HITACHI

GE Hitachi Nuclear Energy

Richard E. Kingston
Vice President, ESBWR Licensing

PO Box 780 M/C A-55
Wilmington, NC 28402-0780
USA

T 910 819 6192
F 910 362 6192
rick.kingston@ge.com

MFN 08-889

Docket No. 52-010

November 13, 2008

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 233 Related to ESBWR Design Certification Application – Radioactive Waste Management Systems – RAI Numbers 11.0-1 and 11.3-13**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) supplemental response to a portion of the U.S. Nuclear Regulatory Commission Request for Additional Information (RAI) sent by NRC Letter 233 (Reference 1). The GEH response to RAI Numbers 11.0-1 and 11.3-13 is addressed in Enclosure 1. The DCD markup pages related to this response are provided in Enclosure 2.

If you have any questions about the information provided here, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

Reference:

1. MFN 08-648, *Letter from the U.S. Nuclear Regulatory Commission to Robert E. Brown, Request for Additional Information Letter No. 233, Related To ESBWR Design Certification Application*, dated August 15, 2008

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 233, Related to ESBWR Design Certification Application – Radioactive Waste Management Systems – RAI Numbers 11.0-1 and 11.3-13
2. Response to Portion of NRC Request for Additional Information Letter No. 233, Related to ESBWR Design Certification Application – Radioactive Waste Management Systems – RAI Numbers 11.0-1 and 11.3-13 - DCD Markups

cc:	AE Cubbage	USNRC (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	eDRF	0000-0090-8543

Enclosure 1

MFN 08-889

Response to Portion of NRC Request for

Additional Information Letter No. 233

Related to ESBWR Design Certification Application

Radioactive Waste Management Systems

RAI Numbers 11.0-1 and 11.3-13

NRC RAI 11.0-1:

A review of DCD Tier 2, Revision 5, revealed a number of inconsistencies in the citations of regulatory references, internally inconsistent citations of DCD tables, incorrect conversions from SI to conventional radiological units, and incomplete listing of radiological sampling points. Specifically, the applicant is requested to review and resolve the following items:

a. *Regarding incomplete and improper citations of references, is it not clear as whether a reference applies to the design bases, design features, regulatory analysis, or is part of a COLA information item? Specific examples include: (i) DCD Sect. 11.2 – Listed references are not cited in the text, e.g., ref. 11.2-8. The reference list includes improper regulatory citations, e.g., ref. 11.2-2; (ii) DCD Sect. 11.3 – Section makes an improper reference to a Section 12.2 table, Table 12.2-18b (wrong) vs 12.2-17 (correct). Listed references are not cited in the text, e.g., ref. 11.3-10. The reference list includes improper regulatory citations, e.g., ref. 11.3-1; and (iii) DCD Sect. 11.4 - Figure 11.4-4 is included but not cited in the text. Listed references are not cited in the text, e.g., ref. 11.4-5. The reference list includes improper regulatory citations, e.g., ref. 11.4-8.*

b. *DCD Sect. 11.5 – Three instances of wrong conversions between MBq/m3 and uCi/m3 were noted: (i) Table 11.5-2 radiation monitor dynamic detection ranges: Turbine Building Normal Ventilation Air HVAC; and Turbine Building Combined Ventilation Exhaust; and (ii) Table 11.5-9, the Liquid Radwaste Discharge Monitor detection range is in error between MBq/m3 and uCi/m3. Given that the detection range is assigned to comply with RG 1.97 and Part 20 limits, the staff cannot resolve such inconsistency via independent means.*

c. *DCD Sect. 11.5 – Sect. 11.5.3.2.13 (Stack Monitoring) refers to DCD Sect. 7.5.3 for compliance with RG 1.97 and TMI Action Plan Items for the plant stacks. However, Sect. 7.5.3 still refers to the "Plant Stack." Given this design change, Sect. 7.5.3 should refer to the new stack design, as the RB/FB, TB, and RWB stacks, as the DCD should not describe two different designs gaseous effluent release points and radiation monitoring systems in complying with Appendix B to Part 20, Appendix I to Part 50, and GDC 60 and 64.*

d *A review of DCD Tier 2, Revision 5, Section 9.2.6.2 indicates that DCD Table 11.5-5 does not include a system line item identifying sampling provisions for condensate water that might be present in the condensate storage tank basin and discharged to the storm drain. The basin's design includes a sump with provisions to pump water out of the basin to the LWMS or to release it to the storm drain in the event of a spill. Accordingly, a new system line item should be added to Table 11.5-5 in describing sampling provisions and criteria allowing the release of condensate water to the storm drain.*

GEH Response:

a. The following references have been corrected:

(i) a. Reference 11.2-8 is not used in this section and is therefore deleted;

b. Reference 11.2-2 title is corrected (ALIs replacing ALTs);

(ii) a. In 11.3.2.4, reference to Table 12.2.18b is deleted and Table 12.2-17 is properly referenced;

b. Reference 11.3-10 is not used and is therefore deleted;

c. Reference 11.3-1 title is corrected;

d. Additional reference correction – 11.3-2 (ALIs replacing ALTs);

(iii) a. Figure 11.4-4 is appropriately referred to within the revised text in 11.4.2.2.3;

b. Reference 11.4-5 is appropriately referred to within the revised text in 11.4.1; and

c. Reference 11.4-8 title is corrected (ALIs replacing ALTs).

b. The following conversions from MBq/m3 to mCi/m3 are corrected as cited.

(i) Corrections to Table 11.5-2

a. TB Normal Ventilation Air HVAC Xe-133 (4.6E5 to 2.7E5)

b. TB Combined Area Ventilation Exhaust Kr-85 (703E4 to 7.03E4)

(ii) Corrections to Table 11.5-9

a. Liquid Radwaste Discharge Co-60 (5.3 E-1 to 5.13E-1 & 5.3E5 to 5.13E5)

c. Plant Stack in 7.5.3 is replaced with three stacks as in Chapters 9 and 11.

- Reactor Building / Fuel Building Stack,
- Turbine Building Vent Stack, and
- Radwaste Building Stack.

d. (i) Note #9 is added to Table 11.5-5, Item #11, to more thoroughly describe sampling provisions.

(ii) Chapter 9 will not require revision as the design bases in 9.2.6.1 specifically address this concern. Furthermore, Section 9.2.6.1 provides specific provisions to sample the CST Sump prior to release (see last bullet before Section 9.2.6.2).

DCD Impact:

DCD Tier 2, Chapter Sections 11.2, 11.3, 11.4, 11.5, and 7.5.3 is revised as noted on the attached mark-ups to address the concerns above.

NRC RAI 11.3-13:

A review of Chapter 11.3.2 DCD Tier 2, Revision 5, indicates inconsistency in Offgas equipment design criteria and code requirements. There is also inconsistency in equipment description.

(a) A review of DCD Tier 2, Revision 5, Table 11.3-2., Offgas System Major Equipment Items, indicates the following: The Preheater tube side design temperature is 575 °F, but the shell side design is 450 °F. The applicant needs to clarify what safety considerations were taken in the event of tube failure when 575 °F gas leaks into the shell side. Also, the applicant needs to clarify pressure safety considerations in the event of tube failure where tube side design is 1250 PSIG and shell side design is 350 PSIG.

(b) There is TEMA C code requirement for the Cooler-condenser but not for the Preheater and Catalyst (both are S&T Heat Ex.). Why?

(c) A review of DCD Tier 2, Revision 5, Figure 11.3-1., Offgas System flow diagram shows Preheater- Recombiner Cooler as one assembly. This is rather confusing since per DCD 11.3.2.2 the Recombiner assembly includes Preheater, Catalyst and Condenser sections. The applicant needs to clarify this and be consistent with the text and flow diagram.

(d) The same flow diagram, Figure 11.3-1, shows eight (8) charcoal beds and two (2) guard beds. Table 11.3-2 calls for 10 vessels "filled with activated charcoal". The applicant needs to clarify and be consistent with the flow diagram.

(e) A review of DCD Tier 2, Revision 5, Chapter 11.3.2.5.4, Drying, does not make it clear what type of dryers will be used (refrigerant dryers or desiccant dryers?). The applicant needs to provide more detail as under this section.

(f) DCD Tier 2, Revision 5, Figure 11.3-1., Offgas System, has a note Material per requirements of Reg. Guide 1.143. Table 1 of this guide is very specific as to material type and grade required for pressure retaining parts (i.e., 304 SS or 316SS, SA 36, or 516 Gr. 70 CS, etc.). DCD Tier 2, Revision 5, Table 11.3-2 is very general as to the materials description. The applicant needs to provide more detail on materials used in this system.

GEH Response:

a) The shell of the heat exchangers is protected from over-pressurization by pressure relief valves in accordance with ASME BPVC Section VIII, Division 1 as directed in RG 1.143, Table 1. An additional failure analysis entry is added to Table 11.3-3 to clarify this. Table 11.3-2 is revised extensively to be consistent with nomenclature and specifications.

Steam to the Off Gas System (OGS) Preheater is supplied by the Turbine Auxiliary Steam System (TASS). TASS design pressure is 250 psig and is protected by relief valves, while the TASS design temperature is 406 °F. The operating TASS pressure and temperature is 175 psig and 378 °F respectively. The shell of the OGS Preheaters is protected by relief valves vented to the Main Condenser. The OGS Preheater shell pressure and temperature design of 350 psig and 450°F will not be exceeded, as the TASS steam supply operating pressure and temperature and TASS design conditions are less than the OGS Preheater design values.

b) Table 11.3-2 is revised as attached to note these specifications for the OGS tube and shell heat exchangers; OGS Preheater, OGS Condenser, and Cooler Condenser.

The OGS Preheater, OGS Condenser, and Cooler-Condenser will all be designed in accordance with TEMA Class C for Tube and Shell Heat Exchangers. The Catalyst Recombiner is a pressure vessel designed under ASME Section VIII, Division 1, and is not a heat exchanger.

c) Nomenclature throughout the text of Section 11.3 is changed for consistency relative to this RAI concern. These changes occur in Tier 2, sub-sections 11.3.2.2, 11.3.2.5.1, 11.3.2.5.9, 11.3.2.6.7, 11.3.2.6.11, Table 11.3-1, Table 11.3-2, Table 11.3-3, and Figure 11.3-1. Tier 2, Figure 9.4-8, and Tier 1, Figure 2.16.2-6 is revised as attached to indicate a flow path from the OGS to the Turbine Building Vent Stack.

The intent of the ESBWR DCD description is that the OGS Preheater, Catalytic Recombiner, OGS Condenser, and Cooler-Condenser can be manufactured as a skid assembly. Only Clinton Station has installed the first three of these components into a single shell, and the supplying vendor no longer exists. Other GE designed BWR sites and GE Hitachi ABWR sites have installed individual components for the Catalytic Recombiner and the associated OGS heat exchangers. The four components can be assembled into a single assembly skid for modularization.

d) All ten Charcoal Adsorber vessels contain activated charcoal. To clarify this concern about the number and function of the vessels, Table 11.3-2 is revised as attached.

