11.5 Process and Effluent Radiological Monitoring and Sampling Systems

The Process and Effluent Radiological Monitoring and Sampling Systems are provided to allow determination of 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:

(1) Radiation instrumentation required for safety and protection.

(2) Radiation instrumentation required for monitor and plant operation.

All critical radioactive release points/paths within the plant are indentified 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. Most measurements are continuously logged in by the process computer and recorded.

For gaseous discharge from the SGTS and from the main plant stack, extended range effluent monitors are provided to measure post-accident levels of noble gases. Additionally, these subsystems have filters that are capable of extracting high levels of radioactive iodines and particulates in the gaseous effluent streams during and following and accident.

Refer to Subsection 11.5.6 for COL license information.

11.5.1 Design Bases

11.5.1.1 Design Objectives

11.5.1.1.1 Radiation Monitors Required for Safety and Protection

The main objective of this radiation monitoring is to initiate appropriate protective action to limit the potential release of radioactive materials from the reactor vessel and primary and secondary containment if predetermined radiation levels are exceeded in major process/effluent streams. Another objective is to provide control room personnel with an indication of the radiation levels in the major process/effluent streams plus alarm annunciation if high radiation levels are detected.

The Process Radiation Monitoring System provides the following design objectives:

(1) Not Used

(2) Reactor building heating, ventilating, and air conditioning (HVAC) exhaust air radiation monitoring

(3) Fuel handling area HVAC exhaust air radiation monitoring

(4) Control building HVAC air intake supply radiation monitoring

(5) Drywell sump discharge radiation monitoring

11.5.1.1.2 Radiation Monitors Required for Plant Operation

The main objective of this radiation monitoring is to provide operating personnel with measurements of the content of radioactive material in all effluent and important process streams. This demonstrates compliance with plant normal operational technical specifications by providing gross radiation level monitoring and by collection of halogens and particulates on filters (gaseous effluents) as required by Regulatory Guide 1.21. Additional objectives are to initiate discharge valve isolation on the offgas or liquid radwaste systems if predetermined release rates are exceeded, and to provide for sampling at certain radiation monitor locations to allow determination of specific radionuclide content.

The Process Radiation Monitoring System also provides the following design objectives:

(1) Monitors Gaseous Effluent Streams

  (a) Plant stack discharge

  (b) Turbine Building ventilation exhaust

  (c) Radwaste Building ventilation exhaust

  (d) Turbine gland seal condenser exhaust

  (e) Standby gas treatment offgas discharge

  (f) Not Used

  (g) Main steamline tunnel area radiation monitoring

(2) Monitors Liquid Effluent Streams

  (a) Radwaste liquid discharge

(3) Monitors Gaseous Process Streams

  (a) Offgas pre-treatment sampling

  (b) Offgas post-treatment sampling

  (c) Charcoal vault ventilation exhaust

(4) Monitors Liquid Process Streams

  (a) Reactor Building closed cooling water intersystem radiation leakage

The Service Building HVAC system contains radiation monitors to monitor radioactivity in the supply air inlet. Functioning of these monitors is described in Subsection 9.4.8.

11.5.1.2 Design Criteria

Design criteria of this system are based on meeting the relevant requirements of General Design Criteria (GDC) 19, 60, 63, and 64 of 10CFR50 Appendix A in accordance with SRP 11.5 of NUREG-0800. These GDCs are in addition to those GDCs specified in Subsection 7.6.2.2 for system instrumentation.

Also, the system is designed to meet the applicable provisions of 10CFR20.1302, RG 1.21 and RG 1.97 and TMI NUREG-0737, Item II.F.1, Attachments 1 and 2.

The safety-related process radiation monitoring subsystems are classified Safety Class 2, Seismic Category I. These subsystems conform to the quality assurance requirements of 10CFR50 Appendix B.

11.5.1.2.1 Radiation Monitors Required for Safety

The design criteria for the safety-related monitors include the following functional requirements:

(1) Withstand the effect of natural phenomena (e.g., earthquakes) without loss of capability to perform their functions.

(2) Perform the intended safety functions in the environment resulting from normal and abnormal conditions (e.g., loss of HVAC and isolation events).

(3) Meet the reliability, testability, independence, and failure mode requirements of engineered safety features.

(4) Provide continuous output of radiation levels in the main control room.

(5) Permit checking of the operational availability of each channel during reactor operation with provisions for calibration function and instrument checks.

(6) Assure an extremely high probability of accomplishing safety functions in the event of anticipated operational occurrences.

(7) Initiate protective action when operational limits are exceeded.

(8) Warn and annunciate the high radiation levels indicative of abnormal conditions.

(9) Insofar as practical, provide self-monitoring of components to the extent that power failure or component malfunction causes annunciation and channel trip.

(10) Register full-scale output if radiation detection exceeds full scale.

(11) Not Used.

(12) Each safety-related monitoring channel is powered from its respective Class 1E power source.

11.5.1.2.2 Radiation Monitors Required for Plant Operation

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

(1) Provide continuous indication of radiation levels in the main control room.

(2) Warn and annunciate the high radiation levels indicative of abnormal conditions.

(3) Insofar as practical, provide self-monitoring of components to the extent that power failure or component malfunction causes annunciation and discharge valve isolation channel trip.

(4) Monitor a sample representative of the bulk stream or volume.

(5) Incorporate provisions for calibration and functional checks.

