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 AP1000 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.

In addition to the gaseous radwaste system release pathway, release of radioactive material to the environment occurs through the various building ventilation systems. These systems are described in Section 9.4 with a summary of system air flow rates and filter efficiencies provided in Table 9.4-1. The estimated annual release reported in subsection 11.3.3 includes contributions from the major building ventilation pathways.

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 550 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 245 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 AP1000 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, moisture separator, drain traps, and automatic isolation of the guard bed inlet on high moisture separator level 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 room containing gaseous radwaste system components incorporates a hydrogen monitor 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 selectable oxygen concentration of 4 percent 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 isolation valve of the gaseous radwaste system 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

11.3.1.2.4.1 Expected Releases

The AP1000 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 due to the releases resulting during plant operation. 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).

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.

11.3.1.3 Compliance with 10 CFR 20.1406

In accordance with the requirements of 10 CFR 20.1406 (Reference 4), the gaseous radwaste system is designed to minimize, to the extent practicable, contamination of the facility and the environment, facilitate decommissioning, and minimize, to the extent practicable, the generation of radioactive waste. This is done through appropriate selection of design technology for the system.

11.3.2 System Description

11.3.2.1 General Description

The AP1000 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 40°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 delay beds in series 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 AP1000, the gaseous radwaste system is inactive. When there is no waste gas inflow to the system, the discharge isolation valve closes, which 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 40°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 temperature, 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 temperature 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.

The seismic design classification and safety classification for the gaseous radwaste system components are listed in Section 3.2. The components listed are located in the Seismic Category I Nuclear Island.

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 (40°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. Together, the beds provide 100 percent of the stated 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 requires isolation of one bed.

The waste gas flows vertically through columns of activated carbon. The activated carbon volume is 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 AP1000 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 closed, 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

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 AP1000 plant are provided in Table 11.2-6. The expected annual releases for a single unit site are presented in Table 11.3-3.

To demonstrate compliance with the effluent concentration limits in Reference 1, the expected releases from Table 11.3-3 are 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 0.030, which is significantly below the allowable value of 1.0.

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 listed in Table 11.3-3, the air doses at ground level at the site boundary are 2.1 mrad for gamma radiation and 10.1 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, design objectives of 10 mrad per year for gamma radiation or 20 mrad per year for beta radiation.

The radiological consequences due to a single failure of an active component in the gaseous radwaste system are evaluated assuming a 1-hour bypass of the delay beds and 30 minutes of decay before release to the environs. This analysis assumes a pre-existing condition of operation with reactor coolant activity corresponding to 1 percent fuel defects as described in the Note for Table 11.1-2. Using the site boundary (0 to 2 hr) atmospheric dispersion factor from Table 2-1, the site boundary whole body dose is 0.1 rem.

11.3.3.5 Maximum Release Concentrations

The annual releases of 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 maximum defined fuel defect level, the releases would be substantially greater. The maximum defined fuel defect level corresponds to the Technical Specification limit on coolant activity which is based on 0.25 percent fuel defects. 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 the maximum defined fuel defect level, and the resulting airborne radionuclide concentrations at the site boundary are compared in Table 11.3-4 with the Reference 1 limits for concentrations in unrestricted areas. As shown in Table 11.3-4, the overall fraction of the effluent concentration limit for operation with the maximum defined fuel defect level is 0.33, which is well below the allowable value of 1.0.

11.3.3.6 Quality Assurance

The quality assurance program for design, fabrication, procurement, and installation of the gaseous radwaste system is in accordance with the overall quality assurance program described in Chapter 17.

11.3.4 Inspection and Testing Requirements

11.3.4.1 Preoperational Testing

Preoperational tests are performed to verify the proper operation of the WGS. The operational tests include automatic closure of the discharge control/isolation valve, WGS-PL-V051, upon receipt of a simulated high radiation signal. The discharge line of the gaseous radwaste system includes a radiation monitor, WGS-RE017, which detects a high radiation condition and generates an alarm that automatically closes the discharge control/isolation valve. By imposing a simulated high radiation alarm signal, proper operation of the discharge control/isolation valve is confirmed by its closure.

