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MFN 10-243

Docket No. 52-010

August 24, 2010

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

Subject: **Transmittal of ESBWR DCD Tier 2 Chapter 12 Markup Related to August 2010 ACRS Subcommittee Concern –Radiation Monitors**

The purpose of this letter is to submit markups to the ESBWR DCD Tier 2, Chapter 12, resulting from a concern raised by the ACRS subcommittee meeting for Chapter 12 on August 17, 2010.

The concern was associated with the use of portable continuous air monitors (CAMs) to evaluate radiological conditions in occupied areas. GEH and NRC personnel described that ESBWR has installed detectors that can be used to supplement CAMs for the purpose of evaluating radiological conditions in occupied areas. The enclosed markup is meant to clarify this point.

Enclosure 1 provides the DCD Tier 2, Chapter 12 markup to be incorporated into the DCD, Rev. 8. The markup associated with this letter is enclosed within a box.

Enclosure 2 provides background information supporting this markup.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

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NRO

Enclosures:

1. Transmittal of ESBWR DCD Tier 2 Chapter 12 Markup Related to August 2010 ACRS Subcommittee Concern –Radiation Monitors – DCD Markup
2. Transmittal of ESBWR DCD Tier 2 Chapter 12 Markup Related to August 2010 ACRS Subcommittee Concern –Radiation Monitors – Selected Radiation Detector DCD References

cc:	AE Cubbage	USNRC (with enclosures)
	JG Head	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	TL Enfinger	GEH/Wilmington (with enclosures)
	eDRF Section	0000-0117-4148, Revision 1

Enclosure 1

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Transmittal of ESBWR DCD Tier 2 Chapter 12 Markup Related to August 2010 ACRS Subcommittee Concern

Radiation Monitors

DCD Markup

Guide 1.183 (Reference 12.3-16). To ensure conservatism, a 1 cfm (0.028 m^3/min) leak-rate from the RB was used.

The source term of the CB EFU for accident dose assessment is the LOCA inventory at the EFU intakes obtained following the assumptions of Reference 12.3-16. To ensure conservatism, a 300 cfm (8.5 m^3/min) leak rate from the RB was used. The activity retained in the filters over 30 days corrected for radioactive decay is shown in Table 12.3-9.

In order to maintain the exposure from filter maintenance ALARA, the shielding wall thickness between RB HVAC filter cubicles is sized so that the dose contribution in any cubicle from the filter in the adjacent one does not exceed 250 μSv/hr (25 mrem/hr) under normal operation.

For the CB EFU and the RB filters, the dose rates in the filter and adjacent rooms in accident conditions are shown in Tables 12.3-10a and 12.3-10b.

12.3.4 Area Radiation and Airborne Radioactivity Monitoring Instrumentation

The following systems are provided to monitor area radiation and airborne radioactivity within the plant:

- The Area Radiation Monitoring System (ARMS) continuously measures, indicates and records the gamma radiation levels at strategic locations throughout the plant except within the primary containment, and activates alarms in the MCR as well as in local areas to warn operating personnel to avoid unnecessary or inadvertent exposure to radiation. This system is classified as nonsafety-related.
- The Containment Monitoring System (CMS) continuously measures, indicates, and records the gamma radiation levels within the primary containment (drywell and suppression chamber), and activates alarms in the main control room on a high radiation level. As described in Subsection 7.5.2, four gamma-sensitive ion chambers are provided within the primary containment to monitor gamma rays during normal, abnormal and accident conditions. Two redundant sensors are located in the drywell and two in the wetwell. The monitors are located, such that they are widely separated to provide independent measurements with a large fraction of the containment volume considered in both the wetwell and drywell. Further, the selection of the location considers reasonable access for personnel to allow for replacement, maintenance and calibration of equipment. The range of each monitor covers seven decades from 0.01 Gy/hr (1R/hr) to 10^5 Gy/hr (10^7 R/hr) as required by Regulatory Guide 1.97 (Reference 12.3-13). The CMS is classified as safety-related. The radiation monitors have been designed in accordance with NUREG-0737, Item II.F.1 (Reference 12.3-17).
- Airborne radioactivity in effluent releases and ventilation air exhausts is continuously sampled and monitored by the Process Radiation Monitoring System (PRMS) for noble gases, air particulates and halogens. As described in Section 11.5, airborne contamination is sampled and monitored at each stack, in the offgas releases, and in the ventilation exhaust from the RB, RW and TB. Samples are periodically collected and analyzed for radioactivity. In addition to this instrumentation, portable air samplers are used for compliance with 10 CFR 20 restrictions to check for airborne radioactivity in work areas prior to entry where potential radiation levels may exceed the allowable limits.

- Portable continuous air monitors (CAMs) provide a means to observe trends in airborne radioactivity concentrations. CAMs equipped with local alarm capability are used in occupied areas where needed to alert personnel to sudden changes in airborne radioactivity concentrations. Surveys to assess airborne radioactivity levels are performed with continuous air monitors (CAMs) and by taking grab samples (using portable low or high volume air samplers) with appropriate media for collecting particulate, iodine, gas, or tritium samples. In order to warn personnel of changing airborne conditions, CAM alarm set points are set at a fraction of the concentration values given in 10 CFR Part 20, Appendix B, Table 1, Column 3, for radionuclides expected to be encountered.

~~The in-plant airborne radiation monitoring instrumentation is located so that selected local areas and ventilation paths are monitored. Each location monitored is supplied with a local audible alarm (visual alarm in high noise areas) and the monitor has variable alarm set points. When appropriate, selected airborne radioactivity sampling points are located upstream of any ventilation filter trains to monitor representative radioactivity concentrations from the areas being sampled. Plant operating personnel are supplied with continuous information about the airborne radioactivity levels throughout the plant. The instruments used for monitoring airborne radioactivity are specified to detect the time integrated change of the most limiting particulate and iodine species equivalent to those concentrations specified in Appendix B of 10 CFR Part 20 in each monitored plant area within 10 hours. Locations are selected based on the potential for leakage into rooms and areas that contain radioactive processes that become airborne and where ersonnel occupancy is required for operation of the reactor plant.~~

- In addition to providing radiological indication of HVAC exhaust prior to entering their respective stacks, the following detectors also provide a gross indication of airborne radiological conditions from occupied areas:
  - Reactor Building HVAC Exhaust (Detector #2)
  - Refuel Handling Area HVAC Exhaust (Detector #3)
  - Turbine Building Normal Ventilation Air HVAC (Detector #5)
  - Turbine Building Compartment Area Air HVAC (Detector #6)
  - Fuel Building General Area HVAC (Detector #21)
  - Fuel Building Fuel Pool HVAC (Detector #22)
  - Containment Purge Exhaust (Detector #23)

  These detectors are located upstream of the main building HEPA filter. These detectors have indication and alarms in the main control room and can be used by plant personnel, in conjunction with portable monitors, to evaluate the airborne radiological conditions in occupied areas. These detectors are also provided with Plant Investment Protection (PIP) standby power.

- The radiation instrumentation that monitors airborne radioactivity is classified as nonsafety-related. Airborne radiation monitoring operational considerations, such as the

Enclosure 2

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Transmittal of ESBWR DCD Tier 2 Chapter 12 Markup Related to August 2010 ACRS Subcommittee Concern

Radiation Monitors

Selected Radiation Detector DCD References

SELECTED RADIATION DETECTOR
DCD REFERENCES

DETECTOR NUMBER	DETECTOR TITLE	DCD REFERENCE LOCATIONS
2	Reactor Building HVAC Exhaust (CONAVS)	Subsection 9.4.6 (Pages 9.4-28 & 29) Subsection 9.4.6.1 (Page 9.4-30) Subsection 9.4.6.2 (Page 9.4-31) Subsection 9.4.6.3 (Page 9.4-34) Subsection 9.4.6.5 (Page 9.4-35) Subsection 11.5.1.1.1 (Page 11.5-1) Subsection 11.5.2.1 (Page 11.5-3 & 4) Subsection 11.5.3.1 (Page 11.5-4) Subsection 11.5.3.1.2 (Page 11.5-5) Subsection 11.5.5.2 (Page 11.5-20) Subsection 11.5.5.3 (Page 11.5-21) Subsection 11.5.5.4 (Page 11.5-21) Subsection 11.5.6.1 (Page 11.5-23) Table 11.5-1 (Page 11.5-29) Table 11.5-2 (Page 11.5-33) Table 11.5-3 (Page 11.5-39) Table 11.5-9 (Page 11.5-48) Figure 11.5-1 (Page 11.5-56)
3	Refuel Handling Area HVAC Exhaust (REPAVS)	Subsection 9.4.6 (Pages 9.4-28 & 29) Subsection 9.4.6.1 (Page 9.4-30) Subsection 9.4.6.2 (Page 9.4-32) Subsection 9.4.6.3 (Page 9.4-34) Subsection 9.4.6.5 (Page 9.4-35) Subsection 11.5.1.1.1 (Page 11.5-1) Subsection 11.5.2.1 (Page 11.5-3 & 4) Subsection 11.5.3.1 (Page 11.5-4) Subsection 11.5.3.1.3 (Page 11.5-5 & 6) Subsection 11.5.5.2 (Page 11.5-20) Subsection 11.5.5.3 (Page 11.5-21) Subsection 11.5.5.4 (Page 11.5-21) Subsection 11.5.6.1 (Page 11.5-23) Table 11.5-1 (Page 11.5-29) Table 11.5-2 (Page 11.5-33) Table 11.5-3 (Page 11.5-39) Table 11.5-9 (Page 11.5-48) Figure 11.5-1 (Page 11.5-56)

SELECTED RADIATION DETECTOR
DCD REFERENCES

DETECTOR NUMBER	DETECTOR TITLE	DCD REFERENCE LOCATIONS
5	Turbine Building Normal Ventilation Air HVAC	Subsection 9.4.4 (Page 9.4-23) Subsection 9.4.4.3 (Page 9.4-27) Subsection 11.5.1.1.2 (Page 11.5-2) Subsection 11.5.2.2 (Page 11.5-4) Subsection 11.5.3.2.9 (Page 11.5-13) Subsection 11.5.5.4 (Page 11.5-22) Subsection 11.5.6.1 (Page 11.5-23) Table 11.5-1 (Page 11.5-30) Table 11.5-2 (Page 11.5-35) Table 11.5-3 (Page 11.5-39) Table 11.5-9 (Page 11.5-51) Figure 11.5-1 (Page 11.5-56)
6	Turbine Building Compartment Area Air HVAC	Subsection 9.4.4 (Page 9.4-23) Subsection 9.4.4.2 (Page 9.4-25) Subsection 11.5.1.1.2 (Page 11.5-2) Subsection 11.5.2.2 (Page 11.5-4) Subsection 11.5.3.2.8 (Page 11.5-13) Subsection 11.5.5.4 (Page 11.5-22) Subsection 11.5.6.1 (Page 11.5-23) Table 11.5-1 (Page 11.5-30) Table 11.5-2 (Page 11.5-35) Table 11.5-3 (Page 11.5-39) Table 11.5-9 (Page 11.5-51) Figure 11.5-1 (Page 11.5-56)
21	Fuel Building General Area HVAC	Subsection 9.4.2.2 (Page 9.4-16) Subsection 11.5.1.1.1 (Page 11.5-1) Subsection 11.5.2.1 (Page 11.5-3 & 4) Subsection 11.5.3.1 (Page 11.5-4) Subsection 11.5.3.1.7 (Page 11.5-8) Subsection 11.5.5.2 (Page 11.5-21) Subsection 11.5.5.3 (Page 11.5-21) Subsection 11.5.5.4 (Page 11.5-21) Subsection 11.5.6.1 (Page 11.5-23) Table 11.5-1 (Page 11.5-29) Table 11.5-2 (Page 11.5-33) Table 11.5-3 (Page 11.5-39) Table 11.5-9 (Page 11.5-48) Figure 11.5-1 (Page 11.5-56)