(6) Use instrumentation compatible with anticipated radiation levels and ranges expected under normal, abnormal and accident conditions (RG 1.97).

(7) Register full-scale output if radiation detection exceeds full scale.

The radiation subsystem that monitors liquid discharges from the radwaste treatment system shall have provisions to alarm and initiate automatic closure of the waste discharge valve on the affected treatment system prior to exceeding the normal operation limits specified in the Offsite Dose Calculation Manual as required by Regulatory Guide 1.21.

11.5.2 System Description

11.5.2.1 Radiation Monitors Required for Safety

Information on these monitors is presented in Table 11.5-1 and the arrangements are shown in Subsection 7.6.1.2. Each potential radioactive path/stream is monitored by an independent PRM subsystem.

11.5.2.1.1 Not Used

11.5.2.1.2 Reactor Building HVAC Radiation Monitoring

This subsystem monitors the radiation level in the secondary containment of the Reactor Building ventilation system exhaust duct. A high activity level in the ductwork could be due to fission gases from a leak or an accident.

The system consists of four redundant instrument channels. Each channel consists of a detector and a radiation monitor. Power is supplied to channels A, B, C, and D monitors from vital 120 VAC Divisions 1, 2, 3 and 4, respectively.

The detectors are located adjacent to the exhaust ducting upstream of the ventilating system isolation valves and monitor the HVAC vent exhausts from the primary containment during purging and from the secondary containment. These detectors have sufficient sensitivity to detect high radiation levels during primary containment purge to alert the operator for corrective action and to initiate the appropriate measures.

Each radiation monitor has three trip circuits: two upscale and one downscale/inoperative.

A high-high or downscale/inoperative trip in the radiation monitor results in a channel trip which is provided to LDS. Any two-out-of-four channel trips will result in the initiation by LDS of the Standby Gas Treatment System (SGTS) and in the isolation of the secondary containment (including closure of the containment purge and vent valves and closure of the Reactor Building ventilating exhaust isolation valves).

All trip circuits will initiate their respective alarms in the main control room.

A downscale or an inoperative trip is displayed on the radiation monitor and actuates a control room annunciator common to all four channels.

Each radiation monitor will display the measured radiation level in mSv/h.

11.5.2.1.3 Fuel Handling Area Ventilation Exhaust Radiation

This subsystem monitors the radiation level in the fuel handling area ventilation exhaust duct. The system consists of four channels which are physically and electrically independent of each other. Each channel consists of a detector and a radiation monitor. Power for channels A, B, C, and D is supplied from the vital 120 VAC Divisions 1, 2, 3 and 4, respectively.

Each radiation monitor has three trip circuits: two upscale and one downscale/inoperative. This subsystem performs the same trip functions as those described in Subsection 11.5.2.1.2 for the Reactor Building HVAC radiation monitoring.

11.5.2.1.4 Control Building HVAC Radiation Monitoring

The Control Building HVAC Radiation Monitoring Subsystem is provided to detect the radiation level in the normal outdoor air supply, automatically closes the outdoor air intake and the exhaust dampers, and initiates automatically the emergency air filtration system. The emergency air filtration system fans shall be started and area exhaust fans stopped on high radiation.

The Control Building HVAC consists of two redundant but independent subsystems.

The radiation monitors for each of the control building HVAC subsystems consist of four redundant channels to monitor the air intake to the building. Each radiation monitor is physically separated and powered from separate vital 120 VAC divisional power. Failure of one channel will not cause isolation of the HVAC System.

The monitors meet the requirements for Class 1E components to provide appropriate reliability. The system will warn of the presence of significant air contamination in inlet air, from any source, and will provide isolation of intake air ducts from accident radiation sources escaping from other plant buildings.

Each radiation channel consists of a detector and radiation monitor.

Each radiation monitor has three trip circuits: two upscale and one downscale/inoperative. All trips are displayed on the appropriate radiation monitor and each actuates a control room annunciator.

11.5.2.1.5 Drywell Sumps Discharge Radiation Monitoring

This subsystem monitors the radiation level in the liquid waste transferred in the drain line from the drywell LCW and HCW sumps to the Radwaste System. One monitoring channel is provided in each sump drain line. Each detector is located on the drain line from the sump just downstream from the outboard isolation valve. The output from each detector is fed to a radiation monitor for display, recording and annunciation.

The radiation monitor provides three trip circuits: two upscale (radiation high-high and high), one downscale/inoperative. The high-high signal is used to close the outboard isolation valve in its respective drain line. All trips are annunciated in the main control room.

11.5.2.2 Radiation Monitors Required for Plant Operation

Each radioactive path/stream is monitored by an independent PRM subsystem.

Information on these monitors is presented in Table 11.5-1

11.5.2.2.1 Offgas Pre-Treatment Radiation Monitoring

This subsystem monitors radioactivity in the condenser offgas at the discharge of the delay pipe after it has passed through the offgas condenser and moisture separator. The monitor detects the radiation level which is attributable to the fission gases produced in the reactor and transported with stream though the turbine to the condenser.

A continuous sample is extracted from the offgas pipe via a stainless steel sample line. It is then passed through a sample chamber and a sample panel before being returned to the suction side of the steam jet air ejector (SJAE). The sample chamber is a stainless steel pipe which is internally polished to minimize plateout. It can be purged with room air to check detector response to background radiation by using a three-way solenoid-operated valve. The valve is

controlled by a switch located in the main control room. The sample panel measures and indicates sample line flow. A detector is positioned adjacent to the vertical sample chamber and is connected to radiation monitors which then send the data to the main control room to display.

