11.5 Process and Effluent Radiological Monitoring and Sampling Systems

The process and effluent radiological monitoring and sampling systems monitor, record, and (for certain subsystems) control the release of radioactive materials that may be generated during normal operation, anticipated operational occurrences (AOO), and postulated accidents. These systems monitor and record radioactivity levels in plant process streams and atmospheres, indicate and alarm excessive radioactivity levels, automatically initiate protective isolation actions, and record the rate of release of radioactive materials to the environment. The systems consist of permanently installed, continuous monitoring devices together with a program of, and provisions for, specific sample collections and laboratory analyses.

Process sampling systems are summarized in this section; a detailed description of these systems is included in Section 9.3.2. In addition to the process and effluent monitoring and sampling systems described in this section, the U.S. EPR also uses the following radioactivity monitoring systems:

- Area radioactivity and airborne monitoring (addressed in Section 12.3).
- Personnel monitoring (addressed in Section 12.5).
- Contamination monitoring (addressed in Section 12.5).
- Radiation monitoring of waste packages (addressed in Section 11.4).

11.5.1 Design Basis

AREVA NP Inc. has designed the process and effluent radiological monitoring and sampling systems in accordance with the requirements of 10 CFR Parts 20, 10 CFR 50.34(a), 10 CFR 50.34(f)(2)(xvii) and 10 CFR 50.34 (f)(2)(xxvii) as these requirements relate to TMI action items and 50.36(a). Additionally, the design for these systems complies with the ANSI standards N13.1-1999 (Reference 1) and ANSI N42.18-2004 (Reference 2), as well as the guidance in RGs 1.21, 1.33, 1.97, 4.15, 1.206, IE Bulletin 80-10, GDC 60, GDC 63, GDC 64, 10 CFR Part 50, Appendix I, 10 CFR 20.1301(e), 10 CFR 20.1302, and NUREG-0800, BTP 7-10 (Reference 3), NUREG-0737 (Reference 4), NUREG-0718 (Reference 5), Generic Letter 89-01 (Reference 6), and Appendix 11.5-A of NUREG-0800 (Reference 7). Quality Assurance (QA) and Control (QC) follow the guidance in RG 1.21 and 4.15.

Consistent with the requirements of 10 CFR 20.1406, the U.S. EPR, including the process and effluent radiological monitoring and sampling systems, is designed to minimize, to the extent practicable, contamination of the facility and the environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste. Minimization of contamination and radioactive waste generation is described in Section 12.3.6.

A COL applicant that references the U.S. EPR design certification and that chooses to install and operate skid-mounted radiation monitoring and sampling systems connected to permanently installed radioactive process and waste management systems will include plant-specific information describing how design features and implementation of operating procedures for the PERMSS will address the requirements of 10 CFR Part 20.1406(b) and guidance of SRP Section 11.5, Regulatory Guides 4.21 and 1.143, IE Bulletin 80-10, ANSI/HPS-13.1-1999 and ANSI N42.18-2004, and NEI 08-08.

11.5.1.1 Design Objectives

Portions of the process and effluent radiological monitoring and sampling systems perform safety related functions. For those portions of the systems, the safety design bases functions are as follows:

- Initiate main control room air conditioning system supplemental filtration in the event of abnormally high gaseous radioactivity in the main control room supply air.
- Initiate fuel handling area ventilation isolation on high exhaust activity from fuel handling area.
- Provide long-term post-accident monitoring (using both safety-related and non-safety-related monitors) in the event of a postulated accident.

11.5.1.2 Design Criteria

The process and effluent radiological monitoring and sampling systems monitor the containment atmosphere; spaces containing components for recirculation of loss of coolant accident fluids; and effluent discharge paths for radioactivity released from normal operations, AOOs, and postulated accidents. Sampling points are located on both process and effluent radiological monitoring and sampling systems to permit representative sampling for radiochemical analysis. The process and effluent radiological monitoring and sampling systems measure, record and provide a readout in the control room for containment radiation levels, and noble gas effluents at all potential, accident release points. The process and effluent radiological monitoring and sampling systems continuously sample for radioactive iodines and particulates in gaseous effluents from all potential accident release points, and provides for onsite capability to analyze and measure these samples. The monitoring of inplant radiation and airborne radioactivity is provided for a broad range of routine and accident conditions.

This design complies with applicable portions of 10 CFR 50.34(f)(2)(xvii) and 10 CFR 50.34(f)(2)(xxvii), 10 CFR Part 50, Appendix A, GDC 64, and RG 1.97.

The process radiological monitoring and sampling systems indicate the existence and, to the extent possible, the magnitude of reactor coolant and reactor auxiliary system leakage to the containment atmosphere, cooling water systems, and the secondary side of the steam generators. Process monitors also provide alarm and gross indication of the extent of failed fuel. They also monitor radioactive waste systems and associated handling areas to detect and alarm conditions that may result in loss of residual heat removal capability and excessive radiation levels. The process monitors that provide a signal for the actuation of engineered safety feature (ESF) systems are designed and qualified to the same criteria as the ESF system. Similarly, the monitors that provide for the actuation of non-ESF systems are designed and qualified to the same criteria as the non-ESF system. This function complies with applicable portions of 10 CFR Part 50, Appendix A, GDC 63.

The effluent radiological monitoring and sampling systems operate continuously during both intermittent and continuous discharges of potentially radioactive plant effluents, in compliance with RG 1.21. The system allows verification of several discharge requirements:

- The most restrictive anticipated radionuclides are at effluent concentrations below the limits specified in Table 2 of Appendix B of 10 CFR Part 20.
- Effluents meet ALARA design objectives of 10 CFR Part, 50 Appendix I.
- Effluents comply with 10 CFR 20.1302 dose limits.
- Effluents comply with EPA environmental radiation standards contained in 40 CFR Part 190.

The effluent radiological monitoring and sampling systems alarm and automatically terminate the release of effluents when radionuclide concentrations exceed the specified limits. The effluent monitors that provide a signal for the actuation of ESF systems are designed and qualified to the same criteria as the ESF system. Similarly, the monitors that provide for the actuation of non-ESF systems are designed and qualified to the same criteria as the non-ESF system. This design complies with 10 CFR Part 50, Appendix A, GDC 60, which requires that “the design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents.” Effluent radiological monitors provide sufficient radioactivity release data to prepare effluent release reports required by RG 1.21.

For monitors that provide an automatic control feature, the isolation or diversion valves or ventilation dampers will be downstream of the monitor so that upon detection of elevated radioactivity levels in the effluent stream will terminate releases by closure of the valves or ventilation dampers in a timely manner to isolate the downstream process stream from further contamination.

11.5.2 System Description

The effluent and process radiological monitoring and sampling systems consist of radiation detectors connected to local black boxes. Each black box processes the detector signal, performs alarm or control functions, and transmits the signal to a control room information and control system. Monitoring systems alarm when setpoint limits are exceeded or when the system becomes inoperable (see Section 7.1.1 for I&C architecture). Alarms are located both locally and in the control room. Information regarding subsystem checks, tests, and maintenance may be found in Section 7.1.1.5.5.

