Chapter 10

STEAM AND POWER CONVERSION SYSTEM

TABLE OF CONTENTS

Chapter 10

STEAM AND POWER CONVERSION SYSTEM

TABLE OF CONTENTS (Continued)

Section Page

Chapter 10

STEAM AND POWER CONVERSION SYSTEM

TABLE OF CONTENTS (Continued)

Chapter 10

STEAM AND POWER CONVERSION SYSTEM

LIST OF TABLES

Chapter 10

STEAM AND POWER CONVERSION SYSTEM

LIST OF FIGURES

Chapter 10

STEAM AND POWER CONVERSION SYSTEM

LIST OF FIGURES (Continued)

Chapter 10

STEAM AND POWER CONVERSION SYSTEM

10.1 SUMMARY DESCRIPTION

The steam and power conversion system is designed to produce electrical energy through conversion of a portion of the thermal energy contained in the steam supplied from the reactor, to condense the main turbine exhaust steam, and to return condensate to the reactor as heated feedwater with a major portion of its gaseous dissolved and particulate impurities removed.

The power conversion system uses the Rankine steam cycle with a closed regenerative feedwater heating cycle. It has the capability to accept 105% of the reactor's rated steam flow. Steam leaves the reactor vessel at 1035 psia. Steam enters the turbine at 1000 psia with a 0.30% moisture content. The turbine is a tandem-compound turbine generator having a six-flow exhaust end. Steam is exhausted into a triple pressure condenser designed for a 2.4-in. Hg average backpressure and is condensed with circulating water cooled by mechanical draft cooling towers. Six stages of regenerative feedwater heating are provided, four heated with extraction steam from the low pressure turbines and two from the high pressure turbine. The final design feedwater temperature at normal full load is 421°F.

The major components of the steam and power conversion system are the turbine generator, main condenser, condensate pumps, condensate booster pumps, mechanical vacuum pumps, steam jet air ejectors, turbine gland sealing system (which includes gland seal steam evaporators and condenser), turbine bypass system, condensate filter demineralizers, turbine driven reactor feed pumps, feedwater heaters, and condensate storage facilities. The turbine cycle heat balance for rated and 104.1% maximum calculated power are given in Figures 10.1-1 and 10.1-2. These figures are representative of the overall power conversion system.

The saturated steam produced by the boiling water reactor is passed through the high pressure turbine where the steam is expanded and is then exhausted to two moisture separator/reheaters (two reheat stages) arranged in parallel. The moisture separators remove the moisture content of the steam and superheat the steam before it enters the low pressure turbines where the steam is expanded further.

Steam for the first-stage reheater is taken from the first extraction point of the high pressure turbine while steam for the second-stage reheater is taken from the main steam header. From the low pressure turbines, the steam is exhausted into the main condenser where it is condensed and deaerated. The condensate pumps take suction from the condenser hotwell and deliver the condensate through the gland seal steam condenser, steam-jet air ejector condenser, offgas condenser, and condensate demineralizers to the condensate booster pump suction. The condensate booster pumps then discharge through the low pressure feedwater heater trains to the reactor feedwater pumps. The reactor feedwater pumps supply feedwater through the high pressure feedwater heaters to the reactor. Steam for heating the feedwater in the heating cycle is supplied from turbine extractions. The drains from the feedwater heaters, the reheaters, and the moisture separators are cascaded to the next lower pressure feedwater heater and finally discharged to the condenser.

The ability of the plant to follow system loads depends on the adjustment of the reactor power level. The steam admission valves are controlled by the initial pressure regulator so that the turbine receives the proper amount of steam required for the load demand. The turbine speed governor, however, may override the initial pressure regulator to close the steam admission valves if an increase in system frequency or loss of generator load causes an increase in turbine speed. Reactor steam in excess of that which the admission valves will pass is bypassed directly to the main condenser through pressure controlled bypass valves. Load rejection in excess of bypass capacity causes the reactor safety/relief valves to open.

The main turbine, main condenser, and moisture separator/reheaters are located in a shielded area with controlled access to limit personnel exposure.

The portions of the power conversion system which constitute part of the reactor coolant pressure boundary are the main steam lines extending from the reactor pressure vessel to the outermost containment isolation valve.

Table 3.2-1 indicates the safety class, quality group classification, and seismic category of the power conversion system. Environmental design bases are discussed in Section 3.11.

Table 10.1-1 presents a summary of important design and performance characteristics of the steam and power conversion system.

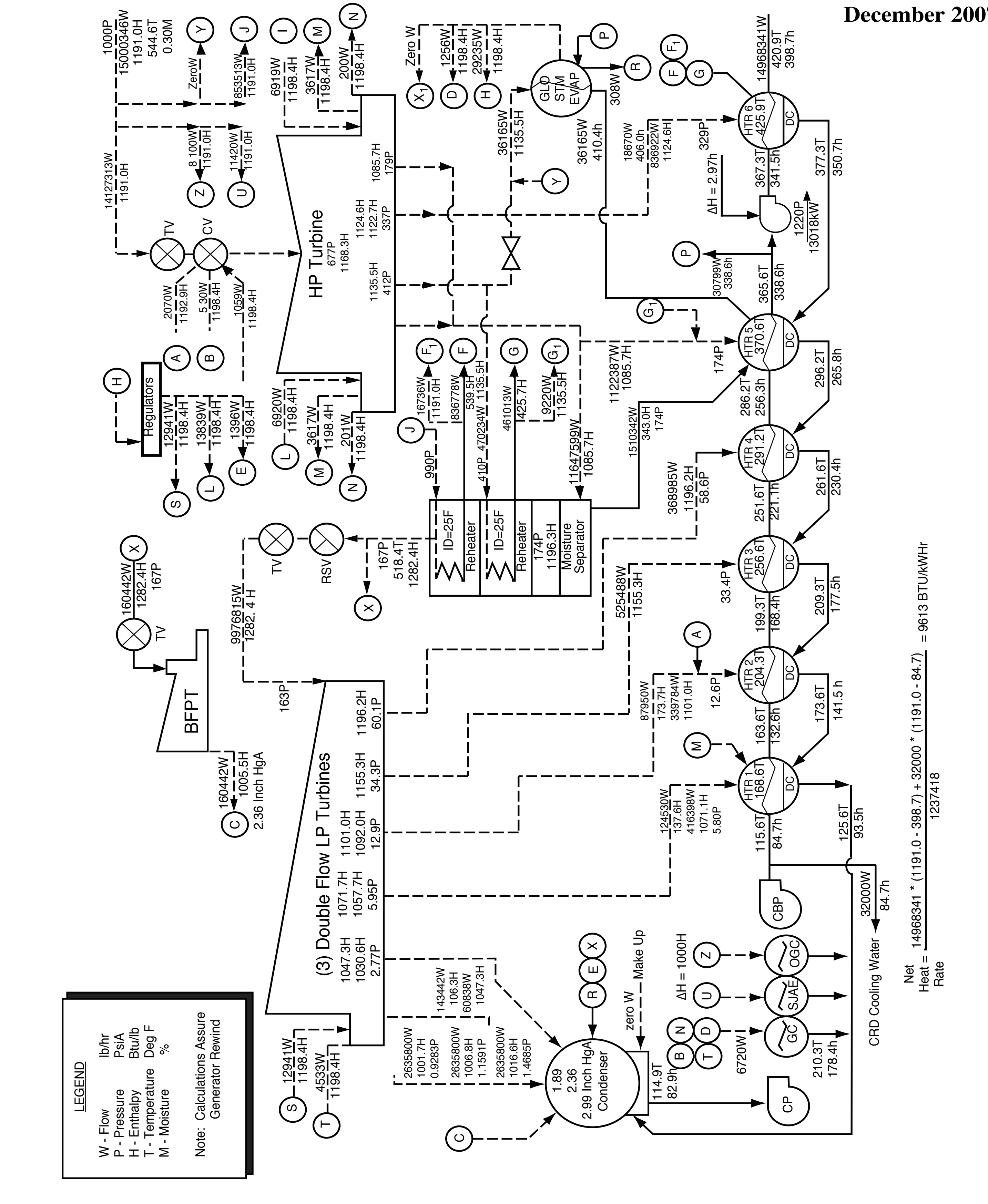
The design of various steam and condensate instrumentation systems are based on the need to monitor and control normal power generation system functions such as level, flow, pressure, and temperature. The instrumentation provides information that enables the control room operator to start up, operate, and shut down these systems.

Table 10.1-1

Design and Performance
Characteristics of Power Conversion System[a]

Turbine Data	
Manufacturer	Westinghouse
HPT building block	BB 296
LPT building block	BB 281R
LPT type/LSB length (in.)	TC6F/47
Number of casings	1-HP, 3-LP
Backpressure zones (in. Hg abs)	1.89/2.36/2.99 (2.4 average)
Generator	
Rating (kVA)	1,230,000
Gross output (MWe)	1230
Power factor	0.975
Voltage (volts)	25,000
Phase/frequency (Hz)	3/60
Hydrogen pressure (psig)	75-78
Steam conditions at throttle valve	
Flow (lb/hr)	14,127,313
Pressure (psia)	1000
Temperature (°F)	544.6
Enthalpy (Btu/lb)	1189.5
Moisture content, maximum (%)	0.30
Turbine cycle heat rate (Btu/kW-hr)	9613
Final feedwater temperature (°F)	420.9
Turbine cycle arrangement	
Steam reheat stages	2
Number of feedwater heating stages	6
Feedwater heater in condenser neck	First stage
Type of condensate demineralizer	Powdered resin
Main steam bypass capacity (%)	25

[a] All data based on 100% load. See Figure 10.1-1.



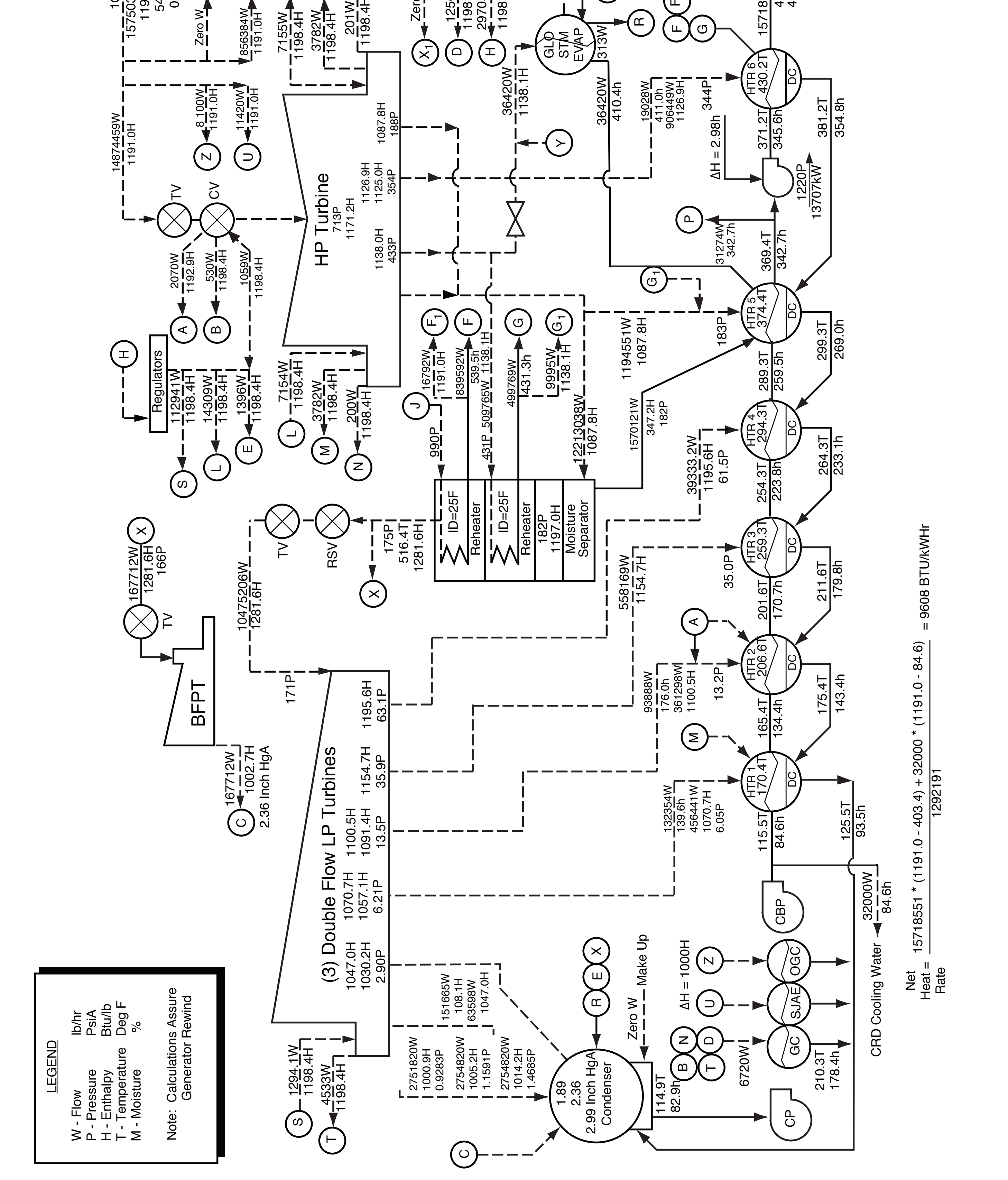
Columbia Generating Station
Final Safety Analysis Report

1237418 kW Net Load Heat Balance

Draw. No. 960222.24	Rev.	Figure 10.1-1

Form No. 960690
LDCN-06-042

Amendment 59
December 2007



Columbia Generating Station Final Safety Analysis Report	1292191 kW Net Load Heat Balance
	Draw. No. 960222.25 | Rev. | Figure 10.1-2

Form No. 960690
LDCN-06-042

10.2 TURBINE GENERATOR

10.2.1 DESIGN BASIS

The turbine generator is designed to receive steam from the boiling water reactor, convert a portion of the thermal energy contained in the steam to electric energy, and provide extraction steam for feedwater heating.

The turbine generator, associated systems, and control characteristics, are integrated with the features of the reactor and associated systems to obtain an efficient and safe power generator unit. The turbine generator is designed to function only during normal plant conditions including startup, power generation, and shutdown. The turbine generator is not required for safe shutdown of the reactor nor to perform safety functions. The turbine generator equipment is in strict conformance with the latest edition in effect at the time of fabrication, of ANSI C.50.10, ANSI C.50.13, and the IEEE standards. The major portion of the manufacture was performed during 1975. The original LP turbine rotors were replaced with fully integral rotors during 1992. Safety class and seismic category are presented in Section 3.2.

The turbine generator design conditions are included in Table 10.1-1.

The turbine generator is intended for base load operation. Normal load swings are limited to the rate of change of power output of the nuclear steam supply system.

The turbine governor valves are capable of full stroke opening and closure within 7 sec for adequate pressure control performance. Normal governor valve closure is shown in Figure 10.2-1.

During events resulting in turbine throttle or governor valve fast closure, turbine inlet steam flow is not reduced faster than permitted by Figures 10.2-2 or 10.2-3.

10.2.2 SYSTEM DESCRIPTION

The main turbine is a tandem-compound unit, consisting of one double-flow high pressure turbine and three double-flow low pressure turbines (Figure 10.3-1), running at 1800 rpm with 47 in. last-stage blades. Exhaust steam from the high pressure turbine passes through two moisture separator/reheaters (two stage reheat) before entering the low pressure turbine inlets. The exhaust steam from the three low pressure turbines is condensed in the main condenser.

The generator is a three phase, 60 cycle, 25,000 V, 1800 rpm unit rated at 1,230,000 kVA at 0.975 power factor. The stator is water cooled and the rotor is hydrogen cooled. The hydrogen system is designed to minimize the hazard from fires or explosions as discussed in Appendix F.

The design of the system, Figures 10.2-4 and 10.2-5, and the specified operating procedures are such that explosive mixtures are not possible under normal operating conditions. The hydrogen gas supply system includes a storage trailer and storage cylinders used as backup if the trailer supply runs low. Pressure regulators are mounted on both the storage trailer and the bottle manifold for control of the hydrogen gas, and a circuit for supplying and controlling the carbon dioxide used in purging the generator during filling and degasing operations. To prevent hydrogen leakage by the generator shaft seals, a hydrogen seal oil system is provided. The hydrogen seal oil system, which includes pumps and controls, deaerates the oil before it is sent to the shaft seals.

The fundamental rule is that hydrogen and air should never be mixed. Carbon dioxide is used as an intermediate gas when changing either from air to hydrogen or from hydrogen to air. When changing from one gas to another, the generator is vented to the atmosphere. The valves, pressure gauges, regulators, and other equipment in the hydrogen gas supply system permit introducing hydrogen or prevent the flow of hydrogen into the generator and also provide means of controlling the gas pressure within the generator.

Steam is transported from the reactor by four main steam lines and flows through the turbine throttle valves and governor valves to the high pressure turbine. The steam lines are combined upstream of the throttle and governor valves. The turbine bypass valves are located upstream of the turbine throttle valves to permit steam bypass to the main condenser during transient conditions.

Two branch lines from the main steam heater supply steam to the two second-stage reheaters per moisture separator. The steam for the two first-stage reheaters per moisture separator is supplied by extraction lines from the high pressure turbine (see Figure 10.3-1). Moisture preseparator units remove moisture from the lower high-pressure turbine discharge exhaust steam as it exits the turbine. The moisture separator/reheaters remove the moisture from the high-pressure turbine exhaust steam and superheat the steam prior to admission to the low pressure turbines, thereby improving overall cycle efficiency. Extraction steam from the high pressure turbine is used in the first-stage reheater and for feedwater heating in heaters No. 5 and 6. Extraction steam from the low pressure turbines is used for the first, second, third, and fourth stage feedwater heaters. Moisture separator/reheater relief valves are provided to prevent overpressurizing the moisture separator/reheaters and the crossover lines in the event of crossover throttle or intercept valve closure; these relief valves discharge to the main condenser.

The turbine generator is equipped with a digital electrohydraulic (DEH) control system. See Section 7.7.1.5 for a detailed description of the turbine control system.

There are four methods of turbine overspeed control protection:

a. Digital Electro-Hydraulic (DEH) speed control,
b. Overspeed protection controller (OPC),
c. Digital control overspeed trip, and
d. Digital trip overspeed trip.

DEH Speed Control

The DEH speed control is designed to maintain turbine speed within 2-3 rpm of setpoint during startup; after the turbine generator has been synchronized to the grid, the grid frequency controls turbine speed. The DEH control system monitors turbine speed via three speed sensors. Upon detecting a separation from the grid and a resulting overspeed condition, the DEH speed control will rapidly close the governor valves via their servo-valves preventing an excessive overspeed condition from occurring.

Overspeed Protection Controller

The OPC primary function is to avoid excessive turbine overspeed such that a turbine trip is avoided. At 103% of rated speed, the OPC solenoids open, rapidly closing the governor and intercept valves to arrest the overspeed before it reaches the trip setting. When turbine speed falls below 101%, turbine speed control is returned to the DEH speed control mode.

Digital Control Overspeed Trip, Digital Trip Overspeed Trip and Quadvoter Hydraulic Trip Block

If the turbine accelerates further than 103% of rated speed, the digital control overspeed trip logic in the DEH control system will provide a trip signal that causes the quadvoter hydraulic trip block to de-energize and trip the turbine. Additionally, the digital trip overspeed trip has three redundant speed sensors and will initiate an independent trip of the quadvoter hydraulic trip block. Both the digital control overspeed trip and the digital trip overspeed trip use two out of three overspeed logic to initiate the trip signal prior to reaching 111% of rated speed. These signals cause the output module for the quadvoter to simultaneously de-energize, or trip, all of the quadvoter valves.

Redundant power supplies are auctioneered to assure loss of one power supply does not cause the quadvoter to trip. The quadvoter provides two channels, each with two solenoid valves in series, to depressurize the trip header and trip all the throttle, governor, intercept and reheat stop valves. The quadvoter design assures that a single failure of a quadvoter valve will neither cause the turbine to trip nor prevent the turbine from tripping if required. The DEH control system is designed to maintain the turbine speed below 120% of rated speed.

The quadvoter trip block assembly is a fail-safe design. Therefore a loss of all power or a loss of all signals to the quadvoter solenoids would cause a turbine trip as all of the quadvoter solenoid valves would de-energize. The turbine overspeed control equipment and electrical wiring may be destroyed by a postulated piping failure; however, this loss would result in a turbine trip based on the fail-safe design. A missile may destroy the electromagnetic speed pickups and associated electrical wiring, but the turbine will still trip on loss of all speed probe signals. Missile damage to the hydraulic lines for the trip block assembly would result in a loss of high pressure fluid thereby depressurizing the trip header and causing a turbine trip.

The operation of the DEH control system is continuously monitored during turbine generator operation. Detection of turbine speed variation is accomplished by the speed-control unit discussed in Section 7.7.1.5. The overspeed protection controller and two digital overspeed trips are tested during reactor startup from refueling outages. The turbine throttle, governor, interceptor, reheat stop valves and quadvoter solenoid valves are periodically tested during operation. Turbine throttle, governor, interceptor and reheat stop valves are periodically inspected. The manner and frequency of the inspection and testing will take into consideration the manufacturer's and others' recommendations and missile probability analysis (see Section 3.5.1.3) in conjunction with the plant generating requirements.

Instrumentation for the turbine generator is provided in the control room and is described in Section 7.7.1.5.

The turbine is equipped for normal operations with a shaft-driven lubricating oil pump and ac motor-driven lubricating oil pump for startup, shutdown, and turning gear, or for emergencies whenever oil pressure falls below set pressure. The turbine is also provided with a dc motor-driven lubricating oil pump with power supplied from storage batteries for emergency operation.

The turbine shaft is supplied with "clean" (essentially nonradioactive) sealing steam which prevents outleakage of steam from the high-pressure turbine and inleakage of air to the low pressure turbines. An evaporator generates essentially nonradioactive steam for turbine gland sealing (see Section 10.4.3).

Overpressure protection of the turbine exhaust hoods and the main condenser shell is provided by rupture diaphragms on the exhaust hoods.

The turbine incorporates protective devices including the exhaust hood relief diaphragms, exhaust hood temperature alarm, pilot dump valve for closing the extraction steam nonreturn valves, low vacuum alarm, thrust bearing wear alarm, and low bearing oil pressure alarm.

In addition, the following tabulation is a list of the turbine generator protective trips:

Mechanical Faults	Electrical Faults
Low vacuum	Generator power differential
Thrust bearing wear	Generator underfrequency
Low oil pressure	Generator differential current
Overspeed	Generator stator ground
Manual	Generator loss of excitation
Anti-motoring	Generator negative sequence
Low DEH pressure	Generator overcurrent during starting
Low EH (electrohydraulic) fluid level	Generator stator ground during starting
Reactor high water level	Generator overexcitation
RCIC-V-13 and 45 open	Generator/transformer overall differential
Moisture separator reheater shell side high level	Manual
Loss of DEH control power	Unit lockout
Both Throttle Valves on a steam chest closed	Unit overall lockout

The main steam throttle and governor valves are located in the steam chest assembly which is parallel to the axis of the high pressure turbine. The nominal closure time for a fully open throttle or governor valve is 0.15 sec. A failure of one governor valve causes the other valves to increase or decrease their opening to compensate for that valve. If one valve fails open at low load condition, the other valves close. If the closing of the other valves is not enough to compensate for that valve, the turbine load increases proportional to steam flow.

The reheat stop and intercept valves are in-line valves located in the crossover piping between the moisture separator/reheater and low pressure turbine. The closure time upon depressionization of the trip header for a fully open valve is 0.15 sec.

The valves described above are periodically tested as required by the Licensee Controlled Specifications (LCS) by using the DEH control system during power operation. Pressure variations caused by closing a governor valve cause the other governor valves to open. Therefore, testing must be done at a reduced power level to provide sufficient margin for pressure control. Details of the pressure control system are discussed in Section 7.7.1.5. In addition, one of each valve will have its internals periodically inspected as required by the LCS.

Each of the extraction steam lines has a reverse current valve and a gate valve, with the exception of the extraction lines to low pressure number 1 heaters. These valves are located near the condenser. On turbine trip the reverse current valves close immediately on reverse flow. Because of the fast closure and the short distance between these valves and the extraction points at the turbine, the amount of steam in these lines does not affect the turbine coastdown following a turbine trip.

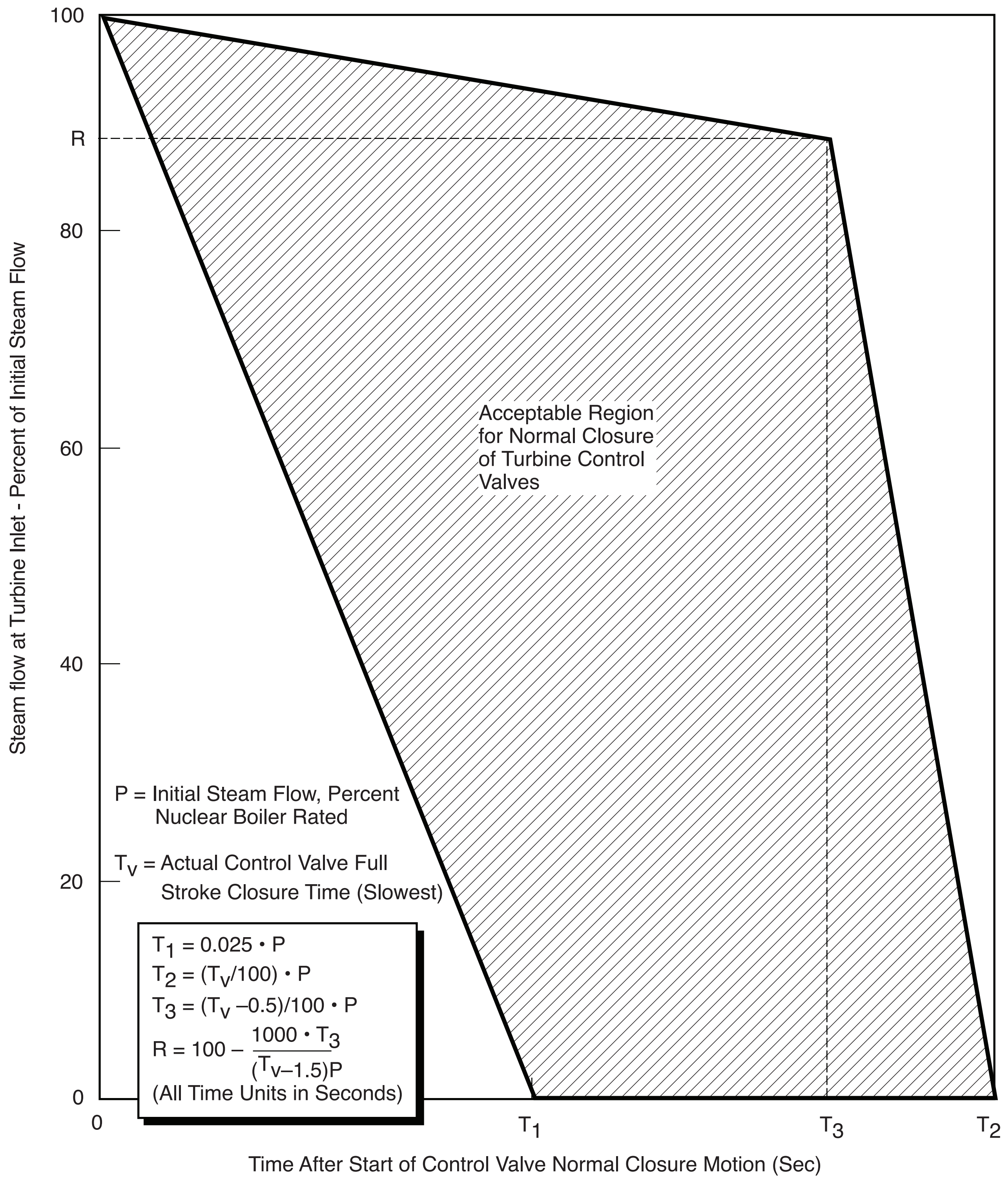
10.2.3 TURBINE DISK INTEGRITY

Analysis of potential turbine missile hazards and drawings showing the orientation of the turbine with respect to important structures are presented in Section 3.5.1.3.

10.2.4 SAFETY EVALUATION

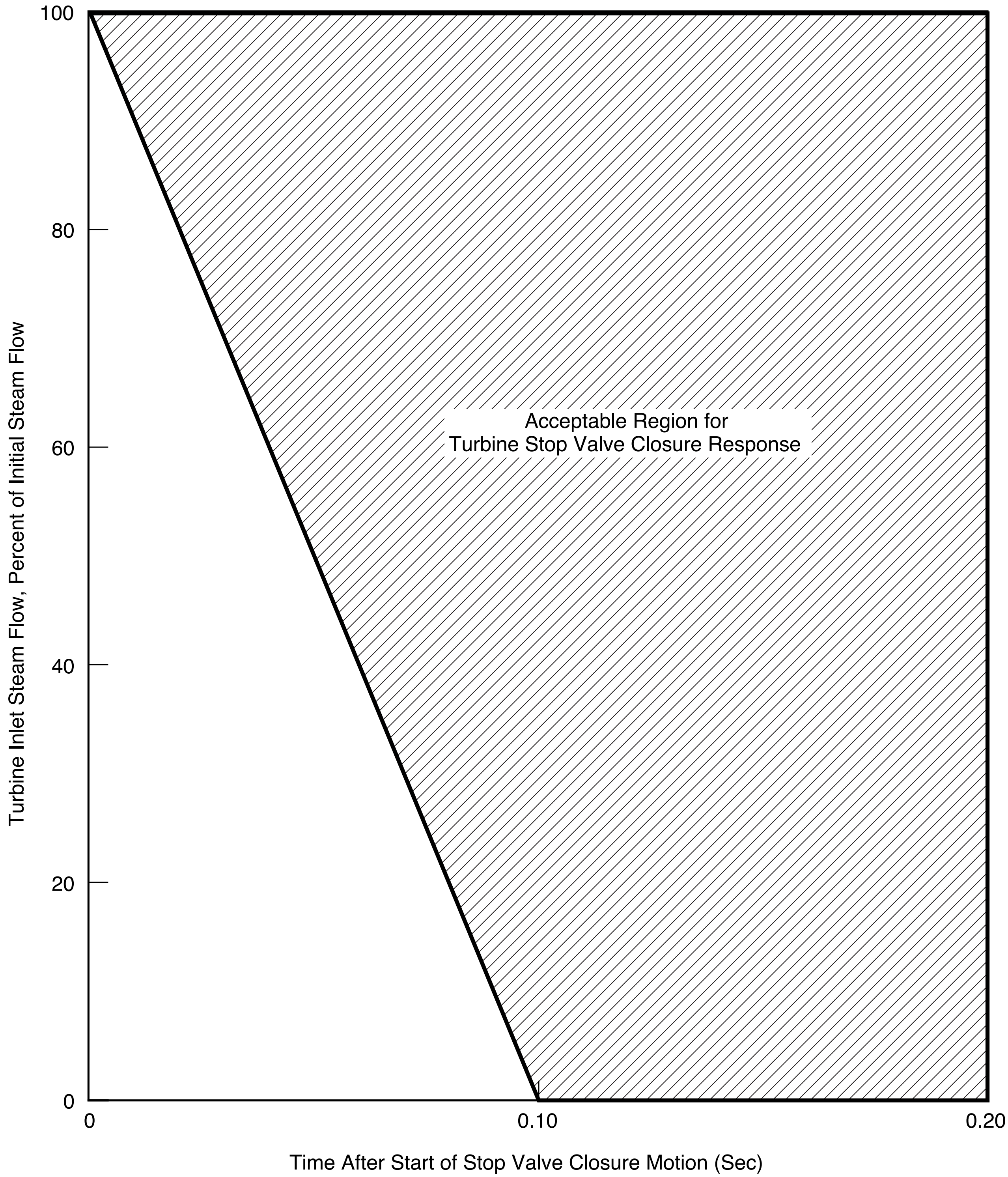
The steam entering the high pressure turbine may contain fission, coolant activation, and activated corrosion products. The anticipated concentration of nitrogen-16, which is the dominant radionuclide entering the high pressure turbine, is discussed in Section 12.2. Moisture separation and transit time between the high pressure and low pressure turbines reduces the concentration of radionuclides in the steam prior to entering the low pressure turbine. Most of the gaseous radioactivity is removed by the steam-jet air ejector and routed to the offgas system (see Section 11.3). The condensate in the condenser hotwell contains significantly less radioactive material than the inlet steam.

Access to the turbine area is controlled. Radiation levels associated with turbine components are described in Section 12.2 and shielding requirements are discussed in Section 12.3.

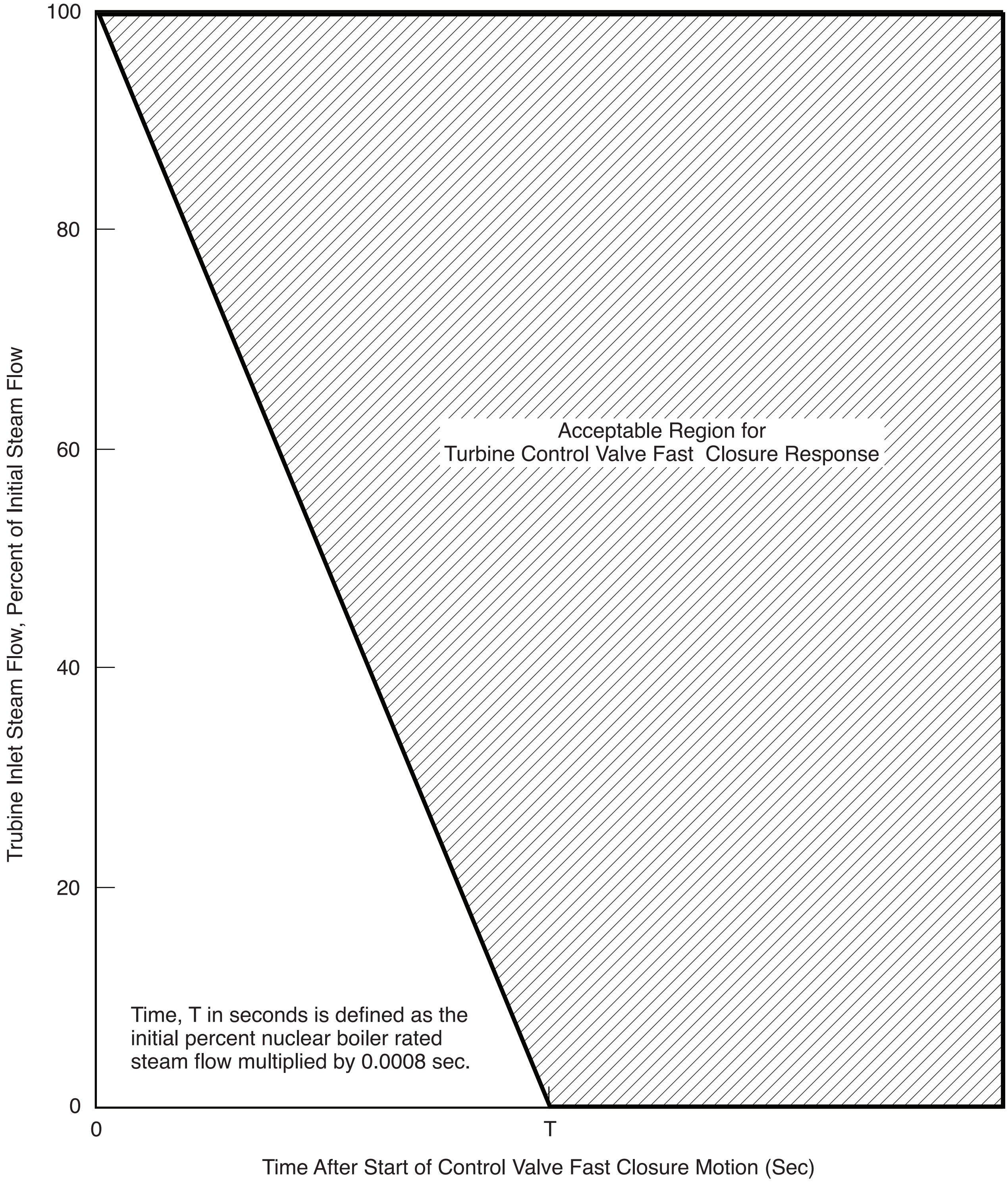


Acceptable Range for Control Valve Normal Closure Motion

Draw. No. 950021.39 | Rev. | Figure 10.2-1



Columbia Generating Station Final Safety Analysis Report	Turbine Stop Valve Closure Characteristic		
	Draw. No. 950021.40	Rev.	Figure 10.2-2



Columbia Generating Station
Final Safety Analysis Report

Turbine Control Valve Fast Closure Characteristic

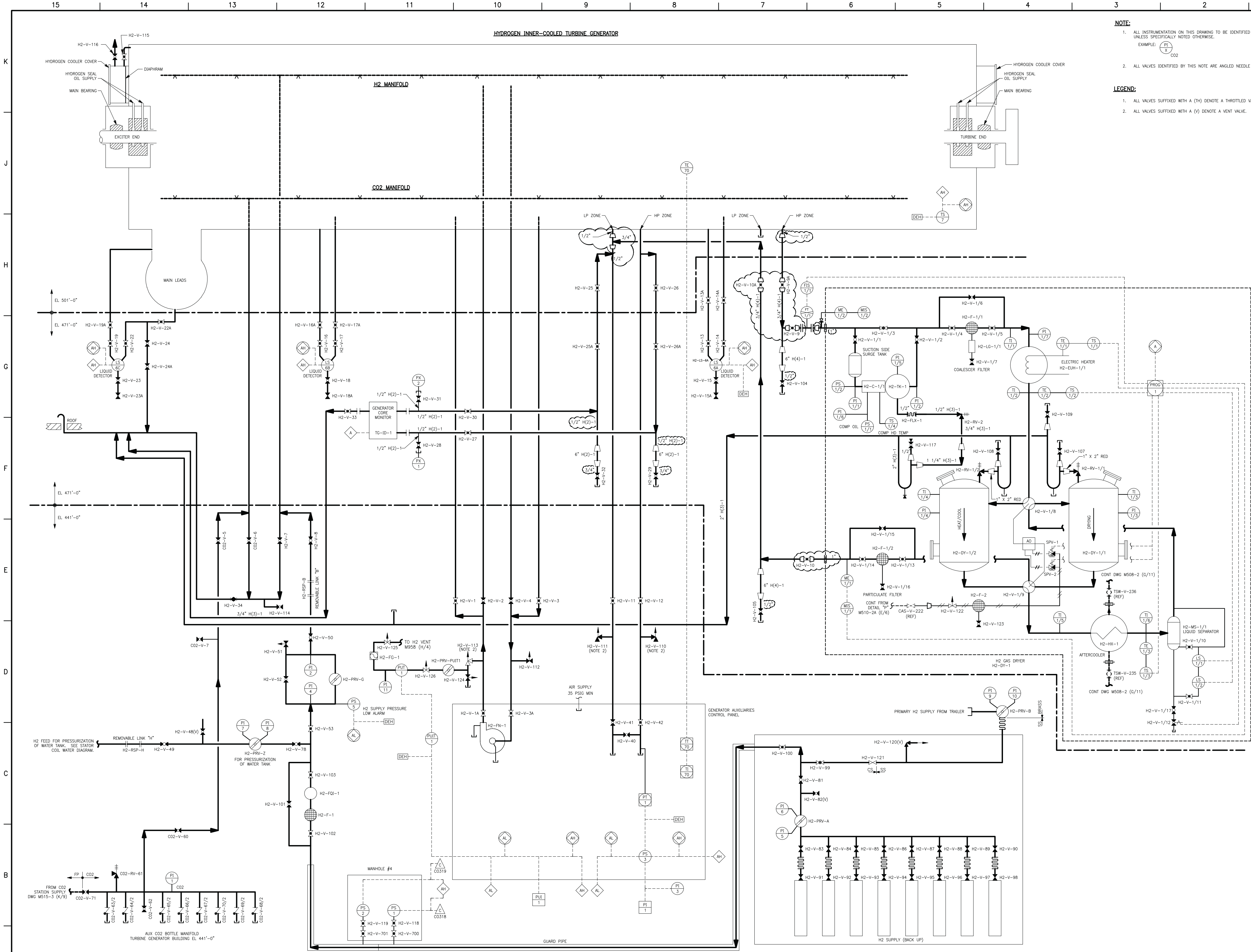
Draw. No. 950021.41	Rev.	Figure 10.2-3

NOTE:

1. ALL INSTRUMENTATION ON THIS DRAWING TO BE IDENTIFIED BY PREFIX "H2", UNLESS SPECIFICALLY NOTED OTHERWISE.
   EXAMPLE: PI X CO2
2. ALL VALVES IDENTIFIED BY THIS NOTE ARE ANGLED NEEDLE VALVES.