Power is supplied from 120 VAC vital non-1E bus for the radiation monitor and from the 120 VAC instrument bus for the local sample and vital sampler panel.

The radiation monitor has three trip circuits: two upscale (high-high and high) and one downscale/inoperative.

The trip outputs are used for alarm function only. Each trip is visually displayed on the radiation monitor and actuates a control room annunciator: offgas high-high, offgas high, and offgas downscale/inoperative. High or low sample line flow measured at the sample panel actuates a main control room offgas sample high-low flow annunciator.

The radiation level output level by the monitor can be directly correlated to the concentration of the noble gases by using a semiautomatic vial sampler to obtain a grab sample. To draw a sample, a serum bottle is inserted into a sampler holder, the sample lines are evacuated, and a solenoid-operated sample valve is opened to allow offgas to enter the bottle. The bottle is then removed and the sample is analyzed in the counting room with a multichannel gamma pulse height analyzer to determine the concentration of the various noble gas radionuclides. A correlation between the observed activity and the monitor reading permits calibration of the monitor.

11.5.2.2.2 Offgas Post-Treatment Radiation Monitoring

This subsystem monitors radioactivity in the offgas piping downstream of the offgas system charcoal adsorbers and upstream of the offgas system discharge valve. A continuous sample is extracted from the Offgas System piping, passed through the offgas post-treatment sample panel for monitoring and sampling, and returned to the Offgas System piping. The sample panel has a pair of filters (one for particulate collection and one for halogen collection) in parallel (with respect to flow) with two detectors. Two radiation monitors analyze the data and then send the data to the main control room to visually display the measured gross radiation level.

The sample panel shielded chambers can be purged with room air to check detector response to background radiation by using solenoid valves operated from the control room. The sample panel measures and indicates sample line flow. A remotely-operated check source for each detector assembly is used to check operability of the gross radiation channel.

Power is supplied from a 120 VAC vital non-1E bus to the radiation monitors and to the local sample panel. A 120 VAC local bus supplies the vital sample to panel.

Each radiation monitor has four trip circuits: three upscale (high-high-high, high-high, high) and one downscale/inoperative. Each trip is determined by the radiation monitor and then sent for visual display to the main control room. The trips actuate corresponding main control room

annunciators: offgas post-treatment high-high-high radiation, offgas post-treatment high-high radiation, and offgas post-treatment high and downscale/inoperative monitor.

High or low flow measured at the sample panel actuates an annunciator in the control room to indicate abnormal flow.

The high-high-high and downscale trip/inoperative outputs initiate closure of the offgas system discharge valve. The high-high-high trip setpoint is provided in the Offsite Dose Calculation Manual. Any one High-High channel trip from the gaseous channels closes the offgas bypass valve.

A vial sampler panel similar to the pre-treatment sampler panel is provided for grab sample collection to allow isotopic analysis and gross monitor calibration.

11.5.2.2.3 Charcoal Vault Radiation Monitoring

The charcoal vault is monitored for gross gamma radiation level with a single instrument channel. The channel includes a detector and a radiation monitor. The detector is located outside the vault on the HVAC exhaust line from the vault. The radiation monitor analyzes the data and then sends the data for visual display to the main control room. The channel provides for sensing and readout of gross gamma radiation over a range of six logarithmic decades.

The monitor has two trip circuits: one upscale trip circuit and one downscale/inoperative trip. The trip outputs are alarmed in the main control room. Power to the monitor is supplied from 120 VAC vital non-1E bus.

11.5.2.2.4 Plant Stack Discharge Radiation Monitoring

This subsystem monitors the stack discharge for gross radiation level during normal plant operation and collects halogen and particulate samples for laboratory analysis.

The discharge through this common plant vent includes HVAC exhausts* from the secondary containment, turbine building, radwaste building, and service building controlled area. Also,

* The Reactor Building essential electrical HVAC, diesel generator HVAC, main control room habitability HVAC, service building clean area exhaust, and electrical equipment area HVAC systems contain no radioactive systems. The only releases to the environs by these systems would first have to be brought into the buildings by their own supply fans. Hence, monitoring of these exhausts are not required or provided.

The control building essential electrical HVAC contain no radioactive system except for the reactor building cooling water system. The reactor building cooling water system is considered a clean system with monitoring to alarm at a radiation level above background from potential leakage sources. Such contamination would require dumping of the cooling water to radwaste and replacing the dumped water with clean water therefore maintaining the cleanliness of the system. In addition the system operates at temperatures below 35°C. At this temperature, potential for airborne contamination is negligible and any releases other than a vanishingly small fraction of 10CFR20 concentration limits are not expected.

this system utilizes a high-range radiation monitor that measures fission products in plant gaseous effluents during and following an accident.

A representative sample is continuously extracted from the ventilation ducting through an isokinetic probe in accordance with ANSI N13.1 and passed through the stack ventilation sample panels for monitoring and sampling, and returned to the ventilation ducting. Each sample panel has a pair of filters (one for particulate collection and one for halogen collection) in parallel (with respect to flow) for continuous gaseous radiation sampling. The radiation detector assembly consists of a shielded gas chamber that houses a detector and a check source. The extended range detector assembly consists of a chamber which measures radiation levels up to 3.7 x 10^3 MBq/cm^3. A radiation monitor analyzes the data and then sends it to the main control room to display the measured radiation level. These sensors are qualified to operate under accident conditions.