11.3.4.2 Preoperational Inspection

The proper performance of the gaseous radwaste system depends upon delay of gaseous radionuclides by chemical adsorption on activated carbon. As the radionuclides are delayed, they decay and are no longer available for release to the environment. The rate of release and site boundary dose rates have been evaluated based upon the quantity of activated carbon in a delay bed being at least 80 cubic feet. An inspection of the gaseous radwaste system activated carbon delay beds, WGS-MV01A and WGS-MV02B, will confirm that the contained volume of each delay bed is at least 80 cubic feet.

11.3.5 Combined License Information

11.3.5.1 Cost Benefit Analysis of Population Doses

The analysis performed to determine offsite dose due to gaseous effluents is based upon the AP1000 generic site parameters included in Chapter 1 and Tables 11.3-1, 11.3-2 and 11.3-4. The Combined License applicant will provide a site specific cost-benefit analysis to demonstrate compliance with 10 CFR 50, Appendix I, regarding population doses due to gaseous effluents.

The Combined License applicant will also provide an analysis to demonstrate compliance with individual dose limits to members of the public in accordance with 10 CFR 50, Appendix I Sections II.B and II.C.

11.3.5.2 Identification of Adsorbent Media

The Combined License information requested in this subsection has been fully addressed in APP-GW-GLR-008 (Reference 5), and the applicable changes are incorporated into the DCD. No additional work is required by the Combined License applicant to address the Combined License information requested in this subsection.

The following words represent the original Combined License Information Item commitment, which has been addressed as discussed above:

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

11.3.6 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 58 FR 67657, 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. "Minimization of Contamination," 10 CFR 20.1406.

5. APP-GW-GLR-008, "Request for Closure of COL Items in DCD Chapter 11, Identification for Adsorbent Media," Westinghouse Electric Company LLC.

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

Table 11.3-2 (Sheet 1 of 2)

COMPONENT DATA (NOMINAL) – GASEOUS RADWASTE SYSTEM

Mechanical Components

Pumps		
Sample Pumps		
Number	2	
Type	Diaphragm	
Heat Exchangers		
Gas Cooler		
Number	1	
Type	Dual tube coil	
	Process Side	**Cooling Side**
Design pressure (psig)	150	150
Design temperature (°F)	200	200
Design flow	1.0 scfm	0.15 gpm
Temperature inlet (°F)	125	40
Temperature outlet (°F)	40.1	42
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)	150	
Design temperature (°F)	200	
Material	Stainless steel	

Table 11.3-2 (Sheet 2 of 2)

COMPONENT DATA (NOMINAL) – GASEOUS RADWASTE SYSTEM SUMMARY OF INSTRUMENT INDICATION AND ALARMS

Instrumentation	Indicate (Note 4)	Alarm
Gas Cooler		
Gas inlet temperature	X	
Cooling water outlet temperature	X	
Gas inlet pressure	X	X – Hi
Carbon Guard Bed		
Gas inlet temperature	X	X – Hi
Carbon Delay Beds		
Gas inlet temperature	X	X – Hi
Gas outlet temperature 2 channels	X	X – Hi
Gas outlet flow	X	
Gas outlet radiation (Note 3)	X	X – Hi
Gas outlet pressure	X	
Carbon Bed Vault		
Vault hydrogen (Note 2)	X	X – Hi
Vault temperature (Note 1)	X	X – Hi
Moisture Separator		
Water level	X	X – Hi
Sampling Subsystem		
Hydrogen concentration	X	X
Oxygen concentration 2 channels	X	X – Hi
Gas flow	X	X – Lo

Notes:

1. Vault temperature monitor common for guard bed and delay bed.
2. Vault hydrogen monitor common for guard bed and delay bed.
3. High outlet radiation alarm closes gas outlet isolation valve.
4. Monitoring of the gaseous radwaste 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. Local indication and control are available on portable displays which may be connected to the data display and processing system. See Chapter 7.