LEGEND:

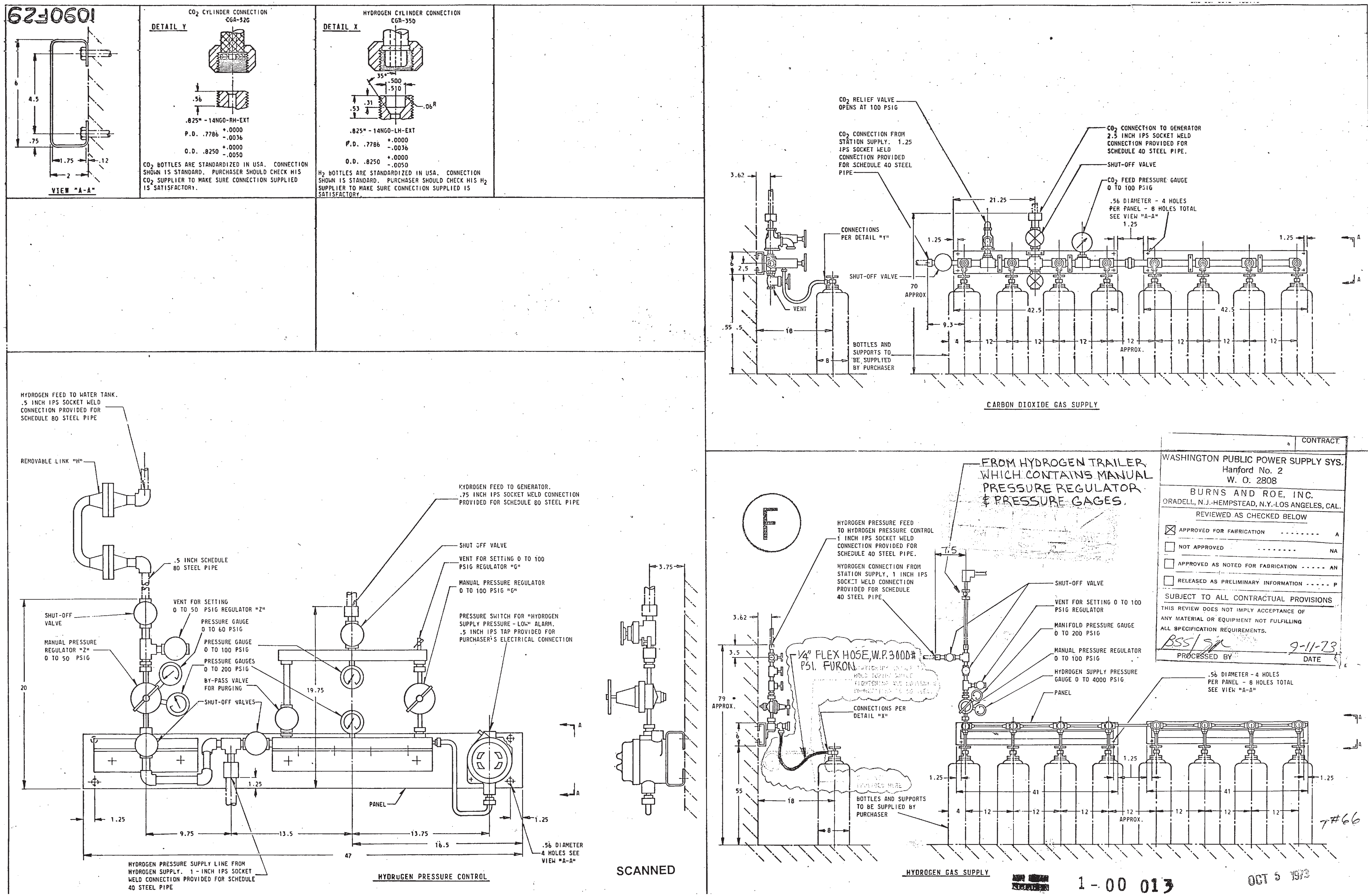
1. ALL VALVES SUFFIXED WITH A (TH) DENOTE A THROTTLED VALVE.
2. ALL VALVES SUFFIXED WITH A (V) DENOTE A VENT VALVE.



Columbia Generating Station
Final Safety Analysis Report

AC Turbine Generator Gas Diagram

Draw. No. M957 | Rev. 23 | Figure 10.2-4

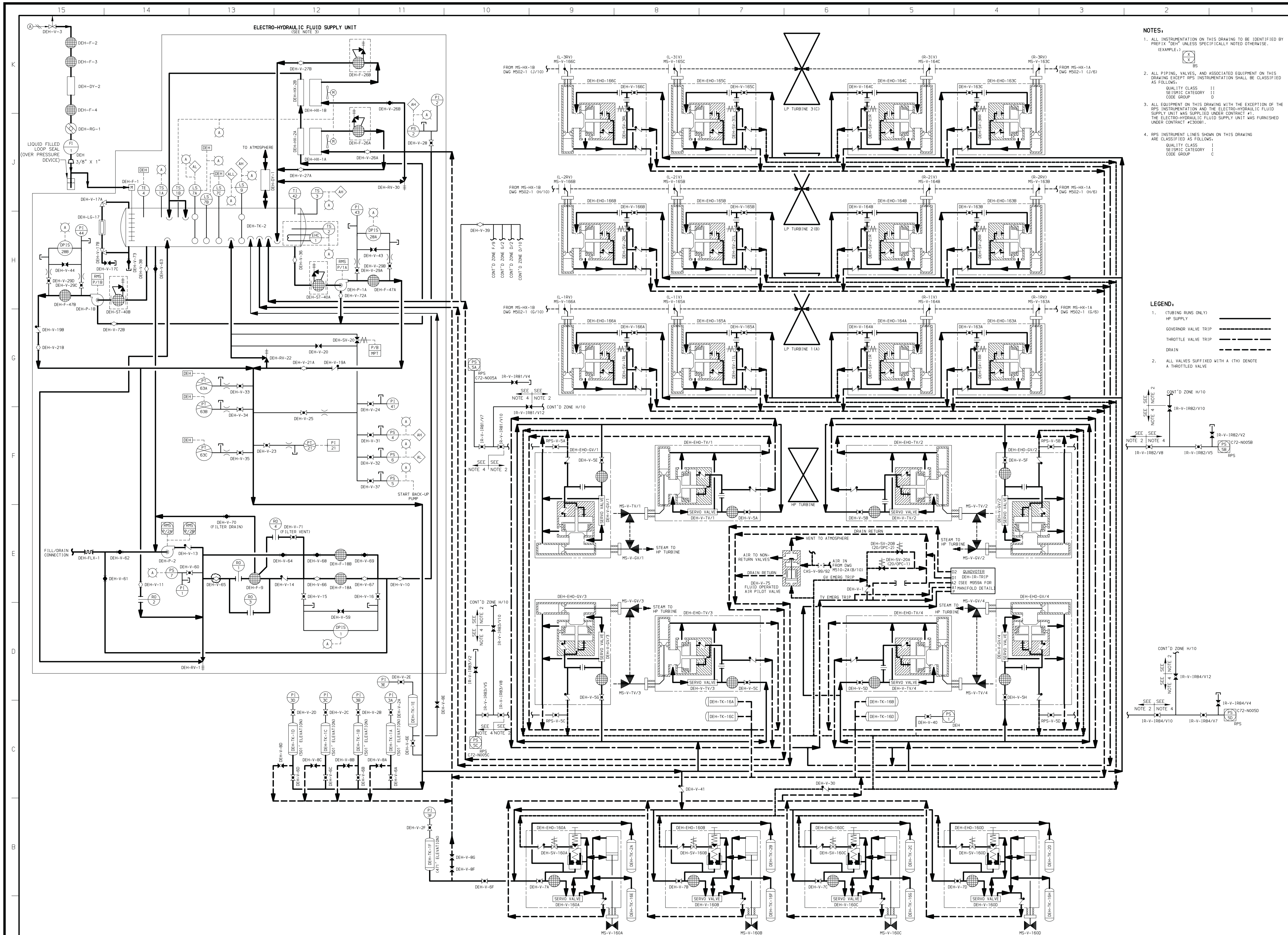


Columbia Generating Station
Final Safety Analysis Report

AC Turbine Generator Gas Supply Outline

Draw. No. 01-00,60	Rev. 4	Figure 10.2-5

Amendment 61
December 2011

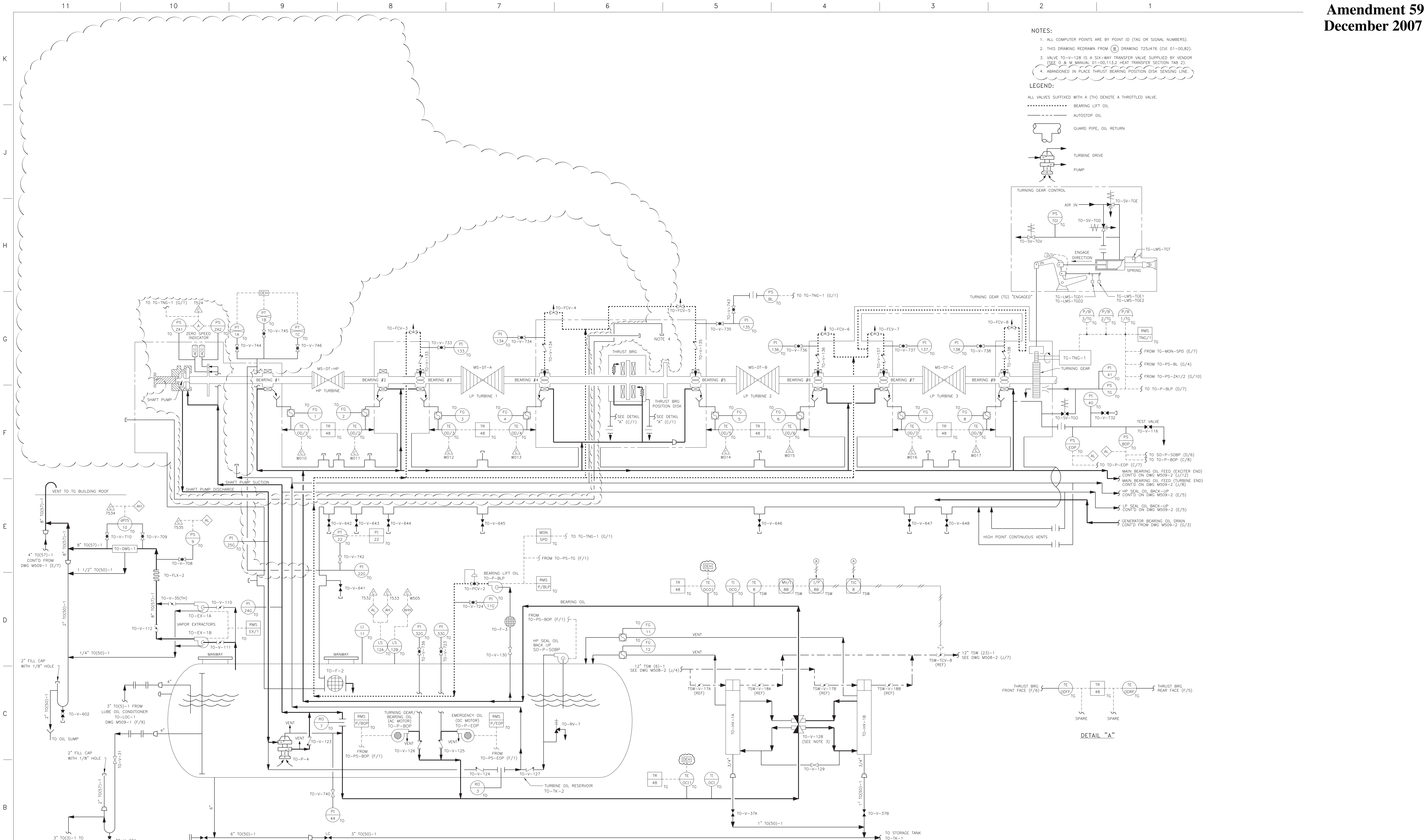


Columbia Generating Station
Final Safety Analysis Report

Electrohydraulic HP Fluid and Lube Oil Diagram

Draw. No. M959	Rev. 16	Figure 10.2-6.1

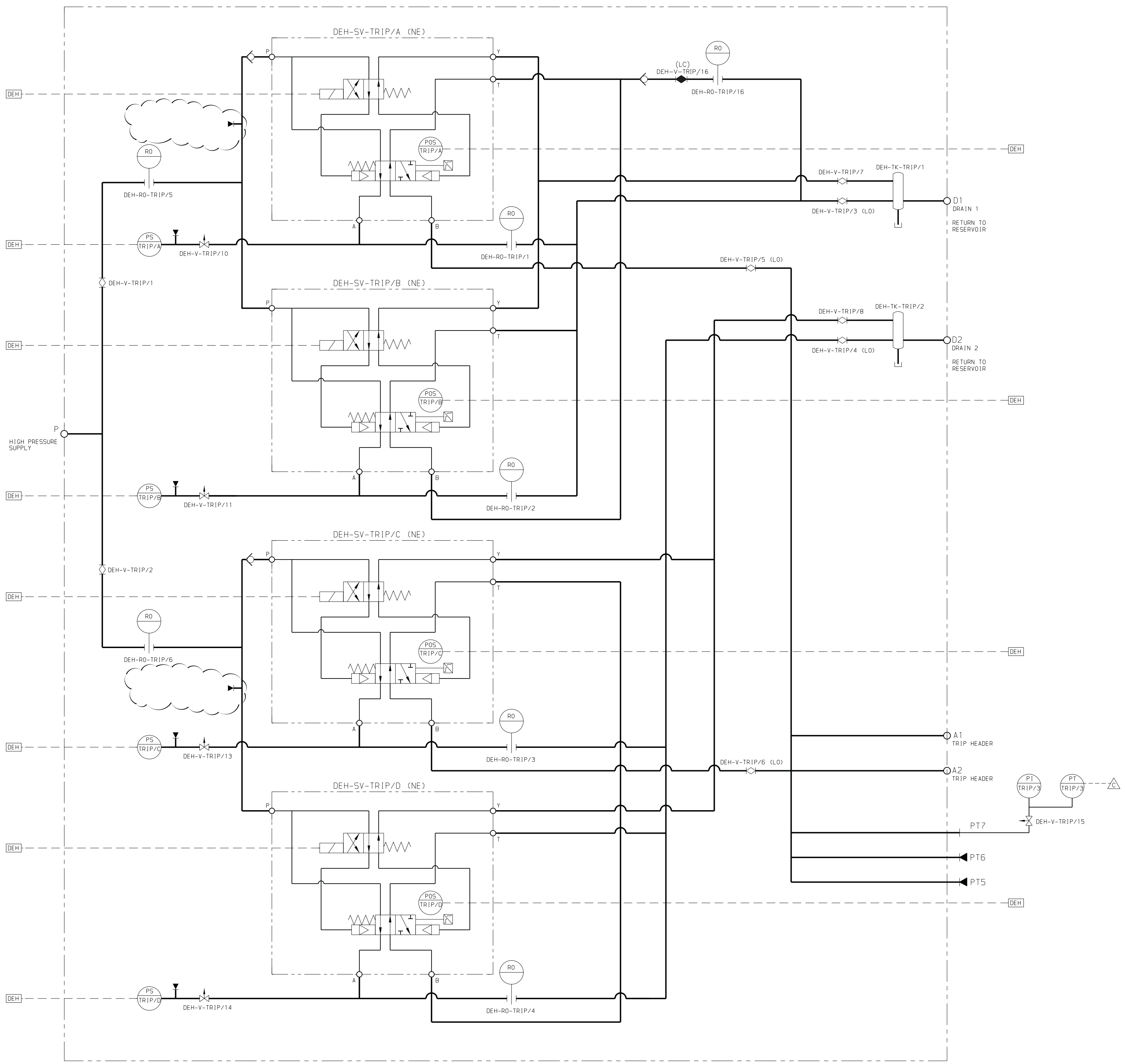
Form No. 960690ai



Columbia Generating Station
Final Safety Analysis Report

Electrohydraulic HP Fluid and
Lube Oil Diagram

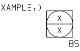
Draw. No. M960 | Rev. 8 | Figure 10.2-6.2



DEH-IR-TRIP
QUADVOTER MANIFOLD DETAIL
SEE M959 (ZONE E/4)

NOTES:

1. ALL INSTRUMENTATION ON THIS DRAWING TO BE IDENTIFIED BY PREFIX "DEH" UNLESS SPECIFICALLY NOTED OTHERWISE.
   (EXAMPLE:)



2. ALL PIPING, VALVES, AND ASSOCIATED EQUIPMENT ON THIS DRAWING SHALL BE CLASSIFIED AS FOLLOWS:

QUALITY CLASS	II
SEISMIC CATEGORY	II
CODE GROUP	D

REFERENCE DRAWINGS

CVI 1095-00,18,1 – QUADVOTER TRIP SYSTEM OUTLINE HYDRAULIC OUTLINE

Columbia Generating Station
Final Safety Analysis Report

Electrohydraulic HP Fluid and Lube Oil Diagram

Draw. No. M959A | Rev. 2 | Figure 10.2-6.3

NOTES:
1. FOR SYMBOL LIST SEE DW

SYMBOL LIST

PRESSURE SWITCHES

63/BL	-BEARING LIFT OIL-OPENS AT 850 PSIG DECR. PRESS.-LOCATED IN TERM. BOX "TB"
DEH-PS-5	-EH FLUID BACKUP PUMP START-CLOSES ON DECREASING PRESSURE 1800 PSIG
63/TG-1	-TURNING GEAR-OPENS AT INCREASE OF "ENGAGE AIR" PRESS. TO 20 PSIG
63/BOP	-BEARING OIL-CLOSES ON DECREASING PRESS AT 11-12 PSIG.-LOCATED IN TERM. BOX "L"
63/EOP	-BEARING OIL-CLOSES ON DECREASING PRESS. AT 10-11 PSIG.-LOCATED IN TERM. BOX "L"
63/XO	-EXHAUST HOOD SPRAY-OPENS ON PRESS. INCREASE AT 9 PSIG (EQUAL TO 15% LOAD)
DEH-PS-2	-EH FLUID RETURN-CLOSES ON INCREASING PRESS. AT 30 PSIG
DEH-DPIS-28A	-EH FLUID PUMP #1 FILTER DIFF. PRESS. SW. CLOSES -50 PSID
DEH-DPIS-28B	-EH FLUID PUMP #2 FILTER DIFF. PRESS. SW. CLOSES -50 PSID
SW-10	-DIFF. PRESS. SW. CLOSES ON LOW AIR SIDE SEAL OIL PUMP PRESSURE
SCW-DPS-15(SW-15)	-DIFF. PRESS. SW. OPERATES WHEN DIFF. PRESS. <60 PSI ON PUMP SCW-P-1
SCW-DPS-16(SW-16)	-DIFF. PRESS. SW. OPERATES WHEN DIFF. PRESS. <60 PSI ON PUMP SCW-P-2
63/EHS-1	-EXHAUST HOOD SPRAY-CLOSES ON DECREASING PRESSURE
63/EHS-2	-EXHAUST HOOD SPRAY-CLOSES ON DECREASING PRESSURE
63/EHS-3	-EXHAUST HOOD SPRAY-CLOSES ON DECREASING PRESSURE
DEH-PS-6	-EH FLUID PRESS. LOW-OPENS ON DECREASE PRESS. 1900 PSIG
DEH-PS-4	-EH FLUID PRESS HI-CLOSES ON INCREASE PRESS. 2420 PSIG
SW-9	-DIFF. PRESS. SW. CLOSES WHEN AIR SIDE SEAL OIL PUMP IS OFF
SW-12	-PRESS SW. CLOSES WHEN SEAL OIL TURBINE BACK-UP PRESS LO.
SW-13	-DIFF. PRESS. SW. CLOSES WHEN H_2 SIDE SEAL OIL PUMP OFF
SW-14	-DIFF. PRESS. SW. CLOSES WHEN AIR SIDE SEAL OIL BACK-UP PUMP RUNNING
SW-17	-DIFF. PRESS. SW. CLOSES WHEN COOLING WATER FILTER CLOGGED
SW-18	-PRESS. SW. CLOSES WHEN MAKE-UP WATER FLOW IS ON
SW-23	-PRESS. SW. CLOSES WHEN STATOR COIL COOLING WATER TANK PRESS. IS HI
SW-24	-DIFF. PRESS. SW. CLOSES WHEN STATOR COIL COOLING WATER FLOW IS LO
SW-25	-DIFF. PRESS SW. CLOSES WHEN STATOR COIL COOLING WATER FLOW IS LO-LO
SW-30	-DIFF. PRESS. SW. CLOSES WHEN GEN. H_2/H_2O DIFF PRESS. LO
63/RPS	-RPS PRESS. SWS. OPENS ON DECREASE OF PRESS.

LIMIT SWITCHES (33)

(FOR DEVELOPMENT SEE E520-2A, EXCEPT AS NOTED)

33/TGD-1	-TURNING GEAR LEVER POSITION SWITCH WIRED TO TERMINAL BOX "K"
33/TGD-2	-TURNING GEAR LEVER POSITION SWITCH WIRED TO TERMINAL BOX "K"
33/TGE-1	-TURNING GEAR LEVER POSITION SWITCH WIRED TO TERMINAL BOX "K"
33/TGE-2	-TURNING GEAR LEVER POSITION SWITCH WIRED TO TERMINAL BOX "K"
33/TGT-1	-TURNING GEAR LEVER POSITION SWITCH WIRED TO TERMINAL BOX "K"
33/RO	-RELATCH OPERATOR-WIRED TO TERM. BOX "A"
33/VTL	-VACUUM TRIP LATCH-WIRED TO TERM. BOX "A"
33/DV	-DRAIN VALVE LIMIT SW.
33/RR	-REHEAT STOP V RIGHT LIMIT SW.
33/RL	-REHEAT STOP V LEFT LIMIT SW.
33/IR	-INTERCEPTOR V RIGHT LIMIT SW.
33/IL	-INTERCEPTOR V LEFT LIMIT SW.
33/RCV	-REHEAT CONTROL VALVE
33/EHS	-EXHAUST HOOD SPRAY
33/a & 33/b	-DISCONNECT SWITCH CONTACTS - 500kV
33/EHB-1	-SEE 33/COND-V-609A DWG. E519-5 -EXHAUST HOOD BY-PASS SPRAY VALVE LIMIT SW.
33/EHB-2	-SEE 33/COND-V-609B DWG. E519-5 -EXHAUST HOOD BY-PASS SPRAY VALVE LIMIT SW.
33/EHB-3	-SEE 33/COND-V-609C DWG. E519-5 -EXHAUST HOOD BY-PASS SPRAY VALVE LIMIT SW.
33/AR-V-3A	- W #33/VB1 -VACUUM BKR LIMIT SWITCH SEE DWG. E523 FOR SW. DEVELOPMENT
33/AR-V-3B	- W #33/VB2 -VACUUM BKR LIMIT SWITCH SEE DWG. E523 FOR SW. DEVELOPMENT
33/AR-V-3C	- W #33/VB3 -VACUUM BKR LIMIT SWITCH SEE DWG. E523 FOR SW. DEVELOPMENT
33/GS1	-ROTOR GLAND STEAM SPILL-OVER S.O. VALVE LIMIT SW. -SEE DWG. E523 FOR SW. DEVELOPMENT
33/GS2	-ROTOR GLAND STEAM SPILL-OVER B.P. VALVE LIMIT SW. -SEE DWG. E523 FOR SW. DEVELOPMENT
DEH-POS-TRIP/A,B,C,D	-TRIP SOLENOID POSITION

ELECTRICALLY OPERATED VALVES (20)

20-1/OPC	-SOL. V-OVERSPEED PROTECTION CONTROLLER WIRED TO TERM. BOX "B"
20-2/OPC	-SOL. V-OVERSPEED PROTECTION CONTROLLER WIRED TO TERM. BOX "B"
20/TGE	-SOL. V-TURNING GEAR ENGAGE -WIRED TO TERM. BOX "K"
20/TGV	-SOL. V-TURNING GEAR ENGAGE AIR VENT -WIRED TO TERM. BOX "K"
20/TGD	-SOL. V-TURNING GEAR DISENGAGE -WIRED TO TERM. BOX "K"
20/DVI	-SOL. VALVE ENERGIZED TO ADMIT AIR TO DRAIN VALVE OPERATOR
20/DVII	-SOL. VALVE ENERGIZED TO ADMIT AIR TO DRAIN VALVE OPERATOR
20/TGO	-TURNING GEAR LOW OIL
20/MPT	-SOL. V-ELECTRO HYDRAULIC PUMP NO'S 1 & 2 AUTO START TEST
20-EHS-1,2,3	-SOL. V TO OPEN EXHAUST HOOD SPRAY WHEN TURB. SPEED EXCEEDS 600RPM
20/RL	-SOL. V -REHEAT STOP V TEST, LEFT
20/RR	-SOL. V -REHEAT STOP V TEST, RIGHT
20/IL	-SOL. V -INTERCEPTOR V TEST, LEFT
20/IR	-SOL. V -INTERCEPTOR V TEST, RIGHT
20/BV1,2,3,4	-SOL. V -STEAM BY-PASS
20/RVB	-SOL. V -FOR TEST OF 63/RVB PRESS SWS.
20/RPS	-SOL. V -FOR TEST OF 63/RPS PRESS SWS.
DEH-SV-TRIP-A,B,C,D	-TRIP BLOCK

MISCELLANEOUS

63-1/ZA	-TURNING GEAR ZERO SPEED ALARM ACTUATING CONTACTS (APPROX. 10 SEC. TIME DELAY)-LOCATED IN TERM. BOX "A"
63-2/ZA	-TURNING GEAR ZERO SPEED ALARM ACTUATING CONTACTS (APPROX. 10 SEC. TIME DELAY)-LOCATED IN TERM. BOX "A"
52a & 52b	-500kV CIRCUIT BREAKER CONTACTS. (IN MICRO WAVE CAB.)
DEH-LS-7A,B,C	-LOW EH FLUID LEVEL LOCKOUT LEVEL SWITCH CLOSES ON LOW EH FLUID
TG-RLY-SPD ARM1/NC1	-TURNING GEAR ACTUATING CONTACT-CLOSED FROM ZERO TO 600RPM TURBINE SPEED-LOCATED IN TG-MON-SPD-BOARD "B" (RELAY NORMALLY DE-ENERGIZED)
TG-RLY-SPD ARM3/NC3	-CONTACT OPENS ON DECREASING TURBINE SPEED 600RPM-LOCATED IN TG-MON-SPD-BOARD "B" (RELAY NORMALLY ENERGIZED)
(N)	-LOAD REJECTION CONTACT IN DEH CONTROLLER CABINET
ARC	-AUX. RELAY CABINET
(GAP)	-ALARM CONTACTS LOCATED IN GEN. AUX. CONTROL PANEL
60/GX	-GENERATOR P.T. FAILURE RELAY-LOCATED IN BOARD "F" IN CONTROL ROOM (DWG. E512-2)
✱	-FURNISHED AND INSTALLED BY W ON TURNING GEAR CONSOLET-WIRED TO TERM. BOX "K"
⬡	-FAN FAILURE ALARM RELAYS LOCATED IN FAN CONTROL PANEL
◇	-LOCATED IN GEN. AUX. CONTROL STATION "GACS."
ø	-LOCATED IN RPS/REVAB1 TEST PANEL
(ø)	-LOCATED IN RPS/REVAB2 TEST PANEL
‡	-CLOSES WHEN E.H. CONTROL POWER SUPPLY FAILS-LOCATED IN DEH GOVERNOR CONTROLLER CABINET
41	-VOLT. REGULATOR SUPPLY BREAKER
PB/MPT	-PUSH BUTTON ELECTRO HYDRAULIC PUMP TEST
71/OL	-HIGH & LOW LUBE OIL LEVEL SW
M/EHB-1	-SEE M/COND-V-609A DWG. E519-5 -EXHAUST HOOD BY-PASS SPRAY VALVE
M/EHB-2	-SEE M/COND-V-609B DWG. E519-5 -EXHAUST HOOD BY-PASS SPRAY VALVE
M/EHB-3	-SEE M/COND-V-609C DWG. E519-5 -EXHAUST HOOD BY-PASS SPRAY VALVE
AFS	-AIR FLOW SWITCH-OPENS ON NO. ISO. PHASE BUS DUCT AIR FLOW (DWG. E519-11)
SW-7	-THERMOSTAT CLOSES ON H_2 HIGH TEMPERATURE
SW-8	-TURBINE END -CONTACT CLOSES ON DEFOAMING TANK LEVEL HI
SW-8A	-EXCITER END -CONTACT CLOSES ON DEFOAMING TANK LEVEL HI
SW-11	-CLOSES ON H_2 SIDE SEAL OIL LEVEL LO
TG-P/B-CR/TT1	-EMERGENCY TRIP PUSHBUTTON-MOUNTED IN BD "B"
TG-P/B-CR/TT2	-EMERGENCY TRIP PUSHBUTTON-MOUNTED IN BD "B"
K-7A,B,C	-REACTOR HIGH WATER LEVEL TRIP
DEH-TS-3	-TEMPERATURE SWITCH EH FLUID TEMPERATURE HI
TG-P/B-TG/TT1,TT2	-TURB. TRIP PUSHBUTTON TG 501
TG-DET-TP/A,B,C,	- THRUST BEARING
HD-LS-HL-20A,B, 21A,B,23A,B	-MSR HIGH LEVEL A,B,C
RFW-LS-624A,B,C	-REACTOR HIGH WATER LEVEL
TG-SE-OS/A,B,C	-SPEED PICKUP
TG-SE-SC/A,B,C	-SPEED PICKUP

RELAYS

86XU	-UNIT TRIP LOCKOUT RELAY (DWG. E512-2)
86XUOA	-UNIT TRIP OVERALL TRIP LOCKOUT RELAY (DWG. E512-2)
14/ZSX	-ZERO SPEED RELAY-LOCATED IN TERM BOX "K"
ACR/BOP	-EMERGENCY OIL PP-AUX. RELAY DEENERGIZED FAILURE. FOR BOP CIRCUIT POWER.
VHTX	-VOLTS/HERTZ AUX. RELAY
VHT	-VOLTS/HERTZ REGULATOR TRIP RELAY
49X-EOP	-EMERGENCY OIL PUMP OVERLOAD
49X-ASOBP	-AIR SIDE SEAL OIL BACK-UP PUMP OVERLOAD
59/81	-EXCESSIVE VOLTS/HERTZ RELAY
59/81T	-EXCESSIVE VOLTS/HERTZ TIMING RELAY
41TD	-REGULATOR SUPPLY BREAKER AUX. RELAY
41/aX1,2	-REGULATOR SUPPLY BREAKER AUX. RELAY
DCF	-DC FAILURE IN GENERATOR AUX. CONTROL PANEL
62/TGS	-TURN GEAR FAILURE T.D. ALARM RELAY 0-30 SEC.
QSV	-QUICK SOL. VALVE OPERATING RELAY
MX	-EMERG. OIL PUMP RUNNING
MX-X	-AUX. RELAY FOR EMERGENCY OIL PUMP RUNNING-ALARM
TG-X/ZSX	-AUX. RELAY FOR 14/ZSX/ZERO SPEED ALARM
86X1U	-UNIT PRIMARY LOCKOUT RELAY (DWG. E512-2)
86X1UOA	-UNIT SECONDARY LOCKOUT RELAY (DWG. E512-2)
30/64F	-FIELD GROUND DETECTION PWR. SUPPLY FAILURE RELAY
90C	-VOLTAGE REGULATOR ON RELAY
94RB	-VOLTAGE REGULATOR TRIP RELAY
K4	-VOLTAGE REGULATOR FORCING ALARM RELAY
V/HZ	-MAXIMUM VOLTZ/HERTZ RELAY
PC1, PC2	-VOLTAGE REGULATOR LOSS OF FIRING PULSE RELAY
41-A	-REGULATOR BKR. AUTO TRIP ALARM RELAY
94-A	-VOLTAGE REGULATOR TRIP ALARM RELAY
FFA	-REG. COOLING FAN FAILURE ALARM RELAY
FA	-FIELD FORCING ALARM RELAY
VH/A	-VOLTZ/HERTZ LIMIT EXCEEDED ALARM RELAY
FP/A	-REGULATOR BLOWN FUSE OR LOSS OF POWER ALARM RELAY
41TD/A	-REGULATOR BKR. CLOSED ALARM RELAY
PSF/A	-REGULATOR POWER SUPPLY FAILURE ALARM RELAY
R1	-D.C. POWER FAILURE RELAY FOR GEN. AUX. CONTROL PANEL
R3	-STATOR COIL WATER INLET CONDUCTIVITY HI RELAY
R4	-STATOR COIL WATER INLET CONDUCTIVITY HI-HI RELAY
R5	-DEMINERALIZER OUTLET CONDUCTIVITY HI RELAY
64X	-GENERATOR GROUND DETECTION ALARM RELAY
64E/X	-EXCITER GROUND DETECTION ALARM RELAY
63Y/AM1	-AUX. RELAY

TRANSMITTERS

TO-PT-1A/1B/1C	-BRG. OIL PRESS TRANSMITTERS
MS-PT-8A,B,C	-CONDENSER 1 PRESSURE TRANSMITTER
DEH-PT-63A,B,C	-EH HEADER PRESS TRANSMITTERS
DEH-PS-TRIP/A,B,C,D	-TRIP BLOCK PRESS
MS-DPT-63A,B,C	-TURB. 1ST STAGE DIFF PRESS.

