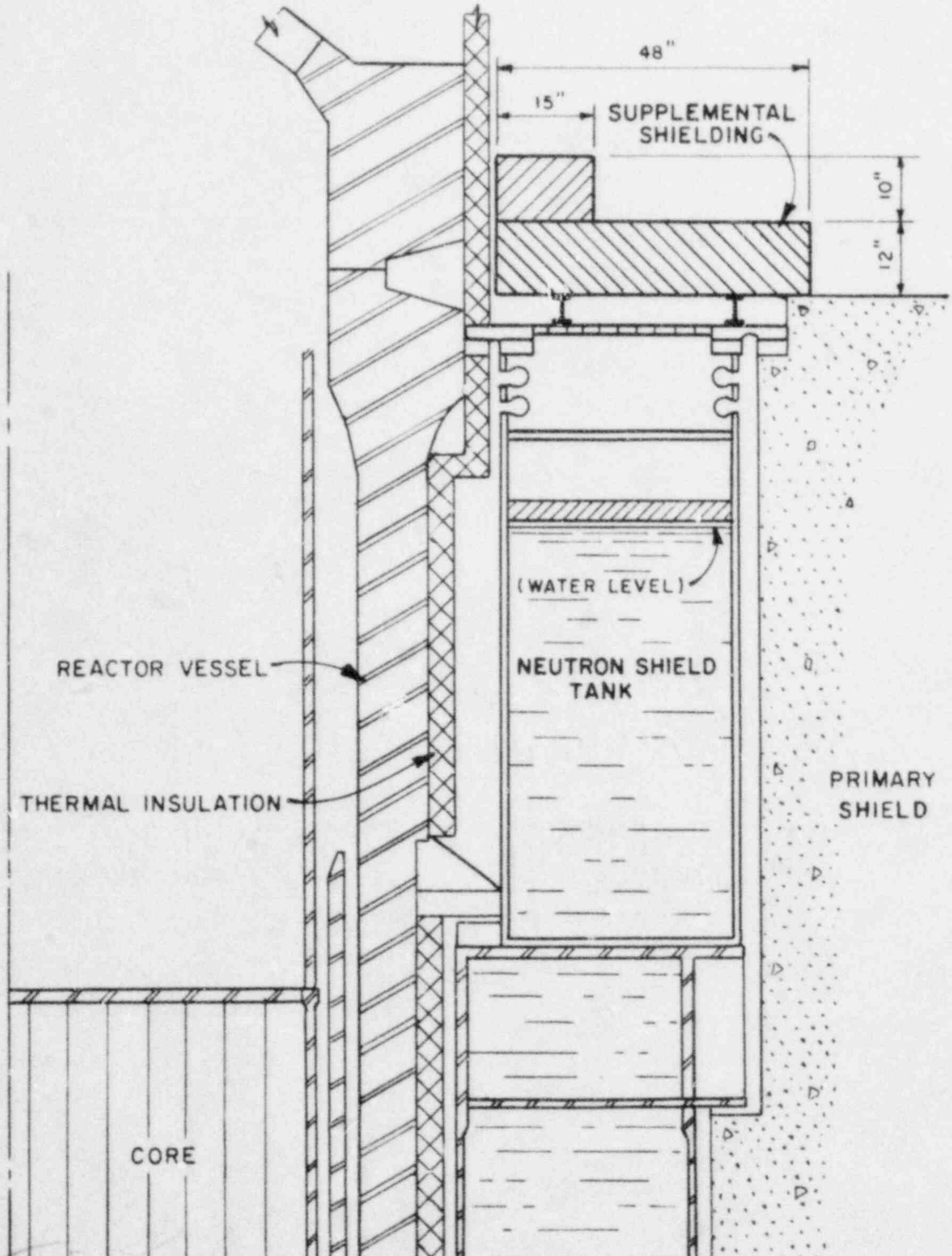
Auxiliary Shielding

Auxiliary shielding is designed to protect personnel in the control room, the sampling room, and in the vicinity of the waste disposal system, the purification system, and the chemical shutdown system. The low activity emanating from the waste disposal system is shielded by fenced exclusion areas. The ion exchangers which operate and are stored in the ion exchanger pit are covered with over 9 ft of water, measured from the top of the capsule. In addition, that portion of the pit which is above ground is shielded by 3 ft of concrete which comprises the walls of the pit. Other auxiliaries, such as the chemical shutdown system, which are housed in the Primary Auxiliary Building, are adequately shielded to protect operating and maintenance personnel from radiation exceeding the maximum tolerance levels. The concrete walls in these buildings vary in thickness depending upon the radiation from nearby equipment. In some cases, the concrete block walls are removable to allow personnel access to equipment during maintenance periods. The control room front wall and roof are concrete, 4 ft in thickness. Under the conditions of the hypothetical accident following a major rupture of the main coolant system and subsequent release of volatile fission products into the vapor container, the shielded control room area allows the operating personnel to shut down the plant without overexposure.

Supplemental Shielding

Supplemental shielding has been installed in order to reduce neutron streaming in an upward direction from the annular space between the reactor vessel and the neutron shield tank to acceptable levels. The location and dimensions of this shielding are shown on Page 232:4.

The shielding material consists of blocks made up of 1/4-inch sheets of tempered masonite. Each block is in the shape of an isosceles trapezoid covering a 15 degree segment extending outward in a radial direction from the reactor vessel. There are three layers of these blocks, each layer shifted laterally from the one below in order to prevent streaming between blocks. The first two layers are 6 inches thick and extend outward from the reactor vessel 48 inches. The third layer is 10 inches thick and extends outward 15 inches. Each block is covered with 20 gauge sheet aluminum so as to be essentially leak-tight to any possible splash or spray from above. The blocks are handled by means of removable eye bolts at the center of gravity.



SUPPLEMENTAL SHIELDING

233 TURBINE GENERATOR

General