The gas shielded chambers can be purged with room air from the control room. The gas chamber is equipped with a check source to test detector response to background radiation, thus checking operability of the radiation channel.

Power is supplied from 120 VAC vital non-1E bus for the radiation monitor and for the sample panel.

The radiation monitor has three trip circuits: two upscale (high-high, high) and one downscale/inoperative from each detector assembly. These trip outputs are alarmed in the main control room. Also, the sampled line is monitored for high or low flow indications and alarming.

Table 11.5-2 presents the gaseous and airborne monitors for the Effluent Radiation Monitoring System.

11.5.2.2.5 Radwaste Liquid Discharge Radiation Monitoring

This subsystem continuously monitors the radioactivity in the radwaste liquid during its discharge to the environment and stops the discharge on high radiation level.

Liquid waste can be discharged from the sample tanks containing liquids that have been processed through one or more treatment systems such as evaporation, filtration, and/or ion exchange. During the discharge, the liquid is extracted from the liquid drain treatment process pipe, passed through a liquid sample panel which contains a detection assembly for gross radiation monitoring, and returned to the process pipe. The detection assembly consists of a detector mounted in a shielded sample chamber equipped with a check source. A radiation monitor analyzes and transmits the measured gross radiation level to the main control room for visual display.

The sample panel chamber and lines can be drained to allow assessment of background buildup. The panel measures and indicates sample line flow. A check source operated from the control room can be used to check operability of the channel.

Based on acceptable radiation levels, discharge is permitted at a specified release rate and dilution rate.

The radiation monitor has three trip circuits: Two upscale trips (high-high and high), and one downscale/inoperative trip. The high-high upscale trip and the downscale/inoperative trip are used to stop the discharge to the environment. Also, the two upscale trips and the low downscale/inoperative trip actuate annunciators in the main control room and in the Radwaste Building control room. Table 11.5-3 describes the liquid monitors used for process radiation monitoring.

11.5.2.2.6 Reactor Building Cooling Water Radiation Monitoring

This subsystem consists of three channels: one for each RCW A, B and C loop for monitoring intersystem radiation leakage into the Reactor Building Cooling Water System.

Each channel consists of a detector which is located in a well near the RCW heat exchanger exit pipe. The output signal from each detector is sent to a separate radiation monitor. This monitor provides two trip circuits: one upscale (high) and one downscale/inoperative indication for annunciation in the control room. Power to the monitors is provided from the non-1E vital 120 VAC source.

11.5.2.2.7 Radwaste Building Ventilation Exhaust Monitoring

This subsystem monitors the Radwaste Building ventilation discharge to the stack, including the radwaste storage tank vents, for gross radiation. The single instrument channel consists of a local detector and a control room digital radiation monitor. Power is supplied to the channel by the 120 VAC vital non-1E bus.

The radiation monitor provides three trip circuits: two upscale (high) radiation and one downscale/inoperative trip.

The trip signals are annunciated in the Radwaste Building control room and in the main control room.

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

11.5.2.2.8 Turbine Building Ventilation Exhaust Monitoring

This subsystem monitors the vent discharge in the Turbine Building for gross radiation levels. The monitoring is provided by four channels (two redundant sets). Two redundant channels monitor radiation in the compartment area air exhaust duct and the other two redundant channels monitor the radiation in the ventilation system air exhaust from the clean area. Each

channel uses a detector located adjacent to the monitored exhaust duct. The output signal from each detector is processed by a separate radiation monitor and then transmitted to the main control room for alarm and display. Each monitor provides two trip circuits: one upscale (high) and one downscale/inoperative.

11.5.2.2.9 Turbine Gland Seal Condenser Exhaust Discharge Monitoring

This subsystem monitors the offgas releases to the stack from the turbine gland seal system. This includes the discharge from the mechanical vacuum pump. The offgas releases are continuously sampled and monitored for noble gases by a detector. The output signal from each detector is processed by a separate radiation monitor and then transmitted to the main control room for alarm and display. This monitor provides three trip circuits: two upscale (high-high, high) and one on radiation low (downscale/inoperative).

A grab sample of the offgas is provided for laboratory analysis. Also, samples of halogens and particulates are collected on filters for periodic analysis.

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

11.5.2.2.10 Standby Gas Treatment System Radiation Monitoring

This subsystem monitors the offgas radiation level in the SGTS exhaust duct to the stack using four channels.

Two detectors are physically located downstream of the exhaust fans on the exhaust duct to the stack and are utilized to monitor the high levels of radioactivity expected under accident conditions. Two other detectors are used during offgas sampling of the gas exhaust to the stack to monitor the normal level of radioactivity expected during normal plant operation.

The sensors are qualified to operate under accident conditions at the installed location.

The subsystem consists of four instrumented channels. Each channel consists of a detector and a radiation monitor.

Power for the channels is supplied from the non-Class 1E vital 120 VAC source.

Each radiation monitor has three trip circuits: two upscale (high-high, high) and one downscale/inoperative. All trips are displayed on the appropriate radiation monitor and each actuates a main control room annunciator for high-high, high and downscale/inoperative indications.

11.5.2.2.11 Not Used

11.5.2.2.12 Main Steamline (MSL) Radiation Monitoring

This subsystem monitors the gamma radiation level of the steam transported by the main steamlines in the MSL tunnel. The normal radiation level is produced primarily by coolant activation gases plus smaller quantities of fission gases being transported with the steam.