SELECTED RADIATION DETECTOR
DCD REFERENCES

DETECTOR NUMBER	DETECTOR TITLE	DCD REFERENCE LOCATIONS
22	Fuel Building Fuel Pool HVAC	Subsection 9.4.2.2 (Page 9.4-16) Subsection 11.5.1.1.1 (Page 11.5-1) Subsection 11.5.2.1 (Page 11.5-3 & 4) Subsection 11.5.3.1 (Page 11.5-4) Subsection 11.5.3.1.8 (Page 11.5-8 & 9) Subsection 11.5.5.2 (Page 11.5-21) Subsection 11.5.5.3 (Page 11.5-21) Subsection 11.5.5.4 (Page 11.5-22) Subsection 11.5.6.1 (Page 11.5-23) Table 11.5-1 (Page 11.5-29) Table 11.5-2 (Page 11.5-34) Table 11.5-3 (Page 11.5-39) Table 11.5-9 (Page 11.5-49) Figure 11.5-1 (Page 11.5-56)
23	Containment Purge Exhaust	Subsection 9.4.6.2 (Page 9.4-33) Subsection 11.5.1.1.1 (Page 11.5-1) Subsection 11.5.2.1 (Page 11.5-3 & 4) Subsection 11.5.3.1 (Page 11.5-4) Subsection 11.5.3.1.9 (Page 11.5-9) Subsection 11.5.5.2 (Page 11.5-21) Subsection 11.5.5.4 (Page 11.5-22) Subsection 11.5.6.1 (Page 11.5-23) Table 11.5-1 (Page 11.5-29) Table 11.5-2 (Page 11.5-33) Table 11.5-3 (Page 11.5-39) Table 11.5-9 (Page 11.5-49) Figure 11.5-1 (Page 11.5-56)

Cooling is provided for FAPCS pump motors, rooms, and/or electrical/instrument panels designed to limit the room/equipment's environmental qualification temperature when the building is isolated.

FBFPVS

Figure 9.4-6 shows the system diagram for the FBFPVS. Table 9.4-5 lists the major equipment for the FBFPVS.

The FBFPVS is a once-through air conditioning and ventilation system with AHU and redundant exhaust fans. The AHU includes filters, heating elements, cooling coils, and redundant AHU supply fans. Outside air is filtered, heated or cooled, and distributed across the Spent Fuel Pool surface and to the equipment areas. Air is exhausted from the Spent Fuel Pool, through redundant FB boundary isolation dampers, to the outside atmosphere through the RB/FB vent stack. During high radiation conditions, the exhaust air may be manually diverted to the Fuel Building HVAC Purge Exhaust Filter Unit. The exhaust fans are also used for smoke removal. Electric unit heaters provide supplementary heating as required. The Chilled Water System provides cooling water for the FBFPVS AHUs. Instrument air is provided for the pneumatic actuators.

The FBFPVS AHUs and exhaust fans are located in the FB HVAC Equipment Area.

During high radiation conditions, the FB boundary isolation dampers close automatically and the supply AHU and exhaust fan shut down automatically in both subsystems.

System Operation

The FBVS operates during all normal, startup and shutdown modes of plant operation.

During normal operation, both the FBGAVS and FBFPVS are fully operable. Each subsystem operates with one supply AHU and one exhaust fan in service. The redundant supply fan (in each AHU) and exhaust fan are maintained in standby. In the event of low airflow in an exhaust duct, the standby exhaust fan starts. Simultaneously, due to a loss of negative pressure in the area, the AHU supply fan serving the area stops. The AHU supply fan restarts upon reestablishment of the required negative pressure. In the event of a fan failure, the failed fan automatically shuts down and the standby fan automatically starts.

Detector #22

Detector #21

On detection of high radiation, the Process Radiation Monitoring System provides a signal that trips the FBGAVS and FBFPVS. Each subsystem's supply AHU and exhaust fan shuts down and their associated dampers close. Exhaust air from either subsystem may be manually diverted to the FB HVAC Purge Exhaust Filter Unit. It is then exhausted to the RB/FB vent stack by the Fuel Building HVAC Purge Exhaust Filter Unit exhaust fan. Normal ventilation for the area is resumed once the area is decontaminated or the source of radioactivity is removed.

The FMCRD room AHU fan is started and stopped locally. A room thermostat modulates the chilled water valve in response to the room temperature.

An individual local thermostat controls each electric unit heater.

9.4.2.3 Safety Evaluation

The FBVS is not required to operate during a Station Blackout (SBO).

Detectors #5 & 6

- Meets GDC 60 by suitably controlling the release of gaseous radioactive effluents to the environment during normal operations. The system directs potentially contaminated building exhaust air to the TBVS system filtration units. Exhaust air from low potential contamination areas is exhausted to the TB vent stack, where it is monitored for radioactive contamination. Exhaust air from high potential contamination areas is filtered using High Efficiency Particulate Air (HEPA) filters before being exhausted to the TB vent stack. The HEPA filters assist in ensuring radioactive material entrained in gaseous effluent will not exceed the limits specified in 10 CFR Part 20, for normal operations and anticipated operational occurrences. TBVS high potential contaminated exhaust subsystems are equipped with HEPA filtration units for localized air cleanup prior to mixing with the turbine building exhaust (TBE). The local HEPA units are designed, tested and maintained in accordance with RG 1.140. The TBE combined ventilation exhaust is monitored for halogens, particulates and noble gas releases. The TB Compartment area and normal ventilation HVAC Process Radiation Monitoring (PRM) subsystems monitor air for gross radiation levels and alarm functions. The TB is maintained at a slight negative pressure to minimize exfiltration. TB equipment rooms are maintained at a negative pressure to minimize potential airborne radioactivity escaping to adjacent areas or to the outside atmosphere during normal operation by exhausting air through filters from the areas in which a significant potential for contamination exists.

9.4.4.1 Design Bases

Safety Design Bases

The TBVS does not perform or ensure any safety-related function, and thus, has no safety design basis.

The TBVS has RTNSS functions as described in Appendix 19A, which provides the level of oversight and additional requirements to meet the RTNSS functions. Performance of RTNSS functions is assured by applying the defense-in-depth principles of redundancy and physical separation to ensure adequate reliability and availability as described in Subsection 19A.8.3.

Power Generation Design Bases

The TBVS:

- Provides temperature control and air movement control for personnel comfort;
- Optimizes equipment performance by the removal of heat dissipated from plant equipment;
- Provides a sufficient quantity of filtered fresh air for personnel;
- Provides for air movement from areas of lesser potential airborne radioactivity to areas of greater potential airborne radioactivity prior to final exhaust;
- Minimizes the possibility of exhaust air recirculation into the air intake;
- Minimizes the escape of potential airborne radioactivity to the outside atmosphere during normal operation;

The TBVS equipment is located in the Turbine Building.

The chiller rooms, located in the Turbine Building, meet ASHRAE-15, Safety Standard for Refrigeration Systems. They are equipped with a dedicated purge system and leak detectors with alarms.

Detailed System Description

Turbine Building Air Supply (TBAS) Subsystem

The TBAS consists of outside air intake louvers, dampers, filters, heating coils, chilled water cooling coils, and three 50% capacity supply fans.

Two of the three fans are normally operating to supply filtered, temperature-controlled air to all levels of the Turbine Building. The third fan is a standby unit that starts automatically upon failure of either operating fan. Each supply fan is provided with pneumatically operated isolation dampers. The TBAS uses 100% outside air during normal plant operation.

The TBAS fans are started manually from the MCR. The supply fans are interlocked with the TBVS exhaust fans and TBVS compartment exhaust fans to ensure that the exhaust fans are running before a supply fan is started.

Temperature elements located at the heating and cooling coils air outlet modulate the TBAS air handling heating and cooling coil operation.

Turbine Building Exhaust (TBE) Subsystem

The TBE fans exhaust air from the building clean and low potential contamination areas. The air is exhausted through the monitored vent stack.

The TBE subsystem is provided with three 50% capacity fans. Two fans are normally in operation and one is in automatic standby.

All three TBE fans can be operated simultaneously to provide maximum smoke removal, if necessary.

Each TBE fan is provided with variable speed drives and isolation dampers. A flow controller automatically adjusts the frequency of the operating fans to vary the system airflow rate. Failure of one operating exhaust fan automatically starts the standby fan. The TBVS exhaust fans are interlocked with the TBAS fans.

Turbine Building Compartment Exhaust (TBCE) Subsystem

The TBCE subsystem consists of two 100% capacity exhaust fans, one filter unit and associated controls. One fan is normally in operation with the other one in automatic standby. The subsystem includes a 100% capacity filter bypass duct for purging smoke in the event of a fire.

The air exhausted from the Turbine Building high potential airborne contamination compartments and equipment vents is passed through a filter before it is released to the atmosphere through the TB vent stack, except during smoke removal. Detector #6

The TBCE subsystem has radiation detectors in the exhaust duct to monitor the air for radioactivity prior to its being discharged to the TB vent stack.

MCR operators normally initiate the smoke purge mode of operation of the Turbine Building. Smoke purge is accomplished by starting two supply fans in the TBAS and two exhaust fans in the TBE subsystem as well as the TBCE and TBLOE exhaust fans. This provides 100% outside air. All three fans in the TBAS and in the TBE subsystem can be started to provide maximum smoke removal.

Loss of Preferred Power (LOPP)

Upon a LOPP, at least one of the fans of the TBE subsystem remains available for operation because it is powered from the nonsafety-related diesel generators.

The local AHUs of the RCCWS, Nuclear Island subsystem of the CWS and Instrument / Service Air System rooms and selected electrical equipment rooms also remain in operation.

9.4.4.3 Safety Evaluation

Detector #5

The TBVS does not perform any safety-related function.

Where a system is provided with a redundant fan, failure of an operating fan automatically starts the standby fan to maintain continuity of ventilation.

The exhaust air from the TBVS is monitored for radioactivity prior to discharge to the plant vent. Alarms annunciate in the MCR upon detection of high radiation. Section 11.5 describes the Process Radiation Monitoring System.

The TBVS components are designed as Seismic Category NS.

9.4.4.4 Tests and Inspections

All major components are tested and inspected as separate components prior to installation and as integrated systems after installation to ensure design performance. Ductwork system airflows are measured and adjusted to meet design requirements and all instruments are calibrated to the design setpoints. The systems are preoperational tested in accordance with the requirements of Chapter 14.

Periodic inspections and measurements including air flows, water flows, air and water temperatures, filter pressure drops, controls positions, are taken to verify the systems operating conditions and to ensure the integrity of the systems for normal plant operation.

The TBVS exhaust filtration components are periodically tested in accordance with RG 1.140, "Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants."