The function of the adsorber beds is thoroughly described in Sections 11.3.2.5.10 and 11.3.7.1. Guard Beds are filled with activated charcoal, as are the larger Charcoal Adsorber Beds. The Guard Beds perform the same delay and filtration functions as the adsorber beds, but are smaller. One active Guard Bed protects the eight Charcoal Adsorber Beds from moisture and from excessive heat that could ignite the charcoal. Moisture blocks pores in the activated charcoal, reduces the effective surface area, and decreases retention time of gases. One Guard Bed is normally in standby with all flow through the in-service Guard Bed. That allows the standby Guard Bed to be purged with nitrogen to extinguish a fire or with air to dry moisture from the activated charcoal. Instrumentation provides indications of high temperature through the Guard Beds and moisture at the Guard Bed exhaust.

e) A refrigerant cycle dryer for the OGS is selected, and Sub-Section 11.3.2.5.4 is revised to reflect that choice. A failure analysis for the Refrigerant Dryer is added to Table 11.3-3.

Desiccant dryers in the Off Gas System gas stream, though operating more passively and being capable of yielding dryer air, require continual drying operations for the standby unit, and they yield solid radwaste periodically. Operating facilities utilizing desiccant dryers frequently experience significant operating problems. Additionally, the standby unit drying function requires the processing of the heated air that becomes contaminated.

Refrigerant dryers require active components and significant power, but can operate without rejuvenation cycles, and will not produce hazardous wastes or radwaste. The moisture content of the exiting gases into the Charcoal Adsorber Beds is sufficiently low as to be acceptably dry for the calculated charcoal volume designed in the ESBWR Off Gas System.

f) No DCD changes for this concern are submitted.

Pressure retaining components are required to meet ASME Sections II and VIII in accordance with Reg Guide 1.143, Table 1. During the detail design phase, specific material specifications will be determined for each component pending input from the supplying vendors.

Wetted surfaces of the Off-Gas System will be manufactured with low corrosion susceptible metals. Structural assemblies not in contact with contaminated fluids can be constructed with coated carbon steel.

DCD Impact:

DCD Tier 2, Subsections 11.3.2.2, 11.3.2.5.1, 11.3.2.5.4, 11.3.2.5.9, 11.3.2.6.7, 11.3.2.6.11, Table 11.3-1, Table 11.3-2, Table 11.3-3, and Figure 11.3-1, Figure 9.4-8, and Tier 1, Figure 2.16.2-6 is revised as noted on the attached mark-up to address the concerns above.

Enclosure 2

MFN 08-889

Response to Portion of NRC Request for

Additional Information Letter No. 233

Related to ESBWR Design Certification Application

Radioactive Waste Management Systems

RAI Numbers 11.0-1 and 11.3-13
DCD Markups

and a digital log radiation monitor, with trip circuits set for high radiation and low/INOP indications.

Oxygen/Hydrogen Concentration Monitoring: Two divisional racks for analysis and measurement sample the oxygen/hydrogen concentration levels in each compartment of the containment. The range of measurement of hydrogen and oxygen contents is displayed in percent (by volume) for the inerted containment. Separate gas indicators for measurement of oxygen and hydrogen content are provided in the MCR for each CMS subsystem. Trip circuits for alarm initiation are set for high oxygen and hydrogen concentration levels and for abnormal sampling flow indication.

7.5.3 Process Radiation Monitoring System

The PRMS provides the instrumentation for radiological monitoring, sampling and analysis of the:

- Turbine Building,
- TSC,
- Radwaste Building,
- Control Building,
- Reactor Building,
- Fuel Building, ~~and~~
- Reactor Building/Fuel Building Stack,
- Turbine Building Stack, and
- Radwaste Building Stack.

~~Plant Stack.~~

The PRMS alerts operators when radiation levels exceed preset limits and initiates automatically the required protection action to isolate, contain or redirect radioactivity releases from the environs. See Subsection 11.5.1.1.2 for process and effluent paths and/or areas with the potential for excessive radiation levels.

The system is configured as shown in Figure 11.5-1 and Table 11.5-3.

7.5.3.1 Design Bases

The design bases are provided in Section 11.5.

7.5.3.2 System Description

The system description is provided in Section 11.5.

The demineralizers are procured with a certain capability to remove ionic species and impurities to meet requirements in NRC Regulations 10 CFR Part 20 and 10 CFR Part 50, Appendix I, to ensure that the decontamination factors for effluent releases do not exceed regulatory limits (Table 11.2-3). Thus, an inspection of the amount of filtration and demineralizer media will be conducted to verify that the loading meets the vendor recommended loading for the demineralizer capabilities as specified in the vendor material, such as a vendor manual, for the equipment.

Replacement filters, charcoal, and resins will be purchased to meet performance standards which support overall system decontamination factors listed in Table 11.2-3.

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

11.2.5 Instrumentation Requirements

The LWMS is operated and monitored from the Radwaste Building Control Room (RWBCR). Major system parameters, i.e., tank levels, process flow rates, filter and ion exchanger differential pressure, ion exchanger effluent conductivity, etc., are indicated and alarmed as required to provide operational information and performance assessment. A continuous radiation detector, as described in Subsection 11.5.3.2.5, is provided to monitor the discharge of radioactivity to the environs. Key system alarms are repeated in the main control room.

11.2.6 COL Information

11.2-1-A Implementation of IE Bulletin 80-10

The COL Applicant is responsible, initially and subsequently, for the identification of LWMS Processing System connections that are considered non-radioactive, but later become radioactive through interfaces with radioactive systems; i.e., a non-radioactive system becomes contaminated due to leakage, valving errors or other operating conditions in radioactive systems using the guidance and information in IE Bulletin 80-10 (May 6, 1980) (Reference 11.2-10) (Subsection 11.2.2.3.3).

11.2-2-A Implementation of Part 20.1406

The COL Applicant will include site-specific information describing how the implementation of operating procedures for the LWMS Processing System will address the requirements of Part 20.1406 (Reference 11.2-9) (Subsection 11.2.2.3.3).

11.2.7 References

11.2-1 Nuclear Regulatory Commission, Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," Revision 2, November 2001.

11.2-2 Title 10 Code of Federal Regulations Part 20 Appendix B, "Annual Limits on Intake (~~ALTs~~ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrates; Concentrations for Release to Sewage."

11.2-3 Title 10 Code of Federal Regulations Part 50.34a "Design Objectives for Equipment to Control Releases of Radioactive Material in Effluents – Nuclear Power Reactors," and Part 52.47 "Contents of Applications; technical information."

11.2-4 Title 10 Code of Federal Regulations Part 50, Appendix A, General Design Criterion 60, "Control of Releases of Radioactive Materials to the Environment."

11.2-5 Nuclear Regulatory Commission, Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable," Revision 3, June 1978.

11.2-6 Title 10 Code of Federal Regulations Part 50, Appendix I, "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."

11.2-7 Nuclear Regulatory Commission, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors," NUREG-0016, Revision 1, January 1979.

11.2-8 ~~Generic Letter 89-01, January 31, 1989, specifically, Enclosure 3, Section 6.13 Process Control Program, PCP.~~(Deleted)

11.2-9 Title 10 Code of Federal Regulations, Part 20.1406 "Minimization of Contamination."

11.2-10 Inspection and Enforcement (IE) Bulletin 80-10, "Contamination of Nonradioactive System and Resulting Potential for Unmonitored, Uncontrolled Release to Environment," May 6, 1980.

11.2-11 NUREG-0800, Standard Review Plan, "For the Review of Safety Analysis Reports for Nuclear Power Plants," Branch Technical Position 11-6, "Postulated Radioactive Releases Due to Liquid-Containing Tank Failures," March 2007.

11.3.2.2 Process Equipment

Major process equipment of the OGS consists of the following:

- Recombiners, including a preheater section, a catalyst section, and a condenser section;
- Cooler-condensers;
- Dryers;
- Activated charcoal adsorbers;
- Monitoring instrumentation; and
- Process instrumentation and controls.

11.3.2.3 Process Facility

The OGS process equipment is housed in a reinforced-concrete structure to provide adequate shielding. Charcoal adsorbers are installed in a temperature-monitored and controlled vault. The facility is located in the TB to minimize piping. Power cycle condensate is used as the coolant for the offgas condensers.

The gaseous waste stream is then cooled in the cooler condenser. Chilled water is provided at the temperature shown in Table 11.3-1. The cooler condenser is located adjacent to the offgas condenser and is designed to allow the condensed moisture from the gaseous waste stream to drain back into the offgas condenser, from which it is sent to the main turbine condenser.

The gaseous waste stream is heated to the value shown in Table 11.3-1 by ambient heating in the charcoal vault.

Chapter 12 provides the radioactivity inventories of the major OGS components during normal plant operation. The radiation shielding design provides adequate protection of instrumentation and plant personnel required to monitor and operate the system.

11.3.2.4 Releases

The significant gaseous wastes discharged to the OGS during normal plant operation are radiolytic hydrogen and oxygen, power cycle injected gasses and air in-leakage, and radioactive isotopes of krypton, xenon, iodine, nitrogen, and oxygen. The radiation dose from gaseous discharge is primarily external, rather than ingestion or inhalation. When releasing gases from the plant, the plume or cloud is the source of radiation to the ground. The maximum radiation corresponds to the zone of maximum ground concentration. This, in turn, is a function of wind velocity and direction, the presence of building obstructions in the wake and other meteorological conditions in the area. As indicated in DCD Subsection 12.2.2.2 and Table 12.2-1~~8b~~7, releases from the turbine building exhaust ventilation stack do not exceed the maximum permissible concentration to the environment.

Radioactive particles are present as a result of radioactive decay from the noble gas parents. These particulates are removed from the offgas stream by the condensation and adsorption equipment. Therefore, the release of radioactive particulates are minimized from the OGS to the turbine building exhaust ventilation stack.

Therefore, this analysis differs from the BTP on the following points:

- There is no motive force to remove any significant inventory from the eight follow-on charcoal tanks while in bypass and, therefore, no activity from these tanks is included in the final release calculations.
- With redundant instrumentation, it is expected that operator intervention to either shut off the bypass or isolate the OGS is predicted to occur within 1 hour. Therefore, the total flow from the system is evaluated for 1 hour and not the 2 hour period stipulated in BTP 11-5 (Reference 11.3-18).

11.3.7.2 Results

The DBA evaluation assumptions are given in Table 11.3-4, the isotopic flows and releases in Table 11.3-5 and Table 11.3-6, and the meteorology and dose results in Table 11.3-7.

The dose results are given in Table 11.3-7, and are within the limiting 25 mSv (2.5 Rem) whole body dose for an offgas system designed to withstand explosions and earthquakes, per BTP 11-5 (Reference 11.3-18) and RG 1.143 (Reference 11.3-3).

11.3.8 COL Information

None.

11.3.9 References

11.3-1 Title 10 Code of Federal Regulations Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As as Is is Reasonably Achievable' for Radioactive Material in Light-Water Water-Cooled Nuclear Power ReactorsReactor Effluents."

11.3-2 Title 10 Code of Federal Regulations Part 20 Appendix B, "Annual Limits on Intake (ALTsALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrates; Concentrations for Release to Sewage."