The MSL radiation monitors consist of four redundant instrument channels. Each channel consists of a local detector and a control room radiation monitor.

The detectors are physically located near the main steamlines (MSL) just downstream of the outboard MSIVs in the steam tunnel. The detectors are geometrically arranged and are capable of detecting significant increases in radiation level with any number of main steamlines in operation. Table 11.5-1 lists the location and range of the detectors.

Each radiation monitor has three trip circuits: two upscale (high-high and high) and one downscale/inoperative. Each trip is visually displayed on the affected radiation monitor. Any two-out-of-four channel trip results in main condenser mechanical vacuum pump (MVP) shutdown, and MVP line discharge valve closure. High and downscale trips do not result in a channel trip. Each radiation monitor displays the measured radiation level in mSv/h. All channel trips are annunciated in the main control room.

11.5.3 Effluent Monitoring and Sampling

All potentially radioactive effluent materials are monitored for radioactivity releases in accordance with GDC 64 as follows:

(1) Liquid releases are monitored for gross gamma radioactivity.

(2) Gaseous releases are monitored for gross gamma radioactivity.

11.5.3.1 Basis for Monitor Location Selection

The detector locations are selected per Regulatory Guide 1.21 to monitor all the major and potentially significant paths for release of radioactive material during normal reactor operation including anticipated operational occurrences. Monitoring of each major path provides measurements that are representative of effluent releases to demonstrate compliance with 10CFR20 limits and/or the technical specifications limits.

11.5.3.2 Expected Radiation Levels

Expected radiation levels are within the ranges specified in Tables 11.5-2 and 11.5-3.

11.5.3.3 Instrumentation

The radiation detectors used to measure radioactivity are listed in Table 11.5-1.

Grab samples are analyzed to identify and quantify the specific radionuclides in effluents and wastes. The results from the sample analysis are used to establish relationships between the gross gamma monitor readings and concentrations or release rates of radionuclides in continuous effluent releases.

11.5.3.4 Setpoints

The trip setpoints that initiate automatic isolation functions are based on calculations developed in accordance with controlled plant procedures or, if pertaining to gaseous or liquid releases within the scope of the Offsite Dose Calculation Manual (ODCM), in accordance with the ODCM.

11.5.4 Process Monitoring and Sampling

11.5.4.1 Implementation of General Design Criterion 19

The control building is provided with radiation monitors that will detect radiation in the intake air supply to the control building and provide warning and adequate radiation protection to operating personnel to permit access and occupancy of the control room under accident conditions.

11.5.4.2 Implementation of General Design Criterion 60

All potentially significant radioactive discharge paths are equipped with a control system to automatically isolate the discharge on indication of a high radiation level. These include:

(1) Offgas post-treatment

(2) Reactor Building HVAC air exhaust

(3) Fuel handling area ventilation exhaust

(4) Drywell sump liquid waste discharge

(5) Radwaste liquid discharge

11.5.4.3 Implementation of General Design Criterion 64

Radiation levels in radioactive and potentially radioactive process streams are monitored for radioactivity releases. These include:

(1) Main steamline

(2) Offgas pre-treatment and post-treatment

(3) Charcoal vault vent

(4) Intersystem leakage into Reactor Building cooling water

11.5.4.4 Basis for Monitor Location Selection

The detector locations are selected per Regulatory Guide 1.21 to monitor all the major and potentially significant paths for release of radioactive material during normal reactor operation including anticipated operational occurrences. Monitoring of each major path provides measurements that are representative of releases to demonstrate compliance with 10CFR20 limits and/or the technical specification limits.

11.5.4.5 Expected Radiation Levels

Expected radiation levels are listed in Tables 11.5-2 and 11.5-3.

11.5.4.6 Instrumentation

The radiation detectors used to measure radioactivity are listed in Table 11.5-1.

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.

11.5.4.7 Setpoints

The radiation trip setpoints for the various monitors are listed in Table 11.5-1.

11.5.5 Calibration and Maintenance

11.5.5.1 Inspection and Tests

During reactor operation, daily 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 will be recorded, 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 will have its response checked with a portable radiation source. A record will be 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. 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 which can be tested by using test signals or portable gamma sources:

(1) Main steamline

(2) Reactor Building vent exhaust

(3) Fuel handling area vent exhaust

(4) Control building air intake supply

(5) Reactor Building cooling water intersystem leakage

(6) SGTS offgas discharge

(7) Turbine Building ventilation exhaust

(8) Offgas pre-treatment

(9) Charcoal vault exhaust

The following monitors include built-in check sources and purge systems which can be operated from the main control room:

(1) Offgas post-treatment

(2) Plant stack discharge

(3) Liquid waste discharge

(4) SGTS offgas discharge

(5) Radwaste building vent exhaust

(6) Gland seal condenser exhaust

11.5.5.2 Calibration

Calibration of radiation monitors is performed using certified commercial radionuclide sources traceable to the National Institute of Standards and Technology. Calibrations are performed in accordance with manufacturers' requirements and controlled by approved plant procedures. Each continuous monitor is calibrated during plant operation or during the refueling outage if the detector is not accessible during power operation.

11.5.5.3 Maintenance

All channel detectors and electronics are serviced and maintained on a periodic basis or in accordance with manufacturers' recommendations to ensure reliable operations. For sampling systems, skids are designed in order to allow periodic maintenance and cleaning. If any work is performed which would affect the calibration, a recalibration is performed at the completion of the work.