) SYSTEM
ALARM RELAYS LOCATED IN ARC

EHL/1X - LEVEL HI
EHL/2X - LEVEL LO-LO
EHL/3X - LEVEL LO
EHPR/X - PRESSURE RETURN HI
EHPF/X - PRESSURE DIFF. ON FILTER
EHPH/X - PRESSURE HI
EHPL/X - PRESSURE LO
EHTH/X - TEMPERATURE HI

VALVE	EPN	LOCATION
RCV1	MS-TCV-115A	
RCV2	MS-TCV-115B	
RCV3	MS-TCV-115C	
RCV4	MS-TCV-115D	
BV1	MS-V-160D	
BV2	MS-V-160C	
BV3	MS-V-160B	
BV4	MS-V-160A	
1RR	MS-V-163A	NORTH
1IR	MS-V-164A	NORTH
1IL	MS-V-165A	SOUTH
1RL	MS-V-166A	SOUTH
2RR	MS-V-163B	NORTH
2IR	MS-V-164B	NORTH
2IL	MS-V-165B	SOUTH
2RL	MS-V-166B	SOUTH
3RR	MS-V-163C	NORTH
3IR	MS-V-164C	NORTH
3IL	MS-V-165C	SOUTH
3RL	MS-V-166C	SOUTH

REFERENCE DWG. LIST

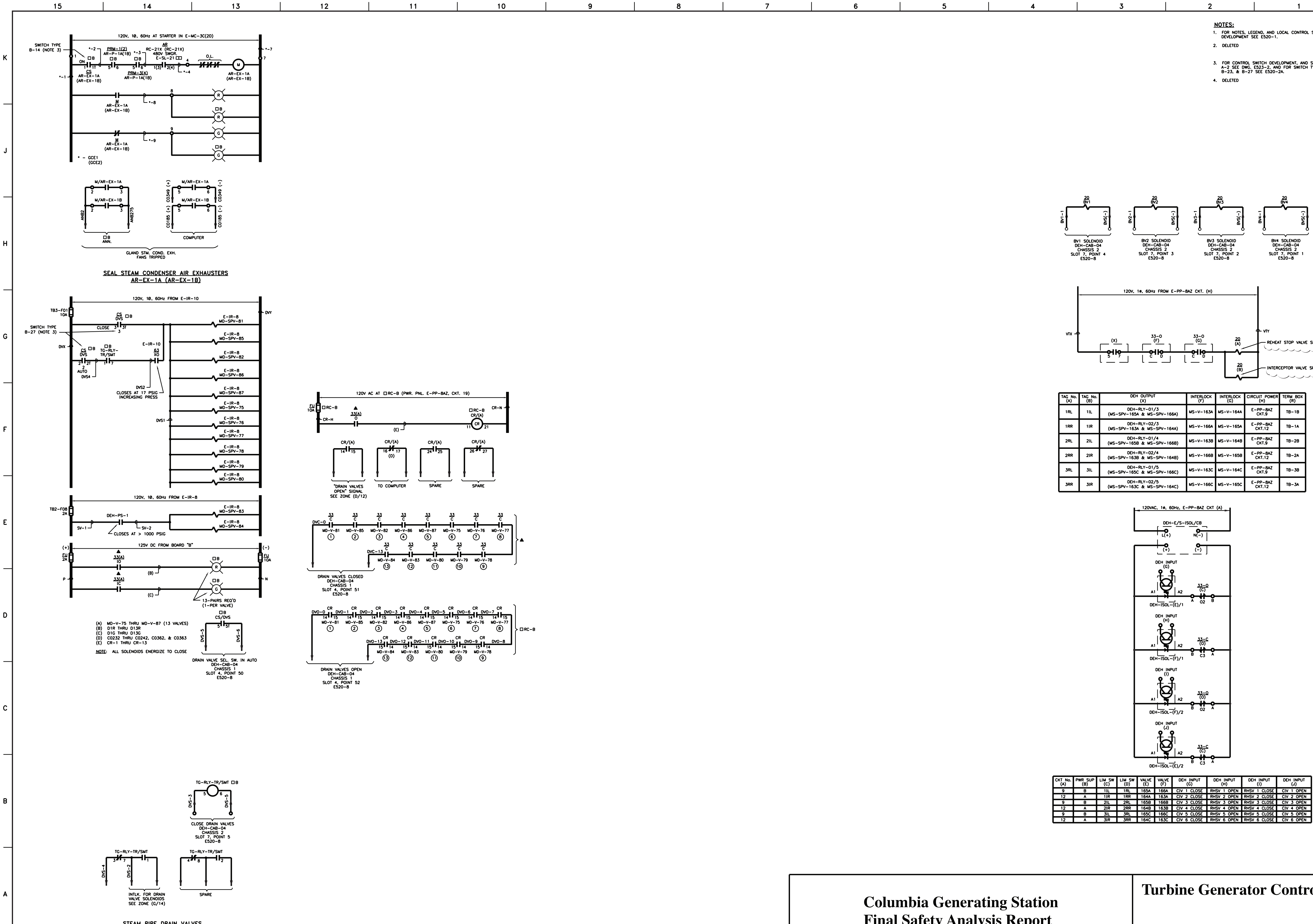
TITLE	DWG.
TURNING GEAR	E520-3
TURNING GEAR SOLENOID VALVES	E520-3
ELECTRO-HYDRAULIC PUMPS	E520-3
BEARING OIL PUMP	E520-3
SEAL OIL BACK UP PUMP	E520-3
BEARING LIFT PUMP	EWD-48E-004
EMERGENCY OIL PUMP	E520-3
OIL VAPOR EXTRACTOR, RESERVOIR	E520-4
OIL VAPOR EXTRACTOR, GENERATOR	E520-4
GLAND STEAM COND AIR EXHAUSTERS	E520-4
EXHAUST HOOD SPRAY VALVES	E520-3
AUTO STOP RESET & VAC TRIP LATCH	E520-4
INTERCEPT & REHEAT STOP VALVES TEST & LIGHTS	E520-4
LOW EH FLUID LEVEL LOCK OUT RELAY	E520-5
ANTIMONITORING PROTECTION	E520-5
TURBINE TRIP CIRCUIT	E520-5
REVERSE CURRENT VALVES	E520-5
TURBINE ALARMS	E520-5
ROTOR GLAND STEAM SPILLOVER SHUT OFF VALVE	E520-4
ROTOR GLAND STEAM SPILLOVER BY PASS VALVE	E520-4
STEAM INLET VALVE TEST INDICATION	E520-4
STEAM BY PASS VALVES INDICATION	E520-4
STEAM PIPE DRAIN VALVES	E520-4
REHEATER CONTROL VALVES	E520-2
VOLTAGE REGULATOR CONTROL	E520-6
VOLTAGE REGULATOR BASE ADJUSTER	E520-6
VOLTAGE REGULATOR VOLTAGE ADJUSTER	E520-6
VOLTAGE REGULATOR ALARMS	E520-6
VOLTAGE REGULATOR SUPPLY BKR	E520-6
FIELD GROUND PROTECTION	E520-6
CONTROL SW DEVELOPMENTS	E520-2A
LIMIT SW DEVELOPMENTS	E520-2
HYDROGEN SIDE SEAL OIL PUMP	E520-7
AIR SIDE SEAL OIL PUMP	E520-7
AIR SIDE SEAL OIL BACK-UP PUMP	E520-7
GENERATOR AUX. PNL. REMOTE ALARMS	E520-7
VACUUM BREAKERS	E520-4
ANTI MOTORING LOCKOUT CIRCUIT	E520-5
QUICK SOL. VALVES	E520-5
RPS/REVAB - GOV. VALVE FAST CLOSURE EH PRESS SW. TEST	E520-2
EXCITER FIELD GROUND DETECTION	E520-6
EWD-51E-017 STATOR COIL WATER PUMP SCW-P-1	-
EWD-51E-018 STATOR COIL WATER PUMP SCW-P-2	-
CVI 218-03,7864 GENERATOR AUX. CONTROL STATION "GACS"	-
TRIP TRICON I/O CARD POINTS	E520-8
MONITORING TRICON I/O CARD POINT-9	E520-9
CONTROL TRICON #1 I/O CARD POINT-10	E520-10
CONTROL TRICON #2 I/O CARD POINT-11	E520-11

Columbia Generating Station
Final Safety Analysis Report

Turbine Generator Control Elementary Diagram

Draw. No. E520-1 | Rev. 13 | Figure 10.2-7.1

Form No. 960690ai



NOTES:

1. FOR NOTES, LEGEND, AND LOCAL CONTROL SWITCH DEVELOPMENT SEE E520-1.
2. DELETED
3. FOR CONTROL SWITCH DEVELOPMENT, AND SWITCH TYPE A-2 SEE DWG. E523-2, AND FOR SWITCH TYPE B-14, B-23, & B-27 SEE E520-2A.
4. DELETED

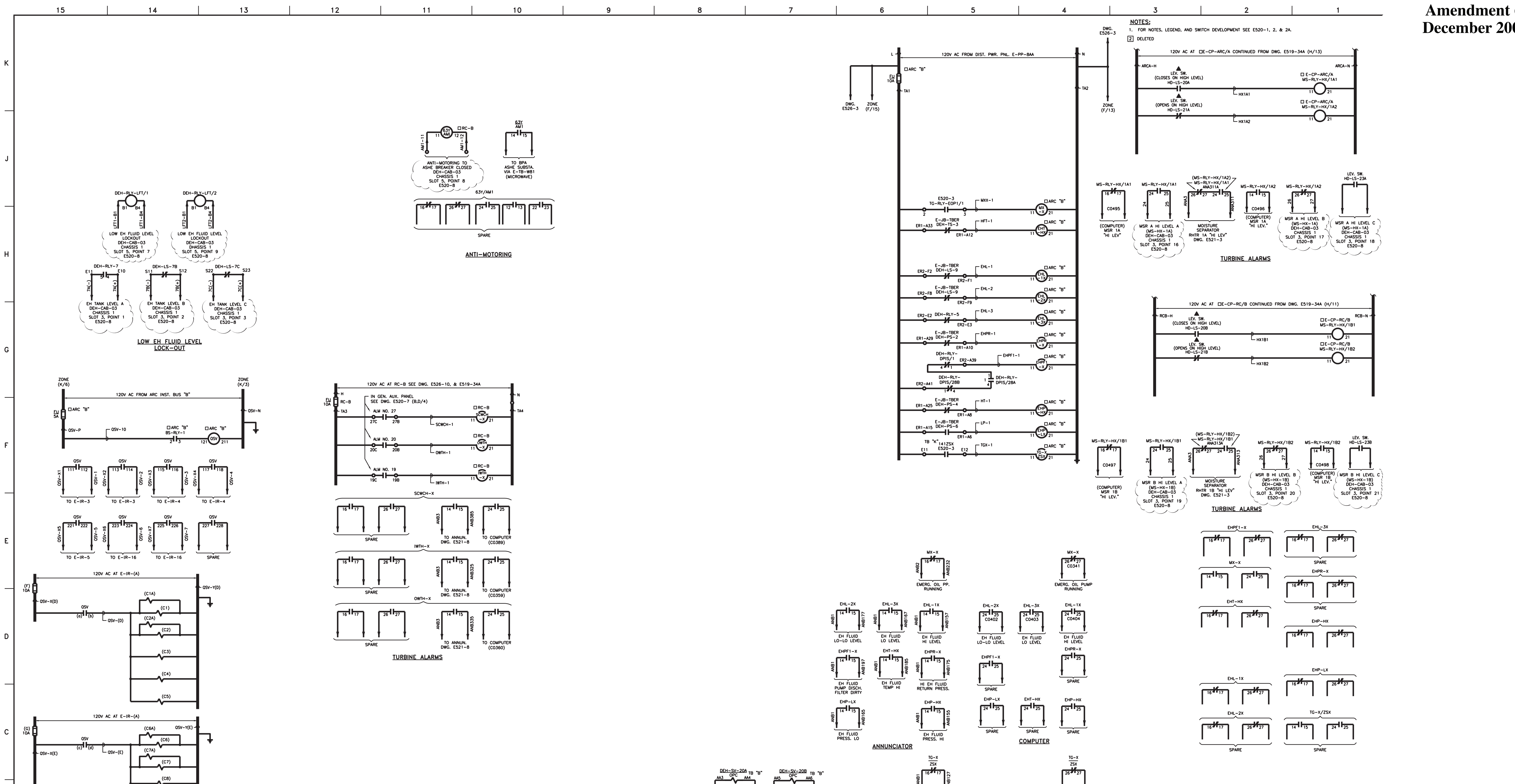
TAG No. (A)	TAG No. (B)	DEH OUTPUT (X)	INTERLOCK (F)	INTERLOCK (G)	CIRCUIT POWER (H)	TERM BOX (R)
1RL	1IL	DEH-RLY-01/3 (MS-SPV-165A & MS-SPV-166A)	MS-V-163A	MS-V-164A	E-PP-8AZ CKT.9	TB-1B
1RR	1IR	DEH-RLY-02/3 (MS-SPV-163A & MS-SPV-164A)	MS-V-166A	MS-V-165A	E-PP-8AZ CKT.12	TB-1A
2RL	2IL	DEH-RLY-01/4 (MS-SPV-165B & MS-SPV-166B)	MS-V-163B	MS-V-164B	E-PP-8AZ CKT.9	TB-2B
2RR	2IR	DEH-RLY-02/4 (MS-SPV-163B & MS-SPV-164B)	MS-V-166B	MS-V-165B	E-PP-8AZ CKT.12	TB-2A
3RL	3IL	DEH-RLY-01/5 (MS-SPV-165C & MS-SPV-166C)	MS-V-163C	MS-V-164C	E-PP-8AZ CKT.9	TB-3B
3RR	3IR	DEH-RLY-02/5 (MS-SPV-163C & MS-SPV-164C)	MS-V-166C	MS-V-165C	E-PP-8AZ CKT.12	TB-3A

CKT No. (A)	PWR SUP (B)	LIM SW (C)	LIM SW (D)	VALVE (E)	VALVE (F)	DEH INPUT (G)	DEH INPUT (H)	DEH INPUT (I)	DEH INPUT (J)
9	B	1IL	1RL	165A	166A	CIV 1 CLOSE	RHSV 1 OPEN	RHSV 1 CLOSE	CIV 1 OPEN
12	A	1IR	1RR	164A	163A	CIV 2 CLOSE	RHSV 2 OPEN	RHSV 2 CLOSE	CIV 2 OPEN
9	B	2IL	2RL	165B	166B	CIV 3 CLOSE	RHSV 3 OPEN	RHSV 3 CLOSE	CIV 3 OPEN
12	A	2IR	2RR	164B	163B	CIV 4 CLOSE	RHSV 4 OPEN	RHSV 4 CLOSE	CIV 4 OPEN
9	B	3IL	3RL	165C	166C	CIV 5 CLOSE	RHSV 5 OPEN	RHSV 5 CLOSE	CIV 5 OPEN
12	A	3IR	3RR	164C	163C	CIV 6 CLOSE	RHSV 6 OPEN	RHSV 6 CLOSE	CIV 6 OPEN

Columbia Generating Station
Final Safety Analysis Report

Turbine Generator Control Elementary Diagram

Draw. No. E520-4 | Rev. 32 | Figure 10.2-7.2



VALVES (C1) TO (C10) DE-ENERGIZE TO CLOSE REVERSE CURRENT VALVES; ALL VALVES ARE LOCATED LOCALLY.

INSTR. RACK	(A)	3	4	5	16	
QSV RELAY CONTACT NUMBERS	(a)-(b)	111-112	115-116	221-222	223-224	
	(c)-(d)	113-114	117-118	NOT APPLICABLE	225-226	
QUICK SOLENOID VALVES	(C1)	BS-QSV-5A	BS-QSV-5B	BS-QSV-8E	HD-QSV-31A/HD-SPV-34A	(C1A)
	(C2)	BS-QSV-7A	BS-QSV-7B	BS-QSV-8F	HD-QSV-31B/HD-SPV-34B	(C2A)
	(C3)	BS-QSV-8A	BS-QSV-8C	BS-QSV-10E	HD-QSV-32A	
	(C4)	BS-QSV-8B	BS-QSV-8D	BS-QSV-10F	HD-QSV-32B	
	(C5)	BS-QSV-10A	BS-QSV-10C	BS-QSV-13C	HD-QSV-33A	
	(C6)	BS-QSV-10B	BS-QSV-10D	NOT USED	HD-QSV-31C/HD-SPV-34C	(C6A)
	(C7)	BS-QSV-13A	BS-QSV-13B	NOT USED	HD-QSV-31D/HD-SPV-34D	(C7A)
	(C8)	BS-QSV-21A	BS-QSV-21B	NOT USED	HD-QSV-32C	
	(C9)	NOT USED	NOT USED	NOT USED	HD-QSV-32D	
	(C10)	NOT USED	NOT USED	NOT USED	HD-QSV-33B	
WIRE NUMBER SUFFIX	(D)	1	3	5	6	
	(E)	2	4	NOT USED	7	
FUSE NUMBER	(F)	TB1A-F21	TB1A-F21	TB6B-F14	TB1A-F07	
	(G)	TB1A-F22	TB1A-F22	NOT USED	TB1B-F07	

QUICK ACTING SOL. VALVES FOR REVERSE CURRENT VALVES

Columbia Generating Station
Final Safety Analysis Report

Turbine Generator Control Elementary Diagram

Draw. No. E520-5 | Rev. 39 | Figure 10.2-7.3

10.3 MAIN STEAM SUPPLY SYSTEM

10.3.1 DESIGN BASES

The main steam supply system is designed for the following conditions:

a. Deliver steam from the reactor to the turbine generator from warmup to 105% of rated load,

b. Provide steam for the second-stage reheaters and steam-jet air ejectors,

c. Bypass steam to the main condenser during startup and in the event steam requirements of the turbine generator are less than that produced by the reactor,

d. Provide steam to the gland seal steam evaporator during startup, low load operation, and shutdown,

e. Provide steam to drive reactor feedwater pumps during startup and low load operation, and

f. Provide steam to the offgas preheaters.

The design pressure and temperature of the main steam piping is 1250 psig and 575°F.

The main steam lines are designed to include accesses to permit inservice inspection and testing (refer to Sections 5.2.4 and 6.6).

Design codes are given in Table 3.2-1, item 2, Nuclear Boiler System, and item 43, Power Conversion System. The environmental design bases for the main steam supply system are contained in Section 3.11.

10.3.2 SYSTEM DESCRIPTION

The main steam supply system is shown in Figures 10.3-1 and piping drawings are shown in Figures 3.6-32, 3.6-33, 3.6-34, 3.6-35, 3.6-50, 3.6-51, 3.6-53, 3.6-58, 3.6-60, and 10.3-2. The main steam line piping consists of four 30-in. (26-in. in reactor building) lines extending from the reactor pressure vessel to the main steam header located upstream of the turbine stop and control valves. This header placement ensures a positive means of bypassing steam via the turbine bypass system during transient conditions and startup. Branch lines from the main steam line provide the steam requirements for the reactor feed pumps, second stage reheaters, gland seal steam evaporator, offgas preheaters, and steam jet air ejectors.

The MSIVs are a wye-pattern-type globe valve utilizing pneumatic air to open and spring load with pneumatic air assist to close. Energizing control valves provide pilot and actuator air to open the valve. Deenergizing the control valves removes pilot air which vents actuator opening air and directs air to assist the spring force in closing the valve.

Loss of compressed air failure mode results are

a. Loss of compressed air due to loss of nonseismic air lines* results in loss of pilot air and closure of the MSIV by both spring force and pneumatic air cylinder force.

b. Loss of compressed air due to loss of Seismic Category I air lines† results in loss of both pilot air and actuator air with the MSIVs closing by spring force only.

Under normal operation the air supply maintains the required air for holding the valve open and charging the air storage tank. The check valve at the air storage tank inlet ensures a pneumatic supply for assist in closing the valve. No safety-related makeup supply is required for closure of the MSIVs for safe plant shutdown.

The removal of electrical power or failure of both the solenoids on the control valve automatically initiates closure of the MSIVs. Safety-related components ensuring removal of power to the solenoids when required are the only electrical power requirement. Section 9.3.1 describes the compressed air systems.

Equalizing lines connecting steam lines outside of the containment are used to equalize pressure across the main steam line isolation valves prior to restart following a steam line isolation. Assuming all steam line isolation valves have closed, the outer containment isolation valves are opened first and the drain lines are used to warm up and pressurize the outside steam lines. Following warmup the inboard main steam line isolation valves are opened.

10.3.3 SAFETY EVALUATION

Table 3.2-1 lists the applicable seismic category, quality group classification, and safety class for the main steam supply system. The effects of main steam line breaks and other accident conditions outside the containment are evaluated in Chapter 15. Protection against dynamic effects associated with the postulated rupture of piping inside or outside of containment is discussed in Section 3.6.

---

* Nonseismic lines are those lines supplying air to the isolation valve upstream of the check valve and to the pilot side of the air pilot valves (Figure 9.3-1, detail B).

† Seismic Category I lines include an air storage tank, check valve, and lines from the check valve to the actuator pilot valve (Figure 9.3-1, detail B).

10.3.4 INSPECTION AND TESTING REQUIREMENTS

The main steam lines were hydrostatically tested prior to initial operation. Nondestructive testing is performed in accordance with the applicable code requirements.

Preoperational and inservice inspection of the main steam lines and the main steam line isolation valves are presented in Sections 5.2.4 and 6.6.

The use of four main steam lines permits inspection and testing of the turbine stop, control, reheat stop, and intercept valves and main steam line isolation valves during plant operation with a minimum of load reduction.

10.3.5 WATER CHEMISTRY

This section is not applicable to a BWR. See Section 10.4.6 for reactor coolant water chemistry considerations.

10.3.6 STEAM AND FEEDWATER SYSTEM MATERIALS

10.3.6.1 Fracture Toughness

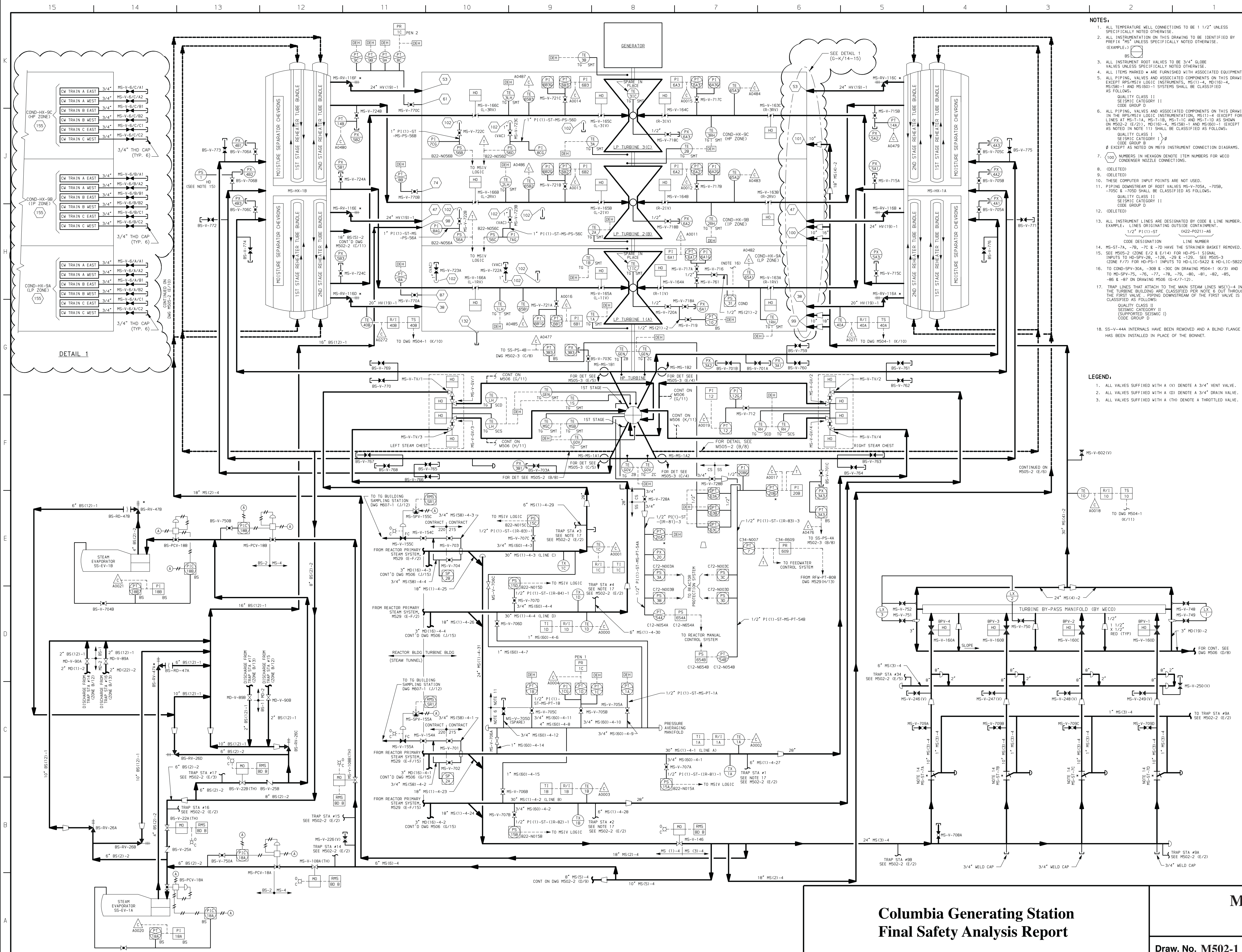
Impact tests in accordance with the size limitations specified in ASME Code Section III, Class 1, are performed on all ASME Code Section III, Class 1, main steam and feedwater materials, as well as Class 2 main steam system materials for all pressure retaining ferritic steel parts. The tests are conducted at a temperature of 45°F or lower in accordance with NB or NC-2310 of the Summer 1972 or Winter 1973 Addendum of ASME Code Section III, as applicable.

10.3.6.2 Materials Selection and Fabrication

All materials used for portions of the main steam system described in this section are included in Appendix I to Section III of the ASME Boiler and Pressure Vessel (B&PV) Code. The requirements for welding the main steam piping from the reactor to the turbine generator are in accordance with ASME Section III, 1971 Edition through the Winter 1973 Addenda. The welding requirements for other steam and feedwater piping are in accordance with ANSI B31.1, October 1973 (see Section 3.2).

Cleaning of components in the main steam system is in accordance with ANSI N45.2.1 (October 1973) or ASTM A380-57 (October 1973) for stainless steel surfaces and Regulatory Guide 1.37.

Degree of conformance to the following Regulatory Guides is addressed in Section 1.8: 1.31, Control of Stainless Steel Welding; 1.36, Nonmetallic Thermal Insulation for Austenitic Stainless Steel; 1.44, Control of the Use of Sensitized Stainless Steel; 1.50, Control of Preheat Temperature for Welding of Low-Alloy Steel; and 1.71, Welder Qualification for Areas of Limited Accessibility.



NOTES:

1. ALL TEMPERATURE WELL CONNECTIONS TO BE 1 1/2" UNLESS SPECIFICALLY NOTED OTHERWISE.
2. ALL INSTRUMENTATION ON THIS DRAWING TO BE IDENTIFIED BY PREFIX "MS" UNLESS SPECIFICALLY NOTED OTHERWISE.
   (EXAMPLE:) BS
3. ALL INSTRUMENT ROOT VALVES TO BE 3/4" GLOBE VALVES UNLESS SPECIFICALLY NOTED OTHERWISE.
4. ALL ITEMS MARKED * ARE FURNISHED WITH ASSOCIATED EQUIPMENT.
5. ALL PIPING, VALVES AND ASSOCIATED COMPONENTS ON THIS DRAWING EXCEPT RPS/MSIV LOGIC INSTRUMENTS, MS(1)-4, MD(16)-4, MS(58)-1 AND MS(60)-1 SYSTEMS SHALL BE CLASSIFIED AS FOLLOWS:
   QUALITY CLASS II
   SEISMIC CATEGORY II
   CODE GROUP D
6. ALL PIPING, VALVES AND ASSOCIATED COMPONENTS ON THIS DRAWING IN THE RPS/MSIV LOGIC INSTRUMENTATION, MS(1)-4 (EXCEPT FOR LINES AT MS-T-1A, MS-T-1B, MS-T-1C AND MS-T-1D AS SHOWN ON M502-2 (E/2)), MD(16)-4, MS(58)-1 AND MS(60)-1 (EXCEPT AS NOTED IN NOTE 11) SHALL BE CLASSIFIED AS FOLLOWS:
   $\left.\begin{array}{l}\text{QUALITY CLASS I}\\\text{SEISMIC CATEGORY I}\\\text{CODE GROUP B}\end{array}\right\}\text{Ø}$
   Ø EXCEPT AS NOTED ON M619 INSTRUMENT CONNECTION DIAGRAMS.
7. 100 NUMBERS IN HEXAGON DENOTE ITEM NUMBERS FOR WECO CONDENSER NOZZLE CONNECTIONS.
8. (DELETED)
9. (DELETED)
10. THESE COMPUTER INPUT POINTS ARE NOT USED.
11. PIPING DOWNSTREAM OF ROOT VALVES MS-V-705A, -705B, -705C & -705D SHALL BE CLASSIFIED AS FOLLOWS:
    QUALITY CLASS II
    SEISMIC CATEGORY II
    CODE GROUP D
12. (DELETED)
13. ALL INSTRUMENT LINES ARE DESIGNATED BY CODE & LINE NUMBER. EXAMPLE: LINES ORIGINATING OUTSIDE CONTAINMENT.
    $\underbrace{\text{1/2" PI(1)-ST}}_{\text{CODE DESIGNATION}}\quad\underbrace{\text{(H22-P021)-A6}}_{\text{LINE NUMBER}}$
14. MS-ST-7A, -7B, -7C & -7D HAVE THE STRAINER BASKET REMOVED.
15. SEE M505-2 (ZONE E/2 & E/14) FOR HD-PS-1 SIGNAL INPUTS TO HD-SPV-28, -128, -29 & -129. SEE M505-3 (ZONE F/7) FOR HD-PS-1 INPUTS TO HD-LIC-5A22 & HD-LIC-5B22.
16. TO COND-SPV-30A, -30B & -30C ON DRAWING M504-1 (K/3) AND TO MD-SPV-75, -76, -77, -78, -79, -80, -81, -82, -85, -86 & -87 ON DRAWING M506 (G-K/7-12).
17. TRAP LINES THAT ATTACH TO THE MAIN STEAM LINES MS(1)-4 IN THE TURBINE BUILDING ARE CLASSIFIED PER NOTE 6 OUT THROUGH THE FIRST VALVE . PIPING DOWNSTREAM OF THE FIRST VALVE IS CLASSIFIED AS FOLLOWS:
    QUALITY CLASS II
    SEISMIC CATEGORY II
    (SUPPORTED SEISMIC I)
    CODE GROUP D
18. SS-V-44A INTERNALS HAVE BEEN REMOVED AND A BLIND FLANGE HAS BEEN INSTALLED IN PLACE OF THE BONNET.

LEGEND:

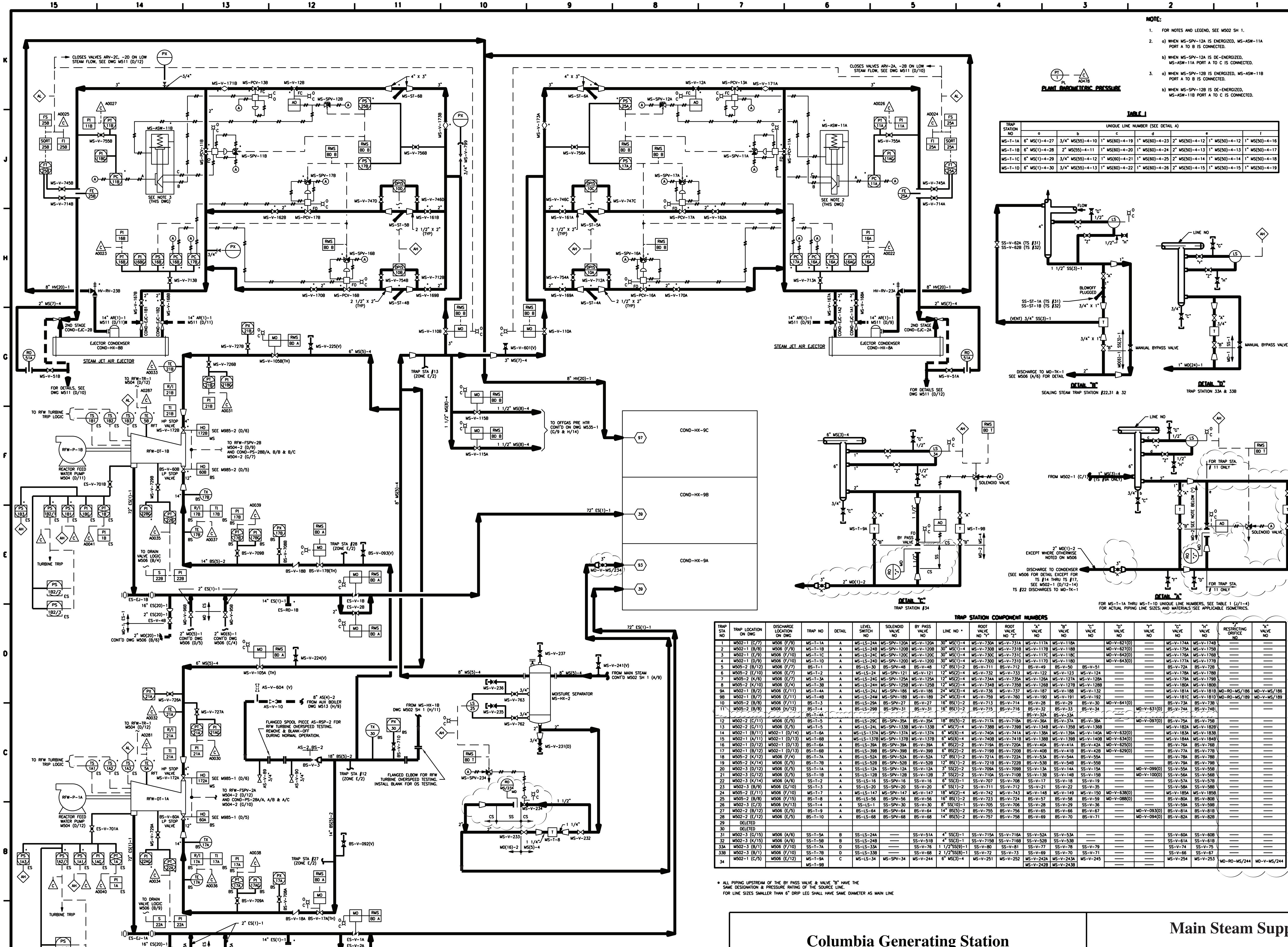
1. ALL VALVES SUFFIXED WITH A (V) DENOTE A 3/4" VENT VALVE.
2. ALL VALVES SUFFIXED WITH A (D) DENOTE A 3/4" DRAIN VALVE.
3. ALL VALVES SUFFIXED WITH A (TH) DENOTE A THROTTLED VALVE.

Columbia Generating Station
Final Safety Analysis Report

Main Steam Supply System

Draw. No. M502-1	Rev. 37	Figure 10.3-1.1

Form No. 960690ai



NOTE:

1. FOR NOTES AND LEGEND, SEE M502 SH 1.
2. a) WHEN MS-SPV-12A IS ENERGIZED, MS-ASW-11A PORT A TO B IS CONNECTED.
   b) WHEN MS-SPV-12A IS DE-ENERGIZED, MS-ASW-11A PORT A TO C IS CONNECTED.
3. a) WHEN MS-SPV-12B IS ENERGIZED, MS-ASW-11B PORT A TO B IS CONNECTED.
   b) WHEN MS-SPV-12B IS DE-ENERGIZED, MS-ASW-11B PORT A TO C IS CONNECTED.