11.3-3 Nuclear Regulatory Commission, Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants."

11.3-4 (Deleted)

11.3-5 (Deleted)

11.3-6 American National Standards Institute, "Gaseous Radioactive Waste Processing Systems for Light Water Reactor Plants," ANSI/ANS-55.4.

11.3-7 W.E. Browning, et al., "Removal of Fission Product Gases from Reactor Offgas Streams by Absorption," June 11, 1959, Oak Ridge National Laboratory (ORNL) CF59-6-47.

11.3-8 D.P. Seigwarth, "Measurement of Dynamic Absorption Coefficients for Noble Gases on Activated Carbon," Proceedings of the12th AEC Air Cleaning Conference.

11.3-9 Dwight Underhill, et al., "Design of Fission Gas Holdup Systems, Proceedings of the Eleventh AEC Air Cleaning Conference," 1970, p. 217.

11.3-10 ~~General Electric Co., "Radiological Accident Evaluation – The CONAC03 Code," NEDO 21143-1, December 1981.~~(Deleted)

11.3-11 General Electric Co., "Pressure Integrity Design Basis for New Off-Gas Systems," NEDE-11146, July 1971 (Proprietary).

11.3-12 (Deleted)

11.3-13 Inspection and Enforcement, Bulletin 80-10, "Contamination of Nonradioactive System and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment," May 6, 1980.

11.3-14 Nuclear Regulatory Commission, Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable," Revision 3, June 1978.

11.3-15 Title 10 Code of Federal Regulations, Part 50, Appendix A, GDC 60 "General Design Criteria for Nuclear Power Plants, Control of Releases of Radioactive Materials to the Environment."

11.3-16 Title 10 Code of Federal Regulations, Part 50, Appendix A, GDC 64 "General Design Criteria for Nuclear Power Plants, Monitoring Radioactivity Releases."

11.3-17 Title 10 Code of Federal Regulations, Part 20.1406 "Minimization of contamination."

11.3-18 NUREG-0800, Standard Review Plan, 11.3 "Gaseous Waste Management System," Revision 3, March 2007 and BTP 11-5 "Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure."

11.3-19 Title 10 Code of Federal Regulations, Part 50, Appendix A, GDC 3 "General Design Criteria, Fire Protection."

11.3-20 Title 10 Code of Federal Regulations, Part 50.34a "Design Objectives for Equipment to Control Releases of Radioactive Material in Effluents – Nuclear Power Reactors" and Part 52.47 "Contents of Applications; technical information."

11.3-21 Nuclear Regulatory Commission, Regulatory Guide 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Nuclear Powered Reactors."

11.4 SOLID WASTE MANAGEMENT SYSTEM

The Solid Waste Management System (SWMS) is designed to control, collect, handle, process, package, and temporarily store wet and dry solid radioactive waste prior to shipment. This waste is generated as a result of normal operation and anticipated operational occurrences.

The SWMS is located in the radwaste building. It consists of the following four subsystems:

- SWMS Collection Subsystem,
- SWMS Processing Subsystem,
- Dry Solid Waste Accumulation and Conditioning Subsystem, and
- Container Storage Subsystem.

The SWMS Processing Diagram depicting all four subsystems is provided in Figure 11.4-1. The radwaste building general arrangement drawings are provided in Figures 1.2-21 through 1.2-25. The SWMS component capacities are provided in Table 11.4-1. The estimated annual shipped waste volumes generated from the SWMS Subsystems are provided in Table 11.4-2. The SWMS can process wastes at rates higher than shown in Table 11.4-2. The SWMS Collection is shown on Figure 11.4-2. The SWMS Processing Subsystem is shown on Figure 11.4-3.

Process and effluent radiological monitoring systems are described in Section 11.5.

11.4.1 SWMS Design Bases

The SWMS has no safety-related function. The SWMS is designed to provide collection, processing, packaging, and storage of bead resin, filter backwash, and dry solid waste resulting from normal operations.

- The SWMS is designed to meet the guidance of RG 1.143 (Reference 11.4-3).
- The SWMS is designed to keep the exposure to plant personnel "as low as reasonably achievable" (ALARA) during normal operation and plant maintenance, in accordance with RG 8.8 (Reference 11.4-4) and RG 8.10 (Reference 11.4-5).
- The SWMS is designed to package solid waste in Department of Transportation (DOT)-approved containers for offsite shipment and burial.
- The SWMS is designed to prevent the release of significant quantities of radioactive materials to the environment so as to keep the overall exposure to the public within 10 CFR 20 limits and in accordance with the limits specified in 10 CFR 50, Appendix I (Reference 11.4-21). Additionally, the SWMS is designed to comply with the requirements of 10 CFR 20.2007 (Reference 11.4-26).
- The SWMS is designed to package the wet and dry types of radioactive solid waste for offsite shipment and disposal, in accordance with the requirements of applicable NRC and DOT regulations, including 10 CFR 61.56 (Reference 11.4-17), 10 CFR 71 (Reference 11.4-22) and 49 CFR 171 (Reference 11.4-24) through 180 (Reference 11.4-25), as applicable. This results in radiation exposures to individuals and the general population within the limits of 10 CFR 20 and 10 CFR 50.

The estimated annual shipped waste volumes from processing wet solid wastes are presented in Table 11.4-2.

11.4.2.2.3 Dry Solid Waste Accumulation and Conditioning Subsystem

Dry solid wastes consist of air filters, miscellaneous paper, rags, etc., from contaminated areas; contaminated clothing, tools, and equipment parts that cannot be effectively decontaminated; and solid laboratory wastes. The offgas system activated carbon is rejuvenated by the offgas system and does not normally generate dry solid waste. Condition-specific action is taken regarding the removal, replacement, and processing of offgas activated carbon in the unlikely event that significant quantity of offgas system activated carbon requires replacement during the life of the plant. The activity of much of the dry solid wastes is low enough to permit handling by contact. These wastes are collected in containers located in appropriate areas throughout the plant, as dictated by the volume of wastes generated during operation and maintenance. The filled containers are sealed and moved to controlled-access enclosed areas for temporary storage.

Most dry waste is expected to be sufficiently low in activity to permit temporary storage in unshielded, cordoned-off areas. Dry Active Waste (DAW) is sorted and packaged in a suitably sized container that meets DOT requirements for shipment to either a licensed offsite processor or for ultimate disposal. The DAW is separated into three categories: non-contaminated wastes (clean), contaminated metal wastes, and the other wastes, i.e., clothing, plastics, HEPA filters, components, etc. Non-contaminated (clean) materials identified during the sorting process are removed for plant re-use or general debris disposal. (See Figure 11.4-4.)

In some cases, large pieces of miscellaneous waste are packaged into metal boxes in accordance with DOT shipping requirements. DAW and other solid waste is stored until enough is accumulated to permit economical transportation to an offsite burial ground for final disposal or an approved radwaste processor.

The capability exists to bring shipping containers into the truck bay. Bagged DAW can be directly loaded into the shipping container for burial or processing in offsite facilities. A weight scale is provided to ensure optimum shipping/disposal weight of the shipping container.

Cartridge filters that are not placed in HICs are placed in suitability-sized containers meeting DOT requirements.

The estimated shipped waste volumes from processing DAWs are presented in Table 11.4-2.

11.4.2.2.4 Container Storage Subsystem

On-site storage space for a six-months volume of packaged waste is provided. Packaged waste includes HICs, shielded filter containers, 55 gallon (208 liter) drums, and other shipping containers as necessary. The container storage schemes and sequencing is shown in Figure 11.4-1.

11.4.2.2.5 Mixed Waste Processing

To the greatest extent practicable, all discarded chemicals (including those classified as EPA hazardous) will be kept out of the Radioactive Waste Management System. Mixed waste volumes generated at ESBWR facilities are anticipated to be less than or equal to the volumes provided in Table 11.4-2. Mixed waste is collected primarily in 55 gallon (208 liters) collection

11.4-2 (Deleted)

11.4-3 Nuclear Regulatory Commission, Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," Revision 2, November 2001.

11.4-4 Nuclear Regulatory Commission, Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable," , Revision 3, June 1978.

11.4-5 Nuclear Regulatory Commission, Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable," Revision 1-R, September 1975.

11.4-6 Title 10 Code of Federal Regulations, Part 20.1302 "Compliance with dose limits for individual members of the public."

11.4-7 Title 10 Code of Federal Regulations, Part 20.1406 "Minimization of contamination."

11.4-8 Title 10 Code of Federal Regulations, Part 20 Appendix B "Annual Limits on Intake (~~ALTs~~ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrates; Concentrations for Release to Sewage."

11.4-9 Title 10 Code of Federal Regulations, Part 20 Appendix G " Requirements for Transfers of Low Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests."

11.4-10 Title 10 Code of Federal Regulations, Part 50.34a "Design Objectives for Equipment to Control Releases of Radioactive Material in Effluents," and 52.47 "Contents of Applications; technical information."

11.4-11 Title 10 Code of Federal Regulations, Part 50.36a "Technical Specifications on Effluents from Nuclear Power Reactors."

11.4-12 Title 10 Code of Federal Regulations, Part 50 Appendix A GDC 60 "General Design Criteria for Nuclear Power Plants, Control of Releases of Radioactive Materials to the Environment."

11.4-13 Title 10 Code of Federal Regulations, Part 50 Appendix A GDC 61 "General Design Criteria for Nuclear Power Plants, Fuel Storage and Handling and Radioactivity Control."

11.4-14 Title 10 Code of Federal Regulations, Part 50 Appendix A GDC 63 "General Design Criteria for Nuclear Power Plants, Monitoring Fuel and Waste Storage."

11.4-15 Title 10 Code of Federal Regulations, Part 50 Appendix A GDC 64 "General Design Criteria for Nuclear Power Plants, Monitoring Radioactivity Releases."

11.4-16 Title 10 Code of Federal Regulations, Part 61.55 "Waste classification."

11.4-17 Title 10 Code of Federal Regulations, Part 61.56 "Waste characteristics."

11.4-18 Title 40 Code of Federal Regulations, Part 190 "Environmental Radiation Protection Standards For Nuclear Power Operations."