11.5.5.4 Audits and Verifications

Audits and verification during normal plant operation are out-of-scope for the Standard ABWR Plant.

11.5.6 COL License Information

11.5.6.1 Calculation of Radiation Release Rates

The COL applicant shall provide and describe in the operation and maintenance manual the procedures and/or methods for the conversion of the radiation measurements into release rates of gaseous discharge from the main plant stack. (Section 11.5)

11.5.6.2 Compliance with the Regulatory Shielding Design Basis

The COL applicant shall describe in the operation and maintenance manual the sampling system design of the SGTS and of the main stack effluent monitoring subsystems and show compliance with the regulatory shielding requirements for low radiation exposure under accident conditions as stipulated in NUREG-0737, Item II.F.1, clarification 2 of Attachment 2. The requirement for the shielding design will be covered in the equipment design specifications. (Section 11.5)

11.5.6.3 Provisions for Isokinetic Sampling

The COL applicant shall describe in the operation and maintenance manual the sampling technique used for monitoring and sampling of effluent gasses to assure that a representative gas sample is extracted and that the sampling system is capable of maintaining isokinetic conditions within 20% of the flow rate during and following as accident as stipulated in NUREG-0737, Item II.F.1, clarification 3 of Attachment 2. (Section11.5)

11.5.6.4 Sampling of Radioactive Iodines and Particulates

The COL applicant shall describe in the operation and maintenance manual the collection technique used to extract representative samples of radioactive iodines and particulates during and following an accident. These measurements are used to determine the quantitative releases for dose calculations and assessment (as stipulated in NUREG-0737, Table II.F.1-2). (Section 11.5)

11.5.6.5 Calibration Frequencies and techniques

The COL applicant shall provide in the operation and maintenance manual for the system the calibration frequencies and techniques for the radiation sensors. This information shall be based on vendor data for the equipment. (Section 11.5)

Table 11.5-1 Process and Effluent Radiation Monitoring Systems

Monitored Process‡	No. of Channels	Sample Line or Detector Location	Channel Range*	Setpoint ACF Trip	Setpoint Scale
A. Safety-Related Monitors					
Reactor Building vent exhaust	4	Exhaust duct upstream of exhaust ventilation isolation valve	1E^{-4} to 1 mSv/h	Offsite Dose Calculation Manual	4 dec. log
Control Building air intake	8†	Intake duct upstream of intake ventilation isolation valve	1E^{-4} to 1 mSv/h	Based on setpoint calculation	4 dec. log
Drywell sump discharge	2	Drain line from LCW & HCW sumps	1E^{-2} to 1E^{4} mSv/h	Based on setpoint calculation	6 dec. log
Fuel handling area air vent exhaust	4	Locally above operating floor	10^{-3} to 10 mSv/h	Offsite Dose Calculation Manual	4 dec. log

ACF = Automatic Control Function

Table 11.5-1 Process and Effluent Radiation Monitoring Systems (Continued)

Monitored Process‡	No. of Channels	Sample Line or Detector Location	Channel Range*	Setpoint ACF Trip	Setpoint Scale
B. Monitors Required for Plant Operation					
Main steamline tunnel area	4	Immediately down-stream of plant main steamline isolation valve	$1E^{-2}$ to $1E^{4}$ mSv/h	Based on setpoint calculation	6 dec. log
Radwaste liquid discharge	1	Sample line	10^{-1} to 10^{4} cpm	Offsite Dose Calculation Manual	5 dec. log
Reactor Building cooling water system	3	RCW Hx line exit	10^{-1} to 10^{4} cpm	None	5 dec. log
Offgas post-treatment	2	Sample line	10 to 10^{6} cpm	Offsite Dose Calculation Manual	5 dec. log
Offgas pre-treatment	1	Sample line	10^{-2} to 10^{4} mSv/h	None	6 dec. log
Charcoal vault vent	1	On charcoal vault HVAC exhaust line	10^{-2} to 10^{4} mSv/h	None	6 dec. log
Plant stack discharge	2**	Sample line	10 to 10^{6} cpm	None	5 dec. log
			10^{-13} to 10^{-6} Amps ($1E^{-2}$ to $1E^{4}$ mSv/h)	None	6 dec. log

ACF = Automatic Control Function

Table 11.5-1 Process and Effluent Radiation Monitoring Systems (Continued)

Monitored Process‡	No. of Channels	Sample Line or Detector Location	Channel Range*	Setpoint	
				ACF Trip	Scale
B. Monitors Required for Plant Operation (Continued)					
Radwaste Building exhaust vent	1	Exhaust ducts	10 to 10^6 cpm	None	5 dec. log
Turbine Building vent exhaust	4	Exhaust duct	$1E^{-4}$ to 1 mSv/h	None	4 dec. log
Standby Gas Treatment System offgas	2**	SGTS exhaust air duct downstream of exhaust fans	1 to 10^6 cpm	None	6 dec. log
			10^{-13} to 10^{-6} Amps ($1E^{-2}$ to $1E^4$ mSv/h)	None	6 dec. log
Turbine gland seal condenser offgas	1	Sample line	1 to 10^6 cpm	None	6 dec. log
Incinerator stack discharge	1	Sample line	1 to 10^6 cpm	Technical Specification	6 dec. log

ACF = Automatic Control Function

* The channel range specified in this table is the equipment measuring or display range of the indicated parameter. Refer to Tables 11.5-2 and 11.5-3 for the dynamic detection range of the monitoring channel expressed as concentration in units of megabecquerels per cubic centimeter, referenced to a specific nuclide. These channel ranges are estimated based on existing plants.

