June 11, 1996

MEMORANDUM TO: AP600 Docket File

FROM: Diane T. Jackson, Project Manager
Standardization Project Directorate
Division of Reactor Program Management, NRR

original signed by:

SUBJECT: SUBMITTAL OF DRAFT STANDARD SAFETY ANALYSIS REPORT MARKUPS PERTAINING TO CHAPTERS 9, 10, AND 11

Attached are Westinghouse draft-markups of the AP600 standard safety analysis report (SSAR) provided to the staff via Federal Express and facsimile. The SSAR section and submittal information are provided below. These markups were discussed in telephone conferences and were sent to the staff to facilitate resolution of open items in the Plant Systems Branch review areas.

Page #	Submittal Date	SSAR Section	Provided via
Page 1	May 20	10.2.3	facsimile
Page 2	May [illegible]	9.1.1.2	facsimile
Page 3 - end	May 24	9.2 9.3 10.4.5 10.4.6 10.4.8 11.2 - 11.5	Federal Express

Docket No. 52-003

Attachment: Draft markups from SSAR Chapters 9, 10, and 11

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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WITH 24 mo FUEL CYCLES

DRAFT FOR OI 360

CONSISTENT WITH A 24 MONTH FUEL CYCLE FOR AP600 AND IS

The valve inspection frequency of four years noted above is based on evaluations performed to support this valve inspection interval at operating plants. A monitoring program is in place at operating nuclear power plants to verify the success of longer valve inspection intervals. A Combined License holder recommendation for a valve inspection frequency longer than four years may be justified when a longer interval is supported by operating and inspection program experience and supported by the missile generation probability calculations.

10.2.4 Evaluation

Components of the turbine-generator are conventional and typical of those which have been extensively used in other nuclear power plants. Instruments, controls, and protective devices are provided to confirm reliable and safe operation. Redundant, fast actuating controls are installed to prevent damage resulting from overspeed and/or full-load rejection. The control system initiates a turbine trip upon reactor trip. Automatic low-pressure exhaust hood water sprays are provided to prevent excessive hood temperatures. Exhaust casing rupture diaphragms are provided to prevent low-pressure cylinder overpressure in the event of loss of condenser vacuum. The diaphragms are flange mounted and designed to maintain atmospheric pressure within the condenser and turbine exhaust housing while passing full flow.

Since the steam generated in the steam generators is not normally radioactive, no radiation shielding is provided for the turbine-generator and associated components. Radiological considerations do not affect access to system components during normal conditions. In the event of a primary-to-secondary system leak due to a steam generator tube leak, it is possible for the steam to become contaminated. Discussions of the radiological aspects of primary-to-secondary leakage are presented in Chapters 11 and 12.

10.2.5 Instrumentation Applications

The turbine-generator is provided with turbine supervisory instrumentation including monitors for the following:

- Speed
- Stop valve position
- Control valve position
- Reheat intercept and stop valve positions
- Temperatures as required for controlled starting, including:
  - External valve chest inner surface
  - External valve chest outer surface
  - First-stage shell lower inner surface
  - Crossover pipe downstream of reheat stop valve No. 1
  - Crossover pipe downstream of reheat stop valve No. 2
  - Crossover pipe downstream of reheat stop valve No. 3
  - Crossover pipe downstream of reheat stop valve No. 4
- Casing and shaft differential expansion
- Vibration of each bearing

9.1.1.2 Facilities Description

The new fuel storage facility is located within the seismic Category I auxiliary building fuel handling area. The facility is protected from the effects of natural phenomena such as earthquakes, wind, tornados, floods, and external missiles by the external walls of the auxiliary building. See Section 3.5 for additional discussion on protection from missiles. The facility is designed to maintain its structural integrity following a safe shutdown earthquake and to perform its intended function following a postulated event such as fire, internal missiles, or pipe break. The walls surrounding the fuel handling area and new fuel storage pit protect the fuel from missiles generated inside the auxiliary building. The fuel handling area does not contain a credible source of missiles. Refer to subsection 1.2.6 for a discussion of the auxiliary building. Refer to Section 3.8 for a discussion of the structural design of the new fuel storage area. Refer to subsection 3.5.1 for a discussion of missile sources and protection.

The dry, unlined, approximately 15.5-feet deep reinforced concrete pit is designed to provide support for the new fuel storage rack. The rack is supported by the pit floor and laterally supported as required at the rack top grid structure by the pit wall structures. The walls of the new fuel pit are seismic Category I. The new fuel pit is normally covered to prevent foreign objects from entering the new fuel storage rack. Since the only crane that can access the new fuel pit does have the capacity to lift heavy objects, as defined in Section 9.1.5, the new fuel pit cover is not designed to protect the fuel assemblies from the effects of dropped heavy objects. Figures 1.2-7 through 1.2-10 show the relationship between the new fuel storage facility and other features of the fuel handling area.

The new fuel storage pit is drained ~~to an auxiliary building sump~~ by gravity drains that are part of the liquid radwaste system (Section 11.2). These drains preclude flooding of the pit by an accidental release of water.

Nonseismic equipment in the vicinity of the new fuel storage racks is evaluated to confirm that its failure could not result in an increase of K_{eff} beyond the maximum allowable K_{eff}. Refer to subsection 3.7.3.13 for a discussion of the nonseismic equipment evaluation.

A jib crane is used to load new fuel assemblies into the new fuel rack and transfer new fuel assemblies from the new fuel pit into the spent fuel pool. The capacity of the jib crane is limited to 2000 lbs. The new fuel pit is not accessed by the fuel handling machine or by the cask handling crane. This precludes the movement of loads greater than fuel components over stored new fuel assemblies.

During fuel handling operations, a ventilation system removes gaseous radioactivity from the atmosphere above the new fuel pit. Refer to subsection 9.4.3 for a discussion of the fuel handling area HVAC system and Section 11.5 for process radiation monitoring. Security for the new fuel assemblies is described in Section 13.6.

the radioactive waste drain system (subsection 9.3.5), draining to the waste holdup tanks which are part of

24 MAY/96

DIANE, TOM AND CHANG

HERE ARE OUR SSAR MARKUP DRAFTS BASED ON OUR PHONE CALL.

IF YOU AGREE WITH MARKUPS, WE CAN ISSUE THEM IN OUR MID-JUNE REVISION 8.

IF NOT, LET'S DISCUSS OVER THE PHONE.

THANKS.

Jim Winters

412-374-5290

ENCLOSED SECTIONS

9.3

10.4.6

10.4.8

11.2

11.3

11.4

11.5

9.2

10.4.5

Table 9.3.3-2 (Sheet 1 of 2)

LOCAL SAMPLE POINT NOT IN THE PRIMARY SAMPLING SYSTEM (NORMAL PLANT OPERATIONS)

Sample Point Name	Type of Sample[a]
Liquid Sample	
1. CVS Boric Acid Tank	Grab
2. CVS Boric Acid Batching Tank	Grab
3. Residual Heat Removal Heat Exchanger	Grab
4. PXS IRWST	Grab
5. Main Steam Line (Outlet SG1)	Continuous
6. Main Steam Line (Outlet SG2)	Continuous
7. SFS Loops (upstream of SFS Pumps)	Grab
8. PCS Water Storage Tank	Grab
9. RC Drain Tank	Grab
10. WLS Degassifier (downstream of degassifier discharge pump)	Grab
11. CCS Component Cooling Surge Tank	Grab
12. CCS Loops (downstream of CCS pumps)	Grab
13. CCS Hot Leg (upstream of CCS pumps)	Continuous
14. WLS Discharge	Continuous
15. WLS Effluent Holdup Tanks MT05A,B	Grab
16. WLS Waste Holdup Tanks MT06A,B	Grab
17. WLS Monitor Tanks MT07A,B,C	Grab
18. WLS Chemical Waste Tank	Grab
19. WSS Spent Resin Tank	Grab

Replace with F

Table 9.3.3-2 (Sheet 2 of 2)

LOCAL SAMPLE POINT NOT IN THE PRIMARY SAMPLING SYSTEM (NORMAL PLANT OPERATIONS)

Sample Point Name	Type of Sample[a]
Gaseous Sample	
20. Reactor Coolant Drain Tank (overpressure gas space)	Grab
21. VES MCR Emergency Air Supply Headers	Grab
22. WGS Effluent Discharge to Environment	Continuous
23. WGS Inlet	Continuous
24. WGS Inlet	Grab
25. WGS Guard Bed Outlet	Grab
26. WGS Delay Bed Outlet	Grab
27. WGS Delay Bed MV02B	Grab

Note:

a. This column shows methods to obtain a sample for analysis. It does not specify the frequency of sampling nor does it specify the actual location of sample collection. "Grab" means that a grab sample is required for the intended analysis. "Continuous" means that the required analysis may be performed via an instrument that monitors the sampling stream continuously.

(F)

LOCAL SAMPLE POINT NOT IN THE PRIMARY SAMPLING SYSTEM (NORMAL PLANT OPERATIONS)

	Sample Point Name	Available Number of Points	Type of Sample(a)	Process Measurement
Liquid Sample				
1.	CVS Boric Acid Tank	1	Grab	pH, chlorine, fluorine, boron, silica, suspended solids, radioisotopic liquid, oxygen
2.	CVS Boric Acid Batching Tank	1	Grab	Boron, chlorine, fluorine
3.	Residual Heat Removal Heat Exchanger	2	Grab	Radioisotopic liquid, suspended solids, radioisotopic gas, gross specific activity, strontium, iron, tritium, hydrogen, I-131, conductivity, pH, oxygen, chlorine, fluorine, boron, aluminum, silica, lithium radioisotopic liquid, lithium radioisotopic particulate, magnesium, sulfate, calcium, lithium
4.	PXS IRWST	1	Grab	pH, oxygen, fluorine, boron, conductivity, gross specific activity, sodium, sulfate, silica
5.	Main Steam Line (Outlet SG1)	1	Continuous	Radiation monitor (See Section 11.5, Table 11.5-1)
6.	Main Steam Line (Outlet SG2)	1	Continuous	Radiation monitor (See Section 11.5, Table 11.5-1)

(F) cont.

Table 9.3.3-2 (Sheet 2 of 5)

LOCAL SAMPLE POINT NOT IN THE PRIMARY SAMPLING SYSTEM (NORMAL PLANT OPERATIONS)

	Sample Point Name	Available Number of Points	Type of Sample* (a)	Process Measurement
7.	BDS Steam Generator Blowdown	1	Grab	Tritium, gross radioactivity and identification and concentration of principal radionuclide and alpha emitters
8.	SFS Purification (Upstream & downstream of SFS Ion Exchangers)	2	Grab	Conductivity, pH, chloride, silica, corrosion product metals, gross activity, corrosion product activity, fission product activity, iodine-131, tritium, turbidity, boron, corrosion product metals, organic impurities
9.	PCS Water Storage Tank	1	Grab	Hydrogen peroxide
10.	RC Drain Tank	1	Grab	Gross radioactivity and identification and concentration of principal radionuclide and alpha emitters. Dissolved gases. State and federal environmental discharge requirements such as pH, suspended solids, oil and grease, iron, copper, and sodium nitrite
11.	WLS Degasifier (downstream of degasifier discharge pump)	1	Grab	Dissolved gases
12.	CCS Component Cooling Surge Tank	1	Grab	pH, sodium, chloride, silica, corrosion product metals, corrosion inhibitors
13.	CCS Loops (downstream of CCS pumps)	2	Grab	pH, sodium, chloride, silica, corrosion product metals, tritium, gross radioactivity and identification and concentration of principal radionuclide and alpha emitters

F cont.

Table 9.3.3-2 (Sheet 3 of 5)

LOCAL SAMPLE POINT NOT IN THE PRIMARY SAMPLING SYSTEM (NORMAL PLANT OPERATIONS)

	Sample Point Name	Available Number of Points	Type of Sample*(a)	Process Measurement
14.	CCS Hot Leg (upstream of CCS pumps)	1	Continuous	Radiation monitor (See Section 11.5, Table 11.5-1)
15.	WLS Discharge	2	Continuous	Radiation monitor (See Section 11.5, Table 11.5-1)
16.	WLS Effluent Holdup Tanks MT05A,B	2	Grab	Gross radioactivity and identification and concentration of principal radionuclide and alpha emitters
17.	WLS Waste Holdup Tanks MT06A,B	2	Grab	Gross radioactivity and identification and concentration of principal radionuclide and alpha emitters
18.	WLS Monitor Tanks MT07A, B, C	3	Grab	Tritium, gross radioactivity and identification and concentration of principal radionuclide and alpha emitters. State and federal environmental discharge requirements such as pH, suspended solids, oil and grease, iron, copper, sodium nitrite

F cont

Table 9.3.3-2 (Sheet 4 of 5)

LOCAL SAMPLE POINT NOT IN THE PRIMARY SAMPLING SYSTEM (NORMAL PLANT OPERATIONS)

	Sample Point Name	Available Number of Points	Type of Sample (a)	Process Measurement
19.	WLS Ion Exchanger Prefilter (downstream)	1	Grab	Suspended solids
20.	WLS Ion Exchanger After-filter (downstream)	1	Grab	Suspended solids
21.	WLS Chemical Waste Tank	1	Grab	Tritium, gross radioactivity and identification and concentration of principal radionuclide and alpha emitters
22.	WSS Spent Resin Tank (liquid)	1	Grab	Tritium, gross radioactivity and identification and concentration of principal radionuclide and alpha emitters
23	SWS Blowdown	1	Grab	Tritium, gross radioactivity and identification and concentration of principal radionuclide and alpha emitters
24.	WWS Turbine Bldg. Drain Tank	2	Grab	Tritium, gross radioactivity and identification and concentration of principal radionuclide and alpha emitters
25.	CPS Spent Resin Sluice Line (liquid)	1	Grab	Tritium, gross radioactivity and identification and concentration of principal radionuclide and alpha emitters

(F) cont.

Table 9.3.3-2 (Sheet 5 of 5)

LOCAL SAMPLE POINT NOT IN THE PRIMARY SAMPLING SYSTEM (NORMAL PLANT OPERATIONS)

	Sample Point Name	Available Number of Points	Type of Sample* (a)	Process Measurement
Gaseous Sample				
26.	VES MCR ~~E~~mergency ~~A~~ir ~~S~~upply ~~H~~eaders	2	Grab	Air quality, oxygen, carbon monoxide, carbon dioxide, contaminants
27.	WGS ~~E~~ffluent ~~D~~ischarge to ~~E~~nvironment	1	Continuous	Radiation monitor (See Section 11.5, Table 11.5-1)
28.	WGS ~~I~~nlet	1	Continuous	Oxygen, hydrogen, moisture
29.	WGS ~~C~~arbon ~~B~~ed ~~V~~ault	1	Continuous	Hydrogen
30.	WGS ~~D~~elay ~~B~~ed ~~O~~utlets MV02A,B	2	Grab	Moisture, noble gases, iodine, particulates, tritium
31.	Condenser ~~A~~ir ~~R~~emoval ~~S~~ystem ~~(Note 1)~~ (b)	1	Grab	Iodine, noble gases, tritium
32.	Gland ~~S~~eal ~~S~~ystem (b) ~~(Note 1)~~	1	Grab	Iodine, noble gases, tritium
33.	Plant ~~V~~ent	1	Continuous & Grab	Iodine, noble gases, particulates

a. This column shows methods to obtain a sample for analysis. "Grab" means that a grab sample is required for the intended analysis. Depending on the sampling condition, this grab sample can be obtained in the laboratory or in the grab sampling unit. "Continuous" means that the required analysis is performed via a probe that monitors the sampling stream continuously.

bold Notes: ~~1.~~ b. Continuous monitoring of discharge for radiation provided in ~~T~~urbine ~~I~~sland ~~V~~ent (See Section 11.5, Table 11.5-1) causes the tower basin water level to fluctuate. The fluctuation is sensed by a level controller which operates the makeup valve to control tower makeup.

The control approach is to allow the makeup water to concentrate naturally to its upper limit. Provisions are made to add chemicals for pH control.

The cycles of concentration at which the cooling tower is operated is dependent on the quality of the cooling tower makeup water. Cooling tower blowdown is discharged to the waste water system.

10.4.6 Condensate Polishing System

The condensate polishing system (CPS) can be used to remove corrosion products and ionic impurities from the condensate system during plant startup, hot standby, power operation with abnormal secondary cycle chemistry, safe shutdown, and cold shutdown operations.

10.4.6.1 Design Basis

10.4.6.1.1 Safety Design Basis

The condensate polishing system serves no safety-related function and therefore has no nuclear safety-related design basis.

10.4.6.1.2 Power Generation Design Basis

The power generation design bases are to:

- Remove corrosion products, dissolved solids and other impurities from the condensate system and maintain a noncorrosive environment within the condensate, feedwater and steam generator systems

- Provide polishing capacity for processing one-third of the maximum condensate flow in a sidestream arrangement

- Provide polishing capability during normal startup and shutdown operations of the plant

- Provide for plant operation with a "continuous" condenser tube leak of .001 gpm or a "faulted" leak of 0.1 gpm until repairs can be completed or until an orderly shutdown is achieved

10.4.6.2 System Description

The condensate polishing system is used during operating modes of startup, hot standby, power operation with abnormal secondary cycle chemistry, safe shutdown, and cold shutdown. Classification of components in the CPS is identified in Section 3.2. The major components for the condensate polishing system are described below. The condensate polishing system is shown in Figure 10.4.6-1.

Deep Bed Mixed Resin Polisher

The polisher vessel is constructed of carbon steel with a protective rubber lining on the inside of the vessel. Leachable sulphur of the rubber lining is less than 20 ppb. Level indication is provided.

Resin Trap

The resin trap is located in the effluent piping of the vessel. Differential pressure across the trap is monitored.

Spent Resin Tank

The spent resin tank is constructed of carbon steel with an interior protective rubber lining. It is used for storage of exhausted or spent resin prior to shipping offsite for regeneration or disposal.

Resin Addition Hopper and Eductor

The resin addition hopper stores regenerated or new resin and the eductor is used to inject resin into the polisher vessel. The hopper is constructed of carbon steel. The eductor uses demineralized water to transfer the resin to the vessel.

10.4.6.3 System Operation

The condensate polishing system cleans up the condensate during startup to meet condensate and feedwater system water chemistry specifications as described in subsection 10.3.5. The condensate system is recirculated to the hotwell during startup until the desired water quality is attained. Condensate system startup operation is described in subsection 10.4.7. Utilization of the condensate polishing system during startup assists in minimizing the startup duration of the plant.

During power operation, the condensate polishers are used only when abnormal secondary cycle conditions exist. This allows for continued operation of the plant with a "continuous" condenser tube leak of 0.0[illegible] gpm or a "faulted" leak of 0.1 gpm until repairs can be made or until an orderly shutdown is achieved. The condensate polisher flow is controlled by the condensate polisher bypass valve.

a truck or to

Exhausted or spent resin is removed from the vessel and replaced with new or regenerated resin. Resin replacement requires the polisher vessel to be out of service. Spent resin is transferred directly from the polisher vessel to the spent resin tank until it can be removed offsite. In the event of radioactive contamination of the resin in a vessel, temporary shielding is installed (if required). Radioactive resin is transferred from the spent resin tank to a ~~truck~~ temporary processing unit

Spent condensate polishing resin will normally be nonradioactive and not require any special packaging prior to disposal.

~~for offsite removal~~. Radiation monitors associated with the steam generator blowdown system, the steam generator system (main steam), and the turbine island vents, drains and relief system provide the means to determine if the secondary side is radioactively contaminated. Subsection 11.4.2 describes waste management of radioactively contaminated resin. A spill containment barrier is provided to contain spent resin tank or condensate polisher vessel contents in the event of a tank failure. The spill containment barrier is a curb surrounding the area containing the spent resin tank and condensate polisher vessel with sufficient height to contain the contents of a full tank or vessel.

The procedures for radiation protection and the handling and processing of radwaste are addressed in Chapters 11 and 12. Shielding design is described in Section 12.3.

Upon removal of the exhausted resin from the polisher vessel, the vessel is rinsed and the new resin is placed in the vessel using the resin addition hopper and eductor. After the new cation and anion resins are placed in the vessel, demineralized water is added until the water level is just above the resin bed. Compressed air from the plant service air system is injected up through the resin bed to fluidize and thoroughly mix the resins. Prior to plant startup, a new resin bed is rinsed and resin performance is verified, with flow through the vessel discharged to the condenser. The polisher vessel is then placed in operation or on standby.

10.4.6.4 Safety Evaluations

The condensate polishing system has no safety-related function and therefore requires no nuclear safety evaluation.

10.4.6.5 Tests and Inspections

The condensate polishing system is operationally checked prior to plant startup to verify proper functioning of the polisher vessels and associated instrumentation and controls.

10.4.6.6 Instrument Applications

When the condensate polishing system is in service, polishing system differential pressure instrumentation provides a control signal to the condensate bypass valve which maintains sufficient flow through the polisher vessel for optimum performance. The polisher is removed from service when: 1) a high differential pressure exists across the polisher vessel, 2) the ion exchange resin capacity becomes exhausted as evidenced by a high effluent conductivity, or 3) at the completion of a pre-determined volume through-put. The resin trap is monitored for high differential pressure and an alarm indicates the need to backwash the trap.

10.4.7 Condensate and Feedwater System

The condensate and feedwater system provides feedwater at the required temperature, pressure, and flow rate to the steam generators. Condensate is pumped from the main condenser hotwell by the condensate pumps, passes through the low-pressure feedwater heaters to the scavenging agent residual in the system which are continuously monitored by the secondary sampling system.

Instrumentation, including pressure indication, flow indication, and temperature indication, required for monitoring the system, is provided in the control room.

10.4.8 Steam Generator Blowdown System

The steam generator blowdown system (BDS) assists in maintaining acceptable secondary coolant water chemistry during normal operation and during anticipated operational occurrences of main condenser inleakage or primary to secondary steam generator tube leakage. It does this by removing impurities which are concentrated in the steam generator. The steam generator blowdown system accepts water from each steam generator and processes the water as required.

10.4.8.1 Design Basis

10.4.8.1.1 Safety-Related Design Basis

The safety-related portion of each blowdown line is part of the steam generator system (SGS). Effects of a blowdown system line break are discussed in Section 3.6. The safety-related design bases are as follows:

- The system is provided with two isolation valves on each steam generator. These valves isolate the secondary side of the steam generators to preserve the steam generator inventory. This action provides a heat sink for a safe shutdown or design basis accident mitigation. It also provides isolation of nonsafety-related portions of the system.

- The steam generator blowdown system safety-related functions can be performed assuming a single, active component failure coincident with the loss-of-offsite or onsite power.

- Piping and valves from the steam generator up to and including the containment isolation valve, the first valve on the outboard side of the containment, are designed to ASME Code, Section III, Class 2, and seismic Category I requirements. The blowdown system piping and valves from the outlet of the containment isolation valve up to and including pipe anchors located at the auxiliary building wall are designed in accordance with ASME Code, Section III, Class 3, and seismic Category I requirements.

- The safety-related portion of the system is designed to withstand the effects of a safe shutdown earthquake. The safety-related portion of the system is protected from the effects of natural phenomena and is capable of performing its intended function following postulated events such as fire, internal missile, and pipe break.

- The safety-related portion of the system is designed so that a single, active failure in the blowdown system will not result in:

- Loss-of-coolant accident
- Loss of integrity of steam lines
- Loss of the capability to effect a safe reactor shutdown
- Transmission of excessive loading to the containment pressure boundary.

- The portion of the steam generator system that is constructed in accordance with ASME Code, Section III, Class 2 and 3, requirements is provided with access to welds and removable insulation, as required for inservice inspection in accordance with ASME Code, Section XI. (See subsection 10.4.8.4.)

- The safety-related portion of the blowdown system is designed to function in the normal and accident environments identified in subsection 3.11.1.

- The safety-related portion of the blowdown system is designed as described in Section 3.6 with regard to high-energy pipe break location and evaluation.

10.4.8.1.2 Power Generation Design Basis

The steam generator blowdown system draws secondary water from each steam generator via the blowdown or drain line and processes this water as required to:

- Assist in controlling steam generator secondary side water chemistry during normal plant operation

- Cool down the steam generator for inspection and maintenance purposes

- Establish and maintain steam generator wet layup conditions during plant shutdown periods

- Drain the secondary side of the steam generators for maintenance

10.4.8.2 System Description

10.4.8.2.1 General Description

Figures 10.4.8-1 and 10.3.2-1 illustrate the steam generator blowdown system piping and instrumentation design. Classification of equipment and components for the steam generator blowdown system is given in Section 3.2. The system consists of two blowdown trains, one for each steam generator. A crosstie is provided to process blowdown from both steam generators through both heat exchangers during high capacity blowdown from one steam generator.

The blowdown water is extracted from each steam generator from a location just above the tube sheet. The blowdown from each steam generator is cooled by a regenerative heat exchanger, and flow is controlled and pressure reduced by a blowdown flow control valve. To recover the thermal energy, the condensate system provides cooling for the heat exchangers. To recover the blowdown fluid, each blowdown train has an electrodeionization (EDI) demineralizing unit which removes impurities from the blowdown flow. Downstream of the electrodeionization units, both trains combine into a common header that contains a relief valve for providing overpressure protection for the low-pressure portion of the system. A back-pressure control valve maintains pressure in the system between the flow control valve and the back-pressure control valve.

A pump is provided to drain the secondary side of the steam generator. The pump is also used for recirculation during low-pressure steam generator wet layup and cooling operations.

System isolation from the steam generator under normal operating and transient conditions is accomplished by the two isolation valves located in the auxiliary building. The valves close on actuation of the passive residual heat removal system, containment isolation, or high blowdown system radiation, temperature, or pressure.

10.4.8.2.2 System Operation

The various modes of operation are described in the following subsections.

10.4.8.2.2.1 Plant Startup

While low-pressure conditions exist in the steam generator, the blowdown flow control valves are bypassed, and the steam generator recirculation/drain pump is used to discharge the blowdown flow to the condensate system (CDS) for processing and recovery.

As the steam generator pressure increases, the blowdown rate is limited to about 200 gpm or less by first tripping and then isolating the recirculation pump. When the steam generator pressure reaches approximately 125 psig, the blowdown flow control valves are throttled to control the blowdown rate. When the desired operational blowdown rate is achieved, the valves are placed in automatic operation. The condensate control valves, which control the supply of cooling water to the heat exchangers, are adjusted during startup. When the condensate outlet temperature increases to a preset level, the condensate control valves are placed in automatic operation. The cooling water flow to the heat exchangers controls blowdown water to a temperature that is acceptable to the blowdown system electrodeionization units.

10.4.8.2.2.2 Normal Operation

The effectiveness of the blowdown system in controlling water chemistry depends upon the blowdown rate. The normal blowdown flowrate varies from a minimum of about 0.1 percent to a maximum of about 1.0 percent of maximum steaming rate. During normal operation, when the impurities are low, the expected blowdown rate is approximately 0.1 percent of maximum steaming rate (about 17 gpm total, or 8.5 gpm per steam generator), which maximizes the detection sensitivity for condenser tube leakage. The blowdown flow is cooled by the heat exchanger, and the pressure is reduced by the flow control valves. The blowdown fluid is processed through the electrodeionization units and discharged to the condensate system (condenser hotwell) for reuse.

In the event of main condenser tube leakage, when the concentration of impurities is high, the blowdown rate is increased to a maximum of approximately 1.0 percent of the maximum steaming rate (about 170 gpm total, or 85 gpm per steam generator). Normal operation is to recover the blowdown flow through the condensate system. However, blowdown with high levels of impurities can be discharged to the waste water system.

The back-pressure control valve is preset to a pressure which prevents flashing of the blowdown fluid in the electrodeionization units.

The blowdown flow and the electrodeionization waste stream (brine) flow are both continuously monitored for radioactivity from steam generator primary to secondary tube leakage. If such radioactivity is detected, the liquid radwaste system (WLS) is aligned to process the blowdown and electrodeionization waste effluent. If radioactivity reaches a preset high level, the blowdown flow control valves and the isolation valves automatically close.

The system operates normally under automatic control, except for flow control adjustments or flow path changes.

10.4.8.2.2.3 Steam Generator Cooling

The blowdown system can be operated to cool the steam generator for inspection and maintenance when the steam generator pressure is less than 125 psig. The blowdown is recirculated to the steam generators by the steam generator recirculation/drain pump, bypassing the blowdown flow control valves, and the electrodeionization units. The steam generator recirculation/drain pump is aligned by opening manual valves upstream and downstream of the pump. The pump recirculates the steam generator water through the heat exchangers at a total flowrate of approximately 200 gpm (100 gpm per steam generator). The condensate control valves are manually controlled to provide the cooling for the heat exchangers.

10.4.8.2.2.4 Steam Generator Wet Layup

The system can be operated to establish and maintain wet layup conditions in the steam generators during plant shutdown periods. During wet layup operation, water is circulated through the steam generators in the same manner as for steam generator cooling, except that the heat exchangers are not required. To maintain the correct pH and oxygen concentration in the secondary water, chemicals are added to the recirculation flow via the turbine island chemical feed system (CFS). (See subsection 10.4.11 for chemical feed system details.)

10.4.8.2.2.5 Steam Generator Drain

The steam generator blowdown system can be operated to drain the steam generator using the recirculation/drain pump and bypassing the flow control valves and the electrodeionization units. Total drain flowrate is approximately 200 gpm. During this mode of operation, the blowdown discharge maybe sent to the waste water system, the liquid radwaste system or the condensate system.

10.4.8.2.2.6 Steam Generator Tube Sheet Flush

The system can be operated for a short time at a total flowrate of approximately 3 percent of the maximum steaming rate (about 260 gpm) from one steam generator. To accommodate the high flow, the blowdown from one steam generator is isolated and the flow from the other steam generator is routed through both heat exchanger trains at a rate of approximately 130 gpm per train. The blowdown flow control valves and the blowdown electrodeionization units are bypassed during this operation. The blowdown flow is controlled by throttling the flow control valve bypass isolation valves which are in series with a flow restricting orifice. The blowdown is discharged to the waste water system (WWS).

10.4.8.2.2.7 Emergency Operation

Blowdown system isolation is actuated on low steam generator water levels. The isolation of steam generator blowdown provides for a continued availability of the steam generator as a heat sink for decay heat removal in conjunction with operation of the passive residual heat removal system and the startup feedwater system.

10.4.8.2.3 Component Description

A description of the major steam generator blowdown system components is provided in this subsection.

10.4.8.2.3.1 Blowdown Regenerative Heat Exchangers

Two regenerative heat exchangers are provided, one for each steam generator blowdown train. The heat exchangers are located in the turbine building at the base slab elevation.

10.4.8.2.3.2 Blowdown Flow Control Valves

Two blowdown flow control valves are provided, one for each steam generator blowdown train. The control valves are capable of controlling the flow and pressure over the range of normal operating conditions.

10.4.8.2.3.3 Recirculation/Drain Pump

One centrifugal pump is provided for use during operating modes when steam generator pressure is low.

10.4.8.2.3.4 Pressure Control Valve

A backpressure control valve is provided to maintain appropriate system backpressure, within the operating range of blowdown flows, and prevent flashing within the low pressure section of the system when the blowdown is discharged to the condenser hotwell.

10.4.8.2.3.5 Blowdown Isolation Valves

Two valves in series, located outside containment in the auxiliary building, are provided to automatically isolate the blowdown system in the event of abnormal conditions within the blowdown system, the reactor coolant system, or the main steam system. The valves are air-operated globe valves that fail close on loss of air or actuating power. See Section 7.2 for a description of the automatic control functions on the valves.

The first isolation valve provides a containment isolation function in addition to redundant isolation of the blowdown system. The valves close on an engineered safeguards actuation signal and provide containment integrity in conjunction with the steam generator and main steam line inside containment. The valves are active, ASME Code, Section III, Safety Class 2, seismic Category I.

The isolation valves provide for redundant isolation of the blowdown system upon actuation of the passive residual heat removal system, low (narrow range) steam generator level, or abnormal conditions in the blowdown system. Each isolation valve receives an actuation signal from the protection and safety monitoring system (PMS) upon passive residual heat removal actuation to preserve steam generator inventory. The valves also close upon receiving a low (narrow range) water level signal to preserve steam generator inventory. Additionally, the valves receive a high radiation signal, high temperature signal, and high pressure signal, indicating abnormal conditions in the blowdown system and actuating automatic isolation of the system. The second isolation valves are active, ASME Code, Section III, Safety Class 3, seismic Category I.

The valves are located outside containment within the auxiliary building and are attached to seismic Category I piping.

10.4.8.2.3.6 Electrodeionization Unit

Two trains of electrodeionization demineralizing units are provided for the steam generator blowdown system electrodeionization. The electrodeionization unit in each train is configured in a stack arrangement. The stack normally contains numerous pairs of stacked membranes. One cell pair consists of an ion-diluting flow (product) channel located between a cation and an anion membrane with an ion concentrating (brine) flow channel located alternately between the cell pairs. A dc potential is maintained across the electrode plates which are located on opposite ends of the stacked membranes. Ion exchange resin is contained within the product flow channel, acting as an ion selective media in the electrodeionization process. Isolation valves are provided for each stack to allow for maintenance of a stack.

A filter, upstream of the electrodeionization stack in each train, removes suspended solids and particulate matter from electrodeionization influent. Electrodeionization effluent flows through a resin trap which collects resin fines and small particulates which pass through the unit.

Each electrodeionization unit includes one centrifugal brine pump which maintains a constant flow in the closed loop brine system and flushes ionic impurities from the brine channels in the stack. A small percentage of blowdown in the brine process is used to control impurity concentration. This electrodeionization brine blowdown waste stream is directed to the waste water system (WWS) or the liquid radwaste system (WLS).

The electrodeionization stacks are located in the turbine building and in a shielded area. The area has no drain. Anionic and cationic resins are contained within the electrodeionization stacks. These resins are not consumed or exhausted in the electrodeionization process. Radiation monitors associated with the steam generator blowdown system, steam generator system (main steam), and the condenser air removal system provides the means to determine if the secondary side is radioactively contaminated.

10.4.8.2.4 Instrumentation Applications

Flow, pressure, temperature, and radioactivity indicators with alarms monitor system operation. If pressure, temperature, or radioactivity reach a high level setpoint, an alarm is annunciated and the blowdown flow control valves and upstream isolation valves are automatically closed.

Flow elements and transmitters measure and control blowdown flow from the steam generators. The flow elements are located downstream of the blowdown flow control valves.

Temperature instrumentation monitors the temperature of blowdown fluid upstream and downstream of each heat exchanger. The heat exchanger outlet temperature controls heat exchanger cooling water flow as well as the blowdown flow to limit high temperature blowdown fluid to the electrodeionization unit.

Radioactivity detection instrumentation detects and monitors the presence of radioactivity in the combined blowdown stream from both trains. A radiation element is located in the common header upstream of the recovered blowdown three-way valve. This three-way valve normally directs the recovered blowdown flow to the condenser. When recovery of the blowdown fluid is not possible, the flow is diverted to the waste water system. Upon detection of significant levels of radioactivity via a radiation transmitter alarm, the steam generator blowdown flow is diverted to the liquid radwaste system for processing. A second radioactive detection instrument is located on the waste stream of the electrodeionization blowdown. Similarly, a three-way valve normally directs this electrodeionization brine blowdown to the waste water system. With detection of significant levels of radioactivity, the brine blowdown is diverted to the liquid radwaste system.

The electrodeionization units are self cleaning. Even after processing radioactive blowdown they will not contaminate succeeding treatment of non-radioactive blowdown.

After prolonged use, the electrodeionization units will be replaced. If they are not radioactively contaminated, they require no special packaging and may be disposed as clean solid waste. If they are radioactively contaminated, they will be dewatered, the nozzles [illegible] and packaged for transport according to DOT regulations.

10.4.8.3 Safety Evaluation

- Each blowdown line is provided with redundant safety-related valves that isolate the secondary side of the steam generator to preserve the steam generator inventory. The inventory is maintained as a heat sink for sensible and decay heat removal from the reactor coolant system.

- The steam generator blowdown system safety-related functions are accomplished by redundant means. A single, active component failure within the safety-related portion of the system does not compromise the safety-related function of the system. Power is supplied by the Class 1E dc power system as described in Chapter 8.

- Section 3.2 delineates the quality group classification. The controls and power supplies necessary for safety-related functions of the steam generator blowdown system are Class 1E, and are described in Chapters 7 and 8.

- The safety-related portion of the steam generator blowdown system are located in the containment and auxiliary buildings. These buildings and areas are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other natural phenomena. Sections 3.3, 3.4, 3.5, 3.7, and 3.8 provide the bases for the adequacy of the structural design of these buildings and areas. The safety-related portions of the steam generator blowdown system are designed to remain functional after a safe shutdown earthquake. Sections 3.7 and 3.9 provide the design loading conditions that are considered.

- No single failure coincident with loss of offsite power compromises the safety-related functions of the system or will result in:

  - Loss-of-coolant accident
  - Loss of integrity of steam lines
  - Loss of the capability to effect a safe reactor shutdown
  - Transmission of excessive loading to the containment pressure boundary.

  Component or functional redundancy is provided so that safety-related functions can be performed, assuming a single, active failure coincident with loss of ac power.

- The steam generator blowdown system is initially tested in accordance with the program described in Chapter 14. Periodic inservice functional testing is done in accordance with subsection 10.4.8.4. Section 6.6 provides the ASME Code, Section XI requirements that are appropriate for the safety-related portions of the steam generator blowdown system.

- The safety-related components of the steam generator blowdown system are qualified to function in normal, test, and accident environmental conditions. The environmental qualification program is provided in Section 3.11.

- Discussions of high energy pipe break locations and evaluation of effects are provided in subsections 3.6.1 and 3.6.2.
- Subsection 6.2.3 delineates the criteria and compliance with applicable requirements and the criteria for the containment isolation provisions.
- The main steam supply system failure modes and effects analysis for the steam generator blowdown system is provided in Table 10.3.3-1.

10.4.8.4 Inspection and Testing Requirements

10.4.8.4.1 Preservice Testing/Inspection

The blowdown system components are tested and inspected during plant startup as a part of the preservice test program as discussed in Chapter 14. The steam generator blowdown system's safety-related functions are designed to include the capability for testing. This includes operation of applicable portions of the protection system. The safety-related components of the system (valves and piping,) are designed and located to permit preservice and inservice inspections to the extent practical.

The steam generator blowdown lines within the containment and the auxiliary building are visually and volumetrically inspected at installation as required by ASME Code, Section XI preservice inspection requirements.

10.4.8.4.2 Inservice Testing/Inspection

The performance and structural leaktight integrity of system components are demonstrated by normal operation.