Table 11.5-2

Process Radiation Monitoring System (Gaseous and Airborne Monitors)

Radiation Monitor	Configuration	Dynamic Detection Range*	Principal Radionuclides Measured	(Deleted)	Alarms*** & Trips
TB Normal Ventilation Air HVAC	Inline (adjacent and internal to HVAC duct)	≈ 1.7E0 to 1E4 MBq/m^3 (4.6E1 to 2.7E5~~4.6E5~~ μCi/m^3) ≈ 3.4E1 to 3.4E5 MBq/m^3 (9.2E2 to 9.2E6 μCi/m^3)	Xe-133 Kr-85		DNSC/INOP High
TB Compartment Area Air HVAC	Inline (adjacent and internal to HVAC duct)	≈ 2E0 to 2E4 MBq/m^3 (5.4E1 to 5.4E5 μCi/m^3) ≈ 4.5E1 to 4.5E5 MBq/m^3 (1.2E3 to 1.2E7 μCi/m^3)	Xe-133 Kr-85		DNSC/INOP High
TB Combined Ventilation Exhaust	Offline	≈ 8E-3 to 8E3 MBq/m^3 (2.16E-1 to 2.16E5 μCi/m^3) ≈ 2.6E-3 to 2.6E3 MBq/m^3 (7.03E-2 to 7.03E4~~703E4~~ μCi/m^3) ≈ 7.4E-7 to 7.4E-1 MBq/m^3 (2.0E-5 to 2.0E1 μCi/m^3) ≈ 7.4E-7 to 7.4E-1 MBq/m^3 (2.0E-5 to 2.0E1 μCi/m^3)	Xe-133 Kr-85 Cs-137 I-131		Abnormal Flow DNSC/INOP High High-High

Table 11.5-5

Provisions for Sampling Liquid Streams

No.	Process Systems as listed in NUREG-0800, SRP 11.5 Table 2 (Draft Rev. 4)	ESBWR System (s) that Perform the Equivalent SRP 11.5 Function (Note 1)	In Process	In Effluent	
			Grab Notes 2 & 7	Grab Notes 2 & 7	Continuous Notes 2 & 7
7.	Chemical & Regeneration Solution Waste Systems	Chemical Waste Drain Subsystem	-	S&A, H3	(S&A) Notes 6 & 8
8.	Laboratory & Sample System Waste Systems	Chemical Waste Drain Subsystem	-	S&A, H3	(S&A) Notes 6 & 8
9.	Laundry & Decontamination Waste Systems	Detergent Drain Subsystem	-	S&A, H3	(S&A) Notes 6 & 8
10.	Resin Slurry, Solidification & Baling Drain Systems	Equipment (Low Conductivity) Drain Subsystem, Floor (High) Drain Subsystem	-	S&A, H3	(S&A) Notes 6 & 8
11.	Storm & Underdrain Water System	COL Applicant Notes 4 & 9	-	(S&A, H3) Notes 3 & 6	(S&A) Notes 3 & 6
12.	Tanks and Sumps Inside Reactor Building	Equipment (Low Conductivity) Drain Subsystem, Floor (High) Drain Subsystem, Chemical Waste Drain Subsystem, Detergent Drain Subsystem	-	S&A, H3	(S&A) Notes 6 & 8
13.	Ultrasonic Resin Cleanup Waste Systems	Note 5	-	Note 5	Note 5
14.	Non-Contaminated Waste Water System	COL Applicant Notes 3 & 4	-	(S&A, H3) Notes 3, 4 & 6	(S&A) Note 4

Table 11.5-5

Provisions for Sampling Liquid Streams

No.	Process Systems as listed in NUREG-0800, SRP 11.5 Table 2 (Draft Rev. 4)	ESBWR System (s) that Perform the Equivalent SRP 11.5 Function (Note 1)	In Process	In Effluent	
			Grab Notes 2 & 7	Grab Notes 2 & 7	Continuous Notes 2 & 7
15.	Liquid Radioactive Waste Processing Systems (Includes Reverse Osmosis Systems)	COL Applicant Notes 3 & 4	S & A	(S&A, H3)	(S&A) Notes 6 & 8

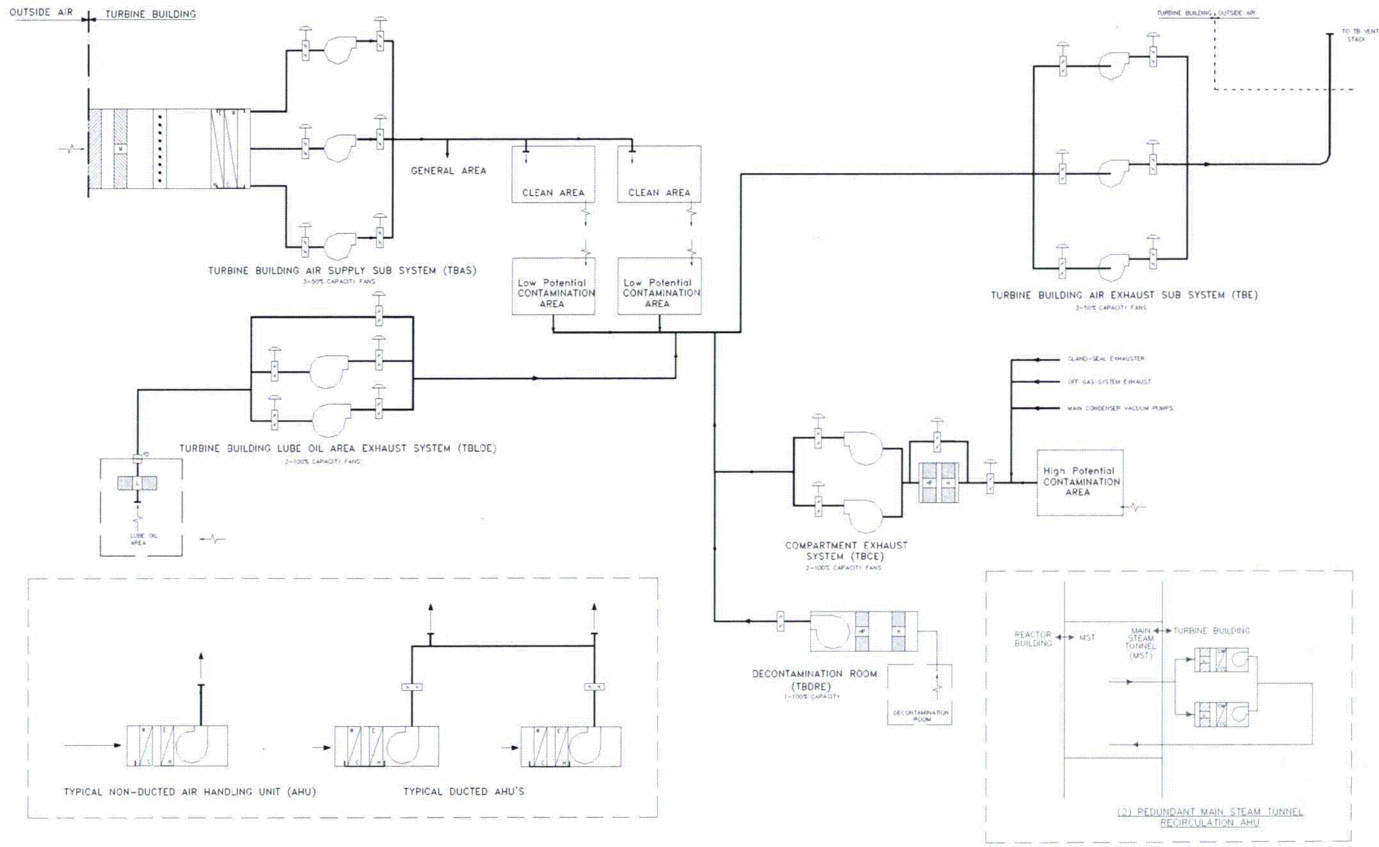
Notes:

1. Table 11.5-5 addresses sampling provisions for BWRs as identified in Table 2 of SRP 11.5. For process systems identified for BWRs in Table 2, but not shown in Table 11.5-5, those systems are not applicable to ESBWR. In some cases, there are multiple subsystems that are used to perform the overall equivalent SRP function and are listed as such in the column.
2. S&A=Sampling & Analysis of radionuclides, to include gross radioactivity, identification and concentration of principal radionuclides and concentration of alpha emitters; R=Gross radioactivity (beta radiation, or total beta plus gamma); H3=Tritium
3. Liquid Radwaste is processed on a batch-wise basis. The Liquid Waste Management System sample tanks can be sampled for analysis of the batch. See Subsection 11.2.2.2 for more information on Liquid Radwaste Management.
4. The COL Applicant will describe provisions for monitoring wastewater systems in the plant specific Offsite Dose Calculation Manual (COL 11.5-2-A).
5. The ESBWR does not include ultrasonic resin cleanup waste system at this time. Should one be installed, the Liquid Waste Management System would provide sampling and monitoring provisions.
6. The use of parenthesis indicates that these provisions are required only for the systems not monitored, sampled, or analyzed (as indicated) prior to release by downstream provisions.
7. The sensitivity of detection, also defined here as the Lower Limit of Detection (LLD), for each indicated measured variable, is based on the applicable radionuclide (or collection of radionuclides as applicable) as given in ANSI/IEEE N42.18 (Reference 11.5-19).
8. Processed through radwaste Liquid Waste Management System (LWMS) prior to discharge. Therefore, this process system is monitored, sampled, or analyzed prior to release by downstream provisions. See Note 6 above. Depending on Utility's discretion, additional sampling lines may be installed. Continuous Effluent sampling is not required per Standard Review Plan 11.5 Draft Rev. 4, April 1996, Table 2 for this system function.
9. CST Containment Dike can either be drained to the Storm Water System or to the LWMS as determined by manual sampling following a rain event. If clean, as determined by ODCM guidelines, storm water will be released to the Storm Water System. Water requiring reprocessing will be recycled to Radwaste Floor Drain Collection Tanks.

Table 11.5-9

Process Radiation Monitoring System Estimated Dynamic Ranges

Radiation Monitor	Estimated Dynamic Detection Range	Principal Radionuclides Measured	Basis for Dynamic Range
Liquid Radwaste Discharge	≈ 2.1E-3 to 2.1E3 MBq/m^3 (5.67E-2 to 5.67E4 μCi/m^3) ≈ 1.9E-2 to 1.9E4 MBq/m^3 (5.13E-1 to 5.13E5~~5.3E-1 to 5.3E5~~ μCi/m^3)	Cs-137 Co-60	The dynamic range is established so that the channel is capable of spanning the10 CFR 20 concentrations in liquid waste for the indicated radionuclides.
Reactor Component Cooling Water Intersystem Leakage	≈ 4.3E-3 to 4.3E3 MBq/m^3 (1.16E-1 to 1.16E5 μCi/m^3) ≈ 3.6E-3 to 3.6E3 MBq/m^3 (9.7E-2 to 9.7E4 μCi/m^3)	Cs-137 Co-60	The dynamic range is established to provide measurement coverage of radionuclide concentrations from a fraction of the 10 CFR 20 effluent limits in water to the concentrations caused by a 1 gpm leak from reactor water into the RCCW system.
Drywell Sump LCW/HCW Discharge	≈ 4 E4 to 4 E10 MBq/m^3 (1.08E6 to 1.08E12 μCi/m^3) ≈ 8 E0 to 8 E6 MBq/m^3 (2.16E2 to 2.16E8 μCi/m^3)	Cs-137 Co-60	The dynamic ranges have been selected to provide sufficient coverage to encompass the radiation dose rates, on the outside of the LCW and HCW pipes, using typical reactor water concentrations of various radionuclides. Reactor water concentrations associated with a LOCA were used to estimate the upper limit of the dynamic range.