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)

		Building/Area Ventilation				
Noble Gases(1)	**Waste Gas System**	**Cont.**	**Auxiliary Building**	**Turbine Building**	**Condenser Air Removal System**	**Total**
Kr-85m	0.	3.0E+01	4.0E+00	0.	2.0E+00	3.6E+01
Kr-85	1.65E+03	2.4E+03	2.9E+01	0.	1.4E+01	4.1E+03
Kr-87	0.	9.0E+00	4.0E+00	0.	2.0E+00	1.5E+01
Kr-88	0.	3.4E+01	8.0E+00	0.	4.0E+00	4.6E+01
Xe-131m	1.42E+02	1.6E+03	2.3E+01	0.	1.1E+01	1.8E+03
Xe-133m	0.	8.5E+01	2.0E+00	0.	0.	8.7E+01
Xe-133	3.0E+01	4.5E+03	7.6E+01	0.	3.6E+01	4.6E+03
Xe-135m	0.	2.0E+00	3.0E+00	0.	2.0E+00	7.0E+00
Xe-135	0.	3.0E+02	2.3E+01	0.	1.1E+01	3.3E+02
Xe-138	0.	1.0E+00.	3.0E+00	0.	2.0E+00	6.0E+00
					Total	1.1E+04
Additionally:						
H-3 released via gaseous pathway						350
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)

Iodines[1]	Fuel Handling Area[2]	Building/Area Ventilation			Condenser Air Removal System	Total
		Cont.	Auxiliary Building	Turbine Building		
I-131	4.5E-03	2.3E-03	1.1E-01	0.	0.	1.2E-01
I-133	1.6E-02	5.5E-03	3.8E-01	2.0E-04	0.	4.0E-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)

Radionuclide[(1)]	**Waste Gas System**	**Building/Area Ventilation**			**Total**
		Cont.	**Auxiliary Building**	**Fuel Handling Area[(2)]**	
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	4.3E-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:

1. 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. For particulates, release is not observed and assumed less than 1 percent of the total particulate releases.
2. The fuel handling area is within the auxiliary building but is considered separately.

Table 11.3-4 (Sheet 1 of 2)

COMPARISON OF CALCULATED OFFSITE AIRBORNE CONCENTRATIONS WITH 10 CFR 20 LIMITS

Radionuclide	Effluent Concentration Limit μCi/ml[(a)]	Expected Site Boundary[(b)] Concentration Limit μCi/ml	Fraction of Concentration Limit[(b)] (expected)	Maximum Site Boundary Concentration Limit μCi/ml[(c)]	Fraction of Concentration Limit[(c)] (maximum)
Kr-85m	1.0E-07	2.9E-11	2.9E-04	1.2E-10	1.2E-03
Kr-85	7.0E-07	3.3E-09	4.6E-03	6.9E-09	9.9E-03
Kr-87	2.0E-08	1.2E-11	5.9E-04	3.0E-11	1.5E-03
Kr-88	9.0E-09	3.6E-11	4.1E-03	1.5E-10	1.7E-02
Xe-131m	2.0E-06	1.4E-09	7.1E-04	1.7E-09	8.7E-04
Xe-133m	6.0E-07	6.9E-11	1.1E-04	1.3E-09	2.1E-03
Xe-133	5.0E-07	3.6E-09	7.3E-03	1.3E-07	2.5E-01
Xe-135m	4.0E-08	5.5E-12	1.4E-04	5.9E-12	1.5E-04
Xe-135	7.0E-08	2.6E-10	3.7E-03	8.5E-10	1.2E-02
Xe-138	2.0E-08	4.8E-12	2.4E-04	7.7E-12	3.8E-04
I-131	2.0E-10	9.5E-14	4.8E-04	2.0E-12	9.8E-03
I-133	1.0E-09	3.2E-13	3.2E-04	3.4E-12	3.4E-03
H-3	1.0E-07	2.8E-10	2.8E-03	2.8E-10	2.8E-03
C-14	3.0E-09	5.8E-12	1.9E-03	5.8E-12	1.9E-03
Ar-41	1.0E-08	2.7E-11	2.7E-03	2.7E-11	2.7E-03
Cr-51	3.0E-08	4.8E-16	1.6E-08	4.8E-16	1.6E-08
Mn-54	1.0E-09	3.4E-16	3.4E-07	3.4E-16	3.4E-07
Co-57	9.0E-10	6.5E-18	7.2E-09	6.5E-18	7.2E-09
Co-58	1.0E-09	1.8E-14	1.8E-05	1.8E-14	1.8E-05
Co-60	5.0E-11	6.9E-15	1.4E-04	6.9E-15	1.4E-04
Fe-59	5.0E-10	6.3E-17	1.3E-07	6.3E-17	1.3E-07
Sr-89	2.0E-10	2.4E-15	1.2E-05	9.9E-14	4.9E-04
Sr-90	6.0E-12	9.5E-16	1.6E-04	2.1E-14	3.5E-03
Zr-95	4.0E-10	7.9E-16	2.0E-06	1.7E-15	4.4E-06
Nb-95	2.0E-09	2.0E-15	9.9E-07	6.1E-15	3.0E-06
Ru-103	9.0E-10	6.3E-17	7.0E-08	6.3E-17	7.0E-08