9.4.4.5 Instrumentation Requirements

All control actuations, indicators, and alarms for normal plant operation are located in the MCR area. Controls and instrumentation for the TBVS include:

- Heating and cooling temperature elements, controls and alarms for the entering air;
- Low and high temperature signals and alarms for heated and cooled air supply;
- Differential pressure indicators, differential pressure transmitters and alarm for the air filters;

- Supply airflow indicator and controls, alarms and trips for supply fans; and
- Airflow failure signals, alarm and trip for each exhaust fan.

This instrumentation conforms to GDC 13. Refer to Subsection 3.1.2.4 for a general discussion of the GDC.

9.4.4.6 COL Information

None

9.4.4.7 References

The applicable HVAC codes and standards are shown in Table 9.4-17.

9.4.5 Engineered Safety Feature Ventilation System

The Emergency Filter Unit (EFU) portion of the CRHAVS supplies the engineered safety feature for CRHA radiological protection as described in Section 6.4 and Subsection 9.4.1.

9.4.6 Reactor Building HVAC System

The RB HVAC System (RBVS) serves the following areas of the RB:

- The potentially contaminated areas (CONAVS);
- The refueling area (REPAVS);
- The non-radiologically controlled areas (CLAVS); and
- Containment during inerting and de-inerting operations.

Relative to the RBVS, this subsection addresses applicable requirements of General Design Criteria (GDC) 2, 5 and 60. These GDCs are discussed in Standard Review Plan (SRP) 9.4.3. The ESBWR:

- Meets GDC 2 via compliance to the guidance of RG 1.29, Position C.2 for nonsafety-related portions. The RBVS is nonsafety-related except for the building isolation dampers. The RBVS components are designed as Seismic Category II except for the safety-related building isolation dampers and associated controls that are Seismic Category I. The RB is a Seismic Category I structure. The FB penthouse that houses the RBVS equipment is Seismic Category II.
- Meets GDC 5 for shared systems and components important to safety for the RB isolation dampers. The RBVS is not shared among other operating units.
- Meets GDC 60 by suitably controlling the release of gaseous radioactive effluents to the environment. The system may direct its exhaust air to the RB HVAC Online Purge Exhaust Filter Unit during periods of high radioactivity. The nonsafety-related RB HVAC Accident Exhaust Filter Units provide the ability to draw a negative pressure on the potentially contaminated ventilation served areas (CONAVS) of the RB. The RB HVAC Online Purge Exhaust Filter Units and RB HVAC Accident Exhaust Filter Units are ~~is~~ designed, tested and maintained in accordance with RG 1.140. Additional testing requirements are described in subsection 9.4.6.4. The RBVS (CONAVS and REPAVS) exhaust subsystems are equipped with control systems to automatically isolate the

Detectors # 2 & 3

Detectors #2 & 3)

effluent on indication of a high radiation level. The RB boundary isolation dampers (CONAVS and REPAVS) close on receipt of a high radiation signal, or on a loss of AC power.

9.4.6.1 Design Bases

Safety Design Bases

With the following exception, the RBVS is nonsafety-related. The isolation dampers and ducting penetrating the RB boundary and associated controls that provide the isolation signal are safety-related. The RBVS performs no safety-related function except for automatic isolation of the RB boundary (CONAVS and REPAVS subsystems) during accidents. The RBVS has nonsafety-related RB HVAC Online Purge Exhaust Filter Units for mitigating and controlling gaseous effluents from the RB. The RBVS has nonsafety-related RB HVAC Accident Exhaust Filter Units for use post accident (>8 hours)~~for use post-accident (>seven days)~~ to create a negative pressure in the RB contaminated areas and exhaust~~ing~~ the filtered air to the RB/FB stack. The filtering efficiency ensures that control room doses are not exceeded for certain beyond design basis LOCAs.

The RBVS has RTNSS functions as described in Appendix 19A, which provides the level of oversight and additional requirements to meet the RTNSS functions. Performance of RTNSS functions is assured by applying the defense-in-depth principles of redundancy and physical separation to ensure adequate reliability and availability. In addition, augmented design standards are applied as described in Subsection 19A.8.3.

Power Generation Design Bases

The RBVS:

- Provides a controlled environment for personnel comfort and safety, and for proper operation and integrity of equipment. See Table 9.4-8 for area temperatures maintained.
- Maintains potentially contaminated areas at a negative pressure to minimize exfiltration of potentially contaminated air. See Table 9.4-8 for area pressurization.
- Maintains clean areas of the building, except for the battery rooms, at a positive pressure to minimize infiltration of outside air. See Table 9.4-8 for area pressurization.
- Maintains airflow from areas of lower potential for contamination to areas of greater potential for contamination. The pressure in these areas hereafter called "Slightly Negative Pressure" is a range from less than zero to –124 PaG (-0.50" w.g.).
- Is provided with redundant active components to increase the reliability, availability, and maintainability of the systems.
- Is capable of exhausting smoke, heat and gaseous combustion products in the event of a fire.
- Prevents smoke and hot gases from migrating into other fire areas by automatically closing smoke dampers upon detection of smoke.

- Smoke control and removal functions are in accordance with NFPA guidelines as described in Section 9.5 Other Auxiliary Systems, Subsection 9.5.1.11, Building Ventilation.

Detectors #2 & 3

- Shuts down during radiological events and isolates the RB boundary (CONAVS and REPAVS subsystems) to prevent uncontrolled releases to the outside atmosphere.
- Provides the ability to draw a negative pressure and exhaust the contaminated ventilation served areas of the RB through the RB HVAC Accident Exhaust Filter Units.

Detector #2

- Provides the capability to manually divert exhaust air for processing through the RB HVAC On-line Purge Exhaust Filter Units.
- Reactor Building HVAC On-line Purge Exhaust Filter Units can be energized to re-circulate the CONAVS area air space.
- Provides pool sweep ventilation air over the refueling area pool surface.
- Maintains its structural integrity after a safe shutdown earthquake.
- Is designed such that failure of the system does not compromise or otherwise damage safety-related equipment.
- Is provided with shutoff dampers on the inlet and outlet of fans and AHUs to allow for maintenance as required.
- Is provided with shutoff valves at the inlet and outlet of cooling coils to allow for maintenance as required.
- Is provided with access doors for AHUs, fans, filter sections, and duct mounted dampers to allow for maintenance as required.
- Is provided with capability for manual control of system fans to facilitate testing and maintenance.
- Maintains the hydrogen concentration levels in the battery rooms below 2% by volume in accordance with RG 1.128.
- Replaces the containment inerted atmosphere with conditioned air during a refueling operation.
- Provides local recirculation AHUs for cooling of the Hydraulic Control Unit area.
- RBVS maintains SLC accumulator room environmental conditions within temperature limits including employing two backup heaters per room. PIP A and PIP B busses provide power for these heaters.
- Provides cooling for CRD and RWCU/SDC pump motors, rooms, and/or electrical/instrument panels designed to limit the room/equipment to within its temperature environmental qualification when the building is isolated. The motor cooler heat sink is the RCCW, while Chilled Water or Direct Expansion Units are provided for electrical cabinet cooling.
- Maintains Battery room temperatures within a range to maximize output and equipment life.

9.4.6.2 System Description

Summary Description

The RBVS maintains space design temperature, quality of air, and pressure control in the RB. The system consists of three subsystems. The RB Contaminated Area HVAC Subsystem (CONAVS) serves the potentially contaminated areas of the RB. The Refueling and Pool Area HVAC Subsystem (REPAVS) serves the refueling area of the RB. The RB Clean Area HVAC Subsystem (CLAVS) serves the clean (non-radiological controlled) areas of the RB.

Detailed System Description

CONAVS

Figure 9.4-10 shows a simplified system diagram for the CONAVS. Table 9.4-11 shows the major equipment for the CONAVS and Subsection 9.4.10 describes component information.

Detector #2

The CONAVS is a two train, once-through ventilation system with each train consisting of an AHU, redundant exhaust fans, and building isolation dampers. It includes a containment purge exhaust fan, recirculation AHUs and unit heaters. The AHU includes filters, heating and cooling coils and redundant supply fans. Outside air is filtered and heated or cooled prior to distribution by the AHU in service. The Chilled Water System provides cooling for the CONAVS AHUs. The Instrument Air System provides instrument air for the pneumatic actuators. A common supply air duct distributes conditioned air to the potentially contaminated areas of the RB. Air is exhausted from the potentially contaminated areas of the RB by the operating exhaust fan and discharged to the Reactor Building/Fuel Building (RB/FB) vent stack. During containment de-inerting operations the supply airflow rate of the AHU supply fan is increased. At the same time the airflow rate of the exhaust fan is increased an equal amount. In the event of a fire, fire dampers close to isolate the fire area. In the event smoke is detected in the air duct, the system is shut down. After the fire is completely extinguished, the exhaust fans are then used for smoke removal with the exhaust air being monitored for radiological contamination. If contaminated, temporary portable filters may be used to exhaust the contaminated air. The building isolation dampers close and the supply and exhaust fans stop due to high radiation in the exhaust ducts. CONAVS also includes redundant RB HVAC Exhaust Filter Units ("Accident" and "Online Purge" Filter Assemblies) and exhaust fans. During radiological events, exhaust air from contaminated areas may be manually diverted through the RB HVAC Online Purge Exhaust Filter Units. The RB Exhaust Filter Units are equipped with pre-filters, HEPA filters, high efficiency filters and carbon filters for mitigating and controlling particulate and gaseous effluents from the RB. The RB HVAC Online Purge Exhaust Filter Units can be used to re-circulate the CONAVS area air and thereby clean up the contaminated environments in the RB.

After a LOCA, one RB HVAC Accident Exhaust Filter Unit (the redundant one is in standby) can be energized to create a negative pressure by exhausting the air in the CONAVS area.

The supply AHU and normal exhaust fan may be shut down during filtered purge exhaust. Recirculation AHUs provide supplementary cooling for selected rooms. Cooling is provided for CRD and RWCU/SDC pump motor coolers from RCCW, and electrical/instrument panels are provided with either Chilled Water or Direct Expansion Units designed to limit the room and associated equipment to within its temperature environmental qualification when the building is isolated. Electric unit heaters provide supplementary heating.

The CONAVS AHUs are located in the FB HVAC Equipment Area. The CONAVS exhaust fans are located in the RB. The RB HVAC Exhaust Filter Units and exhaust fans are located in the RB.

The refueling machine control room recirculating AHU is located in the RB. Electric unit heaters are located in or near the areas they serve.

REPAVS

Figure 9.4-11 shows a simplified system diagram for the REPAVS. Table 9.4-10 shows the major equipment for the REPAVS.

The REPAVS is a once-through ventilation system and consists of an AHU, redundant exhaust fans and building isolation dampers. The AHU includes filters, heating and cooling coils and redundant supply fans. Outside air is filtered and heated or cooled prior to distribution by the AHU in service. The conditioned air is distributed to the refueling area and across the pool surface. Exhaust air is ducted to the exhaust fans and exhausted to the outside atmosphere through the RB/FB vent stack. During a radiological event, exhaust air from the refueling area may be manually diverted through the RB HVAC Online Purge Exhaust Filter Units. The Chilled Water System provides cooling water for the REPAVS AHU. The Instrument Air System provides instrument air for the pneumatic actuators. In the event of a fire, fire dampers close to isolate the fire area. In the event smoke is detected in the air duct, the system is shut down. After the fire is completely extinguished, the exhaust fans are then used for smoke removal with the exhaust air being monitored for radiological contamination. If contaminated, temporary portable filters are used to exhaust the contaminated air. The building isolation dampers close and the supply and exhaust fans stop due to high radiation in the exhaust ducts.