Additional discussion of inservice inspection of the blowdown containment isolation valves is contained in Section 6.6 and subsection 3.9.6.

Instruments and controls are calibrated during startup and recalibrated, as necessary, to maintain system operation within its design specifications.

10.4.9 Startup Feedwater System

The startup feedwater system supplies feedwater to the steam generators during plant startup, hot standby and shutdown conditions, and during transients in the event of main feedwater system unavailability. The startup feedwater system is composed of components from the AP600 main and startup feedwater system (FWS) and steam generator system (SGS).

11.2 Liquid Waste Management Systems

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The liquid waste management systems include the systems that may be used to process disposal liquids containing radioactive material. These include the following:

- Steam generator blowdown processing system (subsection 10.4.8);
- Radioactive waste drain system (subsection 9.3.5);
- Liquid radwaste system (WLS) (Section 11.2).

This section primarily addresses the liquid radwaste system. The other systems are also addressed in subsection 11.2.3, which discusses the expected releases from the liquid waste management systems.

The liquid radwaste system is designed to control, collect, process, handle, store, and dispose of liquid radioactive waste generated as the result of normal operation, including anticipated operational occurrences.

11.2.1 Design Basis

Subsection 1.9.1 discusses the conformance of the liquid radwaste system design with the criteria of Regulatory Guide 1.143.

11.2.1.1 Safety Design Basis

The liquid radwaste system serves no safety-related functions except for:

- Containment isolation; see subsection 6.2.3.

- Draining the passive core cooling system compartments to the containment sump to prevent flooding of these compartments and possible immersion of safety-related components.

- Back flow prevention check valves in the drain lines from the chemical and volume control system compartment and the passive core cooling system compartments to the containment sump, which prevent cross flooding of these compartments. Each drain line has two check valves in series so that a single failure does not compromise the back flow prevention safety function. See subsection 6.3.3.3.2 for a discussion of containment flooding.

11.2.1.2 Power Generation Design Basis

11.2.1.2.1 Capacity

The liquid radwaste system provides adequate capacity to meet the anticipated processing requirements of the plant. The projected flows of various liquid waste streams to the liquid radwaste system under normal conditions are identified in Table 11.2-1.

The liquid radwaste system design can accept equipment malfunctions without affecting the capability of the system to handle both anticipated liquid waste flows and possible surge load due to excessive leakage. Table 11.2-4 contains information on the surge capacity of individual tanks.

Portions of the liquid radwaste system may become unavailable as a result of the malfunctions listed in subsection 11.2.1.2.2.

Ample surge capacity of the system, provisions for using mobile processing equipment and the low load factor of the processing equipment permits the system to accommodate waste until failures can be repaired and normal plant operation resumed. In addition, the liquid radwaste system is designed to accommodate the anticipated operational occurrences described in subsection 11.2.1.2.3.

11.2.1.2.2 Failure Tolerance

11.2.1.2.2.1 Pump Failure

Where operation is not essential and surge capacity is available, a single pump is provided. This applies to most applications in the liquid radwaste system. Two reactor coolant drain tank pumps and two containment sump pumps are provided because the relative inaccessibility of the containment during power operation would hinder maintenance. The containment sump pumps are submersible pumps with permanently lubricated bearings and mechanical seals. To protect them from damage due to loss of suction, each pump is interlocked to stop on a low level condition in the sump. The reactor coolant drain tank pumps are vertical sump type pumps with motors above the reactor coolant drain tank shaft coupled to pumps submersed in the liquid within the reactor coolant drain tank. This arrangement minimizes contamination of the motors and permits removal and maintenance of the motors outside of the radiation area.

Process pumps located outside containment are air-operated, double diaphragm type. These pumps are capable of significant suction lifts, and can thus be located on or near the top of the associated waste tank, with internal suction piping. They can pump slurries with high solids fractions, run deadheaded, and run dry without damage. In addition, they can operate over a wide range of hydraulic conditions by varying the driving air input. This makes it possible to fulfill many different applications with a single pump model, thereby facilitating maintenance and reducing the inventory of spare parts.

11.2.1.2.2.2 Filter or Ion Exchanger Plugging

Instrumentation is provided to give indication of the pressure drop across filters and ion exchangers. Periodic checks of the pressure drops provide indication of equipment fouling, thus permitting corrective action to be taken before an excessive pressure drop is reached. Change of filter cartridges and ion exchange beds is expected to occur based upon radiation survey.

11.2.1.2.3 Anticipated Operational Occurrences

11.2.1.2.3.1 High Primary Coolant System Leakage Rate

The system is designed to handle an abnormal primary coolant system leak in addition to the expected leakage during normal operation. Operation of the system is the same as for normal operation, except that the load on the system is increased.

11.2.1.2.3.2 High Use of Decontamination Water

If large quantities of water are used to decontaminate areas or equipment, the load on the liquid radwaste system is increased. However, the liquid radwaste system is designed to handle a large, continuous input to the waste holdup tanks. If the water can be discharged without processing based on sampling which shows acceptably low activity, the overall liquid radwaste system capacity is increased.

To accommodate the possible use of special decontamination fluids or very large volumes of decontamination fluids, mobile equipment is used as discussed in subsection 11.2.1.2.5.2.

11.2.1.2.3.3 Steam Generator Tube Leakage

During normal operations, steam generator blowdown is returned to the condensate system, as described in subsection 10.4.8. However, if excessive radioactivity is detected, the blowdown is diverted to the liquid radwaste system for processing and disposal.

The blowdown fluid is brought into the waste holdup tanks, which provide some surge capacity to hold the fluid during processing. It is then processed in the same fashion as, and combined with, other inputs.

In the event of a steam generator tube rupture, the condensate storage tank may also become contaminated. In this event, the tank is cleaned by the use of temporary equipment brought to the site for the purpose, as described in subsection 11.2.1.2.5.2.

11.2.1.2.3.4 Refueling

The load on the liquid radwaste system is expected to increase during refueling because of the increased level of maintenance activities in the plant, but operation is the same as for normal plant operation. There is no significant effect on the performance capability of the liquid radwaste system.

11.2.1.2.4 Controlled Release of Radioactivity

The liquid radwaste system provides the capability to reduce the amounts of radioactive nuclides released in the liquid wastes through the use of demineralization and time delay for decay of short-lived nuclides.

The assumed equipment decontamination factors appear in Table 11.2-5. Estimates of the radioactive source terms and annual average flow rate that will be processed in the liquid radwaste system or discharged to the environment during normal operation appear in Table 11.2-1.

Before radioactive liquid waste is discharged, it is pumped to a monitor tank. A sample of the monitor tank contents is analyzed, and the results are recorded. In this way, a record is kept of planned releases of radioactive liquid waste.

The liquid waste is discharged from the monitor tank in a batch operation, and the discharge flow rate is restricted as necessary to maintain an acceptable concentration when diluted by the circulating water discharge flow. These provisions preclude uncontrolled releases of radioactivity.

In addition, the discharge line contains a radiation monitor with diverse methods of stopping the discharge. The first method closes an isolation valve in the discharge line, which prevents any further discharge from the liquid radwaste system. The valve automatically closes and an alarm is actuated if the activity in the discharge stream reaches the monitor setpoint. The second method stops the monitor tank pumps.

To minimize leakage from the liquid radwaste system, the system is of welded construction except where flanged connections are required to facilitate component maintenance or to allow connection of temporary or mobile equipment. Air-operated diaphragm pumps or pumps having mechanical seals are used. These pumps minimize system leakage thereby minimizing the release of radioactive gas that might be entrained in the leaking fluid to the building atmosphere.

Provisions are made to control spills of radioactive liquids due to tank overflows. Table 11.2-3 lists the provisions for tank level indication, alarms, and overflow disposition for liquid radwaste system tanks outside containment.

The liquid radwaste system is designed so that the annual average concentration limits established by 10 CFR 20 (Appendix B, table 2, column 2) (Reference 1) for liquid releases are not exceeded during plant operation with expected levels of fuel cladding defects. Subsection 11.2.3 describes the calculated releases of radioactive materials from the liquid radwaste system and other portions of the liquid waste management systems resulting from normal operation.

11.2.1.2.4.2 Abnormal Operation

Subsections 11.2.1.2.2 and 11.2.1.2.3 describe the capability of the liquid radwaste system to accommodate abnormal conditions for various equipment and other anticipated operational occurrences. During these anticipated occurrences, the effectiveness of the liquid radwaste system in controlling releases of radioactivity remains unaffected, so releases are limited as during normal operation.

Subsection 11.2.3 discusses the calculated releases of radioactive materials from the liquid radwaste system for ~~the~~ abnormal situations ~~of operation at the design basis fuel defect level of 0.25 percent~~.

11.2.1.2.5 Equipment Design

11.2.1.2.5.1 Permanently Installed Equipment

The liquid radwaste system equipment design parameters are provided in Table 11.2-2.

The seismic design classification and safety classification for the liquid radwaste system components and structures are listed in Section 3.2.

11.2.1.2.5.2 Use of Mobile and Temporary Equipment

The liquid radwaste system is designed to handle most liquid effluents and other anticipated events using installed equipment. However, for events occurring at a very low frequency or producing effluents not compatible with the installed equipment, temporary equipment may be brought into the radwaste building mobile treatment facility truck bays.

Connections are provided to and from various locations in the liquid radwaste system to these mobile equipment connections. This allows the mobile equipment to be used in series with installed equipment, as an alternate to it with the treated liquids returned to the liquid radwaste system, or as an ultimate disposal point for liquids that are to be removed from the plant site for disposal elsewhere.

The use of temporary equipment is common practice in operating plants. The radwaste building truck bays and laydown space for mobile equipment, in addition to the flexibility of numerous piping connections to the liquid radwaste system, allow the plant operator to incorporate mobile equipment in an integrated fashion.

Temporary equipment is also used to clean up the condensate storage tank if it becomes contaminated following steam generator tube leakage. This use of temporary equipment is similar to that just described, except that the equipment is used in the yard rather than in the radwaste building truck bays.

11.2.2 System Description

The liquid radwaste system, shown in Figure 11.2-1, includes tanks, pumps, ion exchangers, and filters. The liquid radwaste system is designed to process, or store for processing by mobile equipment, radioactively contaminated wastes in four major categories:

- Borated, reactor-grade, waste water -- this input is collected from the reactor coolant system (RCS) effluents received through the chemical and volume control system (CVS), primary sampling system sink drains and equipment leakoffs and drains.

- Floor drains and other wastes with a potentially high suspended solids content -- this input is collected from various building floor drains and sumps.

- Detergent wastes -- this input comes from the plant hot sinks and showers, and some cleanup and decontamination processes. It generally has low concentrations of radioactivity.

- Chemical waste -- this input comes from the laboratory and other relatively small volume sources. It may be mixed hazardous and radioactive wastes or other radioactive wastes with a high dissolved-solids content.

Nonradioactive secondary-system waste is not processed by the liquid radwaste system. Secondary-system effluent is normally handled by the steam generator blowdown processing system, as described in subsection 10.4.8, and by the turbine building drain system.

Radioactivity can enter the secondary systems from steam generator tube leakage. If significant radioactivity is detected in secondary-side systems, blowdown is diverted to the liquid radwaste system for processing and disposal.

11.2.2.1 Waste Input Streams

11.2.2.1.1 Reactor Coolant System Effluents

The effluent subsystem receives borated and hydrogen-bearing liquid from two sources: the reactor coolant drain tank and the chemical and volume control system. The reactor coolant drain tank collects leakage and drainage from various primary systems and components inside containment. Effluent from the chemical and volume control system is produced mainly as a result of reactor coolant system heatup, boron concentration changes and RCS level reduction for refueling.

Input collected by the effluent subsystem normally contains hydrogen and dissolved radiogases. Therefore, it is routed through the liquid radwaste system vacuum degasifier before being stored in the effluent holdup tanks.

The liquid radwaste system degasifier can also be used to degas the reactor coolant system before shutdown by operating the chemical and volume control system in an open loop configuration. This is done by taking one of the effluent holdup tanks out of normal waste service and draining. Then normal chemical and volume control system letdown is directed through the degasifier to the dedicated effluent holdup tank. From there, it is pumped back to the suction of the chemical and volume control system makeup pumps with the effluent holdup tank pump. The makeup pumps return the fluid to the reactor coolant system in the normal fashion. This process is continued as necessary for degassing the reactor coolant system as described in subsection 9.3.6.

The input to the reactor coolant drain tank is potentially at high temperature. Therefore, provisions are made for recirculation through a heat exchanger for cooling. The tank is inerted with nitrogen and is vented to the gaseous radwaste system. Transfer of water from the reactor coolant drain tank is controlled to maintain an essentially fixed tank level to minimize tank pressure variation.

Reactor coolant system effluents from the chemical and volume control system letdown line or the reactor coolant drain subsystem pass through the vacuum degasifier, where dissolved hydrogen and fission gases are removed. These gaseous components are sent via a water separator to the gaseous radwaste system. A degasifier discharge pump then transfers the liquid to the currently selected effluent holdup tank. If flows from the letdown line and the reactor coolant drain tank are routed to the degasifier concurrently, the letdown flow has priority and the drain tank input is automatically suspended.

In the event of abnormally high degasifier water level, inputs are automatically stopped by closing the letdown control and containment isolation valves.

The effluent holdup tanks vent to the radiologically controlled area ventilation system and, in abnormal conditions, may be purged with air to maintain a low hydrogen gas concentration in the tanks' atmosphere. Hydrogen monitors are included in the tanks vent lines to alert the operator of elevated hydrogen levels.

The contents of the effluent holdup tanks may be recirculated and sampled, recycled through the degasifier for further gas stripping, returned to the reactor coolant system via the chemical and volume control system makeup pumps, discharged to the mobile treatment facility, processed through the ion exchangers, or directed to the monitor tanks for discharge without treatment.

Processing through the ion exchangers is the normal mode.

The AP600 liquid radwaste system processes waste with an upstream filter followed by four ion exchange resin vessels in series. Any of these vessels can be manually bypassed and the order of the last two can be interchanged, so as to provide complete usage of the ion exchange resin.

The top of the first vessel is normally charged with activated carbon, to act as a deep-bed filter and remove oil from floor drain wastes. Moderate amounts of other wastes can also be routed through this vessel. It can be bypassed for processing of relatively clean waste streams. This vessel is somewhat larger than the other three, with an extra sluice connection to allow the top bed of activated carbon to be removed. This feature is associated with the deep bed filter function of the vessel; the top layer of activated carbon collects particulates, and the ability to remove it without disturbing the underlying zeolite bed minimizes solid-waste production.

The second, third and fourth beds are in identical ion exchange vessels, which are selectively loaded with resin, depending on prevailing plant conditions.

After deionization, the water passes through an after-filter where radioactive particulates and resin fines are removed. The processed water then enters one of three monitor tanks. When one of the monitor tanks is full, the system is automatically realigned to route processed water to another tank.

The contents of the monitor tank are recirculated and sampled. In the unlikely event of high radioactivity, the tank contents are returned to a waste holdup tank for additional processing.

Normally, however, the radioactivity will be well below the discharge limits, and the dilute boric acid is discharged for dilution to the circulating water blowdown. The discharge flow rate is set to limit the boric acid concentration in the circulating water blowdown stream to an acceptable concentration for local requirements. Detection of high radiation in the discharge stream stops the discharge flow and operator action is required to re-establish discharge. The raw water system which provides makeup for the circulating water system is used as a backup source for dilution water when cooling tower blowdown is not available for the discharge path.

11.2.2.1.2 Floor Drains and Other Wastes with Potentially High Suspended Solid Contents

Potentially contaminated floor drain sumps and other sources that tend to be high in particulate loading are collected in the waste holdup tank. Additives may be introduced to the tank to improve filtration and ion exchange processes. Tank contents may be recirculated for mixing and sampling. The tanks have sufficient holdup capability to allow time for realignment and maintenance of the process equipment.

The waste water is processed through the waste pre-filter to remove the bulk of the particulate loading. Next it passes through the ion exchangers and the waste after-filter before entering a monitor tank. The monitor tank contents are sampled and, if necessary, returned to a waste holdup tank or recirculated directly through the filters and ion exchangers.

Waste water meeting the discharge limits is discharged to the circulating water blowdown through a radiation detector that stops the discharge if high radiation is detected.

11.2.2.1.3 Detergent Wastes

The detergent wastes from the plant hot sinks and showers contain soaps and detergents. These wastes are generally not compatible with the ion exchange resins described in subsections 11.2.2.1.1 and 11.2.2.1.2. The detergent wastes are not processed and are collected in the chemical waste tank. If the detergent wastes activity is low enough, the wastes can be discharged without processing.

When sufficient detergent wastes are produced and processing is necessary, mobile processing equipment is brought into one of the radwaste building mobile systems facility truck bays provided for this purpose.

11.2.2.1.4 Chemical Wastes

Inputs to the chemical waste tank normally are generated at a low rate. These wastes are only collected; no internal processing is provided Chemicals can be added to the tank for pH or other adjustment. Since the volume of these wastes is low, they can be treated by the use of mobile equipment or by shipment offsite.

11.2.2.1.5 Steam Generator Blowdown

Steam generator blowdown is normally accommodated within the steam generator blowdown system, which is described in subsection 10.4.8.

If steam generator tube leakage results in significant levels of radioactivity in the steam generator blowdown stream, this stream is redirected to the liquid radwaste system for treatment before release. In this event, one of the waste holdup tanks is drained to prepare it for blowdown processing. The blowdown stream is brought into that holdup tank, and continuously or in batches pumped through the waste ion exchangers. The number of ion exchangers in service is determined by the operator to provide adequate purification without excessive resin usage. The blowdown is then collected in a monitor tank, sampled, and discharged in a monitored fashion.

11.2.2.2 Other Operations

11.2.2.2.1 Sampling

Grab sampling taps are provided where required to monitor influent boron and radioactivity concentrations; to monitor performance of various components; to determine tank water characteristics before transfer, processing or discharge; to verify performance of the on-line analyzers; and to collect samples of discharges to the environs for analysis and documentation. Samples are taken in low radiation areas.

11.2.2.2.2 Tank Cleaning

Extraordinary measures for tank cleaning are not normally required because the pumps take suction from the low point of the tank, and the tank bottoms are sloped so that the tank can be fully drained. Recirculation connections are provided to allow the tanks to be effectively mixed. Also, the air-operated double-diaphragm pumps used can pump air, water or slurries without damage, and can run dry to clear the bottoms of the tanks.

Provisions are made for tank cleaning using a portable tank cleaning rig. Suction is taken from the tank bottom via a temporary hose. The pump discharge passes through a filter and the hose to a tank cleaning lance, which is manually inserted through a manway on the tank. The operator can direct the high-velocity water throughout the inside of the tank.

11.2.2.3 Component Description

The general descriptions and summaries of the design basis requirements for the liquid radwaste system components follow. Table 11.2-2 contains the operating parameters for the liquid radwaste system components.

Additional information regarding the applicable codes and classifications is also available in Section 3.2.

11.2.2.3.1 Liquid Radwaste System Pumps

Reactor Coolant Drain Tank Pumps

Two full-capacity, stainless steel, reactor coolant drain tank pumps recirculate the reactor coolant drain tank contents for cooling and to discharge the reactor coolant drain tank contents to the degasifier or to an effluent holdup tank. These vertical sump pumps have permanently lubricated bearings and mechanical seals. The pumps start and stop on high and low level.

Containment Sump Pumps

Two full-capacity containment sump pumps are provided. These pumps discharge the containment sump contents to the waste holdup tank. These submersible sump pumps have permanently lubricated bearings and mechanical seals. The pumps start and stop on high and low level.

Degasifier Vacuum Pumps

Two stainless steel, full-capacity, liquid ring type, degasifier vacuum pumps maintain the degasifier at a low pressure for efficient gas stripping.

These liquid ring pumps use water as the compressant. The water is recycled to minimize consumption. Excess water from vapor condensation is discharged to an effluent holdup tank.

Degasifier Separator Pump

Two full capacity centrifugal pumps are provided to discharge recovered compressor water from the degasifier separator back to the degasifier vacuum pumps. The pump also serves to discharge any excess compressor water accumulation in the separator to an effluent holdup tank. The pumps start and stop to share the duty. The pump is constructed of stainless steel and has a mechanical seal.

Other Pumps

The following air-operated double-diaphragm pumps are mounted near the associated tanks with internal suction piping. Construction is of stainless steel, with elastomeric diaphragms.

- Degasifier discharge pumps (2)
- Effluent holdup tank pumps (2)
- Waste holdup tank pumps (2)
- Monitor tank pumps (3)
- Chemical waste tank pump (1)

11.2.2.3.2 Liquid Radwaste System Heat Exchangers

Reactor Coolant Drain Tank Heat Exchanger

One horizontal U-tube heat exchanger is provided. The heat exchanger has a flanged tubesheet that permits removal of the tube bundle for inspection and cleaning.

The heat exchanger is designed to prevent the reactor coolant drain tank contents from boiling with hot leakage influent as shown in Table 11.2-4.
The reactor coolant drain tank contents flow through the tubes which are stainless steel component cooling water flows through the carbon steel shell.

Vapor Condenser

One horizontal U-tube heat exchanger assists in drying the gases drawn out of the liquid waste by the vacuum pump, before they are sent to the gaseous radwaste system. As the gas bearing water cascades down through the packing in the degasifer vessel, it boils in the low pressure. To minimize the size of the vacuum pumps, a vapor condenser is provided between the degasifer vessel and the vacuum pumps. In the vapor condenser, most of the water vapor is condensed out of the gas stream before it enters the vacuum pump.

The vapor condenser is cooled by chilled water. Chilled water flows through the tubes, which are stainless steel. Water vapor condenses on the tubes and drains through a subcooling section in the stainless steel shell. The non-condensible gases and condensate are recombined in a common pipe leading to the suction of the liquid ring type vacuum pumps.

11.2.2.3.3 Liquid Radwaste System Tanks

Reactor Coolant Drain Tank

One reactor coolant drain tank is provided. The tank is sized to accommodate two vertical sump type pumps and to have a volume above the normal operating water level sufficient to accept the influent rate shown in Table 11.2-4.

The reactor coolant drain tank is a stainless steel, horizontal, cylindrical tank with dished heads. It is provided with a vacuum breaker to prevent excess external pressure during containment leak testing. It is protected from excess internal pressure by a relief valve which vents to the containment sump.

Containment Sump

The containment sump is a stainless steel, rectangular sump tank designed for embedment in concrete. The containment sump is sized as shown in Table 11.2-4.

Degasifier Column

A one-stage, stainless steel degasifier column is provided. The degasifier column is designed to meet the performance parameters shown in Table 11.2-5.

Agitation and surface exposure are accomplished by spraying the influent onto the top of a column of packing which breaks up the flow and spreads it into thin films as it cascades downward. The low pressure causes the inlet water to boil. The flashed vapor accompanies the gas bearing water downward through the packing. Exposure to low pressure draws out the non-condensible gases consistent with Henry's Law and they pass out the vacuum connection. The vacuum connection is located near the last point of contact with the degassed water where the vacuum is greatest and conditions are least conducive to reabsorption. A stainless steel mesh demister is provided at the vessel vacuum connection to remove water droplets which are entrained in the gas/vapor mixture as it is exiting to the vapor condenser.

Degasifier Separator

One stainless steel separator is provided. It is designed to remove compressor water from the vacuum pump discharge flow for reuse. It also serves as a silencer.

Effluent Holdup Tanks

These stainless steel tanks contain effluent waste prior to processing. They are horizontal cylinders with internal pump suction piping at the low point of the tank, and with side manways for maintenance.

Waste Holdup Tanks

These stainless steel tanks contain floor and equipment drain waste before processing. They are vertical cylinders with internal pump suction piping at the low points of the tanks and with side manways for maintenance.

Monitor Tanks

These stainless steel tanks contain processed waste before discharge. They are vertical cylinders with internal pump suction piping at the low points of the tanks and with side manways for maintenance.

Chemical Waste Tank

This stainless steel tank contains chemical waste and hot sinks and shower drains before processing via mobile equipment. The configuration is a vertical cylinder with internal pump suction piping at the low point of the tank and with a side manway for maintenance.

11.2.2.3.4 Liquid Radwaste System Ion Exchangers

Four ion exchange vessels are provided, with resin volumes as shown in Table 11.2-2. The media will be selected by the Combined License holder to optimize system performance. They are stainless steel, vertical, cylindrical pressure vessels with inlet and outlet process nozzles plus connections for resin addition, sluicing, and draining. The process outlet and flush water outlet connections are equipped with resin retention screens designed to minimize pressure drop.

11.2.2.3.5 Liquid Radwaste System Filters

Waste Pre-Filter

This filter is provided to collect particulate matter in the process stream before ion exchange. The unit is constructed of stainless steel and has disposable filter bags.

Waste After-Filter

This filter is provided downstream of the ion exchangers to collect particulate matter, such as resin fines. The unit is constructed of stainless steel and has disposable filter cartridges.

11.2.2.4 Instrumentation Design

Instrumentation readout is available in the main control room. and on the liquid radwaste panel.

Alarms are provided to the data display system including a radwaste system annunciator in the main control room.

Pressure indicators provide pressure drops across demineralizers, filters, and strainers.

Releases to the environment are monitored for radioactivity. Section 11.5 describes this instrumentation.

Each tank is provided with level instrumentation that actuates an alarm on high liquid level in the tank, thus warning of potential tank overflow. High level in redundant tank pairs also diverts the flow to the standby tank. Table 11.2-3 provides a summary of the tank level alarms.

11.2.2.5 System Operation and Performance

11.2.2.5.1 Reactor Coolant System Effluent Processing

11.2.2.5.1.1 Reactor Coolant Systems Effluent: Letdown Line

Chemical and volume control system letdown is directed to the degasifier. This letdown flow automatically takes priority by causing isolation of influent to the degasifier from the reactor coolant drain tank pumps to prevent the design capacity of the degasifier from being exceeded.

When the degasifier and waste gas system are placed in operation one of the degasifier vacuum pumps operates to maintain a vacuum in the degasifier column. The degasifier separator pump operates to return compressor water to the vacuum pump. The degasifier separator vents to the gaseous radwaste system. Its level is automatically controlled by discharging excess water (due to condensation of vapor carryover from the degasifier column) to an effluent holdup tank. In the event of abnormally high level, chemical and volume control system letdown flow is automatically stopped.

Two effluent holdup tanks are provided. One is aligned to receive inputs. When it fills to the appropriate level, an alarm alerts the operator that the tank is full and ready for processing. The inlet diversion valve automatically realigns the system to route input to the other tank upon high-high alarm.

11.2.2.5.1.2 Reactor Coolant System Effluent: Reactor Coolant Drain Tank

The reactor coolant drain tank receives input from the reactor coolant system and other drains inside containment that have the potential to contain radioactive gas or hydrogen.

Initially and after servicing, the reactor coolant drain tank is filled with demineralized water and then purged with nitrogen to dilute and displace oxygen. The tank vent to the gaseous radwaste system normally remains closed. One of the reactor coolant drain tank pumps and the discharge valve are automatically controlled to maintain reactor coolant drain tank water level within a narrow band to minimize tank pressure variation. An alarm alerts the operator if the reactor coolant drain tank reaches a temperatures consistent with the design leak of saturated RCS coolant. The system automatically realigns valves and recirculates the tank contents through the reactor coolant drain tank heat exchanger.

The cumulative quantity discharged from the reactor coolant drain tank is totalized and indicated for use in reactor coolant leakage evaluations.

The discharge may have a relatively high dissolved hydrogen concentration and is therefore aligned to the degasifier. However, during reactor coolant system loop drain operations the hydrogen and radioactive gas concentrations should be low and discharge may be directly aligned to an effluent holdup tank.

11.2.2.5.1.3 Processing of the Reactor Coolant System Effluents

Each effluent holdup tank vent includes a hydrogen detector to monitor the hydrogen concentration in the tank atmosphere. In the event of high alarm, the operator initiates air purge through the tank to dilute the hydrogen gas and maintain it below the flammable limits. The tanks vent to the radiologically controlled area ventilation system.

An effluent holdup tank high level alarm alerts the operator that the tank is full and ready for processing. The inlet diversion valve automatically directs the influent to the other tank upon high-high alarm.

To process the contents of the filled tank, the effluent holdup tank pump is started to recirculate and sample the tank contents. If additional gas stripping is required, the tank contents may be recirculated through the degasifier. The degasifier functions automatically as described in subsection 11.2.2.5.1.1.

The discharge of either effluent holdup tank pump can be aligned to the suction of the chemical and volume control system makeup pumps. This mode of operation is used during reactor coolant system degassing operations. Reactor coolant from the chemical and volume control system letdown is degassed in the degasifier, collected in one of the effluent holdup tanks, and continuously pumped back to the chemical and volume control system makeup pumps. The pump returns the degassed water to the reactor coolant system.

Reactor coolant collected in an effluent holdup tank during reactor coolant system loop drain operations may also be pumped to the chemical and volume control system makeup pumps for refill of the reactor coolant system. Before beginning this process, the operator fully drains the effluent holdup tank receiving the reactor coolant so that the boron concentration of the reactor coolant system is not significantly affected.

The effluent may be transferred to the mobile treatment facility for concentration or solidification. This disposal method is used only during unusual conditions that restrict the normal processed waste discharge mode described in the following paragraphs.

The normal mode of operation is to process the effluent by ion exchange and filtration to remove the radioactive materials. The ion exchangers operate in series as described in subsection 11.2.2.1.1.

The last bed provides a polishing function and also prevents radioactivity breakthrough to the monitor tank when the upstream unit becomes exhausted. This allows the full capacity of the upstream resin beds to be used, reducing the amount of spent resin that is generated.

When the analysis of samples taken periodically downstream of the ion exchange processing indicates an increase in radioactivity above prescribed limits, the operator isolates the expended unit(s) for resin replacement. Flow continues through the other units until a fresh resin bed is ready. When one of the last two ion exchangers has been replenished, the fresh unit is then brought online as the downstream unit.

The after-filter removes resin fines and other particulate matter that may pass through the ion exchangers. A high differential pressure alarm alerts the operator to the need for filter element replacement. Normally, filter element replacement is initiated on high radioactivity determined by periodic survey.

Process discharge is normally aligned to one of the three monitor tanks. When one of the tanks is full, an alarm alerts the operator that the tank is full and ready to be discharged. The inlet diversion valve automatically realigns the system to route processed waste to another tank upon high-high level.

The operator then starts the monitor tank pump to recirculate the tank contents and samples the processed waste. Since the ion exchangers operate in the borated saturated mode, the water contains boric acid. The radioactivity and chemistry of the processed waste is determined by sample analysis. In the unlikely event that radioactivity exceeds discharge limitations, the tank contents are returned to a waste holdup tank for reprocessing.

Once it is confirmed that the waste water is within radioactivity discharge limitations, the operator prepares the system for discharge. The operator initiates discharge by starting the monitor tank pump and opening the remotely operated discharge valve. During controlled discharge, grab samples are taken for laboratory analysis and documentation of discharge.

If the radiation monitor in the discharge line detects high radiation, the valve automatically closes. The operator is alerted to this condition by a high radiation alarm, and is required to take corrective action. A manual drain valve is opened to flush the radiation monitor and confirm low radiation before re-establishing discharge to the circulating water blowdown. Low monitor tank level automatically stops the monitor tank pump.

11.2.2.5.2 Floor Drain and Equipment Drain Waste Processing

Miscellaneous liquid wastes normally include influent from the radioactive floor drains, equipment drains and auxiliary building sump and excess water from the solid radwaste system. These wastes collect in one of two waste holdup tanks.

A high level alarm in the tank alerts the operator that the tank is full and ready to be processed. The inlet diversion valve automatically directs influents to the second waste holdup tank upon high-high level. The waste holdup tank pump is started to recirculate and sample the tank contents. Additives may be introduced to the waste holdup tank to optimize filtration and ion exchange processes.

Floor drain wastes are also brought into the waste holdup tanks from the containment sump. High sump level automatically opens the containment isolation valves and starts a pump to transfer the sump contents. Low level automatically stops the pump and closes the isolation valves. An alarm is provided to alert the operator to abnormally high containment sump level and the standby pump is automatically started. Cumulative flow is totalized and indicated to support reactor coolant leakage analysis.

The normal mode of operation is to process the waste water through the pre-filter, ion exchangers, and after-filter to the monitoring tank as described for the reactor coolant system effluent processing. Under abnormal conditions, the waste may also be transferred directly to a mobile treatment facility.

2

11.2.2.5.3 Detergent Waste Processing

The det gent wastes from the plant hot sinks and showers are routed to the chemical waste tank. Normally, these wastes are sampled and confirmed suitable for discharge without processing.

When a sufficient quantity of waste has accumulated and processing is necessary, mobile processing equipment is brought into one of the truck bays of the mobile systems facility.

11.2.2.5.4 Chemical Waste Processing

Chemical wastes are collected in the chemical waste tank. Chemicals may be added to the tank for pH or other adjustment. The volume of these wastes is expected to be low. When combined with detergent wastes, they may be suitable for processing and discharge. When

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not suitable for processing, they can be treated by the use of mobile equipment or by shipment offsite. 2

11.2.2.5.5 Steam Generator Blowdown Processing

Normal steam generator blowdown processing is accommodated by the steam generator blowdown system, which is described in subsection 10.4.8.

If steam generator tube leakage results in levels of radioactivity in the blowdown stream above what can be accommodated by the secondary-side systems, this stream is directed to the liquid radwaste system. For this function, the operator aligns the steam generator blowdown system to the inlet of the waste holdup tank. The blowdown waste is then processed in the same way as other wastes.

11.2.2.5.6 Ion Exchange Media Replacement

The initial and subsequent fill of ion exchange media is made through a resin fill nozzle on the top of the ion exchange vessel. When the media are spent and ready to be transferred to the solid radwaste system, the vessel is isolated from the process flow. The flush water line is opened to the sluice piping and demineralized water is pumped into the vessel through the normal process outlet connection upward through the media retention screen. The media fluidize in the upward, reverse flow. When the bed has been fluidized, the sluice connection is openeu and the bed is sluiced to the spent resin tanks in the solid radwaste system (WSS). Demineralized water flow continues until the bed has been removed and the siuice lines are flushed clean of spent resin.

11.2.3 Radioactive Releases

Liquid waste is produced both on the primary side (primarily from adjustment of reactor coolant boron concentration and from reactor coolant leakage) and the secondary side (primarily from steam generator blowdown processing and from secondary side leakage). Primary and secondary coolant activity levels are provided in Section 11.1 for both the design case (0.25 percent fuel defect level) and the anticipated case, which is based on operating plant experience.

Except for reactor coolant system degasification in anticipation of shutdown, the AP600 does not recycle primary side effluents for reuse. Primary effluents are discharged to the environment after processing. Fluid recycling is provided for the steam generator blowdown fluid which is normally returned to the condensate system.

11.2.3.1 Discharge Requirements

The release of radioactive liquid effluents from the plant may not exceed the concentration limits specified in Reference 1 nor may the releases result in the annual offsite dose limits specified in 10 CFR 50, Appendix I (Reference 2) being exceeded.

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11.2.2.5.3 Detergent Waste Processing

The detergent wastes from the plant hot sinks and showers are routed to the chemical waste tank. Normally, these wastes are sampled and confirmed suitable for discharge without processing. If processing prior to discharge is necessary, three courses of action are available. The waste water may be transferred to a waste holdup tank and processed in the same manner as other radioactively contaminated waste water. If the on-site processing capabilites are not suitable for the composition of the detergent waste, processing can be performed using mobile equipment brought into one of the truck bays of the mobile systems facility or the waste water can be shipped offsite for processing. After processing by mobile equipment the water may be transferred to a waste holdup tank for further processing by the on-site equipment or transferred to a monitor tank for sampling and discharge.

11.2.2.5.4 Chemical Waste Processing

Radioactively contaminated chemical wastes are collected in the chemical waste tank. Chemicals may be added to the tank for pH or other adjustment. The volume of these wastes is expected to be low. The design includes alternatives for processing or discharge of chemical wastes. They may be processed on-site without being combined with other wastes using mobile equipment. When combined with detergent wastes, they may be suitable for discharge without treatment or for processing by on-site equipment before discharge. When not suitable for on-site processing, they can be treated using ~~by the use of~~ mobile equipment or shipped ~~by shipment~~ offsite for processing. After processing by mobile equipment the water may be transferred to a waste holdup tank for further processing by the on-site equipment or transferred to a monitor tank for sampling and discharge.

11.2.3.2 Estimated Annual Releases

The annual average release of radionuclides from the plant is determined using the PWR-GALE code (Reference 3). The PWR-GALE code models releases which use source terms derived from data obtained from the experience of operating PWRs. The code input parameters used in the analysis to model the AP600 plant are listed in Table 11.2-6. The annual releases for a single-unit site are presented in Table 11.2-7.

In agreement with Reference 3, the total releases include an adjustment factor of 0.16 curies per year to account for anticipated operational occurrences. The adjustment uses the same distribution of nuclides as the calculated releases.

11.2.3.3 Dilution Factor

The dilution factor provided for the activity released is site dependent and is provided by the Combined License applicant. If the available dilution is low, the discharge rate can be reduced to maintain acceptable concentrations.

~~The dilution factor required to meet the 10 CFR 20 maximum permissible concentrations is 270~~. The required dilution flow is dependent on the liquid waste discharge rate and, while the monitor tank pumps have a design flow rate of 100 gpm, the discharge flow is controlled to be compatible with the available dilution flow. With a typical liquid waste release of 1647 ~~2000~~ gallons per day, ~~the required dilution flow is:~~

~~Release Period (hours)~~	~~Required Dilution Flow (gpm)~~
~~8~~	~~1200~~
~~6~~	~~1600~~
~~4~~	~~2400~~
~~2~~	~~4800~~

~~With~~ the nominal circulating water blowdown flow of 3500 gpm ~~there is~~ provides sufficient dilution flow to ~~meet the~~ maintain the annual average discharge concentrations well below the effluent ~~maximum permissible~~ concentration limits ~~with a waste discharge duration of 2.2 hours or longer~~. Actual plant operation is dependent on the waste liquid activity level and the available dilution flow.

11.2.3.4 Release Concentrations

The annual release data provided in Table 11.2-7 ~~represent~~ effluent expected releases from the annual average plant. To demonstrate compliance with the Reference 1 ~~maximum permissible~~ concentration limits, ~~for effluent~~, the discharge concentrations have been evaluated for the release of a typical daily liquid waste volume of 1647 ~~2000~~ gallons per day ~~over a period of 8 hours~~ and using the nominal circulating water blowdown flow of 3500 gpm. Table 11.2-8 lists the nuclide release concentrations and the fraction of the effluent ~~maximum permissible~~ concentration limits ~~for effluent~~. As shown in Table 11.2-8, the overall fraction of the effluent concentration limit is 0.13, which is well below the allowable value of 1.0.

