process area with remote actuated valves for controlling process flow between process stations and permanently installed equipment. The radwaste building control room is located away from high activity sources. Permanently installed cubical walls provide shielding sufficient to maintain a general area radiation level inside the control room below 10 μSv/hr. Cubical walls surrounding installed radioactive waste tanks and components are also designed to reduce the radiation level to less than 10 μSv/hr in areas where routine worker access is required.

LWMS and SWMS process systems are located in the radwaste building process systems area, as shown in Figures 12.3-21 and 12.3-41. LWMS and SWMS process systems are described in DCD Section 11.2 and 11.4, respectively. Radiation levels in the radwaste building process systems area shown in Figure 12.3-21 will vary based on site-specific processing technology and process control considerations. LWMS and SWMS process subsystems include modular shielding and controls sufficient to limit accessible general area radiation levels to less than 10 mSv/hr during normal processing. Radiation levels are limited to permit infrequent operator access to perform activities such as component flushing or sampling. Transient radiation levels during filter media or waste container transfer operations may exceed these levels, but radwaste building and process system provisions for remote operation limit average worker radiation dose rates to less than 150 μSv/hr during these operations.

The radwaste building process systems area is designed to accommodate modular shield walls to further limit access and reduce radiation levels from waste processing equipment.

Dry active waste (DAW) sorting, processing, and packaging operations are also performed in the radwaste building. These operations rely on portable radiation detectors, portable shielding, and remote handling tools when appropriate to reduce radiation levels and occupational exposure.

12.3.1.5 Minimization of Contamination and Radioactive Waste Generation

The ESBWR design features and operational programs that aid in the minimization of contamination of the facility and environment, facilitate decommissioning, and aid in the minimization of the generation of radioactive waste in compliance with Title 10, Section 20.1406, "Minimization of Contamination," of the Code of Federal Regulations (10 CFR 20.1406) (Reference 12.3.1.5.4-1) are discussed in this section.

Design concepts associated with Regulatory Position C.1 through C.4 of Regulatory Guide 4.21 (Reference 12.3.1.5.4-2) are addressed in this section. The COL Applicant will describe operational procedures and program concepts associated with the Regulatory Position. A summary of the relevant design and operational concepts from the Regulatory Position are described in the following subsections.

12.3.1.5.1 Design Considerations

The following design objectives summarize the objectives contained in Regulatory Position C.1 through C.4 of Regulatory Guide 4.21:

- Objective 1 - Minimize leaks and spills and provide containment in areas where such events might occur.
- Objective 2 - Provide adequate leak detection capability to provide prompt detection of leakage from any structure, system, or component that has the potential for leakage.

- Objective 3 - Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult (inaccessible) to conduct regular inspections (such as spent fuel pools, tanks that are in contact with the ground, and buried, embedded, or subterranean piping) to avoid release of contamination.
- Objective 4 - Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.
- Objective 5 - Facilitate decommissioning by (1) minimizing embedded and buried piping, and (2) designing the facility to facilitate the removal of any equipment or components that may require removal or replacement during facility operation or decommissioning.
- Objective 6 - Minimize the generation and volume of radioactive waste during operation and decommissioning (by minimizing the volume of components and structures that become contaminated during plant operation).

ESBWR design features that address the above design objectives are described in individual DCD Tier 2 sections and subsections. Table 12.3-18 provides a cross reference of applicable DCD chapters and subsections for structures/systems that address the six design objectives. Note that the systems/structures that employ the subject design features are of varied construction and purpose and can provide differing functions. As such, not all of the above design concepts are present as a design feature in each system/structure. Additionally, examples of generic and specific design features present in the ESBWR are listed below.

Generic ESBWR design features used to minimize contamination and generation of radioactive waste and facilitate decommissioning include the following:

- Design of equipment to minimize the buildup of radioactive material and to facilitate flushing of crud traps;
- Provisions for design features to plant systems such as the Reactor Water Cleanup/Shutdown Cooling System, liquid and solid radwaste systems and the condensate demineralizer to minimize crud buildup;
- Provisions for draining, flushing, and decontaminating equipment and piping;
- Penetrations through outer walls of a building containing radiation sources are sealed to prevent miscellaneous leaks to the environment;
- Equipment drain sump vents are hard-piped directly to the radwaste HVAC System to collect airborne contaminants released from discharges to the sump;
- Appropriately sloped floors around floor drains in areas where the potential for a spill exists to limit the extent of contamination. The floor drains are monolithic in construction to minimize possibility of liquid penetrating at embedment boundaries. No grout is used in the installation of floor drains. Periodic visual inspections of the installation around the floor drains are performed to ensure no bypass exists in these floor drain areas;
- Provisions for decontaminable epoxy-type wall and floor coverings, which provide smooth surfaces to ease decontamination. Epoxy-type coatings are applied to both steel surfaces and concrete areas appropriate for contamination control. These areas consist of

the walls and floors of the Reactor, Fuel, and Turbine Buildings, radwaste areas, rooms containing equipment with liquid radioactive sources, floor drain areas, washdown bays, and the Radwaste Tunnel;