PLANT BAROMETERIC PRESSURE

TABLE I

TRAP STATION NO	UNIQUE LINE NUMBER (SEE DETAIL A)						
	a	b	c	d	e		f
MS-T-1A	6" MS(1)-4-27	3/4" MS(55)-4-10	1" MS(60)-4-19	1" MS(60)-4-23	2" MS(50)-4-12	1" MS(50)-4-12	1" MS(50)-4-16
MS-T-1B	6" MS(1)-4-28	2" MS(55)-4-11	1" MS(60)-4-20	1" MS(60)-4-24	2" MS(50)-4-13	1" MS(50)-4-13	1" MS(50)-4-17
MS-T-1C	6" MS(1)-4-29	3/4" MS(55)-4-12	1" MS(60)-4-21	1" MS(60)-4-25	2" MS(50)-4-14	1" MS(50)-4-14	1" MS(50)-4-18
MS-T-1D	6" MS(1)-4-30	3/4" MS(55)-4-13	1" MS(60)-4-22	1" MS(60)-4-26	2" MS(50)-4-15	1" MS(50)-4-15	1" MS(50)-4-19

TRAP STATION COMPONENT NUMBERS

TRAP STA NO	TRAP LOCATION ON DWG	DISCHARGE LOCATION ON DWG	TRAP NO	DETAIL	LEVEL SWITCH NO	SOLENOID VALVE NO	BY PASS VALVE NO	LINE NO *	ROOT VALVE NO "Y"	ROOT VALVE NO "Z"	"A" VALVE NO	"B" VALVE NO	"C" VALVE NO	"D" VALVE NO	"F" VALVE NO	"G" VALVE NO	"H" VALVE NO	"J" RESTRICTING ORIFICE NO	"K" VALVE NO
1	M502-1 (C/7)	M506 (F/9)	MS-T-1A	A	MS-LS-24A	MS-SPV-120A	MS-V-120A	30" MS(1)-4	MS-V-730A	MS-V-731A	MS-V-117A	MS-V-118A		MD-V-621(D)	——	MS-V-174A	MS-V-174B	——	——
2	M502-1 (B/8)	M506 (F/9)	MS-T-1B	A	MS-LS-24B	MS-SPV-120B	MS-V-120B	30" MS(1)-4	MS-V-730B	MS-V-731B	MS-V-117B	MS-V-118B		MD-V-627(D)	——	MS-V-175A	MS-V-175B	——	——
3	M502-1 (E/9)	M506 (F/10)	MS-T-1C	A	MS-LS-24C	MS-SPV-120C	MS-V-120C	30" MS(1)-4	MS-V-730C	MS-V-731C	MS-V-117C	MS-V-118C		MD-V-642(D)	——	MS-V-176A	MS-V-176B	——	——
4	M502-1 (D/9)	M506 (F/10)	MS-T-1D	A	MS-LS-24D	MS-SPV-120D	MS-V-120D	30" MS(1)-4	MS-V-730D	MS-V-731D	MS-V-117D	MS-V-118D		MD-V-643(D)	——	MS-V-177A	MS-V-177B	——	——
5	M505-2 (B/12)	M506 (F/7)	BS-T-1	A	BS-LS-30	BS-SPV-48	BS-V-48	12" BS(1)-2	BS-V-711	BS-V-712	BS-V-49	BS-V-50	BS-V-51	——	——	BS-V-72A	BS-V-72B	——	——
6	M505-2 (E/10)	M506 (E/7)	MS-T-2	A	MS-LS-24	MS-SPV-121	MS-V-121	12" MS(2)-4	MS-V-732	MS-V-733	MS-V-122	MS-V-123	MS-V-124	——	——	MS-V-178A	MS-V-178B	——	——
7	M505-2 (K/6)	M506 (E/7)	MS-T-3A	A	MS-LS-24G	MS-SPV-125A	MS-V-125A	12" MS(2)-4	MS-V-734A	MS-V-735A	MS-V-126A	MS-V-127A	MS-V-128A	——	——	MS-V-179A	MS-V-179B	——	——
8	M505-2 (K/10)	M506 (E/4)	MS-T-3B	A	MS-LS-24H	MS-SPV-125B	MS-V-125B	12" MS(2)-4	MS-V-734B	MS-V-735B	MS-V-126B	MS-V-127B	MS-V-128B	——	——	MS-V-180A	MS-V-180B	——	——
9A	M502-1 (B/2)	M506 (E/11)	MS-T-4A	A	MS-LS-24J	MS-SPV-186	MS-V-186	24" MS(3)-4	MS-V-736	MS-V-737	MS-V-187	MS-V-188	MS-V-132	——	——	MS-V-181A	MS-V-181B	MD-RO-MS/186	MD-V-MS/186
9B	M502-1 (B/7)	M506 (E/11)	MS-T-4B	A	MS-LS-24M	MS-SPV-189	MS-V-189	24" MS(3)-4	MS-V-759	MS-V-760	MS-V-190	MS-V-191	MS-V-192	——	——	MS-V-181C	MS-V-181D	MD-RO-MS/189	MD-V-MS/189
10	M505-2 (B/8)	M506 (F/11)	BS-T-3	A	BS-LS-29A	BS-SPV-27	BS-V-27	16" BS(1)-2	BS-V-713	BS-V-714	BS-V-28	BS-V-29	BS-V-30	MD-V-641(D)	——	BS-V-73A	BS-V-73B	——	——
11	M505-2 (B/8)	M506 (H/12)	BS-T-4 BS-T-4A	A	BS-LS-29B	BS-SPV-31	BS-V-31	16" BS(1)-2	BS-V-715	BS-V-716	BS-V-32 BS-V-32A	BS-V-33 BS-V-33A	BS-V-34	—— ——	MD-V-631(D)	BS-V-74A	BS-V-74B	——	——
12	M502-2 (C/11)	M506 (E/5)	BS-T-5	A	BS-LS-29C	BS-SPV-35A	BS-V-35A	18" BS(5)-2	BS-V-717A	BS-V-718A	BS-V-36A	BS-V-37A	BS-V-38A	——	MD-V-097(D)	BS-V-75A	BS-V-75B	——	——
13	M502-2 (G/11)	M506 (E/5)	MS-T-5	A	MS-LS-24L	MS-SPV-133B	MS-V-133B	4" MS(7)-4	MS-V-738B	MS-V-739B	MS-V-134B	MS-V-135B	MS-V-136B	——	——	MS-V-182A	MS-V-182B	——	——
14	M502-1 (B/11)	M502-1 (D/14)	MS-T-6A	A	MS-LS-137A	MS-SPV-137A	MS-V-137A	6" MS(6)-4	MS-V-740A	MS-V-741A	MS-V-138A	MS-V-139A	MS-V-140A	MD-V-632(D)	——	MS-V-183A	MS-V-183B	——	——
15	M502-1 (A/11)	M502-1 (D/13)	MS-T-6B	A	MS-LS-137B	MS-SPV-137B	MS-V-137B	6" MS(6)-4	MS-V-740B	MS-V-741B	MS-V-138B	MS-V-139B	MS-V-140B	MD-V-634(D)	——	MS-V-184A	MS-V-184B	——	——
16	M502-1 (D/12)	M502-1 (D/13)	BS-T-6A	A	BS-LS-39A	BS-SPV-39A	BS-V-39A	6" BS(2)-2	BS-V-719A	BS-V-720A	BS-V-40A	BS-V-41A	BS-V-42A	MD-V-625(D)	——	BS-V-76A	BS-V-76B	——	——
17	M502-1 (B/12)	M502-1 (D/13)	BS-T-6B	A	BS-LS-39B	BS-SPV-39B	BS-V-39B	6" BS(2)-2	BS-V-719B	BS-V-720B	BS-V-40B	BS-V-41B	BS-V-42B	MD-V-629(D)	——	BS-V-77A	BS-V-77B	——	——
18	M505-2 (K/12)	M506 (F/4)	BS-T-7A	A	BS-LS-52A	BS-SPV-52A	BS-V-52A	12" BS(1)-2	BS-V-721A	BS-V-722A	BS-V-53A	BS-V-54A	BS-V-55A	——	——	BS-V-78A	BS-V-78B	——	——
19	M505-2 (K/14)	M506 (E/5)	BS-T-7B	A	BS-LS-52B	BS-SPV-52B	BS-V-52B	12" BS(1)-2	BS-V-721B	BS-V-722B	BS-V-53B	BS-V-54B	BS-V-55B	——	——	BS-V-79A	BS-V-79B	——	——
20	M502-3 (D/12)	M506 (E/5)	SS-T-1A	A	SS-LS-12A	SS-SPV-12A	SS-V-12A	3" SS(2)-2	SS-V-709A	SS-V-709B	SS-V-13A	SS-V-14A	SS-V-15A	——	MD-V-099(D)	SS-V-55A	SS-V-55B	——	——
21	M502-3 (G/12)	M506 (E/5)	SS-T-1B	A	SS-LS-12B	SS-SPV-12B	SS-V-12B	3" SS(2)-2	SS-V-710A	SS-V-710B	SS-V-13B	SS-V-14B	SS-V-15B	——	MD-V-100(D)	SS-V-56A	SS-V-56B	——	——
22	M502-3 (K/14)	M506 (A/6)	SS-T-2	A	SS-LS-16	SS-SPV-16	SS-V-16	6" SS(3)-1	SS-V-707	SS-V-708	SS-V-17	SS-V-18	SS-V-19	——	——	SS-V-57A	SS-V-57B	——	——
23	M502-3 (B/9)	M506 (G/10)	SS-T-3	A	SS-LS-20	SS-SPV-20	SS-V-20	6" SS(1)-2	SS-V-711	SS-V-712	SS-V-21	SS-V-22	SS-V-35	——	——	SS-V-58A	SS-V-58B	——	——
24	M505-2 (E/11)	M506 (F/10)	MS-T-7	A	MS-LS-147	MS-SPV-147	MS-V-147	18" MS(2)-4	MS-V-742	MS-V-743	MS-V-148	MS-V-149	MS-V-150	MD-V-638(D)	——	MS-V-185A	MS-V-185B	——	——
25	M505-2 (B/8)	M506 (F/15)	BS-T-8	A	BS-LS-56	BS-SPV-56	BS-V-56	16" BS(1)-2	BS-V-723	BS-V-724	BS-V-57	BS-V-58	BS-V-59	MD-V-088(D)	——	BS-V-80A	BS-V-80B	——	——
26	M502-3 (C/3)	M506 (H/13)	SS-T-4	A	SS-LS-1	SS-SPV-30	SS-V-30	8" SS(10)-1	SS-V-705	SS-V-706	SS-V-28	SS-V-29	SS-V-36	——	——	SS-V-59A	SS-V-59B	——	——
27	M502-2 (B/12)	M506 (E/5)	BS-T-9	A	BS-LS-64	BS-SPV-64	BS-V-64	14" BS(5)-2	BS-V-755	BS-V-756	BS-V-65	BS-V-66	BS-V-67	——	MD-V-093(D)	BS-V-81A	BS-V-81B	——	——
28	M502-2 (E/12)	M506 (E/5)	BS-T-10	A	BS-LS-68	BS-SPV-68	BS-V-68	14" BS(5)-2	BS-V-757	BS-V-758	BS-V-69	BS-V-70	BS-V-71	——	MD-V-094(D)	BS-V-82A	BS-V-82B	——	——
29	DELETED																		
30	DELETED																		
31	M502-3 (G/15)	M506 (A/6)	SS-T-5A	B	SS-LS-24A	——	SS-V-51A	4" SS(3)-1	SS-V-715A	SS-V-716A	SS-V-52A	SS-V-53A	——	——	——	SS-V-60A	SS-V-60B	——	——
32	M502-3 (K/15)	M506 (A/6)	SS-T-5B	B	SS-LS-24B	——	SS-V-51B	4" SS(3)-1	SS-V-715B	SS-V-716B	SS-V-52B	SS-V-53B	——	——	——	SS-V-61A	SS-V-61B	——	——
33A	M502-3 (B/1)	M506 (F/10)	SS-T-7A	D	SS-LS-33A	——	SS-V-76	1 1/2"SS(9)-1	SS-V-80	SS-V-81	SS-V-77	SS-V-78	SS-V-79	——	——	SS-V-74	SS-V-75	——	——
33B	M502-3 (B/1)	M506 (F/10)	SS-T-7B	D	SS-LS-33B	——	SS-V-68	2 1/2"SS(8)-1	SS-V-72	SS-V-73	SS-V-69	SS-V-70	SS-V-71	——	——	SS-V-66	SS-V-67	——	——
34	M502-1 (C/5)	M506 (E/12)	MS-T-9A MS-T-9B	C	MS-LS-34	MS-SPV-34	MS-V-244	6" MS(3)-4	MS-V-251	MS-V-252	MS-V-242A MS-V-242B	MS-V-243A MS-V-243B	MS-V-245	—— ——	—— ——	MS-V-254	MS-V-253	MD-RO-MS/244	MD-V-MS/244

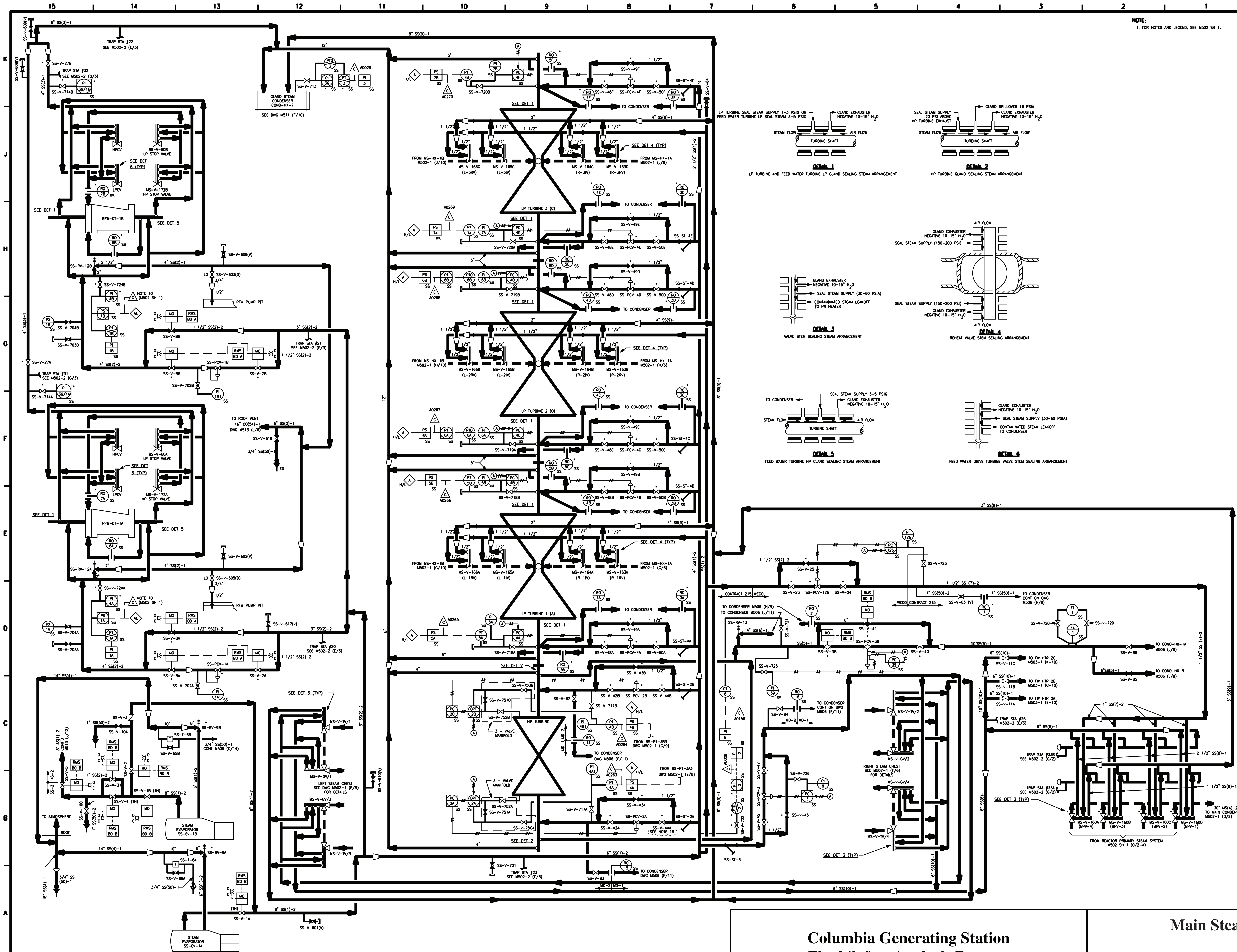
* ALL PIPING UPSTREAM OF THE BY PASS VALVE & VALVE "B" HAVE THE SAME DESIGNATION & PRESSURE RATING OF THE SOURCE LINE.
FOR LINE SIZES SMALLER THAN 6" DRIP LEG SHALL HAVE SAME DIAMETER AS MAIN LINE

Columbia Generating Station
Final Safety Analysis Report

Main Steam Supply System

Draw. No. M502-2 | Rev. 27 | Figure 10.3-1.2

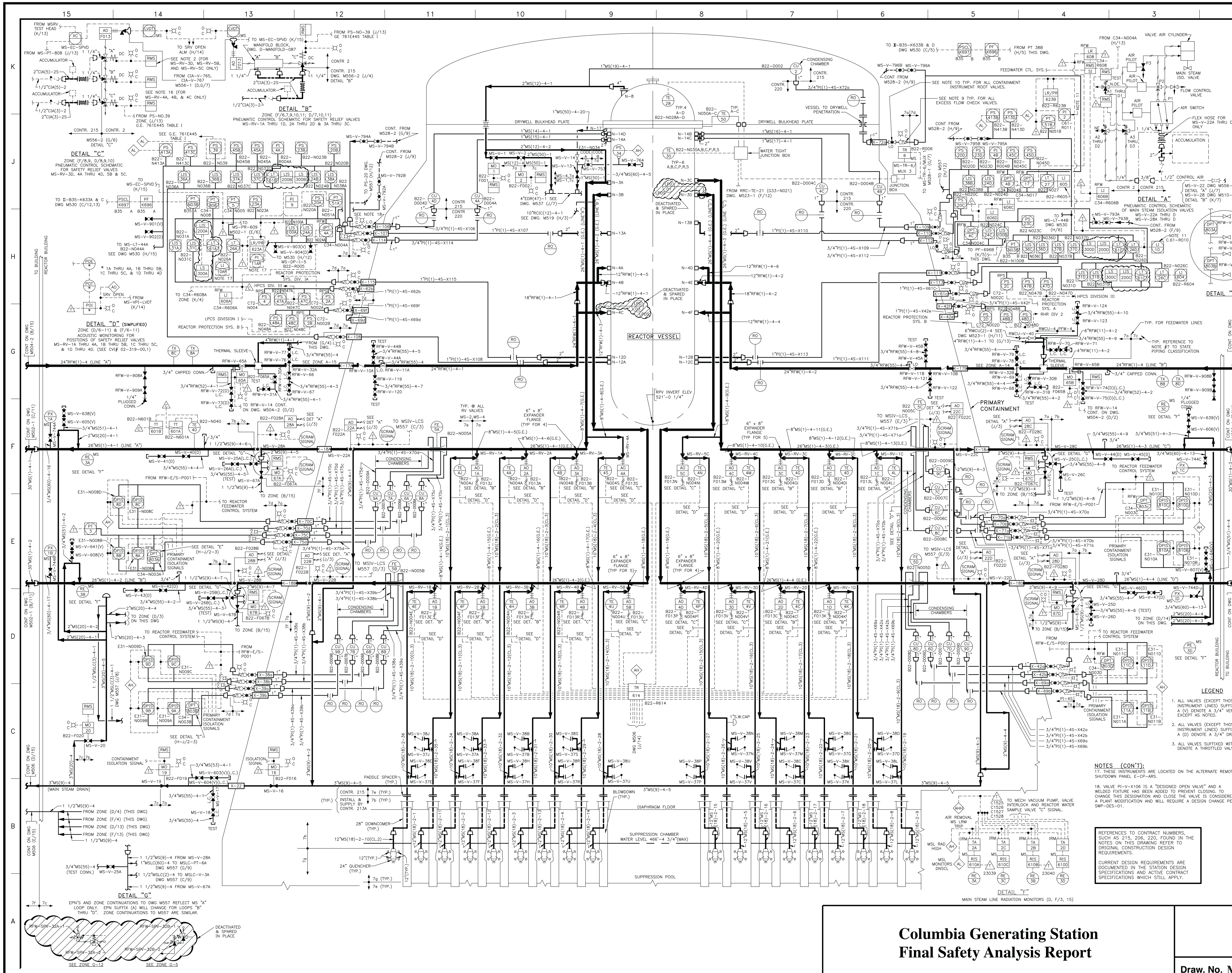
Amendment 60
December 2009



Columbia Generating Station
Final Safety Analysis Report

Main Steam Supply System

Draw. No. M502-3 | Rev. 19 | Figure 10.3-1.3



NOTES:

1. FOR ALL INITIATION SIGNALS SEE G.E. NUCLEAR BOILER SYSTEM B22–1040, DOCUMENT #761E445, TABLE IV & V.

2. THIS EQUIPMENT IS NORMALLY CONTROLLED FROM THE MAIN CONTROL ROOM. IF THE MAIN CONTROL ROOM MUST BE VACATED, THIS CONTROL POINT MAY BE ISOLATED AND CONTROL TRANSFERRED TO THE ALTERNATE REMOTE SHUTDOWN PANEL E–CD–ARS.

3. (DELETED)

4. ALL PIPING SYSTEMS IDENTIFIED BY THE PREFIX "PI" SHALL BE SUPPLIED AND INSTALLED BY CONTRACT #220.

5. (DELETED)

6. (DELETED)

7. PIPING, VALVES, AND ASSOCIATED COMPONENTS ON THIS DWG SHALL BE CLASSIFIED AS FOLLOWS (BREAK POINTS ARE INDICATED ON THE FLOW DIAGRAM):

   a. PROCESS (FEEDWATER OR STEAM) AND INSTRUMENT PIPING WITHIN THE PRIMARY CONTAINMENT AND OUT THROUGH THE OUTERMOST ISOLATION VALVES, EXCEPT SAFETY/RELIEF VALVE DISCHARGE.

      SEISMIC CATEGORY I
      QUALITY CLASS I
      CODE GROUP A

   b. MAIN STEAM PROCESS PIPING BEYOND THE OUTERMOST CONTAINMENT ISOLATION VALVES, EXCEPT BRANCH LINES BEYOND THE FIRST VALVE THAT IS NORMALLY CLOSED OR CAPABLE OF TIMELY ACTUATION. SAFETY/RELIEF DISCHARGE PIPING AS NOTED. INSTRUMENTATION TO THE INSTRUMENT OR AS NOTED TO THE FIRST VALVE THAT IS CAPABLE OF TIMELY ACTUATION.

      SEISMIC CATEGORY I
      QUALITY CLASS I
      CODE GROUP B

   c. FEEDWATER PIPING BEYOND THE OUTERMOST CONTAINMENT ISOLATION VALVES. PIPING DOWNSTREAM OF THE FIRST VALVE CAPABLE OF TIMELY ACTUATION ON BRANCH LINES THAT CONNECT TO THE MAIN STEAM LINE BETWEEN PRIMARY CONTAINMENT AND TURBINE STOP VALVE.

      SEISMIC CATEGORY II ⊕
      QUALITY CLASS II
      CODE GROUP D

   ⊕ THE FEEDWATER PIPING, STEAM PIPING, AND THEIR PIPE SUPPORTS IN THE STEAM TUNNEL, ARE TO BE DESIGNED TO SEISMIC CATEGORY I LOADS.

   d. INSTRUMENTATION CONNECTED TO PRIMARY CONTAINMENT. INSTRUMENT PIPING OUTBOARD OF THE SECOND ISOLATION VALVES ON LINES THAT PENETRATE PRIMARY CONTAINMENT.

      SEISMIC CATEGORY I
      QUALITY CLASS I
      CODE GROUP B

   e. DOWNCOMERS AND SAFETY/RELEIF VALVE DISCHARGE PIPING AS NOTED.

      SEISMIC CATEGORY I
      QUALITY CLASS I
      CODE GROUP C

      CODE STAMP NOT REQUIRED FOR DOWNCOMERS

      ⊕ SEE SECTION 15Q, WNP–2 SPEC

   f. LINE 1 1/2"MS(9)–4 DOWNSTREAM OF MS–V–67A, B, C & D THROUGH THE REACTOR BUILDING WALL IS,

      SEISMIC CATEGORY II ⊕
      QUALITY CLASS II
      CODE GROUP D
      ⊕ SUPPORTED SEISMIC CATEGORY I

      IN THE TURBINE BUILDING THIS LINE IS,

      SEISMIC CATEGORY II
      QUALITY CLASS II
      CODE GROUP D

   g. MSRV QUENCHERS AND DOWNCOMERS AS NOTED SHALL BE CLASSIFIED AS FOLLOWS:

      SEISMIC CATEGORY I
      QUALITY CLASS I

      CODE GROUP: B FOR MATERIAL FABRICATION AND INSTALLATION ONLY. CODE STAMP NOT REQUIRED.

8. ALL INSTRUMENT ROOT VALVES NOT LABELED WILL BE 3/4" GLOBE VALVES UNLESS SPECIFICALLY NOTED OTHERWISE.

9. EXCESS FLOW CHECK VALVES SHALL BE TAGGED AS FOLLOWS: PI–EFC–X (PENETRATION NO).

10. CONTAINMENT INSTRUMENTATION ROOT VALVES SHALL BE TAGGED AS FOLLOWS: PI–V–X (PENETRATION NO).

11. THESE INSTRUMENTS ARE LOCATED ON REMOTE SHUTDOWN PANEL.

12. ALL INSTRUMENTATION ON THIS DRAWING TO BE IDENTIFIED BY A PREFIX "MS" UNLESS OTHERWISE NOTED.

13. ALL INSTRUMENT LINES ARE DESIGNED BY CODE & LINE NUMBER.

    A.) EXAMPLE: LINES ORIGINATING OUTSIDE CONTAINMENT,

    $\underbrace{\text{1/2"PI(1)–ST}}_{\text{CODE DESIGNATION}}$ – $\underbrace{\text{(H22–P021)–A6}}_{\text{LINE NUMBER}}$

    B.) EXAMPLE: LINES ORIGINATING INSIDE CONTAINMENT,

    $\underbrace{\text{1/2"PI(1)–4S}}_{\text{CODE DESIGNATION}}$ – $\underbrace{\text{X106}}_{\text{LINE NUMBER}}$

    C.) EXAMPLE: CONTINUATION OF THE LINE OUTSIDE CONTAINMENT IS DESIGNATED AS FOLLOWS, WITH LINE NUMBERS NOT SHOWN.

    $\underbrace{\text{1/2"PI(1)–4S}}_{\text{CODE DESIGNATION}}$ – $\underbrace{\text{X106}}_{\text{LINE NUMBER}}$

14. ASME CODE CASE N–241 MAY BE APPLIED TO 10" & 12"MS(18)–2 BELOW ELEVATION 466'–0 3/4".

15. CODE BREAK DEFINITIONS FOR THERMOWELLS ARE SHOWN ON M610, "INSTALLATION OF THERMOWELLS & SAMPLE PROBES."

16. THIS EQUIPMENT IS NORMALLY CONTROLLED FROM THE MAIN CONTROL ROOM. IF THE MAIN CONTROL ROOM MUST BE VACATED, THIS CONTROL POINT MAY BE ISOLATED AND CONTROL TRANSFERRED TO THE REMOTE SHUTDOWN PANEL C61–P001.

(NOTES CONTINUED ON LEFT)

LEGEND

1. ALL VALVES (EXCEPT THOSE ON INSTRUMENT LINES) SUFFIXED WITH A (V) DENOTE A 3/4" VENT VALVE EXCEPT AS NOTED.

2. ALL VALVES (EXCEPT THOSE ON INSTRUMENT LINES) SUFFIXED WITH A (D) DENOTE A 3/4" DRAIN VALVE.

3. ALL VALVES SUFFIXED WITH A (TH) DENOTE A THROTTLED VALVE.

NOTES (CON'T):

17. THESE INSTRUMENTS ARE LOCATED ON THE ALTERNATE REMOTE SHUTDOWN PANEL E–CP–ARS.

18. VALVE PI–V–X106 IS A "DESIGNED OPEN VALVE" AND A WELDED FIXTURE HAS BEEN ADDED TO PREVENT CLOSING. TO CHANGE THIS DESIGNATION AND CLOSE THE VALVE IS CONSIDERED A PLANT MODIFICATION AND WILL REQUIRE A DESIGN CHANGE PER SWP–DES–01.

REFERENCES TO CONTRACT NUMBERS, SUCH AS 215, 206, 220, FOUND IN THE NOTES ON THIS DRAWING REFER TO ORIGINAL CONSTRUCTION DESIGN REQUIREMENTS.

CURRENT DESIGN REQUIREMENTS ARE DOCUMENTED IN THE STATION DESIGN SPECIFICATIONS AND ACTIVE CONTRACT SPECIFICATIONS WHICH STILL APPLY.

Columbia Generating Station
Final Safety Analysis Report

Main Steam Supply System Piping

Draw. No. M529	Rev. 102	Figure 10.3-2

10.4 OTHER FEATURES OF STEAM AND POWER CONVERSION SYSTEM

10.4.1 MAIN CONDENSER

10.4.1.1 Design Bases

The purpose of the main condenser is to provide a heat sink for condensing the turbine exhaust steam, turbine bypass steam, reactor feed pump drive turbine exhaust steam, and to provide a receiver for miscellaneous drains. It also provides deaeration, noncondensable gas removal, and storage of condensate, which is returned to the condensate system after a period of radioactive decay.

The main condenser is designed for the following conditions (approximate values):

a.	Duty	7.7 x 10^9 Btu/hr
b.	Circulating water flow	555,600 gpm
c.	Circulating water inlet temperatures	78°F
d.	Circulating water outlet temperatures	106°F
e.	Total steam condensed	8,128,700 lb/hr
f.	Total condensate outflow	15,017,000 lb/hr
g.	Outlet temperature of condensate	105.0°F
h.	Condenser pressure (triple)	2.4 in Hg abs (average)
i.	Cleanliness factor	85%
j.	Number of passes	1
k.	Air inleakage flow rate limit	50 scfm
l.	Hotwell storage capacity	163,000 gal

The main condenser is designed to accept a maximum of 25% of the rated reactor steam flow from the turbine bypass system (described in Section 10.4.4) plus 75% of the rated reactor steam flow through the turbine. This steam flow is accommodated without increasing the condenser backpressure to the turbine trip setpoint or exceeding the allowable turbine exhaust temperature.

The main condenser is designed to deaerate the condensate and provide an oxygen content in the hotwell condensate between 30-100 ppb per liter over the entire load range.

Feedwater quality is maintained by the condensate filter demineralizer system described in Section 10.4.6.

The condenser hotwell is designed to contain the condensate that is required during 5 minutes of full power operation of the turbine. Baffling in the hotwell provides a minimum of 3 minutes condensate hold-up time which permits the decay of short-lived radioactive isotopes.

Condenser construction is designed in accordance with requirements of the Heat Exchange Institute, Standards for Steam Surface Condensers (October 1971). Construction of condenser module bundle replacement is designed in accordance with the Tenth Edition.

The piping associated with the condenser is designed, fabricated, inspected, and erected in accordance with ANSI B31.1 (October 1971). Seismic category, safety class, and design codes are discussed in Section 3.2.

10.4.1.2 System Description

Steam from the low-pressure turbine is exhausted directly downward into the condenser shells through exhaust openings in the bottom of the turbine casings and is condensed. The condenser serves as a heat sink for several other flows, such as exhaust steam from the reactor feedwater pump turbines, cascading feedwater heater drains, air ejector condenser drains, gland seal steam condenser drain, feedwater heater shell operating vents, turbine gland seals, and the offgas preheater drains.

Other flows to the condenser originate from the startup vents of the condensate pumps, the reactor feedwater pumps, condensate booster pumps, the condensate pumps, feedwater line startup flushing, reactor feedwater pump turbine drains, low-point drains, condensate makeup, reactor water cleanup (RWCU), and feedwater heater dumps or drains. All high temperature drains into the condenser shell have impingement baffles or spray pipes to prevent the steam and entrained water particles from impinging on the surface of the tubes. Stainless steel lagging is provided where required to protect other condenser components. The bypass valves are described in Section 10.4.4.2.

During transient conditions, the condenser is designed to receive turbine bypass steam and feedwater heater and drain tank high-level discharges. The condenser is also designed to receive relief valve discharges from moisture separators, feedwater heater shells, steam seal regulators, and various steam supply lines.

The condenser is cooled by the circulating water system described in Section 10.4.5. Air inleakage and noncondensable gases are removed by the main condenser evacuation system described in Section 10.4.2.

Before leaving the condenser, the condensate is deaerated to reduce the level of dissolved oxygen.

10.4.1.3 Safety Evaluation

During operation, radioactive steam, gases, and condensate are present in the shell of the main condenser. The inventory of radioactive contaminants during operation is discussed in Section 12.2.1.2.2.7. Shielding for and controlled access to the main condenser is provided in

Chapter 12. The means of controlling and detecting the leakage of this radioactive inventory in and out of the main condenser is discussed in Sections 11.3 and 11.5.2.2.

Hydrogen is generated by radiolysis in the reactor and injected by the Hydrogen Water Chemistry system.

Hydrogen generation buildup during operation is prevented by continuous evacuation of the main condenser by the air removal system (see Section 10.4.2) and the offgas system (see Section 11.3.2). The radiolytic decomposition rate at rated power is 102 scfm of hydrogen and 51 scfm of oxygen. Hydrogen is introduced into the condensate/feedwater system to mitigate intergranular stress corrosion cracking (IGSCC). The addition of hydrogen into a feedwater system results in reduced radiolysis. The net hydrogen in the steam during Hydrogen Water Chemistry (HWC) is less than during normal water chemistry (NWC) (without hydrogen injection). During plant shutdown, there are no hydrogen sources to the condenser. Hydrogen injection is shut down whenever the reactor is shut down. The inadvertent introduction of hydrogen to condensate/feedwater, from HWC, during extended shutdowns is prevented by isolation of the hydrogen supply, and purging the hydrogen injection system with nitrogen.

The main condenser is not required for safe shutdown of the reactor and does not perform safety functions. However, degradation of the condenser in the form of a leak, loss of circulating water, or air ejector malfunction could lead to a loss of condenser vacuum which removes the effective ability of the condenser as a heat sink. As a consequence, loss of vacuum provides a main steam isolation valve closure signal. See Section 7.3.1.1.2 for a further description. Due to the distance of the main condenser from safety-related equipment areas, there will be no damage to necessary safe shutdown equipment from flooding caused by failure of the condenser.

Exhaust hood overheating protection is provided by sprays located downstream of the last-stage blades of the turbine.

Loss of main condenser vacuum causes the turbine to trip. Should the turbine stop valves, control valves, or bypass valves fail to close on loss of condenser vacuum, rupture diaphragms on each turbine exhaust connection to the condenser protect the condenser and turbine exhaust hoods against overpressurization. In this event, steam would exhaust to the turbine building.

The main condenser is constructed with titanium tubes and the tubesheet is titanium clad carbon steel. Corrosion protection of the wetted carbon steel water boxes, inlet and outlet valves, and circulating water piping is being performed by a combination of a high quality coating, the use of stainless steels, and sacrifical anodes. The sacrifical anodes attach to the wall of the water boxes and will provide protection in case of any coating breaches or coating failure. All small bore nozzles on the circulating water side penetrating the water box 4 inches and less are of stainless steel. The water box coating will wrap into these connections to prevent any carbon steel exposure. Isolation kits will electrically isolate any attached drain piping to help minimize any stray current corrosion.

10.4.1.4 Tests and Inspections

The condenser shell received a field hydrostatic test prior to initial operation. This test consisted of filling the condenser shell with water, and inspecting the entire tube sheet and shell welds and surfaces for visible leakage and/or excessive deflection.

The condenser module bundle replacement final test for tube or joint leakage was performed using a vacuum-bubble leak test.

During normal plant operation, the following parameters are routinely monitored:

a. Condenser vacuum,
b. Conductivity, and
c. Condensate temperature.

Any divergence from established limits for these parameters requires an investigation and testing as necessary to determine the extent of the divergence and correct the problem.

10.4.1.5 Instrumentation

The condenser shell is provided with local and remote hotwell level and pressure indication. The remote indication is by means of indicators and alarms in the main control room. The condensate level in the condenser hotwell is maintained within proper limits by automatic controls that provide for transfer of condensate to and from the condensate storage tanks as needed to satisfy the requirements of the steam system. Condensate temperature is measured in the outlet line of the condensate pumps.

Turbine exhaust hood temperature is monitored and controlled with water sprays to provide protection from exhaust hood overheating.

A main condenser low vacuum alarm is provided. Automatic turbine trip is activated on continued loss of main condenser vacuum followed by main steam isolation valve closure on further degradation of condenser vacuum. See Section 7.3.1.1.2 for a further description of main steam isolation.

Water box pressure and temperature measurements are provided.

Circulating water inleakage to the main condenser is monitored by conductivity elements located in the tube sheet troughs, in the condenser outlet line, and at the condensate pump discharge line (alarm in the main control room). Conductivity of the condensate demineralizer influent is monitored and alarmed in the radwaste control room. A conductivity/chemical species sampling and measurement system is available for characterizing inleakage. Leakage is controlled (prevented) to the extent possible by maintaining chemistry control in the circulating water to provide optimization between scale formation and corrosion. Tube leakage can be corrected by isolating and draining the tube sections containing leaking tubes and then locating and plugging the leaking tube.

10.4.2 MAIN CONDENSER EVACUATION SYSTEM

10.4.2.1 Design Bases

The main condenser evacuation system removes gases from the turbine generator, the reactor feedwater pump turbines, and the main condenser during plant startup and maintains the condenser essentially free of noncondensable gases during operation. This system handles all noncondensable gases which may enter the main turbine and reactor feed pump turbines through their seals, the condensate piping, or which is generated by dissociation of water in the reactor. The main condenser evacuation system discharges to the offgas system through the steam jet air ejectors during normal operation (see Section 11.3).

The piping system associated with the main condenser evacuation system is designed, fabricated, and erected in accordance with ANSI B31.1 (October 1971). The air removal equipment is designed in accordance with the standards for Steam Surface Condensers, published by the Heat Exchange Institute (October 1971).

10.4.2.2 System Description

The main condenser evacuation system includes, for normal operation, two 100%-capacity steam jet air ejector units. Each unit consists of a twin-element first-stage steam jet air ejector and a single-element second-stage, steam jet air ejector which discharges to the offgas system. The capacity of each steam jet air ejector unit is 663 scfm at 70°F total equivalent of mixed gases and vapor at 1-in. Hg absolute. The main condenser design air inleakage flow rate is 50 scfm.

Two mechanical vacuum pumps are provided for hogging operation during startup (see Figure 10.4-1). During startup, both mechanical vacuum pumps can be used to rapidly remove air and noncondensable gases from the main condenser.

The discharge from the vacuum pumps is routed with the gland seal steam exhauster discharge to the reactor building elevated release duct. Because the reactor power is low, a minimal amount of activity is discharged to the environment. A radiation detector monitors the discharge and isolates the vacuum pumps when the radiation level exceeds established limits. The vacuum pumps operate until sufficient steam pressure is available to start the steam jet air ejector.

The source of steam to operate the steam jet air ejector is taken from the main steam header branch line, with steam pressure being regulated by the steam jet air ejector control valves. Air inleakage, noncondensable gases, as well as entrained water vapor, are removed from the main condenser by the first stage of the steam jet air ejector. The gas-vapor mixture is then discharged into the ejector condenser where the vapor is condensed. The resulting condensate is drained back to the main condenser via a loop seal. The ejector condenser is cooled by the condensate discharge from the condensate pumps. The noncondensing second stage of the steam jet air ejector removes the noncondensable gases and some entrained vapor from the ejector condenser and exhausts them to the offgas system (see Section 11.3). The offgas system processes the noncondensable gases and limits the release of radioactive gases to the environment.

10.4.2.3 Safety Evaluation

The main condenser evacuation system is not safety related. Consequently, the system is not designed to Seismic Category I requirements. Safety class and design codes are presented in Section 3.2.

The radionuclides in the effluent from the steam jet air ejector unit have been evaluated in Section 11.3.

The offgas from the main condenser contains hydrogen gas from dissociation of water in the reactor and from hydrogen injection. In the second-stage steam jet air ejector, sufficient steam is provided to dilute the hydrogen content to less than 4% by volume to keep the mixture below flammability limits.

10.4.2.4 Tests and Inspections

The mechanical vacuum pumps and the steam jet air ejectors were cleaned, inspected, and tested at the vendors' plant. System preoperational tests as described in Chapter 14 were successfully performed after installation. Main condenser evacuation system monitoring during normal operation along with routine maintenance and inspection ensures proper functioning and performance in accordance with its design bases. Instrumentation permits the operators to monitor system performance during operation.

10.4.2.5 Instrumentation

A radiation monitor is installed in the air removal piping discharge to the reactor building elevated release duct (a common exhaust line to the mechanical vacuum pumps and the gland seal steam condenser exhaust). A high-radiation signal from the monitor will trip both mechanical vacuum pump motors: The trip causes the suction and discharge valves to close and trips the mechanical vacuum pump seal water pumps. The vacuum pump is equipped with instrumentation to ensure proper operation (Figure 10.4-1).