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The annual releases from the plant have also been evaluated based on operation with the maximum defined fuel defect level. The maximum defined fuel defect level corresponds to 0.25 % fuel defects for the iodine and noble gas nuclides, and 1.0 % fuel defects for the other fission product nuclides. Table 11.2-9 lists the annual average nuclide release concentrations and the fractions of the effluent concentration limits for the maximum defined fuel defects. As shown in Table 11.2-9, the overall fraction of the effluent concentration limit for the maximum defined fuel defect level is 0.36, which is still well below the allowable value of 1.0.

11.2.3.5 Estimated Doses

Estimated doses are site specific and are the responsibility of the Combined License applicant.

11.2.3.6 Quality Assurance

Guidance for the quality assurance program for design fabrication, procurement, and installation issues is outlined in Section 17.1.

11.2.4 Combined License Information

ing by Mobile Equipment

11.2.4.1 Liquid Radwaste System Process Control Program

discuss how any mobile equipment used for processing liquid radwaste conform to

The Combined License applicant will develop a process control program for the liquid radioactive wastes which addresses the requirements of 10 CFR Sections 61.55 and 61.56 and 10CFR Part 71 and DOT regulations. Process control programs will also be provided by vendors providing mobile or portable processing systems. It will be the plant operator's responsibility to ensure that the vendors have appropriate process control programs for the scope of work being contracted at any particular time. The process control program will include a description of the equipment and process to be used and identify the operating procedures for processing liquid radioactive wastes. The mobile systems process control plan will include a discussion of conformance to Regulatory Guide 1.143. The Combined License applicant process control program will ~~include~~ the planned discharge flow rate for borated wastes. and control for limiting the boric acid discharge concentration in the circulating water system blowdo

11.2.4.2 Cost Benefit Analysis of Population Doses

The analysis performed to determine offsite dose due to liquid effluents is based upon the AP600 generic site parameters included in Chapter 1 and Tables 11.2-5 and 11.2-6. For sites outside of the envelope parameters, the Combined License applicant will provide a cost-benefit analysis to address the requirements of 10 CFR 50, Appendix I, regarding population doses due to liquid effluents.

11.2.4.3 Identification of Ion Exchange and Adsorbent Media

The Combined License applicant will identify the types of liquid waste ion exchange and adsorbent media to be used in the liquid radwaste system (WLS). This determination will be based on developments in ion exchange technology and specific characteristics of the liquid radwaste to be processed.

11.2.4.4 Control of Boric Acid Discharge

11.2.5 References

1. "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage," 10 CFR Part 20, Appendix B, Issued by ~~[illegible]~~ 58 FR ~~[illegible]~~ 67657, (~~[illegible]~~ April 28, 1995).

2. "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," 10 CFR Part 50, Appendix I.

3. "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," NUREG-0017, Revision 1, March 1985.

4. ANSI/ANS-55.6, "Liquid Radioactive Waste Processing Systems for Light Water Reactor Plants."

Table 11.2-1 (Sheet 1 of 2)

LIQUID INPUTS AND DISPOSITION

Collection Tank and Sources	Expected Input Rate	Activity	Basis	Disposition
1. Effluent holdup tanks				Filtered, demineralized, and discharged
Chemical and volume control system letdown	131,000 gpy	100% of reactor coolant	AP600-specific calculations	
Leakage inside containment (to reactor coolant drain tank)	6.6 gpd	167% of reactor coolant	~~ANSI/ANS-55.6~~ AP600-specific calculations	
Leakage outside containment (to effluent holdup tanks)	52.6 gpd	100% of reactor coolant	~~ANSI/ANS-55.6~~ AP600-specific calculations	
Sampling drains	200 gpd	100% of reactor coolant	ANSI/ANS-55.6 (x) ~~(Note 1)~~	
2. Waste holdup tank				Filtered, demineralized and discharged
Reactor containment cooling	329 gpd	0.1% of reactor coolant	~~ANSI/ANS-55.6~~ AP600-specific calculations	
Spent fuel pool liner leakage	25 gpd	0.1% of reactor coolant	ANSI/ANS-55.6	
Misc. Drains	675 gpd	0.1% of reactor coolant	ANSI/ANS-55.6	

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Table 11.2-1 (Sheet 2 of 2)

LIQUID INPUTS AND DISPOSITION

Collection Tank and Sources	Expected Input Rate	Activity	Basis	Disposition
3. Detergent waste				Filtered, monitored, and discharged. If necessary, processed with mobile equipment.
Hot shower	0 gpd	10^{-7} μCi/g	ANSI/ANS-55.6	
Hand wash	131 gpd	10^{-7} μCi/g	~~ANSI/ANS-55.6~~ AP600-specific calculations	
Equipment and area decontamination	26 gpd	0.1% of reactor coolant	~~ANSI/ANS-55.6~~ AP600-specific calculations	
Laundry			Offsite laundry	
4. Chemical Wastes	~~Varies~~ 2 gpd	≤ reactor coolant	Estimate	Processed with mobile equipment

bold Notes: 1. ANSI/ANS-55.6 identifies sampling drains activity of 5% of reactor coolant. 100% is used as a conservative input for GALE Code analysis.

Table 11.2-2 (Sheet 1 of 3) **COMPONENT DATA - LIQUID RADWASTE SYSTEM**	
Pumps	
Containment sump pumps Number Design flow (gpm)	 2 100
Reactor coolant drain tank pumps Number Design flow (gpm)	 2 100
Standard Waste Processing Pump Standard waste processing pump used for: <u>Number</u> <u>Application</u> 2 Degasifier discharge pumps 2 Effluent holdup tank pumps 2 Waste holdup tank pumps 3 Monitor tank pumps 1 Chemical waste tank pump	
Number Design flow (gpm)	11 Air-operated, double-diaphragm 100 nominal (can be varied by varying air supply conditions)

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Table 11.2-2 (Sheet 2 of 3)

COMPONENT DATA - LIQUID RADWASTE SYSTEM

Ion Exchangers	
Deep bed filter (WLS-MV03) Number Resin volume (ft^3) Process decontamination factors	 1 50 Layered: Activated carbon on zeolyte resin (Adjustable for plant conditions) See Table 11.2-5
Waste ion exchangers (WLS-MV04, WLS-MV05A/B) Number Resin volume (ft^3) Process decontamination factors	 3 30 One cation, Two mixed (reversing series) (Adjustable for plant conditions) See Table 11.2-5

Table 11.2-2 (Sheet 3 of 3)

COMPONENT DATA - LIQUID RADWASTE SYSTEM

Tanks	
Reactor coolant drain tank (WLS-MT01)	
Number	1
Volume (gal)	900
Containment sump (WLS-MT02)	
Number	1
Volume (gal)	628
Effluent holdup tanks (WLS-MT05A/B)	
Number	2
Volume (gal)	28,000
Waste holdup tanks (WLS-MT06A/B)	
Number	2
Volume (gal)	15,000
Monitor tanks (WLS-MT07A/B/C)	
Number	3
Volume (gal)	15,000
Chemical waste tank (WLS-MT11)	
Number	1
Volume (gal)	15,000

C

Table 11.2-2 (Sheet 1 of 7)

COMPONENT DATA - LIQUID RADWASTE SYSTEM

Pumps

Containment sump pumps	
Number	2
Type	Submersible centrifugal
Design pressure (psig)	15 ext. ?
Design temperature (°F)	250
Design flow (gpm)	100
Material	Stainless steel
Reactor coolant drain tank pumps	
Number	2
Type	Vertical sump type, centrifugal ?
Design pressure (psig)	15 ext.
Design temperature (°F)	250
Design flow (gpm)	100
Material	Stainless steel
Degasifier separator pump (part of vacuum degasifier)	
Number	2
Type	Centrifugal
Design pressure (psig)	125
Design temperature (°F)	200
Design flow (gpm)	7
Material	Stainless steel

external?

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Table 11.2-2 (Sheet 2 of 7)

COMPONENT DATA - LIQUID RADWASTE SYSTEM

Pumps	
Standard ~~W~~aste ~~P~~rocessing ~~P~~ump Standard waste processing pump used for: <u>Number</u> <u>Application</u> 2 Degasifier discharge pumps 2 Effluent holdup tank pumps 2 Waste holdup tank pumps 3 Monitor tank pumps 1 Chemical waste tank pump	
Type	Air-operated, double-diaphragm
Design pressure (psig)	125
Design temperature (°F)	200
Design flow (gpm)	100 (can be varied by varying air supply flow)
Material	Stainless steel body, Elastomeric diaphragm
Degasifier vacuum pumps (part of vacuum degasifier package)	
Number	2
Type	Liquid ring
Design pressure (psig)	125
Design temperature (°F)	200
Design flow (scfm)	0.5 steady, 150 hogging
Material	Stainless steel

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Table 11.2-2 (Sheet 3 of 7)

COMPONENT DATA - LIQUID RADWASTE SYSTEM

Filters

Waste pre-filter	
Number	1
Type	Disposable bag or cartridge
Design pressure (psig)	150
Design temperature (°F)	150
Design flow (gpm)	75
Particle size (micron, 98% retention)	25
Materials	
Housing	Stainless steel
Filter	Polypropylene/Pleated paper
Waste after-filter	
Number	1
Type	Disposable bag or cartridge
Design pressure (psig)	150
Design temperature (°F)	150
Design flow (gpm)	75
Particle size (micron, 98% retention)	0.5
Materials	
Housing	Stainless steel
Filter medium	Polypropylene/Pleated paper

C cont.

Table 11.2-2 (Sheet 4 of 7)

COMPONENT DATA - LIQUID RADWASTE SYSTEM

Heat Exchangers	
Reactor coolant drain tank heat exchanger	
Number	1
Type	Horizontal U-tube
Design pressure (psig)	150
Design temperature (°F)	250 tubeside, 200 shellside
Design flow (lb/hr)	48,700 tubeside, 62,200 shellside
Heat Transfer Design Case	
Temperature inlet (°F)	175 tubeside, 95 shellside
Temperature outlet (°F)	143 tubeside, 120 shellside
Material	SS tubeside, CS shellside
Vapor condenser	
Number	1
Type	Horizontal U-tube
Design pressure (psig)	150
Design temperature (°F)	150
Design flow (lb/hr)	100,000 tubeside, 1700 shellside
Heat Transfer Design Case	
Temperature inlet (°F)	45 tubeside, 84 shellside
Temperature outlet (°F)	63 tubeside, 60 shellside
Material	SS

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Table 11.2-2 (Sheet 5 of 7)

COMPONENT DATA - LIQUID RADWASTE SYSTEM

Ion Exchangers	
Deep bed filter	
Number	1
Design pressure (psig)	150
Design temperature (°F)	150
Design flow (lb/hr)	75
Nominal resin volume (ft3)	50
Material	Stainless steel
Resin type	Layered: Activated charcoal on zeolyte resin (Adjustable for plant conditions)
Process decontamination factors	See Table 11.2-5
Waste ion exchangers	
Number	3
Design pressure (psig)	150
Design temperature (°F)	150
Design flow (lb/hr)	75
Nominal resin volume (ft^3)	30
Material	Stainless steel
Resin type	One cation, Two mixed (Adjustable for plant conditions)
Process decontamination factors	See Table 11.2-5

(C) cont.

Table 11.2-2 (Sheet 6 of 7)

COMPONENT DATA - LIQUID RADWASTE SYSTEM

Tanks	
Reactor coolant drain tank	
Number	1
Nominal volume (gal)	900
Type	Horizontal
Design pressure (psig)	10 int., 15 ext.
Design temperature (°F)	250
Material	Stainless steel
Containment sump	
Number	1
Nominal volume (gal)	220
Type	Rectangular
Design pressure (psig)	Atmospheric
Design temperature (°F)	200
Material	Stainless steel
Effluent holdup tanks	
Number	2
Nominal volume (gal)	28,000
Type	Horizontal
Design pressure (psig)	Atmospheric
Design temperature (°F)	150
Material	Stainless steel
Waste holdup tanks	
Number	2
Nominal volume (gal)	15,000
Type	Vertical
Design pressure (psig)	Atmospheric
Design temperature (°F)	150
Material	Stainless steel
Monitor tanks	
Number	3
Nominal volume (gal)	15,000
Type	Vertical
Design pressure (psig)	Atmospheric
Design temperature (°F)	150
Material	Stainless steel

© cont.

Table 11.2-2 (Sheet 7 of 7) **COMPONENT DATA - LIQUID RADWASTE SYSTEM**	
Chemical waste tank	
Number	1
Nominal volume (gal)	15,000
Type	Vertical
Design pressure (psig)	Atmospheric
Design temperature (°F)	150
Material	Stainless steel
Degasifier separator (part of vacuum degasifier package)	
Number	1
Nominal volume (gal)	45
Type	Vertical
Design pressure (psig)	75
Design temperature (°F)	200
Material	Stainless steel
Degasifier column (part of vacuum degasifier package)	
Number	1
Nominal volume (gal)	900
Type	Vertical
Design pressure (psig)	75 int., 15 ext. internal?
Design temperature (°F)	150
Material	Stainless steel

take off lines

Table 11.2-3

SUMMARY OF TANK LEVEL INDICATION, LEVEL ANNUNCIATORS, AND OVERFLOWS

Tank	Level Indication Location	Alarm Location	Alarm	Overflow To
Effluent holdup	MCR	MCR, LWP	High	Room drains to auxiliary building sump which is pumped to waste holdup tank (Note 2)
Waste holdup	MCR	MCR, LWP	High	Room (Note 2)
Chemical waste	MCR	MCR, LWP	High	Room (Note 2)
Monitor	MCR	MCR, LWP	High	Room (Note 2)

Notes:

1. MCR = main control room ; LWP = liquid radwaste panel
2. Room is within auxiliary building (seismic Category 1) and water-tight with curbs or walls of sufficient height to contain the entire contents of the contained tank.

Remove line

Table 11.2-4

TANK SURGE CAPACITY

Reactor Coolant Drain Tank

- Sized to accept 10 gpm of saturated reactor coolant for 1 hour without discharge or overflow.
- Reactor coolant drain tank heat exchanger designed to limit the temperature to less than 175°F with this input assumed to be at 580°F.

Containment Sump

- Sized to allow collection of 300 gallons of water between pumping cycles.

Effluent Holdup Tanks

- Sized to allow (together) a back-to-back plant shutdown and restart without delay at any time during the first 90 percent of core life. This operation requires nominal processing of the effluent monitor tanks and normal discharge with temporary storage of waste fluid in the cask loading pit.
- Sized to allow (together) a single plant shutdown and restart without delay at any time during the first 80 percent of core life. This operation requires nominal processing to the monitor tanks, but no discharge from the plant.

Other Tanks

- Sized based on accommodating maximum input without operator intervention for reasonable lengths of time.

Table 11.2-5

DECONTAMINATION FACTORS

Decontamination factors assumed per NUREG-0017, Revision 1 (PWR-GALE code input) to be as follow:

Resin Type/Component	Iodine	Cs/Rb	Other
Zeolite/deep bed filter (Note 1)	1	100	1
Cation/waste ion exchanger 1	1	10	10
Mixed/waste ion exchanger 2	100	2 (Note 2)	100
Mixed/waste ion exchanger 3	10	10 (Note 2)	10 (Note 2)

Other components not directly involved in discharge from the plant:

Degasifier Column

Reduce hydrogen by a factor of 40

Assuming inlet flow of 100 gpm at 130°F.

Notes:

1. This component is not included in NUREG-0017. DFs based upon "Reduction of Cesium and Cobalt Activity in Liquid Radwaste Processing Using Clinoptilolite Zeolite at Duke Power Company," by O.E. Ekechokwu, et al., Proc. Waste Management '92, Tucson, Arizona, March 1992, University of Arizona, Tucson.
2. Credit for this decontamination factor not taken in determination of anticipated annual releases.

fine

Table 11.2-6 (Sheet 1 of 3)

INPUT PARAMETERS FOR THE GALE COMPUTER CODE

Thermal power level (MWt)	1933
Mass of primary coolant (lb)	3.46×10^5
Primary system letdown rate (gpm)	100
Letdown cation demineralizer flow rate, annual average (gpm)	10
Number of steam generators	2
Total steam flow (lb/hr)	8.4×10^6
Mass of liquid in each steam generator (lb)	1.075×10^5
Total mass of secondary coolant (lb)	2.15×10^5
Total blowdown rate (lb/hr)	8.4×10^4
Blowdown treatment method	*
Condensate demineralizer regeneration time	N/A
Condensate demineralizer flow fraction	0.33
Primary coolant bleed for boron control	
Bleed flow rate (gpd)	658
Decontamination factor for I	10^3
Decontamination factor for Cs and Rb	2×10^2
Decontamination factor for others	10^3
Collection time (day)	21
Process and discharge time (day)	0
Fraction discharged	1.0
Equipment Drains and Clean Waste	
Equipment drains flow rate (gpd)	90
Fraction of reactor coolant activity	1.07

Gordon: what does this refer to?

Note:

1. A "0" is input to indicate that the blowdown is recycled, to the condensate system demineralizers, after treatment in the blowdown system.

Table 11.2-6 (Sheet 2 of 3)

INPUT PARAMETERS FOR THE GALE COMPUTER CODE

Decontamination factor for I	10^3
Decontamination factor for Cs and Rb	2×10^2
Decontamination factor for others	10^3
Collection time (day)	21
Process and discharge time (day)	0
Fraction discharged	1.0
Dirty Waste	
Dirty waste input flow rate (gpd)	1400
Fraction of reactor coolant activity	0.012
Decontamination factor for I	10^3
Decontamination factor for Cs and Rb	2×10^2
Decontamination factor for others	10^3
Collection time (day)	8
Process and discharge time (day)	0
Fraction discharged	1.0
Blowdown Waste	
Blowdown fraction processed	1
Decontamination factor for I	100
Decontamination factor for Cs and Rb	10
Decontamination factor for others	100
Collection time	N/A
Process and discharge time	N/A
Fraction discharged	0

Table 11.2-6 (Sheet 3 of 3)

INPUT PARAMETERS FOR THE GALE COMPUTER CODE

Regenerant waste	N/A
Gaseous Waste System	
Continuous gas stripping of full letdown purification flow	None
Holdup time for xenon, normal operation (days) RCS degassing (days)	435 8.7
Holdup time for krypton, normal operation (days) RCS degassing (days)	24 0.5
Fill time of decay tanks for gas stripper	N/A
Gas waste system: HEPA filter	None
Auxiliary building: Charcoal filter	None
Auxiliary building: HEPA filter	None
Containment volume (ft^3)	1.73×10^6
Containment atmosphere internal cleanup rate (ft^3/min)	N/A
Containment high volume purge:	
Number of purges per year (in addition to two shut-down purges)	0
Charcoal filter efficiency (%)	90
HEPA filter efficiency (%)	99
Containment normal continuous purge rate (ft^3/min) (based on 20 hrs/week at 4000 ft^3/min)	500
Charcoal filter efficiency (%)	90
HEPA filter efficiency (%)	99
Fraction of iodine released from blowdown tank vent	N/A
Fraction of iodine removed from main condenser air ejector release	0.0
Detergent waste decontamination factor	1.0

Table 11.2-7 (Sheet 1 of 2)

RELEASES TO DISCHARGE CANAL (Ci/Yr) CALCULATED BY GALE CODE

Nuclide	Shim Bleed	Misc. Wastes	Turbine Building	Combined Releases	Adjusted Combined Releases[1]	Detergent Wastes	Total
			Corrosion and Activation Products				
Na-24	0.0[2]	0.0	0.00014	0.00014	0.00281	0.0	0.00280
P-32	0.0	0.0	0.0	0.0	0.0	0.00018	0.00018
Cr-51	0.0	0.0	0.00002	0.00002	0.00039	0.00470	0.00510
Mn-54	0.0	0.0	0.00001	0.00001	0.00020	0.00380	0.00400
Fe-55	0.0	0.0	0.00001	0.00001	0.00015	0.00720	0.00740
Fe-59	0.0	0.0	0.0	0.0	0.00004	0.00220	0.00220
Co-58	0.0	0.0	0.00003	0.00003	0.00059	0.00790	0.00850
Co-60	0.0	0.0	0.0	0.0	0.00007	0.01400	0.01400
Ni-63	0.0	0.0	0.0	0.0	0.0	0.00170	0.00170
Zn-65	0.0	0.0	0.0	0.0	0.00007	0.0	0.00007
W-187	0.0	0.0	0.00001	0.00001	0.00019	0.0	0.00019
Np-239	0.0	0.0	0.00001	0.00001	0.00021	0.0	0.00021
			Fission Products				
Br-84	0.0	0.0	0.0	0.0	0.00008	0.0	0.00008
Rb-88	0.00003	0.0	0.0	0.00003	0.00060	0.0	0.00060
Sr-89	0.0	0.0	0.0	0.0	0.00002	0.00009	0.00011
Sr-90	0.0	0.0	0.0	0.0	0.0	0.00001	0.00002
Sr-91	0.0	0.0	0.0	0.0	0.00004	0.0	0.00004
Y-91M	0.0	0.0	0.0	0.0	0.00003	0.0	0.00003
Y-91	0.0	0.0	0.0	0.0	0.0	0.00008	0.00009
Y-93	0.0	0.0	0.00001	0.00001	0.00019	0.0	0.00019
Zr-95	0.0	0.0	0.0	0.0	0.00005	0.00110	0.00110
Nb-95	0.0	0.0	0.0	0.0	0.00003	0.00190	0.00190
Mo-99	0.0	0.0	0.00003	0.00003	0.00065	0.00006	0.00071
Tc-99M	0.0	0.0	0.00002	0.00002	0.00042	0.0	0.00042
Ru-103	0.0	0.0	0.00004	0.00005	0.00095	0.00029	0.00120
Rh-103M	0.0	0.0	0.00004	0.00005	0.00094	0.0	0.00094
Ru-106	0.00005	0.00001	0.00052	0.00058	0.01151	0.00890	0.02000
Rh-106	0.00005	0.00001	0.00052	0.00058	0.01151	0.0	0.01200

Table 11.2-7 (Sheet 2 of 2)

RELEASES TO DISCHARGE CANAL (Ci/Yr) CALCULATED BY GALE CODE

Nuclide	Shim Bleed	Misc. Wastes	Turbine Building	Combined Releases	Adjusted Combined Releases[1]	Detergent Wastes	Total
Ag-110M	0.0	0.0	0.00001	0.00001	0.00016	0.00120	0.00140
Ag-110	0.0	0.0	0.0	0.0	0.00002	0.0	0.00002
Sb-124	0.0	0.0	0.0	0.0	0.0	0.00043	0.00043
Te-129M	0.0	0.0	0.0	0.0	0.00002	0.0	0.00002
Te-129	0.0	0.0	0.0	0.0	0.00003	0.0	0.00003
Te-131M	0.0	0.0	0.00001	0.00001	0.00012	0.0	0.00012
Te-131	0.0	0.0	0.0	0.0	0.00002	0.0	0.00002
I-131	0.00121	0.00033	0.00025	0.00180	0.03568	0.00160	0.03700
Te-132	0.0	0.0	0.00001	0.00001	0.00017	0.0	0.00017
I-132	0.00016	0.00007	0.00010	0.00033	0.00658	0.0	0.00660
I-133	0.00057	0.00026	0.00062	0.00145	0.02889	0.0	0.02900
I-134	0.00009	0.00004	0.0	0.00014	0.00282	0.0	0.00280
Cs-134	0.00054	0.00003	0.00007	0.00064	0.01281	0.01100	0.02400
I-135	0.00041	0.00019	0.00060	0.00121	0.02402	0.0	0.02400
Cs-136	0.00004	0.0	0.00001	0.00005	0.00106	0.00037	0.00140
Cs-137	0.00072	0.00005	0.00010	0.00086	0.01709	0.01600	0.03300
Ba-137M	0.00001	0.0	0.00009	0.00010	0.00196	0.0	0.00200
Ba-140	0.0	0.0	0.00007	0.00008	0.00153	0.00091	0.00240
La-140	0.00001	0.0	0.00012	0.00013	0.00249	0.0	0.00250
Ce-141	0.0	0.0	0.0	0.0	0.00002	0.00023	0.00025
Ce-143	0.0	0.0	0.00001	0.00001	0.00023	0.0	0.00023
Ce-144	0.0	0.0	0.00002	0.00003	0.00050	0.00390	0.00440
Pr-144	0.0	0.0	0.00002	0.00003	0.00050	0.0	0.00050
All others	0.0	0.0	0.0	0.0	0.00001	0.0	0.00001
Total (except tritium)	0.00391	0.00101	0.00355	0.00848	0.16848	0.08975	0.26000
Tritium release		690 curies per year					

Notes:

1. An adjustment of 0.16 Ci/yr is added by PWR-GALE code to account for anticipated operational occurrences such as operator errors that result in unplanned releases.
2. An entry of 0.0 indicates that the value is less than 10^{-5} Ci/yr.

Table 11.2-8 (Sheet 1 of 2)

COMPARISON OF [redacted] ANNUAL AVERAGE LIQUID RELEASE EFFLUENT CONCENTRATIONS WITH 10 CFR 20 [redacted] CONCENTRATION LIMITS FOR EXPECTED RELEASES

Nuclide	Discharge Conc. (µCi/ml)[1]	~~Maximum Permissible~~ Effluent Conc. Limit (µCi/ml)[2]	Fraction of ~~MPC~~ Conc. Limit
Na-24	2.3 ~~1.2~~ E-~~09~~10	5.0E-05	4.6 ~~2.4~~ E-~~05~~06
~~P-32~~	~~7.7E-11~~	~~9.0E-06~~	~~8.6E-06~~
Cr-51	2.6 ~~2.2~~E-~~09~~10	5.0E-04	5.2 ~~4.4~~ E-~~06~~07
Mn-54	1.9 ~~1.7~~E-~~09~~10	3.0E-05	6.3 ~~5.7~~E-~~05~~06
Fe-55	1.5 ~~3.2~~E-~~09~~10	1.0E-04	1.5 ~~3.2~~E-~~05~~06
Fe-59	2.9 ~~9.4~~E-~~10~~11	1.0E-05	2.9 ~~9.4~~E-~~05~~06
Co-58	4.9 ~~3.6~~ E-~~09~~10	2.0E-05	2.5 ~~1.8~~E-~~04~~05
Co-60	6.6 ~~6.0~~E-~~09~~11	3.0E-06	2.2 ~~2.0~~E-~~03~~05
~~Ni-63~~	~~7.3E-10~~	~~1.0E-04~~	~~7.3E-06~~
Zn-65	6.1 ~~3.0~~ E-11	5.0E-06	1.2 ~~6.0~~ E-~~06~~05
W-187	1.8 ~~8.1~~ E-11	3.0E-05	6.0 ~~2.7~~ E-~~06~~07
Np-239	3.1 ~~9.0~~ E-11	2.0E-05	1.6 ~~4.5~~ E-06
Br-84	3.6 ~~3.4~~E-~~11~~12	4.0E-04	9.0 ~~8.6~~E-~~08~~09
Rb-88	3.9 ~~2.6~~E-~~10~~11	4.0E-04	9.8 ~~6.4~~E-~~07~~08
Sr-89	1.4 ~~4.7~~E-11	8.0E-06	1.8 ~~5.9~~E-06
~~Sr-90~~	~~8.6E-12~~	~~5.0E-07~~	~~1.7E-05~~
Sr-91	3.6 ~~1.7~~ E-~~11~~12	2.0E-05	1.8 ~~8.6~~ E-07
Y-91m	1.8 ~~1.3~~E-~~11~~12	2.0E-03	9.0 ~~6.4~~E-~~09~~10
~~Y-91~~	~~3.9E-11~~	~~8.0E-06~~	~~4.8E-06~~
Y-93	1.6 ~~8.1~~ E-11	2.0E-05	8.0 ~~4.1~~ E-~~06~~07
Zr-95	4.1 ~~4.7~~ E-~~10~~11	2.0E-05	2.1 ~~2.4~~ E-~~05~~06
Nb-95	3.8 ~~8.1~~E-~~10~~11	3.0E-05	1.3 ~~2.7~~E-~~05~~06
Mo-99	1.0 ~~3.0~~ E-10	2.0E-05	5.0 ~~1.5~~ E-~~05~~06
Tc-99m	9.9 ~~1.8~~ E-~~10~~11	1.0E-03	9.9 ~~1.8~~ E-~~07~~08
Ru-103	7.0 ~~5.1~~ E-10	3.0E-05	2.3 ~~1.7~~ E-05
Rh-103m	7.0 ~~4.0~~ E-10	6.0E-03	1.2 ~~6.7~~ E-~~08~~07
Ru-106	1.1 ~~8.6~~ E-~~09~~08	3.0E-06	3.7 ~~2.9~~ E-03
~~Rh-106~~	~~5.1 E-09~~	~~1.0E-04~~	~~5.1 E-05~~

Table 11.2-8 (Sheet 2 of 2)

COMPARISON OF ~~[illegible]~~ ANNUAL AVERAGE LIQUID RELEASE CONCENTRATIONS WITH 10 CFR 20 ~~[illegible]~~ EFFLUENT CONCENTRATION~~S~~ LIMITS FOR EXPECTED RELEASES

Nuclide	Discharge Conc. (µCi/ml)[1]	~~Maximum Permissible~~ Effluent Conc. Limit (µCi/ml)[2]	Fraction of ~~MPC~~ Conc. Limit
Ag-100m	1.5 ~~6.0~~E-10	6.0E-06	2.5 ~~1.0~~E-~~04~~05
~~Ag-110~~	~~8.6 E-12~~	~~1.0E-08~~	~~8.6 E-04~~
~~Sb-124~~	~~1.8E-10~~	~~7.0E-06~~	~~2.6 E-05~~
Te-129m	1.6 ~~8.6~~ E-~~12~~11	7.0E-06	2.3 ~~1.2~~ E-06
Te-129	2.2 ~~1.3~~E-11	4.0E-~~05~~04	5.5 ~~3.2~~E-~~07~~08
Te-131m	1.3 ~~5.6~~ E-11	8.0E-06	1.6 ~~7.0~~ E-06
Te-131	3.6 ~~8.6~~ E-12	8.0 ~~2.0~~E-~~04~~05	4.5 ~~4.3~~ E-08
I-131	1.9 ~~1.6~~ E-~~08~~09	1.0E-06	1.9 ~~1.6~~ E-~~02~~03
Te-132	3.1 ~~7.3~~ E-11	9.0E-06	3.4 ~~8.1~~ E-06
I-132	2.6 ~~2.8~~ E-~~09~~10	1.0E-04	2.6 ~~2.8~~ E-~~05~~06
I-133	9.6 ~~1.2~~ E-~~08~~10	7.0E-06	1.4 ~~1.8~~ E-~~03~~04
I-134	1.2 E-~~09~~10	4.0E-04	3.0 E-~~06~~07
Cs-134	1.4 ~~1.0~~ E-~~08~~09	9.0E-07	1.6 ~~1.1~~ E-~~02~~03
I-135	8.0 ~~1.0~~ E-~~08~~10	3.0E-05	2.7 ~~3.4~~ E-~~04~~05
Cs-136	8.3 ~~6.0~~ E-~~10~~11	6.0E-06	1.4 ~~1.0~~ E-~~04~~05
Cs-137	1.9 ~~1.4~~ E-~~08~~09	1.0E-06	1.9 ~~1.4~~ E-~~02~~03
~~Ba-137m~~	~~8.6 E-10~~	~~1.0E-06~~	~~8.6 E-04~~
Ba-140	7.4 ~~1.0~~ E-~~09~~10	8.0E-06	9.3 ~~1.3~~ E-~~04~~05
La-140	9.8 ~~1.1~~ E-~~09~~10	9.0E-06	1.1 ~~1.2~~ E-04
Ce-141	1.3 ~~1.1~~E-~~10~~11	3.0E-05	4.3 ~~3.6~~E-~~06~~07
Ce-143	2.5 ~~9.8~~ E-11	2.0E-05	1.3 ~~4.9~~ E-06
Pr-143	1.3E-11	2.5E-05	2.2E-07
Ce-144	4.7 ~~1.0~~E-~~09~~10	3.0E-06	1.6 ~~6.3~~ E-04
Pr-144	4.7 ~~2.1~~ E-10	6.0E-04	7.8 ~~3.6~~ E-07
H-3	1.2 ~~3.0~~ E-04	1.0E-03	1.2 ~~3.0-7~~E-01

Total = 1.3E-01

Notes:

1. Annual average Discharge concentration based on release of average daily discharge ~~over an 8-hour period~~ for 292 days per year with 3500 gpm dilution flow.
2. ~~Maximum permissible~~ Effluent limits concentration~~s~~ are from Reference 1.

Table 11.2-~~8~~ 9 (Sheet 1 of 2)

COMPARISON OF ~~CALCULATED~~ ANNUAL AVERAGE LIQUID RELEASE CONCENTRATIONS WITH 10 CFR 20 ~~MAXIMUM PERMISSIBLE~~ EFFLUENT CONCENTRATION~~S~~ LIMITS FOR RELEASES WITH MAXIMUM DEFINED FUEL DEFECTS

Nuclide	Discharge Conc. (µCi/ml)(1)	~~Maximum Permissible~~ effluent Conc. (µCi/ml)(2) limit	Fraction of ~~MPC~~ Conc. Limit
Na-24	2.3 ~~1.2~~ E-~~09~~ 10	5.0E-05	4.6 ~~2.4~~ E-~~05~~ 06
~~P-32~~	~~7.7E-11~~	~~9.0E-06~~	~~8.6E-06~~
Cr-51	2.6 ~~2.2~~E-~~09~~ 10	5.0E-04	5.2 ~~4.4~~ E-~~06~~ 07
Mn-54	1.9 ~~1.7~~E-~~09~~ 10	3.0E-05	6.3 ~~5.7~~E-~~05~~ 06
Fe-55	[illegible] ~~3.2~~E-~~09~~ 10	1.0E-04	1.5 ~~3.2~~E-~~05~~ 06
Fe-59	2.9 ~~9.4~~E-~~10~~ 11	1.0E-05	2.9 ~~9.4~~E-~~05~~ 06
Co-58	4.9 ~~3.6~~ E-~~09~~ 10	2.0E-05	2.5 ~~1.8~~E-~~04~~ 05
Co-60	6.6 ~~6.0~~E-~~09~~ 11	3.0E-06	2.2 ~~2.0~~E-~~03~~ 05
~~Ni-63~~	~~7.3E-10~~	~~1.0E-04~~	~~7.3E-06~~
Zn-65	6.1 ~~3.0~~ E-11	5.0E-06	1.2 ~~6.0~~ E-~~06~~ 05
W-187	1.8 ~~8.1~~ E-11	3.0E-05	6.0 ~~2.7~~ E-~~06~~ 07
Np-239	3.1 ~~9.0~~ E-11	2.0E-05	1.6 ~~4.5~~ E-06
Br-84	3.6 ~~2.4~~E-~~11~~ 12	4.0E-04	9.0 ~~8.6~~E-~~08~~ 09
Rb-88	2.0 ~~2.6~~E-10	4.0E-04	5.0 ~~6.4~~E-07
Sr-89	1.1 ~~4.7~~E-~~11~~ 10	8.0E-06	1.4 ~~5.9~~E-~~06~~ 05
~~Sr-90~~	~~8.6E-12~~	~~5.0E-07~~	~~1.7E-05~~
Sr-91	3.6 ~~1.7~~ E-~~11~~ 12	2.0E-05	1.8 ~~8.6~~ E-07
Y-91m	1.8 ~~1.3~~E-~~11~~ 12	2.0E-03	9.0 ~~6.4~~E-~~09~~ 10
~~Y-91~~	~~3.9E-11~~	~~8.0E-06~~	~~4.8E-06~~
Y-93	1.6 ~~8.1~~ E-11	2.0E-05	8.0 ~~4.1~~ E-~~06~~ 07
Zr-95	4.7 E-~~10~~ 11	2.0E-05	2.4 E-~~05~~ 06
Nb-95	4.8 ~~8.1~~E-~~10~~ 11	3.0E-05	1.6 ~~2.7~~E-~~05~~ 06
Mo-99	2.6 ~~3.0~~ E-~~10~~ 09	2.0E-05	1.3 ~~1.5~~ E-~~05~~ 04
Tc-99m	2.3 ~~1.8~~ E-~~10~~ 09	1.0E-03	2.3 ~~1.8~~ E-~~07~~ 06
Ru-103	7.0 ~~5.4~~ E-10	3.0E-05	2.3 ~~1.7~~ E-05
Rh-103m	7.0 ~~4.0~~ E-10	6.0E-03	1.2 ~~6.7~~ E-~~08~~ 07
Ru-106	1.1 ~~8.6~~ E-~~09~~ 08	3.0E-06	3.7 ~~2.9~~ E-03
~~Rh-106~~	~~5.1 E-09~~	~~1.0E-04~~	~~5.1 E-05~~

Table 11.2-~~8~~9 (Sheet 2 of 2)

COMPARISON OF ~~CALCULATED~~ ANNUAL AVERAGE LIQUID RELEASE EFFLUENT CONCENTRATIONS WITH 10 CFR 20 ~~MAXIMUM PERMISSIBLE~~ CONCENTRATION~~S~~ LIMITS FOR RELEASES WITH MAXIMUM DEFINED FUEL DEFECTS

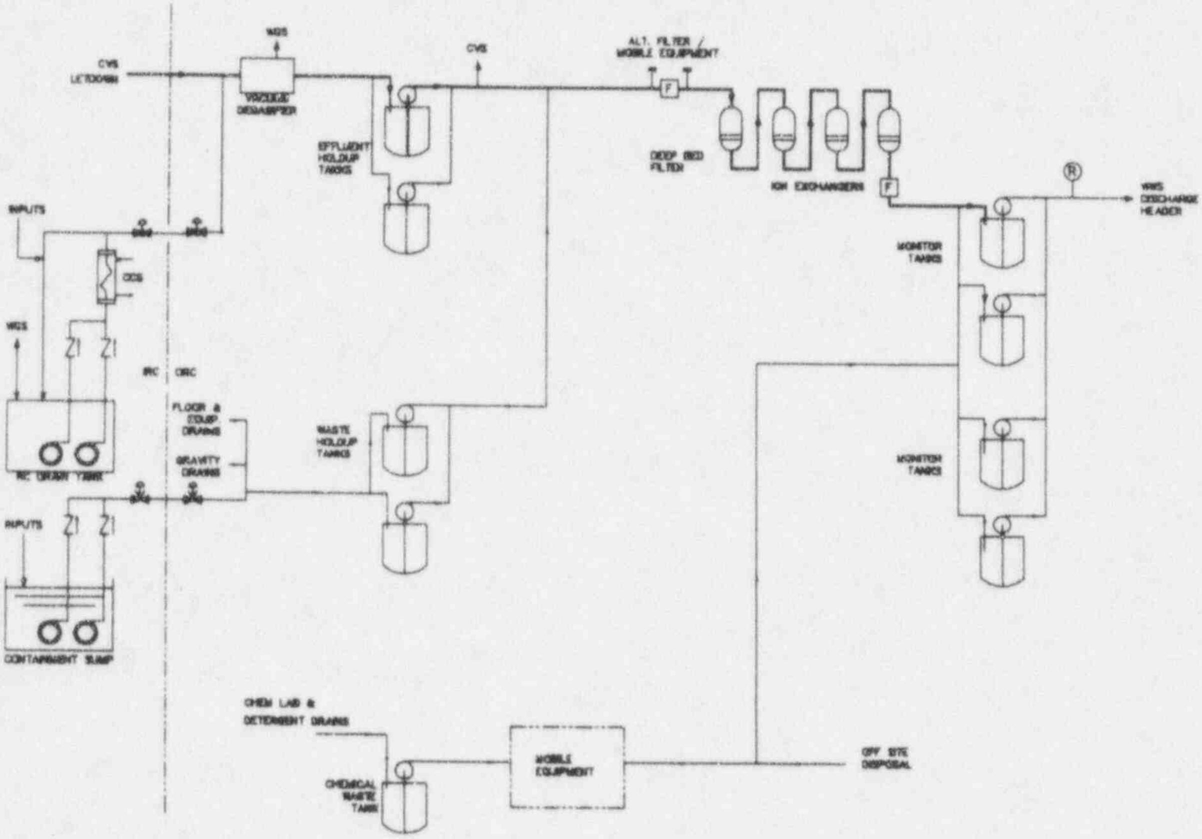
Nuclide	Discharge Conc. (µCi/ml)[1]	~~Maximum Permissible~~ Effluent Conc. Limit (µCi/ml)[2]	Fraction of ~~MPC~~ Conc. Limit
Ag-100m	1.7 ~~6.0~~E-10	6.0E-06	2.8 ~~1.0~~E-~~04~~05
~~Ag-110~~	~~8.6 E-12~~	~~1.0E-08~~	~~8.6 E-04~~
~~Sb-124~~	~~1.8E-10~~	~~7.0E-06~~	~~2.6 E-05~~
Te-129m	2.0 ~~8.6~~ E-~~12~~10	7.0E-06	2.9 ~~1.2~~ E-~~06~~05
Te-129	2.2 ~~1.3~~E-11	4.0E-~~05~~04	5.5 ~~3.2~~E-~~07~~08
Te-131m	6.3 ~~5.6~~ E-11	8.0E-06	7.9 ~~7.0~~ E-06
Te-131	3.6 ~~8.6~~ E-12	8.0 ~~2.0~~E-~~04~~05	4.5 ~~4.3~~ E-08
I-131	7.6 ~~1.0~~ E-~~08~~09	1.0E-06	7.6 ~~1.6~~ E-~~02~~03
Te-132	1.2 ~~7.3~~ E-~~11~~09	9.0E-06	1.3 ~~8.1~~ E-~~06~~04
I-132	3.8 ~~2.0~~ E-~~09~~10	1.0E-04	3.8 ~~2.8~~ E-~~05~~06
I-133	2.5 ~~1.2~~ E-~~08~~09	7.0E-06	3.6 ~~1.0~~ E-~~03~~04
I-134	1.2 E-~~09~~10	4.0E-04	3.0 E-~~06~~07
Cs-134	1.0 E-~~08~~07	9.0E-07	1.1 E-~~02~~01
I-135	9.8 ~~1.0~~ E-~~08~~10	3.0E-05	3.3 ~~3.4~~ E-~~04~~05
Cs-136	1.1 ~~6.0~~ E-~~10~~07	6.0E-06	1.8 ~~1.0~~ E-~~04~~02
Cs-137	9.5 ~~1.4~~ E-08	1.0E-06	9.5 ~~1.4~~ E-02
~~Ba-137m~~	~~8.6 E-10~~	~~1.0E-06~~	~~8.6 E-04~~
Ba-140	24 ~~1.0~~ E-~~09~~10	8.0E-06	9.3 ~~1.3~~ E-~~04~~05
La-140	9.8 ~~1.1~~ E-~~09~~10	9.0E-06	1.1 ~~1.2~~ E-04
Ce-141	2.3 ~~1.1~~E-~~10~~11	3.0E-05	7.7 ~~3.6~~E-~~06~~07
Ce-143	2.5 ~~9.8~~E-11	2.0E-05	1.3 ~~4.9~~ E-06
Pr-143	1.8E-11	2.5E-05	7.2E-07
Ce-144	4.7 ~~1.9~~E-~~09~~-10	3.0E-06	1.6 ~~6.3~~ E-04
Pr-144	4.7 ~~2.1~~ E-10	6.0E-04	7.8 ~~3.6~~ E-07
H-3	1.2 ~~3.0~~ E-04	1.0E-03	1.2 ~~9.0-7~~E-01
			Total = 3.6E-01

Notes:

1. Annual average Discharge concentration based on release of average daily discharge ~~over an 8-hour period~~ for 292 days per year with 3500 gpm dilution flow.
2. ~~Maximum permissible~~ Effluent concentration~~s~~ limits are from Reference 1.