OUTSIDE AIR
TURBINE BUILDING
GENERAL AREA
CLEAN AREA
CLEAN AREA
Low Potential CONTAMINATION AREA
Low Potential CONTAMINATION AREA
TURBINE BUILDING AIR SUPPLY SUB SYSTEM (TBAS)
TURBINE BUILDING LUBE OIL AREA EXHAUST SYSTEM (TBLOE)
TURBINE BUILDING AIR EXHAUST SUB SYSTEM (TBE)
High Potential CONTAMINATION AREA
COMPARTMENT EXHAUST SYSTEM (TBCE)
DECONTAMINATION ROOM (TBDRE)
TYPICAL NON-DUCTED AIR HANDLING UNIT (AHU)
TYPICAL DUCTED AHU'S
REACTOR BUILDING
MST
MAIN STEAM TUNNEL (MST)
TURBINE BUILDING
(2) REDUNDANT MAIN STEAM TUNNEL RECIRCULATION AHU

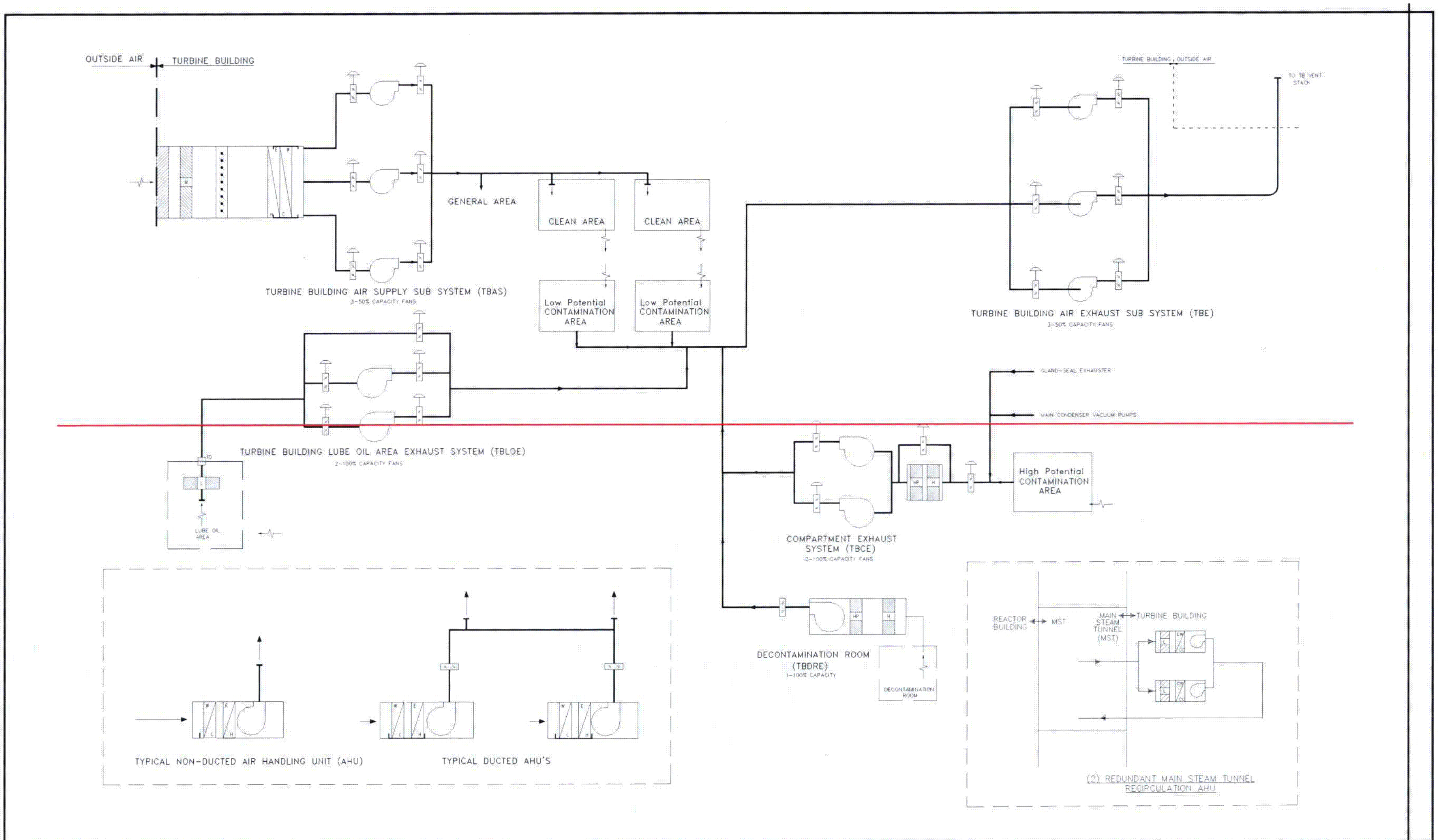
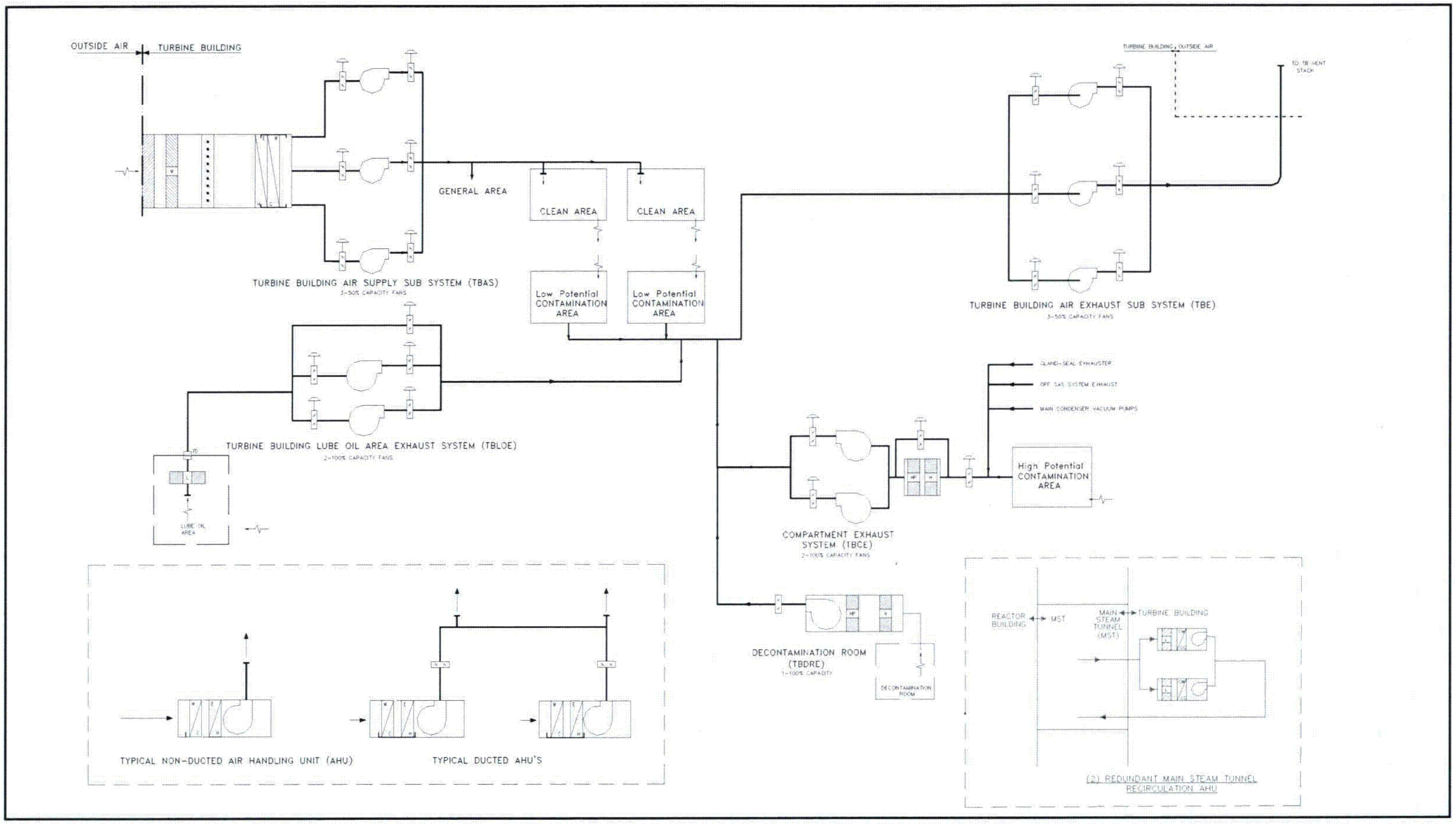


Figure 2.16.2-6. TBVS Functional Arrangement Diagram


OUTSIDE AIR
TURBINE BUILDING
GENERAL AREA
CLEAN AREA
CLEAN AREA
Low Potential CONTAMINATION AREA
Low Potential CONTAMINATION AREA
TURBINE BUILDING AIR SUPPLY SUB SYSTEM (TBAS)
TURBINE BUILDING, OUTSIDE AIR
TO TB VENT STACK
TURBINE BUILDING AIR EXHAUST SUB SYSTEM (TBE)
3-50% CAPACITY FANS
TURBINE BUILDING LUBE OIL AREA EXHAUST SYSTEM (TBLOE)
GLAND-SEAL EXHAUSTER
OFF GAS SYSTEM EXHAUST
MAIN CONDENSER VACUUM PUMPS
High Potential CONTAMINATION AREA
COMPARTMENT EXHAUST SYSTEM (TBCE)
DECONTAMINATION ROOM (TBDRE)
TYPICAL NON-DUCTED AIR HANDLING UNIT (AHU)
TYPICAL DUCTED AHU'S
REACTOR BUILDING
MST
MAIN STEAM TUNNEL (MST)
TURBINE BUILDING
(2) REDUNDANT MAIN STEAM TUNNEL RECIRCULATION AHU