Detector #3

The REPAVS AHU is located in the FB HVAC Equipment Area. The REPAVS exhaust fans are located in the RB. Electric unit heaters are located in or near the areas they serve.

CLAVS

Figure 9.4-9 shows a simplified system diagram for the CLAVS. Table 9.4-9 shows the major equipment for the CLAVS.

The CLAVS is a two train, recirculating ventilation system with each train consisting of an AHU and redundant return/exhaust fans. The AHU includes filters, heating and cooling coils and redundant supply fans. A mixture of outside and return air is filtered and heated/cooled prior to distribution by the AHU in service. A common supply and return/exhaust air duct system distributes conditioned air to and from the RB clean areas. Return air not directed back to the AHU is exhausted directly outdoors. An economizer cycle is used, when outside air conditions are suitable, to reduce mechanical cooling operating hours. The economizer cycle provides all outside air, or a mixture of outside air and return air, to RB clean areas. The temperature of the air provided is at or below the supply air design temperature. In the event of a fire, fire dampers close to isolate the fire area. In the event smoke is detected in the air duct, the system is shut down. After the fire is completely extinguished, the CLAVS exhaust fans are then used for smoke removal. The Chilled Water System provides cooling for the CLAVS AHU. The Instrument Air System provides instrument air for the pneumatic actuators. Electric unit heaters provide supplementary heating. The CLAVS AHU supplies air to the battery rooms. A minimum exhaust air is continuously extracted from battery rooms in order to keep hydrogen concentration below 2%. This extracted air is exhausted from the battery rooms by the battery room exhaust fans which discharge directly to the RB/FB vent stack. Battery room temperature is maintained within a range to maximize output and equipment life. Battery room hydrogen indication and loss of ventilation alarm functions are provided.

The CLAVS AHUs and return/exhaust fans are located in the FB HVAC Equipment Area. The electric unit heaters are located in or near the areas they serve.

System Operation

The RBVS operates during normal power plant operation, plant startup, and plant shutdown. It is not required to operate during a Station Blackout.

CONAVS

During normal operation, each train of CONAVS operates with the AHU and one exhaust fan in service. The exhaust fan starts first to establish negative pressure in the areas served. Then the AHU supply fan starts. Failure of an operating supply or exhaust fan automatically energizes the standby fan and de-energizes the failed fan. The CONAVS AHU supply fan is de-energized due to a loss of room negative pressure. The AHU supply fan is re-energized upon reestablishment of room negative pressure.

Detector #23

Before and during personnel entry into the containment area, the CONAVS is used to de-inert the containment. The CONAVS AHU supply fan provides purge supply air to containment while the containment purge exhaust fan exhausts air from containment. On detection of high radiation in the exhaust air by PRMS, supply and exhaust dampers to containment are automatically closed. During inerting operation, the CONAVS exhausts air from containment while the Containment Inerting System supplies nitrogen to the containment.

REPAVS

During normal operation, the REPAVS operates with the AHU and one exhaust fan in service. The exhaust fan starts first to establish negative pressure in the areas served. Then the AHU supply fan starts. Failure of an operating supply or exhaust fan automatically energizes the standby fan and de-energizes the failed fan. The REPAVS AHU supply fan is de-energized due to a loss of room negative pressure. The AHU supply fan is re-energized upon reestablishment of room negative pressure.

CLAVS

During normal operation, each train of CLAVS operates with the AHU and one return/exhaust fan in service. When outside air conditions are suitable, the CLAVS incorporates an economizer cycle to reduce operating hours for mechanical cooling equipment. Failure of an operating supply or return/exhaust fan automatically energizes the standby fan and de-energizes the failed fan. The return/exhaust fan is de-energized due to a loss of room pressurization. The return/exhaust fan is re-energized upon reestablishment of room positive pressure.

Following a fire recovery, return/exhaust fans are used to remove smoke from the area by exhausting to the outdoors.

Detectors #2 & 3

9.4.6.3 Safety Evaluation

The RBVS is nonsafety-related, except for the building isolation dampers. The safety-related isolation dampers fail closed upon a loss of control signal, power, or instrument air.

The RBVS components are designed as Seismic Category II, except for the safety-related building isolation dampers and associated controls. The building isolation dampers and associated controls are designed as Seismic Category I.

The RBVS does not perform any safety-related functions, except for the CONAVS and REPAVS subsystem boundary isolation dampers closing in the event of radiological events. The CLAVS subsystems is also provided with safety-related building isolation dampers, which close upon Loss of Power or Loss of Instrument Air. Redundant dampers and controls are provided so the RB can be isolated even if one of the dampers or controls fail.

Rooms containing safety-related equipment have passive cooling features designed to limit the room temperature to the equipment's environmental qualification temperature.

RBVS maintains SLC accumulator room environmental conditions within temperature limits.

The n~~N~~on~~-~~safety-related ~~Related,~~ RB HVAC Accident Exhaust Filter Units provide the ability to draw a negative pressure on the contaminated ventilation served areas of the RB (post accident >8 hours). ~~post-accident (>seven days).~~ These accident units are RTNSS components.

The n~~N~~on~~-~~safety r~~R~~elated~~,~~ RB HVAC Online Purge Exhaust Filter Units provide online cleanup of contaminated areas within the CONAVS or REPAVS subsystems. These online units are not RTNSS components.

9.4.6.4 Testing and Inspection Requirements

Routine testing of the RBVS is conducted in accordance with normal power plant requirements for demonstrating system and component operability. Periodic surveillance testing of safety-related building isolation dampers is carried out per IEEE-338.

The RB HVAC ("Accident" and "Online" Purge) Exhaust Filter components are periodically tested in accordance with RG 1.140, Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants. There is an additional requirement that charcoal laboratory testing will be performed on the RB HVAC Accident Exhaust Filter Unit after each ~~1440~~720 hours of operation as recommended by RG 1.52 Rev. 3 for the~~, because RG 1.140 does not specify a~~ time based charcoal testing frequency. The RB HVAC Online Purge Exhaust Filter Units will be tested on a 4-year frequency. The RTNSS RB HVAC Accident Exhaust Filter Units will additionally be operationally tested each month by running each filter unit for 15 minutes as is recommended in RG 1.52 Rev. 3.

9.4.6.5 Instrumentation Requirements

The RBVS is operated from the MCR. A local run/stop control switch is provided for each fan for maintenance and testing purposes. The RBVS is manually controlled, except for certain automatic operations described below:

- Reactor Building boundary isolation dampers for the CONAVS and REPAVS subsystems close on receipt a high radiation signal or on a loss of AC power. There is no automatic high radiation isolation signal for the CLAVS subsystem. As stated in Section 11.5, radiation monitors of the PRMS which initiate automatic building isolation are:
  - Reactor Building HVAC Exhaust (CONAVS) Detector #2
  - Refuel Handling Area HVAC Exhaust (REPAVS) Detector #3
- For systems with redundant fans, the lead fan is selected manually. The standby fan automatically starts upon indication of low flow in the associated discharge duct.
- Fan operation is allowed only when the corresponding fan shutoff dampers are open.
- The CLAVS return/exhaust fan auto starts after the supply fan starts and the ventilated spaces are at a positive pressure.
- Differential pressures between the ventilated spaces and the outside are transmitted to a pressure controller. The controller adjusts the CLAVS return/exhaust fan speed that modulates airflow to maintain the ventilated spaces at a positive pressure.
- A temperature controller modulates the CLAVS outside, return and exhaust air dampers when outside air temperatures are below design supply air temperatures. Damper modulation provides a mixture of outside and return air at or below design supply air temperatures to the ventilated spaces.
- The CONAVS supply fan auto starts after the exhaust fan starts and a negative pressure has been established in the ventilated spaces.
- Differential pressures between the ventilated spaces and the outside are transmitted to a pressure controller. The pressure controller adjusts the CONAVS exhaust fan speed that modulates exhaust airflow to maintain a negative pressure.
- When a recirculating AHU is started, the fan runs continuously. A room thermostat automatically modulates the chilled water supplied to the cooling coil to maintain the room temperature.
- Local thermostats automatically start the unit heaters in rooms served by CLAVS and CONAVS.
- The RBVS component operating status and system parameters are monitored and indicated in the MCR and locally where required.

Indications and alarms include the following:

- Indicators for system operating parameters, including flow rates, control damper position, filter pressure drop, building pressure with respect to atmospheric, temperatures, battery room hydrogen concentration.
- Alarms for high or low conditions, including airflow rates, temperatures, filter pressure drop, building differential pressure, smoke detection, and high battery room hydrogen concentration.

This instrumentation conforms to GDC 13. Refer to Subsection 3.1.2.4 for a general discussion of GDC 13.

11.5 PROCESS RADIATION MONITORING SYSTEM

The Process Radiation Monitoring System (PRMS) allows for determining the content of radioactive material in various gaseous and liquid process and effluent streams. The design objective and criteria are based on the following requirements:

- Radiation instrumentation required for safety and protection, and
- Radiation instrumentation required for monitoring and plant operation.

All radioactive release points/paths within the plant are identified and monitored by this system. All other release points/paths of the plant are located in clean areas where radiological monitoring is not required.

This system provides continuous monitoring and display of the radiation measurements during normal, abnormal, and accident conditions.

11.5.1 Design Bases

11.5.1.1 Design Objectives

11.5.1.1.1 Radiation Monitors Required for Safety and Protection

The Radiation Monitoring Subsystems initiates appropriate protective actions to limit the potential release of radioactive materials to the environment if predetermined radiation levels are exceeded in major process/effluent streams. Another objective is to provide plant personnel with indication and alarm of the radiation levels in the major process/effluent streams.

The following Radiation Monitoring Subsystems of the PRMS provide signals that initiate automatic safety-related functions:

- Reactor Building Heating, Ventilation and Air Conditioning (HVAC) exhaust; Detector #2
- Refuel Handling Area HVAC exhaust; Detector #3
- Control Room Habitability Area HVAC Subsystem (CRHAVS);
- Isolation Condenser Vent Exhaust;
- Fuel Building (FB) General Area HVAC; Detector #21
- Fuel Building Fuel Pool HVAC, and Detector #22
- Containment Purge Exhaust. Detector #23

11.5.1.1.2 Radiation Monitors Required for Plant Operation

These Radiation Monitoring Subsystems provide plant personnel with measurements of the content of radioactive material in important gaseous and liquid effluent and process streams. Additional functions include initiation of discharge valve isolation on the offgas or liquid radwaste systems if predetermined release rates would be exceeded, and provision for sampling at certain radiation monitor locations to allow determination of specific radionuclide content.

The following PRMS Subsystems are provided to meet the above design objectives:

- Monitoring Gaseous Effluent Streams;
  - RB/FB Stack,
  - TB Stack,
  - RW Stack,
  - TB Normal Ventilation Air HVAC, Detector #5
  - TB Compartment Area Air HVAC, Detector #6
  - Radwaste Building Ventilation Exhaust,
  - Main Turbine Gland Seal Steam Condenser Exhaust,
  - FB Combined Ventilation Exhaust, and
  - TB Combined Ventilation Exhaust.
- Monitoring Liquid Effluent Streams;
  - Liquid Radwaste Discharge.
- Monitoring Gaseous Process Streams;
  - Main Steamline (MSL),
  - Offgas Pre-treatment,
  - Offgas Post-treatment,
  - Charcoal vault ventilation, and
  - Drywell Fission Product.
- Monitoring Liquid Process Streams;
  - Reactor Component Cooling Water Intersystem Leakage, and
  - Drywell sumps Low Conductivity Waste/High Conductivity Waste (LCW/HCW) Discharge.
- Monitoring Gaseous Intake Streams;
  - Technical Support Center (TSC) HVAC Air Intake.