Table 11.3-4 (Sheet 2 of 2)

COMPARISON OF CALCULATED OFFSITE AIRBORNE CONCENTRATIONS WITH 10 CFR 20 LIMITS

Radionuclide	Effluent Concentration Limit µCi/ml[(a)]	Expected Site Boundary[(b)] Concentration Limit µCi/ml	Fraction of Concentration Limit[(b)] (expected)	Maximum Site Boundary Concentration Limit µCi/ml[(c)]	Fraction of Concentration Limit[(c)] (maximum)
Ru-106	2.0E-11	6.2E-17	3.1E-06	9.9E-16	4.9E-05
Sb-125	7.0E-10	4.8E-17	6.9E-08	4.8E-16	6.9E-07
Cs-134	2.0E-10	1.8E-15	9.1E-06	9.5E-13	4.7E-03
Cs-136	9.0E-10	6.7E-17	7.5E-08	4.1E-13	4.6E-04
Cs-137	2.0E-10	2.9E-15	1.4E-05	8.1E-13	4.0E-03
Ba-140	2.0E-09	3.3E-16	1.7E-07	3.3E-16	1.7E-07
Ce-141	8.0E-10	3.3E-17	4.2E-08	1.9E-16	2.3E-07
			Total = 3.0E-02		Total = 3.3E-01

Notes:

a. Effluent concentration limit is from Reference 1.

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 2.0×10^{-5} seconds per cubic meter.

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

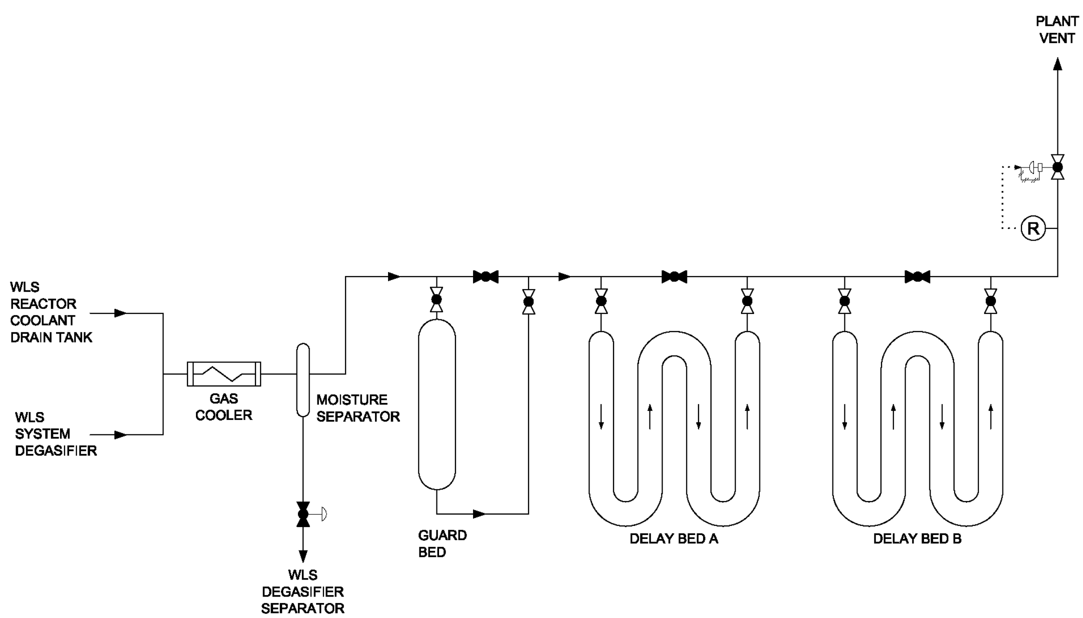

**Figure represents system functional arrangement.
Details internal to the system may differ
as a result of implementation factors such as
vendor-specific component requirements.**