(Following figure is revised)

AP600 – LIQUID RADWASTE SYSTEM



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11.3 Gaseous Waste Management System

During reactor operation, radioactive isotopes of xenon, krypton, and iodine are created as fission products. A portion of these radionuclides is released to the reactor coolant because of a small number of fuel cladding defects. Leakage of reactor coolant thus results in a release to the containment atmosphere of the noble gases. Airborne releases can be limited both by restricting reactor coolant leakage and by limiting the concentrations of radioactive noble gases and iodine in the reactor coolant system.

Iodine is removed by ion exchange in the chemical and volume control system (CVS). Removal of the noble gases from the reactor coolant system (RCS) is not normally necessary because the gases will not build up to unacceptable levels when fuel defects are within normally anticipated ranges. If noble gas removal is required because of high reactor coolant system concentration, the chemical and volume control system can be operated in conjunction with the liquid radwaste system degasifier, to remove the gases. See Subsection 9.3.6 for a description of these operations.

The AP600 gaseous radwaste system (WGS) is designed to perform the following major functions:

- Collect gaseous wastes that are radioactive or hydrogen bearing
- Process and discharge the waste gas, keeping off-site releases of radioactivity within acceptable limits.

11.3.1 Design Basis

Subsection 1.9.1 discusses the conformance of the gaseous radwaste system design with the criteria of Regulatory Guide 1.143.

11.3.1.1 Safety Design Basis

The gaseous radwaste system serves no safety-related functions and therefore has no nuclear safety design basis.

11.3.1.2 Power Generation Design Basis

11.3.1.2.1 Capacity

11.3.1.2.1.1 Gaseous Waste Collection

The gaseous radwaste system is designed to receive hydrogen bearing and radioactive gases generated during process operation. The radioactive gas flowing into the gaseous radwaste system enters as trace contamination in a stream of hydrogen and nitrogen.

The design basis period of operation is the last 45 days of a fuel cycle. During this time, reactor coolant system dilution and subsequent letdown from the chemical and volume control system into the liquid radwaste system is at a maximum. Gaseous radwaste system inputs are as follows:

- Letdown diversion for dilution, reactor coolant system with maximum hydrogen concentration. This input is 0.5 standard cubic feet per minute (scfm) on an intermittent basis carrying a very small volume of radiogas, yielding 500 scf total hydrogen.
- Letdown diversion for reactor coolant system degassing, assumed to remove gases from the reactor coolant system to a level of 1 cc/kg beginning with the reactor coolant system at the maximum hydrogen concentration of 40 cc/kg. At its maximum this input is 0.5 scfm hydrogen carrying a very small volume of radiogas yielding 199 scf total hydrogen.
- Reactor coolant drain tank liquid transfer to maintain proper reactor coolant drain tank level, assuming 0.25 gallons per minute liquid input from the reactor coolant system, intermittently yielding 0.5 scfm hydrogen and nitrogen carrying a very small volume of radiogas, yielding about 80 scf hydrogen and nitrogen total.
- Reactor coolant drain tank gas venting, conservatively estimated at 1 scf per day, yielding 45 scf total nitrogen and hydrogen.

11.3.1.2.1.2 Waste Gas Processing

The gaseous radwaste system is designed to reduce the controlled activity releases in support of the overall AP600 release goals.

Given the various inputs to the gaseous radwaste system, with licensing basis assumptions for analysis and with normally operating gaseous radwaste system equipment available, the combined plant releases must be within the limits outlined in 10 CFR 20 and 10 CFR 50 Appendix I (References 1 and 2, respectively).

11.3.1.2.2 Failure Tolerance

11.3.1.2.2.1 System Leakage

The gaseous radwaste system operates at low pressures, slightly above atmospheric pressure, thus limiting the potential for leakage. Manual valves are the type which eliminate the potential for stem leakage. The system is of welded construction to further limit leakage.

11.3.1.2.2.2 Water Incursion

A number of features prevent wetting the activated carbon delay beds. These features include controls and alarms in the liquid radwaste system to prevent high degasifier separator water level, the gas cooler/vapor condenser moisture separator and traps in the gaseous radwaste system, and moisture monitors in the gaseous radwaste system. Additional protection is provided by the activated carbon guard bed, which removes residual moisture as well as iodine from the gas stream.

If moisture enters the first activated carbon delay bed, the operator bypasses that bed and either dries it with a nitrogen purge or replaces the activated carbon.

11.3.1.2.3 Anticipated Operational Occurrences

11.3.1.2.3.1 Prevention of Hydrogen Ignition

Since the carrier gas for the radiogas inputs to the gaseous radwaste system includes hydrogen, the gaseous radwaste system is designed to prevent hydrogen ignition both within its own boundaries and in connected systems (the liquid radwaste system and the nuclear island radioactive ventilation system).

The gaseous radwaste system is operated at a slightly positive pressure to prevent air ingress. The rooms containing gaseous radwaste system components incorporate hydrogen monitors to detect leakage out of the system before combustible levels are reached. In addition, continuous oxygen analysis, using independent, redundant monitors, is provided within the gaseous radwaste system. Upon high oxygen level in the system, an alarm alerts the operator. At an operator selected oxygen content of 4% or less, the liquid radwaste system vacuum pumps automatically stop to isolate potentially oxygenated inputs to the gaseous radwaste system, and a valve automatically opens to initiate a nitrogen purge. The discharge of the ~~WGS~~ isolation valve is continuously pressurized with nitrogen to prevent ingress of air into the system from the discharge path.

The gaseous radwaste system also eliminates sources of hydrogen ignition. The system incorporates spark-proof valves, electrical grounding, and a nitrogen purge. Discharge to the heating, ventilating and air-conditioning duct is downstream of the exhaust fans to provide additional protection against hydrogen ignition.

11.3.1.2.4 Controlled Release of Radioactivity

gaseous radwaste system

11.3.1.2.4.1 Expected Releases

The AP600 design prevents the annual average concentration limits established by 10 CFR 20 (Appendix B, table 2, column 1) (Reference 1) for gaseous releases from being exceeded during plant operation with design maximum fuel cladding defects (See Table 11.3-4). Subsection 11.3.3 describes the calculated releases of radioactive materials from the gaseous radwaste system and other pathways during normal operation.

Subsection 11.3.3 contains an evaluation which demonstrates that the doses to individuals, at or beyond the site boundary, resulting from the expected releases from the gaseous waste management systems are within numerical design objectives of Appendix I of 10 CFR 50 (Reference 2).

provided by the activated carbon guard bed, which removes residual moisture as well as iodine from the gas stream.

If moisture enters the first activated carbon delay bed, the operator bypasses that bed and either dries it with a nitrogen purge or replaces the activated carbon.

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Since the carrier gas for the radiogas inputs to the gaseous radwaste system includes hydrogen, the gaseous radwaste system is designed to prevent hydrogen ignition both within its own boundaries and in connected systems (the liquid radwaste system and the nuclear island radioactive ventilation system).

The gaseous radwaste system is operated at a slightly positive pressure to prevent air ingress. The rooms containing gaseous radwaste system components incorporate hydrogen monitors to detect leakage out of the system before combustible levels are reached. In addition, continuous oxygen analysis, using independent, redundant monitors, is provided within the gaseous radwaste system. Upon high oxygen level in the system, an alarm alerts the operator, the liquid radwaste system vacuum pumps automatically stop to isolate potentially oxygenated inputs to the gaseous radwaste system, and a valve automatically opens to initiate a nitrogen purge.

The gaseous radwaste system also eliminates sources of hydrogen ignition. The system incorporates spark-proof valves, electrical grounding, and a nitrogen purge. Discharge to the heating, ventilating and air-conditioning duct is downstream of the exhaust fans to provide additional protection against hydrogen ignition.

11.3.1.2.4 Controlled Release of Radioactivity

11.3.1.2.4.1 Expected Releases

The AP600 design prevents the annual average concentration limits established by 10 CFR 20 (Appendix B, table 2, column 1) (Reference 1) for gaseous releases from being exceeded ~~during~~ plant operation, ~~with design maximum fuel cladding defects [illegible]~~). Subsection 11.3.3 describes the calculated releases of radioactive materials from the gaseous radwaste system and other pathways during normal operation.

Subsection 11.3.3 also contains an evaluation which demonstrates that the doses to individuals, at or beyond the site boundary, resulting from the expected releases from the gaseous waste management systems are within numerical design objectives of Appendix I of 10 CFR 50 (Reference 2).

due to the expected releases resulting from normal

11.3.1.2.4.2 Monitoring Releases

Releases from the gaseous radwaste system are continuously monitored by a radiation detector in the discharge line. In addition, the system includes provisions for taking grab samples of the discharge flow stream for analysis. In this manner, the requirements of General Design Criterion 64 are met as described in Section 3.1. Section 11.5 discusses radiation monitoring.

11.3.1.2.4.3 Operator Error or Equipment Malfunction

To prevent the release of radioactive gases resulting from equipment failure or operator error, a radiation monitor is located in the discharge line. This instrument provides an alarm signal at a high level setpoint to alert operators of rising radiation levels. The monitor is also interlocked with an isolation valve in the discharge line; the valve closes at a higher level setpoint.

Few operator actions are required during gaseous radwaste system operation since, once aligned for operation, the system operates automatically in response to the control signals from the instrumentation.

11.3.2 System Description

11.3.2.1 General Description

The AP600 gaseous radwaste system, as shown on Figure 11.3-1 is a once-through, ambient-temperature, activated carbon delay system. The system includes a gas cooler, a moisture separator, an activated carbon-filled guard bed, and two activated carbon-filled delay beds. Also included in the system are an oxygen analyzer subsystem and a gas sampling subsystem.

The radioactive fission gases entering the system are carried by hydrogen and nitrogen gas. The primary influent source is the liquid radwaste system degasifier. The degasifier extracts both hydrogen and fission gases from the chemical and volume control system letdown flow which is diverted to the liquid radwaste system or from the reactor coolant drain tank discharge.

Reactor coolant degassing is not required during power operation with fuel defects at or below the design basis level of 0.25 percent. However, the gaseous radwaste system periodically receives influent when chemical and volume control system letdown is processed through the liquid radwaste system degasifier during reactor coolant system dilution and volume control operations. Since the degasifier is a vacuum type and requires no purge gas, the maximum gas influent rate to the gaseous radwaste system from the degasifier equals the rate that hydrogen enters the degasifier (dissolved in liquid).

The other major source of input to the gaseous radwaste system is the reactor coolant drain tank. Hydrogen dissolved in the influent to the reactor coolant drain tank enters the gaseous radwaste system either via the tank vent or the liquid radwaste system degasifier discharge.

The tank vent is normally closed, but is periodically opened on high pressure to vent the gas that has come out of solution. The reactor coolant drain tank liquid is normally discharged to the liquid radwaste system via the degasifier, where the remaining hydrogen is removed.

The reactor coolant drain tank is purged with nitrogen gas to discharge nitrogen and fission gases to the gaseous radwaste system before operations requiring tank access. The reactor coolant drain tank is also purged with nitrogen gas to dilute and discharge oxygen after tank servicing or inspection operations which allow air to enter the tank.

Influents to the gaseous radwaste system first pass through the gas cooler where they are cooled to about 45°F by the chilled water system. Moisture formed due to gas cooling is removed in the moisture separator.

After leaving the moisture separator, the gas flows through a guard bed that protects the delay beds from abnormal moisture carryover or chemical contaminants. The gas then flows through two 100-percent capacity delay beds where the fission gases undergo dynamic adsorption by the activated carbon and are thereby delayed relative to the hydrogen or nitrogen carrier gas flow. Radioactive decay of the fission gases during the delay period significantly reduces the radioactivity of the gas flow leaving the system.

The effluent from the delay bed passes through a radiation monitor and discharges to the ventilation exhaust duct. The radiation monitor is interlocked to close the gaseous radwaste system discharge isolation valve on high radiation. The discharge isolation valve also closes on low ventilation system exhaust flow rate to prevent the accumulation of hydrogen in the aerated vent.

11.3.2.2 System Operation

11.3.2.2.1 Normal Operation

The gaseous radwaste system is used intermittently. Most of the time during normal operation of the AP600, the gaseous radwaste system is inactive. When there is no waste gas inflow to the system, a small nitrogen gas flow is injected into the discharge line at the inlet of the discharge isolation valve. This nitrogen gas flow maintains the gaseous radwaste system at a positive pressure, preventing the ingress of air during the periods of low waste gas flow.

When the gaseous radwaste system is in use, its operation is passive, using the pressure provided by the influent sources to drive the waste gas through the system.

The largest input to the gaseous radwaste system is from the liquid radwaste system degasifier, which processes the chemical and volume control system letdown flow when diverted to the liquid radwaste system and the liquid effluent from the liquid radwaste system reactor coolant drain tank.

The chemical and volume control system letdown flow is diverted to the liquid radwaste system only during dilutions, borations, and reactor coolant system degassing in anticipation of shutdown. The design basis influent rate from the liquid radwaste system degasifier is the full diversion of the chemical and volume control system letdown flow, when the reactor coolant system is operating with maximum allowable hydrogen concentration. Since the liquid radwaste system degasifier is a vacuum type that operates without a purge gas, this input rate is very small, about 0.5 scfm.

The liquid radwaste system degasifier is also used to degas liquid pumped out of the reactor coolant drain tank. The amount of fluid pumped out, and therefore the gas sent to the gaseous radwaste system, is dependent upon the input into the reactor coolant drain tank. This is smaller than the input from the chemical and volume control system letdown line.

The final input to the gaseous radwaste system is from the reactor coolant drain tank vent. A nitrogen cover gas is maintained in the reactor coolant drain tank. This input consists of nitrogen, hydrogen, and radioactive gases. The tank operates at nearly constant level, with its vent line normally closed, so this input is minimal. Venting is required only after enough gas has evolved from the input fluid to increase the reactor coolant drain tank pressure.

The influent first passes through a gas cooler. Chilled water flows through the gas cooler at a fixed rate to cool the waste gas to about 45°F regardless of waste gas flow rate. Moisture formed due to gas cooling is removed in the moisture separator, and collected water is periodically discharged automatically. To reduce the potential for waste gas bypass of the gas cooler in the event of valve leakage, a float-operated drain trap is provided which automatically closes on low water level.

The gas leaving the moisture separator is monitored for moisture, and a high alarm alerts the operator to an abnormal condition requiring attention. Oxygen concentration is also monitored. On a high oxygen alarm, a nitrogen purge is automatically injected into the influent line.

The waste gas then flows through the guard bed, where iodine and chemical (oxidizing) contaminants are removed. The guard bed also removes any remaining excessive moisture from the waste gas.

The waste gas then flows through the two delay beds where xenon and krypton are delayed by a dynamic adsorption process. The discharge line is equipped with a valve that automatically closes on either high radioactivity in the gaseous radwaste system discharge line or low ventilation exhaust duct flow.

The adsorption of radioactive gases in the delay bed occurs without reliance on active components or operator action. Operator error or active component failure does not result in an uncontrolled release of radioactivity to the environment. Failure to remove moisture prior to the delay beds (due to loss of chilled water or other causes) results in a gradual reduction in gaseous radwaste system performance. Reduced performance is indicated by high moisture and discharge radiation alarms. High-high radiation automatically terminates discharge.

11.3.2.2.2 Purge Operations

The gaseous radwaste system is purged with nitrogen gas to expel residual oxygen gas after servicing operations. The system is purged until the effluent from the outlet indicates a low oxygen concentration. The gaseous radwaste system oxygen analyzer is temporarily aligned to monitor the flow in the discharge line. Nitrogen connections are also provided to the sample system and to the system discharge line for purge before and after maintenance operations.

11.3.2.3 Component Description

The general descriptions and summaries of the design basis requirements for the gaseous radwaste system components follow. Table 11.3-2 lists the key design parameters for the gaseous radwaste system components.

Section 3.2 provides additional information regarding the applicable codes and classifications.

11.3.2.3.1 Sample Pumps

Two sample pumps are provided. One sample pump normally operates continuously to provide flow through the oxygen analyzers. The other sample pump is periodically used to provide flow from various sample points through a sample cylinder. It is used as a backup to provide flow through the oxygen analyzers.

11.3.2.3.2 Gas Cooler

The gas cooler heat exchanger is designed to cool the gas flow to near the temperature of the chilled water supply (45°F) for efficient moisture removal. The pressure of the gas flow through the gas cooler is less than the chilled water pressure to minimize the potential for contaminating the chilled water system.

11.3.2.3.3 Gaseous Radwaste System Tanks

Moisture Separator

The moisture separator is sized for the design basis purge gas flow rate and is oversized for the lower normal flow rate. The unit includes connections for high and low water level sensors.

Guard Bed

The activated carbon guard bed protects the delay beds from abnormal moisture or chemical contaminants. Under normal operating conditions, the guard bed provides increased delay time for xenon and krypton and removes iodine entering the system.

The flow through the activated carbon bed is downward. A retention screen on the outlet of the guard bed prevents the loss of activated carbon from the unit. Activated carbon can be added to or vacuumed from the unit via a blind flange port.

Delay Beds

Two activated carbon delay beds in series are provided. Each delay bed is designed to provide 100 percent of the required system capacity under design basis conditions. During normal operation a single bed provides adequate performance. This provides operational flexibility to permit continued operation of the gaseous radwaste system in the event of operational upsets in the system that require isolation of one bed.

The waste gas flows vertically through columns of activated carbon. The activated carbon volume is twice the theoretical amount required to achieve the holdup times given in Table 11.3-1.

No retention screens are required on the delay beds since the flow enters and leaves each delay bed at its top.

The guard bed and the delay beds, including supports, in the gaseous radwaste system are designed for seismic loads in conformance with Regulatory Guide 1.143. These are the only AP600 components used to store or delay the release of gaseous radioactive waste. The beds are located in the seismic Category I auxiliary building at elevation 66'6".

11.3.2.3.4 Remotely-operated Valves

Moisture Separator Level Control Valve

This normally closed, fail-closed globe valve is located in the liquid drain line from the moisture separator outlet line. It maintains the level in the moisture separator by regulating the flow from the moisture separator to the liquid radwaste system. The valve receives a signal to automatically open on a high level in the moisture separator and to close on low level. The valve can also be manually controlled from the gaseous waste panel.

A float-operated drain trap serves as a backup to this valve. This drain trap automatically closes on a low water level in the moisture separator to stop drain flow to the liquid radwaste system in the event of a valve or instrument failure. This prevents waste gas bypass around the gas cooler due to level control valve failure.

Gaseous Radwaste System Discharge Isolation Valve

This normally open, fail-closed globe valve is at the outlet of the system. The valve is interlocked to close on a high-high radiation signal in the gaseous radwaste system discharge line to prevent the release of radioactivity in the event of a gaseous radwaste system failure. The valve also receives a signal to automatically close in the event of a low ventilation system exhaust flow rate which prevents accumulation of a flammable or explosive concentration of hydrogen in the aerated vent line.

Manual control is provided on the gaseous radwaste panel.

Nitrogen Purge Pressure Control Valve

This is a self-contained pressure regulating valve in the nitrogen purge line. It is set to maintain a small positive pressure in the gaseous radwaste system to prevent ingress of air during periods of low flow.

11.3.3 Radioactive Releases

~~With the annual release of noble gases listed in Table [illegible], the calculated doses to an individual located at the site boundary are [illegible] mrem to the whole body and [illegible] mrem to the skin. These doses are based on the annual average atmospheric dispersion factor from Section 2.3 ([illegible] seconds per cubic meter). These doses are below the 10 CFR 50, Appendix I, limits of five mrem per year to the whole body and 15 mrem per year skin dose.~~ Releases of radioactive effluent by way of the atmospheric pathway occur due to:

- Venting of the containment which contains activity as a result of leakage of reactor coolant and as a result of activation of naturally occurring Ar-40 in the atmosphere to form radioactive Ar-41
- Ventilation discharges from the auxiliary building which contains activity as a result of leakage from process streams
- Ventilation discharges from the turbine building
- Condenser air removal system (gaseous activity entering the secondary coolant as a result of primary to secondary leakage is released via this pathway)
- Gaseous radwaste system discharges.

These releases are on-going throughout normal plant operations. There is no gaseous waste holdup capability in the gaseous waste management system and thus no criteria are required for determining the timing of releases or the release rates to be used.

11.3.3.1 Discharge Requirements

The release of radioactive gaseous and particulate effluents to the atmosphere may not exceed the concentration limits specified in Reference 1 nor may the releases result in the annual offsite dose limits specified in 10 CFR 50, Appendix I (Reference 2) being exceeded.

11.3.3.2 Estimated Annual Releases

The annual average airborne releases of radionuclides from the plant are determined using the PWR-GALE code (Reference 3). The GALE code models releases using realistic source terms derived from data obtained from the experience of many operating pressurized water reactors. The code input parameters used in the analysis to model the AP600 plant are provided in Table 11.2-6. The expected annual releases for a single unit site are presented in Table 11.3-3.

Insert A #

11.3.3.3 Release Points

Airborne effluents are normally released through the plant vent or the turbine building vent. The plant vent provides the release path for containment venting releases, auxiliary building ventilation releases, annex building releases, radwaste building releases, and gaseous radwaste system discharge. The turbine building vents provide the release path for the condenser air removal system, gland seal condenser exhaust and the turbine building ventilation releases.

11.3.3.4 Estimated Doses

With the annual airborne releases ~~of noble gases~~ listed in Table 11.3-3, the ~~maximum~~ air doses ~~to an individual located~~ at ground level at the site boundary are ~~1.3 mrem to the whole body and 3.5 mrem to the skin.~~ 1.4 mrad for gamma radiation and 6.0 mrad for beta radiation. These doses are based on the annual average atmospheric dispersion factor from Section 2.3 (2.0×10^{-5} seconds per cubic meter). These doses are below the 10 CFR 50, Appendix I ~~limits of five mrem per year to the whole body and 15 mrem per year skin dose.~~ design objectives of 10 mrad per year for gamma radiation or 20 mrad per year for beta radiation.

11.3.3.5 Maximum Release Concentrations

The annual releases of maximum defined radioactive gases and iodine provided in Table 11.3-3 represent expected releases from the plant and reflect an expected level of fuel cladding defects. If the plant operates with the ~~design basis~~ fuel defect level, ~~of 0.25 percent~~, the releases would be substantially greater. The maximum defined fuel defect level corresponds to 0.25 percent fuel defects for the iodine and noble gas nuclides, and 1.0 percent fuel defects for the remaining fission product nuclides. To demonstrate compliance with the effluent concentration limits of Reference 1, the releases from Table 11.3-3 have been adjusted to reflect operation with ~~one percent~~ the maximum defined fuel defects and the resulting airborne radionuclide concentrations at the site boundary are ~~listed~~ compared in Table 11.3-4 ~~together~~ with the Reference 1 limits for concentrations ~~in unrestricted areas~~. ~~The~~ As shown in Table 11.3-4, the overall fraction of the effluent concentration limits ~~are met with~~ with operation with the maximum defined ~~at the design basis~~ fuel defect level is 0.17, which is well below the allowable value of 1.0.

11.3.3.6 Quality Assurance

Guidance for the quality assurance program for design fabrication, procurement, and installation issues is outlined in Section 17.1.

Insert A

To demonstrate compliance with the effluent concentration limits in Reference 1, the expected releases from Table 11.3-3 were used to determine the annual average concentration at the site boundary, and the results are compared with the Reference 1 concentration limits for unrestricted areas in Table 11.3-4. As shown in Table 11.3-4, the overall fraction of the effluent concentration limit for the expected releases is 0.019, which is significantly below the allowable value of 1.0.

11.3.4 Combined License Information

11.3.4.1 Cost Benefit Analysis of Population Doses

The analysis performed to determine offsite dose due to gaseous effluents is based upon the AP600 generic site parameters included in Chapter 1 and Tables 11.3-1, 11.3-2 and 11.3-4. For sites outside of the envelope parameters, the Combined License applicant will provide a cost-benefit analysis to demonstrate compliance with 10 CFR 50, Appendix I, regarding population doses due to gaseous effluents.

11.3.4.2 Identification of Adsorbent Media

The Combined License applicant will identify the types of adsorbent media to be used in the gaseous radwaste system (WGS).

11.3.5 References

1. "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage," 10 CFR Part 20, Appendix B, Issued by ~~56~~ 58 FR ~~23360~~ 67657 (~~May 21, 1991~~) (April 28, 1995).

2. "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As-Low-As-Is-Reasonably-Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," 10 CFR Part 50, Appendix I.

3. "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," NUREG-0017, Revision 1, March 1985.

Table 11.3-1

GASEOUS RADWASTE SYSTEM PARAMETERS

Design operating influent pressure (psig)	2
Design influent flow rate (scfm)	0.5
Activated carbon bed design operating temperature (°F)	77
Activated carbon bed design operating dew point (°F)	45
Activated carbon in delay beds (average) (pounds combined total)	4600
Xenon dynamic adsorption coefficient (cc/gm)	1050
Krypton dynamic adsorption coefficient (cc/gm)	38
Xenon holdup time[a]	61.2 days at 0.5 scfm
Krypton holdup time[a]	2.2 days at 0.5 scfm

<u>Note:</u>

a. Holdup times shown are conservatively based on credit for only one half of the activated carbon available in the delay beds and no credit for the guard bed.

Table 11.3-2

COMPONENT DATA - GASEOUS RADWASTE SYSTEM

Tanks	
Guard Bed (WGS-MV01)	
Number	1
Volume (ft^3)	8.2
Delay bed (WGS-MV02A/B)	
Number	2
Volume (ft^3)	80.9

Replace with D

D

Table 11.3-2 (Sheet 1 of 1)

COMPONENT DATA - GASEOUS RADWASTE SYSTEM

Mechanical Components

Pumps		
Sample Pumps		
Number	2	
Type	Diaphragm	
Design pressure (psig)	2	
Design temperature (°F)	45	
Design flow (scfm)	0.2	
Heat Exchangers		
Gas Cooler		
Number	1	
Type	Shell and tubes	
	Tube Side	**Shell Side**
Design pressure (psig)	100	150
Design temperature (°F)	200	150
Design flow	0.7 scfm	2 gpm
Temperature inlet (°F)	175	45
Temperature outlet (°F)	46	51
Material	Stainless steel	Stainless steel
Tanks		
Guard bed		
Number	1	
Nominal volume (ft^3)	8	
Type	Vertical pipe	
Design pressure (psig)	100	
Design temperature (°F)	150	
Material	Stainless steel	
Delay bed		
Number	2	
Nominal volume (ft^3)	80	
Type	Vertical serpentine	
Design pressure (psig)	100	
Design temperature (°F)	150	
Material	Carbon steel	
Moisture separator		
Number	1	
Nominal volume (gal.)	3	
Type	Vertical	
Design pressure (psig)	100	
Design temperature (°F)	150	
Material	Stainless steel	

Table 11.3-3 (Sheet 1 of 3)

EXPECTED ANNUAL AVERAGE RELEASE OF AIRBORNE RADIONUCLIDES AS DETERMINED BY THE PWR-GALE CODE, REVISION 1 (RELEASE RATES IN Ci/yr)

Noble Gases[(a)(b)]	Waste Gas System	Building Ventilation Cont.	Building Ventilation Aux. Bldg spell	Building Ventilation Turbine Building	Condenser Air Removal System	Total
Kr-85m	7.0E+00	2.0E+01	3.0E+00	0.	1.0E+00	3.1E+01
Kr-85	8.1E+01	9.8E+01	1.5E+00	0.	0.	1.8E+02
Kr-87	0.	6.0E+00	3.0E+00	0.	1.0E+00	1.0E+01
Kr-88	4.0E+00	2.3E+01	5.0E+00	0.	3.0E+00	3.5E+01
Xe-131m	7.8E+01	8.6E+02	1.5E+01	0.	7.0E+00	1.0E+03
Xe-133m	1.0E+00	5.1E+01	1.0E+00	0.	0.	5.3E+01
Xe-133	2.4E+02	2.6E+03	5.2E+01	0.	2.4E+01	2.9E+03
Xe-135m	0.	1.0E+00	2.0E+00	0.	1.0E+00	4.0E+00
Xe-135	0.	2.0E+02	1.6E+01	0.	8.0E+00	2.2E+02
Xe-138	0.	0.	2.0E+00	0.	1.0E+00	3.0E+00
					Total	4.4E+03

Additionally:

H-3 released via gaseous pathway	— see next pg	77
C-14 released via gaseous pathway		7.3
Ar-41 released via containment vent		34

Table 11.3-3 (Sheet 2 of 3)

EXPECTED ANNUAL AVERAGE RELEASE OF AIRBORNE RADIONUCLIDES AS DETERMINED BY THE PWR-GALE CODE, REVISION 1 (RELEASE RATES IN Ci/yr)

		Building/Area Ventilation			Condenser Air	
Iodines[a]	Fuel Handling Area(c)	Cont.	Auxiliary Building	Turbine Building	Removal System	Total
I-131	2.6E-03	1.2E-03	6.2E-02	1.1E-04	0.	6.6E-02
I-133	9.4E-03	3.2E-03	2.3E-01	3.2E-04	1.3E-04	2.4E-01

Table 11.3-3 (Sheet 3 of 3)

EXPECTED ANNUAL AVERAGE RELEASE OF AIRBORNE RADIONUCLIDES AS DETERMINED BY THE PWR-GALE CODE, REVISION 1 (RELEASE RATES IN Ci/yr)

		Building/Area Ventilation			
Radionuclide[a]	Waste Gas System	Cont.	Auxiliary Building	Fuel Handling Area[c]	Total
Cr-51	1.4E-05	9.2E-05	3.2E-04	1.8E-04	6.1E-04
Mn-54	2.1E-06	5.3E-05	7.8E-05	3.0E-04	4.4E-04
Co-57	0.	8.2E-06	0.	0.	8.2E-06
Co-58	8.7E-06	2.5E-04	1.9E-03	2.1E-02	2.3E-02
C0-60	1.4E-05	2.6E-05	5.1E-04	8.2E-03	8.7E-03
Fe-59	1.8E-06	2.7E-05	5.0E-05	0.	7.9E-05
Sr-89	4.4E-05	1.3E-04	7.5E-04	2.1E-03	3.0E-03
Sr-90	1.7E-05	5.2E-05	2.9E-04	8.0E-04	1.2E-03
Zr-95	4.8E-06	0.	1.0E-03	3.6E-06	1.0E-03
Nb-95	3.7E-06	1.8E-05	3.0E-05	2.4E-03	2.5E-03
Ru-103	3.2E-06	1.6E-05	2.3E-05	3.8E-05	8.0E-05
Ru-106	2.7E-06	0.	6.0E-06	6.9E-05	7.8E-05
Sb-125	0.	0.	3.9E-06	5.7E-05	6.1E-05
Cs-134	3.3E-05	2.5E-05	5.4E-04	1.7E-03	2.3E-03
Cs-136	5.3E-06	3.2E-05	4.8E-05	0.	8.5E-05
Cs-137	7.7E-05	5.5E-05	7.2E-04	2.7E-03	3.6E-03
Ba-140	2.3E-05	0.	4.0E-04	0.	4.2E-04
Ce-141	2.2E-06	1.3E-05	2.6E-05	4.4E-07	4.2E-05

Notes:

a. The appearance of 0. in the table indicates less than 1.0 Ci/yr for noble gas or less than 0.0001 Ci/yr for iodine.

b. The Kr-85 values generated by the GALE code totaled 1200 Ci/yr. The Kr-85 release values were corrected to a total of 184 Ci/yr to agree with projected release rates of Kr-85 from the fuel into the reactor coolant.

c. The fuel handling area is within the auxiliary building but is considered separately.

