11.0 WASTE PROCESSING AND RADIATION PROTECTION

11.1 WASTE PROCESSING

11.1.1 DESIGN BASIS

The waste processing systems are designed to provide controlled handling and disposal of radioactive liquid, gaseous and solid wastes from both units. Design criteria were established to maintain the release of radioactive material from the plant to the environment at levels which are as low as reasonably achievable (ALARA).

The design of the waste processing systems was based upon processing reactor coolant and miscellaneous waste during operation with 1% failed fuel. The annual radioactive waste releases for this design were shown to meet the dose guidelines of 10 CFR Part 50, Appendix I.

All releases meet the Offsite Dose Calculation Manual (ODCM) limits. By meeting the ODCM limits, the guidelines of 10 CFR Part 50, Appendix I will be met. This is confirmed by the effluent data and doses reported to the Nuclear Regulatory Commission (NRC) in the Radioactive Effluent Release Reports required by the Technical Specifications and 10 CFR 50.36a.

The ODCM is a program governed by requirements described in Technical Specifications. It provides limits for offsite radioactive waste releases, calculational methods to determine those releases, and alternative methods of accounting for and controlling release of radioactive materials. In the event that the radiation monitors described in this chapter for use in the release of liquid and gaseous radioactive material are not available for use, the alternative methods described in the ODCM may be used.

11.1.2 WASTE PROCESSING SYSTEMS

The waste processing systems include the Reactor Coolant Waste Processing System (RCWPS), the Miscellaneous Waste Processing System (MWPS), the Waste Gas Processing System (WGPS) and the Solid Waste Processing System (SWPS). Information on the design and fabrication of the components of these systems is listed in Table 11-1. Radwaste systems seismic requirements are provided in Section 5A.2.1.2.

11.1.2.1 Liquid Waste Processing Systems

11.1.2.1.1 Design Bases

Liquid waste is processed by two systems: the RCWPS and the MWPS. The RCWPS is designed to process reactor coolant concurrent with the letdown flow from the Chemical and Volume Control System (CVCS). The MWPS processes waste from miscellaneous sources. These liquid waste systems are designed to provide adequate dilution through a variable release rate of waste from the designated tanks to the circulating water discharge conduits of either or both units.

The design performance requirements for the liquid waste processing systems were established by examining seafood consumption routes to determine limiting discharge concentrations. Liquid effluent is controlled such that the increases in boron concentration of the circulating water are minimized. Sampling and release of liquid wastes were designed to be accomplished on a batch basis rather than on a continuous basis in order to provide for increased control over effluent discharge.

On order to determine the sizing of waste processing components, the preoperational design for the RCWPS assumed that 14 system volumes of reactor coolant per unit would be processed annually. Operating experience has shown, however, that the amount of reactor coolant typically processed during a year is higher. At any one time, the waste receiver tanks and waste monitor tanks can accommodate six system volumes of reactor coolant.

For the preoperational design estimate, annual average limiting concentrations in the discharge conduits were calculated for each isotope expected to be discharged in the liquid effluents from Calvert Cliffs. These limiting concentrations were calculated based on 1% of the concentrations in 10 CFR Part 20, Appendix B, Table II, Column 2. The intake factors were taken from Oak Ridge National Laboratory ORNL 3721, Supplement 3.

The concentration factors used were taken from the "recommended values" in Table 1 of NUS Report TM-S-121, entitled Concentration Factors of Chemical Elements in Aquatic Organisms in the Chesapeake Bay, May, 1971. For elements not listed in this report, concentration factors were obtained from Lawrence Radiation Laboratory Report UCRL-50564, entitled Concentration Factors of Chemical Elements in Edible Aquatic Organisms, December 30, 1968. The intake and concentration factors presently used to evaluate dose commitment to members of the public from radioactive materials in liquid effluents are given in the ODCM. Preoperational design estimates of expected annual average concentrations from all liquid releases from Calvert Cliffs are listed for each isotope in Table 11-2.

The thyroid dose due to the ingestion of seafood assumed to be grown in the discharge conduits is shown in Table 11-3. This is based on an estimated total discharge of 3.73 curies in the liquid effluents from the plant. It is concluded, therefore, that expected liquid releases will be below the dose objectives listed in the ODCM, considering the seafood ingestion pathway of exposure. The Radioactive Effluent Release Reports confirm that the doses to the maximum exposed individual from ingestion of seafood assumed to be grown in the discharge conduits are indeed within 10 CFR Part 50, Appendix I guidelines.

11.1.2.1.2 Reactor Coolant Waste Processing System

The RCWPS is designed to provide controlled handling and disposal of radioactive liquid wastes from both reactor plants. The system is designed to provide temporary storage for reactor coolant wastes (RCWs) and to process the liquid wastes prior to disposal. This allows the release of radioactive material to the environment to be maintained ALARA, and the concentration of the effluent maintained below the limits set forth in the ODCM.

The RCWPS is shown on Figure 11-1.

The RCWPS consists of two reactor coolant drain tanks (RCDTs), three cartridge filters, two degasifiers, four RCW ion exchangers, two RCW receiver tanks, two evaporators (Retired in place), two RCW monitoring tanks and various system pumps. A provision has been made to process RCW using a radioactive waste processing skid. All system tie-in piping for the skid is designed and built to the original construction code and meets the intent of Regulatory Guide 1.143, Revision 1. The system is designed to simultaneously process reactor coolant and CVCS letdown flow from both Unit 1 and Unit 2.

The RCW liquid is initially stored in one of two RCW receiver tanks. The RCW receiver tanks receive waste liquid from the volume control tank letdown inlet diversion, the RCDTs, and the waste gas surge and decay tanks.

Reactor coolant is diverted to the RCWPS via the CVCS when changes in the Reactor Coolant System (RCS) inventory or boron concentration are necessitated by startups, shutdowns, fuel depletion, or draining of the RCS for maintenance. Any condition which causes a high level signal in the volume control tank of the Unit 1 or Unit 2 CVCS will direct flow to the RCWPS. The flow is directed to the in-service RCW receiver tank via a cartridge filter, degasifiers, and two reactor coolant ion exchangers. The ion exchangers may be bypassed when conditions permit.

Radioactive liquid waste is also diverted to the RCWPS via the RCDTs. The RCDTs are located in the Unit 1 (RCDT 11) and Unit 2 (RCDT 21) Containment Buildings, and receive drains from several sources in the Containment. A high level signal from the RCDT alerts the operator that the collected liquid waste must be pumped to the RCW receiver tank. To preclude any unnecessary alarm conditions, the operator, at his discretion, may pump down the drain tanks at any time.

Condensate from the waste gas system surge and decay tanks is drained to the reactor coolant liquid waste degasifiers. The condensate is then pumped to the RCW receiver tanks.

Waste liquid that is sent to the RCWPS enters through a cartridge filter so that insoluble corrosion products are removed. If the filter becomes plugged, a high differential pressure alarm is actuated on a local control panel. From the filter, the liquid waste enters a degasifier which removes hydrogen, nitrogen, and fission gases and diverts them to the waste gas system's surge tank. When the liquid level in the degasifier reaches the high setpoint, the degasifier pump starts automatically to pump the liquid waste to the ion exchangers. The pump stops when the waste level is sufficiently reduced, and the process of filling the degasifier starts again. The degasifier pump continues to operate in a cyclic manner until the liquid level in the degasifier is stabilized or until the operator stops the evolution.

Reactor coolant and miscellaneous waste [except for the miscellaneous waste monitor tank (MWMT)] streams are combined and processed through the liquid radioactive waste skid.

When requested, the in-service RCW receiver tank is isolated and the other waste receiver tank is placed in service. Liquid waste is processed through the liquid radioactive waste skid and stored in a reactor coolant waste monitoring tank. Once sampled and permitted, the waste is discharged.

If the activity level in the monitor tank is within station and regulatory limits, a waste discharge permit is prepared. The liquid from the monitor tank is normally pumped by the monitor tank pump through a flow element to the liquid waste proportional composite sampler. The flow is monitored on the associated flow indicator while throttling the discharge valve to achieve the flow rate specified by the discharge permit. The liquid then passes through a radiation monitor that continually measures the liquid's activity. If excessive radioactivity is detected, an alarm is actuated and the two air-operated liquid waste discharge isolation valves shut to stop the discharge flow. If the liquid is acceptable for discharge, it is mixed with water from the circulating water system and discharged into the Chesapeake Bay. This discharge liquid can be directed to the discharge conduits of either unit using approved plant procedures with appropriate administrative approvals.

The discharge permit will specify required controls such that the concentration of the radioactive material will be within the liquid effluent concentration limits as described in the ODCM.

A condition that results in an alarm from the liquid waste discharge radiation monitor will automatically shut the two discharge isolation valves to stop the flow of liquid to the discharge conduit(s). Should this condition occur, the radiation monitor must be flushed to the MWPS until the alarm clears. The contents of the monitor tank can then be sampled and the results evaluated in order to determine if the liquid requires further processing, and to determine the source of the radiation monitor alarm.

The liquid waste discharge radiation monitor setpoint is established so that the concentration of radioactive material released to unrestricted areas in liquid effluents does not exceed the limits of the ODCM. The setpoint is established as described in the ODCM.

The liquid waste batch in process is required to be isolated from the time the tank is placed in a recirculation mode in preparation for sampling until the discharge is terminated. If any additions have been made to the tank, the contents will be resampled prior to any discharge to the circulating water system.