† 4 Channels for each air intake.

‡ The alarms and indication for these radiation detectors are displayed locally and in the main control room.

** One each of two different detector types is required to cover the range.

Table 11.5-2 Process Radiation Monitoring System (Gaseous and Airborne Monitors)

Radiation Monitor	Configuration	Dynamic Detection Range‡	Principal Radionuclides Measured	Expected Activity*	Alarms and Trips
Offgas post-treatment	Offline	3.7 x10^{-5} to 3.7 MBq/cm^3	Xe-133† Cs-137 I-131	1.1 x 10^{-3} MBq/cm^3	Flow H/L DNSC/INOP High High-High HIgh-High-High
Offgas pre-treatment	Adjacent to sample chamber	3.7 x10^{-5} to 3.7x10^2 MBq/cm^3	Noble gases fission products	~1.1x10^{-2} MBq/cm^3	High-High High DNSC/INOP Flow H/L
Main steamline tunnel area	Adjacent to steamlines	1.0x10^{-2} mSv/h to 1.0x10^4 mSv/h	Coolant activation gases	~1 mSv/h	High-High High DNSC/INOP
Charcoal vault	Inline	3.7x10^{-5} to 37 MBq/cm^3	Noble gases	Negligible	High
T/B vent exhaust	Inline	3.7x10^{-7} to 3.7x10^{-3} MBq/cm^3	Xe-133† Xe-135	~1.48x10^{-6} MBq/cm^3	High DNSC/INOP
Reactor Building vent exhaust	Inline	3.7x10^{-7} to 3.7 x 10^{-3} MBq/cm^3	Noble gases Xe-133† Xe-135	~1.48x10^{-6} MBq/cm^3	High-High High DNSC/INOP
Plant stack discharge (normal range)	Offline	3.7 x 10^{-9} to 3.7x10^{-3} MBq/cm^3	Xe-133† Cs-137 I-131	~1.85x10^{-6} MBq/cm^3	High-High High DNSC/INOP Flow H/L
Plant stack (high-range)	Offline	3.7x10^{-4} to 3.7x10^3 MBq/cm^3	Xe-133†	~1.85x10^{-6} MBq/cm^3	Flow H/L DNSC/INOP High High-High

Table 11.5-2 Process Radiation Monitoring System (Gaseous and Airborne Monitors) (Continued)

Radiation Monitor	Configuration	Dynamic Detection Range‡	Principal Radionuclides Measured	Expected Activity*	Alarms and Trips
Radwaste Building ventilation exhaust	Offline	3.7 x 10^{-9} to 3.7 x 10^{-3} MBq/cm^3	Xe-133† Cs-137 I-131	~3.7x10^{-7} MBq/cm^3	High-High High DNSC/INOP Flow H/L
Gland seal condenser exhaust discharge	Offline	3.7x10^{-9} to 3.7x10^{-3} MBq/cm^3	Xe-133 Cs-137† I-131	~3.7x10^{-8} MBq/cm^3	High-High High DNSC/INOP Flow H/L
Control Bldg. HVAC air intake	Inline	3.7x10^{-7} to 3.7x10^{-3} MBq/cm^3	Xe-133†	Negligible	High-High High DNSC/INOP
Standby Gas Treatment System exhaust	Offline	3.7x10^{-9} to 3.7x10^{-3} MBq/cm^3	Noble gases Cs-137† I-131	~1.85x10^{-8} MBq/cm^3	High-High High DNSC/INOP Flow H/L
	Inline	3.7x10^{-4} to 3.7x10^{3} MBq/cm^3	Noble gases	~1.85x10^{-8} MBq/cm^3	High-High High DNSC/INOP
Fuel handling area exhaust	Inline	3.7x10^{-5} to 3.7x10^{-1} MBq/cm^3	Noble gases	~2.22x10^{-4} MBq/cm^3	High-High High DNSC/INOP

* Expected activities are estimated and are based on existing plants.

† Sensitivity based upon this radionuclide.

‡ Dynamic Detection Range is calculated based on the radionuclides and the sensitivity of the radiation monitor to the radionuclides. As this calculation is based on vendor supplied info (sensitivity of the monitor), these values are estimated.

Table 11.5-3 Process Radiation Monitoring System (Liquid Monitors)

Radiation Monitor	Configuration	Dynamic Detection Range‡	Principal Radionuclides Measured	Expected Activity*	Alarms & Trips
Radwaste liquid discharge	Offline	3.7×10^{-9} to 3.7×10^{-4} MBq/cm^3	Cs-137† Co-60	~3.7×10^{-8} MBq/cm^3	High/High High DNSC/INOP
Reactor Building cooling water intersystem leakage	Inline	3.7×10^{-7} to 3.7×10^{-2} MBq/cm^3	Cs-137† Co-60	~2.22×10^{-6} MBq/cm^3	High DNSC/INOP
Drywell sump drain liquid discharge	Inline	3.7×10^{-4} to 3.7×10^{2} MBq/cm^3	Gross Gamma Cs-137†	~1.85×10^{-3} MBq/cm^3	High-High High DNSC/INOP

* Expected activities are estimated and are based on existing plants.

† Sensitivity based upon this radionuclide.