Table 11.3-4

COMPARISON OF CALCULATED OFFSITE AIRBORNE CONCENTRATIONS WITH 10 CFR 20 LIMITS

Radionuclide	~~Maximum Permissible~~ Effluent limit Conc. µCi/ml[a]	Expected Site Boundary[b] Conc. µCi/ml	Fraction of ~~MPC~~ Conc. limit[b] (expected)	Maximum Site Boundary Conc. µCi/ml[c]	Fraction of ~~MPC~~ Conc. limit[c] (maximum)
Kr-85m	1.0E-7	1.8 ~~2.5~~E-11	1.8 ~~2.5~~E-4	6.0 ~~9.8~~E-11	6.0 ~~9.8~~E-4
Kr-85	7.0E-7	1.8 ~~1.4~~E-~~10~~ 9	2.6 ~~2.0~~E-~~4~~ 3	4.0 ~~5.4~~E-~~10~~ 9	5.7 ~~7.7~~E-~~4~~ 3
Kr-87	2.0E-8	7.9E-12	4.0E-4	1.5 ~~1.9~~E-11	7.5 ~~9.5~~E-4
Kr-88	9.0E-9	2.4 ~~2.8~~E-11	2.7 ~~3.1~~E-3	7.3 ~~1.1~~E-~~10~~ 11	8.1 ~~1.2~~E-~~2~~ 3
Xe-131m	2.0E-6	8.7 ~~8.0~~E-10	4.4 ~~4.0~~E-4	8.7 ~~6.2~~E-10	4.4 ~~3.1~~E-4
Xe-133m	6.0E-7	4.2E-11	7.0E-5	6.3 ~~3.3~~E-10	1.1 ~~5.5~~E-~~4~~ 3
Xe-133	5.0E-7	2.2 ~~2.3~~E-9	4.4 ~~4.6~~E-3	6.1 ~~7.6~~E-8	1.2 ~~1.5~~E-1
Xe-135m	4.0E-8	3.2E-12	8.0E-5	3.2 ~~3.4~~E-12	8.0 ~~6.0~~E-5
Xe-135	7.0E-8	1.7 ~~1.8~~E-10	2.4 ~~2.6~~E-3	4.8 ~~5.3~~E-10	6.9 ~~7.6~~ E-3
Xe-138	2.0E-8	2.4E-12	1.2E-4	2.8 ~~3.2~~E-12	1.4 ~~1.6~~E-4
I-131	2.0E-10	5.2E-14	2.6E-4	7.5 ~~7.9~~E-13	3.8 ~~4.0~~E-3
I-133	1.0E-9	1.9E-13	1.9E-4	1.5 ~~1.3~~E-12	1.5 ~~1.3~~E-3

Notes:

a. ~~Maximum permissible~~ Effluent limit concentration is from Reference 1, ~~[illegible]~~.

b. Expected site boundary concentration based on annual releases predicted by the PWR-GALE code (Table 11.3-3) and an annual average X/Q of 2.0 x 10^{-5} seconds per cubic meter.

c. Maximum site boundary concentration based on adjusting the releases predicated by the PWR-GALE code (Table 11.3-3) to reflect operation with ~~design basis~~ fuel defect level ~~of 0.25%~~ and an annual average X/Q of 2.0 x 10^{-5} seconds per cubic meter.

maximum defined

Expand table to include nuclides on attached page

Radionuclide	Effluent Conc. Limit µCi/ml	Expected Site Boundary Conc. µCi/ml	Fraction of Conc. Limit (expected)	Maximum Site Boundary Conc µCi/ml	Fraction of Conc. Limit (Maximum
H-3	1.0E-7	6.1E-11	6.1E-4	6.1E-11	6.1E-4
C-14	3.0E-9	5.8E-12	1.9E-3	5.8E-12	1.9E-3
Ar-41	1.0E-8	2.7E-11	2.7E-3	2.7E-11	2.7E-3
Cr-51	3.0E-8	4.8E-16	1.6E-8	4.8E-16	1.6E-8
Mn-54	1.0E-9	3.4E-16	3.4E-7	3.4E-16	3.4E-7
Co-57	9.0E-10	6.5E-18	7.2E-9	6.5E-18	7.2E-9
Co-58	1.0E-9	1.8E-14	1.8E-5	1.8E-14	1.8E-5
Co-60	5.0E-11	6.9E-15	1.4E-4	6.9E-15	1.4E-4
Fe-59	5.0E-10	6.3E-17	1.3E-7	6.3E-17	1.3E-7
Sr-89	2.0E-10	2.4E-15	1.2E-5	6.6E-14	3.3E-4
Sr-90	6.0E-12	9.5E-16	1.6E-4	2.6E-14	4.3E-3
Zr-95	4.0E-10	7.9E-16	2.0E-6	1.3E-15	3.3E-6
Nb-95	2.0E-9	2.0E-15	1.0E-6	4.3E-15	2.2E-6
Ru-103	9.0E-10	6.3E-17	7.0E-8	6.3E-17	7.0E-8
Ru-106	2.0E-11	6.2E-17	3.1E-6	6.2E-17	3.1E-6
Sb-125	7.0E-10	4.8E-17	6.9E-8	4.8E-16	6.9E-7
Cs-134	2.0E-10	1.8E-15	9.0E-6	5.6E-13	2.8E-3
Cs-136	9.0E-10	6.7E-17	7.4E-8	3.8E-13	4.2E-4
Cs-137	2.0E-10	2.9E-15	1.5E-5	6.0E-13	3.0E-3
Ba-140	2.0E-9	3.3E-16	1.7E-7	3.3E-16	1.7E-7
Ce-141	8.0E-10	3.3E-17	4.1E-8	1.3E-16	1.6E-7
			Total = 1.9E-2		Total = 1.7E-

Add 1 Sheet
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

11.4 Solid Waste Management

The solid waste management system (WSS) is designed to collect and accumulate spent ion exchange resins and deep bed filtration media, spent filter cartridges, dry active wastes, and mixed wastes generated as a result of normal plant operation, including anticipated operational occurrences. The system is located in the auxiliary and radwaste buildings. Processing and packaging of wastes are by mobile systems in the auxiliary building rail car bay and in the mobile systems facility part of the radwaste building. The packaged waste is stored in the auxiliary and radwaste buildings until it is shipped offsite to a licensed disposal facility.

The use of mobile systems for the processing functions permits the use of the latest technology and avoids the equipment obsolescence problems experienced with installed radwaste processing equipment. The most appropriate and efficient systems may be used as they become available.

This system does not handle large, radioactive waste materials such as core components or radioactive process wastes from the plant's secondary cycle. However, the volumes and activities of the secondary cycle wastes are provided in this section.

11.4.1 Design Basis

11.4.1.1 Safety Design Basis

The solid waste management system performs no function related to the safe shutdown of the plant. The system's failure does not adversely affect any safety-related system or component; therefore, the system has no nuclear safety design basis.

There are no safety related systems located near heavy lifts associated with the solid waste management system. Therefore, a heavy loads analysis is not required.

11.4.1.2 Power Generation Design Basis

The solid waste management system provides temporary onsite storage for wastes prior to processing and for the packaged wastes. The system has a 60-year design objective and is designed for maximum reliability, minimum maintenance, and minimum radiation exposure to operating and maintenance personnel. The system has sufficient temporary waste accumulation capacity based on normal waste generation rates so that maintenance, repair, or replacement of the solid waste management system equipment does not impact power generation.

11.4.1.3 Functional Design Basis

The solid waste management system is designed to meet the following objectives:

- Provide for the transfer and retention of spent radioactive ion exchange resins and deep bed filtration media from the various ion exchangers and filters in the liquid waste processing, chemical and volume control, and spent fuel cooling systems

- Provide the means to mix, sample, and transfer spent resins and filtration media to high integrity containers or liners for dewatering or solidification as required

- Provide the means to change out, transport, sample, and accumulate filter cartridges from liquid systems in a manner that minimizes radiation exposure of personnel and spread of contamination

- Provide the means to accumulate spent filters from the plant heating, ventilation, and air-conditioning systems

- Provide the means to segregate solid wastes (trash) by radioactivity level and to temporarily store the wastes

- Provide the means to accumulate radioactive hazardous (mixed) wastes

- Provide the means to segregate clean wastes originating in the radiologically controlled area (RCA)

- Provide the means to store packaged wastes for at least 6 months in the event of delay or disruption of offsite shipping

- Provide the space and support services required for mobile processing systems that will reduce the volume of and package radioactive solid wastes for offsite shipment and disposal according to applicable regulations, including ~~Department of Transportation regulation~~ 49 CFR 173 (Reference 1) and ~~NRC regulation~~ 10 CFR 71 (Reference 2)

- Provide the means to return liquid radwaste to the liquid radwaste system (WLS) for subsequent processing and monitored discharge

The solid waste management system is designed according to NRC Regulatory Guide 1.143 to meet the requirements of General Design Criterion (GDC) 60 as discussed in Sections 1.9 and 3.1. The seismic design classifications of the radwaste building and system components are provided in Section 3.2.

Provisions are made in the auxiliary and radwaste buildings to use mobile radwaste processing systems for processing and packaging each waste stream including concentration and solidification of chemical wastes from the liquid waste management system, spent resin dewatering, spent filter cartridge encapsulation and dry active waste sorting and compaction.

The radioactivities of influents to the solid waste management system are based on estimated radionuclide concentrations and volumes. These estimates are based on operating plant experience, adjusted for the size and design differences of AP600. The influent source terms are consistent with Section 11.1.

The solid waste management system airborne process effluents are released through the monitored plant vent as described as part of the 10 CFR 50 (Reference 3), Appendix I, analysis presented in subsection 11.3.3.

The solid waste management system collects and stores radioactive wastes within shielding to maintain radiation exposure to plant operation and maintenance personnel as low as is reasonably achievable (ALARA) according to General Design Criteria 60 as discussed in Section 3.1 and Regulatory Guide 8.8. Personnel exposures will be maintained well below the limits of 10 CFR 20 (Reference 4). Design features incorporated to maintain exposures ALARA include remote and semi-remote operations, automatic resin transport line flushing, and shielding of components, piping and containers holding radioactive materials. Access to the solid waste storage areas is controlled, to minimize inadvertent personnel exposure, by suitable barriers such as heavy storage cask covers and locked or key-card-operated doors or gates (see Section 12.1).

The solid waste management system conforms with the design criteria of NRC Branch Technical Position ETSB 11-3. Suitable fire protection systems are provided as described in subsection 9.5.1.

Waste disposal containers are to be selected from available designs that meet the requirements of the DOT and NRC. The solid waste management system does not require source-specific waste containers. Waste containers must meet the regulatory requirements for radioactive waste transportation in 49 CFR 173 and for radioactive waste disposal in 10 CFR 61 (Reference 5) as well as specific disposal facility requirements.

11.4.2 System Description

11.4.2.1 General Description

The solid waste management system includes the spent resin system. The flows of wastes through the solid waste management system are shown on Figure 11.4-1. The radioactivity of influents to the system are dependent on reactor coolant activities and the decontamination factors of the processes in the chemical and volume control system, spent fuel cooling system, and the liquid waste processing system.

The parameters used to calculate the estimated activity of the influents to the solid waste management system are listed in Table 11.4-1. The estimated expected isotopic curie content of the primary spent resin and filter cartridge wastes to be processed on an annual basis is listed on Table 11.4-2. Table 11.4-3 provides the same information for the estimated maximum annual activities.

The radioactivity of the dry active waste is expected to normally range from 0.1 curies per year to 8 curies per year with a maximum of about 16 curies per year. This waste includes spent HVAC filters, compressible trash, non-compressible components, mixed wastes and solidified chemical wastes. These activities are produced by relatively long lived radionuclides (such as Cr-51, Fe-55, Co-58, Co-60, Nb-95, Cs-134 and Cs-137), and therefore, radioactivity decay during processing and storage is minimal. These activities thus apply to the waste as generated and to the waste as shipped.

The estimated expected and maximum annual quantities of waste influents by source and form are listed in Table 11.4-1 with disposal volumes. The influent volumes are conservatively based on an 18-month refueling cycle. Annual quantities based on a 24-month refueling cycle are less than those for an 18-month cycle. The estimated expected isotopic curie content of the primary spent resin and filter cartridge wastes to be shipped offsite are presented in Table 11.4-4 based on 90 days of decay before shipment. The same information is presented in Table 11.4-5 for the estimated maximum activities based on 30 days of decay before shipment.

Section 11.1 provides the bases for determination of liquid source terms used to calculate several of the solid waste management system influent source terms. The influent data presented in Tables 11.4-2 and 11.4-3 are conservatively based on Section 11.1.

Shipped volumes of radwaste for disposal are estimated in Table 11.4-1 from the estimated expected or maximum influent volumes by making adjustments for volume reduction processing by mobile systems and the expected container filling efficiencies. For drum compaction, the overall volume reduction factor, including packaging efficiency, is 3.6. For box compaction, the overall volume reduction factor is 5.4. These adjustments result in a packaged internal waste volume for each waste source, and the number of containers required to hold this volume is based on the container's internal volume. The disposal volume is based on the number of containers and the external (disposal) volume of the containers.

315 377 1254

The disposal volumes of wet and dry wastes are approximately 329 and 1321 cubic feet per year, respectively. The wet wastes include 250 cubic feet per year of spent ion exchange resins and deep bed filter carbon, which fills two 158 cubic feet high-integrity containers. The spent resin waste container fill station at the west end of the rail car bay of the auxiliary building provides about 5 months of storage. Solidified chemical wastes fill about three 55-gallon drums per year (about 20 cubic feet per year) and are stored in the packaged waste storage room of the radwaste building for up to 3 years as evaluated below. The mixed liquid wastes fill less than three drums per year (about 17 cubic feet per year) and are stored on containment pallets in the waste accumulation room of the radwaste building until shipped offsite for processing. One four-drum containment pallet provides nearly 2 years of storage capacity for the liquid mixed wastes as well as for the 7.5 cubic feet per year (one drum per year) of solid mixed wastes.

line break

High-activity filter cartridges fill three drums per year (22.5 cubic feet per year) and are stored in portable processing or storage casks in the rail car bay of the auxiliary building. One three-drum cask provides storage for 1 year. The other spent filter cartridges may be compacted to fill about 0.26 drums per year ($2 ft^3$/year) and are stored in the packaged waste storage room.

feet

60

The other dry wastes are packaged in drums or steel boxes and are stored in the packaged waste storage room of the radwaste building. About ~~62~~ cubic feet per year of lower activity filter cartridges, activated carbon, and higher activity compactible and noncompactible wastes fill about eight drums per year, and 1186 cubic feet per year of lower activity compactible and noncompactible waste and HVAC exhaust filters fill about 12 boxes (90 cubic feet) per year. Together with the solidified chemical wastes, the total volume to be stored in the packaged waste storage room is 1268 cubic feet per year. The useful storage volume in the packaged waste storage room is approximately 3900 cubic feet (10 feet deep, 30 feet long, and 13 feet high), providing a storage duration of up to 3 years. and the lower activity filter cartridges

Based on continuous operation of the steam generator blowdown purification system, with leakage from the primary to secondary cycles, the volume of radioactively contaminated material is estimated to be 540 cubic feet per year. Provisions for processing and disposal of radioactive steam generator blowdown resins and membranes are described in subsection 10.4.8.

The condensate polishing system includes mixed bed ion exchanger vessels for purification of the condensate as described in ~~Section~~ sub 10.4.6. Should the resins become radioactive, the resins are transferred from the condensate polishing vessel directly to a temporary processing unit. The processing unit, located outside of the turbine building, dewaters and processes the resins as required for offsite disposal. Based on a typical condensate polishing system operation of 30 days per refueling cycle with leakage from the primary system to the secondary system, the volume of radioactively contaminated resin is estimated to be 206 cubic feet per year (one 309 cubic foot bed per refueling cycle). ~~Transport of~~ condensate polishing system resins ~~for processing and disposal~~ is described in subsection 10.4.6. Normal disposal of non radioactive

The parameters used to calculate the activities of the steam generator blowdown solid waste and condensate polishing resins are given in Table 11.4-1. Based on the above volumes, the disposal volume is estimated to be 939 cubic feet per year. The expected and maximum activities of the resins as generated are given in Tables 11.4-6 and 11.4-7, respectively. The expected and maximum activities of resins as shipped, based on 90 days decay prior to shipment, are given in Tables 11.4-8 and 11.4-9, respectively.

11.4.2.2 Component Description

Section 3.2 lists the codes and standards applicable to the solid waste management system. Table 11.4-10 lists the solid waste management system equipment design parameters. The following subsections provide a functional description of the major system components.

Radioactive condensate polishing resin will have very low activity. It will be disposed in high integrity containers as permitted by DOT regulations. After packaging, the resins will be stored in the Auxiliary ~~Bldg~~ Building rail car bay until shipment.

11.4.2.2.1 Spent Resin Tanks

The spent resin tanks provide holdup capacity for spent resin and filter bed media decay before processing. One spent resin tank can hold high-activity chemical and volume control system resins for 59 and 29 months at expected and maximum generation rates, respectively. The other tank can hold other spent resin and bed media for 14 and 2 months at expected and maximum generation rates, respectively. When high- and low-activity resins must be mixed to limit the radioactivity concentration in the waste containers to 10 Ci/ft^3 in accordance with the USNRC Technical Position on Waste Form (Reference 6), the maximum spent resin holdup times prior to processing are estimated to be approximately 11.8 months and 1.7 months for expected and maximum generation rates, respectively.

Resin mixing capability is provided by mixing eductors in each tank, and resin dewatering, air sparging and complete draining capabilities are also provided. The ultrasonic level sensors and dewatering screens are arranged for remote removal. The vent and overflow connections have screens to prevent the inadvertent discharge of spent resin.

11.4.2.2.2 Resin Mixing Pump

The resin mixing pump provides the motive force to fluidize and mix the resins in the spent resin tanks, to transfer water between spent resin tanks, to discharge excess water from the spent resin tanks to the liquid waste processing system, and to flush the resin transfer lines.

11.4.2.2.3 Resin Fines Filter

The resin fines filter minimizes the spread of high-activity resin fines and dislodged crud particles by filtering the water used for line flushing or discharged from the spent resin tanks to the liquid waste processing system.

11.4.2.2.4 Resin Transfer Pump

The resin transfer pump provides the motive force for recirculation of spent resins via either one of the spent resin tanks for mixing and sampling, for transferring spent resin between tanks, and for blending high- and low-activity resins to meet the specific activity limit for disposal. The resin transfer pump is also used to transfer spent resins to a waste container in the fill station or in its shipping cask located in the auxiliary building rail car bay.

11.4.2.2.5 Resin Sampling Device

The resin sampling device collects a representative sample of the spent resin either during spent resin recirculation or during spent resin waste container filling operations. A portable shielded cask is provided for sample jar transfer.

11.4.2.2.6 Filter Transfer Cask

The filter transfer cask permits remote changing of filter cartridges, dripless transport to the storage area in the auxiliary building, transfer of the filter cartridges into and out of the filter storage, and loading of the filter cartridges into disposal containers.

11.4.2.3 System Operation

11.4.2.3.1 Spent Resin Handling Operations

Demineralized water is used to transfer spent resins from the various ion exchangers to the spent resin tanks. A demineralized water transfer pump provides the pressurized water flow to transfer the spent resins as described in subsection 9.2.4. Before the transfer operation, it is verified that the selected spent resin tank is aligned as a receiver and has the capacity to accept the bed. It is also verified that the resin mixing pump is aligned to discharge excess transfer water through the resin fines filter to the liquid waste processing system.

During the transfer operation the tank level is monitored and the resin mixing pump is operated, if required, to limit tank water level. The operator stops the transfer when the CCTV camera viewing the sight flow glass indicates on a control panel monitor that the sluice water is clear and the transfer line is, therefore, flushed of resins.

After the bed transfer, the tank solids level can be checked by operating the resin mixing pump to lower the water level below the solids level. The solids level can be determined by the ultrasonic surface detector.

Between bed transfer operations the water level in the spent resin tanks is maintained above the solids level. Demineralized water is supplied for water level adjustment as well as a backup water source for flushing resin handling lines after resin recirculation and waste disposal container filling operations.

The solids bed can be agitated and mixed at any time by using compressed air or by operating the resin mixing pump in the resin mixing mode. In the resin mixing mode, water is drawn from the spent resin tank via resin retention screens. The water is returned via tank mixing eductors that generate a resin slurry recirculation within the tank equivalent to about four times the flow rate generated by the resin mixing pump. The solids bed is locally fluidized during this operation.

The resin mixing mode is established to fluidize and mix the solids bed in the spent resin tank before waste disposal container filling. The resin transfer pump is then started in the recirculation mode. A resin slurry is drawn from the spent resin tank and returned to the same tank. A representative resin sample may be obtained during recirculation or container filling modes by operating the sampling device.

The portable system's container fill valve is opened to initiate the filling operation. The resin dewatering pump of the portable dewatering system is started to dewater the resin as it accumulates in the container. The resin dewatering pump discharges the water to the recirculation line. The water flows back to the spent resin tank, thereby preserving the water inventory in the system and retaining any resin fines or dislodged crud within the system.

The resin mixing pump can be stopped at any time during the filling operation. When the solids level nears the top of the container, as detected by level sensors and observed by a television camera, the fill valve is closed and cycled to top off the container. Excessive water or solids level automatically closes the fill valve.

When the filling operation is complete, the line flushing sequence controller is manually initiated to automatically operate the pumps and valves to flush the resin transfer lines back to the spent resin tank. The container fill valve is opened for a short time period to flush the remaining resin to the waste container. The resin mixing pump supplies filtered flush water from the spent resin tank. The portable dewatering system's dewatering pump is operated periodically until no further dewatering flow is detected by the pump discharge pressure indicator and/or audible indications from the pump.

11.4.2.3.2 Spent Filter Processing Operations

A filter transfer cask is used to change the higher-activity filters of the chemical and volume control system and spent fuel cooling system. The filter vessel is drained, and the filter cover is opened remotely. The shield plug of the port over the filter is removed and the transfer cask, without its bottom shield cover, is lifted and positioned on the port directly over the cartridge in the filter vessel.

A grapple inside the transfer cask is remotely lowered and connected to the filter cartridge. The cartridge is lifted into the transfer cask, and the cask is transferred over plastic sheeting to the bottom shield cover. The dose rate of the cartridge is measured with a long probe, and the cask is lowered onto and connected to the bottom shield cover. The transfer cask is then moved to the auxiliary building rail car bay.

If recent applicable sample analysis results are available, the filter cartridge can be loaded directly into a disposal container as described in the following paragraph. If analysis is required, or if storage is required prior to processing, the filter cartridge is placed in a storage tube ~~of the~~ high-activity filter storage ~~area~~ for sampling and temporary storage until sample analysis results are available. The transfer cask bottom cover is disconnected, the transfer cask is lifted by the crane and transferred to a position over one of the temporary storage tubes, and the spent filter cartridge is lowered into the tube. After moving the transfer cask away, the crane is used to install a shield plug onto the storage tube. Any water draining from the filter during storage collects in the storage tube which may be drained to a floor drain for subsequent transfer to the liquid radwaste system. A sample of the filter media is obtained through a port in the shielded storage tube.

When sample analysis is complete and packaging requirements are established, the transfer cask is used to retrieve the spent cartridges from storage and deposit them into a waste container via a port in the top of a portable processing and storage cask. Plastic coverings

a sample of the filter media is obtained through a port in the transfer cask.

are removed and the container is capped, smear-surveyed, and decontaminated as required, using reach rod tools through a cask port. The dose rate survey is also made through a cask port. Transfer of the filled waste container to the shipping cask, including cask cover handling, is then performed using the rail car bay crane under remote control.

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Filters with dose rates less than 15 R/hr on contact may be changed from outside of filter vessel shielding by using reach rod tools. The filter vessel is drained, and the cover is removed.

The drum covers are manually installed, and the drums are smear surveyed, decontaminated by wiping, if required, weighed, stacked on pallets, and placed in the packaged waste storage room.

When a truck-load quantity of waste containers accumulates, shipment to a low-level waste disposal facility is initiated by loading pallets of drums and other low-level waste containers into a closed van using the scissor lift or onto a flat-bed trailer using the crane. If the activity level is too high for unshielded shipment, the drums are loaded onto a cask pallet and into a shielded shipping cask using the mobile systems facility crane.

Radioactive filters from ventilation exhaust filtration units are bagged and transported to the radwaste building, where they are temporarily stored. The filters are compacted along with other dry active wastes by a mobile system as described in the following subsection.

11.4.2.3.3 Dry Waste Processing Operations

Dry wastes are segregated by measuring the contact dose rate of the wastes to determine the appropriate processing method. The contact dose rates for initial waste segregation are as follows:

Low activity	<5 mR/hr
Moderate activity	5 mR/hr to 100 mR/hr
High activity	>100 mR/hr

These activity levels may be adjusted by the operator to minimize exposures while maximizing processing efficiency.

Wastes from surface contamination areas in the radiologically controlled area are placed in bags or containers and tagged at the point of origin with information on radiation levels, waste type, and destination. The bags or containers are transported to the radwaste building, where they are placed into low-, moderate-, or high-activity storage, segregated by portable shielding as appropriate.

The high-activity wastes (greater than 100mR/hr) are normally expected to be compacted in drums using a mobile compactor system in the same manner as lower-activity filter cartridges.

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Then the spent filter cartridge is grappled and lifted out and into a filter transfer cask.

At the radwaste building, low and moderate activity filter cartridges are deposited into disposal or storage drums. The drums are stored within portable shield casks in the shielded accumulation room, which is serviced by the mobile systems facility crane. Depending on dose rates and analysis results, stabilization may or may not be required. Cartridges not requiring stabilization are loaded into standard, 55 gallon shipping drums with absorbent and are compacted using a mobile system. When stabilization is required, the cartridges may be loaded into either high integrity containers or standard drums. If standard drums are used, mobile equipment is used to encapsulate the contents of the drums.

Moderate-activity wastes (5 mR/hr to 100 mR/hr) are expected to be sorted in a mobile system to remove reusable items such as protective clothing articles and tools, hazardous wastes, and larger noncompressible items. The remaining wastes are normally compacted by mobile equipment. The packaged wastes may be loaded directly onto a truck for shipment or may be stored in the packaged waste storage room until a truck load quantity accumulates.

Low-activity, dry active waste (less than 5 mR/hr) generally contains a large amount of nonradioactive material. It is expected that these wastes normally will be processed through a mobile radiation monitoring and sorting system to remove non-radioactive items for reuse or local disposal. A radiation survey allows identification and removal of potentially clean items for the clean waste verification. The remaining radioactive wastes are normally compacted or packaged for disposal as appropriate.

Materials that enter the radiologically controlled area are verified as nonradioactive before being released for reuse or disposal. Tools and equipment belonging to personnel and contractors are surveyed at the radiologically controlled area exit in the annex building. If these items cannot be released or decontaminated, they become plant inventory or dry active waste and are handled as described previously.

Other wastes generated in the radiologically controlled area but outside of surface contamination areas are collected in bags or containers and are delivered to the temporary storage location in the radwaste building. These wastes normally are processed through a mobile radiation monitoring system to verify that they are nonradioactive and suitable for disposal in a local waste landfill.

11.4.2.3.4 Mixed Waste Processing Operations

Mixed wastes from the radiologically controlled area are collected in suitable containers and brought to the radwaste building, where separate containment pallets and accumulation drums are provided for solid and liquid mixed wastes. Mixed wastes are normally sent to an offsite facility having mixed-waste processing and disposal capabilities.

11.4.2.4 Waste Processing and Disposal Alternatives

11.4.2.4.1 Portable and Mobile Radwaste Systems Capabilities

Portable or mobile processing and packaging systems can be located in the auxiliary building rail car bay or the radwaste building mobile systems facility. Chemical wastes are normally processed in the radwaste building by a mobile concentration and/or solidification system when a batch accumulates in the chemical waste tank. Mobile systems are also used to encapsulate high-activity filters, to sort, decontaminate and compact dry active wastes, and to verify nonradioactive wastes.

The spent resin system includes connections in the fill station and rail car bay to allow spent resins to be delivered to a disposal container in either location for dewatering using portable equipment.

Branch Technical Position ETSB 11-3 provides guidance for portable solid waste systems in Section IV. Compliance with the four guidance items is achieved as follows:

IV.1 The spent resin tanks are the only tanks that contain a significant volume of wet wastes, and these tanks are permanently installed. Concentrates that may be produced by mobile evaporation systems will be produced and stored by the mobile systems only in small batches prior to being solidified by the mobile systems. As described in subsection 1.2.7, the radwaste building is designed to retain spillage from mobile or portable systems.

IV.2 Permanently installed piping for transport of radioactive wastes to mobile or portable systems is routed as close as practical to the mobile or portable systems thereby minimizing the use of flexible interfacing hose. The hydrostatic test requirements of Regulatory Guide 1.143 will be applied to the flexible interfacing hose.

IV.3 Portable or mobile systems will be located in either the rail car bay of the auxiliary building or in the mobile systems facility in the radwaste building. The spent resin waste container fill station or the shipping cask in the auxiliary building collects spillage of spent resin during waste container filling operations. The radwaste and auxiliary buildings contain and drain spillage to the liquid radwaste system via the radioactive waste drain system as described in subsection 1.2.7 and Section 11.2. Portable or mobile systems will, when required, have their own HEPA filtered exhaust ventilation system. The mobile systems facility has connections on the exhaust ventilation ducts for connecting exhaust duct from mobile or portable processing systems to the building's exhaust ventilation system.

IV.4 Although the seismic criteria of Regulatory Guide 1.143 are not applicable to structures housing mobile or portable solid radwaste systems, the portable equipment used for spent resin container filling and dewatering and high-activity filter cartridge packaging will be housed within the Seismic Category I auxiliary building. The radwaste building, which provides shelter for mobile or portable radwaste systems, is non-seismic in accordance with Branch Technical Posi... ETSB 11-3.

11.4.2.4.2 Central Radwaste Processing Facility

As an alternative to the mobile or portable processes for lower-activity wastes (generally wastes reading below 200 mR/hr), the wastes may be sent to a licensed central radwaste processing facility for processing and disposal. This option requires minimal onsite processing to remove hazardous materials from the waste streams. The wastes are loaded into a cargo container. The mobile systems facility includes a designated laydown area, and the mobile systems facility crane may be used to handle a cargo container.

HEPA filtered exhaust ~~is~~ required when airborne radioactivity would exceed 10CFR20 ~~DAC~~ derived air concentration limits for radiation workers.

11.4.2.5 Facilities

11.4.2.5.1 Auxiliary Building

Resin and filtration media transfer lines from the various ion exchangers are routed to the spent resin tanks on elevation 100' - 0" in the southwest corner of the auxiliary building. The spent resin system pumps, valves, and piping are located in shielded rooms near the spent resin tanks.

Liquid radwaste system transfer lines to and from the radwaste building are routed to the south wall of the auxiliary building where they penetrate and enter into a shielded pipe pit in the base mat of the radwaste building.

Accessways in the auxiliary building are used to move the filter transfer casks. This includes filter transfer cask handling from the containment, where the chemical and volume control filters are located, to the auxiliary building rail car bay, where the filter cartridges are stored and subsequently packaged using mobile equipment. These accessways are also used to move dry active waste from various collection locations to the radwaste building. An enclosed accessway is provided between the auxiliary building and the radwaste building on elevation 100'-0" (grade level).

11.4.2.5.2 Radwaste Building

The radwaste building, described in Section 1.2, houses the mobile systems facility. It also includes the waste accumulation room and the packaged waste storage room. These rooms are serviced by the mobile systems facility crane.

In the mobile systems facility, three truck bays provide for mobile or portable processing systems and for waste disposal container shipping and receiving. A shielded pipe trench to each of the truck bays is used to route liquid radwaste supply and return lines from the connections in the shielded pipe pit at the auxiliary building wall. Separate areas are reserved for empty (new) waste disposal container storage, container laydown, and forklift charging. An area is reserved near the door to the auxiliary building for protective clothing dropoff and frisking.

The waste accumulation room (pre-processing) is divided as needed, using partitions and portable shielding to adjust the storage areas for different waste categories as needed to complement the radioactivity levels and volumes of generated wastes. The accumulation room has lockable doors to minimize unauthorized entry and inadvertent exposure.

The packaged waste storage room may be separated into high- and low-activity areas, using portable shielding to minimize exposure while providing operational flexibility. A lockable door is provided to minimize unauthorized entry and radiation exposure.

The heating and ventilating system for the radwaste building is described in subsection 9.4.8.

11.4.3 System Safety Evaluation

The solid waste management system has no safety-related function and therefore requires no nuclear safety evaluation.

11.4.4 Tests and Inspections

Preoperational tests are conducted as described in subsection 14.2.8. Tests are performed to demonstrate the capability to transfer ion exchange resins and deep bed filtration media from the ion exchangers and filters to the spent resin tanks or directly to a waste disposal container. Preoperational tests of the solid waste management system components are performed to prepare the system for operation.

After plant operations begin, the operability and functional performance of the solid waste management system is periodically evaluated according to Regulatory Guide 1.143 by monitoring for abnormal or deteriorating performance during routine operations. Instruments and setpoints are also calibrated on a scheduled basis. The preventive maintenance program includes periodic inspection and maintenance of active components.

11.4.5 Quality Assurance

Guidance for the quality assurance program for design, installation, procurement, and fabrication issues is outlined in Section 17.1.

11.4.6 Combined License Information for Solid Waste Management System Process Control Program

For wet solid wastes

For both wet and dry solid wastes

The Combined License applicant will develop a process control program ~~for the solid wastes~~ in compliance with 10 CFR Sections 61.55 and 61.56 and 10 CFR Part 71 and DOT regulations. Process control programs will also be provided by vendors providing mobile or portable processing systems. It will be the plant operators responsibility to assure that the vendors have appropriate process control programs for the scope of work being contracted at any particular time. The process control program will identify the operating procedures for processing wet solid wastes. The mobile systems process control program will include a discussion of conformance to Regulatory Guide 1.143.

11.4.7 References

1. "Shippers-General Requirements for Shipments and Packagings," 49 CFR 173.
2. "Packaging and Transportation of Radioactive Material," 10 CFR 71.
3. "Domestic Licensing of Production and Utilization Facilities," 10 CFR 50.
4. "Standards for Protection Against Radiation," 10 CFR 20.
5. "Licensing Requirements for Land Disposal of Radioactive Waste," 10 CFR 61.
6. "USNRC Technical Position on Waste Form," Rev. 1, January, 1991.

Table 11.4-1

ESTIMATED INFLUENT ACTIVITY PARAMETERS

Source	Expected Generation (Ft^3/yr)	Expected Shipped Solid (Ft^3/yr)	Maximum Generation (Ft^3/yr)	Maximum Shipped Solid (Ft^3/yr)
Primary Resins	250(2)	314.8	1060(4)	1334
Primary Filters	3.6(3)	24.5	6.5(3)	48.1
Compactible Dry Waste	4101	872.7	6265	1336
Non-Compactible Solid Waste	233.7	373.2	910	567.3
Mixed Liquid & Chemical Waste	370	44.3	740	88.3
Condensate Polishing Resin(1)	0	0	206(5)	259.4
Steam Generator Blowdown(1) Material (Resin and Membrane)	0	0	540(5)	680

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Notes:

1) Radioactive secondary resins and membranes result from primary to second systems leakage (e.g., SG tube leak)

2). Estimated activity basis is ANSI 18.1 source terms in reactor coolant

3). Estimated activity basis is breakdown and transfer of 10% of resin from upstream ion exchangers

4). Reactor coolant source terms corresponding to 0.25% fuel defects

5). Estimated activity basis from Table 11.1-5, 11.1-7 and 11.1-8 and a typical 30 day process run time, once per refueling cycle like others

Table 11.4-2 (Sheet 1 of 2)

EXPECTED ANNUAL CURIE CONTENT OF PRIMARY INFLUENTS

Isotope	Primary Resin Total Ci/yr	Primary Filter Total Ci/yr
Br-83	-	-
Br-84	1.51E-01	1.51E-02
Br-85	-	-
I-129	-	-
I-130	-	-
I-131	8.31E+01	8.31E+00
I-132	7.65E+00	7.65E-01
I-133	3.30E+01	3.30E+00
I-134	5.29E+00	5.29E-01
I-135	2.36E+01	2.36E+00
Rb-86	-	-
Rb-88	7.69E-01	7.69E-02
Rb-89	-	-
Cs-134	1.68E+02	1.68E+01
Cs-136	1.79E+00	1.79E-01
Cs-137	2.66E+02	2.66E+01
Cs-138	-	-
Ba-137m	2.47E+02	2.47E+01
Cr-51	1.79E+01	1.79E+00
Mn-54	5.85E+01	5.85E+00
Mn-56	-	-
Fe-55	5.66E+01	5.66E+00
Fe-59	2.83E+00	2.83E-01
Co-58	8.39E+01	8.39E+00
Co-60	1.27E+02	1.27E+01
Zn-65	1.70E+01	1.70E+00
Sr-89	1.52E+00	1.52E-01
Sr-90	6.33E-01	6.33E-02
Sr-91	1.14E-01	1.14E-02
Sr-92	-	-
Ba-140	3.62E+01	3.62E+00
Y-90	-	-
Y-91m	-	-
Y-91	3.70E-06	3.70E-07

Table 11.4-2 (Sheet 2 of 2)

EXPECTED ANNUAL CURIE CONTENT OF PRIMARY INFLUENTS

Isotope	Primary Resin Total Ci/yr	Primary Filter Total Ci/yr
Y-92	-	-
Y-93	-	-
La-140	-	-
Zr-95	1.39E-04	1.39E-05
Nb-95	-	-
Mo-99	-	-
Tc-99m	-	-
Ru-103	2.69E-03	2.69E-04
Ru-106	3.21E-02	3.21E-03
Rh-103m	-	-
Rh-106	-	-
Te-132	-	-
Te-125m	-	-
Te-127m	-	-
Te-127	-	-
Te-129m	6.82E-05	6.82E-06
Te-129	-	-
Te-131m	-	-
Total:	1.24E+03	1.24E+02

Note:
Values shown as "-" Ci/yr are those calculated to be lower than 1.0E-10 Ci/yr, and thus considered to have insignificant contributions to total.

Table 11.4-3 (Sheet 1 of 2)

MAXIMUM ANNUAL CURIE CONTENT OF PRIMARY INFLUENTS

Isotope	Primary Resin Total Ci/yr	Primary Filter Total Ci/yr
Br-83	3.00E+00	3.00E-01
Br-84	9.17E-02	9.17E-03
Br-85	1.02E-03	1.02E-04
I-129	1.23E-03	1.23E-04
I-130	2.75E+00	2.75E-01
I-131	1.43E+03	1.43E+02
I-132	9.58E+01	9.58E+00
I-133	6.67E+02	6.67E+01
I-134	1.99E+00	1.99E-01
I-135	1.39E+02	1.39E+01
Rb-86	7.14E+00	7.14E-01
Rb-88	6.74E+00	6.74E-01
Rb-89	3.53E-01	3.53E-02
Cs-134	3.40E+03	3.40E+02
Cs-136	6.31E+02	6.31E+01
Cs-137	4.25E+03	4.25E+02
Cs-138	3.81E+00	3.81E-01
Ba-137m	4.01E+03	4.01E+02
Cr-51	2.20E+01	2.20E+00
Mn-54	6.49E+01	6.49E+00
Mn-56	4.07E+01	4.07E+00
Fe-55	6.27E+01	6.27E+00
Fe-59	3.24E+00	3.24E-01
Co-58	9.34E+01	9.34E+00
Co-60	1.81E+02	1.81E+01
Zn-65	-	-
Sr-89	1.09E+01	1.09E+00
Sr-90	4.37E+00	4.37E-01
Sr-91	5.52E-01	5.52E-02
Sr-92	4.51E-02	4.51E-03
Ba-140	3.08E+00	3.08E-01
Y-90	4.30E+00	4.30E-01
Y-91m	1.16E-01	1.16E-02
Y-91	1.96E-01	1.96E-02

Table 11.4-3 (Sheet 2 of 2)

MAXIMUM ANNUAL CURIE CONTENT OF PRIMARY INFLUENTS

Isotope	Primary Resin Total Ci/yr	Primary Filter Total Ci/yr
Y-92	1.50E-02	1.50E-03
Y-93	6.19E-05	6.19E-06
La-140	2.70E+00	2.70E-01
Zr-95	-	-
Nb-95	-	-
Mo-99	-	-
Tc-99m	-	-
Ru-103	-	-
Ru-106	-	-
Rh-103m	-	-
Rh-106	-	-
Te-132	-	-
Te-125m	-	-
Te-127m	-	-
Te-127	-	-
Te-129m	-	-
Te-129	-	-
Te-131m	-	-
Total:	1.51E+04	1.51E+03

Note:
Values shown as "-" Ci/yr are those calculated to be lower than 1.0E-10 Ci/yr, and thus considered to have insignificant contributions to total.