11.1.2.1.3 Miscellaneous Waste Processing System

The MWPS is designed to provide controlled handling and disposal of various liquid wastes from both reactor plants, as shown in Table 11-4. The system is designed to provide temporary storage for these liquid wastes, and to process the wastes prior to their disposal. The release of radioactive material to the environment is then maintained ALARA, and the concentration of the effluent is below the limits set forth in the ODCM.

The MWPS is shown on Figure 11-2.

The MWPS consists of two tanks, one duplex filter housing, one ion exchanger, and various pumps, strainers and instruments. Connections are installed to provide portable filtration between the Solid Waste Processing System and the MWPS. The MWPS evaporator and the MWPS heat exchanger are Retired in place. The system receives liquid waste from these major sources: Auxiliary Building gravity drains, soapy drains, Materials Processing Facility (MPF) laundry, and containment normal sump and pumped sumps. The MWPS also collects the process liquid wastes from the Solid Waste Processing System, Service Water (SRW) System, Component Cooling System, Blowdown Recovery System, Refueling Water Tanks, Refueling Water Tank Room sump pump, and the SFP.

The primary system interface for the MWPS is with the RCWPS. The portions of the RCWPS utilized by MWPS include the RCW receiver and monitor tanks and the reactor coolant ion exchangers. Flow from the discharge of the RCWPS joins the discharge from the MWPS and goes to the circulating water system. Another system interface is the SWPS. The SWPS receives the spent resin from the miscellaneous waste ion exchanger (MWIE) and the cleansing flush from the MWIE wye strainer.

The MWPS heat exchanger is retired in place, but should it be called into service, its cooling water is supplied by the Component Cooling System. The ion exchanger is serviced by the demineralized water system and the nitrogen system during the process of resin discharge and resin fill.

Miscellaneous liquid waste is collected in the miscellaneous waste receiver tank (MWRT) and the MWMT. All miscellaneous liquid waste is directed to the MWRT, except for hot laboratory and soapy drains which are normally directed to the MWMT. The system is designed to process over a million gallons of miscellaneous waste annually.

The liquid from the MWRT may be pumped through the miscellaneous waste filter, which removes suspended solids from the fluid. The MWIE may be used to lower the activity in the liquid. A wye-type strainer retains any resin beads that might become dislodged from the resin bed. The liquid then flows to the RCWPS.

If activity levels are acceptable, the liquid from the MWMT is pumped to join the discharge flow path of the RCWPS monitor tank pump upstream of the discharge flow element and radioactivity monitor, as shown on Figure 11-2. If activity levels are not acceptable, the liquid is processed via filtration, ion exchanger, or both, or the water is sent to one of the RCW monitor tanks prior to release.

11.1.2.1.4 Liquid Waste Releases

Liquid waste releases consist of RCW processing, miscellaneous waste processing, and a few other system effluents. Radioactivity released via the liquid pathway is measured and maintained within the ODCM limits and is reported to the NRC in the Radioactive Effluent Release Reports. The dose consequences of these releases are determined using the methodology in the ODCM.

<u>Reactor Coolant Waste Processing System Effluents</u>

The RCWPS was originally sized to process 14 RCS volumes. The system was designed to provide maximum flexibility in processing, consequently, larger volumes of liquid radioactive waste with lower radioactivity levels can be processed. In addition, the concentrations of radioisotopes in the reactor coolant are normally lower than the preoperational design estimates due to less failed fuel than originally assumed.

Table 11-4 shows the systems which contribute to the generation of RCWPS waste. Table 11-5 shows the preoperational design estimates for the equilibrium concentration of radioisotopes in the reactor coolant prior to any processing and the associated annual activity discharged after processing through the RCWPS. These values were based upon 1% failed fuel in each reactor, the recycle of boric acid and processed reactor coolant, and conservative decontamination factors for filters, demineralizers, and degasifiers.

Miscellaneous Waste Processing System Effluents

The sources of miscellaneous wastes processed by the MWPS are shown in Table 11-4. Table 11-6 shows the preoperational design estimates for the annual isotopic discharges after processing waste through the MWPS. The average specific activity value for the RCDT was assumed to be equal to the reactor coolant activity. The remaining miscellaneous liquid was assumed to have a specific activity equal to 1% of the reactor coolant values. Steam generator blowdown specific activity was calculated based on 1% failed fuel, 50 gallons/day per steam generator tube leakage, and 0.5 gallons/minute per steam generator blowdown. The calculation of specific activity of the liquid entering the MWPS from the blowdown tank drain includes radioactive decay in the steam generators. The noble gases contained in this liquid are assumed to be released via the gaseous pathways and are included in the calculated total gaseous releases. Conservative decontamination factors were used for estimating purposes.

Other Liquid Effluents

Steam generator blowdown can be recycled by use of the steam generator blowdown recovery system. However, if the analysis of the samples taken from the steam generators indicates that gross activity is within limits, blowdown can be sent to the blowdown tank which can be discharged directly to the circulating water discharge conduits. A radiation monitor is installed in the line from the blowdown tank to the discharge conduit which would alarm on high activity and automatically shut the discharge valve which causes the flow to be routed to the MWPS. This feature provides a backup to the analysis and also terminates the discharge if the gross activity of the steam generator increases above the level allowable for direct discharge during the blowdown.

Additionally, it is expected that there will be leaks in the secondary systems. If there is any iodine or particulate activity in the steam generator, some slight quantities of activity will be carried over and be released by the leaks to the Turbine Building. Most of this activity will remain in the liquid phase and be released via the Turbine Building drains. The preoperational design estimates for the total annual release from the Turbine Building drains are shown in Table 11-7. The drain sumps are sampled in accordance with the ODCM.

The yard oil interceptor is not normally a contaminated system; however, it could potentially become contaminated through cross-over contamination from the Turbine Building drains. The existing set of acceptance criteria found in the ODCM is used to establish the allowed contamination levels in the yard oil interceptor.

For Unit 1 only, the tendon access gallery sumps are operated as a potentially radiologically contaminated system. The existing set of acceptance criteria found in the ODCM is used to establish the allowed contamination levels in the tendon access gallery sumps.

Total Liquid Effluents

Liquid effluents containing, or potentially containing, radioactivity can be released from the plant to unrestricted areas through the following pathways:

a. RCWPS
b. MWPS
c. Low activity steam generator blowdown
d. Turbine Building drains

Table 11-8 lists the preoperational design estimates of annual discharges from the RCWPS, MWPS, steam generator blowdown, and Turbine Building drains. This table lists estimated releases from normal release pathways. Other potential release pathways are sampled according to approved plant procedures. Occasional releases from abnormal pathways are quantified and recorded. All releases, including these occasional releases, are maintained within the ODCM limits.

The Liquid Radwaste Processing System will be used to reduce the radioactive materials in liquid wastes prior to their discharge when the calculated doses due to the liquid effluent released to unrestricted areas exceeds limits specified in the ODCM. The dose limits apply to the combined effluent of Units 1 and 2. This requirement provides assurance that the releases of radioactive materials in liquids will be kept ALARA by implementing the requirements of 10 CFR 50.36a, 10 CFR Part 50, Appendix A, General Design Criteria 60 and the design objectives given in 10 CFR Part 50, Appendix I, Section II.D.

Liquid Effluent Concentration Limits

The ODCM limits on liquid effluent concentration are provided to ensure that the concentration of radioactive materials released in liquid waste effluents to unrestricted areas will be less than the concentration levels specified in 10 CFR Part 20, Appendix B, Table II, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water in unrestricted areas will result in (1) exposures to a member of the public within the design objectives of 10 CFR Part 50, Appendix I, Section II.A, and (2) exposures to the population within the limits of 10 CFR 20.1301.

Liquid Effluent Dose Limits

The ODCM liquid effluent dose limits are provided to implement the requirements of 10 CFR Part 50, Appendix I, Sections II.A, III.A and IV.A. These limits assure that the releases of radioactive material in liquid effluents to unrestricted areas will be kept ALARA, and at the same time providing the required operational flexibility. The actual effluents are provided in the Radioactive Effluent Release Report. The dose calculation methodology and parameters in the ODCM implement the requirements in Appendix I, Section III.A that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a member of the public through appropriate pathways is unlikely to be substantially underestimated.

The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977; Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977; and NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants."

11.1.2.2 Gaseous Waste Processing System

11.1.2.2.1 Design Bases

The WGPS is designed to store the gases removed from liquid waste to allow radioactive decay of the short-lived isotopes before the gases are released from the plant. During normal operation, there is sufficient waste gas decay tank capacity to allow for adequate decay of the noble gases contained in the gases vented from the reactor coolant.

11.1.2.2.2 Waste Gas Processing System

The WGPS is designed to provide controlled handling and disposal of radioactive gaseous wastes from both reactor plants. The system is designed to store the gases removed from liquid waste and other sources to allow radioactive decay of the short-lived isotopes before the gases are released from the plant. The WGPS is shown on Figure 11-2.

The WGPS consists of a surge tank, two compressors, three waste gas decay tanks, and a high efficiency particulate air (HEPA) filter. The WGPS collects, stores, and disposes of gaseous waste from the degasifiers, pressurizer quench tanks, RCDTs, the volume control tanks, and other miscellaneous hydrogenated sources. The gaseous waste is a mixture of hydrogen, nitrogen, water vapor, ammonia, and isotopes of xenon and krypton. The principal gas released from the coolant is hydrogen; radioactive fission products, activated dissolved gases, etc., contribute a small fraction to the total volume of liberated gases.