‡ Dynamic Detection Range is calculated based on the radionuclides and the sensitivity of the radiation monitor to the radionuclides. As this calculation is based on vendor supplied info (sensitivity of the monitor), these values are estimated.

DNSC—Downscale Indication

INOP—Monitor Inoperative

Table 11.5-4 Radiological Analysis Summary of Liquid Process Samples

Sample Description	Grab Sample Frequency	Analysis	Sensitivity MBq/L	Purpose
1 Reactor Coolant				
Filtrate	Daily*	Gross gamma	$3.7x10^{-5}$	Evaluate reactor water activity
Crud	Daily*	Gross gamma	$3.7x10^{-5}$	Evaluate crud activity
Filtrate	Weekly†	I-131, I-133	$3.7x10^{-6}$	Evaluate fuel cladding integrity
Crud and filtrate	Weekly	Gamma spectrum	$1.85x10^{-6}$	Determine radionuclides present in system
2. Reactor water cleanup system	Biweekly	Gross gamma	$3.7x10^{-5}$	Evaluate cleanup efficiency
3. Condenser demineralizer				
Influent	Monthly	Gross gamma	$3.7x10^{-5}$	Evaluate leakage
Effluent	Monthly	Gross gamma	$3.7x10^{-5}$	Evaluate demineralizer performance
4. Condensate storage tank	Weekly	Gross β-γ	$3.7x10^{-5}$	Evaluate water radioactivity
5. Fuel pool filter—demineralizer				
Inlet and outlet	Periodically	Gross β-γ	$3.7x10^{-5}$	Evaluate system performance
6. LCW collector and sampling tanks (4)	Periodically	Gross β-γ	$3.7x10^{-5}$	Evaluate system performance
7. HCW collector tanks (2)	Periodically	Gross β-γ	$3.7x10^{-5}$	Evaluate system performance
8. HSD sample tanks (2)	Periodically	Gross β-γ	$3.7x10^{-5}$	Evaluate system performance
9. Solid waste supply tank (evaporator bottoms)	Periodically	Gross β-γ	$3.7x10^{-5}$	Compare activity with that determined by drum readings
10. HCW distillate tank (evaporator)	Periodically	Gross β-γ	$3.7x10^{-5}$	Evaluate evaporator performance
11. Reactor Building Cooling Water System	Weekly	Gross β-γ	$3.7x10^{-5}$	Evaluate intersystem leakage

* Daily means five times per week.

† Performed more frequently if increase noted on daily gamma count.

Table 11.5-5 Radiological Analysis Summary of Gaseous Process Samples

Sample Description	Sample Frequency	Analysis	Sensitivity MBq/L	Purpose
1. Containment atmosphere (drywell)	Periodically and prior to entry	Gross α&β Tritium	3.7×10^{-10} 3.7×10^{-5}	Determine need for respiratory equipment
2. Offgas monitor sample	Monthly	Gamma spectrum	3.7×10^{-9}	Determine offgas activity
3. Offgas vent sample	Weekly	Gross β^{*}	3.7×10^{-10}	Determine offgas system cleanup
		I-131†	3.7×10^{-9}	
		Gamma spectrum Tritium	3.7×10^{-9} 3.7×10^{-5}	

* On particulate filter

† On charcoal cartridge

Table 11.5-6 Radiological Analysis Summary of Liquid Effluent Samples

Sample Description	Sample Frequency	Analysis	Sensitivity MBq/L	Purpose
1. Detergent drain tanks	Batch*	Gross Gamma	3.7×10^{-6}	Effluent discharge record
2. Liquid radwaste effluent	Weekly†	Ba/La-140 and I-131	1.85×10^{-6}	Effluent discharge record
composite of all discharges	Monthly	Gamma Spectrum	1.85×10^{-6}	
		Tritium	3.7×10^{-4}	
		Gross alpha	3.7×10^{-6}	
		Dissolved gas‡	3.7×10^{-4}	
	Quarterly	Sr 89 and 90	1.85×10^{-6}	
3. Circulating water decant line	Weekly grab of continuously collected proportional sample	Gross Gamma	3.7×10^{-6}	Effluent discharge record (backup sample)
		Tritium	3.7×10^{-4}	
4. Reactor service water	Weekly	Gross Gamma	3.7×10^{-6}	Effluent discharge record
		Tritium	3.7×10^{-4}	

* If tank is to be discharged, analysis will be performed on each batch. If tank is not to be discharged, analysis will be performed periodically to evaluate equipment performance.

† Typical batch of average release. All other samples are proportional composites.

‡ If no discharge event occurs during the week, frequency shall be so adjusted.

Table 11.5-7 Radiological Analysis Summary of Gaseous Effluent Samples

Sample Description	Sample Frequency	Analysis	SensitivityMBq/L	Purpose
1 Plant stack discharge*	Weekly	Gross β†	3.7×10^{-10}	Effluent record
		I-131‡	3.7×10^{-9}	
		Ba/La-140†	3.7×10^{-8}	
	Monthly	Gamma spectrum†	3.7×10^{-9}	
		I-133 and 135‡	3.7×10^{-9}	
		Tritium	3.7×10^{-5}	
		Gross alpha+	3.7×10^{-10}	
	Quarterly	Sr-89 and 90†	3.7×10^{-10}	

* This includes discharges from the Reactor Building, Turbine Building, Radwaste Building, Service Building and Gland steam condenser exhaust.

† On particulate filter.

‡ On charcoal cartridge.