A main steam line radiation monitor (MSLRM) high-radiation signal also trips both mechanical vacuum pump motors. The signal will also trip both gland seal steam condenser exhauster motors (see Section 11.5.2.1.1).

Low steam flow to the second-stage air ejector causes a signal to close the inlet gas valves to the first-stage air ejector. Steam pressure indicators for the first- and second-stage ejectors and a steam flow indicator for the second-stage ejector are provided in the main control room.

10.4.3 TURBINE GLAND SEALING SYSTEM

10.4.3.1 Design Bases

a. The turbine gland sealing system prevents air leakage into, or radioactive steam leakage out of, the main turbine and reactor feedwater pump turbines; and

b. The turbine gland sealing system is designed to provide nonradioactive (clean) sealing steam, at all loads, to the turbine shaft glands and valve stems (main stop, control reheat stop, intercept, and bypass valves). The condensate from the gland seal steam condenser is returned to the main condenser, and the noncondensable gases (inleaking air) are exhausted to the reactor building elevated release duct.

The turbine gland sealing system is in strict conformance with the latest edition in effect at the time of fabrication of the applicable ANSI, ASME, and IEEE standards. The major portion of manufacture was performed during 1975. The gland seal steam evaporators are designed, fabricated, inspected, tested, and stamped in accordance with Section VIII of the ASME Boiler and Pressure Vessel (B&PV) Code and the Standards of the Tubular Exchanger Manufacturers Association, Class R (May 1972). Seismic category, safety class, and design codes are provided in Section 3.2.

10.4.3.2 System Description

The turbine gland sealing system consists of two 100%-capacity gland seal steam evaporators, seal steam pressure regulators, seal steam header, gland seal steam condenser, exhauster blowers, and the associated piping, valves, and instrumentation (see Figures 10.3-1 and 10.4-2). Sealing steam for turbine shaft seal glands and valve stem seal glands (stop, control, reheat stop, intercept, and bypass valves) is supplied from the seal steam header at 200 psig. The source of sealing steam is from the gland seal steam evaporators or the auxiliary steam boiler. The sealing steam is produced in an evaporator which is heated by extraction steam taken from the high pressure turbine. The condensate fed to the evaporator is taken from the suction header of the reactor feedwater pumps in the feedwater system. During startup and low load operations, a branch line taken off the main steam header supplies the necessary heating steam for the evaporator.

Separate seal steam regulators are provided to regulate the pressure of sealing steam for the high pressure turbine, each low pressure turbine, each reactor feed pump turbine shaft seal, the bypass valve assembly, and the main stop and control valve assembly stems.

Since the low pressure (LP) turbine and reactor feedwater pump turbine exhaust pressures are at a vacuum, sufficient sealing steam is supplied to maintain positive pressure in the glands to prevent air inleakage along the shaft. The high pressure (HP) turbine exhaust pressure varies with load and is approximately 177 psia at its maximum. The system is designed to maintain the seal steam supply to the HP turbine glands at a pressure of 16 to 20 psi above HP turbine exhaust to prevent HP turbine exhaust steam leakage through the shaft gland seal.

The main stop, control, and bypass valve stems are provided with an intermediate zone to which sealing steam is supplied. This nonradioactive steam leaks in both directions, towards the HP stem leakoff and towards the LP stem leakoff. The HP stem leakoff contains radioactive steam and is directed to an LP feedwater heater. The LP steam leakoff is nonradioactive and is sent to the gland seal steam condenser. The reheat stop and intercept valve stems are supplied with sealing steam at a pressure greater than the crossover pressure so that any leakage that occurs is into the crossover pipes.

The reactor feedwater pump turbines at the high pressure end are provided with sealing steam at an intermediate point in the turbine gland seal. This nonradioactive steam leaks in both directions, towards the HP end leakoff and towards the LP end leakoff. The HP leakoff contains radioactive steam and is directed to the sixth stage of the turbine. The LP steam leakoff is nonradioactive and is sent to the gland seal steam condenser. Sealing steam for the reactor feed pump turbine LP stop valve, HP stop valve, and control valve is provided in a similar manner.

The outer leakoff of all glands is routed to the gland seal steam condenser which is maintained at a slight vacuum by the exhauster blower. During plant operation, the gland seal steam condenser and one motor-driven blower is in operation. The exhauster blower discharges gland air inleakage to the atmosphere via the reactor building elevated release duct. The gland seal steam condenser is cooled by the main condensate flow.

The steam evaporator is a shell-and-tube heat exchanger designed to provide a continuous supply of clean sealing steam to the seal steam header.

10.4.3.3 Safety Evaluation

The turbine gland sealing system is not safety related.

A supply of clean steam is always available from either of two 100%-capacity steam evaporators or the auxiliary steam boiler. Should the steam packing exhauster fail to function, the sealing steam would continue to flow into the turbine and would be the only steam that could flow out of the glands and into the turbine building. Therefore, no reactor steam would be released to the environment.

A radiation monitor in the discharge of the blower alerts the operator to tube ruptures in the gland seal steam evaporator or other system malfunctions. Sealing system radioactive releases are discussed in Section 11.3.

Relief valves in the seal steam system prevent excessive steam pressure. The valves vent to the condenser and atmosphere.

10.4.3.4 Tests and Inspection

Prior to installation at the site, the gland seal steam evaporator and gland seal steam condensers were cleaned, inspected, and tested at the vendor's plant. Preoperational testing of this equipment included a hydrostatic test for visual inspection of welded joints to confirm leaktightness. The turbine gland sealing system is regularly inspected and monitored during operation to ensure proper functioning and performance in accordance with its design bases.

10.4.3.5 Instrumentation

The level in both the shell and tube sides of the steam evaporator are controlled by level-control valves: the condensate (shell) side by maintaining the water level surrounding the tubes and the steam side by maintaining the water level in the steam evaporator drain tank. The flow of heating steam is regulated by the steam pressure control valve.

Liquid level in the gland seal steam condenser is maintained by a trap connected to the main condenser. A local pressure indicator and high-level alarm switch are provided on the gland seal steam condenser. Temperature and pressure gauges and test points are provided to monitor operation and testing of the system. Instruments for monitoring system operation are provided in the main control room. Low and high level alarms are provided on the gland seal steam evaporator.

10.4.4 TURBINE BYPASS SYSTEM

10.4.4.1 Design Bases

a. The turbine bypass system controls reactor steam pressure by sending excess steam flow directly to the main condenser. This permits independent control of reactor pressure and power during reactor vessel heatup to rated pressure prior to and while the turbine is brought up to speed and synchronized under turbine speed-load control and when cooling down the reactor. Following main turbine generator trips and during power operation when the reactor steam generation exceeds the transient turbine steam requirements, the turbine bypass controls reactor overpressure within its capacity and in accordance with the steam generation rate;

b. The turbine bypass system capacity is 25% of rated reactor steam flow. The bypass system can accommodate a 25% turbine load rejection without causing a significant change in reactor steam flow; and

c. The turbine bypass valves are capable of remote manual operation.

10.4.4.2 System Description

The turbine bypass system consists of four hydraulically operated control valves which are mounted on a valve manifold (see Figure 10.4-3). They are connected to the main steam line header upstream of the turbine main stop valves by four 10 in. lines. The four individual valves lower the pressure of the steam by reducing its flow velocity before it enters the condenser system.

Each valve outlet discharges into the manifold which is piped directly to pressure-reducing perforated pipes located in the condenser shell (see Figure 10.3-1).

The turbine DEH control system is designed to prevent spurious or unnecessary opening of the bypass valves, due to control signal noise or minor transients. The four valves in the manifold are operated automatically by the control system. The amount of steam flow allowed to pass through the turbine is limited by the DEH control system demand signal, which limits the amount that the governor valves can open. The DEH control system controls the governor valve position to maintain reactor pressure. When the governor valve opening position, required to maintain reactor pressure, exceeds the load demand limit, a signal is sent to the bypass valves to open to maintain reactor pressure. The bypass valves automatically trip closed whenever the vacuum in the main condenser is greater than approximately 23 in. Hg absolute. They have regulation capability and a fast-opening response approximately equivalent to the fast closure of the turbine stop and control valves.

The turbine bypass system piping and valves are designed to the class and seismic category presented in Table 3.2-1. The valve body is forged carbon steel while the internals are stainless steel. The environmental design bases for this system are contained in Section 3.11.

Each valve is sized for 8% of the total rated flow; however, all four valves are designed for 25% of the total flow. If the bypass system capacity is exceeded, the main steam relief valves open on high reactor pressure and excess steam is vented to the suppression pool.

10.4.4.3 Safety Evaluation

The effects of a malfunction of the turbine bypass system valves and the effects of such failures on other systems and components are evaluated in Section 15.2.2.

All safety-related components and the turbine speed control system are located remote from the turbine bypass piping and valves. The bypass system is located on the second floor of the turbine building (see Figure 1.2-3) and the speed control and safety-related components are located on the floor above, thus being separated by a concrete floor and wall making any adverse affects from a high-energy line failure in the turbine bypass system extremely unlikely. The turbine overspeed protection system is a fail-safe design, as described in Section 10.2.2.

The effects of a steam line break on the safety-related components in the turbine building are discussed in Section 3.6.1.

10.4.4.4 Tests and Inspections

The opening and closing of the turbine bypass system valves were checked during initial startup and shutdown for performance and timing. The bypass steam lines upstream of the bypass valves to MS-V-146 were hydrostatically tested to confirm leaktightness. Radiography and visual inspection of all pipe weld joints were performed on this piping. The branch connections and branch lines of this piping were examined in accordance with ANSI B31.1 rules.

Each turbine bypass valve can be tested independently and remotely during plant operation. The testing is conducted as required by the Technical Specifications.

10.4.4.5 Instrumentation

The controls and valves are designed so that the bypass valves shut on loss of control system electric power or hydraulic pressure. For testing the bypass valves during operation, the stroke time of the individual valves is increased during testing to limit the rate of bypass flow increase and decrease to approximately 1% per sec of reactor rated flow. Upon turbine trip or generator load rejection, the start of bypass steam flow is not delayed more than 0.1 sec after the start of the stop valve or the control valve fast closure motion. A minimum of 80% of the rated bypass capacity is established within 0.3 sec after the start of the stop valve or the control valve closure motion. For more detail refer to Section 7.7.1.5.

10.4.5 CIRCULATING WATER SYSTEM

10.4.5.1 Design Bases

The circulating water system is designed to provide cooling water for the condenser using the atmosphere as a heat sink via six circular mechanical-induced draft cooling towers designed to remove 7.962 x 10^9 Btu/hr from the circulating water. The design heat gain in the condenser is approximately 7.7 x 10^9 Btu/hr. In addition, the cooling towers have the capacity to cool the plant service water during normal operation and the standby service water during shutdown operation. The operation of the towers is not essential to the safety of the plant.

Makeup for tower evaporation, wind loss, and blowdown is obtained from the Columbia River by makeup pumps. Cooled blowdown from the cooling towers is discharged to the river.

Chemical treatment is provided for the circulating water system to preclude scale, biological growth, and consequent fouling of heat transfer surfaces.

The piping system associated with the circulating water system is designed, fabricated, inspected, and erected in accordance with ANSI B31.1 (October 1973) and AWWA C201. Major piping components are fabricated from carbon steel. Seismic category, safety classification and design codes are given in Section 3.2.

10.4.5.2 System Description

The circulating water system is shown schematically in Figure 10.4-4. The circulating water system is a closed cycle cooling system using six mechanical induced draft, cross-flow cooling towers. Three circulating water pumps, each having a total head of 95 ft at 186,000 gpm, are provided. These pumps, located in the circulating water pump house, take suction from a common intake plenum and discharge through a common 12-ft-diameter pipe to the three waterboxes of the single-pass triple-pressure zone condenser. The water from the condenser is returned to the cooling towers, cooled, and collected in the cooling tower basins which supply the circulating water pumps intake plenum.

In addition, as part of the cooling tower piping, a cooling tower bypass is provided for plant startup during the winter to prevent icing conditions at the towers. Inlet motor-operated valves are provided at each tower to isolate a tower for maintenance.

The towers are designed such that the buildup of ice will not restrict air flow through the louvers. Temperature range and low water temperature limits are maintained during reduced heat loads by shutting down individual towers (fans and flow) as required. In extreme cold weather, desired cold water temperatures can be achieved with all fan motors shut down but free to rotate with natural draft through the towers.

The six mechanical draft cooling towers are located such that there can be no physical interaction between them and plant structures important to safety in the unlikely event of a tower collapse.

The quantity of makeup water to the system is dependent upon cooling tower evaporation, drift losses, and system blowdown requirements. The system blowdown quantity is dependent on the concentration of dissolved solids allowed in the circulating water. The concentration of dissolved solids varies with operating status and the cycles of concentration which are controlled by operation of the blowdown valve. Makeup to the circulating water system is provided via the cooling tower makeup pumps located in a pump house adjacent to the Columbia River. The makeup pumps are designed to pump 12,500 gpm each with a TDH of 204 ft; the makeup flow can be directed into the circulating water bay or to one or both of the plant service water pump suctions by means of a weir box and sluice gate arrangement located in the circulating water inlet bay.

The evaporative-type cooling towers have the potential for creating visible plumes of water vapor under certain atmospheric conditions. The cooling tower system is designed to keep this environmental impact minimal. The cooling tower plumes rarely produce ground level fog or ice in the basin area where the plant is located and do not restrict traffic at the local airports. Since fogging occurs naturally in the area, the estimated incremental occurrences of fog attributable to cooling tower operations are small compared to the natural occurrences.

Cooling tower drift has been identified as a cause of arcing in switchyard equipment. Switchyard equipment is monitored and cleaned (as necessary) to preclude this phenomenon. Offsite environmental effects are monitored per Section 4.2.1 of the Environmental Protection Plan.

The radiological impact and the impact of thermal discharges on the environment are insignificant. The effect of cooling tower blowdown has no significant effect on the Columbia River temperature, and the environmental effect of chemical discharges is considered negligible. The system has no measurable effect on area groundwater.

The environmental considerations mentioned above are discussed in detail in Chapter 5 of the Environmental Report - Operating License Stage.

10.4.5.3 Safety Evaluation

The circulating water system is a non-safety-related system. Consequently, the circulating water system is not designed to Seismic Category I requirements. See Section 9.2.5 for a description of the ultimate heat sink which is designed to perform safety-related functions.

The condenser design ensures that the pressure on the tube side is always maintained higher than the pressure on the shell side, thus eliminating leakage into the circulating water system should tube failure occur. Consequently, the design of the circulating water system precludes radioactive leakage into the system. Chemicals used to treat the CW system to preclude scale and biological growth and to control pH are evaluated in accordance with administrative controls to ensure compatibility with systems and components.

Two evaluations were performed to determine the effects of a postulated failure in the circulating water system inside the turbine building: a "realistic evaluation" and a bounding evaluation. For the "realistic evaluation," a moderate energy crack was postulated to occur in the circulating water system barriers (e.g., the rubber expansion joints) at the inlet to the main condenser. The inlet side was selected because it yields the severest results. For the bounding evaluation, a complete circumferential expansion joint break was assumed.

The entire condenser area is drained by means of sumps (see Figure 9.3-9), each equipped with duplex pumps. Sumps T-2 and T-3, servicing the inlet and outlet of the condenser, each have 50 gpm pumps. Each of these sumps is equipped with a level alarm and is therefore capable of detecting a circulating water system barrier failure. The level alarm will annunciate in the main control room upon reaching high level, providing a means of detecting the postulated failure within 5 minutes.

<u>"Realistic" Break</u>

The crack area for this postulated failure was assumed to be equal to one-half the pipe diameter times one-half the pipe wall thickness.

$$A = \frac{d}{2} x \frac{t}{2}$$ (see Section 3.6.2.1.4.2)

The flow exiting from such a crack would be an orifice flow. The head at expansion joint for normal three-pump operation at 186,000 gpm each was determined (from system energy gradients) to be 90 ft. The flow for these conditions was calculated to be

$$Q = 1737 \text{ gpm}$$

The system has different operating pressures for the various modes of pump operation. The piping was designed for an internal pressure of 60 psig, which is well above the design energy gradient.

The motor-operated inlet and outlet valves at the condenser are designed and manufactured to close in 60 sec to avoid excessive pressures caused by fast valve closure. Therefore, rapid valve closure is not a consideration. After closure of the inlet and outlet valves, however, the system will be operating with two-thirds of the condenser capacity. With three circulating water pumps in operation and two sections of the condenser in operation, the system flow as determined from the pump operating point diagram will be approximately 450,000 gpm.

Comparing the system energy gradients for this mode of operation to that when all three condenser units are in operation, the resultant difference in pressures will be

a. At the inlet side, an increase of approximately 4.3 ft of head (2 psi) occurs,
b. At the outlet side, a decrease of approximately 5.2 ft of head (2 psi) occurs.

Detection of the postulated failure will occur within 5 minutes, as described above, by the annunciation in the control room of the sump high level alarm. It is assumed that there will be a 15-minute time allowance for an operator in the control room to check the circulating water system barriers and close both the inlet and outlet valves of one unit of the condenser as may be required. This closure is accomplished by the activation of a remote manual switch in the control room, and therefore no control circuitry time delays nor coastdown times are involved. Flow will continue, however, after valve closure for about 106 minutes at a decreasing rate, until the remaining water from the condenser is completely discharged.

In the first 5 minutes after a crack, 8435 gal of water will spill into the inlet basin. The capacity of each basin and its capability to store excess flow were calculated to be as follows:

a. Inlet basin: 22,500 gal from el. 436 to el. 441,
b. Outlet basin: 27,500 gal from el. 436 to el. 441, and
c. Net volume under condenser: 180,500 gal from el. 433 to el. 441.

The time required to fill the inlet basin, after a postulated crack occurs, is computed to be 13.3 minutes. This includes the 50-gpm outflow from the sump pump. The circulating water leakage flow will continue for 6.7 minutes after filling the inlet basin, until reaching the total estimated shutoff time of 20 minutes. It can be assumed that 10% of this water will flow out over the floor at el. 441, and the remainder, about 10,170 gal, will flow into the condenser basin area. During this same time period, four sump pumps in the condenser basin area will have alternately pumped out 670 gal, leaving 9500 gal or 0.42 ft of water in the condenser basin. The rate of rise of water, therefore, is 0.021 ft/minute during the first 20 minutes after the postulated crack occurs. Note that on the high sump level, both pumps run simultaneously rather than alternately, thus doubling the calculated outflow capacity.

After the valves are closed, the water contained in the condenser unit water box will continue to discharge to the area. The quantity of water remaining is estimated to be 87,000 gal. The flow will vary with a diminishing head, the head going from about 25 ft to 0 ft. Using a 20-ft head and the same orifice flow criteria, the rate of flow will be approximately 819 gpm, discharging the remaining water in about 106 minutes. There will be an outflow from all the sump pumps of 150 gpm, with 10% of the flow from the crack again assumed to flow out over the floor. The water will accumulate in the condenser basin at about 590 gpm. After 106 minutes, the water level in this basin will rise an additional 2.77 ft, at 0.0261 ft/minute. The total height of water when the discharge has stopped is therefore 3.19 ft to el. 436.19.

This elevation is 5 ft below the floor level of the turbine building (el. 441), thus there will be no impacts on safety-related equipment from this event.

Boundary Evaluation

A complete circumferential expansion joint break in the circulating water system would result in the release of large amounts of water into the turbine generator building. The water would fill the net volume under the condenser, tripping the sump high level alarms that annunciate in the main control room. Remote-manual operation of the circulating water pumps and butterfly valves is provided in the main control room to mitigate the accident.

Disregarding operator action, however, the following evaluation is provided. Water would spill across the grade level floor of the turbine generator building at el. 441 ft, exiting through the railroad bay and access doors. Water could flow into the reactor building stairwells and elevator shafts from 441-ft el. down to the 422-ft 3-in. el., eventually filling the stairwells and elevator shafts with water. There is no safety-related equipment located in the stairwells or elevator shafts. The access doors to the emergency core cooling system (ECCS) and RCIC/CRD pump rooms at el. 422 ft 3 in. are designed to withstand a static head of approximately 44 ft (measured from centerline of door) of water. All penetrations into the reactor building below the 466 ft el. are designed to minimize flooding effects. Flooding will not affect any required safe shutdown equipment in the reactor building.

Water could also spill across the grade level floor into the radwaste/control building. The basement level of this building is 437 ft. It is thus possible to flood this level with 4 ft of water before the water would exit at grade level (441 ft) through access doors. No safety-related components will be affected by this flooding. The railroad bay and access doors of the turbine generator building are not watertight and are not designed to withstand any static head of water; therefore, no significant depth of water could accumulate in the turbine generator building. All safety-related equipment in the turbine generator building is located above the 471-ft el. and would not be affected.

In conclusion, a complete circumferential expansion joint break in the circulating water system inside the turbine generator building would have no effect on safety-related equipment.

Discharge operation of water accumulated under the condenser shall be performed in accordance with radioactivity checking requirements for sump discharges.

10.4.5.4 Tests and Inspections

All system components, except the condenser, are accessible during operation and may be inspected visually. The circulating water pumps were tested during preoperational testing.

The condenser was field hydrostatically tested in accordance with the Steam Surface Condenser Standards published by the Heat Exchange Institute.

All major components were inspected and cleaned prior to installation in the system, and preoperational tests were performed after system installation.

Sampling stations and test connections are provided to allow inservice testing during operation of the system.

10.4.5.5 Instrumentation

The circulating water pumps are individually equipped with shutoff valves that are interlocked with their respective pump motors to prevent startup unless the valve is closed and to prevent shutdown unless the valve is less than 15% open. Isolation valves are provided at the inlets of each condenser shell, which enable any water box to be isolated. The isolation valves are equipped with limit switches and are operated by manual switches located in the main control room. The system is monitored for temperature, pressure, level, and pH.

10.4.6 CONDENSATE FILTER DEMINERALIZER SYSTEM

10.4.6.1 Design Bases

The condensate filter demineralizer system capacity is 32,000 gpm, which is in excess of the 100% rated system capacity of 30,400 gpm.

As a design basis for this system, the effluent water quality is as follows:

NORMAL OPERATION FEEDWATER QUALITY TO THE REACTOR [a]

Parameter Frequency	*Limit*	*Sample*
Conductivity	*0.1 μmho/cm at 25°C* [b]	*Continuous*
pH	*6.5 to 7.5 at 25°C*	*As Required*
Total Metallic Impurity Filter Sample	*15 parts per billion (ppb)*	*Weekly; collected continuously*
Total Copper (Cu)	*2 ppb*	*Weekly*
Total Iron	*5 ppb*	*Weekly*

[a] *Measure after the last feedwater heater unless noted.*
[b] *Measured at demineralizer outlet.*

Nickel (Ni)	*2 ppb*	*Weekly*
Total Silica (SiO_2)	*5 ppb*	*As Required*
Chloride (Cl)	*10 ppb* [c]	*Daily*
Oxygen	*20 to 200 ppb*	*Continuous*

The design basis effluent water quality and sampling frequency was originally specified based on vendor fuel warranty and regulatory guidance. Since that time, enhanced analytical and testing techniques have determined that considerably lower concentrations of impurities can cause damage to system components. Through industry sponsored research, guidelines that are much more restrictive than the original design specifications have been developed and adopted. The implementation and documentation of these more restrictive specifications is controlled by chemistry administrative procedures.

This results in the system being designed to maintain feedwater quality such that the reactor water limits are not exceeded. This is achieved by the following:

a. Operation of the system to a less than 0.065 µS/cm conductivity end-point. After reaching this limit during normal operating conditions, the filter-demineralizer(s) are taken off line, backwashed, and precoated;

b. Establishing metallic impurity limits to preserved fuel performance by controlling the amount available for deposition on heat transfer and fluid transport surfaces. In addition, controlling corrosion product input minimizes the radiological impact from corrosion product activation, transport, and deposition;

c. Controlling undesirable anionic (chloride and sulfate) impurity input to maintain the reactor coolant concentrations below the levels where stress corrosion cracking is induced; and

d. Control of feedwater dissolved oxygen levels between 20 and 200 ppb falls in the minimal portion of the combined generalized and pitting corrosion curve for carbon steel piping. Piping is preserved and corrosion product activation, transport, and deposition are restricted.

This ensures that in conjunction with the RWCU system, reactor water quality will be maintained.

[c] *Or 25% of influent level, whichever is lower, to maintain reactor water quality of 200 ppb at rated operating pressure.*

The condensate filter-demineralizers are designed, fabricated, tested, and stamped in accordance with the ASME B&PV Code Section VIII, Division 1 (November 1971). Seismic category, safety class, and design codes are presented in Section 3.2.

10.4.6.2 System Description

The condensate filter demineralizer system consists of the necessary piping, valves, appurtenances, and instrumentation to control the condensate impurity concentration during plant operation (see Figure 10.4-5).

Six filter demineralizers are provided to polish 100% of the condensate flow: five or six are normally in operation at full power. The six filter demineralizers and associated piping, valves, and instrumentation are similar and piped in parallel.

Each filter demineralizer has an associated hold pump which is brought into service during low flow conditions to recirculate condensate through the filter demineralizer and hold the precoat material on the filter elements.

The individual effluent lines from the filter demineralizer vessels are provided with resin traps to prevent passage of ion exchange resins to the feedwater system.

The system design incorporates the following service systems which are common to all filter demineralizers:

a. Chemical mixing and supply system to circulate a chemical cleaning solution (e.g., inhibited citric acid) for the purpose of cleaning the filter demineralizer units and directing the waste to the chemical waste system (this system is not normally used);

b. A backwash system to remove the spent resin from the filter demineralizers and direct the radioactive waste to the backwash receiving tank (for further discussion of the backwash system discharge to the liquid waste management system, see Section 11.2); and

c. A precoat system wherein fresh precoat material is prepared and then circulated through the filter demineralizers to coat the filter elements.

The system control panels are located outside the equipment areas to permit remote operation of the condensate filter demineralizers without requiring the operator to enter high radiation areas.

The control panel has a graphic display. All major isolation valves, position indicators, and instrumentation are displayed at their respective locations.

10.4.6.3 Safety Evaluation

The condensate filter demineralizer system removes corrosion products, condenser inleakage impurities, and impurities present in the condensed steam.

Purified condensate and feedwater limits ensure sustained, safe plant operation by preserving the integrity of nuclear steam supply system components, vessel internals, fuel, and transport piping.

Due to improved water quality limits, any appreciable circulating water inleakage would result in water chemistry conditions outside acceptable limits and require action(s) to return the water quality to within applicable limits for continued plant operation.

Compliance with Regulatory Guide 1.56 is discussed in Section 1.8.

10.4.6.4 Tests and Inspections

The original condensate filter demineralizers, precoat and chemical mixing tanks, holding pumps, and system valves were hydrostatically tested prior to shipment by the manufacturer.

Field tests were performed after equipment installation to check satisfactory operation and functioning of control equipment, as well as to demonstrate guarantee performance. The guarantee performance test was governed by the ASTM Testing Method Procedures for High Purity Industrial Water.

10.4.6.5 Instrumentation

Instrumentation is provided for the condensate filter demineralizer system for proper operation, control, and protection against malfunction of the equipment.

The system design includes automatic flow balancing control for each filter demineralizer to maintain equal flow through each of the operating vessels by regulating the effluent discharge valve. The filter demineralizer flows are normally balanced manually and routinely monitored to maintain adequate flow balance. The cumulative flow through each filter demineralizer is recorded. Conductivity elements downstream of the flow control valves measure and record demineralizer performance. Differential pressure and conductivity alarms for each filter demineralizer annunciate when the pressure differential across a unit reaches a predetermined value or when the effluent conductivity indicates a significant reduction in ion exchange capacity. System influent and effluent conductivity are monitored and recorded. Alarms are provided for individual demineralizer differential pressures and outlet conductivities, and for the system inlet and outlet conductivities. These alarms annunciate at predetermined levels and corrective action is initiated in accordance with plant procedures and licensee controlled specifications.

Conductivity instrumentation is calibrated in accordance with applicable ASTM Procedures.

An automatic bypass maintains the condensate system flow in the event the number of filter demineralizers in operation or the flow capacity of the units (due to clogging) is inadequate to handle the required flow.

The resin replacement equipment is designed for semiautomatic operation. A remote manual override is included as an alternate mode of operation.

Conductivity recorders, a grab sample rack with the necessary instrumentation and appurtenances to test influent and effluent condensate, differential pressure monitors, pressure indicators, and local alarms are provided for each unit in addition to the main graphic display control panel.

10.4.6.6 Demineralizer Resins

Compliance with Regulatory Guide 1.56 is discussed in Section 1.8.

Pressure precoat filter/demineralizer media on individual vessels is replaced on a cyclic basis when the pressure drop exceeds 25 psid or the effluent conductivity exceeds 0.065 µS/cm during normal operating conditions. The conductivity limitation does not apply when condenser vacuum is broken and during the period when condenser vacuum is being restored.

10.4.6.7 Water Chemistry Analyses

The filter-demineralizer condition during normal power operation is assessed by the effluent conductivity and ionic content. The influent conductivity is related to impurity concentration through the equivalent conductance of the constituents of the process fluid.

Chemical analysis methods used for determination of conductivity and ionic content are as follows:

Conductivity	Measured in accordance to ASTM-D-1125
Chloride	Determined by ion chromatography in accordance with the vendor's operating manual.

10.4.7 CONDENSATE AND FEEDWATER SYSTEMS

10.4.7.1 Design Bases

The condensate and feedwater system provides a reliable source of high purity feedwater during both normal operation and anticipated transient conditions. The system is designed with sufficient capacity to provide for 110% of the feedwater flow at rated load. This provides sufficient margin to provide flow under anticipated transient conditions. The feedwater heaters are designed to provide the required temperature of feedwater to the reactor. The final feedwater temperature is 421°F at rated load.

The condensate and feedwater system is designed and fabricated in accordance with ANSI B31.1, (October 1973) and ASME B&PV Code, Section VIII, Pressure Vessels (November 1971) and 2004 ASME B&PV Code, Section VIII, including 2005 Addenda for RFW-HX-6A and RFW-HX-6B. Seismic category and safety class are discussed in Section 3.2. The environmental design bases for this system are in Section 3.11.

10.4.7.2 System Description

The condensate and feedwater system shown in Figure 10.4-6 is a six-heater regenerative feedwater heating cycle. The extraction steam system supplying heating steam to each feedwater heater is shown in Figure 10.4-7. A discussion of the condensate supply system is presented in Section 9.2.6.

Feedwater heaters 1, 2, 3, and 4 are divided into three one-third capacity parallel trains; heaters nmber 5 and 6 are split into two one-half capacity parallel strings. The final feedwater temperature is approximately 421°F at design output. Tube material for RFW-HX-6A and RFW-HX-6B is type 316 stainless steel. For the rest of the heaters the tubes are type 304 stainless steel. The first-stage heaters are located in the condenser exhaust neck.

Figure 10.4-8 shows the heater drain system. All feedwater heater drains are cascaded back to the condenser (6-5-4-3-2-1 condenser). Reheater drains are carried to the number 6 heaters whereas the moisture separators drain to the number 5 heaters.

Condensate from the condenser hotwell is pumped by three motor-driven pumps of one-third capacity each. The condensate is pumped through the gland seal steam condenser, the steam jet air ejector condensers, the offgas condenser, the condensate demineralization system, and then to the suction of the condensate booster pumps. The condensate pumps are designed to pump approximately 11,000 gpm each with a TDH of 375 ft.

Three motor-driven condensate booster pumps are provided in the system. The capacity of the booster pumps matches that of the condensate pumps, one-third capacity for each pump at design rated feedwater flow. The booster pumps provide the required head to pump the condensate through the five low pressure heaters and provide sufficient excess head to ensure sufficient net positive suction head (NPSH) at the reactor feedwater pumps suction.

The condensate booster pumps are designed to pump approximately 11,000 gpm each with a TDH of 925 ft. Using the condensate pumps, the condensate booster pumps and a series of heat exchangers, the system delivers 14,981,600 lb/hr of condensate at 467 psig and 366°F to the reactor feedwater pumps. Minimum flow through the gland seal steam condenser and steam jet air ejector condenser is controlled by using a recirculation control valve located in the condensate pump discharge lines to permit recirculation of condensate to the condenser.

Two one-half nominal capacity turbine-driven reactor feedwater pumps are provided. Each pump is capable of providing two-thirds of the rated feedwater flow during one pump operation. Minimum flow through the reactor feedwater pumps is controlled by using recirculation control valves located in the pump discharge lines to permit recirculation of feedwater to the condenser.

To minimize the corrosion product input to the reactor, a startup recirculation line is provided from the reactor feedwater supply lines, downstream of the high pressure feedwater heaters, to the main condenser.

The feedwater control system automatically controls the flow of feedwater into the reactor pressure vessel to maintain the water level in the vessel within predetermined levels during all modes of plant operation.

A hydrogen injection system is installed across the condensate booster pumps. The system uses discharge pressure to the pumps to feed dissolved hydrogen into the suction of the booster pumps.

A depleted zinc oxide (DZO) passive injection system (zinc) is installed across the feedwater pumps. The discharge pressure of the pumps can be used to inject a soluble zinc solution into the suction header of the feedwater pumps. Injection of zinc reduces the radioactive contamination on primary piping and components by reducing the levels of cobalt-60.

An iron injection system, installed on the suction line of the condensate booster pumps, can be used to inject an iron oxalate solution into the reactor feedwater. This iron injection system can be used to increase the reactor feedwater iron concentration to build a thin iron film on the inside of the piping to the vessel, vessel internals, and on the fuel.

Table 10.4-1 presents some of the major characteristics of equipment in this system.

10.4.7.3 Safety Evaluation

During operation, radioactive steam and condensate are present in the feedwater heating portion of the system which includes the extraction steam piping, feedwater heater shells, heater drain piping, and heater vent piping. Shielding and controlled access are discussed in Chapter 12. The condensate and feedwater system is designed to minimize leakage with welded construction used throughout the piping system. Feedwater heater shell-side relief valve discharges and operating vents are routed to the condenser.

The condensate and feedwater system is not required to effect or support the safe shutdown of the reactor or perform safety functions.

If it is necessary to remove a component such as a feedwater heater, pump, or control valve from service, continued operation of the system is possible by use of the multistream arrangement and the provisions for isolating and bypassing equipment and sections of the system.

The analysis of both the condensate and feedwater individual component failures is bounded by the feedwater component system failure analysis. These analyses are provided in Sections 15.1.1, 15.1.2, and 15.2.7. Included also in Section 15.6.6, are the isolation provisions that minimize release of radioactivity to the environment.

Criteria for feedwater isolation of the reactor coolant system is presented in Section 6.2.4.

10.4.7.4 Tests and Inspections

Each feedwater heater, heater drain tank, condensate pump, condensate booster pump, reactor feedwater pump, and system valves were shop hydrostatically tested at 1.5 times their design pressure. All pumps were shop performance tested. All tube joints of feedwater heaters were shop leak tested. Prior to initial operation portions of the completed ANSI B31.1 feedwater system welds were 100% X-rayed. The remainder of the completed condensate and feedwater system received a field hydrostatic test.

Pressure, temperature, conductivity, and flow instrumentation are provided to monitor system performance during operation. A separate, additional wireless monitoring system comprised of pressure, temperature and flow measuring equipment, is installed to monitor Feedwater Heaters 6A and 6B, as well as the Main Condensate Heaters 5A and 5B. The EMI/RFI characteristics were evaluated and found to be acceptable. Inservice inspection of applicable reactor feedwater piping is presented in Section 5.2.4.

10.4.7.5 Instrumentation

Feedwater flow-control instrumentation measures the feedwater flow rate from the condensate and feedwater system. This measurement is used by the feedwater control system that regulates the feedwater flow to the reactor to meet system demands. The feedwater control system is described in Section 7.7.1.4.

The isolation criteria for the feedwater system is loss of feedwater flow. Isolation valves are remotely operated from the main control room using signals which indicate loss of feedwater flow.

Instrumentation and controls regulate pump recirculation flow rate for the condensate pumps, condensate booster pumps, and reactor feed pumps. Measurements of pump suction and discharge pressures are provided for all pumps in the system. Sampling means are provided for monitoring the quality of the final feedwater (see Section 9.3.2). Temperature measurements are provided for each stage of feedwater heating and these include measurements at the inlet and outlet on both the steam and water sides of the heaters. Steam-pressure measurements are provided at each feedwater heater. Instrumentation and controls are provided for regulating the heater drain flow rate to maintain the proper condensate level in each feedwater heater shell and heater drain tank. High-level alarm and automatic dump-to-condenser on high level are provided.

Pressure, temperature, conductivity, and flow instrumentation are provided to monitor system performance. The operation of the hotwell makeup and high level dump valves is controlled by the hotwell level controller (Figure 10.4-6).

10.4.8 STEAM GENERATOR BLOWDOWN SYSTEMS

This section is not applicable to a BWR.

10.4.9 AUXILIARY FEEDWATER SYSTEM

This section is not applicable to a BWR.

10.4.10 HYDROGEN WATER CHEMISTRY SYSTEM

10.4.10.1 Design Bases

The Hydrogen Water Chemistry System (HWC) is designed to lower the electrochemical corrosion potential (ECP) of reactor coolant. Studies have shown that the lowering of ECP in the core below -230 mV_{SHE} will mitigate any existing intergranular stress corrosion cracking (IGSCC) and prevents future development of IGSCC in stainless steel components in the reactor coolant recirculation piping and lower reactor internals.

The HWC system injects hydrogen into the feedwater stream, increasing the concentration of dissolved hydrogen in reactor coolant. The presence of dissolved hydrogen suppresses the radiolytic generation of oxygen in the core and acts as a catalyst for the recombination of hydrogen and oxidants on the surface of piping and reactor internals. As a result, oxygen concentrations are reduced. The lower oxygen concentration reduces the ECP of the coolant.