11.5.2 System Design Bases and Criteria

The instrumentation used in the subsystems of the PRMS is designed to be in conformance with the relevant requirements and guidelines of:

- 10 CFR 20.1302 (Reference 11.5-1), 10 CFR 20.1301(e) (Reference 11.5-22), 10 CFR 20 Appendix B (Reference 11.5-16), 10 CFR 20.1406 (Reference 11.5-23), 10 CFR 50.34a and 10 CFR 52.47 (Reference 11.5-2), 10 CFR 50.36a (Reference 11.5-4);
- 10 CFR 50, Appendix A, GDC 19 (Reference 11.5-17), 60 (Reference 11.5-5), 63 (Reference 11.5-6), and 64 (Reference 11.5-7);

- 10 CFR 50 Appendix I (Reference 11.5-8);
- 10 CFR 50.34(f)(2)(viii), 10 CFR 50.34(f)(2)(xvii), 10 CFR 50.34(f)(2)(xxvii), and 10 CFR 50.34(f)(2)(xxviii) (Reference 11.5-3);
- Regulatory Guides 1.21 (Reference 11.5-9), 1.45 (Reference 11.5-10), 1.97 (Reference 11.5-11), 4.15 (Reference 11.5-12);
- Standard Review Plan 11.5. (Reference 11.5-18) of NUREG-0800;
- NUREG-0737 (Reference 11.5-15), Item II.F.1, Attachments 1 and 2;
- ANSI/HPS N13.1-1999 (Reference 11.5-13);
- ANSI/Institute of Electrical and Electronic Engineers (IEEE) N42.18-2004 (Reference 11.5-19);
- BTP HICB-10 (Reference 11.5-26).

Radiation monitoring is provided during normal reactor operations, anticipated operational occurrences, and post-accident conditions.

The safety-related Process Radiation Monitoring Subsystems are classified Safety Class 2, Seismic Category I. These subsystems conform to the quality assurance requirements of 10 CFR 50 Appendix B (Reference 11.5-20).

11.5.2.1 Radiation Monitors Required for Safety

Detectors #2, 3, 21, 22, & 23

The design criteria for the safety-related functions as defined in Subsection 11.5.1.1 include the following functional requirements:

- Withstand the effect of natural phenomena (e.g., earthquakes) without loss of capability to perform their functions.
- Perform the intended safety-related functions in the environment resulting from normal and abnormal conditions (e.g., loss of HVAC and isolation events).
- Meet the reliability, testability, independence, and failure mode requirements of engineered safety-related features.
- Provide continuous output of radiation levels to the main control room.
- Permit checking of the operational availability of each channel during reactor operation with provisions for calibration function and instrument checks.
- Ensure an extremely high probability of accomplishing safety-related functions in the event of anticipated operational occurrences.
- Initiate protective action when operational limits are exceeded.
- Annunciate the high radiation levels in the main control room to alert operating personnel of abnormal conditions.
- Insofar as practical, provide self-monitoring of the radiation monitors to the extent that power failure or equipment failure causes annunciation in the main control room and initiation of the required protective action.

- Register full-scale output if radiation detection exceeds full scale.
- Use instrumentation compatible with anticipated radiation levels and ranges expected under normal, abnormal and accident conditions, per RG 1.97 (Reference 11.5-11). Provide expanded ranges to take into consideration additional source term resulting from damaged core. Provide overlapping sensor/instrument ranges where the desired accuracy is not achieved with a single sensor/instrument.
- Use redundant divisional channels that satisfy the separation and single failure criteria, for the initiation of safety-related functions.

Detectors #5 & 6

11.5.2.2 Radiation Monitors Required for Plant Operation

The design criteria for operational radiation monitoring includes the following functional requirements:

- Provide continuous indication of radiation levels in the main control room.
- Annunciate the high radiation levels in the main control room to alert operating personnel to the abnormal conditions.
- Insofar as practical, provide self-diagnosis of the radiation monitors to the extent that power failure or equipment failure causes annunciation in the main control room and isolation of the effluents paths as required.
- Monitor a representative sample of the bulk stream or volume.
- Incorporate provisions for calibration and functional checks.
- Use instrumentation compatible with anticipated radiation levels and ranges expected under normal, abnormal and accident conditions (Regulatory Guide 1.97). Provides expanded ranges to take into consideration additional source term from damaged core. Provide overlapping sensor/instrument ranges where the desired accuracy is not achieved with a single sensor/instrument.
- Register full-scale output if radiation detection exceeds full scale.
- Monitor selected non-radioactive systems for intrusion of radioactivity into the system.

11.5.3 Subsystem Description

Detectors #2, 3, 21, 22, & 23

11.5.3.1 Radiation Monitors Required for Safety

The design description of each PRMS Subsystem's radiological monitoring and sampling function, as identified in Subsection 11.5.1.1.1, is provided in this section under its designated name. The types of instrumentation, together with pertinent parameters for each subsystem, are presented in Tables 11.5-1, 11.5-2, and 11.5-4. Figure 11.5-1 in conjunction with Table 11.5-3 provides radiation detector location diagrams.

Figure 11.5-2 shows the block diagram of a safety-related PRMS channel. Signal Conditioning Units (SCUs) are located in the proximity of the radiation detectors when practical or in the Main Control Room (MCR) back panel area. Displays for alarm and radiation level are provided at the SCUs, and also at the MCR console Video Display Units (VDUs). The Safety-Related

Distributed Control and Information System (Q-DCIS) receives signals from the SCUs, performs control functions, and also feeds the signals to the Nonsafety-Related Distributed Control and Information System (N-DCIS) for display, alarm, and data recording functions.

Detector #2

11.5.3.1.1 (Deleted)

11.5.3.1.2 Reactor Building Heating, Ventilation and Air Conditioning Exhaust Radiation Monitoring Subsystem

This subsystem monitors the gross radiation level in the exhaust duct of the RB. The principal path that this subsystem monitors is exhaust from the contaminated area, which is served by Reactor Building Contaminated Area HVAC Subsystem (CONAVS). A high activity level in the ductwork could be due to fission gases from a leak or an accident.

The subsystem consists of four redundant instrument channels. Each channel consists of a gamma-sensitive detector and a Main Control Room (MCR) radiation monitor.

The detectors are located adjacent to the exhaust ducting upstream of the ventilating system isolation valves and monitor the Reactor Building HVAC exhausts. The detectors are physically located upstream of the ventilation exhaust duct isolation dampers such that closure of the dampers can be accomplished prior to exceeding radioactive effluent limits imposed by 10 CFR 20, Appendix B (Reference 11.5-16).

The Leak Detection and Isolation System receives the individual channel signals and compares the signal level to the setpoint trips.

Any two-out-of-four channel trips result in the closure of the RB ventilation dampers and stoppage of the Reactor Building HVAC fans.

Trip circuits initiate their respective alarms in the MCR.

A single channel may be taken out-of-service for testing without affecting the protective functionality of the remaining channels. Two-out-of-three channel trips cause protective actions in the test mode.

Each channel has a monitor failure alarm in the MCR.

The range of channel measurement and display is as shown in Table 11.5-1 and Table 11.5-2. The range is selected to provide sufficient coverage for radioactivity released during normal operation up to the amount associated with an accident and the subsequent ventilation flow into the RB Ventilation.

Detector #3

11.5.3.1.3 Refuel Handling Area HVAC Exhaust

This subsystem monitors the gross radiation level in the refuel handling area and pool area HVAC ventilation exhaust duct that is part of the Reactor Building Refueling and Pool Area HVAC Subsystem (REPAVS).

The subsystem consists of four redundant instrument channels. Each channel consists of a gamma-sensitive detector and a MCR radiation monitor.

The detectors are located around the refuel area and are physically and electrically separated from one another.

The Leak Detection and Isolation System receives the individual channel signals and compares the signal level to the setpoint trips.

Any two-out-of-four channel trips result in the closure of the RB ventilation dampers and stoppage of the Reactor Building HVAC fans.

Trip circuits initiate their respective alarms in the MCR.

A single channel may be taken out-of-service for testing without affecting the protective functionality of the remaining channels. Two-out-of-three channel trips cause protective actions in the test mode.

Each channel has a monitor failure alarm in the MCR.

The range of channel measurement and display is shown in Table 11.5-1 and Table 11.5-2. The range is selected to provide sufficient coverage for radioactivity released during normal operation up to the amount associated with a refueling accident and the subsequent flow into the RB Ventilation system.

11.5.3.1.4 Control Room Habitabililty Area HVAC Radiation Monitoring Subsystem

The Control Room Habitability Area HVAC radiation monitoring subsystem consists of four redundant monitors for the Control Building Air Intake and four redundant monitors for each of the two redundant Emergency Filter Unit (EFU) Outlets.

The Air Intake monitors are provided to detect the gross radiation level in the normal outdoor air intake supply and to automatically initiate closure of the outdoor air intake and the exhaust dampers, the restroom exhaust, and startup the emergency air filtration system. The EFU outlet monitors are provided to detect the gross radiation level coming from the in-service EFU and to automatically initiate isolation of the operating EFU and to place the standby EFU in service.

The radiation monitors for the air intake consist of four redundant channels to monitor the air intake to the building. Each radiation channel consists of a gamma sensitive detector and a radiation monitor that is located in the MCR.

Any two-out-of-four channel trips result in the closure of the Control Building Air Intake and exhaust dampers and starting the Emergency air filtration system.

Trip circuits initiate their respective alarms in the MCR.

A single channel may be taken out-of-service for testing without affecting the protective functionality of the remaining channels. Two-out-of-three channel trips cause protective actions in this case.

Each channel has a monitor failure alarm in the MCR.

The radiation monitors for the EFU outlets consist of four redundant channels on each filter train outlet to monitor the filtered air to the Control Building Habitability Area. Each radiation channel consists of a gamma sensitive detector and a radiation monitor that is located in the MCR.

Any two-out-of-four channel trips result in the automatic shutdown of the in-service EFU and automatic start-up of the standby EFU.

Trip circuits initiate their respective alarms in the MCR.

Any two-out-of-four channel trips result in the closure of isolation valves in the steam line to this condenser and in the condensate return line from this condenser.

Trip circuits initiate their respective alarms in the MCR.

A single channel may be taken out-of-service for testing without affecting the protective functionality of the remaining channels. Two-out-of-three channel trips cause protective actions in the test mode.

Each channel has a monitor failure alarm in the MCR.

The range of channel measurement and display is shown in Table 11.5-1 and Table 11.5-2. The range is selected to provide sufficient coverage from normal operation up to, and several decades beyond, for radioactivity released prior to exceeding limits of 10 CFR 20 (Reference 11.5-21). Under normal operation, there should not be radioactivity exhausted from this path since there should be no leakage into the pool area.

Detector #21

11.5.3.1.7 Fuel Building General Area HVAC

This subsystem monitors the gross radiation level in the Fuel Building HVAC System (FBVS) exhaust duct for the general area. The system consists of four channels that are physically and electrically independent of each other. The subsystem monitors the radiation levels of the air exiting the FB general areas as well as the rooms with the fuel pool cooling and cleanup equipment.