Waste gases are collected in three headers. One header collects radioactive gases from the RCDTs and the pressurizer quench tanks and discharges to the waste gas surge tank. A second header collects radioactive gases from Auxiliary Building sources, including the RCWPS degasifiers and evaporators and directs them to the waste gas surge tank. The third header collects other vents and relief valve discharges and connects to the gas release header upstream of the gas discharge radiation monitor. The waste gas surge tank stores the waste gas and provides a suction reservoir for the waste gas compressors. A relief valve that relieves to the plant vent upstream of the radiation monitor protects the surge tank from overpressurization. When the gas pressure in the surge tank increases to above a certain setpoint, a waste gas compressor will start and pump the gas to one of the three waste gas decay tanks where the gas is stored at a pressure not to exceed the design pressure of 150 psig. Relief valves on each decay tank discharge to the waste gas surge tank prevent the uncontrolled release of gases to the atmosphere in the event of overpressurization of the decay tanks. Rupture disks are installed upstream of each decay tank relief valve to facilitate relief valve maintenance. The decay tank is sampled, and when the activity level has decayed to an acceptable level, the contents are discharged by permit at a controlled rate, through the release header, to the plant vent. A relief valve that relieves to the surge tank protects the release header from overpressurization. The rate of release is controlled by throttling a valve. The release header contains an absolute filter, a radiation monitor, and redundant, automatic discharge isolation valves. A high radiation monitor alarm, which is annunciated in the Control Room, automatically shuts the isolation valves.

Refer to Figures 9-20A, 9-20B, and 9-21 for the plant ventilation system and to Figure 11-4 for locations of the radiation monitoring device in the main plant vent. Ventilation flow rates are shown in Table 9-18. All major subsystems exhaust into the main plant vent through a common header. An automatic damper installed in the fresh air duct leading into the main exhaust plenum will maintain a constant flow into the main exhaust plenum, even though some of the subsystems are not in operation; and thus, the flow rate from the plant vent remains approximately constant. Other inflows to the plant vent, such as the waste gas system, the condenser vacuum pump discharge and the vent from the containment gaseous monitor contribute negligible flow when compared to the ventilation flow rate.

11.1.2.2.3 Gaseous Waste Releases

Waste Gas Processing System Effluents

The WGPS is sized to allow for adequate decay prior to release of the gaseous isotopes contained in the RCS from each unit and other miscellaneous sources of gaseous wastes. Table 11-4 shows the sources of these gaseous wastes. Table 11-9 shows the preoperational design estimates for annual isotopic releases from the WGPS.

Other Gaseous Effluents

There are other potential sources of gaseous releases from the plant which are not collected in the WGPS for holdup. If leaks occur in systems containing reactor coolant, radioactive gases could be released as a result of purging the Containment Structures, from the Condenser Air Removal Systems, Turbine Building ventilation systems and aerated tank vents. All of these potential sources except the Turbine Building ventilation are released through the plant vent.

Table 11-9 shows the preoperational design estimates for isotopic discharge from these sources. In order to estimate these releases, assumptions were made for failed fuel, volume of liquid waste processed, steam generator tube leakage, reactor coolant leakage to the containment, containment filtration and containment purging.

Total Gaseous Effluents

Gaseous effluents containing, or potentially containing, radioactivity can be released from the plant to unrestricted areas through the following pathways:

a. WGPS
b. Containment Structure purge
c. Auxiliary Building ventilation
d. Condenser air removal system and gland seal exhauster
e. Aerated tank vents
f. Turbine Building ventilation

Table 11-8 lists the preoperational design estimates of annual discharges from these pathways. This table lists normal release pathways. Other potential release pathways are sampled according to approved plant procedures. Occasional releases from abnormal pathways are quantified and recorded. All releases, including these occasional releases, are maintained within ODCM limits.

The Gaseous Radwaste Processing System will be used to reduce the radioactive materials in gaseous wastes prior to their discharge whenever a suitable fraction of the dose design objectives set forth in 10 CFR Part 50, Appendix I, Sections II.B and II.C are reached. The dose limits apply to the combined effluent of Units 1 and 2. This requirement provides assurance that the releases of radioactive materials in gaseous effluents will be kept ALARA by implementing the requirements of 10 CFR 50.36a, 10 CFR Part 50, Appendix A, General Design Criteria 60 and the design objectives given in 10 CFR Part 50, Appendix I, Section II.D.

Gaseous Effluent Dose Rate

The ODCM limits on gaseous effluent dose rate is provided to ensure that the dose at any time at and beyond the site boundary from gaseous effluents will be within the annual dose limits of 10 CFR Part 20 for unrestricted areas. The annual dose limits are the doses associated with the concentrations of 10 CFR Part 20, Appendix B, Table II, Column 1. These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a member of the public in an unrestricted area, exceeding the limits specified in 10 CFR Part 20, Appendix B, Table II (10 CFR 20.1301). For members of the public who may at times be within the site boundary, the amount of time that they are expected to remain at the site will be

sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the site boundary.

Gaseous Effluent Dose Limitations

The ODCM limits on gaseous effluent dose are provided to implement the requirements of 10 CFR Part 50, Appendix I, Sections II.B (for noble gases), II.C (for Iodine-131 and radionuclides in particulate form), III.A and IV.A. These limits will ensure that the releases of radioactive material in gaseous effluents to unrestricted areas will be kept ALARA, and at the same time provide the required operational flexibility. The ODCM surveillance requirements implement the requirements in Appendix I, Section III.A that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a member of the public through appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology and parameters established in the ODCM for calculating the doses due to the actual release rates of radioactive matter in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977; Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Reactors," Revision 1, July 1977; and NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants." The ODCM equations for determining the air doses at and beyond the site boundary are based upon the historical annual average atmospheric conditions.

The release rate limits for Iodine-131 and radionuclides in particulate form with half-lives greater than 8 days are dependent upon the existing radionuclide pathways to man, in the areas at and beyond the site boundary. The pathways that were examined in the development of these calculations were: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

11.1.2.3 Solid Waste Processing System

11.1.2.3.1 Design Bases

Solid waste is to be packaged so as to meet the applicable requirements of 10 CFR Parts 61 and 71 and 49 CFR for burial and transportation. The SWPS provides the capability for preparing solid waste for shipment to an offsite disposal facility or processor. The system is designed to minimize radiation exposure to personnel during the handling of solid wastes. The process parameters are included in the Process Control Program.

11.1.2.3.2 Solid Waste Processing System

The SWPS is designed to provide for the controlled handling and offsite disposal of solid waste originating from both units.

The SWPS equipment is located at Elevation 45'0" and 30'0" in the Auxiliary Building.

Spent radioactive ion exchanger resin is sluiced to a shielded spent resin metering tank at Elevation 45'0", where it is stored and partially dewatered via portable filtration to the MWRT. The portable filtration system may be bypassed as permitted. It is then sluiced to a suitable container where it is prepared for shipment. This operation is controlled from Elevation 45'0", so that the operators are shielded from primary radioactivity sources.

Reactor Coolant Waste Processing System evaporator bottoms are normally recycled. If they are not recycled, they may be disposed of in accordance with an approved process control program.

Radioactive filters are transported from each filter housing to the waste disposal area. A shielded filter transfer cask is available to transport the filters if required due to high radiation levels. The filters are lowered from the transfer cask to a shipping container or placed in a suitable storage area.

11.1.2.3.3 Solid Waste Releases

All solid wastes are packaged in containers suitable for burial or transfer to an offsite processor prior to leaving the site.

11.1.2.4 Materials Processing Facility

The MPF was designed in accordance with Generic Letter (GL) 81-38, "Storage of Low-Level Radioactive Wastes at Power Reactor Sites," to provide interim storage of dry active waste (DAW) until they can be shipped to a permanent disposal facility. The storage capacity of the MPF does not exceed the expected waste generated at

Calvert Cliffs for five years, based upon normal rates of operation and generation when the facility was designed. Provisions have been provided for expansion for an additional five years, if required.

The MPF is located on the plant site, outside of the protected area, and has an established physical security program consisting of locked doors and periodic patrols. Radiation protection has been incorporated into the structural design to prevent dose rates outside the facility from exceeding established limits in uncontrolled, unlimited access areas. A restricted area for radiation protection has also been established. Area radiation monitors or portable survey meters are used to monitor the general area radiation levels at various locations in the MPF.

The MPF is included in the site's Structural Monitoring Program. Design criteria were established according to the requirements of GL 81-38 to maintain the onsite radiation exposure ALARA and the calculated offsite contribution to less than 1 mrem per year. Design evaluations have demonstrated that the offsite dose resulting from accident scenarios involving the MPF would be negligible when compared to the Waste Processing System Incident in Section 14.23.

The overall functions of the MPF are:

a. Interim storage of DAW and low-level processed wastes.
b. Decontamination of clothing, respirators, tools, hardware, and radioactive material.
c. Provide the capability for temporary hold-up of liquid wastes generated during laundry and decontamination activities.
d. Provide capability for receiving, sorting, compacting, packaging and offsite return shipment of DAW. Receipt of offsite shipments of site's DAW is only permitted if the DAW was originally generated at Calvert Cliffs, then shipped offsite for volume reduction and returned to the site for interim storage.
e. Provide office space for radwaste management activities.
f. Additional capability is provided for storage of spare plant equipment and components.
g. The processing of liquid waste in the Decontamination Area of the MPF in preparation of offsite shipment. The volume of liquid waste in the MPF is limited to two 55-gallon drums (one being processed and one staged for processing), with secondary containment devices designed to hold the contents of both drums. The quantity of liquid waste to be processed and staged in the MPF is limited so that curie content will be within the limits of the following.