The detector procurement specifications will require purging or flushing taps for cleaning the sampling pathway within the detector with clean air or water. The design allows the detector to be taken offline and isolated. Then, either the detector is replaced or removed for maintenance. Maintenance technicians will bag and tag the detector as required, transport it to the equipment decontamination facility for decontamination and purging or flushing, and transport it to the instrument shop for repair, cleaning, calibration, and functional checks, as appropriate. The detector would then be reinstalled.

Purge or flush fluids will be captured in the equipment decontamination facility (see Section 12.3.1.6) and sent to the liquid waste management system (LWMS). Gases are routed through a monitored exhaust. Provisions to prevent cross-contamination of purge and flush supply systems are described in Section 12.3.6.5, which demonstrates isolations to prevent cross-contamination of distributed purge and flush supply systems.

AREVA NP Inc. has designed safety-related process and effluent radiological monitoring and sampling systems in accordance with the following criteria:

- Radiation detectors and black boxes are powered from the uninterruptible power supply system; sample pumps and heat-tracing systems are powered from Class 1E power.
- Components are environmentally qualified as applicable. Section 3.11 addresses the environmental qualification of instrumentation.
- Components are seismically qualified as applicable. Sections 3.10 and 3.11 address the qualification of instrumentation.
- Systems comply with the fire protection criteria addressed in Section 9.5.
- Multiple (redundant) systems are used and are physically separated in accordance with criteria addressed in Section 8.3.2.

Process and effluent radiological monitoring and sampling systems that sample airborne radioactive materials are designed in accordance with the general principles and guidance contained in ANSI Standard N.13.1-1999 (Reference 1). Use of this ANSI standard is in accordance with RG 1.21.

Refer to Section 12.3.6.5.4 for radioactive waste management system design features which demonstrate compliance with the requirements of 10 CFR 20.1406.

A COL applicant that references the U.S. EPR design certification will fully describe, at the functional level, elements of the process and effluent monitoring and sampling programs required by 10 CFR Part 50, Appendix I and 10 CFR 52.79(a)(16). This program description, Offsite Dose Calculation Manual (ODCM), will specify how a licensee controls, monitors, and performs radiological evaluations of releases. The program will also document and report radiological effluents discharged to the environment. NEI 07-09A (Reference 10) is an alternate means of demonstrating compliance with GL 89-01 and SECY 05-0197 until a plant and site-specific ODCM is developed under a license condition. The lower limits of detection (LLD) for liquid and gaseous process monitors and detection sensitivities for liquid and gaseous process monitors will be calculated in accordance with the methodology provided in the ODCM.

A COL applicant that references the U.S. EPR design certification is responsible for deriving PERMSS subsystem's lower limits of detection or detection sensitivities, and set-points (alarms and process termination/diversion) for liquid and gaseous process radiation monitoring equipment not covered by the ODCM based on plant and site-specific conditions and operating characteristics of each installed radiation monitoring subsystem.

A COL applicant that references the U.S. EPR design certification is responsible for developing a plant-specific process and effluent radiological sampling and analysis plan for systems not covered by the ODCM, including provisions describing sampling and analytical frequencies, and radiological analyses for the expected types of liquid and gaseous samples and waste media generated by the LWMS, GWMS, and SWMS.

11.5.3 Effluent Monitoring and Sampling

Sections 12.1 and 12.3 describe how the ALARA provisions of RG 8.8 and RG 8.10 are implemented in system designs and operation to comply with occupational dose limits of 10 CFR 20.1201 and 10 CFR 20.1202 and occupational limits of Table 1, annual limit on intake (ALI) and derived air concentration (DAC), of Appendix B to 10 CFR Part 20.

11.5.3.1 Gaseous Effluents

Compartment exhaust air from the controlled area and system exhaust air are discharged into the vent stack exhaust. The gaseous effluent monitoring and sampling system monitors the Reactor Containment Building (including the low flow purge subsystem and the internal filtration subsystem), the Fuel Building, the Annulus Ventilation System, the Nuclear Auxiliary Building, the mechanical area of the Safeguard Buildings, the controlled area of the Access and Radioactive Waste Processing Buildings and the vent stack. The U.S. EPR ventilation systems are described in Section 9.4.

Continuously operating measurement devices monitor vent stack gaseous effluent for noble gases, aerosol, and iodine. Samples are also collected for laboratory analysis of tritium, noble gases, aerosols and iodine. Two permanently installed monitoring and sampling systems provide gaseous samples from the vent stack to the measurement devices. Each sampling system has separate sample lines and independent nozzle arrays, located within the vent stack, to retrieve gaseous samples. The system is designed in accordance with ANSI N13.1-1999 (Reference 1) to provide extraction of a representative gaseous sample. The vent stack gaseous effluent monitoring system functional location is shown in Figure 11.5-1—Radioactive Effluent Flow Paths With Process and Effluent Radiation Monitors, as well as Figure 11.3-1—Gaseous Waste Processing System - Normal Operation, and Figure 11.3-2—Gaseous Waste Processing System - Gaseous Waste Sources.

The ODCM (see Section 11.5.2) includes the following information for each location subject to routine gaseous effluent sampling: the sampling frequency and the analytical process and sensitivity for selected radioanalytical methods and types of sampling media.

The gaseous effluent monitoring and sampling system has the following general characteristics:

- Noble gas activity is monitored with gamma and beta-sensitive detectors. The gross output of the monitor is periodically normalized to the radionuclide composition by performing a gamma-spectroscopic analysis on a representative grab sample.
- Aerosol activity is monitored with the use of an aerosol filter through which sample flow is continuously maintained. Aerosol particles are removed by the filter, which is monitored by a gamma-sensitive detector.
- Iodine activity is monitored by a dual filter for organic and inorganic iodine. Gamma-sensitive detectors monitor each filter.

For both aerosol and iodine monitoring, the gross outputs of the monitors are normalized by laboratory analysis of a duplicate set of filters installed in parallel with the primary ones. Measurement ranges of noble gas, aerosol, and iodine monitors are shown in Table 11.5-1—Radiation Monitor Detector Parameters. The gaseous effluent radiological monitoring and sampling for the vent stack does not perform automatic actions. The system monitors, records, and alarms in the control room if monitored radiation levels increase beyond specified setpoints.

The ODCM (see Section 11.5.2) contains the standard radiological gaseous effluent controls for the plant. This includes a description of how effluent release rates will be derived and parameters used in setting instrumentation alarm setpoints to control or terminate effluent releases in unrestricted areas that are above the effluent concentrations in Table 2 of Appendix B to 10 CFR Part 20. In addition, the ODCM describes how the guidance of NUREG-1301 (Reference 8) and NUREG-0133 (Reference 9) were used in developing the bases of alarm setpoints.

11.5.3.1.1 Gaseous Waste Processing System (GWPS)

Airborne releases can be limited by restricting reactor coolant leakage and by limiting the concentrations of radioactive gases in the reactor coolant system (RCS), however, these gases escape from reactor coolant during normal operations and require treatment in the gaseous waste processing system. The purpose of the monitoring system is to control the subsequent release of processed waste gases to the atmosphere in compliance with regulatory limits. See Section 11.3 for a complete discussion. Gamma-sensitive radiation detectors continuously monitor the gaseous waste delay beds. A gamma-sensitive radiation detector is located upstream of the beds (R-1) and a beta-sensitive radiation detector is located downstream (R-2). The upstream monitor measures the gamma radiation emitted by the radionuclides entering the beds, and provides station personnel with an indication of the amount of radioactivity entering the beds. The downstream monitor is a beta-sensitive instrument, because krypton-85 generally forms the main constituent (about 95 percent) of the radioactive noble gases. The gaseous waste disposal radiation monitoring system provides control room and local indication only. This system initiates an automatic action to close the discharge valve on high activity.