The HWC system can inject up to 30 SCFM of hydrogen into the condensate/feedwater stream, resulting in a hydrogen concentration of up to 0.52 ppm in feedwater. Since the radiolytic generation of oxygen is suppressed, HWC also injects Service Air into the condenser Offgas stream to ensure that a stoichiometic ratio of hydrogen and oxygen are maintained for recombination.

10.4.10.2 System Description

The HWC system is shown schematically in Figures 10.4-9.1, 10.4-9.2, and 10.4-9.3. The system consists of a Hydrogen Storage and Supply Facility (HSSF), a hydrogen injection module, an air injection module, and a main control panel. The HSSF is located approximately 0.6 miles south-southeast of the Plant. A buried 2-inch pipe supplies hydrogen gas from the HSSF to the Turbine Generator Building (TGB) at approximately 200 psig. The hydrogen injection module, located on TGB 441′, regulates the gas flow to a sparger in a bypass line across the condensate booster pumps.

10.4.10.2.1 Hydrogen Storage and Supply Facility

The HSSF stores up to 14,000 gallons of liquid hydrogen at approximately 80 psig. The liquid H_2 is pumped, vaporized, and stored in six ASME storage tubes at approximately 2450 psig. The ASME tubes have a 40,000 SCF capacity, and serve as the primary source of gaseous H_2 for the HWC system. Gaseous hydrogen flows to a pressure control manifold that reduces the pressure to the 200 psig for supply to the TGB.

Two 100% capacity parallel pump trains, each with its own vaporizer, are provided for system reliability. One pump operates while the other acts as a backup. The ASME storage tubes are pressurized in a batch process, with pumping initiated when pressure in the tubes decays to approximately 650 psig.

The HSSF has a backup tube trailer that stores approximately 120,000 SCF of gaseous H_2. The HSSF has space for a second tube trailer that is used in the event of the functional loss of the liquid H_2 supply. Upon depletion of the inventory in the ASME tubes, the plant supply of hydrogen automatically switches to the tube trailer. As the inventory of the tube trailer is depleted, a replacement tube trailer is brought in. The depleted tube trailer is removed, replenished, and returned. In this way, the HSSF ensures a continuous, reliable supply of gaseous H_2 to the HWC system.

The HSSF also has a liquid nitrogen storage tank and vaporizer. Gaseous nitrogen is used for HSSF control functions and purging operations.

The operation of the hydrogen supply system at the HSSF is normally automatic, using programmable logic controllers (PLCs) located in a local pump control panel and hydrogen control panel.

The piping at the HSSF is designed to ASME B31.3, Chemical Plant and Petroleum Refinery Piping. The underground yard piping is designed to the requirements of ASME B31.1, Power Piping. All liquid and gas storage vessels are designed, fabricated, and stamped as ASME Boiler and Pressure Vessel Code, Section VIII, Division I, Unfired Pressure Vessels. The applicable fire protection codes are found in Appendix F Table F.3-1.

10.4.10.2.2 Hydrogen and Air Injection

The rate of hydrogen injection is regulated by a PLC in the HWC main control panel, located on the 471′ elevation of the TGB. Hydrogen injection is manually initiated above 5% reactor power, and is then automatically maintained at a rate proportional to reactor power when above 20% power. The injection rate is modulated based on reactor power.

HWC's suppression of radiolysis in the core results in an imbalance of hydrogen and oxygen in the condenser offgas stream. This imbalance is corrected by the injection of air into the Offgas system, upstream of the catalytic hydrogen recombiners. The Service Air system supplies the air for injection into offgas. The injection system is designed for a maximum flow rate of 93 SCFM.

The air injection rate is modulated based upon the rate of hydrogen injection. Since air leakage into the condenser contributes to the oxygen available for recombination, the required rate of air injection is reduced to account for the rate of air in-leakage.

The Mitigation Monitoring System (MMS) provides an indication of ECP in the reactor water. The MMS system contains an iron oxide element and a platinum element that may be used for measurement of the ECP of reactor water. ECP may also be monitored using an ECP LPRM probe in the core (see Section 7.6.1.4.2.2). The MMS and ECP LPRM provide an initial correlation of ECP to hydrogen injection to establish a baseline for operation of HWC.

10.4.10.3 Safety Evaluation

The HWC system does not fall within the definitions of any of the safety classifications identified in FSAR Section 3.2.3. However, the storage and handling of a combustible gas entails numerous safety issues that were addressed in the system's design.

The system was designed, procured, and installed to Quality Class II and Seismic Category II requirements. Exceptions are identified below.

- HWC cable terminations, electrical relays, and switches in the main control room panels are Quality Class I. Indicating lights in control room panels are Seismic Category 1M.

- HWC piping in the interfacing portion of the offgas system is Quality Class II+.

- The HSSF liquid hydrogen storage tank, its support foundation and soil were analyzed and installed to Quality Class I and Seismic Category I requirements.

All tanks and pipelines are provided with relief valves for overpressure protection. The liquid H_2 storage tank has redundant rupture discs for added protection.

The effects of the catastrophic failures of HSSF tanks at normal or elevated pressure were analyzed, and it was determined that the energy from such failures would not directly affect safety related or important to safety structures, systems, or components. Missiles generated from vessel failures at normal operating pressure would have insufficient energy to reach safety related or important to safety structures, systems, or components. Analysis has shown that missiles generated from an over pressurization event would have a total annual probability of impact less than 10^{-7} and therefore are not considered credible.

The hydrogen storage tanks at the HSSF are designed to stay in place for all natural phenomena (i.e., earthquakes, tornado winds, floods). No event will cause the tanks to be transported closer to the Plant. Local flooding from a Probable Maximum Precipitation (PMP) event would submerge the tanks (see Section 2.4.2.3), but not dislodge them. Similarly, the vent stack of the liquid H_2 storage tank is designed for flood conditions, with its outlet above PMP flood level. The vent stack design ensures that the tank will continue to off-gas vaporized hydrogen during the flood.

The HSSF is not designed to withstand tornado missiles. A tornado missile could cause the gross failure of a storage tank at the HSSF. However, as noted above, vessel failures have no effect on safety related or important to safety structures, systems, or components.

Similarly, an atmospheric release of all hydrogen stored at the HSSF will have no adverse impact on control room habitability. The HSSF has a maximum storage capacity of approximately 9800 pounds of liquid and gaseous hydrogen. The storage of this amount of hydrogen at the HSSF is not considered a hazard for control room habitability due to the distance from the plant air and remote air intakes to the HSSF.

Malfunctions at the HSSF will not have any adverse impact on Plant safety. The major potential effect of failures is the loss of supply of gaseous hydrogen for injection into condensate. The loss of hydrogen injection will cause a release of metallic radionuclides in reactor coolant, a transient N^{16} spike in the Main Steam lines and increase ECP in the reactor core. The Plant will continue to operate safely on loss of H_2 injection.

The buried supply line between the HSSF and the Plant is welded 2 in. schedule 80 pipe. Since the buried pipe passes under, and is routed next to a railroad track, the design was demonstrated to be in compliance with the American Railway Engineering Association (AREA) Manual for Railway Engineering.

In the area of the Plant, the buried H_2 supply line is encased in a guard pipe. The guard pipe provides mechanical protection, and a means to monitor the pipe for leakage. The vent of the buried line's guard pipe is directed to a hydrogen detector at the hydrogen supply valve station immediately outside the TGB. Hydrogen detectors are also located in the hydrogen injection module and at the Condensate system injection point. The HWC system is automatically shut down upon receipt of a high-high hydrogen signal from any of these detectors.

The hydrogen does not add to the combustible material in the TGB, since it is contained within welded pipe, and appropriate flow-limiting devices are included in the system. Excess flow valves are located in the supply line at both the HSSF and outside the TGB. The automatic closure of either excess flow valve would mitigate the effects of ruptures of the hydrogen supply line in or around the TGB.

The inadvertent introduction of hydrogen to condensate/feedwater during extended shutdowns is prevented by isolation of the hydrogen supply, and purging the hydrogen injection system with nitrogen.

The injection of hydrogen results in a transient increase in N^{16} activity in steam exiting the reactor, and an increase in the transport of metallic radionuclides to the recirculation system's piping and components. These effects are similar to those resulting from NobleChem injection (Section 5.2.3.2.2). The increased dose rates have no effect on equipment qualification.

The injection of hydrogen into feedwater reduces radiolysis in the reactor core, and results in a net reduction of hydrogen in Main Steam. The injection of hydrogen decreases secondary-side concentrations of dissolved oxygen. Secondary side chemistry is maintained in accordance with EPRI NP-5283-SR-A, "Guidelines for Permanent BWR Hydrogen Water Chemistry Installations". Dissolved oxygen is maintained in a range where Flow-Accelerated Corrosion (FAC) will not be exacerbated.

Hydrogen injection terminates automatically when feedwater flow drops below 25%. Hydrogen injection can also be terminated manually from the control room.

The injection of air into offgas increases the transport rate of radioactive species through the system with no adverse effect on system function. Offsite releases are maintained within the limits of 10 CFR 50 Appendix I and 10 CFR 20 Appendix B, Table II.

With the lowered net flow of hydrogen through offgas, the condenser's steam jet air ejectors provide sufficient dilution steam to maintain the hydrogen concentration below the maximum allowable concentration of 4% by volume (FSAR Section 10.4.2.3).

10.4.10.4 Tests and Inspections

The Hydrogen Water Chemistry system underwent a series of factory acceptance tests and site tests. The tests verified the operability of components, the logic of PLC programming, and the functionality of the integrated system. Site testing included the tuning of the HWC system to achieve the required ECP in the core, and benchmarking the Columbia Station's response to hydrogen and air injection.

10.4.10.5 Instrumentation

The Hydrogen Water Chemistry system is controlled by an integrated system of instrumentation and programmable logic controllers.

The HSSF is automatically operated by two PLCs, one located in the pump control panel and the other in the hydrogen control panel. The PLCs:

- Monitor pressures, temperatures and levels of the hydrogen and nitrogen systems,
- Control and monitor the hydrogen pumps and associated interlocks,
- Contain industrial safety interlocks for the HSSF facility, and
- Provide system status, process and alarm data to a remote annunciator panel.

The remote annunciator panel is located in the chemistry laboratory of the Radwaste Building, el 487′. The panel includes a human-machine interface PC that displays mimics, process information, and all HSSF alarms. The panel has one control interface with the HSSF, allowing the remote isolation of the HSSF from the Plant. The panel also receives HWC process information from a PLC in the HWC control panel, located on TGB el 441′.

The HWC control panel's PLC controls the injection of hydrogen and air into the condensate and offgas systems, respectively. The PLC control logic is based upon input flow signals from the hydrogen control module, oxygen control module, and feedwater system. In addition, the PLC receives signals from TGB hydrogen leakage detectors, offgas hydrogen analyzers, and a summed alarm from the HSSF PLCs. Finally, the PLC receives an enable signal from a switch located on a panel in the main control room. The switch is a permissive for the operation of the hydrogen water chemistry system. The switch can also be used to shut the system down.

Hydrogen and air injection is manually initiated from the HWC Control Panel. Injection is automatically terminated by the PLC when the reactor is shut down. Injection can also be manually terminated at the HWC control panel.

Alarms from the HSSF and the HWC injection system are annunciated at the HWC control panel and in the main control room. HSSF process alarms display as a summed "HSSF Trouble Alarm" at the HWC control panel and as "HWC Trouble" in the main control room. The HWC control panel has annunciators for the display of specific, local process alarms. The HWC process alarms also actuate the summed "HWC Trouble" alarm in the main control room.

Any manual or automatic shutdown of HWC is annunciated as "HWC Shutdown" in the main control room. Automatic shutdown occurs if any of the following signals is received:

Reactor Scram
Offgas Isolation
High Hydrogen Flow
PLC Fault
High Hydrogen Pressure
Loss of Feedwater or H_2 Flow Signal
Low Process Air Pressure
Offgas Analyzers O.O.S.
High-High Area Hydrogen
Low Condensate flow at Injector
Offgas % Hydrogen High Shutdown
Purge
Local Shutdown Demand
Control Room Shutdown Demand

These signals simultaneously annunciate on the HWC control panel.

Table 10.4-1

Feedwater System Equipment Characteristics[a]

Condensate pumps	
Quantity	3
Capacity[a]	11,000 gpm/pump
Total discharge head	375 ft
Minimum flow	5600 gpm/pump
Driver	1250 hp ac motor
Condensate booster pumps	
Quantity	3
Capacity[a]	11,030 gpm/pump
Total discharge head	925 ft
Minimum flow	2500 gpm/pump
Driver	3000 hp ac motor
Reactor feedwater pumps	
Quantity	2
Capacity[a]	18,520 gpm/pump
Total discharge head	2585 ft
Minimum flow	Designed for 4600 gpm/pump at 5100 ft breakdown
Driver	Steam turbine
Steam jet air ejectors condenser	
Quantity	2-100%
Minimum cooling flow	5000 gpm
Gland seal steam condenser	
Quantity	2-100%
Design flow	6500 gpm
Pressure drop	6 psi

Table 10.4-1

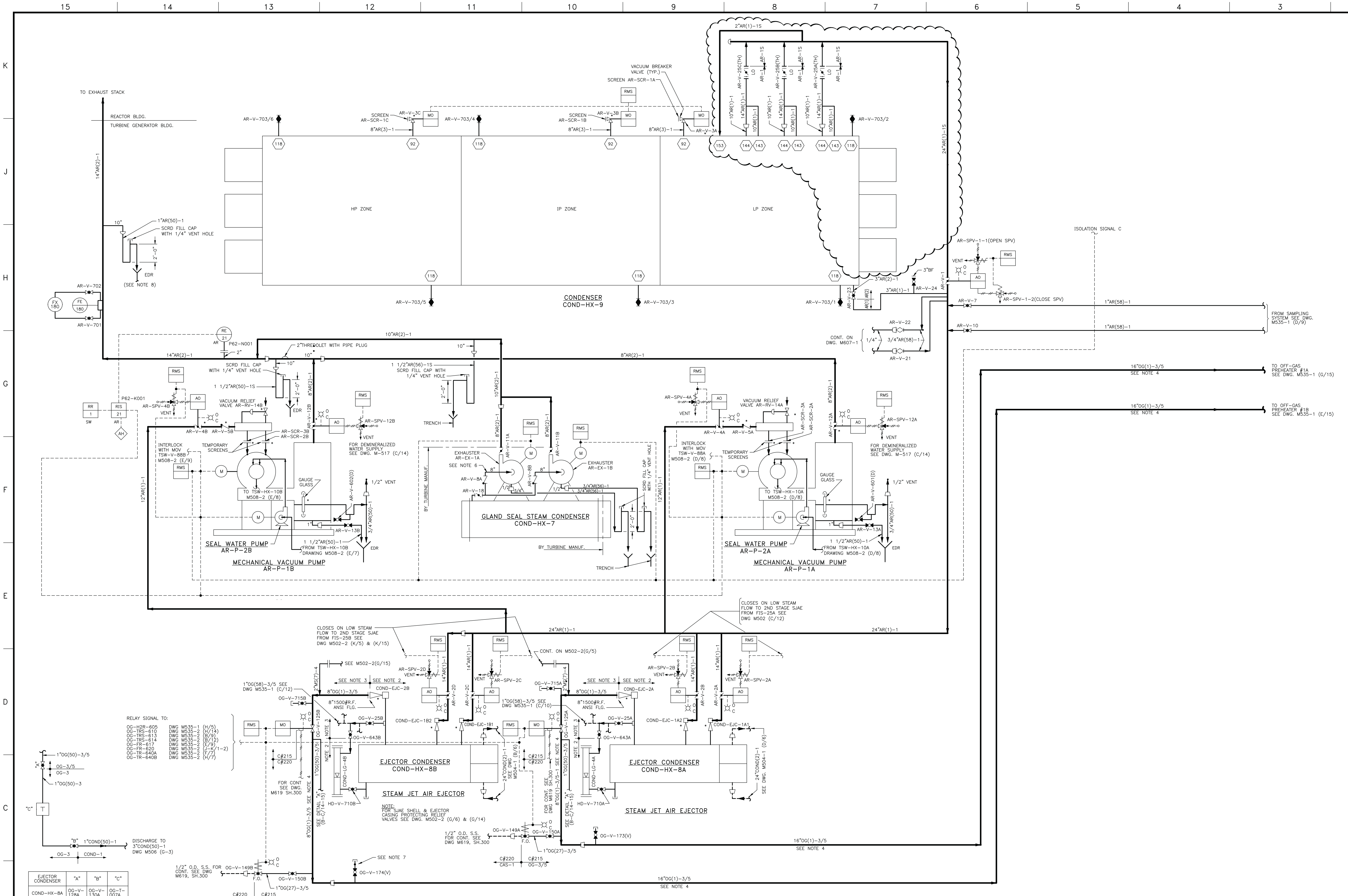
Feedwater System Equipment Characteristics (Continued)

Feedwater heaters	
Quantity	16 (one-third capacity up to and including heater 4 and one-half capacity for heaters 5 and 6)

Condensate (tube-side original design conditions)

Heaters	Flow/Chain (lb/hr)	Pressure Drop at Design Flow (psi)	Inlet Temp (°F)	Outlet Temp (°F)
1A, 1B, 1C	4,752,000	5.8	109.4	168.8
2A, 2B, 2C	4,752,000	5.4	168.8	208.5
3A, 3B, 3C	4,752,000	3.5	208.5	262.1
4A, 4B, 4C	4,752,000	6.0	262.1	291.3
5A, 5B	7,128,000	4.0	291.3	358.4
6A, 6B	7,128,000	9.9	360.1	419.8

[a] Capacity is based on 115% of the original rated condensate/feedwater flow.



NOTES:

1. ALL ITEMS MARKED * ARE FURNISHED WITH ASSOCIATED EQUIPMENT.
2. ALL PIPING, VALVES, AND ASSOCIATED COMPONENTS ON THIS DRAWING IN THE AIR REMOVAL SYSTEM SHALL BE AS FOLLOWS EXCEPT FOR THE AIR EJECTOR DISCHARGES
   QUALITY CLASS II
   SEISMIC CATEGORY II
   CODE GROUP D
3. ALL PIPING, VALVES, & ASSOCIATED COMPONENTS ON THIS DRAWING IN THE OFF GAS SYSTEM OR AIR EJECTOR DISCHARGES SHALL BE AS FOLLOWS:
   QUALITY CLASS II+
   SEISMIC CATEGORY II
   CODE GROUP D+
   +SEE NOTE 12, WNP-2 SPEC, SECTION 15B.1, TABLE 2 NOTES.
4. IF L/D RATIO OF THIS LINE IS < 7.0 DECREASED DESIGN PRESSURE PERMITS USE OF SCHEDULE 40 PIPING AND 600LB ANSI-RATED FLANGES.
5. ALL INSTRUMENT ROOT VALVES NOT LABELED WILL BE 3/4" GLOBE VALVES UNLESS SPECIFICALLY NOTED OTHERWISE.
6. GLAND STEAM CONDENSER EXHAUSTER (AR-EX-1A & 1B) SUCTION PIPING INCLUDING CHECK VALVES AR-V-8A & 8B ARE FURNISHED WITH THE GLAND STEAM CONDENSER (CONTRACT #1) WITH THE EXCEPTION THAT THROTTLE VALVE AR-V-18 AND ITS MATING SET OF FLANGES ARE TO BE FURNISHED AND INSTALLED BY THE 215 CONTRACTOR IN THE LOCATION SHOWN.
7. INDICATES VENT OR DRAIN VALVE PIPE CAP WAS SEAL WELDED TO ENABLE SYSTEM TO PASS HELIUM LEAK TESTING.
8. THIS EQUIPMENT DRAIN ROUTES TO FDR SUMP R4 (SEE M537 & M539).

LEGEND

1. ALL VALVES SUFFIXED WITH A (V) DENOTE A 3/4" VENT VALVE.
2. ALL VALVES SUFFIXED WITH A (D) DENOTE, A 3/4" DRAIN VALVE.
3. ALL VALVES SUFFIXED WITH A (TH) DENOTE A THROTTLED VALVE.

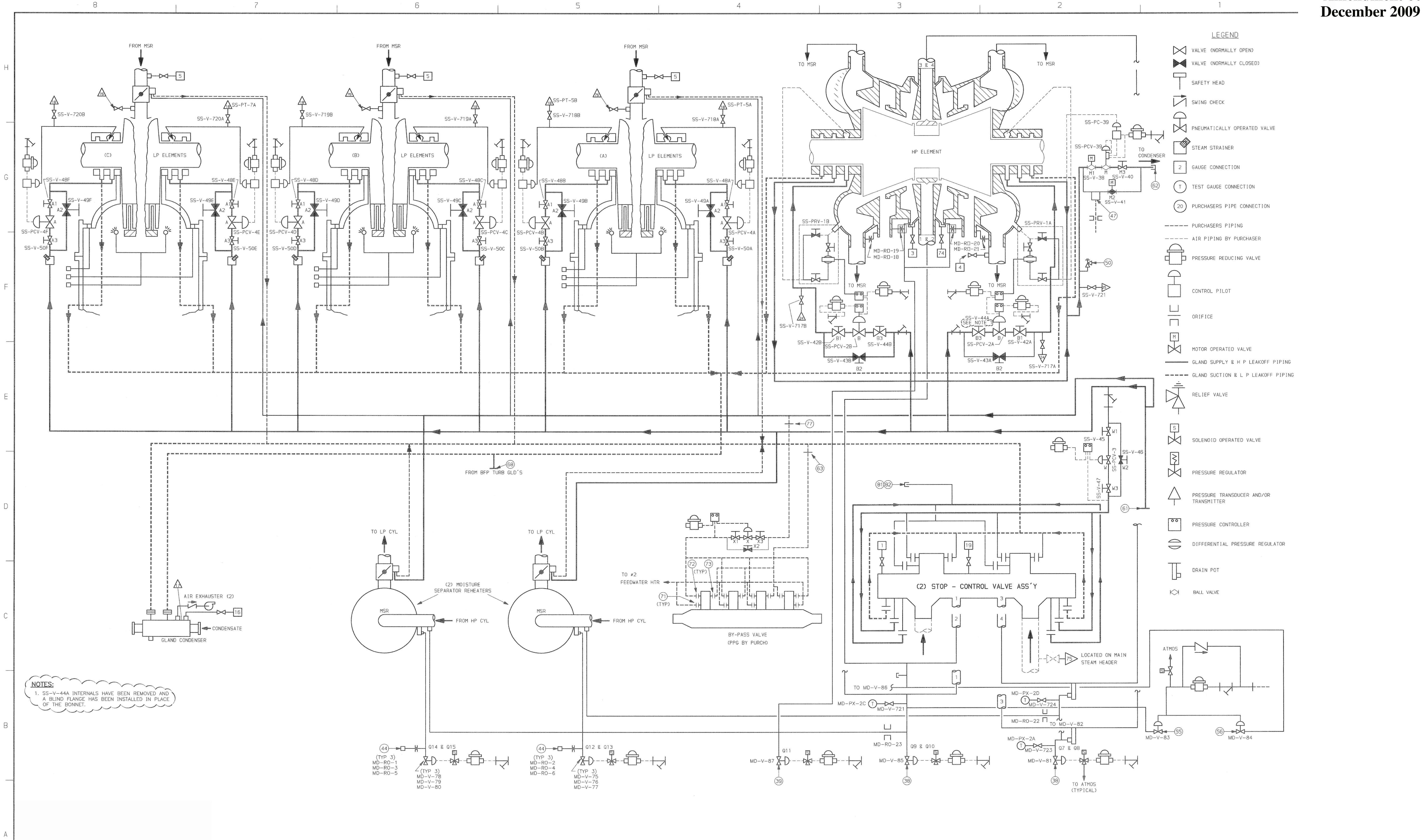
EJECTOR CONDENSER	"A"	"B"	"C"
COND-HX-8A	OG-V-128A	OG-V-130A	OG-T-007A
COND-HX-8B	OG-V-128B	OG-V-130B	OG-T-007B

DETAIL "A"

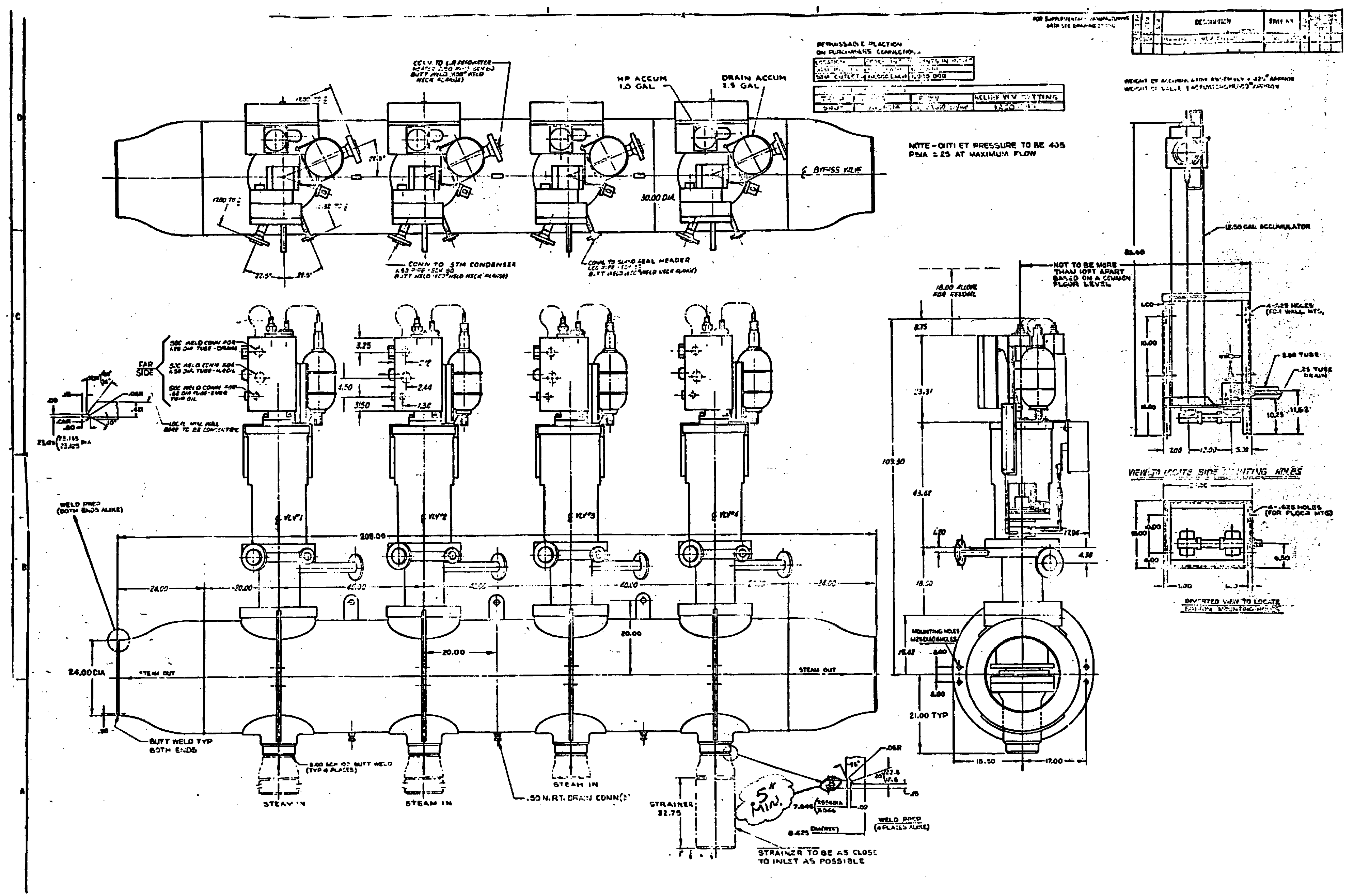
Columbia Generating Station
Final Safety Analysis Report

Main Condenser Evacuation System

Draw. No. M511 | Rev. 56 | Figure 10.4-1



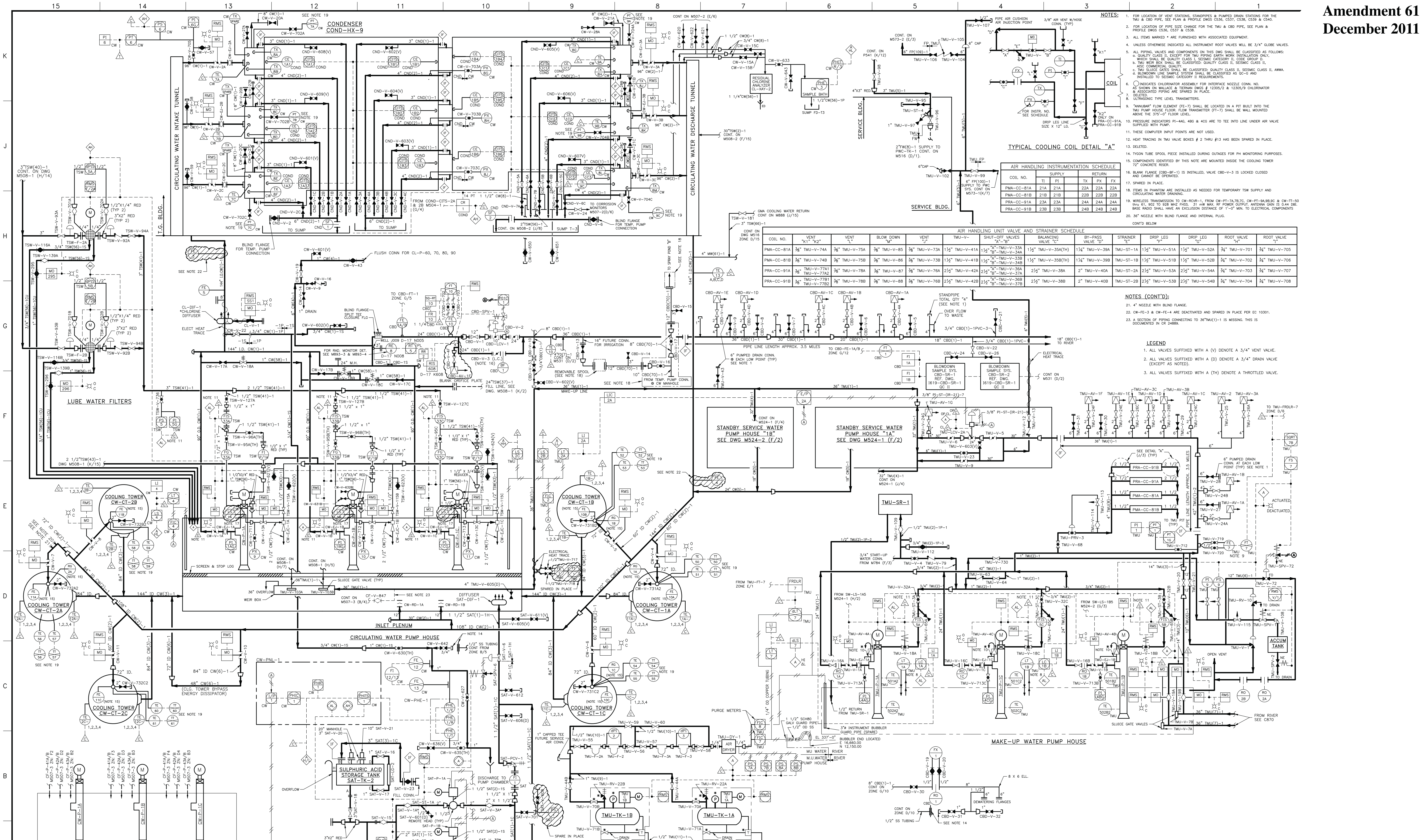
Columbia Generating Station Final Safety Analysis Report	Turbine Gland Sealing System		
	Draw. No. 01-00,143,1	Rev. 13	Figure 10.4-2



Columbia Generating Station
Final Safety Analysis Report

Turbine Bypass Valve Outline

Draw. No. 01-00,110	Rev. 4	Figure 10.4-3



NOTES:

1. FOR LOCATION OF VENT STATIONS, STANDPIPES & PUMPED DRAIN STATIONS FOR THE TMU & CBD PIPE, SEE PLAN & PROFILE DWGS C536, C537, C538, C539 & C540.
2. FOR LOCATION OF PIPE SIZE CHANGE FOR THE TMU & CBD PIPE, SEE PLAN & PROFILE DWGS C536, C537 & C538.
3. ALL ITEMS MARKED * ARE FURNISHED WITH ASSOCIATED EQUIPMENT.
4. UNLESS OTHERWISE INDICATED ALL INSTRUMENT ROOT VALVES WILL BE 3/4" GLOBE VALVES.
5. ALL PIPING, VALVES AND COMPONENTS ON THIS DWG SHALL BE CLASSIFIED AS FOLLOWS:
   a. QUALITY CLASS II, EXCEPT FOR TMU PIPING EARTH WORK INSTALLATION ONLY, WHICH SHALL BE QUALITY CLASS I, SEISMIC CATEGORY II, CODE GROUP D.
   b. TMU WEIR BOX SHALL BE CLASSIFIED: QUALITY CLASS II, SEISMIC CLASS II, AISC COMMERCIAL QUALITY.
   c. TMU SLUICE GATES SHALL BE CLASSIFIED: QUALITY CLASS II, SEISMIC CLASS II, AWWA.
   d. BLOWDOWN LINE SAMPLE SYSTEM SHALL BE CLASSIFIED AS QC-G AND INSTALLED TO SEISMIC CATEGORY II REQUIREMENTS.
6. INDICATES CHLORINATOR ASSEMBLY FOR INTERFACE NOZZLE CONN. NO. AS SHOWN ON WALLACE & TIERNAN DWGS # 12305/2 & 12305/9 CHLORINATOR & ASSOCIATED PIPING ARE SPARED IN PLACE.
7. DELETED.
8. ULTRASONIC TYPE LEVEL TRANSMITTERS.
9. "ANNUBAR" FLOW ELEMENT (FE-7) SHALL BE LOCATED IN A PIT BUILT INTO THE TMU PUMP HOUSE FLOOR. FLOW TRANSMITTER (FT-7) SHALL BE WALL MOUNTED ABOVE THE 375'-0" FLOOR LEVEL.
10. PRESSURE INDICATORS PI-4AG, 4BG & 4CG ARE TO TEE INTO LINE UNDER AIR VALVE SUPPLIED WITH PUMP.
11. THESE COMPUTER INPUT POINTS ARE NOT USED.
12. HEAT TRACING IN TMU VALVE BOXES # 2 THRU #13 HAS BEEN SPARED IN PLACE.
13. DELETED.
14. TYGON TUBE SPOOL PIECE INSTALLED DURING OUTAGES FOR PH MONITORING PURPOSES.
15. COMPONENTS IDENTIFIED BY THIS NOTE ARE MOUNTED INSIDE THE COOLING TOWER 72" CONCRETE RISER.
16. BLANK FLANGE (CBD-BF-1) IS INSTALLED, VALVE CBD-V-3 IS LOCKED CLOSED AND CANNOT BE OPERATED.
17. SPARED IN PLACE.
18. ITEMS IN PHANTOM ARE INSTALLED AS NEEDED FOR TEMPORARY TSW SUPPLY AND CIRCULATING WATER DRAINING.
19. WIRELESS TRANSMISSION TO CW-RCVR-1, FROM CW-PT-7A,7B,7C, CW-PT-9A,9B,9C & CW-TT-50 thru 61, 902 TO 928 MHZ FHSS. 31 mW MAX. RF POWER OUTPUT. ANTENNA GAIN IS 0.44 DBI. BASE RADIO SHALL HAVE AN EXCLUSION DISTANCE OF 1'-0" MIN. TO ELECTRICAL COMPONENTS
20. 36" NOZZLE WITH BLIND FLANGE AND INTERNAL PLUG.

CONT'D BELOW

AIR HANDLING INSTRUMENTATION SCHEDULE

COIL NO.	SUPPLY			RETURN		
	TI	PI		TX	PX	FX
PMA-CC-81A	21A	21A		22A	22A	22A
PMA-CC-81B	21B	21B		22B	22B	22B
PRA-CC-91A	23A	23A		24A	24A	24A
PRA-CC-91B	23B	23B		24B	24B	24B

AIR HANDLING UNIT VALVE AND STRAINER SCHEDULE

COIL NO.	VENT "K1" "K2"	VENT "L"	BLOW DOWN "M"	VENT "J"	TMU-V-	SHUT-OFF VALVES "A"-"B"	BALANCING VALVE "C"	BY-PASS VALVE "D"	STRAINER "E"	DRIP LEG "F"	DRIP LEG "G"	ROOT VALVE "H"	ROOT VALVE "I"
PMA-CC-81A	3/8" TMU-V-74A	3/8" TMU-V-75A	3/8" TMU-V-85	3/8" TMU-V-73A	1½" TMU-V-41A	1½" "A"-TMU-V-33A "B"-TMU-V-34A	1½" TMU-V-35A(TH)	1¼" TMU-V-39A	TMU-ST-1A	1½" TMU-V-51A	1½" TMU-V-52A	¾" TMU-V-701	¾" TMU-V-705
PMA-CC-81B	3/8" TMU-V-74B	3/8" TMU-V-75B	3/8" TMU-V-86	3/8" TMU-V-73B	1½" TMU-V-41B	1½" "A"-TMU-V-33B "B"-TMU-V-34B	1½" TMU-V-35B(TH)	1¼" TMU-V-39B	TMU-ST-1B	1½" TMU-V-51B	1½" TMU-V-52B	¾" TMU-V-702	¾" TMU-V-706
PRA-CC-91A	3/8" TMU-V-77A1 TMU-V-77A2	3/8" TMU-V-78A	3/8" TMU-V-87	3/8" TMU-V-76A	2½" TMU-V-42A	2½" "A"-TMU-V-36A "B"-TMU-V-37A	2½" TMU-V-38A	2" TMU-V-40A	TMU-ST-2A	2½" TMU-V-53A	2½" TMU-V-54A	¾" TMU-V-703	¾" TMU-V-707
PRA-CC-91B	3/8" TMU-V-77B1 TMU-V-77B2	3/8" TMU-V-78B	3/8" TMU-V-88	3/8" TMU-V-76B	2½" TMU-V-42B	2½" "A"-TMU-V-36B "B"-TMU-V-37B	2½" TMU-V-38B	2" TMU-V-40B	TMU-ST-2B	2½" TMU-V-53B	2½" TMU-V-54B	¾" TMU-V-704	¾" TMU-V-708

NOTES (CONT'D):

21. 4" NOZZLE WITH BLIND FLANGE.
22. CW-FE-3 & CW-FE-4 ARE DEACTIVATED AND SPARED IN PLACE PER EC 10301.
23. A SECTION OF PIPING CONNECTING TO 36"TMU(1)-1 IS MISSING. THIS IS DOCUMENTED IN CR 24889.