Isotope	Activity (μCi)
Sn-113	20.10
CE-144	16.10
Zr-95	38.20
Co-57	16.30
Co-58	2871.00
Co-60	779.00
Cs-134	50.00
Cs-137	736.00
Mn-54	151.00
Sb-125	121.00
Total	4798.70

To accomplish these functions, the MPF is physically divided into several areas: interim storage, DAW processing, decontamination, office space, miscellaneous storage, and shipping and receiving.

Packages containing gaseous wastes, wastes containing free liquids, solidified wastes, or dewatered wastes are prohibited from storage in the MPF since the facility is a non-seismic and non-safety-related structure. The liquid waste generated in the MPF laundry facility is collected, sampled, when necessary, and then transferred to the Auxiliary Building, via a transfer truck, for processing through the existing plant radwaste system.

Dry active waste is collected from central sites at both units and delivered to the MPF's DAW processing area where it is sorted and segregated according to activity levels. Activities performed in the decontamination facility include the removal of residual surface and fixed thin layer contamination from plant equipment. For respirators, a wet cleaning method is utilized. All waste is then packaged, shipped offsite for processing and volume reduction (if appropriate), then returned to the site for storage in the interim storage area, or shipped to an offsite burial facility. As a precaution, the stored waste is isolated from the MPF processing areas.

11.1.2.5 Interim Resin Storage Facility

The interim resin storage facility is located in the Lake Davies area of the site (Figure 1-1) and was designed in accordance with Generic Letter 81-38, "Storage of Low-Level Radioactive Wastes at Power Reactor Sites." Waste to be stored at the facility is limited to spent resins and filters and is processed by the Solid Waste Processing System (Section 11.1.2.3). The following waste forms are specifically excluded from storage at the interim resin storage facility: mixed wastes, spent fuel or fuel-related wastes, liquid or gaseous wastes, and wastes not generated by Calvert Cliffs Nuclear Power Plant.

Design criteria were established according to the requirements of Generic Letter 81-38 to maintain the onsite radiation exposure ALARA, and the calculated offsite contribution to the nearest permanent resident to less than 1 mrem per year.

11.1.2.6 West Road Cage

The West Road Cage is located due west of the Auxiliary Building on the 45' Elevation and evaluated in accordance with Generic Letter 81-38, "Storage of Low-Level Radioactive Wastes at Power Reactor Sites," to provide interim storage for up to five years (unless NRC approval for an extended storage time is obtained). Waste to be stored at the facility is limited to spent resins and filters and is processed by the Solid Waste Processing System (Section 11.1.2.3). Other radioactive materials contaminated by byproduct material may be stored in the area provided the materials are controlled in accordance with the Materials Safety Program (Section 11.4.1).

11.1.2.7 Original Steam Generator Storage Facility

The Original Steam Generator Storage Facility is a reinforced concrete structure with a footprint measuring approximately 75' x 85'. The building size allows for the storage of four original steam generator (OSG) lower assemblies in two bays. The building is located on the West side of the plant, just North of the Independent Spent Fuel Storage Installation. The structure is constructed of cast-in-place reinforced concrete with the exception of the East wall, which is constructed of pre-cast concrete sections. These sections allow for placement of the OSG lower assemblies inside the building and simplify the eventual removal of the OSG lower assemblies from storage. The facility is designed to house the OSG lower assemblies until the plant is decommissioned and the OSG lower assemblies are permanently disposed of.

Nuclear Regulatory Commission Generic Letter 81-38, was considered in the design of the Original Steam Generator Storage Facility, since this document applies to onsite storage of radwaste. However, in accordance with the intent of NRC Inspection Procedure 50001, "Steam Generator Replacement Inspection," for purposes of onsite storage of the OSGs, NRC Generic Letter 81-38 was reviewed only for applicability of proper controls for facility access and dose rates at the perimeter to ensure compliance with the limits of 10 CFR Part 20.

11.1.3 MONITORING INSTRUMENTATION

The monitoring instrumentation used to measure, record, and control the release of radioactivity to unrestricted areas includes the liquid waste discharge, the steam generator blowdown, and the main vent radiation monitoring systems. A list of the effluent monitors is provided in Table 11-10. The methodology for establishing the monitor trip setpoints is described in the ODCM. Calibration frequency is discussed in Section 11.2.3.

The liquid waste discharge, steam generator blowdown and main vent gaseous radiation monitoring systems are able to measure and control effluent releases within the requirements of the ODCM.

Liquid waste and steam generator blowdown monitoring must be in compliance with the ODCM during liquid releases from these pathways. These monitors are used to automatically terminate the release should the setpoint be reached, and to estimate the quantity of radioactive material discharged as a backup to laboratory analyses. Release of expected volumes of liquids below the monitor setpoints will ensure that ODCM levels will not be exceeded.

The main vent monitoring systems consist of a gas monitor and a fixed filter for particulate and iodine sampling. A laboratory isotopic analysis of the samples collected on the fixed filters is used to demonstrate compliance with the release limits for particulates and iodine.

Under normal operation, the blowdown tank vent is routed to Feedwater Heaters No. 13A and 13B, shell side for Unit 1, and to the heater drain tanks for Unit 2. Line-up of the blowdown tank vent to the heater drain tank is preferred during Unit 1 startup up to 30% power to prevent water hammering in the Feedwater heaters No. 13A and 13B. Therefore, there will be no direct pathway for radioactive material from blowdown vents to unrestricted areas. Any radioactivity in the blowdown tank vents will be monitored by the condenser offgas and the main vent monitoring systems.

11.1.4 TESTS AND INSPECTIONS

Functional tests and inspections to the waste processing system are made as required to ensure performance consistent with the requirements of 10 CFR Part 50, Appendix I and the ODCM. Routine surveillance is conducted during operator tours for detection of system leaks and for monitoring of system performance. Radiation detectors and monitors are routinely checked for operability. Alarm circuits and automatic features of flow diversion for waste liquid and gaseous effluents are routinely tested. The monitors are calibrated in accordance with the ODCM and approved plant procedures.

11.1.5 CONCLUSIONS

The waste processing systems are designed to allow flexible and reliable operations. All waste processing components in the RCWPS are redundant. In the event the components in the MWPS are inoperative, liquid waste normally processed by this system can be transferred to the RCWPS. If both redundant RCWPS components and the MWPS components are inoperative simultaneously, sufficient tank capacity exists in the RCWPS to hold 360,000 gallons. Both the RCWPS and MWPS are designed to allow reprocessing of liquid in the event activity levels are too high after the initial processing. Three gas decay tanks are provided, each of which is sized to store the gaseous waste produced by a simultaneous cooldown and degasification of both units. The waste processing systems are designed to prevent uncontrolled releases to the environment in the event of the failure of a single active component or an operator error.

For the preoperational design estimates, the total annual radiological impact as a result of operating Calvert Cliffs Unit 1 and Unit 2 with 1% failed fuel is shown in Table 11-3. The actual releases are provided in the Radioactive Effluent Release Reports.

Actual effluent data provided in the Radioactive Effluent Release Reports has been used as input to the calculational methods provided in the ODCM in order to calculate the offsite doses. These calculated doses are within the guidelines of 10 CFR Part 50, Appendix I and the limits of the ODCM.

To meet the dose limitations of 40 CFR Part 190, the ODCM requires the preparation and submittal of a special report whenever the calculated doses from plant generated radioactive effluents and direct radiation exceed 25 mrems to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrems. The special report will describe a course of action that should result in the limitation of the annual dose to a member of the public to within the 40 CFR Part 190 limits. For the purposes of the special report, it may be assumed that the dose commitment to the member of the public from other uranium fuel cycle sources is negligible.

TABLE 11-1

WASTE PROCESSING SYSTEMS COMPONENT DESCRIPTION

MISCELLANEOUS WASTE RECEIVER TANK PUMP

Type	Horizontal centrifugal, end suction, mechanical seal
Quantity	One
Capacity (gpm)	120
Head (ft of H_2O)	110
Material:	
Case	316 Stainless Steel
Impeller	316 Stainless Steel
Shaft	316 Stainless Steel
Motor	7.5 hp, 3 phase, 60 Hz, 480 Volt
Code	National Electrical Manufacturers Association (NEMA), American Society of Mechanical Engineers (ASME) - Pumps and Valves for Nuclear Power

MISCELLANEOUS WASTE MONITOR TANK PUMP

Type	Horizontal centrifugal, end suction, mechanical seal
Quantity	One
Capacity (gpm)	120
Head (ft of H_2O)	110
Material:	
Case	316 Stainless Steel
Impeller	316 Stainless Steel
Shaft	316 Stainless Steel
Motor	7.5 hp, 3 phase, 60 Hz, 480 Volt
Code	NEMA, ASME - Pumps and Valves for Nuclear Power

MISCELLANEOUS WASTE MONITOR TANK METERING PUMP

Type	Horizontal centrifugal, end suction, mechanical seal
Quantity	One
Capacity (gpm)	10
Head (ft of H_2O)	60
Material:	
Case	316 Stainless Steel
Impeller	316 Stainless Steel
Shaft	316 Stainless Steel
Motor	1 hp, 3 phase, 60 Hz, 480 Volt
Code	NEMA, ASME - Pumps and Valves for Nuclear Power

MISCELLANEOUS WASTE RECEIVER TANK[(a)]

Type	Horizontal
Quantity	One
Design Pressure	Atmospheric
Volume (gal)	4000
Code	ASME Section III, Class C
Material	304 Stainless Steel