The radiation monitors in the gaseous waste processing system are shown on Figure 11.3-1 and Figure 11.3-2. In addition, Section 9.4 includes simplified diagrams of the ventilation systems that show the radiation monitors. Measurement ranges of the gaseous waste disposal radiation monitoring system are shown in Table 11.5-1. The safety classification for these instruments is non-safety, augmented quality. Portable check sources are used to check the detector and instrumentation circuitry.

11.5.3.1.2 Main Condenser Evacuation System (MCES)

Noncondensable gases (air and noble gases) in the secondary steam system are continuously removed during operation by the main condenser evacuation system (see

Section 10.4.2). These gases discharge to the vent stack via the main condenser evacuation system air vent sub-system and via the nuclear auxiliary building ventilation system. To monitor noble gas radioactivity, the monitoring system extracts part of the flow from the vent line (see Figure 10.4.2-2 and Figure 11.5-1) and passes it through a measuring vessel with a beta-sensitive detector (R-3). If the monitoring system detects noble gas radioactivity in the secondary steam system, then it provides local and control room indication and alarms. The task of the monitor is to provide information and alarm about any increase of activity in the secondary system. This alarm is an indication of breach of fuel cladding, primary coolant boundary, or containment leak. Table 11.5-1 shows the measurement ranges of the main condenser evacuation system. This system does not initiate automatic actions.

Measurement ranges of the main condenser evacuation radiation monitoring system are shown in Table 11.5-1. The safety classification for these instruments is non-safety. Portable check sources are used to check the detector and instrumentation circuitry.

11.5.3.1.3 Sampling Activity System

The vent stack exhaust air is sampled by means of a redundant nozzle array which meets requirements for obtaining a representative sample to determine the release of radioactive substances in gaseous and aerosol-bound form. The sampling points are located down-stream of the last compartment air outlet into the vent stack at a point where there has been achieved an adequate mixture of the entire exhaust air flow.

The sampling activity system consists of three arrays of detectors at measurement points R-4, R-5, and R-6, which measure gaseous activity in the vent stack as shown in Figure 11.3-2 and Figure 11.5-1. The R-4 continuous effluent monitors consist of one noble gas, one iodine, and one aerosol monitors plus one iodine and one aerosol accident monitors in the vent stack. Effluent grab sample provisions consist of one noble gas, one iodine, one aerosol sample points, plus one noble gas, one iodine, and one aerosol accident sample points, and an H-3, C-14 sample point in the vent stack. The R-5 continuous effluent monitors consist of two noble gas monitors in the vent stack. Effluent grab sample provisions consist of one iodine and one aerosol sample points, plus one noble gas, one iodine, and one aerosol accident sample points, and an H-3, C-14 sample point in the vent stack. Tritium is monitored by continuously taking a sample from the exhaust air. The R-6 continuous effluent monitors consist of two noble gas accident monitors in the vent stack.

Coupled with a vent stack air flow rate instrument in the immediate vicinity of the detector arrays, the monitors provide the data necessary to determine the release of gaseous effluents through the vent stack. This monitoring system provides local and control room indication and alarms. This system does not initiate automatic actions.

Measurement ranges of the sampling activity system are shown in Table 11.5-1. The safety classification for these instruments is non-safety. Portable check sources are used to check the detector and instrumentation circuitry.

11.5.3.1.4 Containment Building Ventilation System (CBVS) - Low Flow Purge

Aerosol monitors, iodine monitors and noble gas monitors are used for monitoring airborne radioactivity in the cells exhaust air and in the exhaust air of the containment before filters. Especially for the containment atmosphere, an additional tritium monitor is used. Releases of radioactivity into compartment air and contamination of the compartment air in the course of plant operation are monitored by this equipment. Airborne radioactivity monitoring serves for personnel protection and overall plant monitoring.

The CBVS low flow purge is described in Section 9.4.7.2. The CBVS monitoring system consists of three sets of detectors at measurement points R-7, R-8, and R-9, which measure gaseous activity in the ventilation system as shown in Figure 9.4.7-2 and Figure 11.5-1. Measurement points R-7 and R-8 are upstream of the filtration trains and point R-9 is downstream of the filtration trains.

The R-7 continuous effluent monitors consist of one noble gas, one iodine, and one aerosol monitors. Effluent grab sample provisions consist of one aerosol sample point. The R-8 continuous effluent monitors consist of one tritium monitor with a beta-sensitive detector and effluent grab sample provisions. The R-9 continuous effluent monitors consist of two noble gas monitors. This monitoring system provides local and control room indication and alarms. This system automatic actions are described in Table 11.5-1.

Measurement ranges of the CBVS monitoring system are shown in Table 11.5-1. The safety classification for the R-7 and R-8 instruments is non-safety. The safety classification for the R-9 instruments is non-safety, augmented quality. Built-in check sources are used to check the detector and instrumentation circuitry to eliminate the need for special containment entries for circuit checks.

11.5.3.1.5 Containment Building Ventilation System (CBVS) - Internal Filtration

The internal filtration subsystem limits the release of radioactive material by reducing radioactive iodine contamination inside the equipment compartment. The CBVS internal filtration is described in Section 9.4.7.2. The CBVS monitoring system consists of three detectors and sample station at measurement point R-10 shown in Figure 9.4.7-3 and Figure 11.5-1. The R-10 continuous process monitors consist of one noble gas, one iodine, and one aerosol monitors. This aerosol monitor is used for RCS leakage detection to satisfy TS 16.3.4.14. Grab sample provisions consist of one aerosol sample point. This monitoring system provides local and control room indication and alarms. This system does not initiate automatic actions.

Measurement ranges of the CBVS monitoring system are shown in Table 11.5-1. The safety classification for the R-10 instruments is non-safety, augmented quality. A built-in check source is used to check the detector and instrumentation circuitry to eliminate the need for special containment entries for circuit checks.

11.5.3.1.6 Nuclear Auxiliary Building Ventilation System (NABVS)

The system provides conditioned air to the Nuclear Auxiliary Building (NAB), Fuel Building (FB), Containment Building, and the annulus area between the Containment Building and the Shield Building. The exhaust air from the NAB, FB, Safeguard Building (SB), Containment Building, and the annulus is processed through the NABVS filtration trains prior to release to the environment via the vent stack. Consequently, monitoring the exhaust air from each of these buildings also takes place in the NABVS. The NABVS is described in Section 9.4.3.

The NABVS monitoring system consists of six measurement points, R-11, R-12, R-13, R-14, R-15, and R-16. R-11 (NAB cell 1), R-12 (NAB cell 2), and R-13 (NAB cell 3) are shown in Figure 9.4.3-3 and Figure 11.5-1. R-14 (hot workshop) and R-15 (laboratory) are shown in Figure 9.4.3-2. R-16 (laboratory exhaust from iodine filter train) is shown in Figure 9.4.3-5.