Table 11.4-4 (Sheet 1 of 2)

EXPECTED ANNUAL CURIE CONTENT OF SHIPPED PRIMARY WASTES

Isotope	Primary Resin Total Ci/yr	Primary Filter Total Ci/yr
Br-83	-	-
Br-84	-	-
Br-85	-	-
I-129	-	-
I-130	-	-
I-131	3.56E-02	3.56E-03
I-132	-	-
I-133	-	-
I-134	-	-
I-135	-	-
Rb-86	-	-
Rb-88	-	-
Rb-89	-	-
Cs-134	1.54E+02	1.54E+01
Cs-136	1.48E-02	1.48E-03
Cs-137	2.63E+02	2.63E+01
Cs-138	-	-
Ba-137m	2.50E+02	2.50E+01
Cr-51	1.89E+00	1.89E-01
Mn-54	4.79E+01	4.79E+00
Mn-56	-	-
Fe-55	5.31E+01	5.31E+00
Fe-59	6.98E-01	6.98E-02
Co-58	3.48E+01	3.48E+00
Co-60	1.23E+02	1.23E+01
Zn-65	1.32E+01	1.32E+00
Sr-89	4.59E-01	4.59E-02
Sr-90	6.30E-01	6.30E-02
Sr-91	-	-
Sr-92	-	-
Ba-140	2.75E-01	2.75E-02
Y-90	-	-
Y-91m	-	-
Y-91	2.67E-04	2.67E-05

Table 11.4-4 (Sheet 2 of 2)

EXPECTED ANNUAL CURIE CONTENT OF SHIPPED PRIMARY WASTES

Isotope	Primary Resin Total Ci/yr	Primary Filter Total Ci/yr
Y-92	-	-
Y-93	-	-
La-140	3.17E-01	3.17E-02
Zr-95	-	-
Nb-95	-	-
Mo-99	-	-
Tc-99m	-	-
Ru-103	-	-
Ru-106	-	-
Rh-103m	-	-
Rh-106	-	-
Te-132	-	-
Te-125m	-	-
Te-127m	-	-
Te-127	-	-
Te-129m	-	-
Te-129	-	-
Te-131m	-	-
Total:	9.43E+02	9.43E+01

Note:
Values shown as "-" Ci/yr are those calculated to be lower than 1.0E-10 Ci/yr, and thus considered to have insignificant contributions to total.

Table 11.4-5 (Sheet 1 of 2)

MAXIMUM ANNUAL CURIE CONTENT OF SHIPPED PRIMARY WASTES

Isotope	Primary Resin Total Ci/yr	Primary Filter Total Ci/yr
Br-83	-	-
Br-84	-	-
Br-85	-	-
I-129	1.23E-03	1.23E-04
I-130	-	-
I-131	1.08E+02	1.08E+01
I-132	-	-
I-133	-	-
I-134	-	-
I-135	-	-
Rb-86	2.35E+00	2.35E-01
Rb-88	-	-
Rb-89	-	-
Cs-134	3.30E+03	3.30E+02
Cs-136	1.27E+02	1.27E+01
Cs-137	4.21E+03	4.21E+02
Cs-138	-	-
Ba-137m	3.98E+03	3.98E+02
Cr-51	1.04E+01	1.04E+00
Mn-54	6.08E+01	6.08E+00
Mn-56	-	-
Fe-55	6.14E+01	6.14E+00
Fe-59	2.03E+00	2.03E-01
Co-58	6.96E+01	6.96E+00
Co-60	1.79E+02	1.79E+01
Zn-65	-	-
Sr-89	7.29E+00	7.29E-01
Sr-90	4.37E+00	4.37E-01
Sr-91	-	-
Sr-92	-	-
Ba-140	6.06E-01	6.06E-02
Y-90	4.34E+00	4.34E-01
Y-91m	-	-
Y-91	1.40E-01	1.40E-02

Table 11.4-5 (Sheet 2 of 2)

MAXIMUM ANNUAL CURIE CONTENT OF SHIPPED PRIMARY WASTES

Isotope	Primary Resin Total Ci/yr	Primary Filter Total Ci/yr
Y-92	-	-
Y-93	-	-
La-140	6.11E-01	6.11E-02
Zr-95	-	-
Nb-95	-	-
Mo-99	-	-
Tc-99m	-	-
Ru-103	-	-
Ru-106	-	-
Rh-103m	-	-
Rh-106	-	-
Te-132	-	-
Te-125m	-	-
Te-127m	-	-
Te-127	-	-
Te-129m	-	-
Te-129	-	-
Te-131m	-	-
Total:	1.21E+04	1.21E+03

Note:

Values shown as "-" Ci/yr are those calculated to be lower than 1.0E-10 Ci/yr, and thus considered to have insignificant contributions to total.

Table 11.4-6 (Sheet 1 of 2)

EXPECTED ANNUAL CURIE CONTENT OF SECONDARY WASTE AS GENERATED

Isotope	Secondary Resin Total Ci/yr
NA-24	1.73E-02
CR-51	3.81E-02
MN-54	2.62E-02
FE-55	2.01E-02
FE-59	3.94E-03
CO-58	6.75E-02
CO-60	9.10E-03
ZN-65	8.27E-03
BR-84	2.59E-05
RB-88	1.01E-04
SR-89	1.96E-03
SR-90	2.03E-04
SR-91	2.01E-04
Y-90	1.80E-04
Y-91	2.19E-04
Y-91M	1.98E-04
Y-93	9.10E-04
ZR-95	5.66E-03
NB-95	4.52E-03
NB-95M	4.74E-03
MO-99	1.36E-02
TC-99M	1.35E-02
RU-103	1.00E-01
RU-106	1.48E+00
RH-103M	9.68E-02
RH-106	1.44E+00
AG-110	2.12E-02
AG-110M	2.12E-02
TE-129	2.52E-03
TE-129M	2.41E-03
TE-131	1.28E-03
TE-131M	1.32E-03
TE-132	4.21E-04

Table 11.4-6 (Sheet 2 of 2)

EXPECTED ANNUAL CURIE CONTENT OF SECONDARY WASTE AS GENERATED

Isotope	Secondary Resin Total Ci/yr
I-131	1.45E-01
I-132	8.39E-03
I-133	4.88E-02
I-134	1.30E-03
I-135	2.56E-02
XE-131M	-
XE-133	-
XE-135	-
CS-134	2.17E-01
CS-135	4.70E-10
CS-136	1.30E-02
CS-137	2.88E-01
BA-136M	1.39E-02
BA-137M	2.88E-01
BA-140	1.09E-01
LA-140	1.35E-01
CE-141	1.88E-03
CE-143	2.58E-03
CE-144	6.37E-02
PR-143	2.04E-03
PR-144	6.37E-02
Total:	4.83

Table 11.4-7 (Sheet 1 of 2)

MAXIMUM ANNUAL CURIE CONTENT OF SECONDARY WASTE AS GENERATED

Isotope	Secondary Resin Total Ci/yr
NA-24	4.62E-04
CR-51	5.17E-01
MN-54	3.55E-01
MN-56	2.75E-01
FE-55	2.78E-01
FE-59	5.88E-02
CO-58	9.25E-01
CO-60	1.23E-01
BR-83	2.27E-02
BR-84	1.03E-03
BR-85	1.30E-06
KR-83M	-
KR-85	-
KR-85M	-
RB-88	3.57E-02
RB-89	1.24E-03
SR-89	3.59E-01
SR-90	2.50E-02
SR-91	1.42E-02
SR-92	4.89E-04
Y-90	2.22E-02
Y-91	1.75E-02
Y-91M	1.29E-02
Y-92	1.09E-03
Y-93	4.77E-03
ZR-95	3.15E-02
NB-95	3.36E-02
NB-95M	5.52E-02
MO-99	5.80E+00
TC-99M	6.30E+00
RU-103	2.51E-02
RU-103M	3.87E-02
RH-103M	2.54E-02
RH-106	4.32E-02

Table 11.4-7 (Sheet 2 of 2)

MAXIMUM ANNUAL CURIE CONTENT OF SECONDARY WASTE AS GENERATED

Isotope	Secondary Resin Total Ci/yr
AG-110	1.34E-02
AG-110M	1.01E-01
TE-129	5.34E-01
TE-129M	4.24E-01
TE-131	1.01E+00
TE-131M	8.65E-02
TE-132	2.65E+00
TE-134	1.03E-03
I-130	4.91E-02
I-131	5.74E+01
I-132	4.26E+00
I-133	1.23E+01
I-134	3.32E-02
I-135	1.88E+00
XE-131M	-
XE-133	-
XE-135	-
CS-134	2.27E+02
CS-135	6.16E-08
CS-136	2.75E+02
CS-137	2.10E+02
CS-138	2.62E-02
BA-136M	6.35E+02
BA-137M	2.17E+02
BA-140	1.13E-01
LA-140	8.28E-01
CE-141	2.72E-02
CE-143	1.89E-03
CE-144	2.67E-02
PR-143	1.83E-02
PR-144	2.67E-02
Total:	1660

Table 11.4-8 (Sheet 1 of 2)

EXPECTED ANNUAL CURIE CONTENT OF SHIPPED SECONDARY WASTES

Isotope	Secondary Resin Total Ci/yr
NA-24	-
CR-51	4.04E-03
MN-54	2.13E-02
FE-55	1.88E-02
FE-59	1.01E-03
CO-58	2.82E-02
CO-60	8.81E-03
ZN-65	6.41E-03
BR-84	-
RB-88	-
SR-89	6.00E-04
SR-90	2.02E-04
SR-91	-
Y-90	2.02E-04
Y-91	5.80E-09
Y-91M	-
Y-93	-
ZR-95	2.18E-03
NB-95	3.54E-03
NB-95M	2.32E-03
MO-99	2.43E-12
TC-99M	2.56E-12
RU-103	2.07E-02
RU-106	1.25E+00
RH-103M	2.00E-02
RH-106	1.21E+00
AG-110	1.66E-02
AG-110M	1.66E-02
TE-129	3.79E-04
TE-129M	3.87E-04
TE-131	2.77E-25
TE-131M	2.83E-25

Table 11.4-8 (Sheet 2 of 2)

EXPECTED ANNUAL CURIE CONTENT OF SHIPPED SECONDARY WASTES

Isotope	Secondary Resin Total Ci/yr
TE-132	1.81E-11
I-131	6.24E-05
I-132	1.84E-11
I-133	4.62E-34
I-134	-
I-135	-
XE-131M	-
XE-133	-
XE-135	-
CS-134	2.00E-01
CS-135	4.86E-10
CS-136	1.38E-04
CS-137	2.86E-01
BA-136M	1.47E-04
BA-137M	2.86E-01
BA-140	8.33E-04
LA-140	9.58E-04
CE-141	2.76E-04
CE-143	5.15E-23
CE-144	5.12E-02
PR-143	2.38E-05
PR-144	5.12E-02
Total:	3.50

Table 11.4-9 (Sheet 1 of 2)

MAXIMUM ANNUAL CURIE CONTENT OF SHIPPED SECONDARY WASTES

Isotope	Secondary Resin Total Ci/yr
NA-24	- -
CR-51	5.47E-02
MN-54	2.89E-01
MN-56	-
FE-55	2.60E-01
FE-59	1.50E-02
CO-58	3.87E-01
CO-60	1.19E-01
BR-83	-
BR-84	-
BR-85	-
KR-83M	-
KR-85	-
KR-85M	-
RB-88	-
RB-89	-
SR-89	1.10E-01
SR-90	2.48E-02
SR-91	-
SR-92	-
Y-90	2.46E-02
Y-91	4.52E-07
Y-91M	-
Y-92	-
Y-93	-
ZR-95	1.21E-02
NB-95	2.11E-02
NB-95M	2.70E-02
MO-99	1.04E-09
TC-99M	1.14E-09
RU-103M	3.27E-02
RU-103	5.20E-03

Table 11.4-9 (Sheet 2 of 2)

MAXIMUM ANNUAL CURIE CONTENT OF SHIPPED SECONDARY WASTES

Isotope	Secondary Resin Total Ci/yr
RH-103M	5.25E-03
RH-106	3.65E-02
AG-110	1.05E-02
AG-110M	7.88E-02
TE-129	8.60E-02
TE-129M	6.83E-02
TE-131	2.18E-22
TE-131M	1.85E-23
TE-132	1.14E-08
TE-134	-
I-130	-
I-131	2.48E-02
I-132	1.49E-08
I-133	1.16E-31
I-134	-
I-135	-
XE-131M	-
XE-133	-
XE-135	-
CS-134	2.09E+02
CS-135	6.36E-08
CS-136	2.89E+00
CS-137	2.09E+02
CS-138	-
BA-136M	6.69E+00
BA-137M	2.15E+02
BA-140	8.70E-04
LA-140	7.17E-03
CE-141	3.98E-03
CE-143	3.77E-23
CE-144	2.14E-02
PR-143	1.88E-04
PR-144	2.14E-02
Total:	644

Table 11.4-10 (Sheet 1 of 2)

COMPONENT DATA - SOLID WASTE MANAGEMENT SYSTEM (NOMINAL)

Tanks

Spent resin tank

Number	2
Total volume (ft^3)	300
Type	Vertical, conical bottom, dished top
Design pressure (psig)	15
Design temperature (°F)	150
Material	Stainless steel (SS)

Pumps

Resin mixing pump

Number	1
Type	Pneumatic diaphragm
Design pressure (psig)	125
Design temperature (°F)	150
Design flow rate (gpm)	120
Design head (ft)	160
Air supply pressure (psig)	100
Air consumption (scfm)	130
Material	Stainless steel housing, Buna N diaphragms

Resin transfer pump

Number	1
Type	Progressing cavity
Design pressure (psig)	150
Design temperature (°F)	150
Design flow rate (gpm)	100
Material	Stainless steel housing, internals and rotor, Buna N stator liner

Filters

Resin fines filter

Number	1
Type	Filter cartridge for inside to outside flow
Design pressure (psig)	150
Design temperature (°F)	150
Design flowrate (gpm)	120
Filtration rating	10 microns
Material	Stainless steel housing and pleated polypropylene cartridge with stainless steel screen outer jacket

Table 11.4-10

COMPONENT DATA - SOLID WASTE MANAGEMENT SYSTEM (NOMINAL)

Tanks	
Spent resin tank	
Number	2
Total volume (ft^3)	300
Pumps	
Resin mixing pump	
Number	1
Design flow rate (gpm)	120
Resin transfer pump	
Number	1
Design flow rate (gpm)	100
Filters	
Resin fines filter	
Number	1
Design flowrate (gpm)	120

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Table 11.4-12 (Sheet 2 of 2)

COMPONENT DATA - SOLID WASTE MANAGEMENT SYSTEM (NOMINAL)

Sampler

Resin sampling device

Number	1
Type	Inline sampler, positive displacement sample collection and portable pig for sample jar
Material	Stainless steel and EPDM wetted parts

Cask

Filter transfer cask and cart

Number	1
Type	Annular shield body with removable top and bottom shield covers
Filter handling	Power winch and grapple
Shielding	4" lead nominal inch
Material	Stainless steel and lead

11.5 Radiation Monitoring

The radiation monitoring system (RMS) provides plant effluent monitoring, process fluid monitoring, airborne monitoring, and continuous indication of the radiation environment in plant areas where such information is needed. Radiation monitors that have a safety-related function are qualified environmentally, seismically, or both. Class 1E radiation monitors conform to the separation criteria described in subsection 8.3.2 and to the fire protection criteria described in subsection 9.5.1.

The radiation monitoring system is installed permanently and operates in conjunction with regular and special radiation survey programs to assist in meeting applicable regulatory requirements. The radiation monitoring system is designed in accordance with ANSI N13.1.

The radiation monitoring system is divided functionally into two subsystems:

- Process, airborne, and effluent radiological monitoring and sampling
- Area radiation monitoring

11.5.1 Design Basis

11.5.1.1 Safety Design Basis

While the radiation monitoring system is primarily a surveillance system, certain detector channels perform safety-related functions. The components used in these channels meet the qualification requirements for safety-related equipment as described in subsection 7.1.4.

Channel and equipment redundancy is provided for safety-related monitors to maintain the safety-related function in case of a single failure.

The design objectives of the radiation monitoring system during postulated accidents are:

- Initiate containment air filtration isolation in the event of abnormally high radiation inside the containment (High-1)

- Initiate normal residual heat removal system suction line containment isolation in the event of abnormally high radiation inside the containment (High-2)

- Initiate main control room supplemental filtration in the event of abnormally high gaseous radioactivity in the main control room supply air

- Initiate main control room ventilation isolation and actuate the main control room emergency habitability system in the event of abnormally high particulate or iodine radioactivity in the main control room supply air

- Provide long-term post-accident monitoring (using both safety-related and nonsafety-related monitors)

The scope of the radiation monitoring system for post-accident monitoring is set forth in General Design Criterion 64 and in the provisions of Regulatory Guide 1.97.

11.5.1.2 Power Generation Design Basis

The radiation monitoring system is designed to support the requirements of 10 CFR 20 and to provide:

- Equipment to meet the applicable regulatory requirements for both normal operation and transient events
- Data to aid plant health physics personnel in limiting release of radioactivity to the environment and limiting exposure of operation and maintenance personnel to meet ALARA (as-low-as-reasonably-achievable) guidance
- Early indication of a system or equipment malfunction that could result in excessive radiation dose to plant personnel or lead to plant damage
- Data collection and data storage to support compliance reporting for the applicable NRC requirements and guidelines, such as General Design Criterion 64 and Regulatory Guide 1.21.

INSERT A

11.5.2 System Description

11.5.2.1 Radiation Monitoring System

The radiation monitoring system uses distributed radiation monitors, where each radiation monitor consists of one or more radiation detectors and a dedicated radiation processor.

Each radiation processor receives, averages and stores radiation data and transmits alarms and data to the plant control system (protection and safety monitoring system for safety-related monitors) for control (as required), display and recording. These alarms include: low (fail), alert, and high. Selected channels have a rate-of-rise alarm. Storage of radiation readings is provided.

Each radiation detector, except the in-duct radiation detectors and the containment high range ion chambers, has a check source that is actuated from the associated local radiation processor. The check source is used to verify detector and monitor operation. The check source is shielded to meet ALARA requirements, and returns to its fully retracted/shielded position upon loss of actuator power. Check sources on detectors can be actuated from the main control room. The in-duct radiation detector operation may be checked using an internal LED to simulate light pulses emitted in response to radiation. The containment high range monitors

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- Exhausts to the environment from the personnel areas in the Annex building, electrical and mechanical equipment rooms in the Annex and auxiliary buildings, and the diesel generator rooms will not be radioactive because they contain no radioactive materials and, therefore, need not be monitored.

have an internal source that provides a minimum reading; loss of signal from the detector indicates detector inoperability.

Radiation monitoring data, including alarm status, are provided to AP600 operators via the plant control system (and the protection and safety monitoring system for Class 1E monitors). The information is available in either counts per minute (count rate), microCuries/cc (activity concentration), or R/hr (radiation dose rate).

Safety-related channels are environmentally qualified and are powered from the Class 1E dc and uninterruptible power supply system. Nonsafety-related channels are powered from the non-Class 1E dc and uninterruptible power supply system.

11.5.2.2 Monitor Functional Description

The process and effluent radiological monitoring and sampling subsystem provides radiation monitoring for the four functional classifications listed below. Individual monitors may provide functionality in more than one of these classifications.

- Fluid process monitors determine concentrations of radioactive material in plant fluid systems
- Airborne monitors provide operators with information on concentrations of radioactivity at various points in the ventilation system, providing information on airborne concentrations in the plant
- Liquid and gaseous effluent monitors measure radioactive materials discharged to the environs
- Post-accident monitors monitor potential pathways for release of radioactive materials during accident conditions

The area radiation monitoring subsystem provides plant personnel information on radiation at fixed locations in AP600. Post-accident monitoring functions are also performed by certain area monitors.

11.5.2.3 Monitor Descriptions

For offline gaseous monitors, the radiation monitor includes a low pressure drop flow sensor suitable for measuring the sample flow. The radiation processor receives an analog signal input from this flow sensor. This signal is used by the radiation processor to control sample flow. The analog signal is transmitted to the plant control system (protection and safety monitoring system for safety-related monitors). For offline liquid monitors, a flow indicator is provided for manual adjustment of the flow.

11.5.2.3.1 Fluid Process Monitors

Steam Generator Blowdown Radiation Monitors

The steam generator blowdown radiation monitors (BDS-JE-RE010, RE011) measure the concentration of radioactive material in the blowdown from the steam generators. One measures radiation in the purification process effluent before it is returned to the condensate system. The other measures radioactivity in the blowdown system electrodeionization waste brine before it is discharged to the waste water system. The presence of radioactive material in the steam generator blowdown indicates a leak between the primary side and the secondary side of the steam generator. Refer to subsection 5.2.5 for details of leakage monitoring and to subsections 10.4.8 and 11.2 for process system details. The steam generator blowdown radiation monitors meet the guidelines of Regulatory Guide 1.97 as discussed in Appendix 1A and Section 7.5.

AP600 has two steam generators, each of which has a blowdown line. Each blowdown line has a heat exchanger upstream of the blowdown flow control valve. The steam generator blowdown radiation detectors are located in the lines downstream of these heat exchangers. Therefore, the radiation monitors do not require a sample cooler.

When its predetermined setpoint is exceeded, each steam generator blowdown radiation monitor initiates an alarm in the main control room, initiates closure of the steam generator blowdown containment isolation valves and the steam generator blowdown flow control valves, and diverts flow to the liquid radwaste system.

The steam generator blowdown radiation monitors use inline gamma-sensitive, thallium-activated, sodium iodide scintillation detectors. The steam generator blowdown radiation monitor detector range and principal isotopes are listed in Table 11.5-1.

The arrangement for the steam generator blowdown radiation monitor is shown in Figure 11.5-1.

Component Cooling Water System Radiation Monitor

The component cooling water system radiation monitor (CCS-JE-RE001) measures the concentration of radioactive material in the component cooling water system. Radioactive material in the component cooling water system provides indication of leakage. Refer to subsection 5.2.5 for details of leakage monitoring and to subsection 9.2.2 for process system details.

If the concentration of radioactive materials exceeds a predetermined setpoint, the component cooling water system radiation monitor initiates an alarm in the main control room.

The component cooling water system radiation monitor is an offline monitor that uses a gamma-sensitive, thallium-activated, sodium iodide scintillation detector. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the component cooling water system radiation monitor is shown in Figure 11.5-7.

Main Steam Line Radiation Monitors

The main steam line radiation monitors (SGS-JE-RE026 and SGS-JE-RE027) measure the concentration of radioactive materials in the two main steam lines. Additionally, the main steam line radioisotope concentration data are used to calculate releases to the environment if the steam generator safety relief or power operated relief valves release steam to the atmosphere. Each main steam line radiation monitor meets the guidelines of Regulatory Guide 1.97 as discussed in Appendix 1A and Section 7.5. If the concentration of radioactive materials exceeds a predetermined setpoint, the main steam line radiation monitors initiate alarms in the main control room.

The main steam line radiation monitors are positioned adjacent to the steam lines. Each monitor detector shield is arranged so that the detector sensitive volume is exposed to the radiation originating inside the steam line on which it is located, and is shielded from radiation originating in the other steam line. Radioactive material in the main steam line provides early indication of leakage in the form of a steam generator tube leak. Refer to subsection 5.2.5 for details of leakage monitoring and to Section 10.3 for process system details.

The main steam line radiation monitor detectors use gamma-sensitive detectors.

Each main steam line radiation monitor range and principal isotopes are listed in Table 11.5-1.

The arrangement for a main steam line radiation monitor is shown in Figure 11.5-8.

Service Water Blowdown Radiation Monitor

The service water blowdown radiation monitor (SWS-JE-RE008) measures the concentration of radioactive materials in the blowdown flow from the service water system. Upstream of the radiation monitor, local grab sampling is available.

The service water blowdown radiation monitor initiates an alarm in the main control room if the concentration of radioactive materials exceeds a predetermined setpoint. Following the alarm, the operator can manually isolate the blowdown flow. Refer to subsection 9.2.1 for system details.

The service water blowdown monitor is an offline monitor using a gamma-sensitive, thallium-activated, sodium iodide scintillation detector that views the liquid sample volume. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the service water blowdown radiation monitor is shown in Figure 11.5-7.

Primary Sampling System Liquid Sample Radiation Monitor

The primary sampling system (PSS) liquid sample radiation monitor (PSS-JE-RE050) measures and indicates the concentration of radioactive materials in the samples from the reactor coolant system. The liquid sample radiation monitor's primary function is to indicate elevated sample radiation levels following a design basis or severe accident. High radiation levels show the need for sample dilution to limit operator exposure during sampling and sample transport for analysis. The monitor may also be used to provide early indication of a significant increase in the radioactivity of the reactor coolant indicating a possible fuel cladding breach. When a predetermined setpoint is exceeded, the primary sampling system liquid sample radiation monitor isolates the sample flow by closing the outside containment isolation valve and initiates an alarm in the main control room and locally to alert the operator. Refer to subsection 9.3.3 for system details.

The primary sampling system liquid sample radiation monitor utilizes a gamma-sensitive radiation detector that is adjacent to the sampling line immediately downstream of the sample cooler. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the primary sampling system liquid sample radiation monitor is shown in Figure 11.5-8.

Primary Sampling System Gaseous Sample Radiation Monitor

The primary sampling system gaseous sample radiation monitor (PSS-JE-RE052) measures the concentration of radioactive materials in the gaseous samples taken from containment atmosphere. The gaseous sample radiation monitor is used to provide indication of significant radioactivity in the gaseous sample being taken and the need for dilution of the sample to limit operator exposure during sampling and transport for analysis. When a predetermined setpoint is exceeded, the primary sampling system gaseous sample radiation monitor initiates an alarm locally and in the main control room to alert the operator. Refer to subsection 9.3.3 for system details.

The primary sampling system gaseous sample radiation monitor utilizes a gamma-sensitive radiation detector that is adjacent to the sampling line immediately upstream of the sample bottle. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the primary sampling system gaseous sample radiation monitor is shown in Figure 11.5-8.

Main Control Room Supply Air Duct Radiation Monitors

The main control room supply air duct radiation monitors (particulate detectors VBS-JE-RE001A and VBS-JE-RE001B, iodine detectors VBS-JE-RE002A and VBS-JE-RE002B, and noble gas detectors VBS-JE-RE003A and VBS-JE-RE003B) are offline monitors that continuously measure the concentration of radioactive materials in the air that is supplied to the main control room by the nuclear island nonradioactive ventilation system air handling units. The technical support center ventilation is also part of this air supply system. The air supply is partially outside air. Refer to subsection 9.4.1 for system details. The main control room supply air duct radiation monitors receive safety-related power. When predetermined setpoints are exceeded, the monitors provide signals to initiate the supplemental air filtration system on high gaseous concentration, and to isolate the main control room air intake and exhaust ducts and activate the main control room emergency habitability system on high particulate or iodine concentrations. Alarms are also provided in the main control room for these high concentrations.

The main control room supply air duct radiation monitor components are qualified environmentally and seismically in accordance with the guidelines of Regulatory Guides 1.89 and 1.100, respectively. Each monitor meets the guidelines of Regulatory Guide 1.97 as discussed in Appendix 1A and Section 7.5.

The particulate detectors are beta-sensitive scintillation detectors that view a fixed filter. The iodine detectors are gamma-sensitive, thallium-activated, sodium iodide scintillation detectors that view a fixed charcoal filter. The gas detectors are beta-sensitive scintillation detectors. The range and principal radioisotopes are listed in Table 11.5-1.

The arrangement for a main control room supply air duct radiation monitor is shown in Figure 11.5-6.

Containment Air Filtration Exhaust Radiation Monitor

The containment air filtration exhaust radiation monitor (VFS-JE-RE001) measures the concentration of radioactive materials in the containment purge exhaust air.

The monitor provides an alarm in the main control room when the concentration of radioactive gases in the exhaust exceeds a predetermined setpoint. Refer to subsection 9.4.7 for system details.

The containment air filtration exhaust radiation monitor is an inline monitor that uses a beta-sensitive scintillation detector. It is located downstream of the containment air filtration units with its sensitive volume inside the duct. The detector range and principal radioisotopes are listed in Table 11.5-1.

The arrangement of the containment air filtration exhaust radiation monitor is shown in Figure 11.5-5.

Gaseous Radwaste Discharge Radiation Monitor

The gaseous radwaste discharge radiation monitor (WGS-JE-RE017) measures the concentration of radioactive materials in the releases from the gaseous radwaste system to the plant vent. The measurement is made before the discharge reaches the plant vent or is diluted by any other flows.

The gaseous radwaste discharge radiation monitor provides an alarm in the main control room and terminates the release of radioactive gas to the plant vent by closing the discharge isolation valve when a predetermined setpoint is exceeded. Refer to Section 11.3 for system details.

The monitor is an inline monitor using a beta-sensitive scintillation detector with its sensitive volume inside the piping. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the gaseous radwaste discharge radiation monitor is shown in Figure 11.5-1.

Containment Atmosphere Radiation Monitor

The containment atmosphere radiation monitor measures the radioactive gaseous (PSS-JE-RE026) and N^{13}/F^{18} (PSS-JE-RE027) concentrations in the containment atmosphere. The containment atmosphere radiation monitor is a part of the reactor coolant pressure boundary leak detection system described in subsection 5.2.5. The presence of gaseous or N^{13} radioactivity in the containment atmosphere is an indication of reactor coolant pressure boundary leakage. Refer to subsection 5.2.5 for further details. Conformance with Regulatory Guide 1.45 is discussed in Appendix 1A.

The containment atmosphere radiation monitor accepts analog signal inputs for sample flow and temperature. These signals are used to calculate concentrations at standard conditions.

The radiogas detector is a beta-sensitive scintillation detector. The N^{13}/F^{18} detector is a gamma-sensitive, thallium-activated, sodium iodide scintillation detector with a window at the N^{13}/F^{18} 0.511 MeV decay energy. The ranges and principal isotopes are listed in Table 11.5-1.

The arrangement for the containment atmosphere radiation monitor is shown in Figure 11.5-3.

11.5.2.3.2 Airborne Monitors

Fuel Handling Area Exhaust Radiation Monitor

The fuel handling area exhaust radiation monitor (VAS-JE-RE001) measures the concentration of radioactive materials in the exhaust air from the fuel handling area. This radiation monitor is located upstream of the exhaust air isolation damper.

When a predetermined setpoint is exceeded, the fuel handling area exhaust radiation monitor provides signals to alarm in the main control room, to initiate closure of the fuel handling area supply and exhaust air isolation dampers, to open the fuel handling area exhaust air isolation damper to the containment air filtration exhaust units, and to start a containment air filtration exhaust unit. These actions provide a filtered air path from the fuel handling area to the plant vent. Refer to subsection 9.4.3 for system details.

The fuel handling area exhaust radiation monitor is an inline monitor that uses a beta-sensitive scintillation detector. It is located with the sensitive volume inside the exhaust duct. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the fuel handling area exhaust radiation monitor is shown in Figure 11.5-5.

Auxiliary Building Exhaust Radiation Monitor

radiologically controlled area ventilation system

The auxiliary building exhaust radiation monitor (VAS-JE-RE002) measures the concentration of radioactive materials in the exhaust air from the auxiliary building. The auxiliary building radiation monitor detector is upstream of the exhaust air isolation damper.

When a predetermined setpoint is exceeded, indicating abnormal airborne radiation, the auxiliary building exhaust radiation monitor provides signals to alarm in the main control room, to initiate closure of the auxiliary building supply and exhaust air isolation dampers, to open the auxiliary building exhaust air isolation damper to the containment air filtration exhaust units, and to start a containment air filtration exhaust unit. These actions provide a filtered air path from the auxiliary building to the plant vent. Refer to subsection 9.4.3 for system details.

The auxiliary building exhaust radiation monitor is an inline monitor that uses a beta-sensitive scintillation detector. It is located with the sensitive volume inside the exhaust duct. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the auxiliary building exhaust radiation monitor is shown in Figure 11.5-5.

Annex Building Exhaust Radiation Monitor

radiologically controlled area ventilation system

The annex building exhaust radiation monitor (VAS-JE-RE003) measures the concentration of radioactive materials in the exhaust air from the annex building. The annex building exhaust radiation monitor is located upstream of the annex building exhaust air isolation damper.

When a predetermined setpoint is exceeded, indicating abnormal airborne radiation, the annex building exhaust radiation monitor provides signals to alarm in the main control room, to initiate closure of the annex building supply and exhaust air isolation dampers, to open the annex building exhaust air isolation damper to the containment air filtration units, and to start a containment air filtration exhaust unit. These actions provide a filtered air path from the annex building to the plant vent. Refer to subsection 9.4.3 for system details.

The annex building monitor is an inline monitor that uses a beta-sensitive scintillation detector. It is located with the sensitive volume inside the exhaust duct. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the annex building exhaust radiation monitor is shown in Figure 11.5-5.

Health Physics and Hot Machine Shop Exhaust Radiation Monitor

The health physics and hot machine shop exhaust radiation monitor (detector VHS-JE-RE001) measures the concentration of radioactive materials in the exhaust air from the health physics area and the hot machine shop. The monitor provides an alarm in the main control room when the concentration of radioactive gases in the exhaust exceeds a predetermined setpoint. Refer to subsection 9.4.11 for system details.

The monitor is an offline monitor, located downstream of the exhaust fans, that uses a beta-sensitive scintillation detector viewing a fixed particulate filter. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the health physics and hot machine shop exhaust radiation monitor is shown in Figure 11.5-9.

Radwaste Building Exhaust Radiation Monitor

The radwaste building exhaust radiation monitor (VRS-JE-RE023) measures the concentration of radioactive materials in the exhaust air from the radwaste building. The monitor provides an alarm in the main control room when radioactive material concentrations in the exhaust duct exceed a predetermined setpoint. Refer to subsection 9.4.8 for system details.

The monitor is an offline monitor, located downstream of the exhaust fans, that uses a beta-sensitive scintillation detector viewing a fixed particulate filter. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the radwaste building exhaust radiation monitor is shown in Figure 11.5-9.

11.5.2.3.3 Liquid and Gaseous Effluent Monitors

Plant Vent Radiation Monitor

The plant vent radiation monitor measures the concentration of radioactive airborne contamination being released through the plant vent, which is the only design pathway for the release of radioactive materials to the atmosphere. The plant vent radiation monitor sample is provided using an isokinetic sampling nozzle assembly that has flow sensors. Heat tracing is provided for the sample line. The monitor also provides particulate, iodine, and gaseous grab sampling capability.

The plant vent is sampled continuously for the full range of concentrations between normal conditions and those postulated in Regulatory Guide 1.97. The plant vent radiation monitor is a post-accident monitor and meets the guidelines of Regulatory Guide 1.97 and NUREG-0737 as discussed in Appendix 1A and Section 7.5. Alarms are provided in the main control room if radioactivity concentrations exceed predetermined setpoints. The plant vent radiation monitor also provides data for plant effluent release reports identified in Regulatory Guide 1.21. For further process details, refer to subsection 11.3.3.

The normal range particulate detector, VFS-JE-RE101, uses a beta-sensitive scintillation detector that views a fixed filter. The accident range particulate filter is fixed and identical to the normal range filter. The accident range particulate filter is analyzed in a laboratory.
n on-site

The normal range iodine detector, VFS-JE-RE102, is a gamma-sensitive, thallium-activated, sodium iodide, scintillation detector that views a fixed charcoal filter. The accident range iodine filter is a fixed silver zeolite filter. The accident range iodine filter is analyzed in a n laboratory.
on-site

The three radiogas channels measure the entire specified range, with overlap in the detector ranges. The normal range radiogas detector, VFS-JE-RE103, is a beta-sensitive scintillation detector. The accident range radiogas detectors, VFS-JE-RE104A (high range) and VFS-JE-RE104B (mid-range), are beta/gamma-sensitive detectors with small sensitive volumes compared to the normal range radiogas detector.

The plant vent radiation monitor detector ranges and principal radioisotopes are listed in Table 11.5-1. The arrangement for the plant vent radiation monitor is shown in Figure 11.5-4.

The plant vent radiation monitor accepts analog signal inputs from process and sample sensors for plant vent effluent flow and temperature. These signals are used to control the sample flow to maintain isokinetic extraction at the sample nozzles, and to calculate concentrations, releases and flow rates at standard conditions. These analog signals are also used to calculate total process flow, total sample flow, and total discharge for an operator-selected period.

The normal range particulate, iodine, and radiogas detectors are deactivated automatically when the gas channel concentration exceeds the normal range. The sample flow bypasses the normal range detectors and a small portion is extracted for the accident range particulate and iodine sample filters and radiogas detectors. This prevents normal range detector damage and allows these detectors to be used to measure the concentrations after they decrease again to within the normal range detector ranges.

Turbine Island Vent Discharge Radiation Monitor

The turbine island vent discharge radiation monitor (TDS-JE-RE001) measures the concentration of radioactive gases in the steam and non-condensable gases that are discharged by the condenser vacuum pumps and the gland seal steam condenser. This measurement provides early indication of leakage between the primary and secondary sides of the steam generators. The monitor provides an alarm in the main control room if concentrations exceed a predetermined setpoint. Refer to subsection 5.2.5 for leakage monitoring details and to subsections 10.4.2 and 10.4.3 for process system details. The turbine island vent discharge radiation monitor meets the guidelines of Regulatory Guide 1.97 as discussed in Appendix 1A and Section 7.5.

The turbine island vent discharge radiation monitor provides data for reports of gaseous releases of radioactive materials in accordance with Regulatory Guide 1.21. The monitor is an inline monitor that uses two beta/gamma-sensitive Geiger-Mueller tubes with overlap in the detector ranges. The range and principal isotopes are listed in Table 11.5-1.

The arrangement for the turbine island vent discharge radiation monitor is shown in Figure 11.5-1.