The subsystem consists of four redundant instrument channels. Each channel consists of a gamma-sensitive detector and a MCR radiation monitor.

The individual channel signals are compared to the setpoint trips.

Any two-out-of-four channel trips result in the closing of the isolation dampers and tripping of the FB General Area fans.

Trip circuits initiate their respective alarms in the MCR.

A single channel may be taken out-of-service for testing without affecting the protective functionality of the remaining channels. Two-out-of-three channel trips cause protective actions in the test mode.

Each channel has a monitor failure alarm in the MCR.

The range of channel measurement and display is shown in Tables 11.5-1 and Table 11.5-2. The range is selected to provide sufficient coverage for radioactivity released during normal operation up to, and including several decades beyond, the amount associated with a refueling accident and the subsequent air flow into the FBVS.

Detector #22

11.5.3.1.8 Fuel Building Fuel Pool HVAC

This subsystem consists of a total of four channels that monitor the radiation level of the air exiting the FB Spent Fuel Storage Pool and equipment areas.

The subsystem consists of four redundant instrument channels. Each channel consists of a gamma-sensitive detector and a MCR radiation monitor.

The individual channel signals are compared to the setpoint trips.

Any two-out-of-four channel trips result in the closing of the isolation dampers and tripping of the FB Fuel Pool Ventilation fans.

Trip circuits initiate their respective alarms in the MCR.

A single channel may be taken out-of-service for testing without affecting the protective functionality of the remaining channels. Two-out-of-three channel trips cause protective actions in the test mode.

Each channel has a monitor failure alarm in the MCR.

The range of channel measurement and display is addressed in Table 11.5-1 and 11.5-2. The range is selected to provide sufficient coverage for radioactivity released during normal operation up to, and including several decades beyond, the amount associated with a refueling accident and the subsequent air flow into the FBVS.

11.5.3.1.9 Containment Purge Exhaust Detector #23

This subsystem monitors the gross radiation level in the exhaust duct leading from the containment.

The detectors are located adjacent to the exhaust ducting upstream of the ventilating system isolation valves. The detectors are physically located upstream of the ventilation exhaust duct isolation dampers such that closure of the dampers can be accomplished prior to exceeding radioactive effluent limits.

The subsystem consists of four redundant instrument channels. Each channel consists of a gamma-sensitive detector and a MCR radiation monitor.

The individual channel signal levels are compared to the setpoint trips.

Any two-out-of-four channel trips result in the closure of the Reactor Building HVAC isolation dampers and stoppage of the Reactor Building HVAC exhaust fans.

Trip circuits initiate their respective alarms in the MCR.

A single channel may be taken out-of-service for testing without affecting the protective functionality of the remaining channels. Two-out-of-three channel trips cause protective actions in the test mode.

Each channel has a monitor failure alarm in the MCR.

The range of channel measurement and display is addressed in Table 11.5-1 and Table 11.5-2.

11.5.3.2 Radiation Monitors Required for Plant Operation

The design description of each PRMS Subsystem's radiological monitoring and sampling function identified in Subsection 11.5.1.1.2 is provided in this section. The types of instrumentation, together with pertinent parameters for each subsystem, are presented in Tables 11.5-1, 11.5-2, and 11.5-4. Figure 11.5-1 in conjunction with Table 11.5-3 provides radiation detector location diagrams.

Figure 11.5-2 shows the block diagram of a nonsafety-related PRMS channel. SCUs are mounted locally. Displays for alarm and radiation level are provided at the SCUs, and also at the

The range of channel display is shown in Table 11.5-1 and Table 11.5-4.

11.5.3.2.7 Radwaste Building Ventilation Exhaust

This subsystem monitors the Radwaste Building ventilation exhaust for halogens, particulates and noble gas during normal and accident conditions. Each instrument channel consists of a local detector and a radiation monitor. The radiation monitor provides upscale and inoperative trips. Also, abnormal flow, measured at the sample panel, is annunciated in the MCR.

A sample, continuously extracted, passes through the panel and returns to the exhaust. Sampling is performed in accordance with ANSI/HPS N13.1 (Reference 11.5-13). Automatic compensation for variation in process flow is provided to maintain the sample panel flow proportional to the main flow.

Provisions for grab sample collection are provided and can be used for isotopic analysis and monitor calibration.

The subsystem has provisions for purging the sample panel with room air to check detector response to the background radiation level reading.

Tritium grab sampling and monitoring is also provided by the subsystem.

A remotely-operated gamma check source is provided for testing channel operability.

The trip signals are annunciated in the Radwaste Building General Area and in the MCR. The ranges of channel display are shown in Table 11.5-1 and Table 11.5-2. The subsystem provides data for reports of airborne releases of radioactive materials in accordance with Regulatory Guide 1.21 (Reference 11.5-9).

Detector #6

11.5.3.2.8 Turbine Building Compartment Area Air HVAC

This subsystem monitors the air in the compartment area HVAC in the TB for gross radiation levels. Two channels provide monitoring. Each channel uses a gamma sensitive detector located internal to the monitored exhaust duct. The outputs from the detectors are fed into radiation monitors for display and annunciation. Each monitor provides alarm trips in the MCR on high radiation and when a monitor is inoperative.

The range of channel display is shown in Table 11.5-1 and Table 11.5-2.

Detector #5

11.5.3.2.9 Turbine Building Normal Ventilation Air HVAC

This subsystem monitors the normal ventilation air HVAC from the clean area in the TB for gross radiation levels. Two channels provide the monitoring. Each channel uses a gamma sensitive detector located internal to the monitored exhaust duct. The outputs from the detectors are fed into radiation monitors for display and annunciation. Each monitor provides alarm trips in the MCR on high radiation and when a monitor is inoperative.

The range of channel display is as shown in Table 11.5-1 and Table 11.5-2.

11.5.3.2.10 Main Turbine Gland Seal Steam Condenser Exhaust

This subsystem monitors the releases to the TB Combined Ventilation exhaust from the main turbine gland seal condenser system. The releases are continuously sampled and monitored for

The LWMS provisions for sampling liquid and gaseous waste streams identified in Tables 11.5-5 and 11.5-6 respectively, will be included in the ODCM.

11.5.4.6 Process and Effluent Monitoring Program

In addition, the COL Applicant is responsible for the site-specific programs, aspects of the process and effluent monitoring and sampling as specified in Tables 11.5-5 and 11.5-6 per ANSI/HPS N13.1 (Reference 11.5-13) and Regulatory Guides 1.21 (Reference 11.5-9) and 4.15 (Reference 11.5-12) (COL 11.5-3-A).

11.5.4.7 Sensitivity or Subsystem Lower Limit of Detection

The derivation of each installed effluent radiation monitor's lower limit of detection, and the derivation of each installed process radiation monitor's sensitivity are to be determined by the COL Applicant based on site-specific conditions and operating characteristics (COL 11.5-1-A).

Dynamic detection ranges for process and effluent radiation monitors are found in Table 11.5-2 and Table 11.5-4 and are adjusted according to plant unique configurations and radiation background.

11.5.4.8 Site Specific Offsite Dose Calculation

The COL Applicant is responsible for addressing 10 CFR 50, Appendix I (Reference 11.5-8) guidelines for maximally exposed offsite individual doses and population doses via liquid and gaseous effluents (COL 11.5-4-A).

11.5.4.9 Instrument Sensitivities

The COL Applicant is responsible for the sensitivities, sampling and analytical frequencies and basis for each gaseous and liquid sample (COL 11.5-5-A).

11.5.5 Process Monitoring and Sampling

11.5.5.1 Implementation of General Design Criterion 19

The Control Building is provided with detectors that sense radiation in the intake air supply to the control building and provide warning and initiate actions to protect operating personnel for access and occupancy of the control room under accident conditions.

In addition, the TSC ventilation air intake is provided with radiation detection to initiate actions to protect personnel.

11.5.5.2 Implementation of General Design Criterion 60

All potentially significant radioactive discharge paths are equipped with a control system to automatically isolate the effluent on indication of a high radiation level. The subsystems providing these features include:

- Offgas Post-treatment;
- Reactor Building HVAC Exhaust; Detector #2
- Refuel Handling Area HVAC Exhaust; Detector #3

- Liquid Radwaste Discharge;
- FB General Area HVAC; Detector #21
- Isolation Condenser Vent Exhaust;
- MSL;
- Containment Purge Exhaust; and Detector #23
- FB Fuel Pool HVAC. Detector #22

11.5.5.3 Implementation of General Design Criterion 63

Fuel storage and radioactive waste systems and their associated handling areas are monitored for excessive radiation levels. The subsystems monitoring these areas include:

- Offgas Pre-treatment;
- Offgas Post-treatment;
- Radwaste Building Ventilation Exhaust;
- FB Fuel Pool HVAC; Detector #22
- FB Combined Ventilation Exhaust;
- Charcoal Vault Ventilation;
- FB General Area HVAC; Detector #21
- Refuel Handling Area Exhaust; ~~and~~ Detector #3
- Reactor Building HVAC Exhaust. Detector #2

11.5.5.4 Implementation of General Design Criterion 64

Radiation levels in the reactor containment atmosphere, spaces containing components for the recirculation of loss-of-coolant accident fluids, effluent discharge paths and important process streams are monitored for radioactivity. The subsystems monitoring these paths and areas include:

- Reactor Building HVAC Exhaust; Detector #2
- Refuel Handling Area HVAC Exhaust; Detector #3
- Drywell Sumps LCW/HCW Discharge;
- Isolation Condenser Vent Exhaust;
- FB General Area HVAC; Detector #21
- MSL;
- Offgas Pre-treatment and Offgas Post-treatment;
- Charcoal Vault Ventilation;
- Reactor Component Cooling Water Intersystem Leakage;

- TB Combined Ventilation Exhaust;
- Radwaste Building Ventilation Exhaust;
- Liquid Radwaste Discharge;
- Main Turbine Gland Seal Steam Condenser Exhaust;
- Drywell Fission Products;
- FB Combined Ventilation Exhaust;
- FB Fuel Pool HVAC; Detector #22
- TB Normal Ventilation Air HVAC; Detector #5
- TB Compartment Area Air HVAC; Detector #6
- RB/FB Stack;
- TB Stack;
- RW Stack; and
- Containment Purge Exhaust. Detector #23

11.5.5.5 Basis for Monitor Location Selection

The detector locations are selected to monitor the major and potentially significant paths for release of radioactive material during normal reactor operation including anticipated operational occurrences, thus meeting the intent of RG 1.21 (Reference 11.5-9) and SRP 11.5 (Reference 11-18). Monitoring of each major path provides measurements that are representative of releases to demonstrate compliance with 10 CFR 20 Appendix B (Reference 11.5-21) limits.

11.5.5.6 Expected Radiation Levels

Expected radiation levels are listed in Section 12.2.

11.5.5.7 Instrumentation

Grab samples are analyzed to identify and quantify the specific radionuclides in process streams. The results from the sample analysis are used to establish relationships between the gross gamma monitor readings and concentration and radionuclides in the process streams.

11.5.5.8 Setpoints

The trip setpoints for the certain safety-related radiation monitors are specified in the ODCM (COL 11.5-2-A). Trip setpoints for nonsafety-related radiation monitors are specified in plant operating procedures.