The R-11, R-12, and R-13 measurement points continuous process monitors each consist of one noble gas, one iodine, and one aerosol monitors. These three measurement points grab sample provisions consist of one aerosol sample point at each measurement point. This monitoring system provides local and control room indication and alarms. The monitors for each of these measurement points initiate an automatic control feature that diverts the ventilation air flow to the NABVS iodine filter train on high activity. This is a non-safety function. The R-14 and R-15 measurement points continuous process monitors each consist of one aerosol monitor. These two measurement points grab sample provisions consist of one aerosol sample point at each measurement point. This monitoring system provides local and control room indication and alarms. The monitors for these measurement points do not initiate automatic actions. The R-16 measurement point has no monitors and the grab sample provisions consist of one iodine and one aerosol sample points in the laboratory exhaust that has been processed through the iodine filter train as shown in Figure 9.4.3-5.

Figure 9.4.3-3 depicts how the various building ventilation systems are combined into the NABVS, filtered, and passed through the NABVS iodine filter trains as required and sent to the vent stack. In addition to measurement points R-11, R-12, and R-13 described above, measurement points R-17 and R-18 (Fuel Building ventilation system) and measurement point R-25 (Safeguard Building ventilation system) are shown at the interface between the ventilation systems. An unmonitored line at the bottom of the figure shows the Reactor Building exhaust. This is the Reactor Building full flow purge exhaust which only operates during Mode 5. Fuel will have been off-loaded and the Reactor Building may be open to the outside atmosphere, and no monitoring is required.

Measurement ranges of the NABVS monitoring system are shown in Table 11.5-1. The safety classification for the R-11, R-12, R-13, R-14, R-15, and R-16 are provided in Table 11.5-1. Portable check sources are used to check the detector and instrumentation circuitry.

11.5.3.1.7 Fuel Building Ventilation System (FBVS)

The FBVS is described in Section 9.4.2. The monitoring system consists of three measurement points, R-17, R-18, and R-19. R-17 (FB cell 4) and R-18 (FB cell 5) are shown in Figure 9.4.3-3. R-19 (FB fuel handling hall) is shown in Figure 9.4.2-1 and Figure 11.5-1.

The R-17 and R-18 measurement points continuous process monitors each consist of one noble gas, one iodine, and one aerosol monitors. These two measurement points grab sample provisions consist of one aerosol sample point at each measurement point. This monitoring system provides local and control room indication and alarms. The monitors for each of these measurement points initiate an automatic control feature that diverts the ventilation air flow to the NABVS iodine filter train on high activity. This is a non-safety function. The R-19 measurement point continuous process monitor consists of two noble gas monitors. This monitoring system provides local and control room indication and alarms. The monitors for this measurement point initiate an automatic control feature that isolates the fuel handling area ventilation on high activity in the exhaust.

Measurement ranges of the FBVS monitoring system are shown in Table 11.5-1. The safety classification for the R-17 and R-18 instruments is non-safety augmented quality. The safety classification for the R-19 instruments is non-safety, augmented quality. Portable check sources are used to check the detector and instrumentation circuitry.

11.5.3.1.8 Radioactive Waste Processing Building Ventilation System (RWPBVS)

The RWPBVS monitoring system consists of five measurement points, R-20, R-21, R-22, R-23, and R-24. R-20 (RWPB cell 2) and R-22 (RWPB cell 1) are shown in Figure 9.4.8-2. R-21 (room exhaust) is shown in Figure 9.4.8-2 and Figure 11.5-1. R-23 (decontamination room) and R-24 (mechanical workshop) are shown in Figure 9.4.8-1. See Section 9.4.8 for a complete discussion of the radioactive waste processing building ventilation.

The R-20 and R-22 measurement points continuous process monitors each consist of one iodine and one aerosol monitor upstream of the filters. These two measurement points grab sample provisions consist of one aerosol sample point at each measurement point. The R-21 measurement point grab sample provisions consist of 1 aerosol sample point downstream of the filters. The R-23 and R-24 measurement points grab sample provisions each consist of one aerosol sample point. This monitoring system provides local and control room indication and alarms. The monitors R-20 and R-22 initiate automatic actions as described in Table 11.5-1.

Measurement ranges of the RWPBVS monitoring system are shown in Table 11.5-1. The safety classification for the R-20 R-21, R-22, R-23, and R-24 instruments are provided in Table 11.5-1. Portable check sources are used to check the detector and instrumentation circuitry.

11.5.3.1.9 Safeguard Building Ventilation System (SBVS)

The SBVS, through its interconnections to the SBVSE and the nuclear auxiliary building ventilation system (NABVS), provides conditioned air for ventilation to the mechanical part of the SBs. The purpose of the SBVS monitoring system is to monitor and record the radioactivity levels of noble gases, iodines and aerosols in the SBVS exhaust and to divert air flow to the NABVS iodine filter train on high activity. The SBVS monitoring system consists of two measurement points, R-25 and R-26. R-25 (SB cell 6) is shown in Figure 9.4.3-3. R-26 (downstream of accident iodine filters) is shown in Figure 9.4.5-2.

The R-25 measurement point continuous process monitors consists of one noble gas, one iodine, and one aerosol monitors. This measurement point grab sample provisions consist of one aerosol sample point at the measurement point. The monitors for this measurement point initiate an automatic control feature that diverts the ventilation air flow to the NABVS iodine filter train on high activity. This is a non-safety function. The R-26 measurement point continuous effluent monitor consists of two noble gas monitors on the exhaust of the accident iodine filtration trains. This monitoring system provides local and control room indication and alarms. The monitors for this measurement point initiate an automatic control feature that diverts SBVS to the iodine filtration train.

Measurement ranges of the SBVS monitoring system are shown in Table 11.5-1. The safety classification for the R-25 and R-66 instruments is non-safety. The safety classification for the R-26 instruments is non-safety augmented quality. Portable check sources are used to check the detector and instrumentation circuitry of measurement points R-25 and R-26.

11.5.3.1.10 Annulus Ventilation System (AVS)

The AVS monitoring system consists of two measurement points, R-27 and R-28. Both of these points are on the exhaust of the iodine filtration trains from the annulus as shown in Figure 6.2.3-2.

The R-27 measurement point continuous effluent monitors consist of two noble gas monitors that are designed for post accident operation. The monitors for this measurement point do not initiate automatic actions. The R-28 measurement point grab sample consists of an iodine and aerosol sampling on the exhaust of the iodine filtration trains that are designed for post accident operation.

Measurement ranges of the AVS monitoring system are shown in Table 11.5-1. The safety classification for the R-27 instruments is non-safety augmented quality. The safety classification for the R-28 instruments is non-safety. Built-in check sources are used to check the detector and instrumentation circuitry of measurement point R-27.

11.5.3.1.11 Control Room Air Conditioning System (CRACS)

The main control room air conditioning system (CRACS) is designed to maintain a controlled environment in the control room envelope (CRE) area for the comfort and safety of control room personnel and to support operability of the control room components during normal operation, anticipated operational occurrences and design basis accidents. See Section 9.4.1 for a complete discussion. The purpose of the CRACS monitoring system is to monitor the air intakes for incoming radioactivity during accident conditions and then when the activity reaches the set-point, to isolate the MCR ventilation from the outside atmosphere, and initiate emergency habitability and supplemental filtration. The CRACS monitoring system consists of two measurement points, R-29 and R-30. R-29 and R-30 are shown in Figure 9.4.1-1.