The turbine, having a rating of 145,000 kw at 3 1/2 in. Hg abs back pressure with 3% make-up and three stages of extraction heating, operates at 1,800 rpm with steam supplied at 465 psia, 459.6F, and 1/4% moisture. Maximum expected throttle flow for these steam conditions is 2,000,000 lb per hr. The turbine is tandem compound construction with a double flow high pressure element with fifteen stages (1 Rateau and 14 reaction) and a double flow low pressure element having nine reaction type stages and exhausting into a condenser located immediately beneath the turbine and set at right angles to the turbine shaft. Steam is admitted to the turbine through two throttle valves. Each throttle valve discharges to two control valves, one upper and one lower. Steam from each of the two high pressure turbine element outlets discharges through a moisture separator to the low pressure element. The longitudinal section of the turbine is shown on drawing No. 631-J-915.

The generator is rated 160,000 kva, 3 phase, 60 cycles, 18 kv with .95 pf and 30 psi gage hydrogen pressure and has a short circuit ratio of .64 and is directly connected to the turbine. Excitation is from a 400 kw direct connected main exciter.

The turbine generator, in the Secondary Plant Building, has its shaft perpendicular to the radius of the vapor container. It is extremely unlikely that a major accident to the turbine generator, such as an explosion or disintegration of the turbine or generator rotors, could cause release of radioactive material either from the vapor container shell or radioactive piping within the vapor container. The intervening structures, in particular the 3 ft thick concrete shield wall and roof of the control room, are substantial barriers to protect the vapor container. It is unreasonable to assume that such a turbine accident might occur at the same time as a large loss of water accident in the vapor container or that debris from an accident might penetrate the vapor container shell and 5 ft of concrete to damage radioactive piping.

The turbine generator has the usual accessories including a throttle pressure regulator. Governing devices function through hydraulic relays.

Throttle Valves

Each throttle valve is a single seated, oil operated, spring closing valve controlled primarily by the throttle control but also by the turbine overspeed trip device. Each throttle control is provided with a handwheel for manual operation located on the turbine governor end pedestal and a motor operator for remote testing and must be manually reset after operation of the overspeed trip before the throttle valves can be opened. The turbine overspeed trip pilot can be actuated by one of the following to close the throttle valves:

Turbine thrust bearing trip
Low bearing oil pressure trip
Low condenser vacuum
Solenoid trip
Overspeed trip

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Each throttle valve has limit switches which operate valve position lights on the turbine startup panel and the turbine section of the main control board. These limit switches are also in the electrical interlock system to operate the turbine trip auxiliary relay.