TABLE 11-1

WASTE PROCESSING SYSTEMS COMPONENT DESCRIPTION

MISCELLANEOUS WASTE MONITOR TANK[(a)]

Type	Horizontal
Quantity	One
Design Pressure	Atmospheric
Volume (gal)	4000
Code	ASME Section III, Class C (Code "N" Stamp Removed)
Material	304 Stainless Steel

ION EXCHANGERS

Type	Mixed bed, non-regenerable
Quantity	Five
Design Pressure (psig)	200
Flow (gpm)	128
Material:	
Vessel Shell	ASME Section III, Class C; Section VIII, (Paragraph UW-2a, applies)
Vessel Head	ASME SA240, Type 304
Internals	ASME SA240, Type 304 Austenitic Stainless Steel

FILTERS

Type	Cartridge
Quantity	Three
Design Pressure (psig)	125
Flow (gpm)	120
Code	ASME Section III, Class C

WASTE GAS COMPRESSORS

Type	Single stage, 1 head, diaphragm
Quantity	Two
Capacity (scfm)	4.0 to 7.0
Design Discharge Pressure (psig)	150
Motor	3.0 hp, 3 phase, 60 Hz, 460 Volt
Code	NEMA

WASTE GAS SURGE TANK[(a)]

Type	Vertical
Design Pressure (psig)	50
Volume (ft^3)	610
Code	ASME Section III, Class C
Material	304 Stainless Steel

WASTE GAS DECAY TANKS[(a)]

Type	Vertical
Quantity	Three
Design Pressure (psig)	150
Volume (ft^3)	610
Code	ASME Section III, Class C
Material	American Society for Testing and Materials (ASTM) A264, Type 304 Stainless Steel clad

TABLE 11-1

WASTE PROCESSING SYSTEMS COMPONENT DESCRIPTION

REACTOR COOLANT DRAIN TANK PUMPS

Type	Horizontal centrifugal, end suction, mechanical seal
Quantity	Two
Capacity (gpm)	100
Head (ft of H_2O)	113
Material:	
Case	316 Stainless Steel
Impeller	316 Stainless Steel
Shaft	316 Stainless Steel
Motor	7.5 hp, 3 phase, 60 Hz, 480 Volt
Code	NEMA, ASME - Pumps and Valves for Nuclear Power

DEGASIFIER PUMPS

Type	Horizontal centrifugal, end suction, mechanical seal
Quantity	Two
Capacity (gpm)	150
Head (ft of H_2O)	221
Material:	
Case	316 Stainless Steel
Impeller	316 Stainless Steel
Shaft	316 Stainless Steel
Motor	20 hp, 3 phase, 60 Hz, 480 Volt
Code	NEMA, ASME - Pumps and Valves for Nuclear Power

REACTOR COOLANT WASTE RECEIVER TANK PUMPS

Type	Horizontal centrifugal, end suction, mechanical seal
Quantity	Two
Capacity (gpm)	120
Head (ft of H_2O)	204
Material:	
Case	316 Stainless Steel
Impeller	316 Stainless Steel
Shaft	316 Stainless Steel
Motor	15 hp, 3 phase, 60 Hz, 480 Volt
Code	NEMA, ASME - Pumps and Valves for Nuclear Power

REACTOR COOLANT WASTE MONITOR TANK PUMPS

Type	Horizontal centrifugal, end suction, mechanical seal
Quantity	Two
Capacity (gpm)	120
Head (ft of H_2O)	204
Material:	
Case	316 Stainless Steel
Impeller	316 Stainless Steel
Shaft	316 Stainless Steel
Motor	15 hp
Code	NEMA, ASME - Pumps and Valves for Nuclear Power

TABLE 11-1

WASTE PROCESSING SYSTEMS COMPONENT DESCRIPTION

REACTOR COOLANT WASTE MONITOR TANK METERING PUMP

Type	Horizontal centrifugal, end suction, mechanical seal
Quantity	One
Capacity (gpm)	10
Head (ft of H_2O)	60
Material:	
Case	316 Stainless Steel
Impeller	316 Stainless Steel
Shaft	316 Stainless Steel
Motor	15 hp, 3 phase, 60 Hz, 480 Volt
Code	NEMA, ASME - Pumps and Valves for Nuclear Power

REACTOR COOLANT DRAIN TANK[a]

Type	Horizontal
Quantity	Two
Design Pressure (psig)	50
Volume (gal.)	900
Code	ASME Section III, Class C
Material	304 Stainless Steel

REACTOR COOLANT WASTE RECEIVER TANKS[a]

Type	Vertical
Quantity	Two
Design Pressure (psia)	15
Volume (gal.)	90,000
Code	ASME Section VIII
Material	304 Stainless Steel

REACTOR COOLANT WASTE MONITOR TANKS[a]

Type	Vertical
Quantity	Two
Design Pressure (psia)	15
Volume (gal.)	90,000
Code	ASME Section VIII
Material	304 Stainless Steel

REACTOR COOLANT DEGASIFIERS

Type	Packed tower
Quantity	Two
Design Pressure (psia)	75
Reactor coolant bleed (gpm)	0-120
Code	ASME Section III, Class C; ANSI B31.1

LIQUID WASTE EVAPORATORS (Retired in place)

Quantity	Two
Type	Horizontal, vacuum
Design Pressure (psia)	30
Design Distillate Flow (gpm)	20
Code	ASME Section III, Class C
Mode of Operation	Batch (RCWPS), Continuous (MWPS)
Feed Tank Capacity (gal)	1000

[a] Additional design and quality control requirements for these tanks are given in Section 6.3.5.1.

TABLE 11-2

PREOPERATIONAL DESIGN ESTIMATES OF LIQUID EFFLUENT CONCENTRATIONS

(Operation with 1% Failed Fuel)

ISOTOPE	PREOPERATIONAL ESTIMATED DISCHARGE CONCENTRATIONS (μCi/cc)
Sr-89	4.56×10^{-14}
Sr-90	9.22×10^{-15}
Sr-91	3.30×10^{-14}
Y-90	8.94×10^{-15}
Y-91	3.04×10^{-13}
Mo-99	2.33×10^{-11}
Ru-103	1.04×10^{-13}
Ru-106	8.41×10^{-15}
Te-129	2.25×10^{-13}
Te-132	3.90×10^{-12}
I-129	1.68×10^{-17}
I-131	3.56×10^{-10}
I-132	4.90×10^{-11}
I-133	2.86×10^{-10}
I-134	2.72×10^{-11}
I-135	1.24×10^{-10}
Cs-134	3.46×10^{-12}
Cs-136	4.53×10^{-13}
Cs-137	1.14×10^{-11}
Ba-140	1.08×10^{-13}
La-140	6.13×10^{-14}
Ce-144	1.01×10^{-11}
Pr-143	5.19×10^{-14}
Cr-51	4.61×10^{-14}
Mn-54	3.54×10^{-14}
Mn-56	2.75×10^{-11}
Fe-59	2.52×10^{-14}
Co-58	4.84×10^{-12}
Co-60	6.34×10^{-13}
Zr-95	2.96×10^{-15}
H-3	1.79×10^{-7}

TABLE 11-3

PREOPERATIONAL DESIGN ESTIMATES OF TOTAL ANNUAL RADIOLOGICAL IMPACT

(Operation With 1% Failed Fuel in Both Reactors)

ANNUAL LIQUID RELEASES

		ANNUAL AVERAGE LIQUID EFFLUENT CONCENTRATION IN CIRCULATING WATER (μCi/cc)	TOTAL CURIES RELEASED (Ci/yr)	MAXIMUM INDIVIDUAL DOSE (mrem/yr)	REMARKS
1.	Tritium	1.79×10^{-7}	682	4.13×10^{-4}	Whole body dose from seafood ingestion.
2.	All isotopes except tritium and noble gases	9.40×10^{-10}	3.73	5.84×10^{-2}	Whole body dose from seafood ingestion.
				3.37×10^{-4}	Thyroid dose from seafood ingestion.

ANNUAL GASEOUS RELEASES

		ANNUAL AVERAGE CONCENTRATION (μCi/cc)	TOTAL CURIES RELEASED (Ci/yr)	MAXIMUM INDIVIDUAL DOSE (mrem/yr)	REMARKS
1.	Noble gases in liquid	1.22×10^{-13}	1.61	2.29×10^{-4}	Whole body dose at site boundary assuming gases come out of the solution at the end of discharge conduit.
2.	Noble gases (excluding noble gases in liquid)	6.41×10^{-10}	9.19×10^{3}	1.23	Whole body dose at site boundary.
3.	Iodine-131	6.79×10^{-17}	0.0305	0.192	Child thyroid dose due to ingestion of milk.
4.	All iodine isotopes	6.22×10^{-15}	0.0890	0.0308	Thyroid inhalation dose at site boundary.
5.	Particulates	1.77×10^{-18}	7.99×10^{-4}	7.52×10^{-5}	Dose calculation assumes all particulates are Cs-137 (actually Cs-137 is less than 40%). Dose to liver of standard man due to the ingestion of milk and beef.