The R-29 and R-30 measurement points continuous process monitors each consist of two radiation monitors. This monitoring system provides control room indication and alarms. The monitors for each of these measurement points initiate an automatic control feature that isolates MCR ventilation from the outside atmosphere and initiates emergency habitability and supplemental filtration. See Section 7.3.1.2.16 for details regarding the actuation of this automatic control feature.

Measurement ranges of the CRACS monitoring system are shown in Table 11.5-1. The safety classification for the R-29 and R-30 instruments is safety. Built-in check sources are used to check the detector and instrumentation circuitry.

11.5.3.1.12 Access Building Ventilation System (ABVS)

The access building ventilation system (ABVS) maintains room ambient conditions inside the Access Building to permit personnel access to the Nuclear Island (NI), and to control the concentration of airborne radioactive material in the controlled areas of the building during normal operation, including maintenance and refueling shutdowns, and during anticipated operational occurrences. The purpose of the ABVS monitoring system is to measure and record the radioactivity level in the exhaust of the ABVS system (see Section 9.4.14). The ABVS monitoring system consists of one measurement point, R-31 which is shown in Figure 9.4.14-2. The R-31 measurement point effluent grab sample provisions consist of one iodine and one aerosol sample point at the measurement point. The safety classification for the R-31 instruments is non-safety.

11.5.3.2 Liquid Effluents

The liquid effluent radioactive waste monitoring and sampling system measures the concentration of radioactive materials in liquids released to the environment. Liquid radionuclide concentration levels are designed to comply with 10 CFR Part 20 and dose requirements specified in 10 CFR Part 50. Liquid radioactive waste is discharged in batches from waste monitoring tanks. Prior to release of a liquid radioactive waste from a monitoring tank, the system obtains a representative sample and the sample is radiochemically analyzed. The ODCM (see Section 11.5.2) includes the following information for each location subject to routine liquid effluent sampling: (1) the sampling frequency, and (2) the analytical process and sensitivity for selected radioanalytical methods and types of sampling media. Results of this analysis are used in conjunction with dilution factor data to determine a release setpoint for the liquid waste monitoring system. Two continuously operating radiation sensors monitor the release line from the monitoring tanks. If a set limit is exceeded or if the monitoring system is inoperable, the release is automatically terminated. To terminate a release, one of the radiation sensors closes both isolation valves.

The liquid effluent radioactive waste monitoring system functional location is shown on Figure 11.2-1. Measurement ranges of the liquid radioactive waste monitoring system are shown in Table 11.5-1. The ODCM contains the plant's standard radiological effluent controls. This includes a description of how liquid effluent release rates are derived and parameters used in setting instrumentation alarm setpoints to control or terminate effluent releases in unrestricted areas that are above the effluent concentrations in Table 2 of Appendix B to 10 CFR Part 20. In addition, the ODCM describes how the guidance of NUREG-1301 (Reference 8) and NUREG-0133 (Reference 9) were used in developing the bases of alarm setpoints.

The liquid radwaste monitoring system consists of one measurement point, R-32 which is shown in Figure 11.2-1 and Figure 11.5-1. The R-32 measurement point continuous effluent monitors consists of two liquid monitors on the liquid radwaste release line. This monitoring system provides local and control room indication and alarms. The monitors for this measurement point initiate an automatic control feature to close two downstream isolation valves, close the upstream isolation valve, and shut down the operating recirculation and discharge pump(s). The safety classification for the R-32 instruments is non-safety augmented quality.

11.5.4 Process Monitoring and Sampling

Process radiation monitoring detects, at an early stage, the escape of radioactive materials from radioactivity-containing systems into systems that are normally free of activity. Process radiation monitors generally operate continuously and provide both local and control room indication and alarm. Certain systems automatically initiate isolation actions along with control room alarm upon the detection of high radiation levels. Information regarding subsystem checks, tests, and maintenance may be found in Section 7.1.1.5.5.

11.5.4.1 Main Steam Radiation Monitoring System

Radioactivity releases from the reactor coolant system (RCS) to the main steam system can occur because of steam generator tube leakage. Radioactivity (nitrogen-16, noble gases) in the main steam system is monitored over a wide power range by four redundant detectors per main steam line, for a total of 16 detectors for the system. These detectors are located at measuring points R-55, R-56, R-57, and R-58 as shown on Figure 10.3-1. The gamma sensitive detectors are mounted adjacent to the main steam lines within the main steam and feedwater valve compartments. The detectors are placed within specially designed lead shields that limit the angle of view to the steam line being monitored. Such an arrangement minimizes the contribution of scatter radiation as well as direct radiation emanating from the adjacent steam lines. The redundant measurement signals are processed, and provide alarm in the control room upon detection of radioactivity.

At both low and high power levels, the detected radiation emanating from the main steam lines is primarily due to the presence of N-16 (at a concentration of 4.5E-06 μCi/cc for full-power operation and the Technical Specification leakage rate of 150 gallons per day). The photon radiation from noble-gas decay is predominantly of low energy in comparison to the high-energy radiation emitted by N-16 and, as a result, undergoes significant attenuation in traversing the 1.9 inch steel wall of the main steam lines. Specifically, for the same N-16 and noble-gas concentration at the radiation monitor location, N-16 yields a radiation field at the detector which is about 50 times higher than that generated by the realistic noble-gas mix. The noble-gas concentration at the radiation monitor location is expected to range between 1.1E-06 μCi/cc at 10 percent power to 8.1E-07 μCi/cc at full power, based on the RCS realistic noble gas concentration of 2.0 μCi/gm (from Table 11.1-7—RCS and Secondary Coolant System Realistic Source Terms) and the Technical Specification limit of 150 gallons per day for primary-to-secondary leakage. The drop in the steam noble gas concentration with power level is due to the non-direct proportionality between steam volumetric flow and power level for the U.S. EPR design. Specifically, a 10-fold increase in the power level (from 10 to 100 percent) corresponds with a steam volumetric flow increase by a factor of 13.6.

Noble-gas radioactivity within the steam lines is relied upon for mitigation of a steam generator tube rupture accident (SGTR), after plant cooldown has already been initiated and the N-16 radiation field no longer exists. Following such an event, the noble-gas concentration at the MSL detectors of the affected steam generator would be sufficiently high to generate the needed post-accident signal for identification and automatic isolation of the affected SG.

The main steam radiation monitoring system is also used in conjunction with the condenser air removal and steam generator blowdown radiation monitoring systems to identify a steam generator tube leak. The main steam radiation monitoring system provides alarms and signals to the protection system for automatic isolation of an affected steam generator. This monitoring system provides control room indication and alarms. However, this is not the only required signal for the automatic control feature to actuate. With an actuated partial cooldown signal, either a high steam generator water level or high main steam activity will actuate the signal to isolate the affected steam generator. See Section 7.3.1.2.14 for additional information.

Measurement ranges of the main steam radiation monitoring system are shown in Table 11.5-1. The safety classification for the R-55, R-56, R-57, and R-58 instruments is safety. Built-in check sources are used to check the detector and instrumentation circuitry of measurement points R-55, R-56, R-57, and R-58.