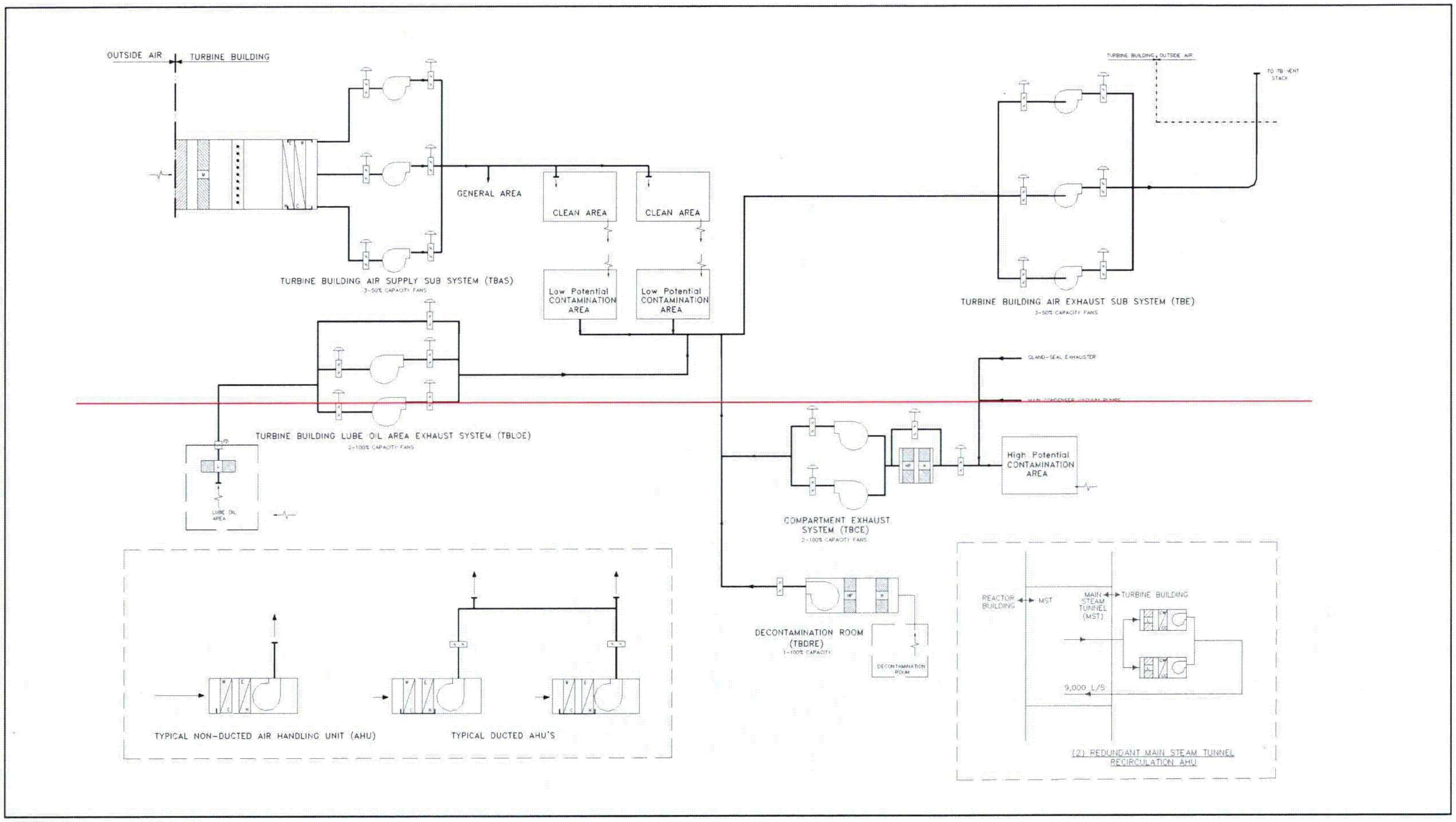


Figure 9.4-8. TBVS Simplified System Diagram

11.3.2.2 Process Equipment

Major process equipment of the OGS consists of the following:

~~Recombiners, including a preheater section, a catalyst section, and a condenser section;~~

- OGS Preheaters;
- Catalytic Recombiners;
- OGS Condensers;
- Cooler-condensers;
- Dryers;
- Activated charcoal adsorbers;
- Monitoring instrumentation; and
- Process instrumentation and controls.

11.3.2.3 Process Facility

The OGS process equipment is housed in a reinforced-concrete structure to provide adequate shielding. Charcoal adsorbers are installed in a temperature-monitored and controlled vault. The facility is located in the TB to minimize piping. Power cycle condensate is used as the coolant for the offgas condensers.

The gaseous waste stream is then cooled in the cooler condenser. Chilled water is provided at the temperature shown in Table 11.3-1. The cooler condenser is located adjacent to the offgas condenser and is designed to allow the condensed moisture from the gaseous waste stream to drain back into the offgas condenser, from which it is sent to the main turbine condenser.

The gaseous waste stream is heated to the value shown in Table 11.3-1 by ambient heating in the charcoal vault.

Chapter 12 provides the radioactivity inventories of the major OGS components during normal plant operation. The radiation shielding design provides adequate protection of instrumentation and plant personnel required to monitor and operate the system.

11.3.2.4 Releases

The significant gaseous wastes discharged to the OGS during normal plant operation are radiolytic hydrogen and oxygen, power cycle injected gasses and air in-leakage, and radioactive isotopes of krypton, xenon, iodine, nitrogen, and oxygen. The radiation dose from gaseous discharge is primarily external, rather than ingestion or inhalation. When releasing gases from the plant, the plume or cloud is the source of radiation to the ground. The maximum radiation corresponds to the zone of maximum ground concentration. This, in turn, is a function of wind velocity and direction, the presence of building obstructions in the wake and other meteorological conditions in the area. As indicated in DCD Subsection 12.2.2.2 and Table 12.2-1~~8b~~7, releases from the turbine building exhaust ventilation stack do not exceed the maximum permissible concentration to the environment.

Radioactive particles are present as a result of radioactive decay from the noble gas parents. These particulates are removed from the offgas stream by the condensation and adsorption equipment. Therefore, the release of radioactive particulates are minimized from the OGS to the turbine building exhaust ventilation stack.

Radioiodines (notably I-131) may be present in significant quantities in the reactor steam and to some extent carried over through the condensation stages of the OGS. Adsorption of iodine takes place in the passage of process gas through the activated charcoal adsorbers, so that essentially no iodine is released from the OGS to the turbine building exhaust ventilation stack.

The criterion for release of gaseous wastes to the atmosphere, excluding accident sequences, is that maximum external radiation dosage to the environment be maintained below the maximum dose objectives of Appendix I to 10 CFR 50 (Reference 11.3-1) in terms for doses to individuals in unrestricted areas. An instantaneous release rate, established by 10 CFR 20 (Reference 11.3-2), of several times the annual average permissible release rate limit is permitted as long as the annual average is not exceeded. Every reasonable effort has been made to keep radiation exposures and release of radioactive materials "as low as reasonably achievable" (ALARA). The OGS discharge is routed to the turbine building exhaust ventilation stack.

11.3.2.5 Process Design

Primary design features are shown on the simplified offgas diagram (Figure 11.3-1).

The Steam Jet Air Ejectors (SJAE) are described in Subsection 10.4.2.

11.3.2.5.1 Preheating

~~Recombiner p~~Preheaters ~~pre~~heat gases to provide for efficient catalytic recombiner operation and to ensure the absence of liquid water that suppresses the activity of the recombiner catalyst. Maximum preheater temperature does not exceed the value shown in Table 11.3-1 should gas flow be reduced or stopped. This is accomplished by using steam from the ~~main~~Turbine Auxiliary Steam System (TASS) ~~steam~~. During startup, steam at ~~this~~ TASS pressure, is available before the process offgas is routed through the preheater ~~section~~ to the catalytic recombiner ~~catalyst section~~. Electrical preheaters are not exposed directly to the offgas. Each preheater ~~section~~ connects to an independent final stage air ejector to permit separate steam heating of both catalytic recombiners during startup or drying one catalytic recombiner while the other is in operation. For reliability, preheater steam is ~~nuclear~~ TASS steam. The preheater is sized to handle a dilution steam load of 115% of rated flow in addition to allowing for 5% plugged tubes.

11.3.2.5.2 Hydrogen/Oxygen Recombination

Minimum performance criteria for the catalytic recombiners are as follows:

- In normal full power operation, the hydrogen in the recombiner effluent does not exceed 0.1% by volume on a moisture-free basis, at the defined minimum air flow shown in Table 11.3-1.
- During startup or other reduced power operations (between 1 and 50% of reactor rated power), the hydrogen in the recombiner effluent does not exceed 1.0% by volume on a moisture free basis at the defined minimum air flow.

- An intentional air bleed equal to minimum air flow is introduced into the system upstream of the operating recombiner when the turbine condenser air in-leakage falls below the defined minimum air flow. The out-of-service recombiner catalysts is heated to the value shown in Table 11.3-1 by dilution steam injection and preheat steam before admitting process gas (containing hydrogen) to the recombiner. Three temperature-sensing elements are provided in each catalyst bed and are located to measure the temperature profile from inlet to outlet.

11.3.2.5.3 Condensing

The offgas condensers cool the recombiner effluent gas to the maximum temperatures shown in Table 11.3-1 for normal operation and startup operation. The condenser includes baffles to reduce moisture entrainment in the offgas. The unit is sized to handle a dilution steam load of 115% of rated flow, in addition to allowing for 5% plugged tubes. The drain line is capable of draining the entire process condensate, including the 15% excess plus 2.5 l/s (40 gpm), from the unit at both startup and normal operating conditions, taking into account the possibility of condensate flashing in the return line to the main condenser. The drain line also incorporates a flow element so that higher flows caused by tube leakage can be identified, and a passive loop seal with a block valve operable from the main control room. A gas sample tap is provided downstream of and near the offgas condensers to permit gas sampling.

The gaseous waste stream is further cooled in the cooler condenser. The cooler condenser is designed to remove condensed moisture by draining it to the offgas condenser.

11.3.2.5.4 Drying

The dew point of the offgas, from the cooler-condenser, is reduced to less than 7°C (45°F) to enhance the adsorption performance of the charcoal in one of two redundant parallel dryers. Refrigerant cycle dryers will be utilized to minimize maintenance and eliminate waste production generated with desiccant dryers.

11.3.2.5.5 Adsorption

The activated charcoal uses general adsorption coefficient Karb values for krypton and xenon. Separate Karb laboratory determinations of krypton and xenon are made for each manufacturer's lot unless the manufacturer can supply convincing proof to the purchaser that other lots of the same production run immediately adjacent to the lot tested are equivalent to the lot tested with respect to krypton and xenon adsorption. Other adsorption tests (e.g., dynamic coefficients) may be acceptable, provided their equivalence to Karb tests for this purpose can be demonstrated. Charcoal particle size, moisture content and minimum charcoal ignition temperature in air are shown in Table 11.3-1.

Properties of activated charcoal used in the adsorber vessels are an optimization of the following:

- High adsorption for krypton and xenon,
- High physical stability,
- High surface area,
- Low pressure drop,

process gas by two check valves in series in order to comply with Bulletin 80-10, May 6, 1980 (Reference 11.3-13).

11.3.2.5.8 Rangeability

The process can accommodate reactor operation from 0 to 100% of full power. In normal operation, radiolytic gas production varies linearly with thermal power. The process can accommodate the airflow range shown in Table 11.3-1 for the full range of reactor power operation.

In addition, the process can mechanically accommodate a higher startup airflow upon initiation of the SJAEs. This startup airflow results from evacuation of the turbine condensing equipment while the reactor is in the range of about 3% to 7% of rated power.

11.3.2.5.9 Redundancy

Active equipment (e.g., catalytic recombiners trains, dryers and valves) whose operation is necessary to maintain operability of the OGS is redundant. Passive equipment (e.g., charcoal adsorber) is not redundant. Instrumentation that performs an information function, and is backed up by design considerations or other instrumentation, is not redundant. Instrumentation used to record hydrogen concentration or activity release (e.g., flow measurement and hydrogen analyzers) is redundant.

Design provisions are incorporated that preclude the uncontrolled release of radioactivity to the environment as a result of a single equipment failure, short of the equipment failure accident described in Subsection 11.3.7. An analysis of single equipment piece malfunctions is provided in Table 11.3-3.