11.5.5.9 Process and Post-Accident Sampling Programs – Regulatory Compliance

The design considerations, acceptance criteria, and sample point locations described in the Standard Review Plan Subsection 9.3.2 for sampling of radioactive streams and processes via the Process Sampling System were evaluated for the ESBWR design. Post-accident monitoring program uses sample point parameters and key sample locations as described in DCD Tier 2 Subsections 9.3.2 and 7.5.1.

In addition, where practicable, provisions are made to include the ability to collect samples at central sample stations in order to reduce leakage, spillage and radiation exposures to operating personnel. The Process Radiation Monitoring Subsystems are designed to maintain radiation exposures ALARA in accordance with 10 CFR Part 20.1101(b) (Reference 11.5-21).

11.5.6 Calibration and Maintenance

11.5.6.1 Inspection and Tests

During reactor operation, periodic checks of system operability are made by observing channel behavior. At periodic intervals during reactor operation, the detector response of each monitor provided with a remotely positioned check source is verified, together with the instrument background count rate, to ensure proper functioning of the monitors. Any detector whose response cannot be verified by observation during normal operation or by using the remotely positioned check source is response checked with a portable radiation source. A record is maintained showing the background radiation level and the detector response.

The system incorporates self-diagnostics and online calibration for its process radiation monitors that operate continuously to assure maximum availability and minimum down time. In addition, a provision for using test signals for checking system operability is included in the design. Also, each radiation channel is tested and calibrated periodically using a standard radiation source to validate channel operability.

The following monitors have alarm trip circuits that can be tested by using test signals or portable gamma sources:

- MSL;
- Reactor Building HVAC Exhaust; Detector #2
- Refuel Handling Area HVAC Exhaust; Detector #3
- Control Room, Habitability Area HVAC Subsystem (CRHAVS);
- FB General Area HVAC; Detector #21
- Isolation Condenser Vent Exhaust;
- TB Normal Ventilation Air HVAC; Detector #5
- TB Compartment Area Air HVAC; Detector #6
- Charcoal Vault Ventilation;
- Drywell Sump LCW/HCW Discharge;
- TSC HVAC Air Intake;
- Offgas Pre-treatment;
- FB Fuel Pool HVAC; and Detector #22
- Containment Purge Exhaust HVAC. Detector #23

Table 11.5-1

Process and Effluent Radiation Monitoring Systems

Monitored Process	No. of Channels	Sample Line or Detector Location	Displayed Channel Range* and **
A. Safety-Related Monitors			
Reactor Building HVAC Exhaust Detector #2	4	Exhaust duct upstream of exhaust ventilation isolation valve	1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h)
Refuel Handling Area HVAC Exhaust Detector #3	4	Exhaust duct upstream of exhaust ventilation isolation valve	1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h)
Control Room Habitability Area HVAC (Air Intake) Control Room Habitability Area (EFU Outlet)	4 8	Intake duct upstream of intake ventilation isolation valve Outlet duct downstream of each filter train	1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h) 1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h
FB General Area HVAC Detector #21	4	Exhaust duct upstream of exhaust ventilation isolation valve	1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h)
Isolation Condenser Vent Exhaust	16	Exhaust of air space surrounding isolation condensers	1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h)
Containment Purge Exhaust Detector #23	4	Exhaust duct upstream of exhaust ventilation isolation valve	1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h)
FB Fuel Pool HVAC Detector #22	4	On HVAC duct leaving Fuel Pool Area	1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h)

Table 11.5-1

Process and Effluent Radiation Monitoring Systems

Monitored Process	No. of Channels	Sample Line or Detector Location	Displayed Channel Range* and **
B. Monitors Required for Plant Operation			
MSL	4	Immediately downstream of plant MSL isolation valve	1E-2 to 1E4 mSv/h (1E0 to 1E6 mRem/h)
RB/FB Stack	3	On Stack exhaust	1E-3 to 1E10 MBq/m^3 (gaseous) (2.7E-2 to 2.7E11 μCi/m^3) 1E-6 to 1E7 MBq/m^3 (2.7E-5 to 2.7E8 μCi/m^3) (particulate & halogen)
TB Stack	3	On Stack exhaust	1E-3 to 1E10 MBq/m^3 (gaseous) (2.7E-2 to 2.7E11 μCi/m^3) 1E-6 to 1E7 MBq/m^3 (2.7E-5 to 2.7E8 μCi/m^3) (particulate & halogen)
RW Stack	3	On Stack exhaust	1E-3 to 1E10 MBq/m^3 (gaseous) (2.7E-2 to 2.7E11 μCi/m^3) 1E-6 to 1E7 MBq/m^3 (2.7E-5 to 2.7E8 μCi/m^3) (particulate & halogen
TB Normal Ventilation Air HVAC Detector #5	2	Exhaust duct from TB Normal ventilation	1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h)
TB Compartment Area Air HVAC Detector #6	2	Exhaust duct from Compartment area	1E-4 to 1E0 mSv/h (1E-2 to 1E2 mRem/h)
TB Combined Ventilation Exhaust	3	On TB combined exhaust line	1E-3 to 1E3 MBq/m^3 (2.7E-2 to 2.7E4 μCi/m^3) (gaseous) 1E-7 to 1E-1 MBq/m^3 (2.7E-6 to 2.7E0 μCi/m^3) (particulate and iodine)

Table 11.5-2

Process Radiation Monitoring System (Gaseous and Airborne Monitors)

Radiation Monitor	Configuration	Dynamic Detection Range Note 1	Principal Radionuclides Measured	(Deleted)	Alarms & Trips Note 3
A. Safety-Related Monitors					
Reactor Building HVAC Exhaust Detector #2	In-line (adjacent and external to HVAC duct)	≈ 1.5E3 to 1.5E7 MBq/m^3 (4.05E4 to 4.05E8 μCi/m^3)	Xe-133		DNSC/INOP High High-High
Refuel Handling Area HVAC Exhaust Detector #3	In-line (adjacent and external to HVAC duct)	≈ 7.3E2 to 7.3E6 MBq/m^3 (1.97E4 to 1.97E8 μCi/m^3)	Xe-133		DNSC/INOP High High-High
Control Room Habitability Area HVAC (Air Intake)	In-line (adjacent and external to HVAC air intake duct)	≈ 8E1 to 8E5 MBq/m^3 (2.16E3 to 2.16E7 μCi/m^3)	Xe-133		DNSC/INOP High High-High
Control Room Habitability Area HVAC (EFU Outlet)	In-line (adjacent and external to HVAC EFU Outlet duct)	≈ 8E1 to 8E5 MBq/m3 (2.16E3 to 2.16E7 μCi/m3)	Xe-133		DNSC/INOP High High-High
FB General Area HVAC Detector #21	In-line (adjacent and external to HVAC duct)	≈ 7.4E1 to 7.4E5 MBq/m^3 (2.0E3 to 2.0E7 μCi/m^3)	Xe-133		DNSC/INOP High High-High
Isolation Condenser Vent Exhaust Note 2	In-line (adjacent to vent duct)	≈ 1.5E3 to 1.5E7 MBq/m^3 (4.05E4 to 4.05E8 μCi/m^3)	Xe-133		DNSC/INOP High High-High
Containment Purge Exhaust Detector #23	In-line (adjacent and external to HVAC	≈ 1.5E3 to 1.5E7 MBq/m^3 (4.05E4 to 4.05E8 μCi/m^3)	Xe-133		DNSC/INOP High

Table 11.5-2

Process Radiation Monitoring System (Gaseous and Airborne Monitors)

Radiation Monitor	Configuration	Dynamic Detection Range Note 1	Principal Radionuclides Measured	(Deleted)	Alarms & Trips Note 3
	duct)				High-High
FB Fuel Pool HVAC Detector #22	In-line and internal to HVAC duct	≈ 5.5E0 to 5.5E4 MBq/m^3 (1.49E2 to 1.49E6 $\mu Ci/m^3$) ≈ 1E2 to 1E6 MBq/m^3 (2.7E3 to 2.7E7 $\mu Ci/m^3$)	Xe-133 Kr-85		DNSC/INOP High
B. Monitors Required for Plant Operation					
MSL	Offline (adjacent to MSLs)	≈ 1.4E2 to 1.4E8 MBq/m^3 (3.78E3 to 3.78E9 $\mu Ci/m^3$)	N-16, O-19 & Coolant activation		DNSC/INOP High High-High
Offgas Post-treatment	Offline	≈ 8E-3 to 8E3 MBq/m^3 (2.16E-1 to 2.16E5 $\mu Ci/m^3$) ≈ 2.6E-3 to 2.6E3 MBq/m^3 (7.03E-2 to 7.03E4 $\mu Ci/m^3$) ≈ 3.7E-7 to 3.7E-1 MBq/m^3 (1.0E-5 to 1.0E1 $\mu Ci/m^3$) ≈ 7.4E-7 to 7.4E-1 MBq/m^3 (2.0E-5 to 2.0E1 $\mu Ci/m^3$)	Xe-133 Kr-85 Cs-137 I-131		Abnormal Flow DNSC/INOP High High-High High-High-High
Offgas Pre-treatment	Offline (adjacent to sample chamber)	≈ 1.7E2 to 1.7E8 MBq/m^3 (4.59E3 to 4.59E9 $\mu Ci/m^3$) ≈ 1.0E2 to 1.0E8 MBq/m^3 (2.7E3 to 2.7E9 $\mu Ci/m^3$)	Xe-138 Kr-88		DNSC/INOP High High-High

Table 11.5-2

Process Radiation Monitoring System (Gaseous and Airborne Monitors)

Radiation Monitor	Configuration	Dynamic Detection Range Note 1	Principal Radionuclides Measured	(Deleted)	Alarms & Trips Note 3
Main Turbine Gland Seal Steam Condenser Exhaust	Offline	≈ 8E-3 to 8E3 MBq/m^3 (2.16E-1 to 2.16E5 $\mu Ci/m^3$) ≈ 2.6E-3 to 2.6E3 MBq/m^3 (7.03E-2 to 7.03E4 $\mu Ci/m^3$)	Xe-133 Kr-85		Abnormal Flow DNSC/INOP High High-High
Charcoal Vault Ventilation	In-line (adjacent and internal to HVAC duct)	≈ 5.1E2 to 5.1E8 MBq/m^3 (1.38E4 to 1.38E10 $\mu Ci/m^3$) ≈ 1E2 to 1E8 MBq/m^3 (2.7E3 to 2.7E9 $\mu Ci/m^3$)	Xe-133 Kr-85		DNSC/INOP High
TB Normal Ventilation Air HVAC Detector #5	In-line (adjacent and internal to HVAC duct)	≈ 1.7E0 to 1E4 MBq/m^3 (4.6E1 to 2.7E5 $\mu Ci/m^3$) ≈ 3.4E1 to 3.4E5 MBq/m^3 (9.2E2 to 9.2E6 $\mu Ci/m^3$)	Xe-133 Kr-85		DNSC/INOP High
TB Compartment Area Air HVAC Detector #6	In-line (adjacent and internal to HVAC duct)	≈ 2E0 to 2E4 MBq/m^3 (5.4E1 to 5.4E5 $\mu Ci/m^3$) ≈ 4.5E1 to 4.5E5 MBq/m^3 (1.2E3 to 1.2E7 $\mu Ci/m^3$)	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 $\mu Ci/m^3$) ≈ 2.6E-3 to 2.6E3 MBq/m^3 (7.03E-2 to 7.03E4 $\mu Ci/m^3$) ≈ 7.4E-7 to 7.4E-1 MBq/m^3 (2.0E-5 to 2.0E1 $\mu Ci/m^3$) ≈ 7.4E-7 to 7.4E-1 MBq/m^3 (2.0E-5 to 2.0E1 $\mu Ci/m^3$)	Xe-133 Kr-85 Cs-137 I-131		Abnormal Flow DNSC/INOP High High-High