Quantification of the primary-to-secondary leakage rate by the MSL radiation monitors is based on correlations which account for the following:

- Power-related transit time of the leaking fluid to the radiation monitor location (for decay correction of the N-16 concentration from the SG leakage point)
- Geometry-dependent factor for conversion of the N-16 activity concentration within the MSLs to the corresponding radiation field at the monitors
- Monitor-dependent calibration data.

A similar approach is used under equilibrium conditions, along with measured values of the leakage rate based on SG blowdown activity, to determine the alarm setpoint.

Plant procedures verify that the installed MSL radiation monitor system sensitivity is sufficient to satisfy the primary-to-secondary RCS leakage rate technical basis. Items related to the development of procurement specifications by a COL applicant for the related radiation monitoring instrumentation, and for its placement, shielding, and operational requirements are listed below.

Monitor Location and Source/Receptor Geometry

The monitoring system consists of four high-sensitivity gamma radiation detectors installed on each main steam line in the valve compartments adjoining the annulus, in relatively low radiation areas. The detectors are arranged around the section of main steam pipe between the annulus and SG isolation valve within the valve compartment. The MSL piping has an internal diameter of 27.5 inches and a wall thickness of 1.9 inches, and is insulated by a 4 inch mineral fiber.

The radiation detectors are arranged parallel to the pipe axis, but held at a fixed distance by a cradle arrangement. The detector heads are mounted within a lead housing with an open window towards the radiation source, as close as possible to the MSL. The housing lead thickness is suitable for attenuation of any extraneous radiation, including radiation emanating from the adjacent MSL. Direct shine from radiation emanating from within the reactor building is expected to affect each radiation monitor to the same degree, and can therefore be differentiated from radiation fields resulting from genuine leakage in any single steam generator.

Expected N-16 Concentrations and Radiation Fields at the Monitor Locations

At the Technical Specification limit of 150 gallons per day for primary-to-secondary leakage, the steam concentration of N-16 at the monitor locations is expected to vary between 1.7E-07 μCi/cc at 10 percent power and 4.5E-06 μCi/cc at full power, The corresponding radiation fields range between 0.14 and 3.6 μR/hr, respectively, at 4 inches from the pipe surface.

Monitor Instrumentation

To avoid spurious trip and failure, the four detectors on each steam line are linked in a two-out-of-four logic circuit.

11.5.4.2 Main Condenser Evacuation Radiation Monitoring System

Noncondensable gases (air and noble gases) in the secondary steam system are continuously removed during operation by the main condenser evacuation system (see Section 10.4.2). These gases discharge to the vent stack via a vent line. To monitor noble gas radioactivity, the monitoring system extracts part of the flow from the vent line (see Figure 10.4.2-2) and passes it through a measuring vessel with a beta-sensitive detector. If the monitoring system detects noble gas radioactivity in the secondary steam system, then it provides local and control room alarm. This alarm is an indication of breach of fuel cladding, primary coolant boundary, or containment leak. Table 11.5-1, Monitor R-3 shows the measurement ranges of the condenser air removal radiation monitoring system. This system does not initiate automatic actions.

11.5.4.3 Steam Generator Blowdown Radiation Monitoring System

The evaporation process within the steam generator results in the concentration of contaminants in the liquid phase. These contaminants include non-gaseous radioactive substances that have entered the secondary system from the RCS due to tube leakage in a steam generator.

Sampling lines extract blowdown water from the individual blowdown lines for chemical analysis. These lines are located ahead of the primary isolation valve within the reactor containment. Flow is continuously extracted from each of these lines and fed to gamma activity measurement equipment. This configuration allows each steam generator to be monitored separately and continuously for radioactivity carryover to the secondary side.

The steam generator blowdown radiation monitoring system provides an additional qualitative means to identify and verify a steam generator with a tube leak. These monitors may provide an indication from trending of a steam generator tube leak when the activity level is too low at the main steam line radiation monitors to develop a response from N-16 or noble gases.

The steam generator blowdown monitoring system consists of four measurement points, one on each blowdown line, R-46, R-47, R-48, and R-49. The R-46, R-47, R-48, and R-49 measurement points grab sample provisions consist of one liquid sample point at each measurement point. This monitoring system provides control room indication and alarms. This system does not solely initiate automatic actions. However, when a partial cooldown signal exists, a high activity signal from a steam generator blowdown radiation monitor will initiate an automatic control feature to isolate steam generator blowdown in the affected steam generator.

The steam generator blowdown radiation monitoring system functional location is shown on Figure 11.5-1. Measurement ranges of the steam generator radiation monitoring system are shown in Table 11.5-1. The safety classification for the R-46, R-47, R-48, and R-49 instruments is non-safety. Portable check sources are used to check the detector and instrumentation circuitry.

11.5.4.4 Component Cooling Water Radiation Monitoring System

The component cooling water system consists of a closed-loop system of coolers (heat exchangers) used to transfer heat from nuclear components to essential service water. The system consists of many subsystems, two of which are the general component cooling water radiation monitoring subsystem which cools the residual heat removal system and the high-pressure (HP) cooling water radiation monitoring subsystem. The HP cooling water radiation monitoring subsystem is described in Section 11.5.4.17. The general component cooling water radiation monitoring system functional location (including subsystems) is shown in Figure 11.5-1.

The general component cooling water radiation monitoring subsystem uses gamma-sensitive radiation detectors in each of its four separate safety-related trains to monitor the fluid for the escape of radioactivity from the various radioactivity-containing systems that make up the nuclear components served by the component cooling circuits. The general component cooling water radiation monitoring subsystem consists of four measurement points, R-35, R-36, R-37, and R-38, one for each train. The gamma-sensitive detectors are lead-shielded and are installed adjacent to the piping in this subsystem. This subsystem provides local and control room indication alarms in the event that component cooling water gamma radiation levels exceed the monitor setpoint. The monitors for this measurement point initiate an automatic control feature that isolates the CCWS train on high activity. The R-35, R-36, R-37, and R-38 measurement points grab sample monitor consists of one liquid grab sample point in each train.

Measurement ranges of the component cooling water radiation monitoring system are shown in Table 11.5-1. The safety classification for the R-35, R-36, R-37, and R-38 instruments is non-safety, augmented quality. Portable check sources are used to check the detector and instrumentation circuitry of measurement points R-35, R-36, R-37, and R-38.

11.5.4.5 Gaseous Waste Disposal Radiation Monitoring System

Gamma-sensitive radiation detectors continuously monitor the gaseous waste delay beds. A gamma-sensitive radiation detector is located upstream of the beds (R-1) and a beta-sensitive radiation detector is located downstream (R-2). The upstream monitor measures the gamma radiation emitted by the radionuclides entering the beds, and provides station personnel with an indication of the amount of radioactivity entering the beds. The downstream monitor is a beta-sensitive instrument, since krypton-85 generally forms the main constituent (about 95 percent) of the radioactive noble gases. The gaseous waste disposal radiation monitoring system provides control room and local indication only. This system initiates automatic actions to close discharge valves on high activity.

The radiation monitors in the gaseous waste processing system are shown on Figures 11.3-1 and 11.3-2. Measurement ranges of the gaseous waste disposal radiation monitoring system are shown in Table 11.5-1.