LEGEND

1. ALL VALVES SUFFIXED WITH A (V) DENOTE A 3/4" VENT VALVE.
2. ALL VALVES SUFFIXED WITH A (D) DENOTE A 3/4" DRAIN VALVE (EXCEPT AS NOTED).
3. ALL VALVES SUFFIXED WITH A (TH) DENOTE A THROTTLED VALVE.

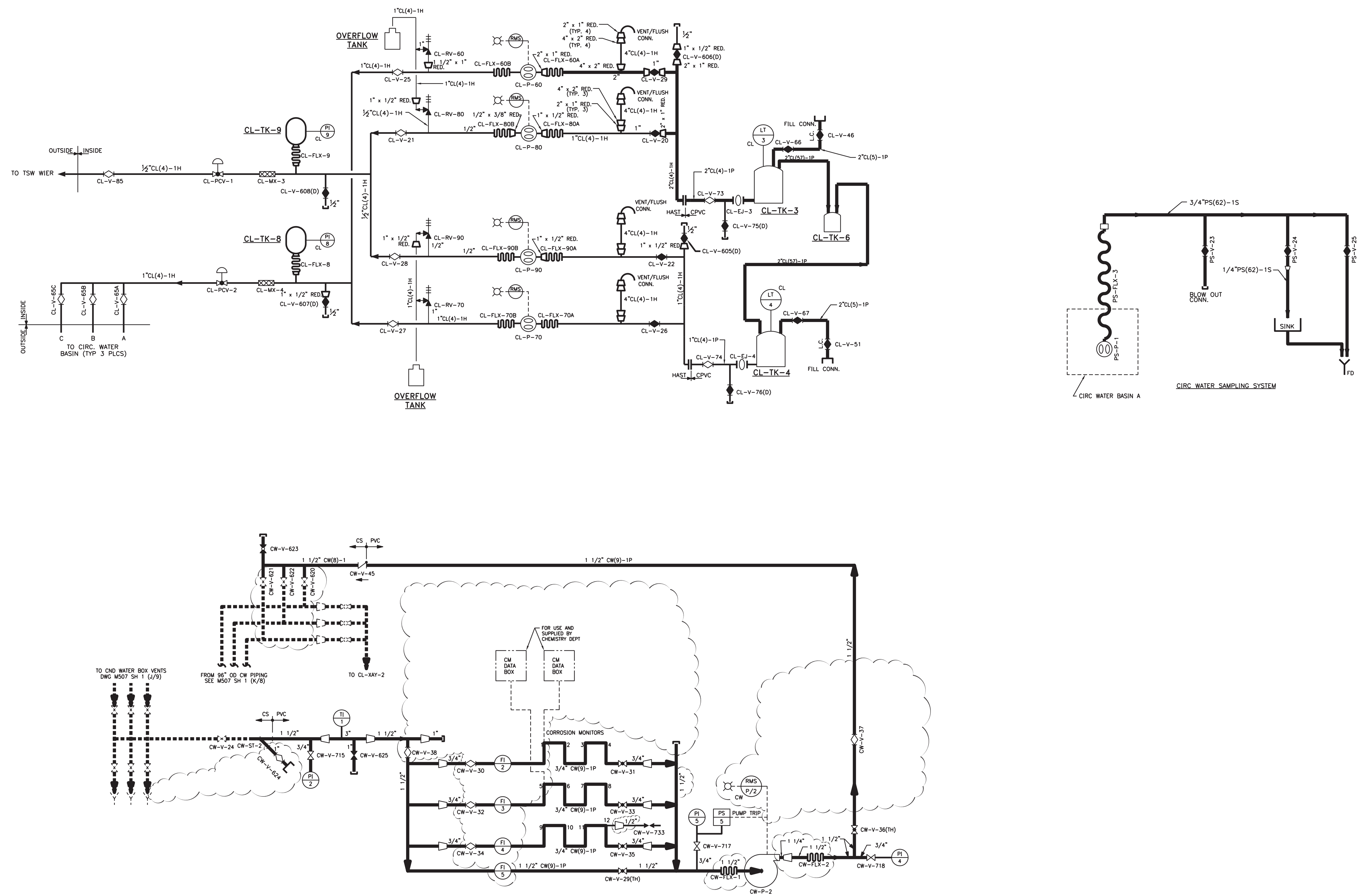
Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Circulating Water System - Turbine Generator Building and Yard

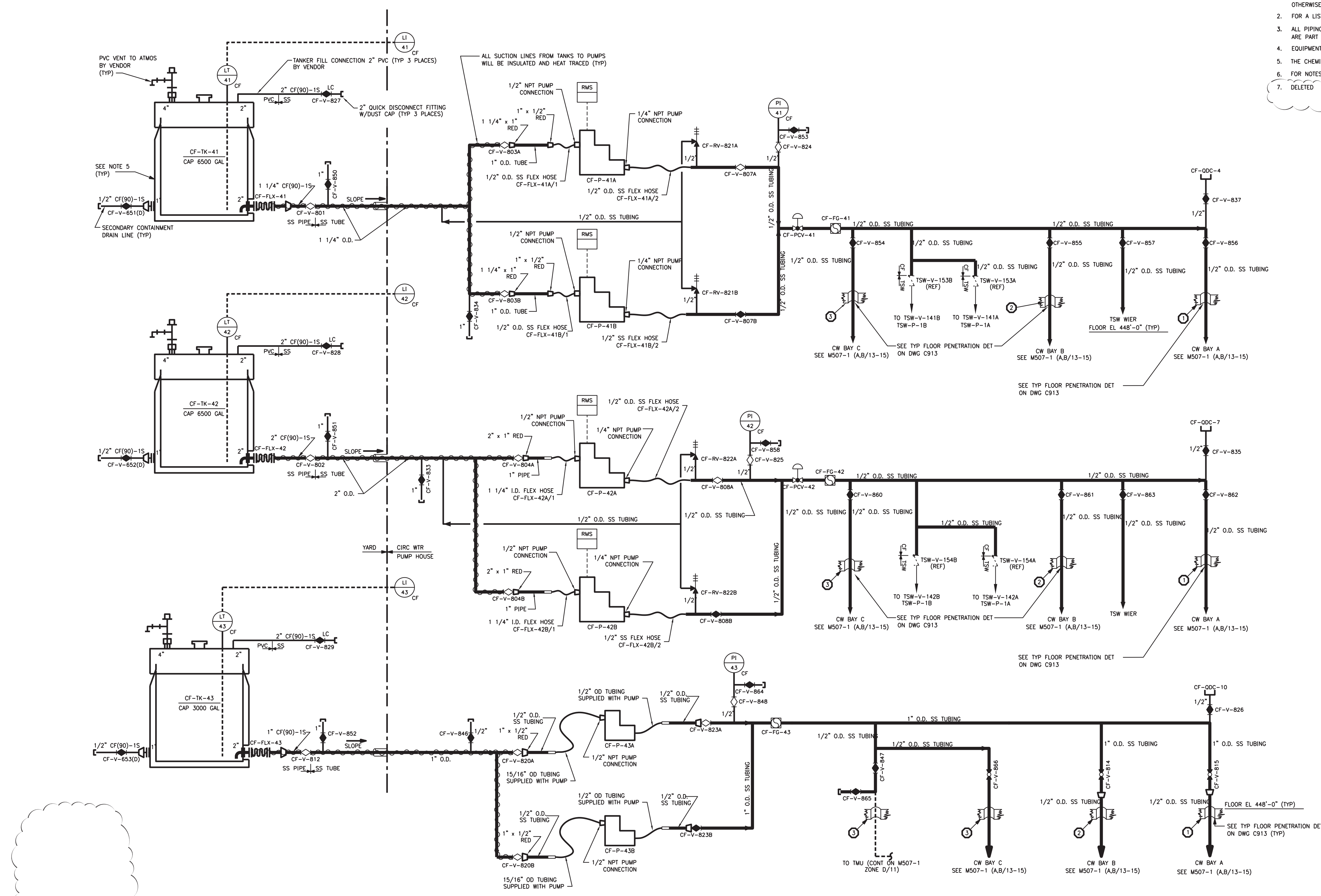
Draw. No. M507-1	Rev. 158	Figure 10.4-4.1

NOTES:

1. FOR NOTES AND LEGEND SEE DRAWING M507-1.



Columbia Generating Station Final Safety Analysis Report	Flow Diagram - Circulating Water System - Turbine Generator Building and Yard		
	Draw. No. M507-2	Rev. 7	Figure 10.4-4.2



NOTES:

1. ALL WORK ON THIS DRAWING SHALL BE QUALITY CLASS G UNLESS OTHERWISE NOTED.
2. FOR A LIST OF REFERENCE DWGS REFER TO DWG C912.
3. ALL PIPING, VALVES, TANKS, PUMPS, INSTRUMENTS, ETC. ON THIS DWG ARE PART OF THE CHEMICAL FEED SYSTEM (CF).
4. EQUIPMENT IS LOCATED IN SOUTHEAST PORTION OF CIRC WATER PUMPHOUSE.
5. THE CHEMICAL STORAGE TANKS ARE HEAT TRACED AND INSULATED.
6. FOR NOTES AND LEGEND SEE DRAWING M507-1.
7. DELETED

FLOOR PENETRATION LOCATION

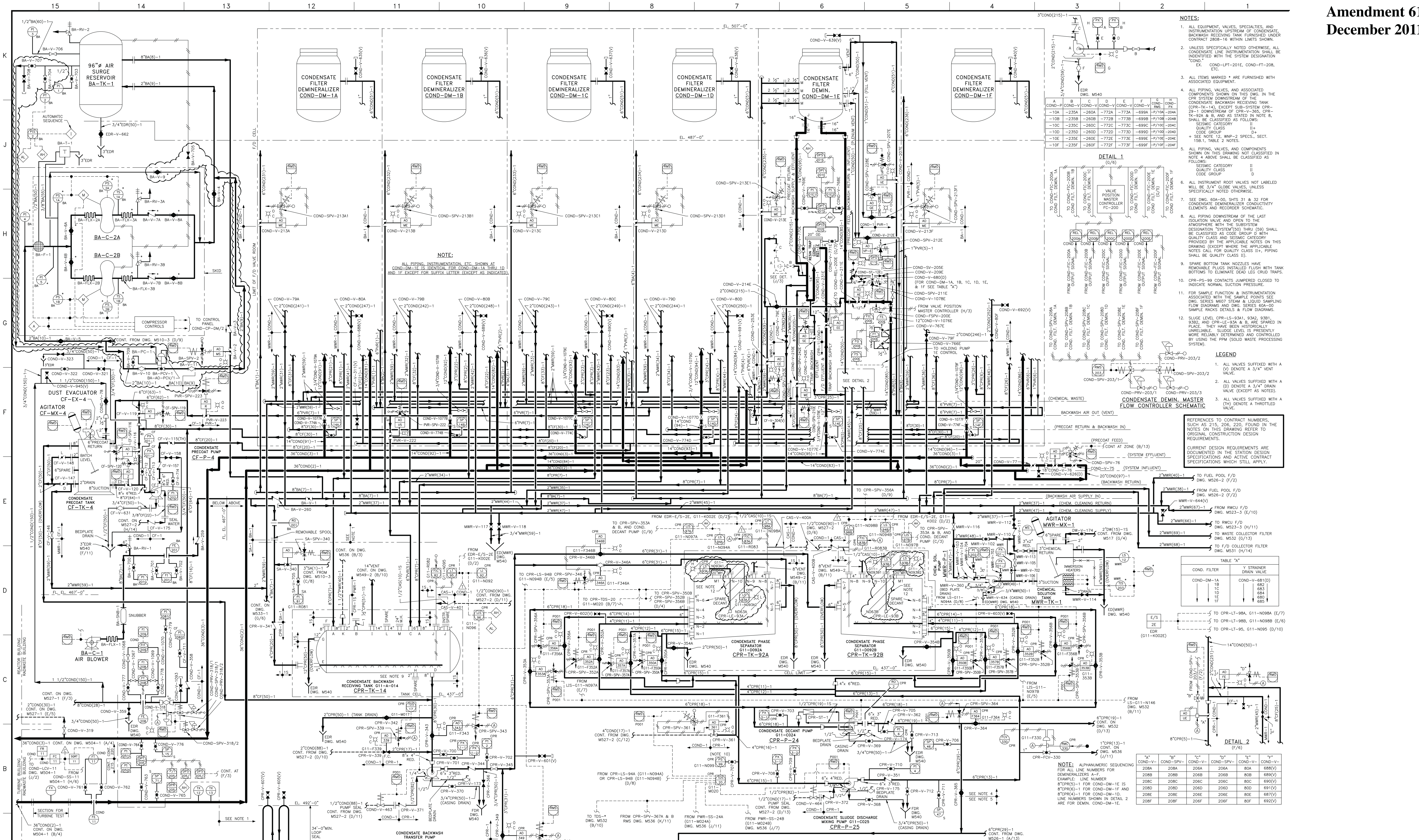
PEN NO	SUCTION BAY	APPROXIMATE COLUMN GRID LOCATION	
1	CW-P-1A	4.8	W.55
2	CW-P-1B	4.8	X.55
3	CW-P-1C	4.8	Z.55

Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Circulating Water System - Turbine Generator Building and Yard

Draw. No. M507-3	Rev. 13	Figure 10.4-4.3

Amendment 61
December 2011

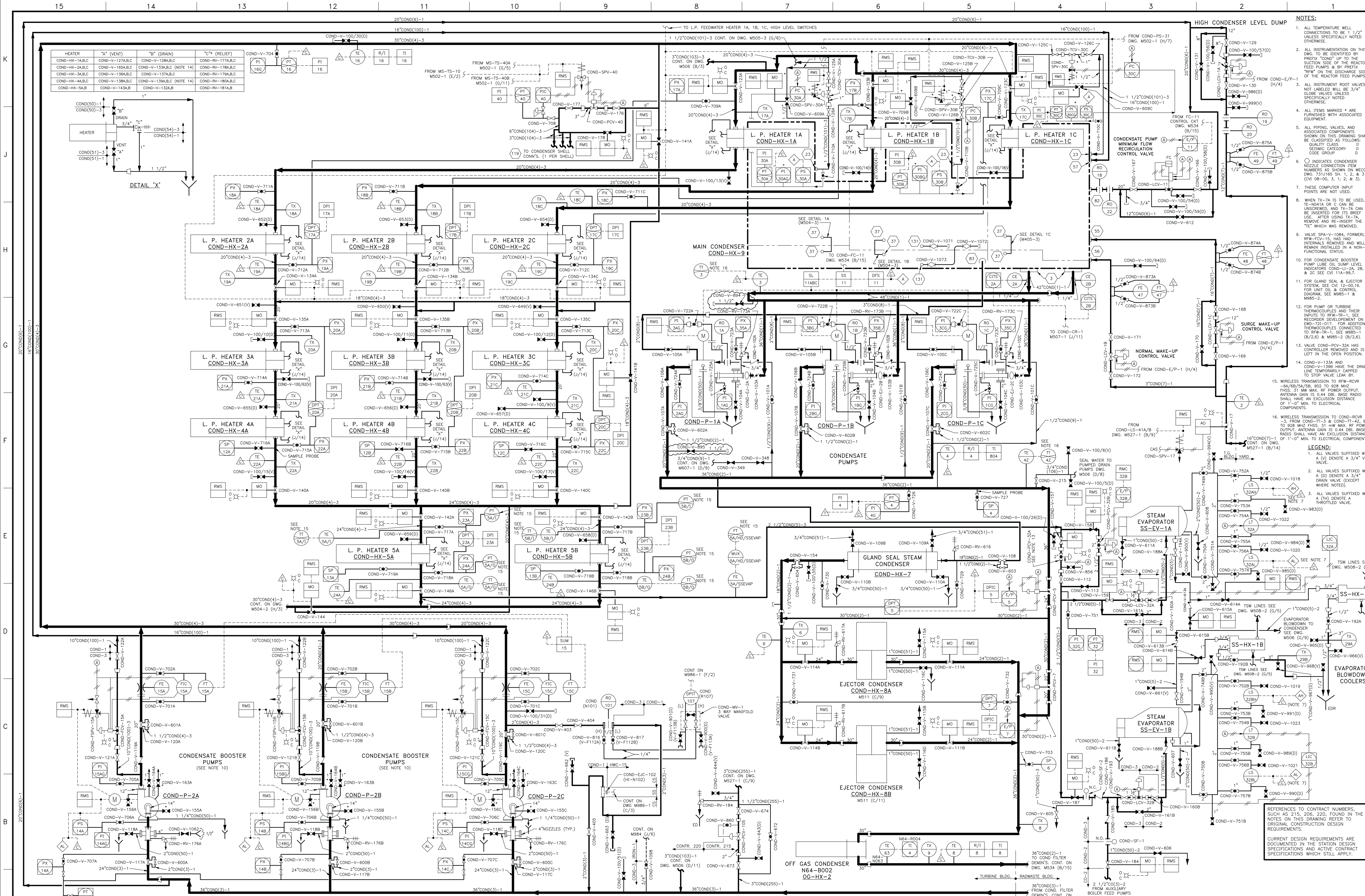


Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Radioactive Waste System
Condensate Demineralization

Draw. No. M534	Rev. 67	Figure 10.4-5

Form No. 960690ai



NOTES:

1. ALL TEMPERATURE WELL CONNECTIONS TO BE 1 1/2" UNLESS SPECIFICALLY NOTED OTHERWISE.
2. ALL INSTRUMENTATION ON THIS DWG. TO BE IDENTIFIED BY PREFIX "COND" UP TO THE SUCTION SIDE OF THE REACTOR FEED PUMPS & BY PREFIX "RFW" ON THE DISCHARGE SIDE OF THE REACTOR FEED PUMPS.
3. ALL INSTRUMENT ROOT VALVES NOT LABELED WILL BE 3/4" GLOBE VALVES UNLESS SPECIFICALLY NOTED OTHERWISE.
4. ALL ITEMS MARKED * ARE FURNISHED WITH ASSOCIATED EQUIPMENT.
5. ALL PIPING, VALVES, AND ASSOCIATED COMPONENTS SHOWN ON THIS DRAWING SHALL BE CLASSIFIED AS FOLLOWS:
   QUALITY CLASS II
   SEISMIC CATEGORY II
   CODE GROUP D
6. ⬡ INDICATES CONDENSER NOZZLE CONNECTION ITEM NUMBERS AS SHOWN ON WECO DWG. 731J165 SH. 1, 2, & 3 (CVI 08-00, 3, 1; 2; & 3).
7. THESE COMPUTER INPUT POINTS ARE NOT USED.
8. WHEN TX-7A IS TO BE USED, TE-N041A OR C CAN BE UNSCREWED, AND TX-7A CAN BE INSERTED FOR ITS BRIEF USE. AFTER USING TX-7A, REMOVE AND RE-INSERT THE "TE" WHICH WAS REMOVED.
9. VALVE SPA-V-1084, FORMERLY RFW-FCV-15, HAS HAD INTERNALS REMOVED AND WILL REMAIN INSTALLED IN A NON-FUNCTIONAL STATUS.
10. FOR CONDENSATE BOOSTER PUMP LUBE OIL SUMP LEVEL INDICATORS COND-LI-2A, 2B, & 2C SEE CVI 11A-99,7.
11. FOR GLAND SEAL & EJECTOR SYSTEM, SEE CVI 12-00,16. FOR UNIT OIL & CONTROL DIAGRAM, SEE M985-1 & M985-2.
12. FOR PUMP OR TURBINE THERMOCOUPLES AND THEIR INPUTS TO RFW-TR-1, SEE RECORDER DEVELOPEMENT ON EWD-72I-017. FOR ADDITIONAL THERMOCOUPLES CONNECTED TO RFW-TR-1, SEE M985-1 (B/2,6) & M985-2 (B/2,6).
13. VALVE COND-PCV-32A HAS CONTROLLER REMOVED AND IS LEFT IN THE OPEN POSITION.
14. COND-V-133A AND COND-V-139B HAVE THE DRAIN LINE TEMPORARILY CAPPED TO STOP VALVE LEAK BY.
15. WIRELESS TRANSMISSION TO RFW-RCVR -6A/6B/5A/5B, 902 TO 928 MHZ FHSS. 31 MW MAX. RF POWER OUTPUT. ANTENNA GAIN IS 0.44 DBI. BASE RADIO SHALL HAVE AN EXCLUSION DISTANCE OF 1'-0" MIN. TO ELECTRICAL COMPONENTS.
16. WIRELESS TRANSMISSION TO COND-RCVR -3, FROM COND-TT-3 & COND-TT-4Z, 902 TO 928 MHZ FHSS. 31 mW MAX. RF POWER OUTPUT. ANTENNA GAIN IS 0.44 DBI. BASE RADIO SHALL HAVE AN EXCLUSION DISTANCE OF 1'-0" MIN. TO ELECTRICAL COMPONENTS.

LEGEND:

1. ALL VALVES SUFFIXED WITH A (V) DENOTE A 3/4" VENT VALVE.
2. ALL VALVES SUFFIXED WITH A (D) DENOTE A 3/4" DRAIN VALVE (EXCEPT WHERE NOTED).
3. ALL VALVES SUFFIXED WITH A (TH) DENOTE A THROTTLED VALVE.

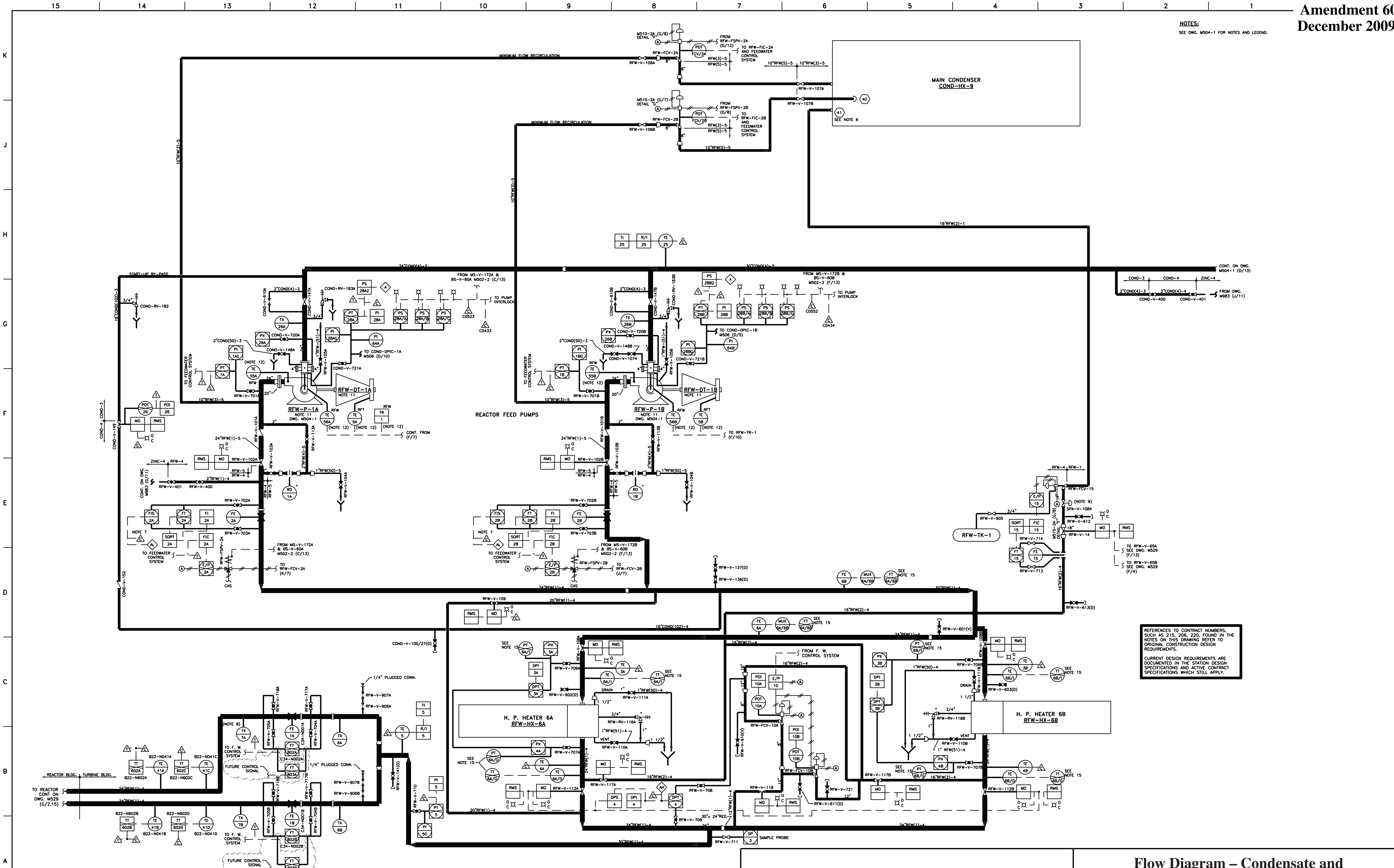
REFERENCES TO CONTRACT NUMBERS, SUCH AS 215, 206, 220, FOUND IN THE NOTES ON THIS DRAWING REFER TO ORIGINAL CONSTRUCTION DESIGN REQUIREMENTS.

CURRENT DESIGN REQUIREMENTS ARE DOCUMENTED IN THE STATION DESIGN SPECIFICATIONS AND ACTIVE CONTRACT SPECIFICATIONS WHICH STILL APPLY.

Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Condensate and Feedwater Systems

Draw. No. M504-1 | Rev. 103 | Figure 10.4-6.1



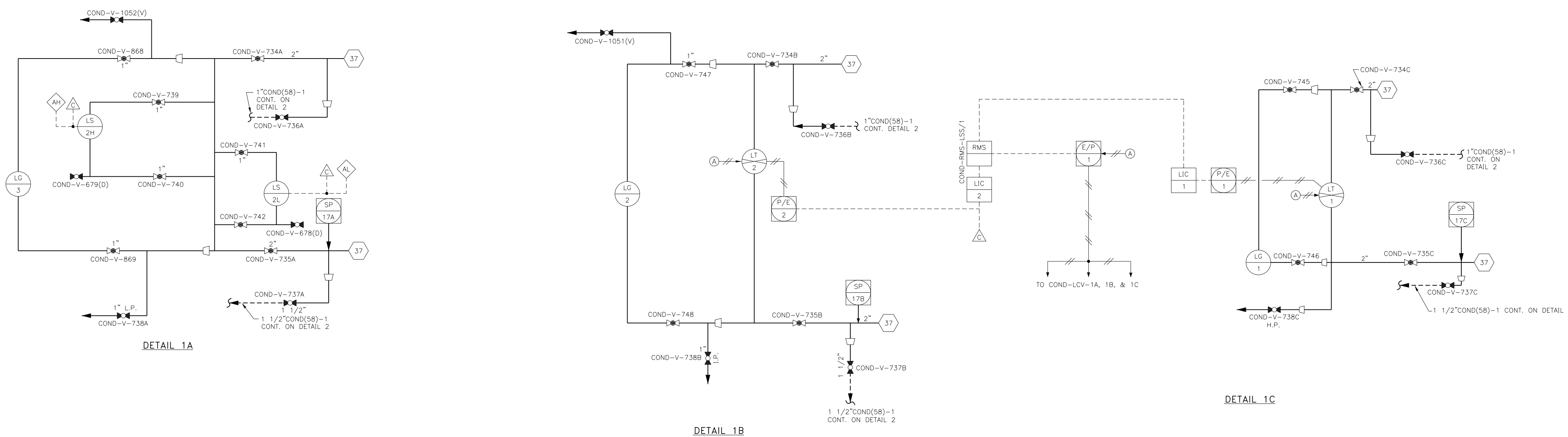
Columbia Generating Station
Final Safety Analysis Report

Flow Diagram – Condensate and Feedwater Systems

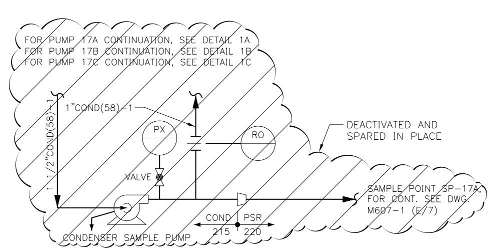
Draw. No. M504-2	Rev. 9	Figure 10.4-6.2

NOTES:

1. SEE DWG. M504-1 FOR NOTES AND LEGEN



LEVEL CONTROL ARRGT. AT CONDENSER HOTWELL



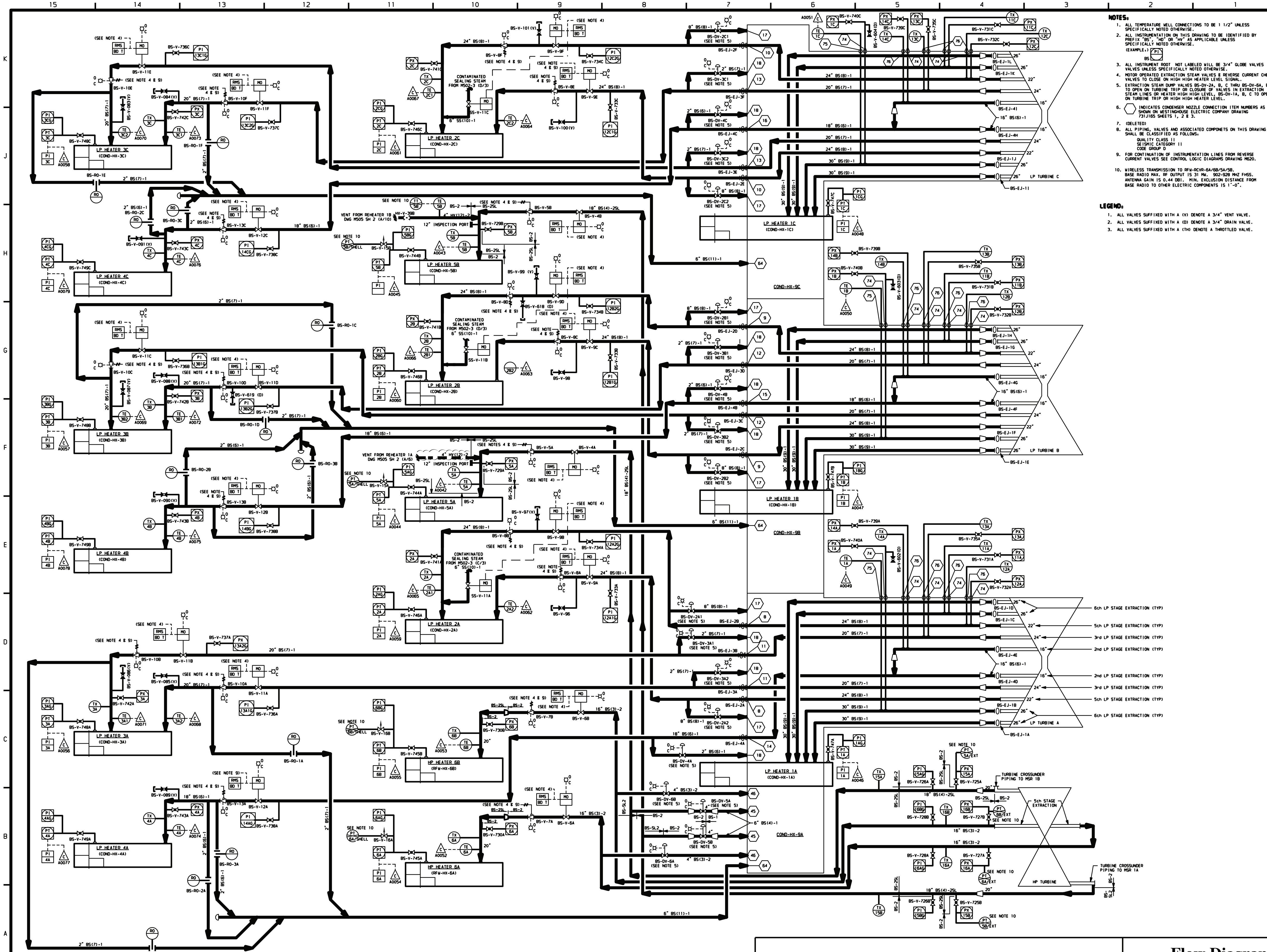
CONDENSER SAMPLE PUMP TAG NUMBERS					
PUMP No.	RO	SP	PX	VALVE	REMARKS
COND-P-17A	17A	17A	10A	COND-V-855A	PUMP IS NOT INSTALLED. PIPING IS SPARED IN PLACE.
COND-P-17B	17B	17B	10B	COND-V-855B	PUMP IS NOT INSTALLED. PIPING IS SPARED IN PLACE.
COND-P-17C	17C	17C	10C	COND-V-855C	PUMP IS NOT INSTALLED. PIPING IS SPARED IN PLACE.