TABLE 11-4

RADIOACTIVE WASTE PROCESSING SYSTEM SOURCES

REACTOR COOLANT WASTE PROCESSING SYSTEM	MISCELLANEOUS WASTE PROCESSING SYSTEM	WASTE GAS PROCESSING SYSTEM
Chemical and Volume Control System	Laboratory Sink Drains	RCDT No. 11
Regenerative Heat Exchanger No. 21	Spent Fuel Cask	RCDT Washdown Area Drains
Safety Injection Tanks Leakage	Spent Fuel Storage Area Drains	Pressure Quench Tank No. 11
Loop 11A Drains	Low Point Piping Drains	Pressure Quench Tank No. 21
Loop 11B Drains	Auxiliary Building Gravity Drains	Volume Control Tank No. 11
Loop 12A Drains	Auxiliary Building Pumped Sumps	Volume Control Tank No. 21
Loop 12B Drains	Laundry	Degasifier No. 11 and No. 12
Quench Tank Drains	Showers	Evaporator No. 11 and No. 12 (Retired in place)
Flange Leakage Detector Drain	Component Cooling System Relief Valves	Miscellaneous Sources
Loop No. 11 Hot Leg Drain	Boric Acid Preparation Area Drains	
Leakoff from Valves in Containment	Equipment Drains	
Reactor Coolant Pump Seal Leakage	High & Low Pressure Safety Injection Pump Seal and Bearing Water	
	Blowdown Tank Drain	
	Charging Pumps	

TABLE 11-5

PREOPERATIONAL DESIGN ESTIMATES OF RADIOACTIVITY CONCENTRATIONS IN REACTOR COOLANT AND REACTOR COOLANT WASTE PROCESSING SYSTEM EFFLUENTS

(Operation With 1% Failed Fuel)

ISOTOPE	CONCENTRATION IN REACTOR COOLANT (μCi/cc)	ANNUAL DISCHARGE (Ci/yr)	ISOTOPE	CONCENTRATION IN REACTOR COOLANT (μCi/cc)	ANNUAL DISCHARGE (Ci/yr)
Br-84	4.66×10^{-2}	1.53×10^{-2}	Xe-133	181	1.49x10
Kr-85m	1.49	1.2×10^{-1}	Te-134	2.62×10^{-2}	8.60×10^{-3}
Kr-85	8.85×10^{-1}	7.28×10^{-2}	I-134	6.20×10^{-1}[(a)]	1.0
Kr-87	8.1×10^{-1}	6.66×10^{-2}	Cs-134	1.0×10^{-1}	3.29×10^{-2}
Kr-88	2.6	2.14×10^{-1}	I-135	2.7[(a)]	4.4
Rb-88	2.55	8.0×10^{-1}	Xe-135	7.53	6.20×10^{-1}
Rb-89	6.4×10^{-2}	2.11×10^{-2}	Cs-136	2.55×10^{-2}	8.40×10^{-3}
Sr-89	5.07×10^{-3}	1.66×10^{-3}	Cs-137	3.20×10^{-1}	1.05×10^{-1}
Sr-90	2.61×10^{-4}	0.85×10^{-1}	Xe-138	3.60×10^{-1}	2.96×10^{-2}
Y-90	1.02×10^{-3}	0.33×10^{-3}	Cs-138	6.90×10^{-1}	2.27×10^{-1}
Sr-91	3.56×10^{-3}	1.17×10^{-3}	Ba-140	6.11×10^{-3}	2.01×10^{-3}
Y-91	1.11×10^{-1}	3.65×10^{-2}	La-140	5.85×10^{-3}	1.92×10^{-3}
Mo-99	2.03	6.68×10^{-1}	Ce-144	4.0×10^{-3}	1.36×10^{-3}
Ru-103	4.13×10^{-3}	1.36×10^{-3}	Pr-143	5.80×10^{-3}	1.92×10^{-3}
Ru-106	2.48×10^{-4}	0.82×10^{-4}	Cr-51	3.8×10^{-5}	1.25×10^{-4}
Te-129	2.51×10^{-2}	0.83×10^{-2}	Mn-54	2.75×10^{-5}	9.06×10^{-5}
I-129	7.21×10^{-8}	1.19×10^{-7}	Mn-56	2.30×10^{-2}	7.57×10^{-2}
I-131	3.97[(a)]	6.74	Fe-59	2.13×10^{-5}	7.01×10^{-5}
Xe-131m	1.48	1.22×10^{-1}	Co-58	4.66×10^{-3}	1.53×10^{-2}
Te-132	3.30×10^{-1}	1.09×10^{-1}	Co-60	5.19×10^{-4}	1.71×10^{-3}
I-132	1.09[(a)]	1.8	Zr-95	9.35×10^{-7}	3.08×10^{-6}
I-133	5.66[(a)]	9.3	H-3	1.309×10^{-1}	1.077×10^{3}

[(a)] Conservative preoperational estimate for design purposes.

Total non-H^3 = 41.5 Ci/yr

Total non-H^3 Less Gases = 25.4 Ci/yr

TABLE 11-6

PREOPERATIONAL DESIGN ESTIMATES OF MISCELLANEOUS WASTE PROCESSING SYSTEM EFFLUENTS

(Operation With 1% Failed Fuel)

ISOTOPE	BLOWDOWN (Ci/yr)	OTHER (Ci/yr)	TOTAL (Ci/yr)
Br-84	$2.44x10^{-5}$	$4.47x10^{-4}$	$4.71x10^{-4}$
Rb-88	$7.56x10^{-6}$	$2.44x10^{-2}$	$2.44x10^{-2}$
Rb-89	$7.08x10^{-11}$	$6.13x10^{-4}$	$6.13x10^{-4}$
Sr-89	$1.57x10^{-7}$	$4.86x10^{-5}$	$4.88x10^{-5}$
Sr-90	$1.59x10^{-6}$	$2.50x10^{-6}$	$4.09x10^{-6}$
Y-90	$5.84x10^{-7}$	$9.75x10^{-6}$	$1.03x10^{-5}$
Sr-91	$3.34x10^{-7}$	$3.41x10^{-5}$	$3.44x10^{-5}$
Y-91	$4.72x10^{-4}$	$1.07x10^{-3}$	$1.54x10^{-3}$
Mo-99	$1.21x10^{-3}$	$1.94x10^{-2}$	$2.06x10^{-2}$
Ru-103	$1.54x10^{-5}$	$3.96x10^{-5}$	$5.50x10^{-5}$
Ru-106	$1.43x10^{-6}$	$2.37x10^{-6}$	$3.80x10^{-6}$
Te-129	$2.76x10^{-7}$	$2.41x10^{-4}$	$2.41x10^{-4}$
I-129	$2.20x10^{-10}$	$3.47x10^{-9}$	$3.69x10^{-9}$
I-131	$2.88x10^{-2}$	$1.88x10^{-1}$	$2.17x10^{-1}$
Te-132	$2.28x10^{-4}$	$3.17x10^{-3}$	$3.40x10^{-3}$
I-132	$1.21x10^{-4}$	$5.24x10^{-2}$	$5.25x10^{-2}$
I-133	$5.64x10^{-3}$	$2.72x10^{-1}$	$2.78x10^{-1}$
Te-134	$1.60x10^{-7}$	$2.51x10^{-4}$	$2.51x10^{-4}$
I-134	$2.68x10^{-5}$	$2.98x10^{-2}$	$2.98x10^{-2}$
Cs-134	$5.94x10^{-4}$	$9.58x10^{-4}$	$1.55x10^{-3}$
I-135	$8.78x10^{-4}$	$1.30x10^{-1}$	$1.31x10^{-1}$
Cs-136	$5.20x10^{-5}$	$2.44x10^{-4}$	$2.96x10^{-4}$
Cs-137	$1.97x10^{-3}$	$3.07x10^{-3}$	$5.04x10^{-3}$
Cs-138	$3.64x10^{-6}$	$6.62x10^{-3}$	$6.62x10^{-3}$
Ba-140	$1.24x10^{-5}$	$5.86x10^{-5}$	$7.10x10^{-5}$
La-140	$2.16x10^{-6}$	$5.61x10^{-5}$	$5.83x10^{-5}$
Pr-143	$5.56x10^{-9}$	$5.56x10^{-5}$	$5.56x10^{-5}$
Ce-144	$2.32x10^{-5}$	$3.83x10^{-5}$	$6.15x10^{-5}$
Cr-51	$1.20x10^{-5}$	$3.66x10^{-5}$	$4.86x10^{-5}$
Mn-54	$1.56x10^{-5}$	$2.64x10^{-5}$	$4.20x10^{-5}$
Mn-56	$5.80x10^{-3}$	$2.21x10^{-2}$	$2.79x10^{-2}$
Co-58	$2.10x10^{-3}$	$4.48x10^{-3}$	$6.58x10^{-3}$
Fe-59	$8.24x10^{-6}$	$2.05x10^{-5}$	$2.87x10^{-5}$
Co-60	$3.14x10^{-4}$	$4.99x10^{-4}$	$8.13x10^{-4}$
Zr-95	$4.02x10^{-7}$	$9.00x10^{-7}$	$1.30x10^{-6}$
H-3	$4.02x10^{1}$	$6.29x10^{1}$	$1.03x10^{2}$
Total Non-H-3			$8.09x10^{-1}$
Total H-3			$1.03x10^{2}$

TABLE 11-7

PREOPERATIONAL DESIGN ESTIMATES OF TOTAL ANNUAL LIQUID RELEASE VIA TURBINE BUILDING DRAINS

(Operation with 1% Failed Fuel)

ISOTOPE	ANNUAL LIQUID RELEASE (Ci/yr plant)
I-129	$4.44x10^{-7}$
I-131	5.72
I-132	$2.42x10^{-2}$
I-133	1.14
I-134	$5.38x10^{-3}$
I-135	$1.76x10^{-1}$
Total Iodine	7.07
Total Particulates	$5.0x10^{-1}$
Total H-3	$4.04x10^{-2}$