11.5.4.6 Nuclear Sampling System

The nuclear sampling and severe accident sampling monitoring system consists of one measurement point, R-41. R-41 measures the noble gas activity concentration in the gaseous volume flow subsequent to the degasifier for primary coolant of the Nuclear Sampling System as shown in Figure 9.3.2-1 and Figure 11.5-1.

The R-41 measurement point continuous process monitor consists of one noble gas monitor. This measurement point grab sample provisions consist of one liquid sample point at the measurement point. This monitoring system provides local and control room indication and alarms. The monitors for this measurement point do not initiate automatic actions.

Measurement ranges of the nuclear sampling and severe accident sampling monitoring system are shown in Table 11.5-1. The safety classification for the R-41 instrument is non-safety, augmented quality. Portable check sources are used to check the detector and instrumentation circuitry of measurement points R-41.

The severe accident sampling system is a separate system described in Section 9.3.2.2.1.3.

11.5.4.7 Chilled Water Supply for the Gaseous Waste Disposal Sampling System

The closed-loop chilled water system serves various components in the gaseous waste disposal system and the coolant degasification system. The radioactive sides of these operational components are separated from the chilled water system by means of both material and pressure barriers. The higher pressure on the non-contaminated side prevents radioactivity from escaping to the chilled water system except in the event of coincident failure of both of these barriers. The sampling point for extracting samples from this system for radiochemistry laboratory evaluation is provided in the return manifold of the chilled water system.

The chilled water supply monitoring system consists of one measurement point, R-61. The R-61 measurement point grab sample provisions consists one liquid sample point at the measurement point. The safety classification for the R-61 sample point is non-safety.

11.5.4.8 Radiation Monitoring System for RCS Leakage Detection

Containment atmosphere particulate radioactivity monitoring is one of the systems used in the U.S. EPR design for RCS leakage detection described in Section 5.2.5. The particulate radiation monitoring system continuously monitors airborne radioactivity in the containment equipment area. Radiation levels are indicated in the MCR. Alarms alert the operators of elevated levels of radioactivity to allow for prompt identification of RCS leakage into the equipment area. The monitor is located in the service area of the containment, which is accessible during normal operation. The system draws air from the containment building ventilation system which filters airborne radioactivity within the equipment area. The sampled flow is returned to the equipment area.

The particulate monitor is a low-range monitor capable of detecting 3E-10 to 1E-6 µCi/cc (Radiation Monitoring Point R-10 in Table 11.5-1). The monitor sensitivity requirement is to be able to detect a leakage increase of one gpm within one hour based on a realistic RCS source term (Table 11.1-7) consistent with RG 1.45 and RIS-2009-02 (Reference 11). Typical radionuclides of interest are as follows:

1-member decay chains:	Na-24	Y-93
	Te-129	
2-member decay chains:	Kr-88 / Rb-88	Ru-106 / Rh-106
	Xe-138 / Cs-138	Ba-140 / La-140

The stated dynamic response of the radiation monitor requires the continuous removal of airborne radioactivity from the containment building equipment area by the internal filtration system (KLA-5), as designed. The filtered-recirculation flow rate is equivalent to 0.5 air changes per hour.

The dynamic response of the monitor is relative to the pre-existing airborne activity and the associated background radiation level. The alarm setpoint will be established as a multiple of the background radiation (at least a factor of two). Therefore, the dynamic response is characterized as a multiple of the pre-existing activity.

Quantification of the leakage is based on correlations which predict the time-dependent buildup of radioactivity within the equipment area, making use of both the pre-existing concentration of airborne radioactivity therein and of the RCS radioactivity level at the onset of increased leakage. The leakage rate is quantified by correlating the measured airborne concentrations with analytical predictions. A similar approach is used under equilibrium conditions (with constant airborne radioactivity and radiation monitor reading) to determine the alarm setpoint.

A number of items impact the ability of the containment atmosphere particulate monitoring instrumentation and sampling system to detect and operate over the stated dynamic range. These items are listed below, along with clarifying comments:

- Representativeness of Chosen Sampling Location

  During normal operation (i.e., without containment purge), the equipment area atmosphere is conditioned by the normal ventilation system (KLA-6) with a mixing flow of 130,000 cfm. Airborne radioactivity is removed by the internal filtration system (KLA-5) at a flow rate of 4120 cfm through HEPA and charcoal filters. KLA-5 draws air from the upper portion of the area housing the Reactor Coolant Pump #3, and discharges it to the return duct of the compartment with the KLA-6 main supply fans.

  The particulate radiation monitoring system for RCS leakage detection within the equipment area is located in the service area of the containment (in Room UJA 29-022). The system draws air from the KLA-5 ventilation system just upstream of the filtration unit (also located therein), and discharges it back to the same airduct. The radionuclide concentration at the monitoring sampling location is the same as at the intake to KLA-5.

In view of the mixing provided by KLA-6, equivalent to 16.4 volumes per hour, the selected sampling location for RCS leakage detection is representative. Analysis has shown that the buildup of airborne concentrations at the monitor sampling location for the actual multi-compartment configuration of the equipment area will require no more than an additional five minutes to arrive at the concentration predicted by a single-compartment model with instantaneous mixing, no matter where within the equipment area the RCS leakage occurs. This five minute delay has been included in the required one hour response time for leakage identification.

- Need for Isokinetic Sampling

  The expected particle size, as well as the configuration of KLA-5 ductwork and installed particulate monitor can have an impact on obtaining a representative aerosol sample.

- Minimization of Sampling Line Losses and Associated Corrections

  The sample line losses can have an impact on obtaining a representative aerosol sample. These losses are minimized by optimizing air flow to verify high efficiency sampling and applying appropriate correction factors to account for sample line losses.

- Sample Collection Media

  The filter media retention properties have an impact on the collection and retention of specific radionuclides. This impact is addressed by applying appropriate correction factors to account for the specific properties of the filter media selected and the radionuclides of interest.

- Sample Collection System

  The sample collection system is a moving-filter type, where airborne particulate radioactivity is continuously drawn from the containment atmosphere and accumulated on a filter medium, and the emitted radiation is measured. Features that impact the monitor response for this type of collection system are sample flow rate and sample collection interval, as dictated by the detector view window and the speed of the traversing filter tape. These variables are adjusted as required to achieve a sufficient normal background reading (i.e., with minimal unidentified RCS leakage into containment) close to and above the monitor lower limit of detection (LLD), while at the same time minimize the filter roll replacement frequency and associated entries to the containment service area.

- Radiation Detection Methods and Detection Efficiencies

  The containment particulate monitor measures airborne particulate beta activity, with active gamma compensation (coincidence counting of beta/gamma radiation emitted by the same decaying radionuclide to reduce background radiation). The detector uses gross beta detection and as such does not identify airborne concentration for any specific radionuclide; radioanalytical and/or empirical correlations are, therefore, required to convert the measurements to RCS leakage. The monitor response is impacted by the source/receptor geometry and detection efficiencies for given isotopes. The range is selected to meet the technical specification requirements.

- Placement of Radiation Monitoring Instrumentation

  The radiation level in the area housing the monitoring instrumentation is less than 25 mrem/hr (refer to Figure 12.3-13—Reactor Building Cross-Section Radiation Zones). Shielding is used to minimize the interferences from ambient external radiation levels, including shine from the potential accumulation of radioactivity on the KLA-5 filtration system.