Removable strainers are in each throttle valve body to protect the valves and turbine from foreign material in the steam. The pressure drop through each strainer with a total throttle flow of 2,000,000 lb per hr does not exceed 9 psi. Temporary fine mesh strainers should be installed during initial startup and the maximum allowable pressure drop across these strainers is 45 psi at which time the strainers must be removed and cleaned.

Test switches located on a local panel on the mezzanine permit the operator to close each throttle valve and observe the valve operation when the unit is in service to assure the operators that the valves are operable and free to close in an emergency. It is estimated that with main steam pressure of 509 psia, one throttle valve can pass 1,560,000 lb per hr, and that with one valve closed for test, the unit can carry about 125,000 kw. Red and green indicating lights on the turbine startup panel indicate valve position. On the main turbine board a red light indicates that either throttle valve is open, and a green light indicates that both valves are closed.

Control Valves

Four hydraulically operated valves of the single seated plug type open and close in sequence to control steam admission and are actuated by the following devices:

Turbine speed governor, responsive to turbine speed which includes:

- A speed changer or synchronizing device
- A load limit device
- Governing emergency trip valve, actuated when the throttle valves are tripped to close the control valves
- Accelerometer, responsive only to rate of turbine speed increase to close the control valves

Throttle pressure regulator, responsive only to turbine throttle pressure to close the control valves on decrease on steam pressure below the set pressure which varies with turbine load

A solenoid controlled air operated hydraulic pilot valve is provided for each control valve to test the operation of the valve. Test switches with red and green indicating lights for the two upper control valves are on the turbine startup panel and test switches and lights for the two lower control valves are on a local panel on the mezzanine.

Turbine Interstage Moisture Separator

Two moisture separators each 8 ft-6 in. OD by about 21 ft long are in the steam piping between the high pressure turbine exhaust and the low pressure turbine. At maximum turbine load, the moisture of steam entering the separators is estimated at about 10 to 11% and leaving the separators at about 1/4 to 1%. Level switches on the separator drain pots trip the turbine throttle valves and sound an alarm on high water level to prevent the separators from flooding and water from being carried into the low pressure turbine. Connections in the inlet and discharge piping permit sampling to determine the steam moisture content and the efficiency of the separator. In the drain line from each separator is a flanged piece of pipe about 5 ft long, which can be replaced with a flowmeter test section to assist in testing the separator performance.

Turbine Governing Devices

The normal governing devices which operate through hydraulic relays to operate the control valves are as follows:

The governor handwheel at the unit

The governor synchronizing motor which is controlled by a switch on the electrical section of the main control board for raising or lowering turbine speed or load

The load limit handwheel at the unit

The load limit motor which is controlled by a switch on the turbine section of the main control board

The pre-emergency devices which function similarly to the normal governing devices to operate the control valves in case of abnormal operating conditions are the accelerometer which closes the control valves on rapid increase in turbine speed and the throttle pressure regulator which closes the control valves on decrease in throttle steam pressure below a set point that varies with turbine load. The control valves will be actuated by either the speed governor, load limit, or throttle pressure regulator and the device delivering the lowest oil pressure will be in control. Pressure gages are on the turbine startup panel and on the main control board to indicate the oil pressure from these devices.

The emergency devices which will trip the throttle valves, the control valves, and the air relay dump valve are as follows:

Overspeed emergency governor
Solenoid trip
Low condenser vacuum trip
Low bearing oil trip
Thrust bearing trip
Hand trip at unit

Air Relay Dump Valve

A 3-way diaphragm valve is in the steam generator blowdown line to permit the blowdown to go normally to the blowdown flash tank but, on turbine throttle trip, to divert the blowdown to the blowdown tank. An oil operated air pilot valve in the turbine oil tank controls the 3-way valve and is actuated by the turbine overspeed and hand trip.