TABLE 11-8

PREOPERATIONAL DESIGN ESTIMATES OF ANNUAL DISCHARGES

(Operation With 1% Failed Fuel)

LIQUID RELEASES (Ci/yr)

ISOTOPE	RCWPS	MWPS	LOW ACTIVITY STEAM GENERATOR BLOWDOWN	TURBINE BUILDING DRAINS	TOTAL
Br-84	$1.53x10^{-3}$	$4.71x10^{-5}$	$4.01x10^{-6}$	--	$1.58x10^{-3}$
Kr-85m	$1.20x10^{-2}$	--	--	--	$1.20x10^{-2}$
Kr-85	$7.28x10^{-3}$	--	--	--	$7.28x10^{-3}$
Kr-87	$6.66x10^{-3}$	--	--	--	$6.66x10^{-3}$
Kr-88	$2.14x10^{-2}$	--	--	--	$2.14x10^{-2}$
Rb-88	$8.00x10^{-2}$	$2.44x10^{-3}$	$1.26x10^{-4}$	--	$8.25x10^{-2}$
Rb-89	$2.11x10^{-3}$	$6.13x10^{-5}$	$1.17x10^{-9}$	--	$2.17x10^{-3}$
Sr-89	$1.66x10^{-4}$	$4.88x10^{-6}$	$2.58x10^{-6}$	--	$1.74x10^{-4}$
Sr-90	$8.50x10^{-6}$	$4.09x10^{-7}$	$2.63x10^{-5}$	--	$3.52x10^{-5}$
Y-90	$3.30x10^{-5}$	$1.03x10^{-6}$	$9.65x10^{-6}$	--	$4.37x10^{-5}$
Sr-91	$1.17x10^{-4}$	$3.44x10^{-6}$	$5.52x10^{-6}$	--	$1.26x10^{-4}$
Y-91	$3.65x10^{-3}$	$1.54x10^{-4}$	$7.79x10^{-3}$	--	$1.16x10^{-2}$
Mo-99	$6.68x10^{-2}$	$2.06x10^{-3}$	$2.00x10^{-2}$	--	$8.89x10^{-2}$
Ru-103	$1.36x10^{-4}$	$5.50x10^{-6}$	$2.54x10^{-4}$	--	$3.96x10^{-4}$
Ru-106	$8.20x10^{-6}$	$3.80x10^{-7}$	$2.35x10^{-5}$	--	$3.21x10^{-5}$
Te-129	$8.30x10^{-4}$	$2.41x10^{-5}$	$4.55x10^{-6}$	--	$8.59x10^{-4}$
I-129	$1.19x10^{-8}$	$3.69x10^{-10}$	$7.28x10^{-9}$	$4.44x10^{-8}$	$6.40x10^{-8}$
I-131	$6.74x10^{-1}$	$2.17x10^{-2}$	$9.54x10^{-2}$	$5.72x10^{-1}$	1.36
Xe-131m	$1.22x10^{-2}$	--	--	--	$1.22x10^{-2}$
Te-132	$1.09x10^{-2}$	$3.40x10^{-4}$	$3.71x10^{-3}$	--	$1.49x10^{-2}$
I-132	$1.80x10^{-1}$	$5.25x10^{-3}$	$3.97x10^{-4}$	$2.42x10^{-3}$	$1.87x10^{-1}$
I-133	$9.30x10^{-1}$	$2.78x10^{-2}$	$1.87x10^{-2}$	$1.14x10^{-1}$	1.09
Xe-133	1.49	--	--	--	1.49
Te-134	$8.60x10^{-4}$	$2.51x10^{-5}$	$2.98x10^{-6}$	--	$8.88x10^{-4}$
I-134	$1.00x10^{-1}$	$2.98x10^{-3}$	$8.85x10^{-5}$	$5.38x10^{-4}$	$1.04x10^{-1}$
Cs-134	$3.29x10^{-3}$	$1.55x10^{-4}$	$9.77x10^{-3}$	--	$1.32x10^{-2}$
I-135	$4.40x10^{-1}$	$1.31x10^{-2}$	$2.89x10^{-3}$	$1.76x10^{-2}$	$4.74x10^{-1}$
Xe-135	$6.20x10^{-2}$	--	--	--	$6.20x10^{-2}$
Cs-136	$8.40x10^{-4}$	$2.96x10^{-5}$	$8.60x10^{-4}$	--	$1.73x10^{-3}$
Cs-137	$1.05x10^{-2}$	$5.04x10^{-4}$	$3.24x10^{-2}$	--	$4.34x10^{-2}$
Xe-138	$2.96x10^{-3}$	--	--	--	$2.96x10^{-3}$
Cs-138	$2.27x10^{-2}$	$6.62x10^{-4}$	$6.00x10^{-5}$	--	$2.33x10^{-2}$
Ba-140	$2.01x10^{-4}$	$7.10x10^{-6}$	$2.04x10^{-4}$	--	$4.12x10^{-4}$

TABLE 11-8

PREOPERATIONAL DESIGN ESTIMATES OF ANNUAL DISCHARGES

(Operation With 1% Failed Fuel)

LIQUID RELEASES (Ci/yr)

ISOTOPE	RCWPS	MWPS	LOW ACTIVITY STEAM GENERATOR BLOWDOWN	TURBINE BUILDING DRAINS	TOTAL
La-140	$1.92x10^{-4}$	$5.83x10^{-6}$	$3.59x10^{-5}$	--	$2.34x10^{-4}$
Ce-144	$1.36x10^{-4}$	$6.15x10^{-6}$	$3.84x10^{-2}$	--	$3.85x10^{-2}$
Pr-143	$1.92x10^{-4}$	$5.56x10^{-6}$	$9.20x10^{-8}$	--	$1.98x10^{-4}$
Cr-51	$1.25x10^{-4}$	$4.86x10^{-5}$	$1.99x10^{-6}$	--	$1.76x10^{-4}$
Mn-54	$9.06x10^{-5}$	$4.20x10^{-5}$	$2.57x10^{-6}$	--	$1.35x10^{-4}$
Mn-56	$7.57x10^{-2}$	$2.79x10^{-2}$	$9.57x10^{-4}$	--	$1.05x10^{-1}$
Fe-59	$7.01x10^{-5}$	$2.87x10^{-5}$	$1.36x10^{-6}$	--	$1.00x10^{-4}$
Co-58	$1.53x10^{-2}$	$6.58x10^{-3}$	$3.48x10^{-5}$	--	$2.22x10^{-2}$
Co-60	$1.71x10^{-3}$	$8.13x10^{-4}$	$5.34x10^{-5}$	--	$2.58x10^{-3}$
Zr-95	$3.08x10^{-6}$	$1.30x10^{-6}$	$6.80x10^{-8}$	--	$4.45x10^{-6}$
H-3	$5.43x10^{2}$	$5.19x10^{1}$	$1.33x10^{-2}$	$8.74x10^{1}$	$6.82x10^{2}$
Particulates	--	--	--	$5.27x10^{-2}$	$5.27x10^{-2}$
	Total activity in liquid excluding H-3 and noble gases				3.73
	Total H-3 in liquid				$6.82x10^{2}$
	Total noble gases in liquid				1.61

TABLE 11-8

PREOPERATIONAL DESIGN ESTIMATES OF ANNUAL DISCHARGES

(Operation With 1% Failed Fuel)

GASEOUS RELEASES (Ci/yr)

ISOTOPE	CONTAINMENT PURGE	GLAND SEAL AND CONDENSER AIR REMOVAL	AUXILIARY BUILDING VENT	WGPS AND AERATED TANK VENTS	TURBINE BUILDING VENTILATION	TOTAL
Br-84	--	--	--	--	--	--
Kr-85m	1.03	4.60×10^{1}	5.73×10^{-1}	--	--	4.76×10^{1}
Kr-85	4.16×10^{1}	2.72×10^{1}	3.40×10^{-1}	7.25×10^{2}	--	7.94×10^{2}
Kr-87	2.82×10^{-1}	2.50×10^{1}	3.12×10^{-1}	--	--	2.56×10^{1}
Kr-88	1.37	8.02×10^{1}	1.00	--	--	8.26×10^{1}
Rb-88	--	--	--	--	--	--
Rb-89	--	--	--	--	--	--
Sr-89	--	--	--	--	--	--
Sr-90	--	--	--	--	--	--
Y-90	--	--	--	--	--	--
Sr-91	--	--	--	--	--	--
Y-91	--	--	--	--	--	--
Mo-99	--	--	--	--	--	--
Ru-103	--	--	--	--	--	--
Ru-106	--	--	--	--	--	--
Te-129	--	--	--	--	--	--
I-129	1.42×10^{-10}	1.31×10^{-10}	2.78×10^{-10}	7.28×10^{-12}	4.44×10^{-10}	1.00×10^{-9}
I-131	7.42×10^{-3}	1.73×10^{-3}	1.53×10^{-2}	4.01×10^{-4}	5.72×10^{-3}	3.05×10^{-2}
Xe-131m	3.30×10^{1}	4.56×10^{1}	5.69×10^{-1}	3.82×10^{1}	--	1.17×10^{2}
Te-132	--	--	--	--	--	--
I-132	1.87×10^{-3}	7.30×10^{-6}	4.20×10^{-3}	1.10×10^{-4}	2.42×10^{-5}	6.21×10^{-3}
I-133	9.50×10^{-3}	3.37×10^{-4}	2.16×10^{-2}	5.72×10^{-4}	1.14×10^{-3}	3.21×10^{-2}
Xe-133	2.16×10^{3}	5.58×10^{3}	6.96×10^{1}	5.83×10^{1}	--	7.87×10^{3}
Te-134	--	--	--	--	--	--
I-134	9.22×10^{-4}	1.66×10^{-6}	2.38×10^{-3}	6.26×10^{-5}	5.38×10^{-6}	3.38×10^{-3}
Cs-134	--	--	--	--	--	--
I-135	5.92×10^{-3}	5.24×10^{-5}	1.04×10^{-2}	2.73×10^{-4}	1.76×10^{-4}	1.68×10^{-2}
Xe-135	9.44	2.32×10^{2}	2.09	--	--	2.44×10^{2}
Cs-136	--	--	--	--	--	--
Cs-137	--	--	--	--	--	--
Xe-138	--	1.11×10^{1}	1.34×10^{-1}	--	--	1.12×10^{1}
Cs-138	--	--	--	--	--	--