DETAIL 2

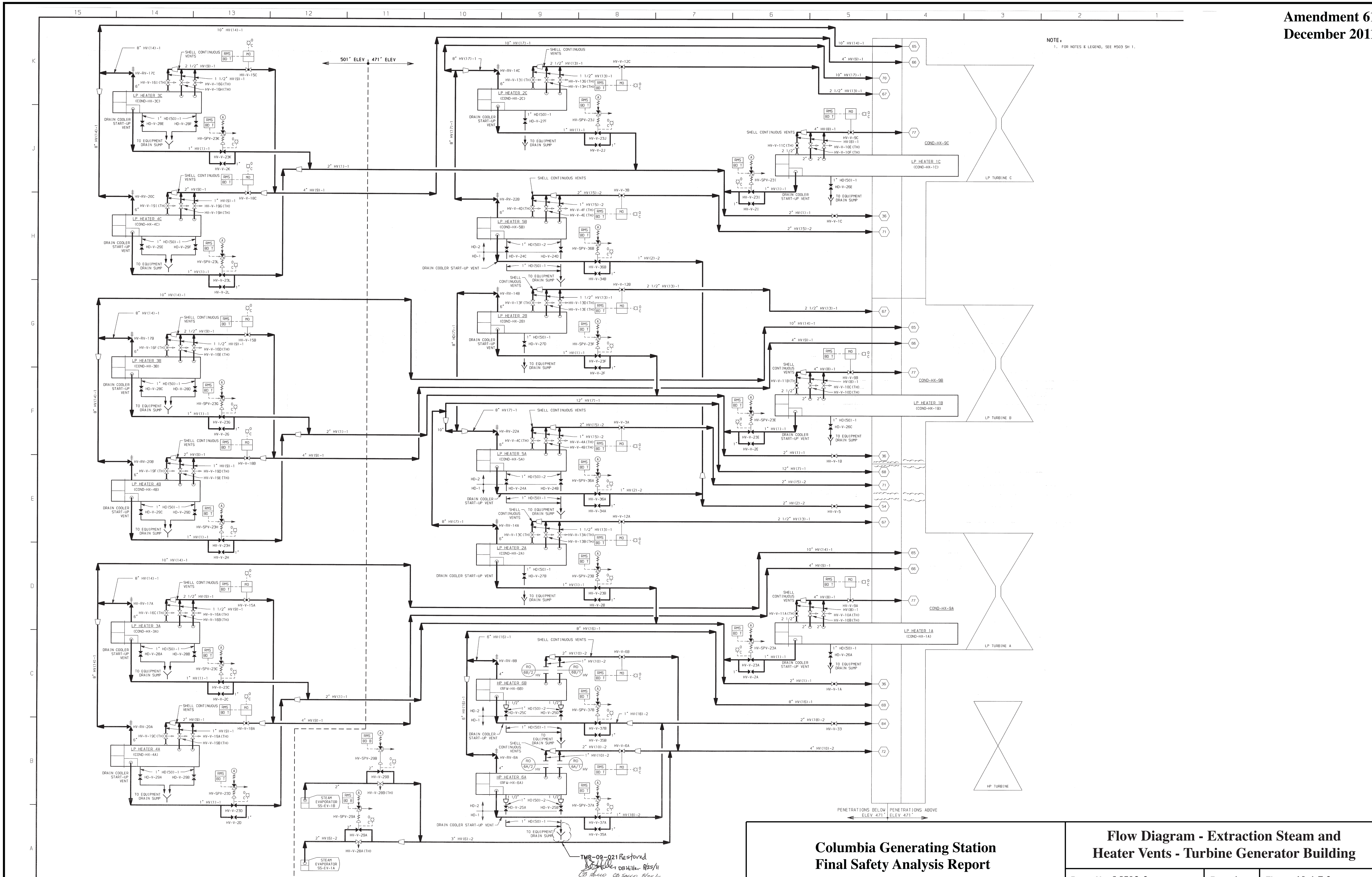
Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Condensate and Feedwater Systems

Draw. No. M504-3 | Rev. 1 | Figure 10.4-6.3



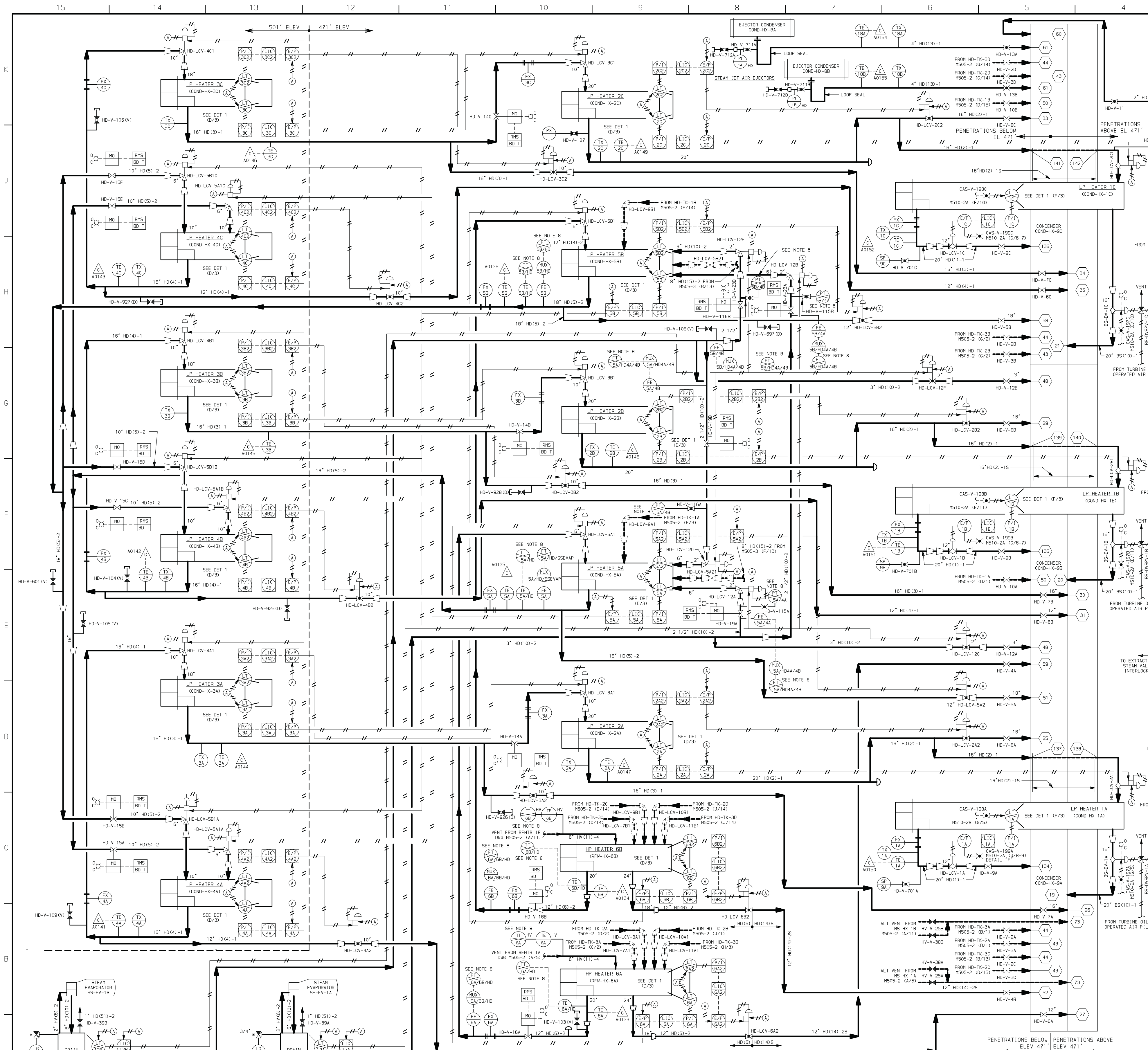
Columbia Generating Station Final Safety Analysis Report	Flow Diagram - Extraction Steam and Heater Vents - Turbine Generator Building
	Draw. No. M503-1 / Rev. 10 / Figure 10.4-7.1



Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Extraction Steam and Heater Vents - Turbine Generator Building

Draw. No. M503-2 | Rev. 4 | Figure 10.4-7.2

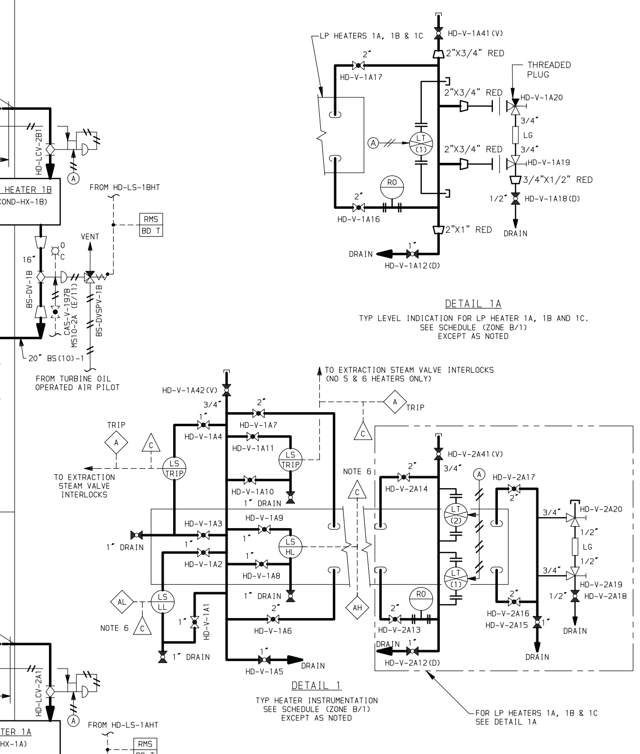


NOTES:

1. ALL TEMPERATURE WELL CONNECTIONS TO BE 1 1/2" UNLESS SPECIFICALLY NOTED OTHERWISE.
2. ALL INSTRUMENTATION ON THIS DRAWING TO BE IDENTIFIED BY PREFIX "HD", UNLESS SPECIFICALLY NOTED OTHERWISE. (EG. HD-TE-1A, HD-LT-1A, ETC.)
3. ALL INSTRUMENT ROOT VALVES NOT LABLED TO BE 3/4" GLOBE VALVES UNLESS SPECIFICALLY NOTED OTHERWISE.
4. ALL PIPING, VALVES AND ASSOCIATED COMPONETS ON THIS DRAWING SHALL BE CLASSIFIED AS FOLLOWS:
   QUALITY CLASS II
   SEISMIC CATEGORY II
   CODE GROUP D
5. ALL SAMPLE CONNECTIONS TO BE 3/4" UNLESS SPECIFICALLY NOTED OTHERWISE.
6. THESE COMPUTER INPUT POINTS ARE NOT USED.
7. (DELETED)
8. WIRELESS TRANSMISSION TO RFW-RCVR-6A/6B/5A/5B BASE RADIO OPERATES BETWEEN 902 TO 928 MHZ FHSS. MAXIMUM RF OUTPUT FOR BASE RADIO IS 31 MW. ANTENNA GAIN IS 0.44 BASE RADIO SHALL HAVE AN EXCLUSION DISTANCE OF 1'-0" MIN. TO OTHER ELECTRONIC COMPONENTS.

LEGEND:

1. ALL VALVES SUFFIXED WITH A (V) DENOTE A 3/4" VENT VALVE.
2. ALL VALVES SUFFIXED WITH A (D) DENOTE A 3/4" DRAIN VALVE. (EXCEPT WHERE NOTED)
3. ALL VALVES SUFFIXED WITH A (TH) DENOTE A THROTTLED VALVE.



DETAIL 1A

TYP LEVEL INDICATION FOR LP HEATER 1A, 1B AND 1C. SEE SCHEDULE (ZONE B/1) EXCEPT AS NOTED

DETAIL 1

TYP HEATER INSTRUMENTATION SEE SCHEDULE (ZONE B/1) EXCEPT AS NOTED

FOR LP HEATERS 1A, 1B & 1C SEE DETAIL 1A

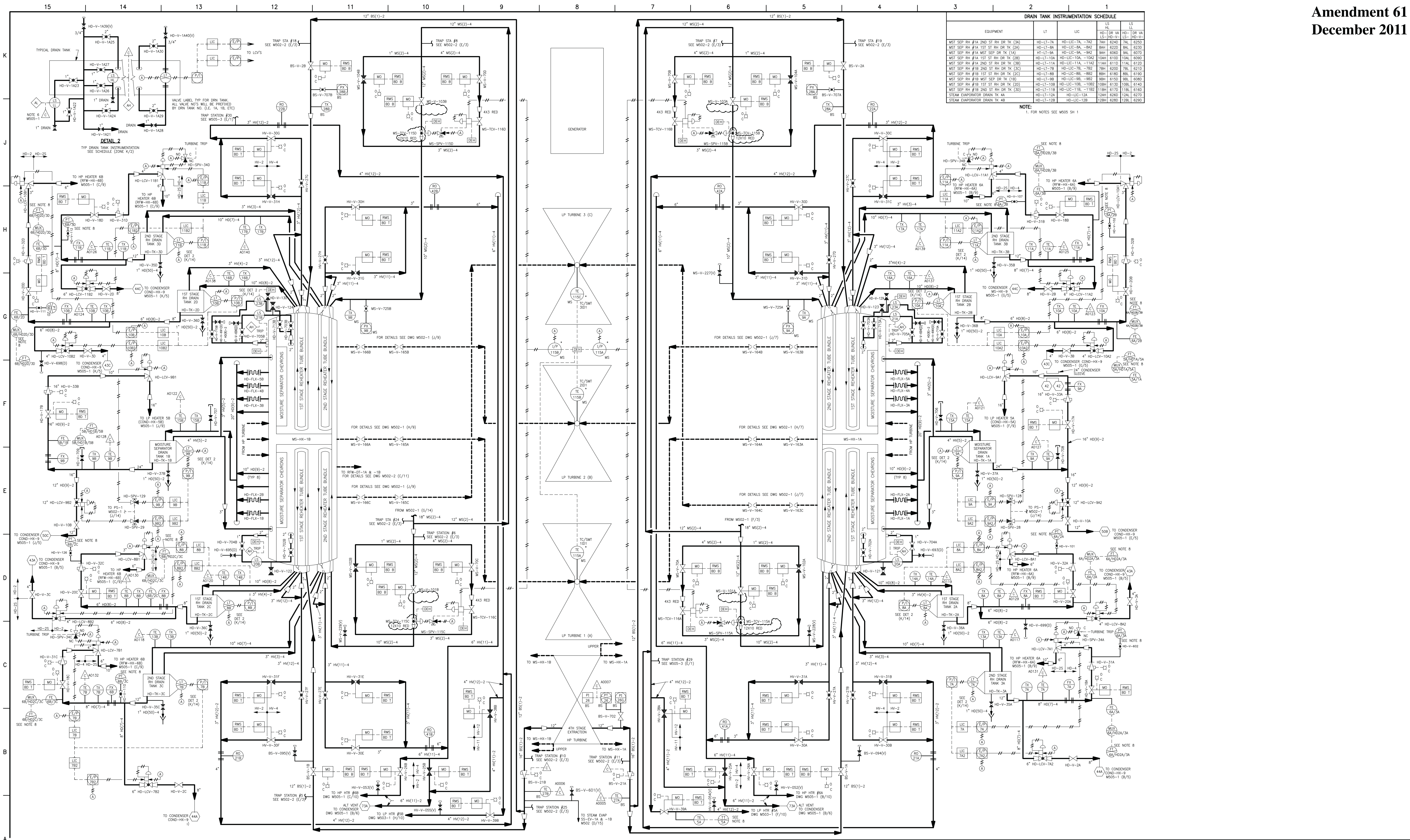
HEATER INSTRUMENTATION SCHEDULE					LEVEL SWITCHES							
					LS HL		LS LL		LS TRIP		LS TRIP	
EQUIPMENT	RESTRICTING ORIFICE #	LG	LT (1)	LT (2)	HD-LS-	DR VA HD-V-	HD-LS-	DR VA HD-V-	HD-LS-	DR VA HD-V-	HD-LS-	DR VA HD-V-
* LP HEATER #1-A	HD-RO-4	HD-LG-1A	HD-LT-1A	———	1AH	632D	1AL	631D	1AHT	630D	-	-
LP HEATER #2-A	HD-RO-1	HD-LG-2A	HD-LT-2A	HD-LT-2A2	2AH	641D	2AL	640D	2AHT	639D	-	-
LP HEATER #3-A	HD-RO-7	HD-LG-3A	HD-LT-3A	HD-LT-3A2	3AH	673D	3AL	674D	3AHT	675D	-	-
LP HEATER #4-A	HD-RO-10	HD-LG-4A	HD-LT-4A	HD-LT-4A2	4AH	664D	4AL	665D	4AHT	666D	-	-
LP HEATER #5-A	HD-RO-13	HD-LG-5A	HD-LT-5A	HD-LT-5A2	5AH	650D	5AL	651D	5AHT	649D	5AIT	648D
HP HEATER #6-A	HD-RO-15		HD-LT-6A	HD-LT-6A2	6AH	659D	6AL	658D	6AHT	657D	6AIT	656D
* LP HEATER #1-B	HD-RO-5	HD-LG-1B	HD-LT-1B	———	1BH	635D	1BL	634D	1BHT	633D	-	-
LP HEATER #2-B	HD-RO-2	HD-LG-2B	HD-LT-2B	HD-LT-2B2	2BH	644D	2BL	643D	2BHT	642D	-	-
LP HEATER #3-B	HD-RO-8	HD-LG-3B	HD-LT-3B	HD-LT-3B2	3BH	676D	3BL	677D	3BHT	678D	-	-
LP HEATER #4-B	HD-RO-11	HD-LG-4B	HD-LT-4B	HD-LT-4B2	4BH	667D	4BL	668D	4BHT	669D	-	-
LP HEATER #5-B	HD-RO-14	HD-LG-5B	HD-LT-5B	HD-LT-5B2	5BH	654D	5BL	655D	5BHT	653D	5BIT	652D
HP HEATER #6-B	HD-RO-16		HD-LT-6B	HD-LT-6B2	6BH	663D	6BL	662D	6BHT	661D	6BIT	660D
* LP HEATER #1-C	HD-RO-6	HD-LG-1C	HD-LT-1C	———	1CH	638D	1CL	637D	1CHT	636D	-	-
LP HEATER #2-C	HD-RO-3	HD-LG-2C	HD-LT-2C	HD-LT-2C2	2CH	647D	2CL	646D	2CHT	645D	-	-
LP HEATER #3-C	HD-RO-9	HD-LG-3C	HD-LT-3C	HD-LT-3C2	3CH	679D	3CL	680D	3CHT	681D	-	-
LP HEATER #4-C	HD-RO-12	HD-LG-4C	HD-LT-4C	HD-LT-4C2	4CH	670D	4CL	671D	4CHT	672D	-	-

* SEE DETAIL-1A FOR HD-LT-1A, -1B, -1C, HD-LG-1A, -1B AND -1C.

Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Heater Drain System - Turbine Generator Building

Draw. No. M505-1 | Rev. 18 | Figure 10.4-8.1



DRAIN TANK INSTRUMENTATION SCHEDULE

EQUIPMENT	LT	LIC	LS HL HD–LS–	LS HL DR VA HD–V–	LS LL HD–LS–	LS LL DR VA HD–V–
MST SEP RH #1A 2ND ST RH DR TK (3A)	HD–LT–7A	HD–LIC–7A, –7A2	7AH	624D	7AL	625D
MST SEP RH #1A 1ST ST RH DR TK (2A)	HD–LT–8A	HD–LIC–8A, –8A2	8AH	622D	8AL	623D
MST SEP RH #1A MST SEP DR TK (1A)	HT–LT–9A	HD–LIC–9A, –9A2	9AH	606D	9AL	607D
MST SEP RH #1A 1ST ST RH DR TK (2B)	HD–LT–10A	HD–LIC–10A, –10A2	10AH	610D	10AL	609D
MST SEP RH #1A 2ND ST RH DR TK (3B)	HD–LT–11A	HD–LIC–11A, –11A2	11AH	611D	11AL	612D
MST SEP RH #1B 2ND ST RH DR TK (3C)	HD–LT–7B	HD–LIC–7B, –7B2	7BH	620D	7BL	621D
MST SEP RH #1B 1ST ST RH DR TK (2C)	HD–LT–8B	HD–LIC–8B, –8B2	8BH	618D	8BL	619D
MST SEP RH #1B MST SEP DR TK (1B)	HD–LT–9B	HD–LIC–9B, –9B2	9BH	615D	9BL	608D
MST SEP RH #1B 1ST ST RH DR TK (2D)	HD–LT–10B	HD–LIC–10B, –10B2	10BH	613D	10BL	614D
MST SEP RH #1B 2ND ST RH DR TK (3D)	HD–LT–11B	HD–LIC–11B, –11B2	11BH	617D	11BL	616D
STEAM EVAPORATOR DRAIN TK 4A	HD–LT–12A	HD–LIC–12A	12AH	626D	12AL	627D
STEAM EVAPORATOR DRAIN TK 4B	HD–LT–12B	HD–LIC–12B	12BH	628D	12BL	629D

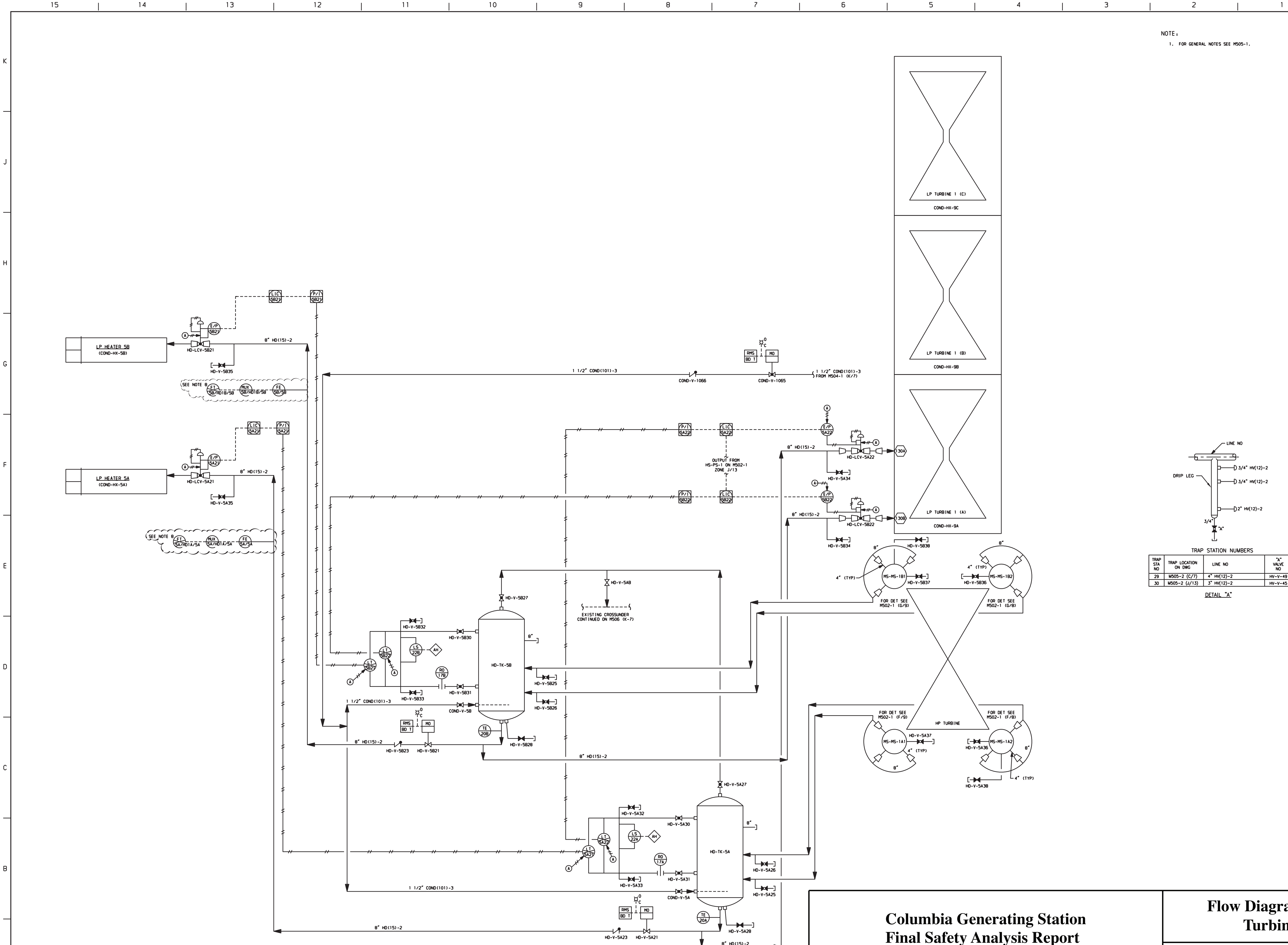
NOTE:
1. FOR NOTES SEE M505 SH 1

Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Heater Drain System - Turbine Generator Building

Draw. No. M505-2 | Rev. 12 | Figure 10.4-8.2

NOTE:
1. FOR GENERAL NOTES SEE M505-1.



TRAP STATION NUMBERS

TRAP STA NO	TRAP LOCATION ON DWG	LINE NO	"A" VALVE NO
29	M505-2 (C/7)	4" HV(12)-2	HV-V-49
30	M505-2 (J/13)	3" HV(12)-2	HV-V-45

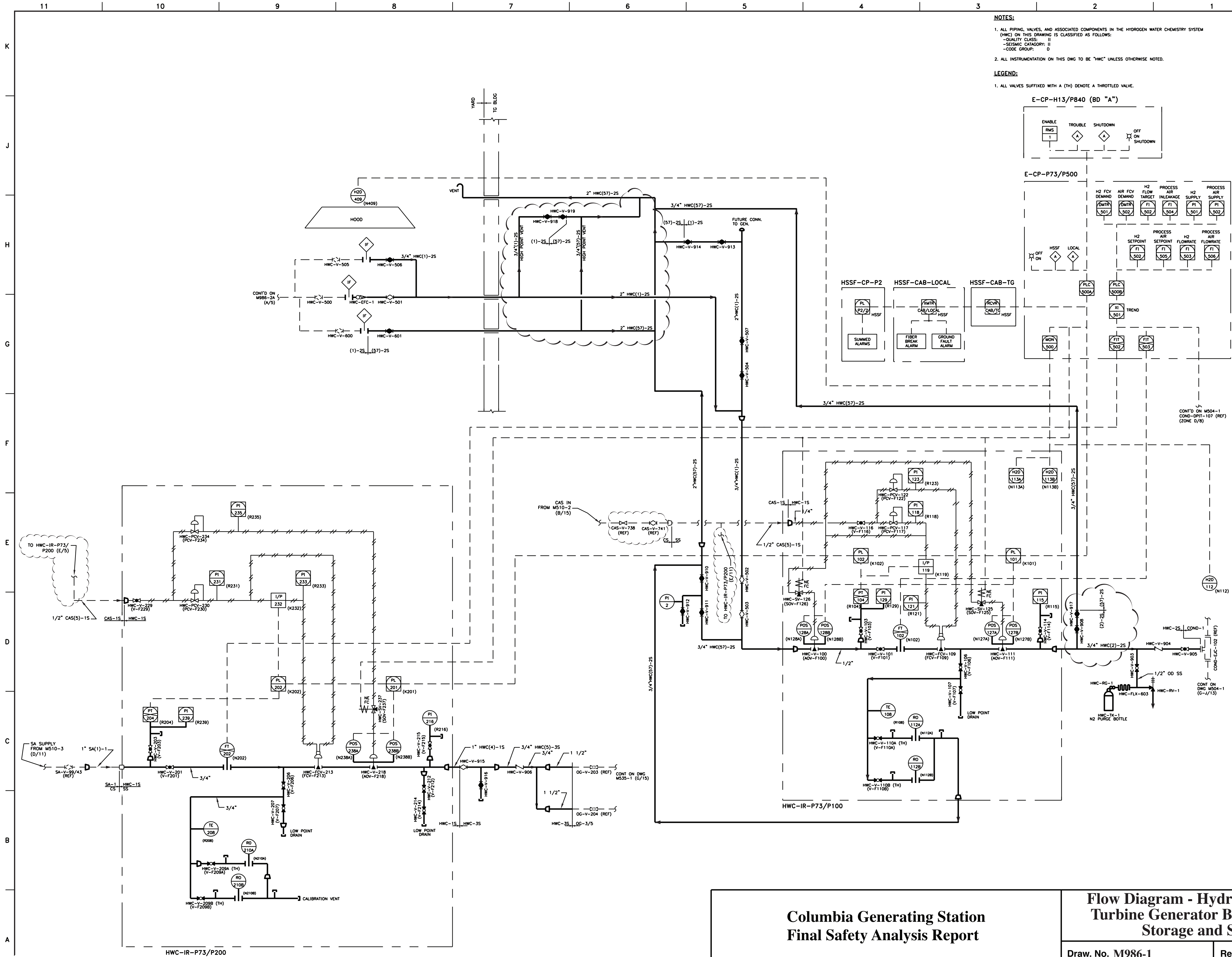
DETAIL "A"

Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Heater Drain System - Turbine Generator Building

Draw. No. M505-3 | Rev. 7 | Figure 10.4-8.3

Form No. 960690ai



NOTES:

1. ALL PIPING, VALVES, AND ASSOCIATED COMPONENTS IN THE HYDROGEN WATER CHEMISTRY SYSTEM (HWC) ON THIS DRAWING IS CLASSIFIED AS FOLLOWS:
   - QUALITY CLASS: II
   - SEISMIC CATAGORY: II
   - CODE GROUP: D
2. ALL INSTRUMENTATION ON THIS DWG TO BE "HWC" UNLESS OTHERWISE NOTED.

LEGEND:

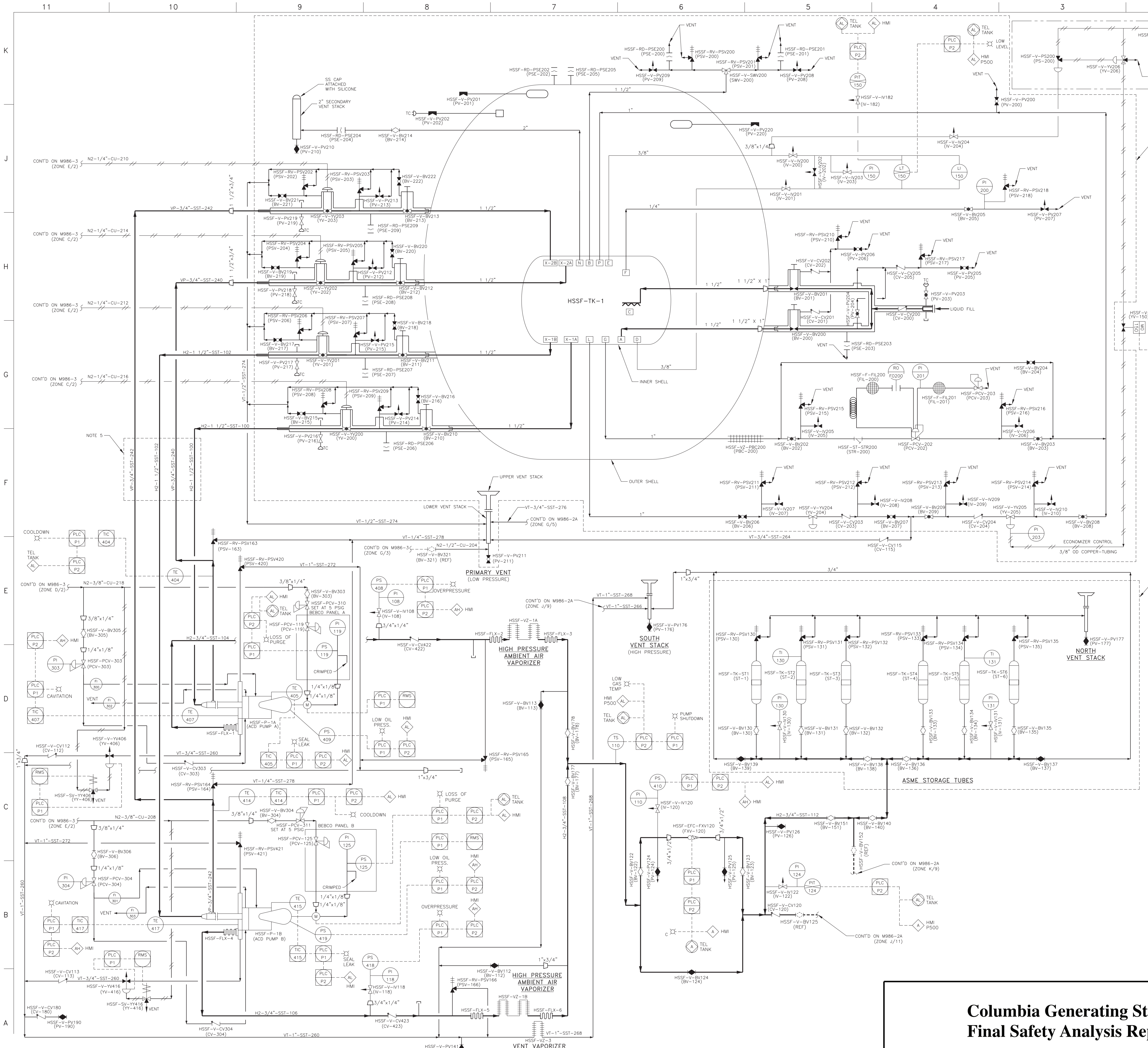
1. ALL VALVES SUFFIXED WITH A (TH) DENOTE A THROTTLED VALVE.

Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Hydrogen Water Chemistry Turbine Generator Building and Hydrogen Storage and Supply Facility

Draw. No. M986-1	Rev. 4	Figure 10.4-9.1

Amendment 59
December 2007



INTERNAL LINE SIZES

LINE	SIZE	FUNCTION
A	1 1 /2" NPS	BOTTOM FILL
B	1 1 /2" NPS	VENT
C	1 1 /2" NPS	TOP FILL
D	3/8" ODT	BOTTOM GAGE LINE
E	3/8" ODT	TOP GAGE LINE
F	1/4" NPS	FULL TRYCOCK
G	1" NPS	PRESSURE BUILD LIQUID
L	1" NPS	LIQUID DRAW
N	2" NPS	AUXILIARY VENT LINE
P	1" NPS	PRESSURE BUILD VAPORS
X-1A/B	1 1 /2" NPS	PUMP LIQUID LINE (2 LINES)
X-2A/B	1 1 /2" NPS	PUMP VAPOR LINE (2 LINES)

NOTES:

1. ALL PIPING, VALVES AND ASSOCIATED COMPONENTS IN THE HYDROGEN WATER CHEMISTRY SYSTEM (HWC) AND THE HYDROGEN SUPPLY STORAGE FACILITY (HSSF) ON THIS DRAWING ARE
   - QUALITY CLASS: II
   - SEISMIC CATEGORY: II
   - CODE GROUP: D

   WITH THE EXCEPTION OF THE HYDROGEN TANK (HSSF-TK-1) WHICH IS
   - QUALITY CLASS: II+
   - SEISMIC CATEGORY: I
   - CODE GROUP: D
2. ALL VALVES AND INSTRUMENTS HSSF UNLESS OTHERWISE NOTED.
3. ALL EQUIPMENT AND INTERCONNECTING PIPING WITHIN THIS BOX SUPPLIED AND DESIGNED BY CHART MANUFACTURING. SEE CVI # 1002-00,102 AND CVI # 1002-00,76 FOR BILL OF MATERIALS AND SPECIFICATIONS FOR THESE COMPONENTS AND PIPING.
4. ALL EQUIPMENT AND INTERCONNECTING PIPING WITHIN THIS BOX SUPPLIED AND DESIGNED BY ELEET CRYOGENICS INC. SEE CVI # 1002-00,86 FOR BILL OF MATERIALS AND SPECIFICATIONS FOR THESE COMPONENTS AND PIPING.
5. THE FOLLOWING LINE NUMBERS ARE ACTUALLY DUAL FLEX HOSE ASSEMBLIES BUILT BY CPC/CRYOLABS.
   H2-1 1/2"-SST-100
   VP-3/4"-SST-240
   H2-1 1/2"-SST-102
   VP-3/4"-SST-242
   FOR DETAILS ON THESE FLEX HOSE ASSEMBLIES SEE CVI # 1002-00,109.
6. ALL OTHER EQUIPMENT ON THIS DRAWING, NOT SPECIFIED BY NOTES 3, 4, & 5 MEETS THE REQUIREMENTS AS SPECIFIED IN CVI # 1002-00,7 AND CVI # 1002-00,8.

Columbia Generating Station
Final Safety Analysis Report

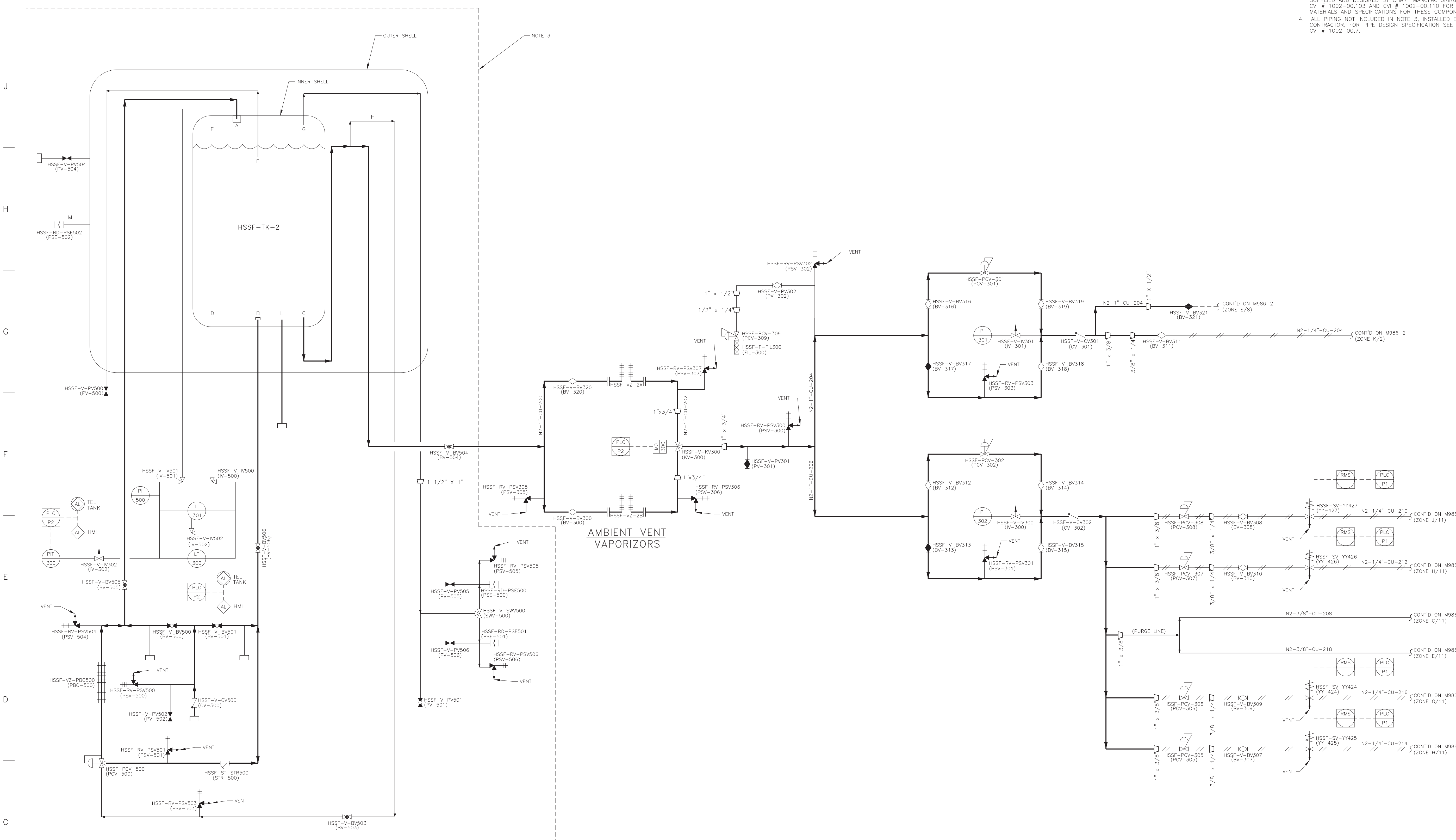
Flow Diagram - Hydrogen Water Chemistry Turbine Generator Building and Hydrogen Storage and Supply Facility

Draw. No. M986-2	Rev. 2	Figure 10.4-9.2

Form No. 960690ai

NOTES:

1. ALL PIPING, VALVES AND ASSOCIATED COMPONENTS IN THE HYDROGEN WATER CHEMISTRY SYSTEM (HWC) AND THE HYDROGEN SUPPLY STORAGE FACILITY (HSSF) ON THIS DRAWING ARE
   - QUALITY CLASS: II
   - SEISMIC CATEGORY: II
   - CODE GROUP: D
2. ALL VALVES AND INSTRUMENTS HSSF UNLESS OTHERWISE NOTED.
3. ALL EQUIPMENT AND INTERCONNECTING PIPING WITHIN THIS BOX SUPPLIED AND DESIGNED BY CHART MANUFACTURING. SEE CVI # 1002-00,103 AND CVI # 1002-00,110 FOR BILL OF MATERIALS AND SPECIFICATIONS FOR THESE COMPONENTS AND PIPING.
4. ALL PIPING NOT INCLUDED IN NOTE 3, INSTALLED BY INSTALLATION CONTRACTOR, FOR PIPE DESIGN SPECIFICATION SEE CVI # 1002-00,7.



INNER VESSEL CONNECTIONS	
A	TOP FILL
B	BOTTOM FILL
C	LIQUID DRAW DIP TUBE
D	BOTTOM GAUGE LINE
E	TOP GAUGE LINE
F	FULL TRYCOCK
G	VENT
H	ECONOMIZER LINE
L	BOTTOM WITHDRAWAL LIQUID LINE
M	EVACUATION LINE

Columbia Generating Station
Final Safety Analysis Report

Flow Diagram - Hydrogen Water Chemistry Turbine Generator Building and Hydrogen Storage and Supply Facility

Draw. No. M986-3	Rev. 2	Figure 10.4-9.3