Lubricating Oil System

The main oil pump which supplies oil to the hydraulic mechanisms and bearings is a centrifugal pump mounted on the turbine shaft. It is supplied with oil at about 30 psi gage from the oil ejectors located in the oil tank. Oil discharging from the main pump at about 325 psi gage is piped back to the oil tank where a portion of it passes through the oil ejectors to supply the main oil pump suction and a pressure reducer to supply oil to the bearing oil system, and the remainder passes through filters to the hydraulic governing control system.

The turbine main auxiliary oil pump driven by a 100 hp motor supplies oil at about 250 psi gage to the hydraulic header and to the main oil pump suction and bearing header through an oil ejector. This pump is used when the turbine is at a standstill or below rated speed. During starting, the main auxiliary oil pump supplies all the oil and the main pump pumps against a closed check valve. As the turbine speed reaches about 1,600 rpm, the main oil pump discharge builds up to a pressure greater than that supplied by the auxiliary oil pump and supplies the oil requirements of the turbine. When the turbine is running at 1,800 rpm and oil pressures are normal, the turbine main auxiliary oil pump may be shut down. The pump motor is controlled by a 440 v air circuit breaker having 125 v d-c control and located in the 440 v station service switchgear. Operation of this circuit breaker is controlled to start the pump manually from a switch on the turbine startup panel. A pressure switch in the turbine bearing oil header automatically starts the pump on decreasing oil pressure of 9 psi gage and below.

The alternating current motor driven turning gear oil pump with 15 hp motor drive supplies oil to the turbine bearings when the unit is on turning gear. The pump discharge pressure is not sufficient to operate the turbine hydraulic control and governing system. The pump motor is controlled by a magnetic starter in motor control center No. 2. This contactor is manually started and stopped by a control switch on the turbine startup panel. A pressure switch in the turbine bearing oil header automatically starts this pump on decreasing oil pressure below 7 lb.

The direct current motor driven emergency bearing oil pump with 15 hp motor drive provides the final backup for the bearing oil system and is supplied with 125 v d-c from the station battery. Operation of the motor is controlled by a locally mounted magnetic starter. Operation of this starter is manually controlled by a start and stop control switch on the turbine startup panel. A pressure switch in the turbine bearing oil header automatically starts the pump on decreasing oil pressure of 3 1/2 psi gage and below.

The following system of controls applies to the three motor driven oil pumps P-37, P-38, and P-39:

> The pumps start automatically but are not arranged to stop automatically when pressure is restored. They will run until manually stopped.
>
> The motor overload protection stops the pumps and annunciates this condition on the main control board.
>
> Red, green, and amber lights on the turbine startup panel indicate pump running, stopped, and overload trip, respectively.

The vapor extractor with 2 hp, 440 v motor located on the turbine oil tank, draws a small amount of air down the drain lines continuously and removes any traces of hydrogen that might tend to pocket in the bearing pedestals or tank. The extractor also serves to ventilate the air space above the oil in the tank and aids in removing any moisture laden air in the oil system. A by-pass line is provided on the extractor from the discharge to the suction to be adjusted to maintain a negative pressure in the oil tank of about 1/2 to 1 in. of water. The vapor extractor motor is controlled by a magnetic starter provided with overload protection and located in motor control center No. 2. Operation of the starter is manually started and stopped by a control switch on the turbine startup panel. Red, green, and amber indicating lights on the turbine startup panel indicate running, stopped, and overload trip, respectively.

Two coolers in the oil tank cool the oil before it is fed to the bearings. It is necessary to use only one cooler at a time and a transfer valve permits switching coolers when the unit is carrying load. Before switching coolers, it is essential to fill the spare cooler with oil to prevent sending a slug of air to the bearings. To fill the spare cooler, the cooler filling valve should be opened and the cooler vent observed. When the vent starts discharging oil, the transfer valve can be turned and the filling valve shut.

Hydrogen Seal Oil System

The seal oil system separates the bearing oil system from the generator hydrogen and removes the hydrogen absorbed by the seal oil by a vacuum treatment.

The main seal oil pump has a 7 1/2 hp motor controlled by a 440 v magnetic starter located in motor control center No. 2 and equipped with overload protection. The starter is controlled by a maintaining contact "Start-Stop" push button located near the seal oil unit. Indicating lights and automatic starting of the pump are not provided.