Design precautions taken to prevent uncontrolled releases of activity include the following:

- The system design minimizes ignition sources so that a hydrogen detonation is highly unlikely even in the event of a recombiner failure.
- The system pressure boundary is detonation-resistant as described in Subsection 11.3.2.6, in addition to the measure taken to avoid a possible detonation.
- All discharge paths to the environment are monitored. The Process Radiation Monitoring System (PRMS) monitors the normal effluent path and the Area Radiation Monitoring System monitors the equipment areas.
- Dilution steam flow to the SJAE is monitored and alarmed, and the valving is required to be such that loss of dilution steam cannot occur without coincident closure of the process gas suction valve(s) so that the process gas is sufficiently diluted if it is flowing at all.

11.3.2.5.10 Charcoal Adsorber Bypass

A piping and valving arrangement is provided, which allows isolation and bypass of the charcoal adsorber vessel that may have caught fire or become wetted with water, while continuing to process the offgas flow through the remaining adsorber vessels. A nitrogen purge can be injected upstream of the vault entrance so that further combustion is prevented and the charcoal is cooled below its ignition temperature. Normal offgas flow is through one Guard Bed and eight large charcoal beds. Capability is provided to employ all or a portion of the charcoal

11.3.2.6.7 Catalytic Recombiners

The recombiners are mounted with the gas inlet at the bottom. The inlet piping has sufficient drains and moisture separators to prevent liquid water from entering the recombiner vessel during startup. The recombiners are catalytic type with non-dusting catalyst supported on a metallic base. The catalyst is replaceable without requiring replacement or removal of the external pressure vessel.

Each catalytic recombiner is ~~part of an integrated~~preceded by a preheater~~-recombiner-condenser pressure vessel assembly~~ and followed by a condensing heat exchanger. The preheater ~~section~~ uses steam to heat the offgas process stream gases to at least the minimum values shown in Table 11.3-1 before it reaches the catalyst in the recombiner~~-section~~. The recombined hydrogen and oxygen, in the form of super-heated steam, which leaves the catalytic recombiner~~-section~~, is then condensed (by power cycle condensate) to liquid water in the condenser ~~section of the assembly~~, while the noncondensable gases are cooled to temperatures below the maximum value shown in Table 11.3-1. The condensed water in the condenser ~~section~~-is drained to a loop seal that is connected to the main condenser hotwell. Condensed preheater ~~section~~-steam is drained to the above loop seal that is connected to the hotwell.

No flow paths above low power operation exist whereby unrecombined offgas can bypass the recombiners.

11.3.2.6.8 Charcoal Adsorber Vessels

The charcoal adsorber vessels are to be cylindrical tanks installed vertically.

Channeling in the charcoal adsorbers is prevented by supplying an effective flow distributor on the inlet and by a high bed-to-particle diameter ratio. Temperature elements are installed along the charcoal adsorber vessels in sufficient quantity to monitor the temperature profile along the flow path during operation.

11.3.2.6.9 Charcoal Adsorber Vault

The temperature within the charcoal adsorber vault is maintained and controlled by appropriate connection(s) to the TBVS. The decay heat is sufficiently small that, even in the no-flow condition, there is no significant loss of adsorbed noble gases because of temperature rise in the adsorbers.

The charcoal adsorber vault itself is designed for the temperature range shown in Table 11.3-1 because it may be necessary to heat a vessel or the vault to the maximum temperature (by the use of portable heaters) to facilitate drying the charcoal. A smoke detector is installed in the charcoal adsorber vault to detect and provide alarm to the operator as a charcoal fire within the vessel(s) results in the burning of the exterior paint surface (Subsection 9.4.4).

11.3.2.6.10 Construction of Process Systems

Pressure-retaining components of process systems employ welded construction to the maximum practicable extent. Process piping systems include the first root valve on sample and instrument lines.

11.3.2.6.11 Moisture Separator

A moisture separator is incorporated into the cooler-_condenser heat exchanger.

11.3.2.6.12 Maintenance Access

The system equipment is generally not accessible for maintenance during system operation. Therefore, equipment is intended to be accessible during the plant outages. The following are exceptions:

- The redundant offgas recombiner trains are located in separate rooms to allow maintenance access to the standby train when processing offgas in the operable train.
- Control valving and hydrogen analyzers are accessible for maintenance during the out-of-service portion of their cycle.
- Charcoal vault air conditioning and ventilation equipment are accessible for maintenance during plant operation.

The OGS is designed, constructed, and tested to be as leak tight as practicable.

Design features which reduce or ease required maintenance or which reduce personnel exposure during maintenance include the following:

- Redundant components for all active, in-process equipment pieces located in separate shielded cells.
- Block valves with air bleed pressurization for maintenance, which may be required during plant operation.
- Shielding of non-radioactive auxiliary subsystems from the radioactive process stream.

Design features that reduce leakage and releases of radioactive material include the following:

- Extremely stringent leak rate requirements placed upon all equipment, piping and instruments and enforced by requiring helium leak tests of the entire process system as described in Section 11.3.5.
- Use of welded joints wherever practicable.
- Specification of valve types with extremely low leak rate characteristics (i.e., bellows seal, double stem seal, or equal).
- Routing of most drains through loop seals to the main condenser.
- Specification of stringent seat-leak characteristics for valves and lines discharging to the environment.

11.3.2.7 Seismic Design

OGS is in compliance with the requirements of RG 1.143 for seismic design RW-IIa.

11.3.3 Ventilation System

Radioactive gases are present in the power plant buildings as a result of process leakage and steam discharges. The process leakage is the source of the radioactive gases in the air discharged

Table 11.3-1

Offgas System Design Parameters*

Design Parameter	Design Value
Design basis noble radiogas release rate	3700 MBq/s (100,000 μCi/s)
Assumed air in-leakage	51 m^3/h standard (30 scfm)
Xenon delay	60-day**
Krypton delay	78.6 hours**
Argon delay	27.2 hours**
Iodine removal efficiency	99.99** and ***
Maximum gaseous waste stream temperature	67°C (153°F)
Charcoal temperature (approximate)	35°C (95°F)
Maximum cooler condenser temperature	18°C (65°F)
Chilled water temperature (approximate)	7°C (45°F)
Gaseous waste stream temperature (approximate)	35°C (95°F)
Nominal ~~recombiner~~ off gas preheater temperature	177°C (351°F)
Maximum ~~recombiner~~ off gas preheater temperature	210°C (410°F)
Out-of-service hydrogen/oxygen catalytic recombiner minimum temperature	121°C (250°F)
Minimum activated charcoal ignition temperature	156°C (313°F)
Minimum air bleed supply rate****	0.17 m^3/min (6 scfm)
Air bleed to standby recombiner train at startup and normal operation	0.17 m^3/min (6 scfm)
Radiolytic gas flow range	0 to 8.6 m^3/min (302 scfm)
Charcoal adsorber vault temperature range	29°C (84°F) to 40°C (104°F)
Charcoal particle size	8–16 mesh United States Standard (USS) with less than 0.5% under 20 mesh
Charcoal moisture content	< 5% by weight
Maximum offgas activity input concentration	5.9E+6 Bq/cm^3
Charcoal Guard Bed Mass	33,000 lbs (15 metric tons)
Charcoal Bed Mass	490,000 lbs (222 metric tons)

* For additional information on radioactive releases, refer to Sections 11.1 and 12.2.
** Offgas processing equipment will meet or exceed these values.
*** No Iodine is assumed to be released.
**** Minimum 6 scfm refers to leakage plus bleed air.

Table 11.3-2

Offgas System Major Equipment Items

Recombiner Train(2 required, contains preheater, catalyst, and condenser ~~sections~~)	
~~Carbon Steel Shell~~Inter-Connecting Piping	
Design pressure:	2.41 MPa gauge (350 psig)
Design temperature:	232°C (450°F)
Code of construction:	ANSI/ASME ~~Section VIII, Division 1~~B31.3
Preheater ~~Section~~	Shell and tube heat exchanger
Shell-side design pressure:	2.41 MPa gauge (350 psig)
Shell-side design temperature:	232°C (450°F)
Shell Pressure Protection	Relief Valve – ASME BPVC Section VIII, Division 1
Tubes:	Stainless steel
Tube-side design temperature:	302°C (575°F)
Tube-side design pressure:	8.6 MPa gauge (1250 psig)
~~Design temperature~~Code of construction:	~~232°C (450°F)~~TEMA Class C
~~Catalyst Section~~Catalytic Recombiner	
Catalyst support:	Stainless steel
Design temperature:	482°C (900°F)
Catalyst:	Precious metal on metal base
Code of construction:	ASME BPVC Section VIII, Division 1
Offgas Condenser ~~Section~~	Shell and tube heat exchanger
Shell-side design pressure:	2.41 MPa gauge (350 psig)
Shell-side design temperature:	482°C (900°F)
Shell Pressure Protection	Relief Valve – ASME BPVC Section VIII, Division 1
Tubes:	Stainless steel
Tube-side design pressure:	2.41 MPa gauge (350 psig)
Design temperature:	482°C (900°F)
Code of construction:	TEMA Class C
Cooler Condenser (2 required)	
Shell and Tube Heat Exchanger, Carbon Steel Vessel	
Shell-side design pressure:	2.41 MPa gauge (350 psig)
Shell-side design temperature:	121°C (250°F)

Table 11.3-2

Offgas System Major Equipment Items

Shell Pressure Protection	Relief Valve – ASME BPVC Section VIII, Division 1
Tubes:	Stainless steel
Tube-side design pressure:	1 MPa gauge (145 psig)
Code of construction:	TEMA Class C
Dryer (2 required)	
Design pressure	2.41 MPa gauge (350 psig)
Design temperature	121°C (250°F)
Dew point temperature	7°C (45°F)
Code of construction	ASME Section VIII, Division 1
Charcoal Adsorbers (10 required – 2 Guard Beds and 8 Main Beds)	
Carbon Steel Vessels Filled with Activated Charcoal	
Design pressure:	2.41 MPa gauge (350 psig)
Design temperature:	121°C (250°F)
Code of construction:	ASME Section VIII, Division 1

Table 11.3-3

Equipment Malfunction Analysis

Equipment Item	Malfunction	Result(s)	Design Precautions
Steam jet air ejectors	Low flow of motive high pressure steam	If the hydrogen and oxygen concentrations exceed 4 % volume, the catalytic recombiners temperature rise is excessive.	Automatic system isolation on low steam flow.
		Inadequate steam flow causes overheating and may result in exceeding the design temperature of the catalytic recombiner vessel.	Steam flow to be held at constant maximum flow regardless of plant power level.
	Wear of steam supply nozzle of ejector	Increased steam flow to the catalytic recombiner could reduce degree of recombination at low power levels. High discharge temperature from catalytic recombiner ~~condenser~~ could result because of inadequate condenser capacity.	Temperature alarms on preheater exit (catalyst inlet). Downstream H_2 analyzer alarms. High temperature alarms on exit from catalytic recombiner.
~~Recombiner~~ OGS ~~p~~Preheater	Steam leak	Steam consumption and shell temperature would increase. Relief valves would limit shell pressure.	Spare recombiner train.
	Low pressure steam supply	Catalytic ~~R~~recombiner performance could fall off at low-power level, and hydrogen content of recombiner gas discharge could increase eventually to a combustible mixture.	Low temperature alarms on preheater exit (catalyst inlet). Downstream H_2 analyzer alarm.
Catalytic Recombiner ~~catalyst~~	Catalyst gradually deactivates	Temperature profile changes through catalyst. Eventually excess H_2 would be detected by H_2 analyzer or by offgas flowmeter. Eventually the gas could become combustible.	Temperature probes in catalyst bed and H_2 analyzer provided. Spare recombiner train.