RCS leakage quantification can also be based on the detection of activation products, such as F-18, which is generated by the O^{18} (proton, neutron) F^{18} reaction as the RCS coolant passes through the core. This particular isotope is of particular interest for RCS leakage detection because it is not a fission product (and, therefore, not dependent on fuel clad defects), has a reasonable half life (about 110 min), decays by positron emission (followed by annihilation radiation, which is readily detectable), and combines with lithium in the water to form LiF (a particulate). It is not addressed in the U.S. EPR design for RCS leakage detection due to the unavailability of analytical values for its equilibrium concentration within the RCS as LiF, and the loss mechanisms it is subjected to when released to the containment atmosphere as a result of leakage.

11.5.4.9 Essential Service Water System

The essential service water system (ESWS) is designed to remove heat from plant components. This is accomplished by providing cooling water from the essential service water (ESW) cooling tower basins to the component cooling water system (CCWS) heat exchangers (HX), emergency diesel generator (EDG) HXs, and ESW pump room coolers. The interface between the ESWS and CCWS is monitored for cross-contamination by monitoring points R-66 through R-70.

11.5.4.10 Fuel Pool Purification System

The fuel pool purification monitoring system consists of one measurement point, R-39. The R-39 measurement point grab sample provisions consists of one liquid sample point at the measurement point. The safety classification for the R-39 sample point is non-safety.

11.5.4.11 Nuclear Island Vent and Drain System

The Nuclear Island vent and drain monitoring system consists of two measurement points, R-40 and R-44. The R-40 and R-44 measurement points grab sample provisions consist of one liquid sample point at each measurement point. The safety classification for the R-40 and R-44 sample points is non-safety.

11.5.4.12 Laundry Handling Room and Decontamination System

The laundry and decontamination monitoring system consists of one measurement point, R-42. R-42 measures the radioactive contamination on clothing. Although an onsite laundry facility is not in the U.S. EPR design, the monitor may be used to spot check laundry from an offsite facility to verify the cleanliness of the protective clothing. This monitor is also suitable to measure the contamination of the clothes before washing to divide the clothes into very high, high, and low contamination categories for selection of individual washing programs at the offsite facility.

The R-42 measurement point process monitor consists of one protective clothing monitor. This measurement point grab sample provision consists of one liquid sample point of the decontamination waste at the measurement point. The monitors for this measurement point do not initiate automatic actions.

The safety classification for the R-42 instrument is non-safety. Portable check sources are used to check the detector and instrumentation circuitry of measurement points R-42.

11.5.4.13 Solid Radwaste System

The radiation monitoring of waste packages will be performed in the drum measuring station. The solid radwaste monitoring equipment, R-43, is comprised of seven dose rate monitors, one gamma spectroscopy system with a multi-channel analyzer, and drum identification, weighing, rotation, registration and archiving-equipment. R-43 is shown in Figure 11.4-1. The dose rate is measured at several positions while the drum is turning. The background dose rate level is measured at a representative position close to the drum measuring equipment. Simultaneously, the activity of gamma emitting nuclides will be detected and measured. A liquid grab sample may be drawn from the drum and analyzed in the laboratory.

Measurement ranges of the solid radwaste monitoring system are shown in Table 11.5-1. The safety classification for the R-43 instruments is non-safety. Portable check sources are used to check the detector and instrumentation circuitry.

11.5.4.14 Reactor Boron and Water Makeup System

The reactor boron and water makeup monitoring system consists of one measurement point, R-45. The R-45 measurement point grab sample provision consists of one liquid sample point at the measurement point. The safety classification for the R-45 sample point is non-safety.

11.5.4.15 Turbine Building Drains and Vents System

The Turbine Building drains and vents monitoring system consists of one measurement point, R-50 on the common release line as shown in Figure 11.5-1. The task for this measurement point is to monitor the liquid effluent from the Plant Drainage System before it is discharged to the retention pond.

The R-50 measurement point continuous effluent monitor consists of one liquid monitor. This measurement point effluent grab sample provisions consist of one liquid sample point at the measurement point. This monitoring system provides local and control room indication and alarms. The monitor for this measurement point does not initiate automatic actions.

The safety classification for the R-50 instrument is non-safety. Portable check sources are used to check the detector and instrumentation circuitry of measurement points R-50.

11.5.4.16 Clean Drains System

The clean drains monitoring system consists of one sampling point, R-65. The clean drains are collected and routed to the main condenser. The safety classification for the R-65 sample point is non-safety.

11.5.4.17 Chemical and Volume Control System (CVCS) High Pressure Coolers

The component cooling water system consists of a closed-loop system of coolers (heat exchangers) used to transfer heat from nuclear components to essential service water. The system consists of many subsystems, two of which are the general component cooling water radiation monitoring subsystem which cools the residual heat removal system and the high-pressure (HP) cooling water radiation monitoring subsystem. The general component cooling water radiation monitoring subsystem is described in Section 11.5.4.4.

The HP cooling water radiation monitoring subsystem consists of five measurement points, R-51, R-52, R-53, R-54, and R-64. The R-51 and R-52 monitoring points are on the CCWS inlet and outlet of CVCS HP cooler 1 as shown on Figure 9.2.2-2. The R-53 and R-54 monitoring points are on the CCWS inlet and outlet of CVCS HP cooler 2 as shown on Figure 9.2.2-3. The R-64 monitoring point is downstream of the severe accident heat removal system heat exchangers. The gamma-sensitive detectors are lead-shielded and are installed adjacent to the piping in this subsystem. This subsystem provides local and control room alarms in the event that component cooling water gamma radiation levels exceed the monitor setpoint. The monitors for this measurement point initiate an automatic control feature that isolates the CCWS train on high activity.

Measurement ranges of the component cooling water radiation monitoring system are shown in Table 11.5-1. The safety classification for the R-51, R-52, R-53, and R-54 instruments is non-safety, augmented quality. The safety classification for the R-64 instrument is non-safety. Built-in check sources are used to check the detector and instrumentation circuitry of measurement points R-51, R-52, R-53, R-54, and R-64.

11.5.4.18 Safety Chilled Water System

The safety chilled water system (SCWS) supplies refrigerated chilled water to the safety-related heating, ventilation and air conditioning (HVAC) systems and the low head safety injection system (LHSI) pumps and motors in Safeguard Buildings (SB) 1 and 4 and the fuel building ventilation system (FBVS). See Section 9.2.8 for a complete discussion. The purpose for radiation monitoring is to detect leakage of radioactive fluid from the reactor coolant side of the LHSI heat exchanger to the safety chilled water side and to alert the operator that a leak exists.

The safety chilled water monitoring system consists of two measurement points, R-59 and R-60 downstream of the LHSI sealing fluid cooler as shown in Figure 9.2.8-1 and Figure 11.5-1. The task for this measurement point is to monitor the residual heat removal heat exchanger for leakage.

The R-59 and R-60 measurement point continuous process monitor consists of one liquid monitor. This measurement point grab sample provision consists of one liquid sample point at the measurement point. This monitoring system provides local and control room indication and alarms. The monitor for this measurement point does not initiate automatic actions.

The safety classification for the R-59 and R-60 instruments is non-safety. Portable check sources are used to check the detector and instrumentation circuitry of measurement points R-59 and R-60.

11.5.5 References

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