TABLE 11-8

PREOPERATIONAL DESIGN ESTIMATES OF ANNUAL DISCHARGES

(Operation With 1% Failed Fuel)

GASEOUS RELEASES (Ci/yr)

ISOTOPE	CONTAINMENT PURGE	GLAND SEAL AND CONDENSER AIR REMOVAL	AUXILIARY BUILDING VENT	WGPS AND AERATED TANK VENTS	TURBINE BUILDING VENTILATION	TOTAL
Ba-140	--	--	--	--	--	--
La-140	--	--	--	--	--	--
Ce-144	--	--	--	--	--	--
Pr-143	--	--	--	--	--	--
Cr-51	--	--	--	--	--	--
Mn-54	--	--	--	--	--	--
Mn-56	--	--	--	--	--	--
Fe-59	--	--	--	--	--	--
Co-58	--	--	--	--	--	--
Co-60	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--
H-3	--	--	--	--	--	--
Particulates	$1.21x10^{-6}$	$1.57x10^{-4}$	$2.44x10^{-6}$	$1.11x10^{-6}$	$5.27x10^{-4}$	$7.99x10^{-4}$
		Total noble gases airborne				$9.19x10^{3}$
		Total iodine-131 airborne				$3.05x10^{-2}$
		Total short-lived iodine airborne				$5.85x10^{-2}$

NOTE: Although all tritium released from the plant has been assumed to be released via the liquid discharges for the purpose of these calculations, a small percentage of the total may be released via the gaseous pathways (primarily the containment purge).

All noble gases that leak to the steam generator are assumed to be released via the condenser air removal system.

TABLE 11-9

PREOPERATIONAL DESIGN ESTIMATES OF TOTAL PLANT GASEOUS EFFLUENTS

(Operation With 1% Failed Fuel)

ANNUAL DISCHARGE (Ci/yr)

ISOTOPE	CONTAINMENT PURGE	TURBINE BUILDING VENTILATION	GLAND SEAL AND CONDENSER AIR REMOVAL	AUXILIARY BUILDING VENTILATION	WGPS AND AERATED TANK VENTS	TOTAL
Kr-85m	$1.03x10^{1}$	--	$4.60x10^{2}$	5.73	--	$4.76x10^{2}$
Kr-85	$4.16x10^{2}$	--	$2.72x10^{2}$	3.40	$7.25x10^{3}$	$7.94x10^{3}$
Kr-87	2.82	--	$2.50x10^{2}$	3.12	--	$2.56x10^{2}$
Kr-88	$1.37x10^{1}$	--	$8.02x10^{2}$	$1.00x10^{1}$	--	$8.26x10^{2}$
Xe-131m	$3.30x10^{2}$	--	$4.56x10^{2}$	5.69	$3.82x10^{2}$	$1.17x10^{3}$
Xe-133	$2.16x10^{4}$	--	$5.58x10^{4}$	$6.96x10^{2}$	$5.83x10^{2}$	$7.87x10^{4}$
Xe-135	$9.44x10^{1}$	--	$2.32x10^{3}$	$2.09x10^{1}$	--	$2.44x10^{3}$
Xe-138	--	--	$1.11x10^{2}$	1.34	--	$1.12x10^{2}$
Particulates	$1.12x10^{-5}$	$5.00x10^{-3}$	$1.49x10^{-3}$	$2.26x10^{-5}$	$6.35x10^{-4}$	$7.16x10^{-3}$
I-129	$1.42x10^{-9}$	$4.44x10^{-9}$	$1.31x10^{-9}$	$2.78x10^{-9}$	$7.28x10^{-11}$	$1.00x10^{-8}$
I-131	$7.42x10^{-2}$	$5.72x10^{-2}$	$1.73x10^{-2}$	$1.53x10^{-1}$	$4.01x10^{-3}$	$3.05x10^{-1}$
I-132	$1.87x10^{-2}$	$2.42x10^{-4}$	$7.30x10^{-5}$	$4.20x10^{-2}$	$1.10x10^{-3}$	$6.21x10^{-2}$
I-133	$9.50x10^{-2}$	$1.14x10^{-2}$	$3.37x10^{-3}$	$2.16x10^{-1}$	$5.72x10^{-3}$	$3.21x10^{-1}$
I-134	$9.22x10^{-3}$	$5.38x10^{-5}$	$1.66x10^{-5}$	$2.38x10^{-2}$	$6.26x10^{4}$	$3.38x10^{-2}$
I-135	$5.92x10^{-2}$	$1.76x10^{-3}$	$5.24x10^{-4}$	$1.04x10^{-1}$	$2.73x10^{-3}$	$1.68x10^{-1}$

NOTE: All noble gases that leak to the steam generator are released via the condenser air removal system.

TABLE 11-10

PROCESS AND EFFLUENT RADIATION MONITORS

RADIATION MONITORING SYSTEM	DETECTION EQUIPMENT	SENSITIVITY μCi/cc	RANGE
Steam Generator Blowdown Monitor (R-4014)	Off-Line Scintillation	$3.77x10^{-8}$ Cs^{137}	10^1 to 10^6 CPM
Liquid Waste Discharge Monitor (R-2201)	Off-Line Scintillation	$3.77x10^{-8}$ Cs^{137}	10^1 to 10^6 CPM
Condenser Vacuum Pump Suction (R-1752)	In-Line Scintillation	$9.3x10^{-7}$ Xe^{133}	10^1 to 10^{-7} CPM
Control Room Vent Supply (R-5350A/B)	In-Line GM Tube	$1.5x10^{-7}$ Xe^{133}	10^1 to 10^6 CPM
Fuel Handling Vent Exhaust (R-5420)	Off-Line GM Tube	$3.0x10^{-6}$ Xe^{133}	10^1 to 10^6 CPM
Access Control Vent Exhaust (R-5425)	Off-Line GM Tube	$3.0x10^{-6}$ Xe^{133}	10^1 to 10^6 CPM
Waste Processing Vent Exhaust (R-5410)	Off-Line GM Tube	$3.0x10^{-6}$ Xe^{133}	10^1 to 10^6 CPM
ECCS Pump Room Vent Exhaust (R-5406)	Off-Line GM Tube	$3.0x10^{-6}$ Xe^{133}	10^1 to 10^6 CPM
Gaseous Waste Discharge (R-2191)	In-Line GM Tube	$2.5x10^{-7}$ Kr^{85}	10^1 to 10^6 CPM
Containment[(a)] Atmosphere Particulate (R-5280)	Off-Line Scintillation	$7.09x10^{-12}$ Cs^{137}	10^1 to 10^6 CPM
Containment[(a)] Atmosphere Gaseous (R-5281)	Off-Line Scintillation	$1.0x10^{-7}$ Xe^{133}	10^1 to 10^6 CPM
Component Cooling (R-3819)	Off-Line Scintillation	$4.5x10^{-8}$ Cs^{137}	10^1 to 10^6 CPM
SRW (R-1595)	Off-Line Scintillation	$4.5x10^{-8}$ Cs^{137}	10^1 to 10^6 CPM
Steam Generator Blowdown Recovery System Discharge (R-4095)	Off-Line Scintillation	$3.77x10^{-8}$ Cs^{137}	10^1 to 10^6 CPM
Main Steam Header (R-5421, 5422)	Adjacent-to-Line GM Tube	$2.16x10^{-1}$ Cs^{137}	10^{-2} to 10^{+5} μCi/cc
Main Steam N-16 Header (R-5421A, 5422A)	Adjacent-to-Line Scintillation	$2.16x10^{-1}$ Cs^{137}	10^{-7} to 10^{-1} μCi/ml
Wide Range Effluent (R-5416A, 5417A, 5418A)	Off-Line Scintillation (R-5416A)	$2.0x10^{-7}$ Xe^{133}	10^1 to 10^{13} μCi/sec
	Solid State (R-5417A, 5418A)	$1.0x10^{-4}$ Xe^{133}	
Main Vent Gaseous Monitor (R-5415)	Off-Line Geiger Mueller (GM) Tube	$5.0x10^{-6}$ Xe^{133}	10^1 to 10^6 CPM
Access Control Vent (R-7030, 7031)	In Duct	$1.0x10^{-6}$ Xe^{133}	10^{-6} to 10^{-1} CPM

TABLE 11-10

PROCESS AND EFFLUENT RADIATION MONITORS

(a) Operability of this detector ensures that RCS boundary leakage detection can be monitored during normal operation. The setpoint is reduced to a point as close as practical to the background level without incurring spurious alarms in order to enhance leak detection capabilities. The detectors are described in Sections 11.2.3.2.7 and 4.3.