The emergency seal oil pump has a 7 1/2 hp, 125 v d-c motor controlled by a locally mounted magnetic starter without overload protection. The starter is controlled by a local manually operated "Start-Stop" push button. A differential pressure switch on the seal oil unit automatically starts the pump. Once the pump is automatically started, it runs until manually stopped. Automatic starting of the pump is not annunciated in the control room, but a red light on the hydrogen control board indicates when the pump is running.

A backup oil supply to the seal oil system is provided from the turbine high pressure hydraulic oil system.

The seal oil vacuum pump has a 3 hp motor controlled by a 400 v magnetic starter located in motor control center No. 2 and equipped with overload protection. The starter is controlled by a maintaining contact "Start-Stop" push button located near the seal oil unit. Indicating lights and automatic starting of the pump are not provided.

To provide additional protection against contamination of the bearing oil by hydrogen, a loop seal is provided in the generator bearing drain line. A vapor extractor with 1 hp, 440 v motor removes the hydrogen released in the loop seal. The extractor motor is controlled by a magnetic starter with overload protection in motor control center No. 2. Operation of the starter is manually started and stopped by a control switch on the turbine startup panel. Red, green, and amber lights on this panel indicate running, stopped, and overload trip, respectively.

Turbine Turning Gear Drive

The 30 hp, 440 v turbine turning gear motor is controlled by a magnetic starter in motor control center No. 2. This starter is operated manually by a "Start-Stop" push button on the turbine casing. A pressure switch in the turbine bearing oil header prevents operation of the turning gear with bearing oil pressure below 4 1/2 psi gage. An ammeter located at the turbine indicates turning gear load.

Turbine Shaft Sealing System

An oil operated steam seal regulator controls the flow of steam to and from the turbine shaft seals, admits main steam to the seal header, or dumps steam from the header to maintain constant header pressure of about 4 psi gage.

Leakage of sealing steam along the shaft at each seal is carried away by the gland exhauster system consisting of two blowers with 2 hp, 440 v motors, one a spare and the shell and tube heat exchanger or the gland steam condenser. This system maintains a vacuum of about 4 in. of water on the shaft seal steam leak-off header and, therefore, it insures that steam does not leak into the room from the packings. The low pressure steam leak-offs from the turbine throttle and control valves are also connected to this exhaust system.

The 2 hp blower motors are controlled by magnetic starters provided with overload protection and located in motor control center No. 2. The starters are manually operated by a "Start-Stop" switch on the turbine startup panel. Red, green, and amber indicating lights on the turbine startup panel indicate running, stopped, and overload trip, respectively.

Hydrogen and CO_2 Systems

The hydrogen storage and a four-bottle supply manifold for the turbine generator, together with the hydrogen and inert gas manifolds serving the rest of the plant, are in an extension to the west end of the primary auxiliary buildings. From the storage area hydrogen is supplied at about 60-100 psi gage to a pressure reducing station located beneath the generator on the ground floor and designed to maintain generator hydrogen pressure at a preset value between 1/2 and 30 psi gage. A manual by-pass around the PRV permits rapid filling of the generator.

The hydrogen control cabinet and a four-bottle CO_2 supply manifold are also on the ground floor beneath the generator.

Automatic Tripping of the Unit and Electrical Interlocks

The manual and automatic tripping of the unit under various emergency conditions is arranged as follows:

Operation of the generator overcurrent, differential and loss of field, No. 1 station service transformer differential and overcurrent and No. 4 station service transformer overcurrent relays automatically initiate the following actions:

Trip 115 kv oil circuit breakers Nos. Y-177 and Z-126.

Trip No. 1 station service transformer air circuit breaker No. 124.

Trip No. 4 station service transformer air circuit breaker No. 448.

Trip generator field.

Annunciate on main control board.

Actuate turbine throttle valve solenoid trip.

Scram the reactor if turbine load is above 15 mw.

Operation of the unit differential relays initiates the following actions:

Trips 115 kv oil circuit breakers Nos. Y-177 and Z-126.

Trips No. 1 station service transformer air circuit breaker No. 124.

Trips No. 4 station service transformer air circuit breaker No. 448.

Trips generator field.