Liquid Radwaste Discharge Radiation Monitor

The liquid radwaste discharge radiation monitor (WLS-JE-RE229) measures the concentration of radioactive materials in liquids released to the environment. The liquid releases are made in batches that are mixed thoroughly and sampled. The samples are analyzed on site before discharge to determine that the discharge is within allowable concentration limits and within allowable totals.

The liquid radwaste discharge radiation monitor provides data for reports of liquid releases of radioactive materials in accordance with Regulatory Guide 1.21.

The liquid radwaste discharge radiation monitor is an offline monitor that provides signals to isolate the discharge of liquid radwaste, stop the liquid radwaste system discharge pumps and alarms in the main control room if the concentrations exceed a predetermined setpoint. For process system details refer to Section 11.2.

The range and principal isotopes are listed in Table 11.5-1. The detector is a gamma-sensitive, thallium-activated, sodium iodide scintillation detector that views the liquid sample volume.

The arrangement for the liquid radwaste discharge radiation monitoring channel is shown in Figure 11.5-7.

Waste Water Discharge Radiation Monitor

The waste water discharge radiation monitor (WWS-JE-RE021) measures the concentration of radioactive materials in the discharge from the waste water system. The waste water discharge radiation monitor provides data for reports of liquid releases of radioactive materials in accordance with Regulatory Guide 1.21.

The waste water discharge radiation monitor is an offline monitor. It stops the turbine drain tank pumps and the basin transfer pumps and initiates an alarm in the main control room if the concentration of radioactive materials exceeds a predetermined setpoint. Following an alarm, the operator can manually realign the discharge to the liquid radwaste system for processing. For process system details refer to subsection 9.2.9.

The range and principal isotopes are listed in Table 11.5-1. The detector is a gamma-sensitive, thallium-activated, sodium iodide scintillation detector that views the liquid sample volume.

The arrangement for the waste water discharge radiation monitor is shown in Figure 11.5-7.

11.5.2.4 Inservice Inspection, Calibration, and Maintenance

The operability of each radiation monitoring system channel is checked periodically.

Test and inspection requirements for safety-related channels and certain nonsafety-related channels are provided in the Technical Specifications, Chapter 16.

11.5.3 Effluent Monitoring and Sampling

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The primary means of quantitatively evaluating the isotopic activities in effluent paths is a program of sampling and laboratory measurements. Gross activity measurements provided by the radiation monitors described in subsection 11.5.2.3 are used to determine the activities released in effluent paths by calibrating the monitors against normalized laboratory results.

Sample points are located on the gaseous effluent radiation monitor skids.

The requirements of General Design Criterion 64 are satisfied by the sampling program and the effluent radiation monitors described in subsection 11.5.2.3.

11.5.4 Process and Airborne Monitoring and Sampling

Radiation monitors are used to initiate automatic closure of isolation valves and dampers in liquid and gaseous process systems as described in subsection 11.5.2.3. These radiation monitors address the requirement of General Design Criterion 60 to suitably control the release of radioactive materials in gaseous and liquid effluents.

Radiation monitors are used in the radioactive waste processing systems as described in subsection 11.5.2.3. These radiation monitors address the requirement of General Design Criterion 63 to monitor radiation levels in radioactive waste systems.

Radiation monitors are used in the ventilation systems as described in subsection 11.5.2.3 to ensure that airborne concentrations within the plant are within the limits of 10 CFR 20.

11.5.5 Post-Accident Radiation Monitoring

The radiation monitors listed below meet the guidelines of Regulatory Guide 1.97 and are described in subsections 11.5.2.3 and 11.5.6.2. For further Regulatory Guide 1.97 information refer to Appendix 7A and Section 7.5.

- Main steam line radiation monitors

- Steam generator blowdown radiation monitor

- Main control room supply air duct radiation monitors

- Plant vent radiation monitor

- Turbine island vent discharge radiation monitor

- Containment high range radiation monitors

- Primary sampling room area monitor

- Technical support center area monitor

The post-accident sampling system is described in subsection 9.3.3 and is used to obtain samples for laboratory analysis, including radioisotopic analysis, after a postulated accident.
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11.5.6 Area Radiation Monitors

The area radiation monitors are provided to supplement the personnel and area radiation survey provisions of the AP600 health physics program described in Section 12.5 and to comply with the personnel radiation protection guidelines of 10 CFR 20, 10 CFR 50, 10 CFR 70, and Regulatory Guides 1.97, 8.2, 8.8, and 8.12.

During refueling operations in containment and the fuel handling area, criticality monitoring functions, as stated in 10 CFR 70.24 and Regulatory Guide 8.12, are performed by the area radiation monitors in combination with portable bridge monitors.

11.5.6.1 Design Objectives

The design objectives of the area radiation monitors during normal operating plant conditions and anticipated operational occurrences are to:

- Measure the radiation intensities in specific areas of AP600

- Warn of uncontrolled or inadvertent movement of radioactive material in AP600

- Provide local and remote indication of ambient gamma radiation and local and remote alarms at key points where substantial changes in radiation flux might be of immediate importance to personnel

- Annunciate and warn of possible equipment malfunctions and leaks in specific areas of AP600

- Furnish information for radiation surveys

- Minimize the time, effort, and radiation received by operating personnel during routine maintenance and calibration

- Incorporate modular design concepts throughout, to provide easy maintenance

By meeting the above objectives, the radiation monitoring system aids health physics personnel in keeping radiation exposures as-low-as-reasonably-achievable (ALARA).

Locations of area monitor detectors are based on the following criteria:

- Area monitors are located in areas that are normally accessible and where changes in normal plant operating conditions can cause significant increases in exposure rates above those expected for the areas.

- Area monitors are located in areas that are normally or occasionally accessible where significant increases in exposure rates might occur because of operational transients or maintenance activities.

- Area monitors are located to best measure the increase in exposure rates within a specific area and to avoid shielding of the detector by equipment or structural materials.

- In the selection of area monitors, consideration is given to the environmental conditions under which the monitor operates.

- Area monitors are located to provide access so that minimal maintenance equipment is required and to provide an uncluttered area near the detector and local processing electronics to allow for field alignment and calibration.

The area radiation monitors are listed in Table 11.5-2.

11.5.6.2 Post-Accident Area Monitors

The following area monitors are provided to meet Regulatory Guide 1.97 guidelines as discussed in Appendix 1A and Section 7.5.

Containment High Range Radiation Monitor

The containment high range radiation monitors (PXS-JE-RE160, PXS-JE-RE161, PXS-JE-RE162, and PXS-JE-RE163) measure the radiation from the radioactive gases in the containment atmosphere. The monitors receive safety-related power. The detectors are ion chambers, designed to measure the radiation from the radioactive gases inside the containment in accordance with Regulatory Guide 1.97 and NUREG-0737. The monitors are qualified environmentally and seismically in accordance with the guidelines of Regulatory Guides 1.89 and 1.100, respectively.

The containment high range radiation data are displayed in the main control room. When predetermined setpoints are exceeded, the containment high range radiation monitors provide main control room alarms and signals to the protection and safety monitoring system for containment air filtration isolation and normal residual heat removal system valve closure (refer to Section 7.3 for further details). The containment high range radiation monitors provide data for maintaining a record of the gamma radiation intensities after a postulated accident as a function of time, so that the inventory of radioactive materials in the containment volume can be estimated.

The range and principal isotopes are listed in Table 11.5-1.

The high range radiation detectors are mounted inside the containment on the containment wall in widely separated locations. The locations allow the detectors to be exposed to a significant volume of containment atmosphere without obstruction so that the readouts are representative of the containment atmosphere. The arrangement for a containment high range monitor is shown in Figure 11.5-2.

Primary Sampling Room Area Monitor

The primary sampling station is the location where samples are collected and/or analyzed after a postulated accident. The primary sampling room area radiation monitor (RAMS-JE-RE008) is located so that its readout is representative of the radiation to which the operating personnel are exposed. A local readout, an audible alarm, and visual alarms are provided in the primary sampling room to alert operating personnel to increasing exposure rates. A local readout, an audible alarm, and visual alarms are provided outside of the primary sampling room and are visible to operating personnel prior to entry. Indication and alarms are also provided in the main control room.

The monitor is an extended range monitor that uses a gamma-sensitive ion chamber. The monitor range and principal isotopes are listed in Table 11.5-2.

Technical Support Center Area Monitor

The Technical Support Center is the location from which engineering support will be provided to the operators following a postulated accident. The Technical Support Center area radiation monitor (RAMS-JE-RE016) is located so that its readout is representative of the radiation to which the support personnel are exposed. A local readout, an audible alarm, and visual alarms are provided locally to alert personnel to increasing exposure rates. A local readout, an audible alarm, and visual alarms are provided outside of the room and are visible to personnel prior to entry. Indication and alarms are also provided in the main control room.

The monitor is a normal range monitor that uses a gamma-sensitive Geiger-Mueller tube. The monitor range and principal isotopes are listed in Table 11.5-2.

11.5.6.3 Normal Range Area Monitors

Normal range area radiation monitors are located in accordance with the location criteria given in subsection 11.5.6.1. A local readout, an audible alarm, and visual alarms are provided in each monitored area to alert operating personnel to increasing exposure rates. Visual alarms are provided outside of each monitored area so that they are visible to operating personnel prior to entry. Indication and alarms are also provided in the main control room.

The monitor detectors are gamma-sensitive Geiger-Mueller tubes. The monitors and their ranges, and principal isotopes are listed in Table 11.5-2.

11.5.6.4 Quality Assurance

Guidance for the quality assurance program for design, procurement, fabrication and installation issues is outlined in Section 17.1.

11.5.7 Combined License Information

The Combined License applicant will develop an offsite dose calculation manual that contains the methodology and parameters used for calculation of offsite doses resulting from gaseous and liquid effluents. The ~~Combined License applicant~~ will address operational setpoints for the radiation monitors and address programs for monitoring and controlling the release of radioactive material to the environment, which eliminates the potential for unmonitored and uncontrolled release. The offsite dose calculation manual will include planned discharge flow rates. The Combined License applicant will demonstrate that the process and effluent monitoring and sampling are in compliance with ANSI N13.1-19?? and Regulatory Guides 1.21 and 4.15. The Combined License applicant will demonstrate compliance with 10CFR50, Appendix I guidelines for maximally exposed offsite individual doses and population doses via liquid and gaseous effluents.

Table 11.5-1 (Sheet 1 of 2)

RADIATION MONITOR DETECTOR PARAMETERS

Detector	Type	Service	Isotopes	Nominal Range
BDS-JE-RE010	γ	Steam Generator Blowdown Electrodeionization Effluent	Cs-137	1.0E-6 to 1.0E-1 μCi/cc
BDS-JE-RE011	γ	Steam Generator Blowdown Electrodeionization Brine	Cs-137	1.0E-6 to 1.0E-1 μCi/cc
CCS-JE-RE001	γ	Component Cooling Water System	Cs-137	1.0E-7 to 1.0E-2 μCi/cc
VFS-JE-RE101	β	Plant Vent Particulate	Sr-90 Cs-137	1.0E-12 to 1.0E-7 μCi/cc
VFS-JE-RE102	γ	Plant Vent Iodine	I-131	1.0E-11 to 1.0E-6 μCi/cc
VFS-JE-RE103	β	Plant Vent Gas (Normal Range)	Kr-85 Xe-133	1.0E-7 to 1.0E-2 μCi/cc
VFS-JE-RE104A	β/γ	P.V. Extended Range Gas (Accident High Range)	Kr-85 Xe-133	1.0E-1 to 1.0E+5 μCi/cc
VFS-JE-RE104B	β/γ	P.V. Extended Range Gas (Accident Mid Range)	Kr-85 Xe-133	1.0E-4 to 1.0E+2 μCi/cc
PSS-JE-RE026	β	Containment Atmosphere Gas (Note 2)	Kr-85 Xe-133	1.0E-7 to 1.0E-2 μCi/cc
PSS-JE-RE027	γ	Containment Atmosphere N^{13}/F^{18} (Note 2)	N-13 F-18	1.0E-7 to 1.0E-2 μCi/cc
PSS-JE-050	γ	Primary Sampling Liquid	I-131 Cs-137	1.0E-4 to 1.0E+2 μCi/cc
PSS-JE-052	γ	Primary Sampling Gaseous	Kr-85 Xe-133	1.0E-7 to 1.0E-2 μCi/cc
SGS-JE-RE026	γ	Main Steam Line	Cs-137	1.0E-1 to 1.0E+3 μCi/cc
SGS-JE-RE027	γ	Main Steam Line	Cs-137	1.0E-1 to 1.0E+3 μCi/cc
SWS-JE-RE008	γ	Service Water Blowdown	Cs-137	1.0E-7 to 1.0E-2 μCi/cc
TDS-JE-RE001	β/γ	Turbine Island Vent Discharge (Note 3)	Kr-85 Xe-133	1.0E-6 to 1.0E+5 μCi/cc (Note 4)
VAS-JE-RE001	β	Fuel Handling Area Exhaust	Kr-85 Xe-133	1.0E-6 to 1.0E-1 μCi/cc
VAS-JE-RE002	β	Auxiliary Building Exhaust	Kr-85 Xe-133	1.0E-6 to 1.0E-1 μCi/cc
VAS-JE-RE003	β	Annex Building Exhaust	Kr-85 Xe-133	1.0E-6 to 1.0E-1 μCi/cc
VBS-JE-RE001A	β	Main Control Room Supply Air Duct (Particulate) (Note 1)	Sr-90 Cs-137	1.0E-12 to 1.0E-7 μCi/cc
VBS-JE-RE001B	β	Main Control Room Supply Air Duct (Particulate) (Note 1)	Sr-90 Cs-137	1.0E-12 to 1.0E-7 μCi/cc
VBS-JE-RE002A	γ	MCR Supply Air Duct (Iodine) (Note 1)	I-131	1.0E-11 to 1.0E-5 μCi/cc
VBS-JE-RE002B	γ	MCR Supply Air Duct (Iodine) (Note 1)	I-131	1.0E-11 to 1.0E-5 μCi/cc

Table 11.5-1 (Sheet 2 of 2)

RADIATION MONITOR DETECTOR PARAMETERS

Detector	Type	Service	Isotopes	Nominal Range
VBS-JE-RE003A	β	MCR Supply Air Duct (Gas) (Note 1)	Kr-85 Xe-133	1.0E-7 to 1.0E-2 μCi/cc
VBS-JE-RE003B	β	MCR Supply Air Duct (Gas) (Note 1)	Kr-85 Xe-133	1.0E-7 to 1.0E-2 μCi/cc
VFS-JE-RE001	β	Containment Air Filtration Exhaust	Kr-85 Xe-133	1.0E-6 to 1.0E-1 μCi/cc
VHS-JE-RE001	β	H.P. & Hot Machine Shop Exhaust	Sr-90 Cs-137	1.0E-13 to 1.0E-7 μCi/cc
VRS-JE-RE023	β	Radwaste Building Exhaust	Sr-90 Cs-137	1.0E-13 to 1.0E-7 μCi/cc
WGS-JE-RE017	β	Gaseous Radwaste Discharge	Kr-85 Xe-133	1.0E-5 to 1.0E+1 μCi/cc
WLS-JE-RE229	γ	Liquid Radwaste Discharge	Cs-137	1.0E-7 to 1.0E-2 μCi/c
WWS-JE-RE021	γ	Waste Water Discharge	Cs-137	1.0E-7 to 1.0E-2 μCi/cc

Notes:

1. Safety-related
2. Seismic Category 1
3. The condenser air removal system (CMS) and the gland seal system (GSS) discharge into the turbine island vents, drains and relief system (TDS). The exhaust from the TDS into the turbine island vent is continuously monitored for radiation.
4. Turbine Island Vent Radiation Monitor includes two GM tubes with nominal ranges of 1.0E-6 to 1.0E+0 μCi/cc and 1.0E-1 to 1.0E+5 μCi/cc.

Table 11.5-2

AREA RADIATION MONITOR DETECTOR PARAMETERS

Detector	Type	Service	Nominal Range
PXS-JE-RE160	γ	Containment High Range (Note 3)	1.0E-0 to 1.0E+7 R/hr
PXS-JE-RE161	γ	Containment High Range (Note 3)	1.0E-0 to 1.0E+7 R/hr
PXS-JE-RE162	γ	Containment High Range (Note 3)	1.0E-0 to 1.0E+7 R/hr
PXS-JE-RE163	γ	Containment High Range (Note 3)	1.0E-0 to 1.0E+7 R/hr
RMS-JE-RE008	γ	Primary Sampling Room	1.0E-1 to 1.0E+7 mR/hr
RMS-JE-RE009	γ	Containment Area - Personnel Hatch	1.0E-1 to 1.0E+4 mR/hr (Note 1)
RMS-JE-RE010	γ	Main Control Room	1.0E-1 to 1.0E+4 mR/hr
RMS-JE-RE011	γ	Chemistry Laboratory Area	1.0E-1 to 1.0E+4 mR/hr
RMS-JE-RE012	γ	Fuel Handling Area	1.0E-1 to 1.0E+4 mR/hr (Note 2)
RMS-JE-RE013	γ	Rail Car Bay Area/Auxiliary Bldg. Loading Bay (Note 4)	1.0E-1 to 1.0E+4 mR/hr
RMS-JE-RE014	γ	Liquid and Gaseous Radwaste Area	1.0E-1 to 1.0E+4 mR/hr
RMS-JE-RE016	γ	Technical Support Center	1.0E-1 to 1.0E+4 mR/hr
RMS-JE-RE017	γ	Radwaste Bldg. Mobile Systems Facility (Note 4)	1.0E-1 to 1.0E+4 mR/hr
RMS-JE-RE018	γ	Hot Machine Shop	1.0E-1 to 1.0E+4 mR/hr
RMS-JE-RE019	γ	Annex Staging & Storage Area	1.0E-1 to 1.0E+4 mR.hr

Notes:

1. Radiation levels are monitored by the permanent containment area radiation monitor and by a portable bridge monitor during refueling operations. The containment area radiation monitor is located to best measure the increase in exposure rates for this area and to provide an alarm locally and in the main control room.

2. Radiation levels are monitored by the permanent fuel handling area radiation monitor and by a portable bridge monitor during fuel handling operations. The fuel handling area radiation monitor is located to best measure the increase in exposure rates for this area and to provide an alarm locally and in the main control room.

3. Safety-related

4. Monitors areas used for storage of wet wastes (including processed and packaged spent resins) and dry wastes.

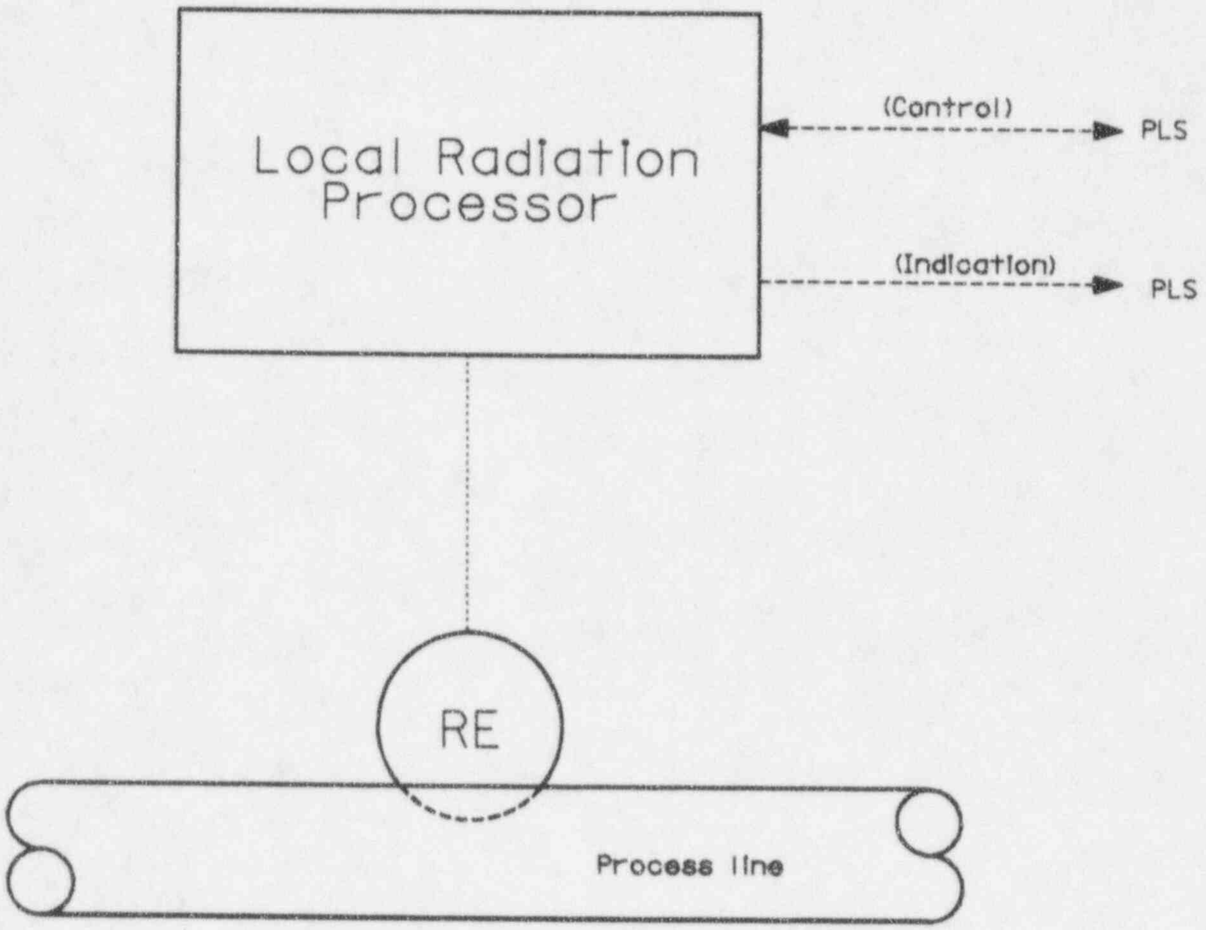

Figure 11.5-1

Process In-Line Radiation Monitor

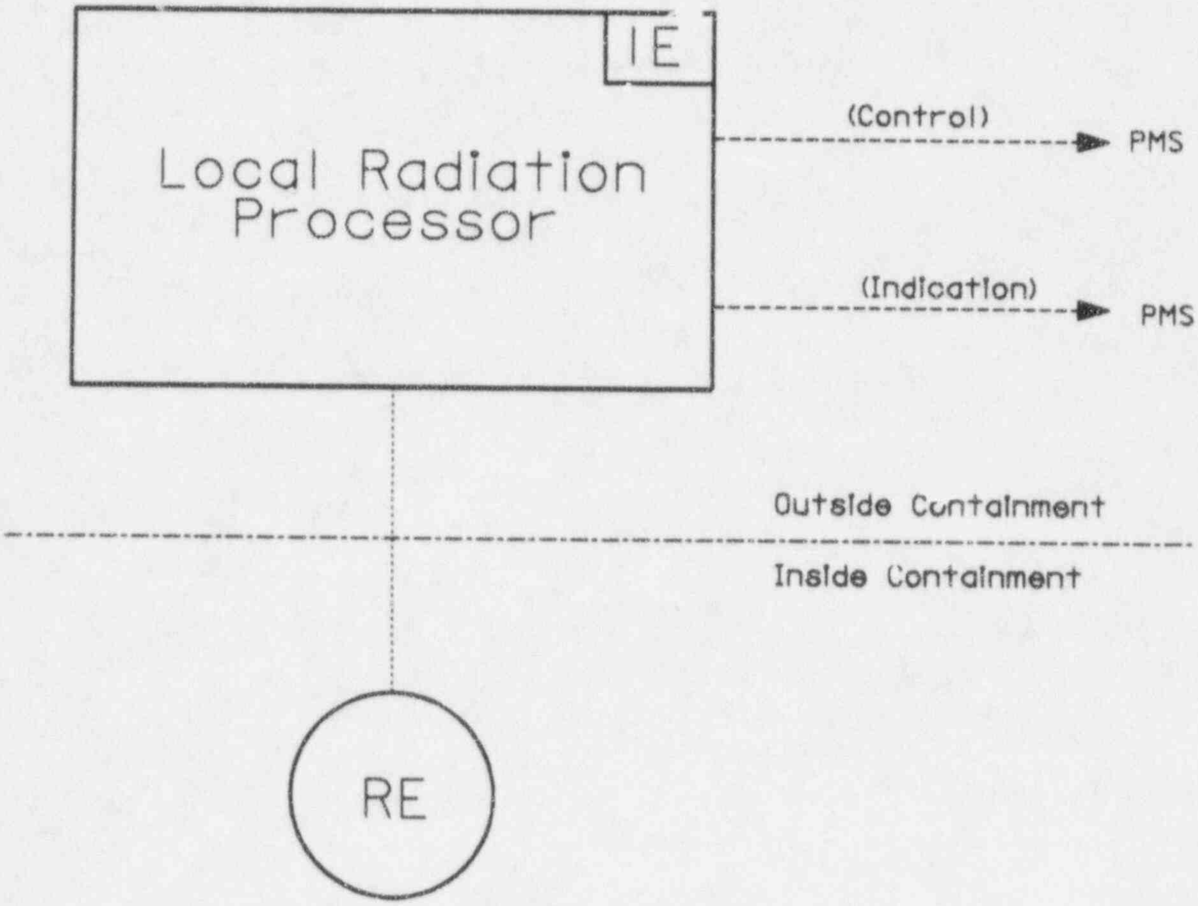

Figure 11.5-2

Safety-Related Containment High Range Radiation Monitor

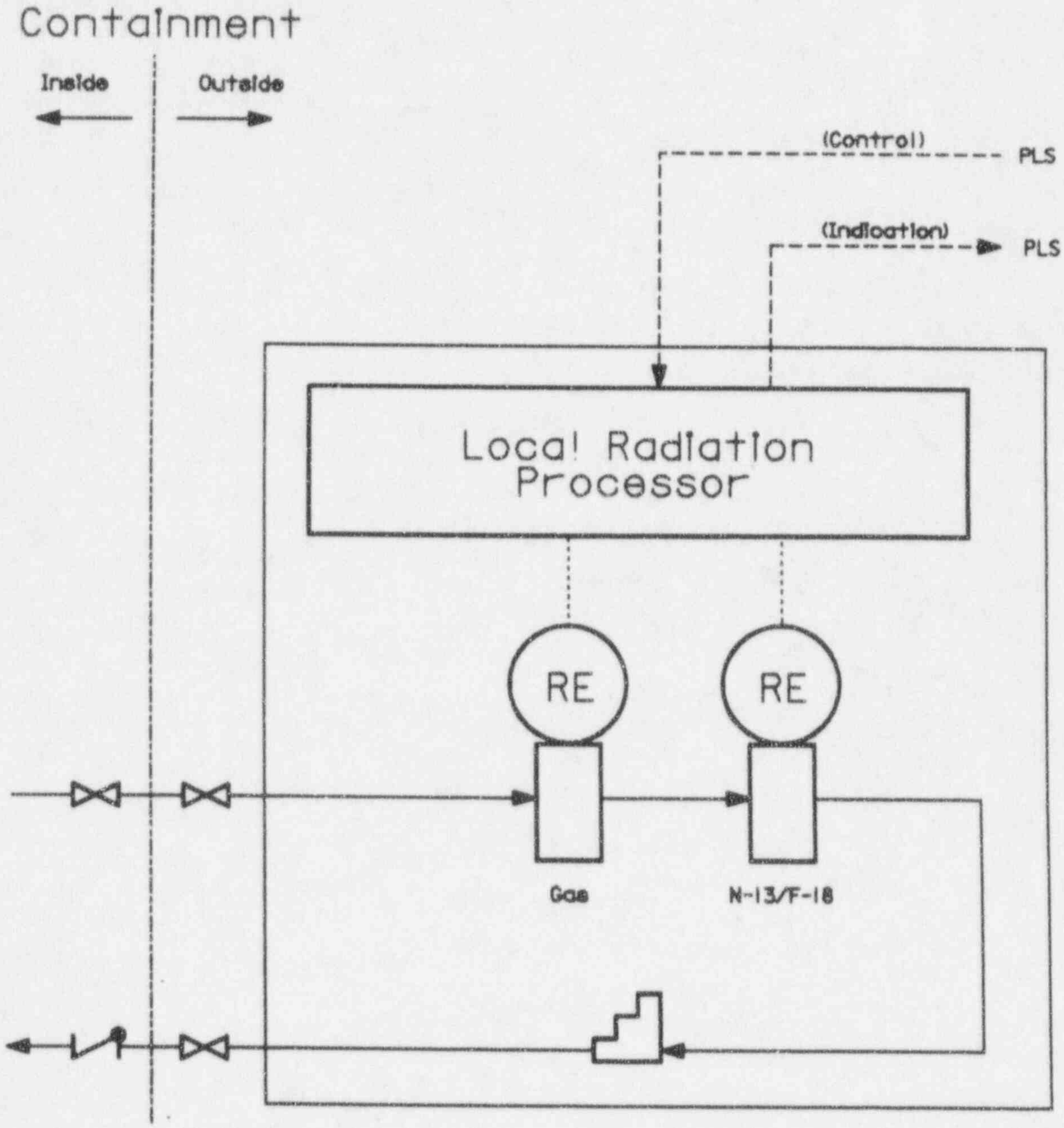

Figure 11.5-3

Containment Atmosphere Radiation Monitor

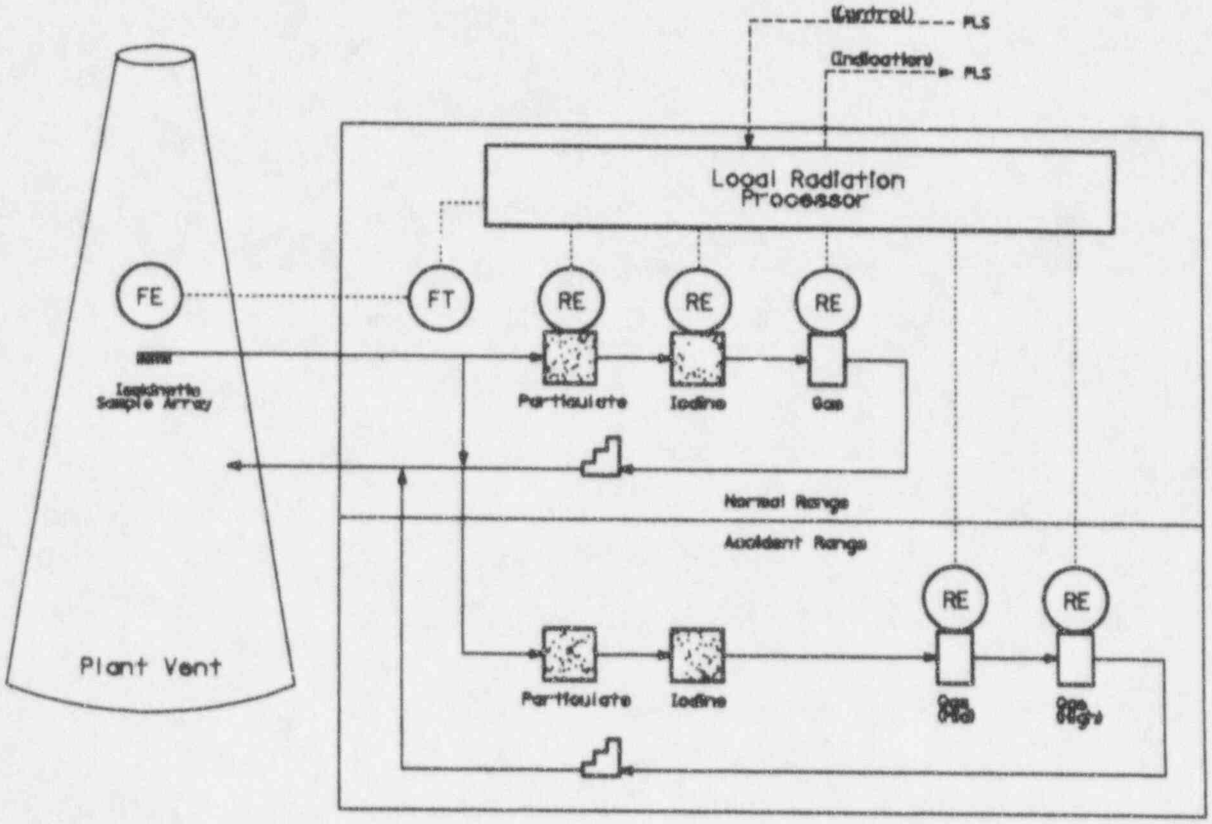

Figure 11.5-4

Plant Vent Radiation Monitor

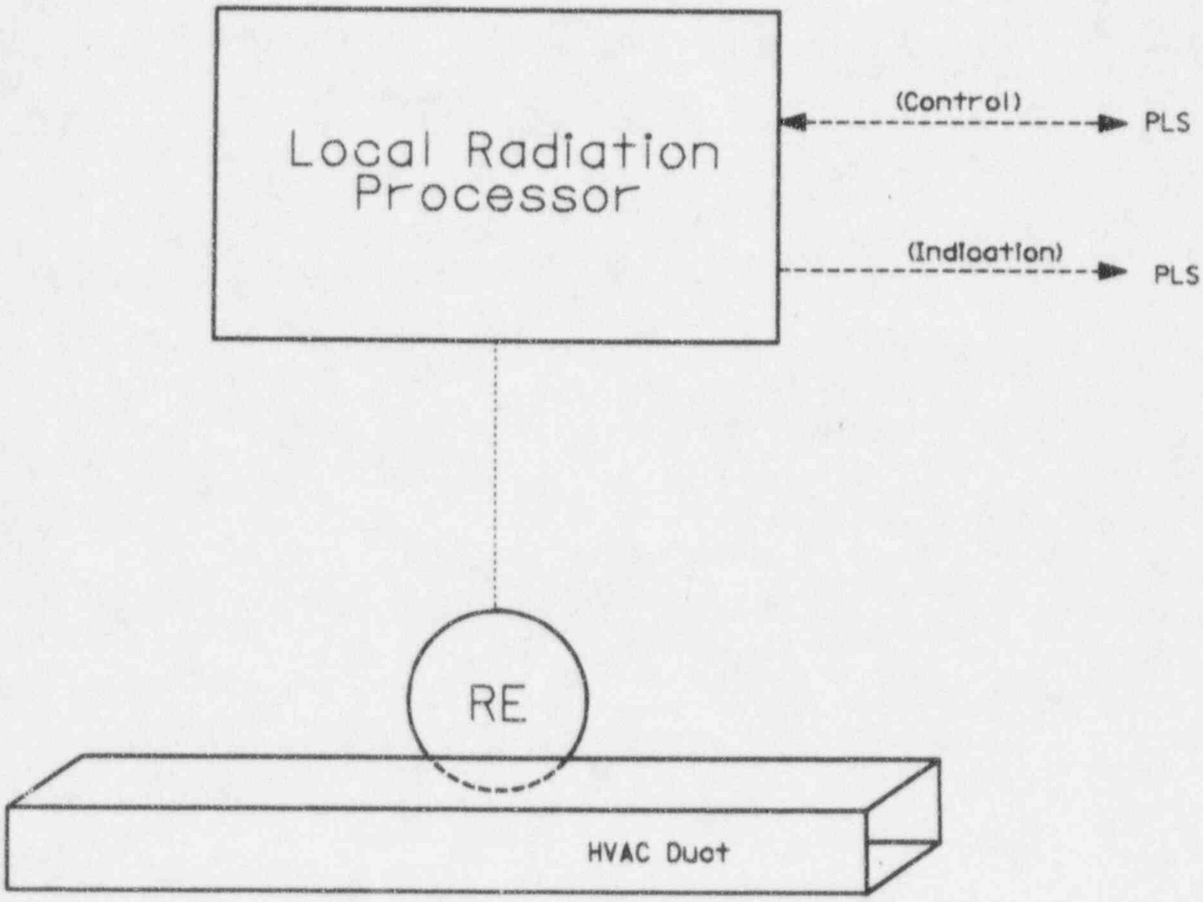

Figure 11.5-5

In-Line HVAC Duct Radiation Monitor

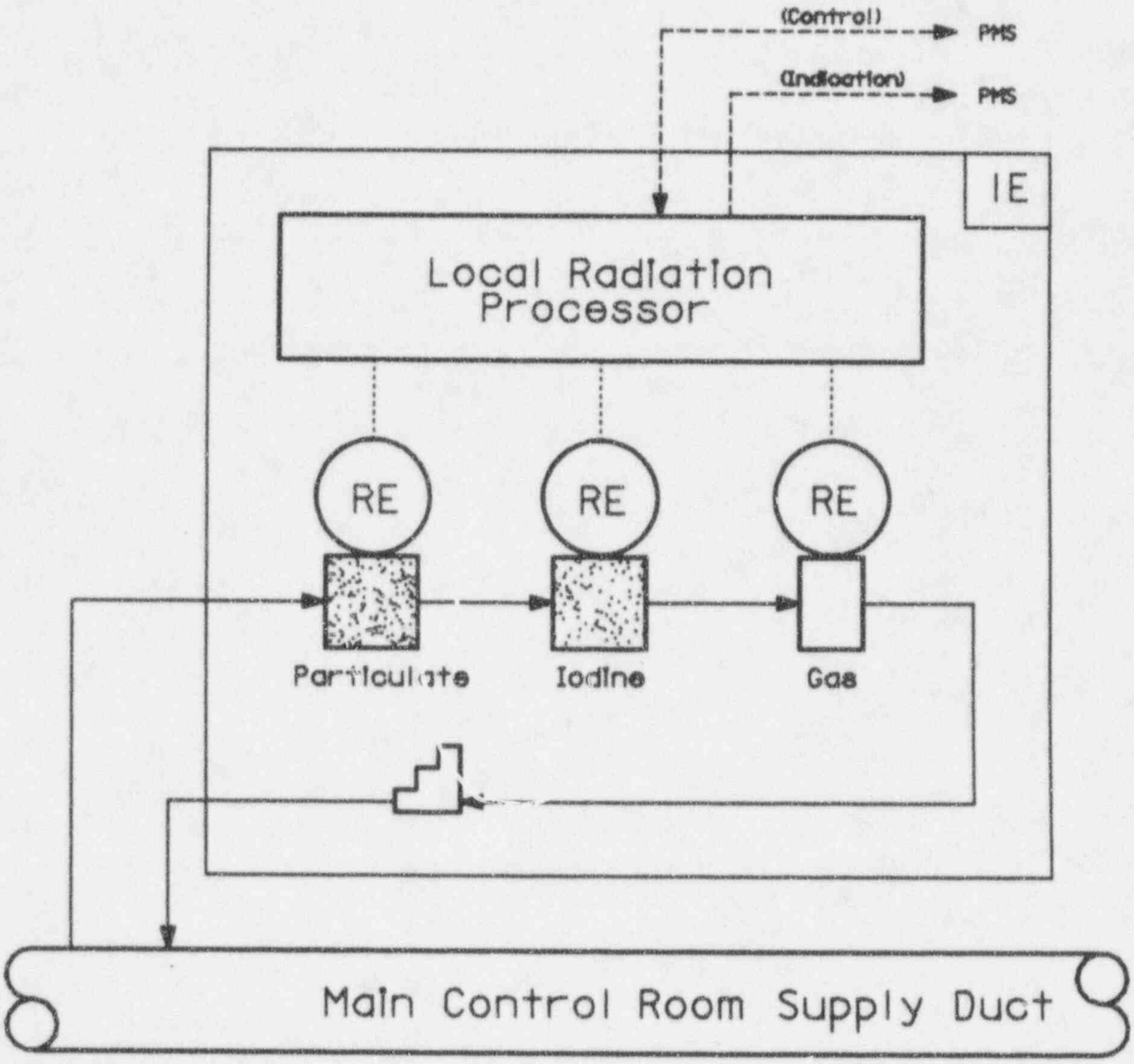

Figure 11.5-6

Safety-Related Main Control Room Supply Duct Radiation Monitor

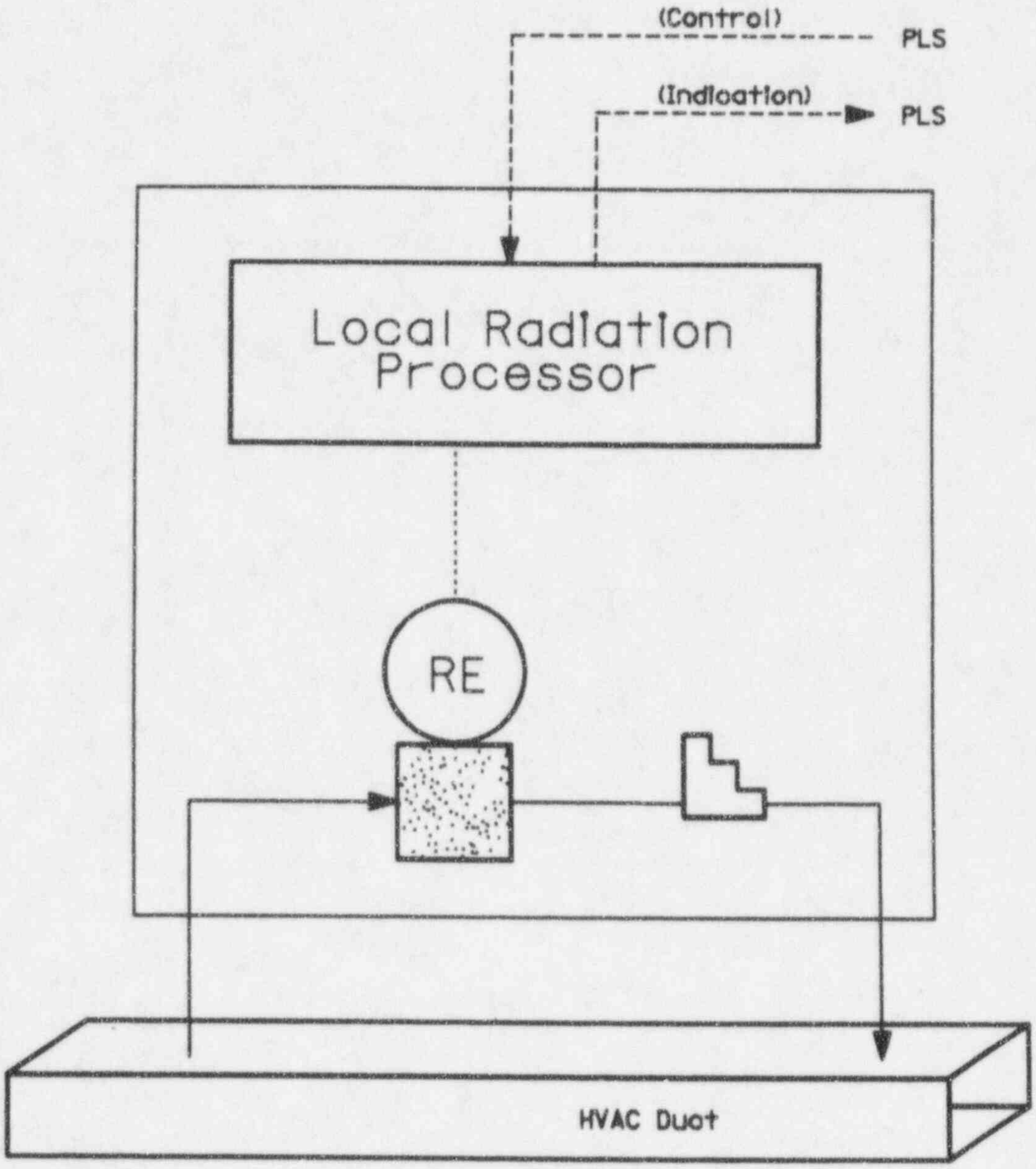

Figure 11.5-9

HVAC Duct Particulate Radiation Monitor

The circled numbers in the margin of the marked-up SSAR pages for sections 9.2 and 10.4.5 correspond to the numbers in NRC FAX from T. Kenyon to W Jim Winters dated May 9, 1996.

processed in the demineralized water transfer and storage system to remove dissolved oxygen. In addition to supplying water for makeup of systems which require pure water, the demineralized water is used to sluice spent radioactive resins from the ion exchange vessels in the chemical and volume control system (as described in subsection 9.3.6), the spent fuel pool cooling system (as described in subsection 9.1.3), and the liquid radwaste system (as described in section 11.2) to the solid radwaste system.