Figure 11.3-1

**Gaseous Radwaste System
Simplified Sketch**

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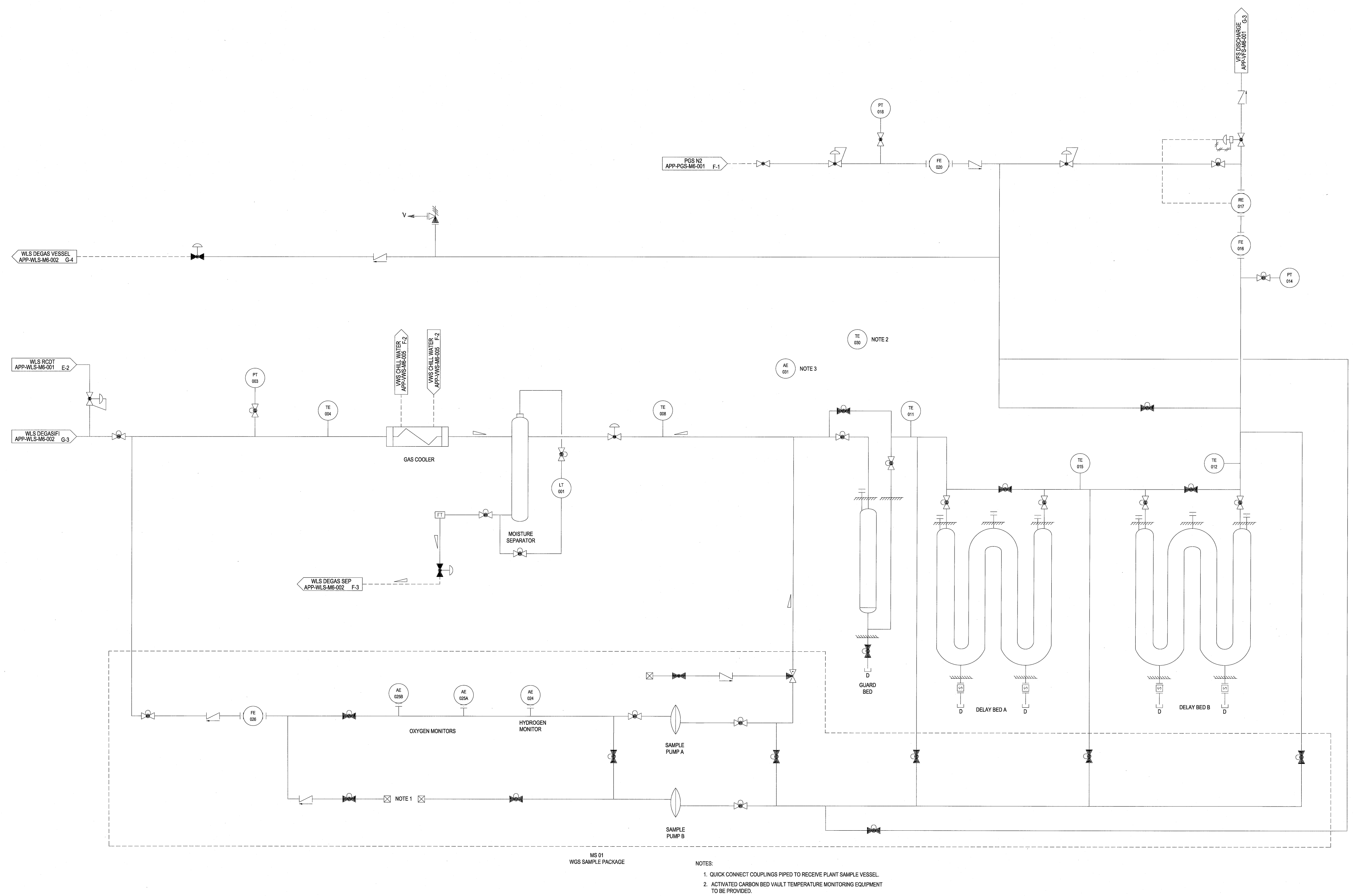

Figure 11.3-2

Gaseous Radwaste System
Piping and Instrumentation Diagram
(REF) WGS 001

Figure represents system functional arrangement. Details internal to the system may differ as a result of implementation factors such as vendor-specific component requirements.