Table 11.3-3

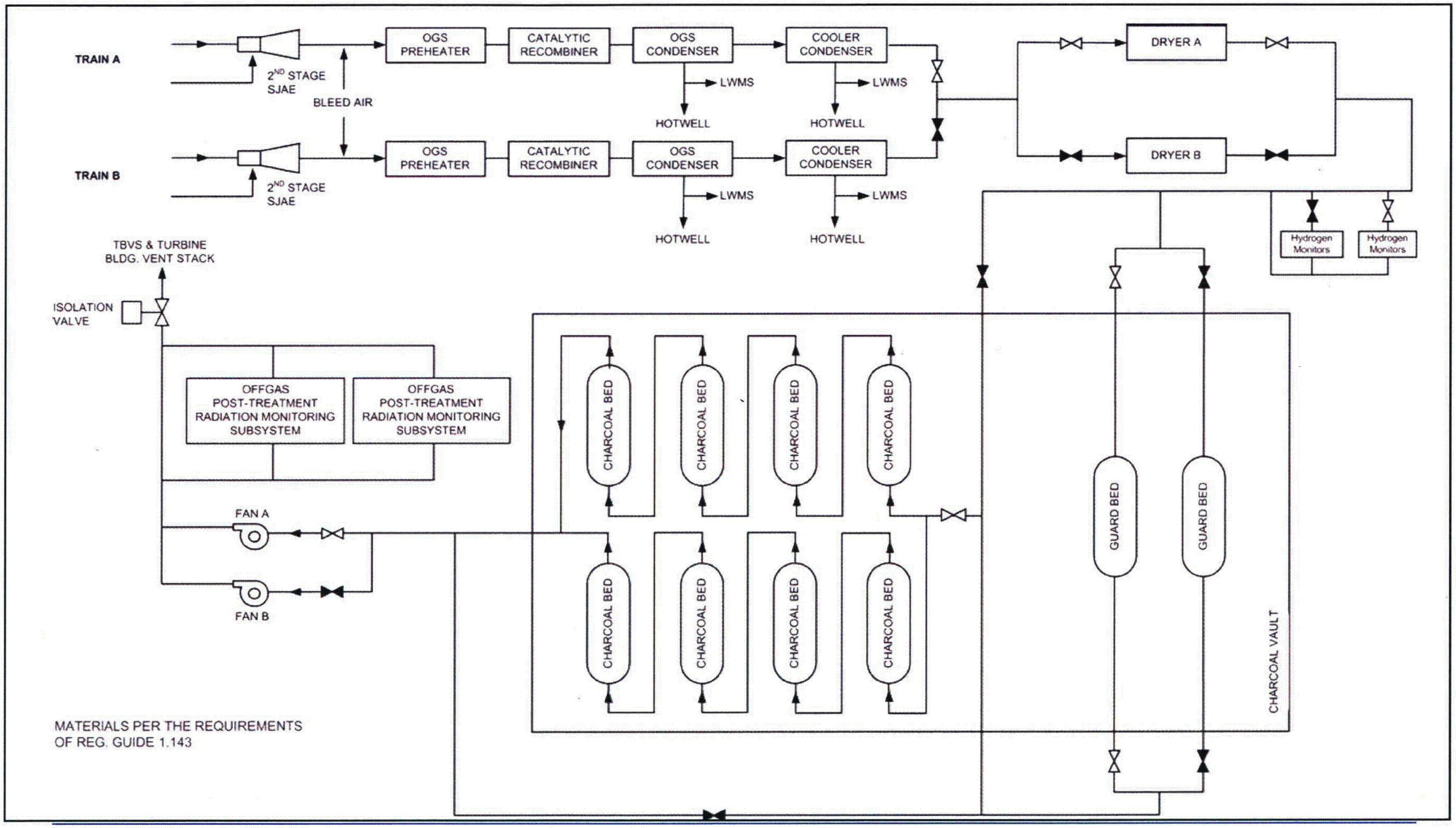
Equipment Malfunction Analysis

Equipment Item	Malfunction	Result(s)	Design Precautions
	Catalyst gets wet at start	H_2-O_2 recombination fails. Eventually the gas downstream of the catalytic recombiner could become combustible.	Condensate drains, temperature probes in catalytic recombiner., Aair bleed system at startup., sSpare recombiner train,. and Hhydrogen analyzers.
Recombiner OGS eCondenser	Cooling water leak	The coolant (reactor condensate) would leak to the process gas (shell) side. This would be detected by drain flow increase. Moderate leakage would be of no concern from a process standpoint. (The process condensate drains to the hotwell.)	Drain high flow alarm. Redundant recombiner train.
Cooler condenser	Corrosion of tubes	Water would leak into process (shell) side and be sent to main condenser hotwell.	Stainless steel tubes specified. Conductivity cell in condenser drain.
Moisture separator in cooler condenser	Corrosion of wire mesh element	Increased moisture would be retained in process gas routed to charcoal over a long period.	Stainless steel mesh specified. Spare cooler condenser provided. Levels in pre-charcoal drain.
Refrigerant Dryer	Refrigerant gas leaks	Compressor parameters exceed operating limits. Compressor trips.	Guard Bed absorbs moisture until flow is rerouted to redundant dryer.
Charcoal adsorbers	Charcoal gets wet	Charcoal performance deteriorates gradually as moisture deposits. Holdup times for krypton and xenon would decrease, and plant emissions would increase. Provisions made for drying charcoal as required during annual outage.	High instrumented, mechanically simple gas dehumidification system.

Table 11.3-3

Equipment Malfunction Analysis

Equipment Item	Malfunction	Result(s)	Design Precautions
System	Internal detonation	Release of radioactivity if pressure boundary fails.	Main process equipment and piping are designed to contain a detonation.
		Internal damage to the catalytic recombiner and its heat exchanger.	Redundant catalytic recombiner, damaged internals can be repaired.
		Damage to instrumentation sensors.	Redundant, damaged sensors can be replaced.
System	Earthquake damage	Release of radioactivity.	System is designed in accordance with RG 1.143 to withstand the effects of earthquakes (Subsection 11.3.7).


TRAIN A
2ND STAGE SJAE
BLEED AIR
OGS PREHEATER
CATALYTIC RECOMBINER
OGS CONDENSER
COOLER CONDENSER
LWMS
HOTWELL
DRYER A
DRYER B
TRAIN B
Hydrogen Monitors
TBVS & TURBINE BLDG. VENT STACK
ISOLATION VALVE
OFFGAS POST-TREATMENT RADIATION MONITORING SUBSYSTEM
CHARCOAL BED
GUARD BED
CHARCOAL VAULT
FAN A
FAN B
MATERIALS PER THE REQUIREMENTS OF REG. GUIDE 1.143

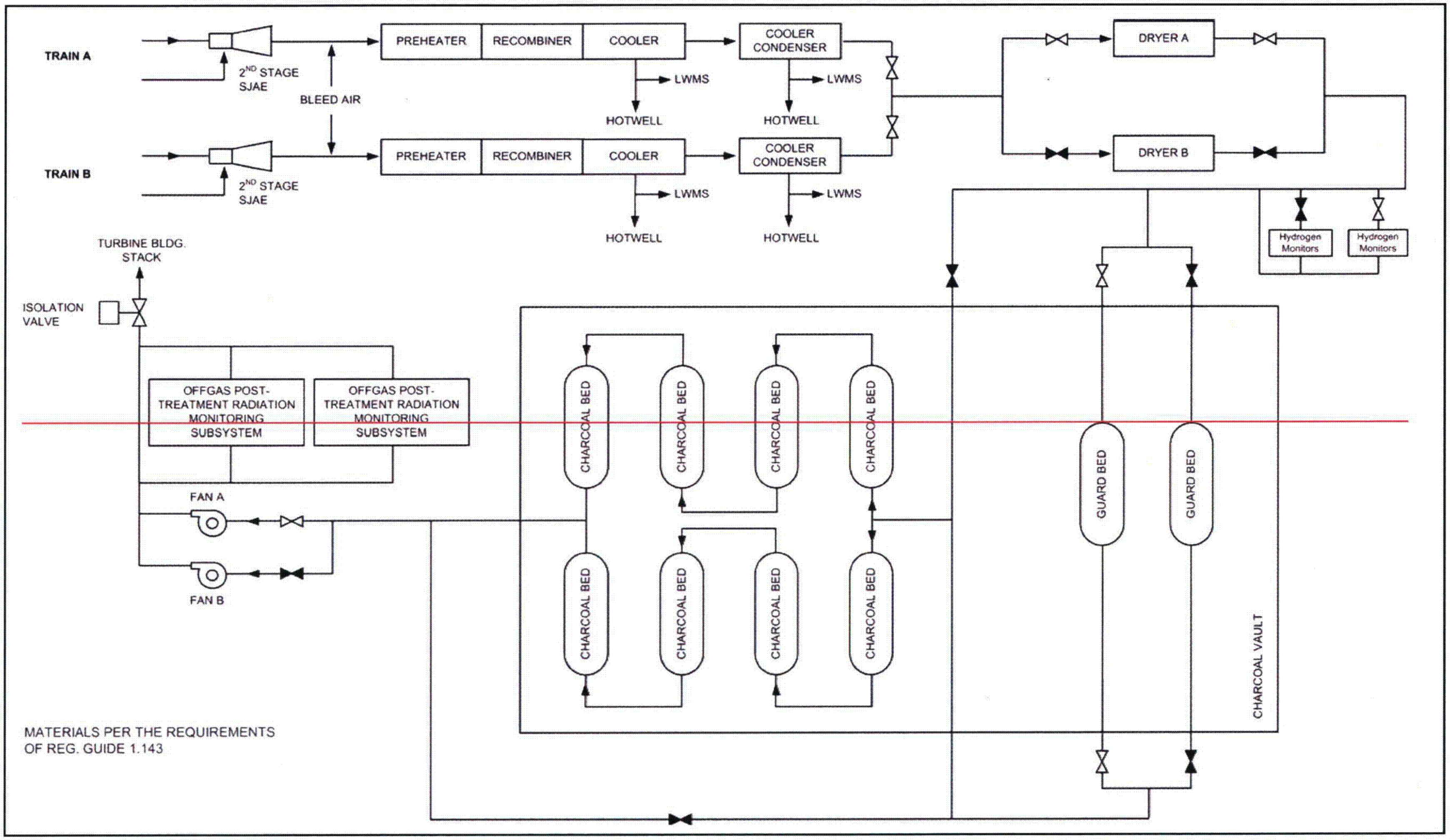


Figure 11.3-1. Offgas System