The demineralized water treatment system is described in subsection 9.2.3.

9.2.4.1 Design Basis

9.2.4.1.1 Safety Design Basis

The demineralized water transfer and storage system serves no safety-related function other than containment isolation, and therefore has no nuclear safety-related design basis except for containment isolation. See subsection 6.2.3 for the containment isolation system.

9.2.4.1.2 Power Generation Design Basis

- The demineralized water transfer and storage system provides demineralized water through the demineralized water storage tank to fill the condensate storage tank and to meet required demands and usages of demineralized water in other plant systems.

- The demineralized water transfer pumps provide adequate capacity and head for the distribution of demineralized water.

- The demineralized water storage tank supplies a source of demineralized water to the chemical and volume control makeup pumps during startup and required boron dilution evolutions. The demineralized water transfer and storage system supplies the required amount of water to the chemical and volume control system for reactor water makeup.

① This provides a functional requirement

- The oxygen content of water supplied to the demineralized water distribution system from the demineralized water storage tank is 100 ppb or less.

- Sufficient storage capacity is provided in the condensate storage tank to satisfy condenser makeup demand based on maximum steam generator blowdown operation during a plant startup duration.

- The condensate storage tank provides the water supply for the startup feedwater pumps during startup, hot standby, and shutdown conditions.

- The condensate storage tank provides a sufficient supply of water to the startup feedwater system to permit 8 hours of hot standby operation, followed by an orderly plant cooldown from normal operating temperature to conditions which permit operation of the normal residual heat removal system over a period of approximately 6 hours.

- The piping from the condensate storage tank to the startup feedwater pumps allows adequate net positive suction head (NPSH) at maximum tank water temperature and minimum water level.

- The condensate storage tank serves as a reservoir to supply or receive condensate as required by the condenser hotwell level control system.

① This provides a functional requirement

- The oxygen content of water stored in the condensate storage tank is 100 ppb or less.

9.2.4.2 System Description

9.2.4.2.1 General Description

Component and equipment classification for the demineralized water transfer and storage system is given in Section 3.2.

9.2.4.2.2 Component Description

Demineralized Water Storage Tank

The demineralized water storage tank has a capacity of approximately 100,000 gallons. The tank is a vertical cylindrical tank constructed of stainless steel. The tank is provided with level and temperature instrumentation; level controls the operation of the demineralized water treatment system and sends a signal to the reverse osmosis feed pumps to start and stop, thus supplying water to the storage tank. Tank temperature is monitored and controls an immersion-type electric heater to keep the tank contents from freezing.

Demineralized Water Transfer Pump

Two motor-driven, centrifugal, horizontal pumps, located near the demineralized water storage tank, provide the plant demineralized water distribution system pressure and capacity. Each pump provides full flow recirculation through the catalytic oxygen reduction unit as well as providing the required system demand.

Catalytic Oxygen Reduction Units

Oxygen control of the demineralized water is performed by catalytic oxygen reduction units. Two catalytic oxygen reduction units are used in the AP600 plant. One unit is provided for the demineralized water distribution system as water is pumped from the tank to the distribution system. The second unit is provided at the condensate storage tank to maintain a low oxygen content within the tank and is used in a recirculation path around the tank.

Each catalytic oxygen reduction unit consists of a mixing chamber, a catalytic resin vessel, and a resin trap. The mixing chamber is a stainless steel, in-line, static mixer where dissolution of the reducing agent occurs. Dissolved oxygen is removed chemically by mixing the effluent from the storage tank with hydrogen gas. Hydrogen is supplied from the plant gas system. The resin vessel is a rubber lined, carbon steel vessel containing catalytic resin. The stainless steel resin trap contains a cartridge filter to collect resin fines discharged from the resin vessel.

Condensate Storage Tank

The condensate storage tank has a capacity of 300,000 gallons and is a vertical cylindrical tank constructed of stainless steel. Level and temperature instrumentation are provided with the tank level controlled by the makeup valve. Freeze protection is supplied by immersion-type electric heaters.

9.2.4.3 System Operation

9.2.4.3.1 Normal Operation

The water level in the demineralized water storage tank controls the demineralized water treatment system. When the level in the demineralized water storage tank falls to a preset level, the pumps in the demineralized water treatment system start automatically. High water level in the tank stops operation of the demineralized water treatment system. This action, along with the capacitance in the tank, maintains the desired volume to supply the expected demands for demineralized water during normal plant operation.

The demineralized water transfer pumps, taking suction from the demineralized water storage tank, supply water through a catalytic oxygen reduction unit to the demineralized water distribution header. From this header, demineralized water is supplied to the condensate storage tank, is supplied as makeup to the chemical and volume control system pumps, and is distributed throughout the plant. The demineralized water distribution header pressure is maintained by the operation of one transfer pump. This pump recirculates water that exceeds system demand to the demineralized water storage tank. Controls are provided to automatically start the second pump upon failure of the first to maintain system pressure and demand. A low level alarm on the demineralized water storage tank signals the plant operator to isolate demands on the tank other than chemical and volume control system supply. Demineralized water is distributed to the containment, auxiliary, radwaste, annex, and turbine buildings for system usage.

② No reserved water is required since the demin transfer pump can supply "...water that exceeds system demand..." and the pumps will start automatically once level falls to preset level.

The condensate storage tank level is maintained by a level control valve in the tank supply line. The valve opens when the water level in the tank drops to a specified level and closes when the level increases to a specified setpoint. When high oxygen levels exist in the condensate storage tank, an oxygen analyzer signal starts the catalytic oxygen reduction unit pump. The pump is shut off when low levels of oxygen are detected. Low oxygen demineralized water is circulated from the tank outlet connection, through the catalytic oxygen reduction unit, and is returned to the tank via the normal inlet supply line of the tank. An orifice controls the recirculation pressure and flow returning to the tank.

Changes in the condensate system inventory are controlled by the condenser hotwell level system. As level falls in the hotwell, makeup from the condensate storage tank is supplied to the hotwell by the makeup control valve. As level rises in the hotwell, condensate is rejected to the condensate storage tank via the condensate pump's discharge control valve. Subsection 10.4.1 describes the function of the condenser hotwell level system.

In the event the main feedwater system is unavailable to supply water to the steam generators during startup, hot standby, or shutdown, the startup feedwater pumps may be activated and require water from the condensate storage tank. Subsection 10.4.9 describes the startup feedwater system function and operation.

Water supplied from the condensate storage tank to the auxiliary steam supply system is described in subsection 10.4.10.

9.2.4.4 Safety Evaluation

The demineralized water transfer and storage system has no safety-related function other than for containment isolation, and therefore requires no nuclear safety evaluation, other than containment isolation which is described in subsection 6.2.3.

Failure of system components has no impact on safety-related systems, structures, or components. Flooding due to demineralized water transfer and storage system component failures which may affect safe shutdown equipment are described in Section 3.4.

The condensate storage tank normally contains no significant radioactive contaminants.

A check valve or atmospheric gap, in conjunction with a block valve or control valve, is used to prevent backflow of fluids from systems that interface with the demineralized water transfer and storage system. For interfacing systems that have a higher operating pressure than the demineralized water transfer and storage system and that normally do not require a supply of demineralized water during plant operations, a check valve with a normally closed block valve is used. For interfacing systems that have a higher operating pressure than the demineralized water transfer and storage system and that normally require demineralized water during plant operations, a check valve is used to prevent backflow into the demineralized water transfer and storage system. For interfacing systems with a lower operating pressure than the demineralized water transfer and storage system, system operating pressure prevents backflow into the demineralized water transfer and storage system; when the demineralized water transfer and storage system is shut down for maintenance, the check valve, closed block or control valve, or atmospheric gap is relied upon to prevent backflow into the demineralized water transfer and storage system.

9.2.4.5 Tests and Inspections

Proper system performance and integrity during normal plant operation are confirmed by system operation and visual inspections.

Grab samples may be taken from the demineralized water storage tank or the condensate storage tank to verify water chemistry is maintained within acceptable limits. Grab samples are taken to the secondary sampling laboratory for analysis. Water chemistry specifications for demineralized water supplied to the demineralized water transfer and storage system are described in subsection 9.2.3.

9.2.4.6 Instrumentation Applications

Water level is measured and automatically controlled and alarmed in the demineralized water and condensate storage tanks.

3

Instrumentation is provided to control the recirculation and distribution of demineralized water from the storage tank through the pumps and to the supply header and condensate storage tank. Controls are provided for automatic starting of the demineralized water transfer and storage system pumps.

See Insert A

An oxygen analyzer signal starts and stops the condensate storage tank catalytic oxygen reduction unit pump on low and high oxygen levels.

9.2.5 Potable Water System

9.2.5.1 Design Basis

The potable water system (PWS) is designed to furnish water for domestic use and human consumption. It complies with the following standards:

- Bacteriological and chemical quality requirements as referenced in EPA "National Primary Drinking Water Standards," 40 CFR Part 141.
- The distribution of water by the system is in compliance with 29 CFR 1910, Occupational Safety and Health Standards, Part 141.

9.2.5.1.1 Safety Design Basis

The potable water system serves no safety-related function and therefore has no nuclear safety design basis.

9.2.5.1.2 Power Generation Design Basis

- Potable water is supplied to provide a quantity of 100 gallons/person/day for the largest number of persons expected to be at the station during a 24-hour period during normal plant power generation or outages.
- Water heaters provide a storage capacity equal to the probable hourly demand for potable hot water usage and provide hot water for the main lavatory, shower areas, and other locations where needed.

INSERT A

Monitoring of the demineralized water transfer and storage system is performed through the data display and processing system. Control functions are performed by the plant control system. Appropriate alarms and displays are available in the control room. See Chapter 7.

- A minimum pressure of 20 psig is maintained at the furthermost point in the distribution system.
- No interconnections exist between the potable water system and any potentially radioactive system or any system using water for purposes other than domestic water service.

9.2.5.2 System Description

9.2.5.2.1 General Description

Classification of components and equipment for the potable water system is given in Section 3.2.

The source of water for the potable water system is the raw water system. The potable water system consists of a potable water storage tank, two potable water pumps, a jockey pump, a distribution header around the power block, hot water storage heaters, and necessary interconnecting piping and valves. Disinfection is by a liquid sodium hypochlorite chlorination system (see subsection 10.4.11, turbine island chemical feed system for details) provided upstream of the potable water storage tank.

9.2.5.2.2 Component Description

Potable Water Storage Tank

capacity less than 10,000 gallons and

(4) The potable water storage facility consists of a carbon steel tank with coated interior which stores water for distribution throughout the plant.

Potable Water Pumps

Each of the two motor-driven potable water pumps takes suction from the potable water storage tank and discharges to the domestic water distribution header. The pumps are operated as required to meet the potable water demand in the plant at a minimum supply pressure of 20 psig.

Jockey Pump

A continuously operated jockey pump is used to supply potable water to the distribution header and maintains the pressure of the system during low-flow requirement periods. This motor-driven pump takes suction from the potable water system storage tank and pumps water through the distribution system. A recirculation line to the potable water system storage tank is provided to allow continuous running of the jockey pump when the system demand is low.

Hot Water Heaters

Electric immersion heating elements located inside the potable water hot water tank are used to produce hot water. This hot water is routed to the shower and toilet areas and to other plumbing fixtures and equipment requiring domestic hot water service. Point of use, inline electric water heating elements are used to generate hot water for the main control room and the turbine building secondary sampling laboratory.

9.2.5.3 System Operation

Filtered water from the raw water system is stored in the top portion of one of the two fire water tanks which act as a clearwell for the raw water. This filtered water is pumped to the potable water system. Low water level instrumentation in the potable water storage tank generates a signal to activate the clearwell pumps supplying makeup to the potable water system storage tank. High water levels in the potable water system storage tank produce a signal which stops the clearwell pumps.

Prior to entering the potable water system storage tank, supply water is disinfected by injection of liquid sodium hypochlorite. A minimum residual chlorine level of 0.5 ppm is maintained in the system prior to entering the potable water system storage tank. The chlorination system is activated and deactivated by a flow signal generated by the fill valve located upstream of the potable water system storage tank.

Two potable water pumps and a system jockey pump are used to supply potable water throughout the plant. The potable water system pumps are activated sequentially to maintain an appropriate pressure throughout the distribution system. A pressure transmitter is provided downstream of the potable water system pumps to control their start/stop sequences. The jockey pump operates continuously to maintain system pressure.

Potable water is supplied to areas that have the potential to be contaminated radioactively. Where this potential for contamination exists, the potable water system is protected by a reduced pressure zone type backflow prevention device.

including any potentially radioactive system.

5 No interconnections exist between the potable water system and any system using water for purposes other than domestic water service. The common supply from the onsite raw water system is designed to use an air gap to prevent contamination of the potable water system from other systems supplied by the raw water system.

9.2.5.4 Safety Evaluation

The potable water system has no safety-related functions and therefore requires no nuclear safety evaluation.

9.2.5.5 Tests and Inspections

The potable water system is hydrostatically tested for leak-tightness in accordance with the Uniform Plumbing Code. Inspection of the system is in compliance with the Uniform Plumbing Code or governing codes having jurisdiction. The system is then disinfected, flushed with potable water, and placed in service. The presence of residual chlorine can be confirmed through laboratory tests of samples at the potable water storage tank and at other sampling points as required. Tests for microbiological and bacteria presence in potable water are conducted periodically.

9.2.5.6 Instrumentation Applications

Thermostats, high-temperature limit controls, and temperature indication are installed on the potable water system hot water tank. Thermostats and high-temperature limit controls are installed on the inline water heaters. Pressure regulators are employed in those parts of the distribution system where pressure restrictions are imposed.

Control signals for the chlorinator (located in the turbine island chemical feed system) are provided by flow instrumentation associated with the potable water system tank fill valve.

Instrumentation on the potable water system storage tank provides level indication for the tank, alarm signals, and control signals for the fill valve and the potable water system pumps. Should the potable water system storage tank become depleted, the potable water system pumps are tripped.

A pressure transmitter located downstream of the potable water system pumps controls the stop/start sequence of the pumps. The jockey pump runs continuously to maintain system pressure. If the jockey pump is unable to maintain system pressure, a potable water system pump is started. The second potable water system pump starts if the distribution system flow rates are such that all three pumps are required to maintain an acceptable system pressure.

9.2.6 Sanitary Drainage System

The sanitary drainage system (SDS) is designed to collect the site sanitary waste for treatment, dilution and discharge.

9.2.6.1 Design Basis

9.2.6.1.1 Safety Design Basis

The sanitary drainage system serves no safety-related function and therefore has no nuclear safety design basis.

9.2.6.1.2 Power Generation Design Basis

6 The sanitary drainage system is designed to accommodate 25 gallons/person/day for ~~the largest number of~~ approximately 500 persons ~~expected to be at the station~~ during a 24-hour period.

9.2.6.2 System Description

9.2.6.2.1 General Description

The sanitary drainage system collects sanitary waste from plant restrooms and locker room facilities in the turbine building, auxiliary building, and annex building, and carries this waste to the treatment plant where it is processed.

The sanitary drainage system does not service facilities in radiologically controlled areas (RCA).

Although this sanitary drainage system transports sanitary waste to the waste treatment plant, the waste treatment plant is site specific and is addressed in the Combined License application. This system description provides a conceptual basis for the site interface design.

9.2.6.2.2 Component Description

Trunk Line

The trunk line is the primary line that the sanitary drainage system piping connects into for transport of the sanitary drainage to the site treatment plant.

Branch Lines

Branch lines are the sanitary drainage lines that connect the restroom facilities to the trunk line.

Manholes

Manholes are required in the trunk line at the connection of the branch lines into the trunk line, at the change in direction of the trunk line, or at the change in slope or direction of the trunk line. Quantity and location are site specific.

Lift Stations

Lift stations are required in the trunk line when the uniform slope of the trunk line results in excessively deep and costly excavation. Quantity and location are site specific.

9.2.6.3 Safety Evaluation

The sanitary drainage system has no safety-related function and therefore requires no nuclear safety evaluation. There are no interconnections between this system and systems having the potential for containing radioactive material. Potentially radioactive drains are addressed in subsection 9.3.5 dealing with the radioactive waste drain system.

9.2.6.4 Test and Inspection

The sanitary drainage system is tested by water or air and established to be watertight in accordance with the Uniform Plumbing Code Section 318. System inspection is performed in compliance with the Uniform Plumbing Code Section 318 or governing codes specific to the site.

9.2.6.5 Instrument Application

The instruments associated with this system are part of the waste treatment plant which is site specific. Sufficient instrumentation for operation is provided with the treatment plant.

9.2.7 Central Chilled Water System

The plant heating, ventilation, and air conditioning (HVAC) systems require chilled water as a cooling medium to satisfy the ambient air temperature requirements for the plant. The central chilled water system (VWS) supplies chilled water to the HVAC systems and is functional during reactor full-power and shutdown operation.

9.2.7.1 Design Basis

9.2.7.1.1 Safety Design Basis

The central chilled water system serves no safety-related function other than containment isolation, and therefore has no nuclear safety design basis except for containment isolation. See subsection 6.2.3 for the containment isolation system.

9.2.7.1.2 Power Generation Design Basis

The central chilled water system provides chilled water to the cooling coils of the supply air handling units and unit coolers of the plant HVAC systems. It also supplies chilled water to the liquid radwaste system, gaseous radwaste system, secondary sampling system, and the temporary air supply units of the containment leak rate test system.

9.2.7.1.3 Codes and Standards

The central chilled water system is designed to the applicable codes and standards listed in Section 3.2.

A radiation monitor located on the common turbine building drain tank pump discharge piping initiates an alarm and trips the drain tank and waste water retention basin pumps when radioactivity above a preset high level point is detected in the waste stream.

9.2.10 Hot Water Heating System

The hot water heating system (VYS) supplies heated water to selected nonsafety-related air handling units and unit heaters in the plant during cold weather operation and to the containment recirculating fans coil units during cold weather plant outages.

9.2.10.1 Design Basis

9.2.10.1.1 Safety Design Basis

The hot water heating system serves no safety-related function and therefore has no nuclear safety design basis.

9.2.10.1.2 Power Generation Design Basis

- During normal plant operation, the hot water heating system maintains acceptable design ambient air temperatures in various areas throughout the AP600.
- During plant outages in cold weather, the hot water heating system supplies hot water to the plant chilled water piping serving the containment building recirculation fan coil units to maintain acceptable ambient air temperatures inside containment.

9.2.10.2 System Description

9.2.10.2.1 General Description

Major components of the heating system include heat exchangers, pumps a surge tank and a chemical feed tank.

(1) Component and equipment classification for the hot water heating system is given in Section 3.2. The hot water heating system consists of a heat transfer package for the production of hot water and a distribution system to the various HVAC systems and unit heaters. The hot water heating system is a nonsafety-related system.

During cold weather plant operation, the hot water heating system supplies hot water throughout the plant to protect equipment from freezing and for personnel comfort. During cold weather plant outages, the hot water heating system supplies hot water to the containment building recirculation fan coil units to maintain acceptable ambient air temperatures inside containment. During a loss of normal ac power, provisions are made to power the hot water heating system from the onsite diesel generators as an investment protection load. In this mode of operation, heating steam is supplied from the auxiliary steam supply system.

The hot water heating system, using a steam source from high-pressure turbine crossunder piping or the auxiliary boiler, extracts heat energy from the steam through a heat exchanger and transfers this energy to heat water. The heated water is pumped in a closed loop system to hot water coils in the air conditioning systems. Condensate from the heat exchanger is level controlled and drained to the main condenser or auxiliary boiler feedwater system.

Two 50-percent capacity system pumps take suction from the return main of the closed loop system, pump water through two 50-percent capacity system heat exchangers, and supply hot water to the heating system main header. To match system heat load and maintain fluid system temperature, part of the water passes through the heater while the remainder is diverted through the heater bypass. To prevent flashing of the heated water into steam, the pump in combination with the system surge tank keeps the system pressure above saturation conditions. The surge tank uses both elevation and nitrogen overpressure to keep the minimum system pressure above saturation conditions at the pump suction. Demineralized water is supplied to the system for surge tank makeup.

During plant outages in cold weather, hot water flows to the containment building recirculation fan coil units to heat the containment atmosphere. The recirculation fan coil units, containment supply and return piping to these units, and the containment isolation valves are part of the central chilled water system as described in subsection 9.2.7. During normal plant operation the hot water heating system is isolated from the containment recirculation fan coils.

The hot water heating system is a manually actuated system and may operate when the site ambient temperature is 73°F or below.

9.2.10.2.2 Component Description

Major component design data of the hot water heating system are listed in Table 9.2.10-1.

Heat Exchanger

Each heat exchanger is a horizontal, shell-and-tube type, with an integral drain cooler, and uses the heat of vaporization of low-pressure steam for the heating of water. The heat exchanger is located in the closed loop hot water heating system downstream of the system pumps in the turbine building. This heat exchanger provides heated water for selected air handling unit and unit heater hot water coils.

Pumps

Two pumps distribute hot water to the various HVAC and unit heater systems. They are motor driven centrifugal pumps.

Surge Tank

The surge tank maintains system pressure by allowing the water to expand when the water temperature increases and provides a volume to accept makeup water to the hot water heating system.

The tank is a carbon steel, welded, pressure vessel with nitrogen supply, tank recirculation, and instrument connections.

Chemical Feed Tank

The chemical feed tank provides a means of chemical mixing in the system. Addition of chemicals provides control of corrosion.

a capacity of less than 150 gallons tank

8 The tank is a vertical cylinder of carbon steel construction with a top hinged opening for introducing the chemicals and side connections for transporting water through the chemical mixing tank from the pump discharge or the demineralized water transfer and storage system supply.

9.2.10.2.3 System Operation

As the system is filled with demineralized water, samples are taken and the closed loop water chemistry adjusted with chemicals recirculated through the chemical mixing tank with the use of a single pump. A pump is started and steam is admitted to a hot water system heat exchanger and the system is gradually heated.

The three-way diverting valve modulates hot water heating flow through each hot water heating system heat exchanger maintaining a constant heat exchanger outlet temperature, measured at the heat exchanger outlet.

A condensate level is maintained in each system heat exchanger by throttling the heat exchanger discharge flow to the condenser. During a plant outage when extraction steam is shutdown and auxiliary steam is used from the auxiliary boiler, a manual block valve is opened to establish flow of condensate from each heat exchanger to the auxiliary steam supply system deaerator.

Hot water flowing to individual heating coils is controlled either by flow balancing fixed orifices or by temperature controlled solenoid valves, according to the requirements of the heating system. Area temperatures are controlled by cycling the fans in unit heaters, by use of integral face/bypass dampers in air handling units, or by thermostats controlling hot water solenoids in heating coils of HVAC ducts. Further detail of hot water heating of the individual unit heaters, air handling units, and duct heating coils is provided in Section 9.4. In the radwaste building, normally isolated hot water supply and return connections are provided for a mobile radwaste system.

9.2.10.3 Safety Evaluation

The hot water heating system has no safety-related function and therefore requires no nuclear safety evaluation.

The hot water heating system interfaces with only nonsafety-related systems. Hot water heating is used in the containment to keep piping and components from freezing during cold weather when the plant is not operating. A hot water heating system interface with the c chilled water system is outside containment and in nonsafety-related piping of the chilled water system. Piping is shared inside the containment between hot water heating and central chilled water. During normal plant operation, the hot water system is isolated from the central chilled water system and containment. Containment isolation by the central chilled water system is described in subsection 6.2.3.

The hot water heating system is a high energy system. Hot water heating piping is generally excluded from safety-related plant areas outside the containment. Piping of this system routed in safety-related areas is 1 inch and smaller and is not evaluated for pipe ruptures. Design bases for routing high energy pipe in safety-related areas and protection against the dynamic effects associated with the postulated rupture of piping are given in Section 3.6. The effects of flooding on the safe shutdown capability of the plant are described in Section 3.4.

The temperature control range for areas serviced by the hot water heating system is described in Section 9.4 with the ventilation systems.

9.2.10.4 Tests and Inspections

The hot water heating piping circuits are hydrostatically tested and balanced to provide designed flowrates and temperatures. Active component performance is monitored by instrumentation on the system. System performance and integrity during normal plant operation are verified by system operation and visual inspections.

9.2.10.5 Instrument Applications

Instruments are provided for monitoring system parameters. Essential system parameters are monitored in the main control room.

Total system flow is monitored and displayed in the main control room. The system heat exchangers are level controlled with the instrument signals controlling the level control valve as well as sending level indication and low- and high-level alarms to the data system. Temperature measured downstream of the heat exchangers controls fluid flow to, and around, the heat exchangers and indicates the temperature of heated water being sent to the hot water heating coils. Also temperature is monitored in the system return main.

Pressure is measured in the pump suction and at the pump discharge.

Level instrumentation on the surge tank provides both high- and low-level alarms. At tank low-level, makeup is provided from the demineralized transfer and storage system. At a low-low-level point in the tank, a signal is sent to stop the hot water heating system pumps.

9.2.11 Combined License Information

This section has no requirement for information to be provided in support of the Combined License application.

10.4.4.5 Inspection and Testing Requirements

Before the system is placed in service, turbine bypass valves are tested to verify they function properly. The steam lines are hydrostatically tested to confirm leaktightness. The bypass valves may be tested while the unit is in operation. System piping and valves are accessible for inspection. No inservice inspection and testing is required.

10.4.4.6 Instrumentation Applications

Turbine bypass controls are described in Section 7.7. Controls in the main control room are provided for selection of the system operating mode. Pressure indication and valve position indication are also provided in the main control room.

10.4.5 Circulating Water System

10.4.5.1 Design Basis

10.4.5.1.1 Safety Design Basis

The circulating water system (CWS) serves no safety-related function and therefore has no nuclear safety design basis.

10.4.5.1.2 Power Generation Design Basis

The circulating water system supplies cooling water to remove heat from the main condensers, the turbine building closed cooling water system (TCS) heat exchangers, and the condenser vacuum pump seal water heat exchangers under varying conditions of power plant loading and design weather conditions.

10.4.5.2 System Description

10.4.5.2.1 General Description

Classification of components and equipment in the circulating water system is given in Section 3.2. The circulating water system and cooling tower are subject to site specific modification or optimization. The system described here is applicable to a broad range of sites. The Combined License applicant will determine the final system configuration.

The circulating water system consists of two 50-percent-capacity circulating water pumps, one hyperbolic natural draft cooling tower, and associated piping, valves, and instrumentation.

Makeup water to the CWS is provided by the raw water system (RWS). In addition, water chemistry is controlled by the turbine island chemical feed system (CFS).

10.4.5.2.2 Component Description

Circulating Water Pumps

The two circulating water pumps are vertical, wet pit, single-stage, mixed-flow pumps driven by electric motors. The pumps are mounted in an intake structure, which is connected to the cooling tower by a canal. The two pump discharge lines connect to a common header which connects to the two inlet water boxes of the condenser as well as supplies cooling water to the TCS and condenser vacuum pump seal water heat exchangers. Each pump discharge line has a motor-operated butterfly valve located between the pump discharge and the main header. This permits isolation of one pump for maintenance and allows single-pump operation.

Cooling Tower

The cooling tower is site specific with this description provided as a reference design using a hyperbolic natural draft structure. Operation of the cooling tower during conditions that are more restrictive than design conditions may result in higher condenser back pressure.

The cooling tower has a basin which serves as storage for the circulating water inventory and allows bypassing of the cooling tower during cold weather operations. This basin is connected to the intake of the circulating water pumps by a canal.

Cooling Tower Makeup and Blowdown

The circulating water system makeup is provided by the raw water system. Makeup to and blowdown from the circulating water system is controlled by the makeup and blowdown control valves. These valves, along with the turbine island chemical feed system provide chemistry control in the circulating water in order to maintain a noncorrosive, nonscale-forming condition and limit biological growth in circulating water system components.

Piping and Valves

The underground portions of the circulating water system piping are constructed of concrete pressure piping. The remainder is carbon steel, with an internal coating of a corrosion-resistant compound. Motor-operated butterfly valves are provided in each of the circulating water lines at their inlet to and exit from the condenser shell to allow isolation of portions of the condenser. Control valves provide regulation of cooling tower blowdown and makeup.

1 The circulating water system is designed to withstand the maximum operating discharge pressure of the circulating water pumps. Piping includes the expansion joints, butterfly valves, condenser water boxes, and tube bundles. The piping design pressure is site specific and therefore will be provided by the COL applicant. (See 10.4.12.1)

A TCS heat exchanger can be taken out of service by closing the inlet isolation valve. Water chemistry in the isolated heat exchanger train is maintained by a continuous flow of circulating water through a small bypass valve around the inlet isolation valve.

Backwashable strainers are provided upstream of each TCS heat exchanger. They are actuated by a timer and have a backup starting sequence initiated by a high differential pressure across each individual strainer. The backwash can be manually activated.

Circulating Water Chemical Injection

Circulating water chemistry is maintained by the turbine island chemical feed system. Turbine island chemical equipment injects the required chemicals into the circulating water downstream of the CWS pumps. This maintains a noncorrosive, nonscale-forming condition and limits the biological film formation that reduces the heat transfer rate in the condenser and the heat exchangers supplied by the circulating water system.

and therefore will be provided by the COL applicant (See 10.4.12.1

1 The specific chemicals used within the system are determined by the site water conditions. The chemicals can be divided into six categories based upon function: biocide, algicide, pH adjustor, corrosion inhibitor, scale inhibitor, and a silt dispersant. The pH adjustor, corrosion inhibitor, scale inhibitor, and dispersant are metered into the system continuously or as required to maintain proper concentrations. The biocide application frequency may vary with seasons. The algicide is applied, as necessary, to control algae formation on the cooling tower.

Addition of biocide and water treatment chemicals is performed by turbine island chemical feed injection metering pumps and is adjusted as required. Chemical concentrations are measured through analysis of grab samples from the CWS. Residual chlorine is measured to monitor the effectiveness of the biocide treatment.

Chemical injections are interlocked with each circulating water pump to prevent chemical injection when the circulating water pumps are not running.

10.4.5.2.3 System Operation

The two circulating water pumps take suction from the circulating water intake structure and circulate the water through the TCS, the condenser vacuum pump seal water heat exchangers, and the tube side of the main condenser and back through the piping discharge network to the cooling tower. The natural draft cooling tower cools the circulating water by discharging the water over a network of baffles in the tower. The water then falls through fill material to the basin beneath the tower and, in the process, rejects heat to the atmosphere. Provision is made during cold weather to direct a portion of the circulating water flow into freeze-prevention spray headers on the periphery of the cooling tower. Air flowing through the peripheral spray is thus heated and allows deicing in the central cooling tower spray baffles.

The flow to the cooling tower can be diverted directly to the basin, bypassing the cooling tower internals. This is accomplished by opening the bypass valve while operating one of the two circulating water pumps. The bypass is normally used only during plant startup in cold weather or to maintain circulating water system temperature above 40°F while operating at partial load during periods of cold weather.

10.4.5.3 Safety Evaluation

The circulating water system has no safety-related function and therefore requires no nuclear safety evaluation.

10.4.5.4 Tests and Inspections

Components of the circulating water system are accessible as required for inspection during plant power generation. The circulating water pumps are tested in accordance with standards of the Hydraulic Institute. Performance, hydrostatic, and leakage tests associated with preinstallation and preoperational testing are performed on the circulating water system. The system performance and structural and leaktight integrity of system components are demonstrated by continuous operation.

10.4.5.5 Instrumentation Applications

Instrumentation provided indicates the open and closed positions of motor-operated butterfly valves in the circulating water piping. The motor-operated valve at each pump discharge is interlocked with the pump so that the pump trips if the discharge valve fails to reach the full-open position shortly after starting the pump.

Local grab samples are used to periodically test the circulating water quality to limit harmful effects to the system piping and valves due to improper water chemistry.

Pressure indication is provided on the circulating water pump discharge lines. A differential pressure transmitter is provided between one inlet and outlet branch to the condenser. This differential pressure transmitter is used to determine the frequency of operating the condenser tube cleaning system (CES).

Temperature indication is supplied on the common CWS inlet header to the TCS heat exchanger trains. This temperature is also representative of the inlet cooling water temperature to the main condenser.

A flow element is provided on the common discharge line from the TCS heat exchangers to allow monitoring of the total flow through the TCS heat exchangers. Flow measurement for the raw water makeup to the cooling tower and for the cooling tower blowdown is also provided.

Level instrumentation provided in the circulating water pump intake structure activates makeup flow from the RWS to the cooling tower basin when required. Level instrumentation also annunciates a low-water level in the pump structure and a high-water level in the cooling tower basin.

(2) The circulating water chemistry is controlled by cooling tower blowdown and chemical addition. The system accomplishes this by regulating the blowdown valve. This regulation

to maintain the circulating water with an acceptable Langelier Index range or an acceptable Stability Index range as provided by the COL applicant. (See 10.4.12.1)

See INSERT (B)

INSERT B

Monitoring of the circulating water system is performed through the data display and processing system. Control functions are performed by the plant control system. Appropriate alarms and displays are available in the control room. See Chapter 7.