Actuates turbine throttle valve solenoid trip.

Annunciates on main control board.

Trips main transformer No. 1 oil pumps.

Scrams the reactor if turbine load is above 15 mw.

A turbine throttle valve trip will automatically open the 115 kv oil circuit breakers Nos. 1 and 2.

A turbine throttle valve trip will automatically scram the reactor if turbine load is above 15 mw.

If turbine load is below 15 mw as in startup or is reduced to less than 15 mw and continues below 15 mw for a preset adjustable time 0-10 sec, tripping the turbine throttle valves will not scram the reactor. A relay with a time delay drop-out characteristic variable from 0-10 sec is employed to insure scramming of the reactor when the turbine generator is tripped at a load above 15 mw due to an electrical fault or mechanical trouble.

High water level in the turbine moisture separators will actuate the turbine solenoid trip.

High pressure in the vapor container will actuate the turbine solenoid trip.

Whenever the nuclear reactor is scrammed, the turbine throttle valves are tripped automatically within 2 sec.

234 CONDENSER

The main condenser condenses steam from the turbine generator low pressure element exhausts. It also receives the discharge from the turbine steam by-pass line to condense steam produced by the steam generators which is not used by the turbine generator as during startup, shutdown, and any transient plant operating conditions.

The condenser is single pass with a total tube surface of 85,000 sq ft consisting of 12,495, 7/8 in. OD, No. 18 BWG admiralty metal tubes, 30 ft overall length expanded into both tube sheets. A stainless steel expansion joint in the condenser neck is welded to the turbine exhaust and the condenser is grouted to the ground floor, El. 1,022'-8" with 2 in. of grout. From an economic evaluation in which were considered initial costs, condenser performance, and turbine capability, with both pond water and possible future cooling tower operation as the circulating water for the condenser, an 85,000 sq ft single pass surface condenser was selected as the optimum size.

The condenser hot well is of the deaerating type capable of reducing the oxygen content in the condensate to less than 0.01 cc per liter because a deaerating feed water heater is not provided in the feed water cycle. All trays, shells or other inaccessible accumulations of condensate inside the condenser are arranged to be self-draining to prevent long time retention of radioactive fluid if the condenser should become contaminated.

The condenser shell or hot well is equipped with nozzles having internal impingement baffles, serrated weirs or perforated spray baffles as required for the return of miscellaneous drips and drains. Included in these drains are those for feed water heater drains and vents, heater drain and boiler feed pump recirculation lines, condensate recirculation for the gland steam leak-off condenser and air ejector unit, steam line drains and condensate make-up.

A special connection on the condenser shell is designed to take steam from the turbine steam by-pass line without objectionable noise or damage to the condenser tubes. The steam by-pass control system has capacities of 100,000, 100,000, and 23,000 lb per hr with main steam line pressure of 990, 475, and 97 psia, respectively.

The condenser vacuum is produced and maintained by a twin element 2-stage air ejector unit with inter and after condenser, a main priming jet, and an auxiliary priming jet. Each pair of jets of the air ejector unit is designed for steam pressures of 300 psi gage and above, has a capacity of 12.5 cfm equivalent free dry air with an inlet pressure of 1 in. Hg abs, and, depending on air leakage, is capable of reducing condenser pressure to 1 in. Hg abs. The drains from the intercondenser and aftercondenser return to the condenser through a loop seal and drainer, respectively. A flowmeter in the by-pass of the air ejector unit discharge indicates air leakage to the condenser.

The main priming jet is designed for steam pressures of 300 psi gage and above, has a capacity of 4,050 lb per hr of 70 F free air with inlet pressure of 15 in. Hg abs, and, depending on the air leakage, may reduce condenser pressure to about 2 in. Hg abs. The auxiliary priming jet is designed for steam pressure of 60 psi gage and above, has a capacity of 340 lb per hr of 70 F free dry air with inlet pressure of 14 in. Hg abs, and, depending on air leakage, may maintain with reasonable steam consumption a minimum condenser pressure of 3-4 in. Hg abs during plant startup and also when the reactor is being shut down and the turbine steam by-pass line is in operation.