Table 11.5-3

Key to Radiation Monitors Shown on Figure 11.5-1

ID on Figure 11.5-1	Description
1	MSL
2	Reactor Building HVAC Exhaust
3	Refuel Handling Area HVAC Exhaust
4A, 4B, 4C	Control Room Habitability Area Subsystem HVAC (CRHAVS)
5	TB Normal Ventilation Air HVAC
6	TB Compartment Area Air HVAC
7	Offgas Pre-treatment
8	Charcoal Vault Ventilation
9A, 9B	Offgas Post-treatment
10	TB Combined Ventilation Exhaust
11	Liquid Radwaste Discharge
12	Drywell Sump LCW/HCW Discharge
13A	RB/FB Stack
13B	TB Stack
13C	RW Stack
14	Main Turbine Gland Seal Steam Condenser Exhaust
15A, 15B	Reactor Component Cooling Water Intersystem Leakage
16	Drywell Fission Product
17	Radwaste Building Ventilation Exhaust
18	FB Combined Ventilation Exhaust
19	Isolation Condenser Vent Exhaust
20	TSC HVAC Air Intake
21	FB General Area HVAC
22	FB Fuel Pool HVAC
23	Containment Purge Exhaust

Table 11.5-9

Process Radiation Monitoring System Estimated Dynamic Ranges

Radiation Monitor	Estimated Dynamic Detection Range	Principal Radionuclides Measured	Basis for Dynamic Range
A. Safety-Related Monitors			
Reactor Building HVAC Exhaust Detector #2	≈ 1.5 E3 to 1.5E7 MBq/m^3 (4.05E4 to 4.05E8 $\mu Ci/m^3$)	Xe-133	The dynamic range has been selected to provide sufficient coverage to detect both the radiation dose rates associated with normal RB ventilation releases up to the dose rate expected in the ventilation system resulting from a Fuel Handling Accident (FUHA).
Refuel Handling Area HVAC Exhaust Detector #3	≈ 7.3E2 to 7.3E6 MBq/m^3 (1.97E4 to 1.97E8 $\mu Ci/m^3$)	Xe-133	The dynamic range has been selected to provide sufficient coverage to detect the radiation dose rates associated with normal RB ventilation releases up to the dose rate expected in the ventilation system resulting from a FUHA.
Control Room Habitability Area HVAC (Air Intake and EFU Outlet)	≈ 8E1 to 8E5 MBq/m^3 (2.16E3 to 2.16E7 $\mu Ci/m^3$)	Xe-133	The range of channel measurement and display is shown in Table 11.5-1 and Table 11.5-2. The range is selected to cover normal operation and be sensitive enough to initiate isolation of the MCR prior to exceeding the 10 CFR 50 Appendix A GDC 19 (Reference 11.5-17) guidelines of 0.05 Sieverts (5Rem) total effective dose equivalent (TEDE).
FB General Area HVAC Detector #21	≈ 7.4E1 to 7.4E5 MBq/m^3 (2.0E3 to 2.0E7 $\mu Ci/m^3$)	Xe-133	The dynamic range has been selected to provide sufficient coverage to detect a radiation dose rate associated with normal FB ventilation releases up to the dose rate expected after a FUHA occurring in the FB.

Table 11.5-9

Process Radiation Monitoring System Estimated Dynamic Ranges

Radiation Monitor	Estimated Dynamic Detection Range	Principal Radionuclides Measured	Basis for Dynamic Range
Isolation Condenser Vent Exhaust	≈ 1.5E3 to 1.5E7 MBq/m^3 (4.05E4 to 4.05E8 $\mu Ci/m^3$)	Xe-133	The dynamic range has been selected to provide coverage of the isolation condenser pool exhaust vent releases to the environment prior to exceeding 10 CFR 20 (Reference 11.5-1) limit airborne concentrations.
Containment Purge Exhaust Detector #23	≈ 1.5E3 to 1.5E7 MBq/m^3 (4.05E4 to 4.05E8 $\mu Ci/m^3$)	Xe-133	The dynamic range has been selected to provide sufficient coverage to detect a radiation dose rate associated with radionuclide concentrations in the drywell during a purge to the environment and providing isolation prior to exceeding 10 CFR 20 (Reference 11.5-1) limits.
FB Fuel Pool HVAC Detector #22	≈ 5.5E0 to 5.5E4 MBq/m^3 (1.49E2 to 1.49E6 $\mu Ci/m^3$) ≈ 1E2 to 1E6 MBq/m^3 (2.7E3 to 2.7E7 $\mu Ci/m^3$)	Xe-133 Kr-85	The dynamic ranges have been selected to provide sufficient coverage to detect a radiation dose rate associated with normal FB ventilation releases up to the dose expected after a FUHA that occurs in the FB.
(Deleted)			
B. Monitors Required for Plant Operation			
MSL	≈ 1.4E2 to 1.4E8 MBq/m^3 (3.78E3 to 3.78E9 $\mu Ci/m^3$)	N-16, O-19 & coolant activation gases	The dynamic range has been selected so that sufficient coverage is provided to detect both the radiation dose rates associated with releases of activation gases and fission products from low reactor power and those that would be associated with a major release of fission products from the reactor core.

Table 11.5-9

Process Radiation Monitoring System Estimated Dynamic Ranges

Radiation Monitor	Estimated Dynamic Detection Range	Principal Radionuclides Measured	Basis for Dynamic Range
Main Turbine Gland Seal Steam Condenser Exhaust	≈ 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 (7.0E-2 to 7.0E4 µCi/m^3)	Xe-133 Kr-85	The dynamic ranges have been selected to be able to detect 10 CFR 20 (Reference 11.5-11) concentration limits in the Main Turbine Gland Seal Steam Condenser exhaust prior to its combination with other exhausts of the TB ventilation system.
Charcoal Vault Ventilation	≈ 5.1E2 to 5.1E8 MBq/m^3 (1.38E4 to 1.38E10 µCi/m^3) ≈ 1E2 to 1E8 MBq/m^3 (2.7E3 to 2.7E9 µCi/m^3)	Xe-133 Kr-85	The dynamic ranges have been selected so that radionuclide intrusion, from the offgas charcoal beds into charcoal vault ventilation ducting, is detected prior to its combination with other TB ventilation exhausts.
TB Normal Ventilation Air HVAC Detector #5	≈ 1.7E0 to 1.7E4 MBq/m^3 (4.6E1 to 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	The dynamic ranges have been selected to provide sufficient coverage to provide indication of 10 CFR 20 (Reference 11.5-1) effluent limits, accounting for bounding typical site meteorology.
TB Compartment Area Air HVAC	≈ 2E0 to 2E4 MBq/m^3 (5.4E1 to 5.4E5 µCi/m^3) ≈ 4.5E1 to 4.5E5 MBq/m^3 (1.22E3 to 1.22E7 µCi/m^3)	Xe-133 Kr-85	The dynamic ranges have been selected to provide sufficient coverage to provide indication of 10 CFR 20 (Reference 11.5-1) effluent limits, accounting for bounding typical site meteorology.

Detector #6

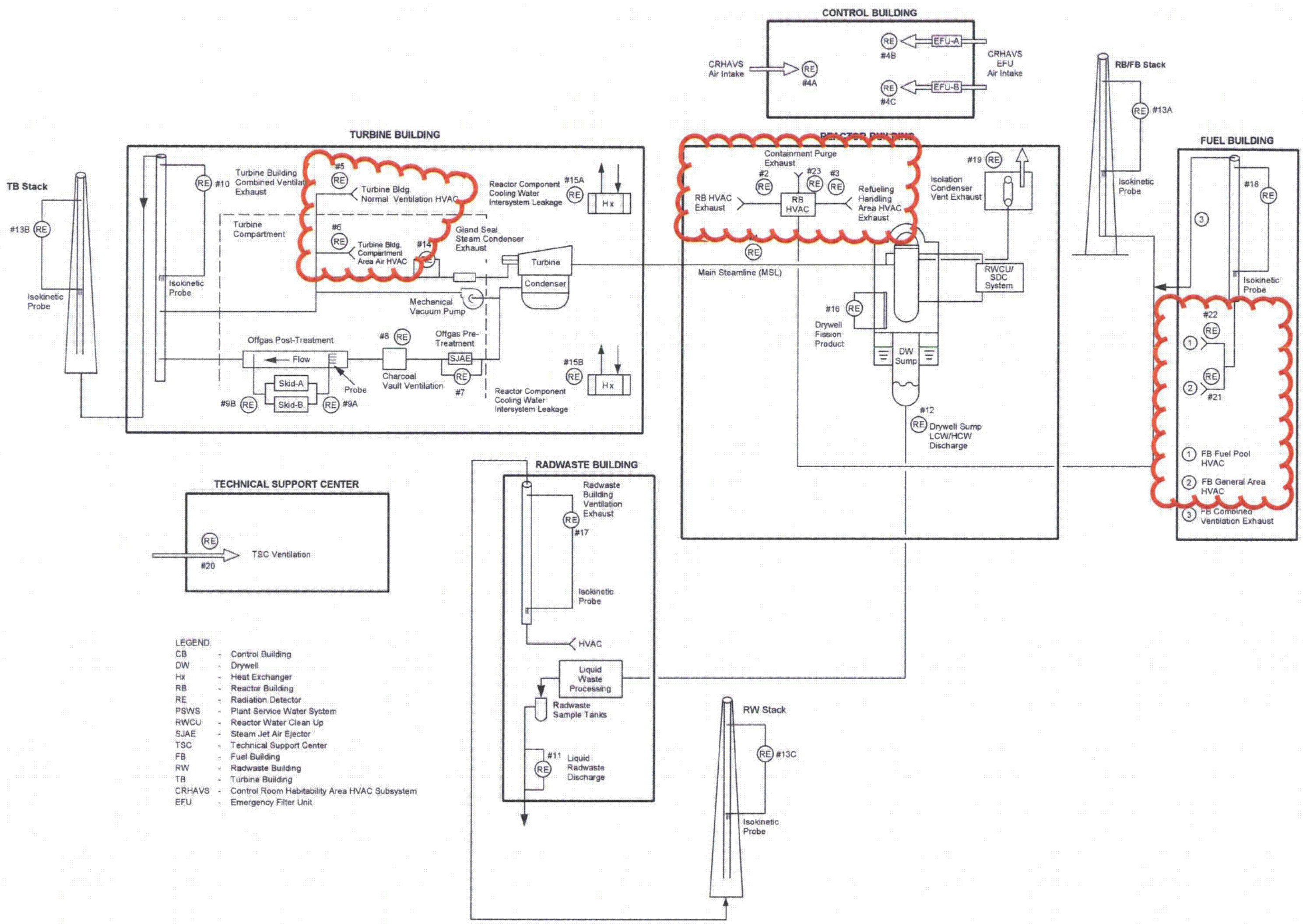

Figure 11.5-1. Location of Radiation Monitors