235 ARCHITECTURAL AND STRUCTURAL FEATURES

Foundations

Foundations are reinforced concrete, resting on soil consisting of fine sands and gravel, with many cobbles and boulders. The maximum bearing value on the soil allowed in the design is 4 tons per sq ft, with some reduction for shallow or small footings. All the principal foundations rest on undisturbed soil. Where frost may occur in the ground, as in the case of all footings for exterior walls and detached structures, all foundations have been carried down to a minimum of 5 ft below the finished yard grade. For general purpose building foundations, concrete with an ultimate strength of 2,500 psi has been used. For the foundations of the vapor container, reactor enclosure, turbine support, and other important structures, 3,000 psi concrete has been used.

Structural Steel

Structural steel conforms to the Specifications for Structural Steel for Bridges, ASTM A7. The structural framing has been designed, fabricated, and erected in accordance with the standard specifications and codes of the American Institute of Steel Construction and the American Welding Society. In general, the structural framing is shop riveted and has been erected in the field with high strength bolts in lieu of rivets.

Building Walls, Floors and Roof Construction

The exterior walls of the upper part of Turbine Building are faced with insulated steel siding of "sandwich" construction, consisting of two layers of metal with Fiberglas insulation between. The outer layer of steel siding consists of corrugated metal covered with asphalt-saturated asbestos sheets bonded to the steel with synthetic resin and protected by a plastic coating on the weather side. The inner faces are paneled with galvanized steel. The walls of the Control Room Area adjacent to the turbine room on the side facing the reactor are solid concrete 4 ft thick, constructed thus in order to serve both as building walls and as shielding in case unusual radioactivity should develop. The exterior walls of the lower part of the Turbine Building, Service Building, Auxiliary Equipment Building, Waste Disposal Building, Guardhouse, and Circulating Water Pump House are of hollow concrete block construction with a heavy exterior weather-protection coating of vinyl plastic. The small Office Building attached to the Turbine Building has exterior insulated steel paneled, porcelain enameled curtain walls. Window sash of all buildings is aluminum. Doors are industrial steel or rolling steel curtains as the case may be. Interior partitions are all concrete blocks, ordinarily of the standard hollow type, but made solid where shielding is required. Solid block exterior walls are used in some parts of the Waste Disposal Building to provide shielding. All exterior building walls are designed for the wind loads established by the American Standard Building Code.

The storage vault for new fuel is constructed with a reinforced concrete frame, roof deck, and floor slab. The walls have no windows and are partly reinforced concrete and partly concrete masonry. The single large door is of the type known as "industrial steel" of heavy construction with tubular steel stiles and rails and sheet steel panels. There is a small access door in the large door. Both the large door and the access door are secured with cylinder locks.

Building floors in general are reinforced concrete, both when supported by structural framing and when laid on well-tamped earth fill. Steel decking is used throughout for roof construction, except over the control room where reinforced concrete 4 ft thick is used to provide shielding and over the fuel vault where a solid reinforced concrete roof deck is installed. All roof decks are covered with 20 yr bonded built-up tar and gravel roofing, flashed with lead coated copper.

Building floors and roofs are designed for the following live loads.

Office areas - 2,000 lb concentrated, or	100 psf
Stairways	100 psf
Control room - weight of installed equipment, or	50 psf
Turbine room - weight of dismantled pieces of equipment when laid down in designated areas; in all other areas	200 psf
Laboratories	100 psf
Toilet and locker room	100 psf
Work areas and special equipment areas	As required
Roof snow load	40 psf

Earthquake Considerations

The general area is seismically stable. Reference has been made to "Earthquake History of the United States" by N. [illegible] Heck, Special Publication No. 149, U.S. Department of Commerce, Coast and [illegible]etic Survey and to information obtained from Rev. Daniel Linehan, S.J., Director, Weston Observatory, noted authority in regard to earthquakes. Experience has indicated that damage from earthquakes is at a minimum for structures founded on compact solid soils close to bedrock, as at this site. Normal framed structures and equipment supports having the lateral stability inherent in any proper design will, in general, without special provision, safely withstand an earthquake of light intensity. There is no historical record of any more than light tremors in this area of very infrequent occurrence. Accordingly, no special provisions for seismic design have been made at this plant.