- Equipment and floor drain sumps are stainless steel lined to reduce crud buildup (corrosion) and provide surfaces that are easily decontaminated;
- For all areas with potential airborne radioactivity, the ventilation systems are designed such that during normal and maintenance operations, airflow between areas is always from an area of low potential contamination to an area of higher potential contamination;
- The ESBWR is designed to limit the use of cobalt bearing materials on moving components that have historically been identified as major sources of radioactivity in water;
- To facilitate decommissioning, the Reactor, Fuel, Turbine, and Radwaste Buildings are designed for large equipment removal, consisting of entry doors from the outside and numerous equipment hatches within the buildings;
- To facilitate decommissioning and ease of access, the radwaste process systems are skid-mounted and located in the radwaste building to allow truck access, and system skid loading and unloading;
- For some piping, feed-throughs with short sections, the piping may be embedded in concrete as discussed in DCD Tier 2 Subsection 12.3.1.2.4. Minimization of short sections with embedded piping to the extent practicable facilitates the dismantlement of the systems and decommissioning;

Specific ESBWR design features used to minimize the generation of radioactive waste include the following:

- LWMS is divided into several subsystems, so liquid wastes from various sources can be segregated and processed separately, based on the most efficient process for each specific type of impurity and chemical content. This segregation allows for efficient processing and minimization of overall liquid waste.
- During liquid processing by LWMS, radioactive contaminants are removed and the bulk of the liquid is purified and either returned to the condensate storage tank or discharged to the environment, minimizing overall liquid waste. The radioactivity removed from liquid waste is concentrated in filter media ion exchange resins and concentrated waste. The filter sludge, ion exchange resins and concentrated waste are discharged to SWMS for further processing.
- SWMS is designed to segregate and package wet and dry types of radioactive solid waste for off-site shipment and storage. This segregation allows for efficient processing and minimization of overall quantity of solid waste.
- For management of gaseous radioactive waste, the Offgas System (OGS) minimizes and controls the release of radioactive material into the atmosphere by delaying release of the offgas process stream initially containing radioactive isotopes of krypton, xenon, iodine, nitrogen, and oxygen.

12.3.1.5.2 Operational/Programmatic Considerations

Operational programs and procedures that address the requirements of 10 CFR 20.1406 are necessary adjuncts of the design features. The following operational and post-construction objectives summarize Regulatory Guide 4.21 Position C.1 through C.4 and are addressed by the COL applicants:

- Periodically review operational practices to ensure operating procedures reflect the installation of new or modified equipment, personnel qualification and training are kept current, and facility personnel are following the operating procedures.
- Facilitate decommissioning by maintenance of records relating to facility design and construction, facility design changes, site conditions before and after construction, onsite waste disposal and contamination and results of radiological surveys.
- Develop a conceptual site model (based on site characterization and facility design and construction) that aid in the understanding of the interface with environmental systems and the features that control the movement of contamination in the environment.
- Evaluate the final site configuration after construction to assist in preventing the migration of radionuclides offsite via unmonitored pathways.

The COL Applicant will address the operational and post-construction objectives of Regulatory Guide 4.21 (COL 12.3.1.5-1-A).

12.3.1.5.3 COL Information

12.3.1.5-1-A Compliance with 10 CFR 20.1406

The COL Applicant will address the operational and post-construction objectives of Regulatory Guide 4.21 (Subsection 12.3.1.5.2).

12.3.1.5.4 References

12.3.1.5.4-1 Title 10 Code of Federal Regulations, Part 20.1406, "Minimization of Contamination."

12.3.1.5.4-2 USNRC, "Minimization of Contamination and Radioactive Waste Generation: Life Cycle Planning," Regulatory Guide 4.21, June 2008.

12.3.2 Shielding

12.3.2.1 General Design Guides

The primary objective of the radiation shielding is to protect operating personnel and the general public from radiation emanating from the reactor, the power conversion systems, the radwaste process systems, and the auxiliary systems, while maintaining appropriate access for operation and maintenance. The radiation shielding is also designed to keep radiation doses to equipment below levels where disabling radiation damage occurs.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
3.1	Design of Structures, Components, Equipment, and Systems: Conformance With NRC General Design Criteria
3.1.2.5 Criterion 14 — Reactor Coolant Pressure Boundary	Piping and equipment pressure parts of the RCPB are assembled and erected by welding unless applicable codes permit flanged or threaded joints. Welding procedures are employed which produce welds of complete fusion that are free of unacceptable defects.
3.4	Design of Structures, Components, Equipment, and Systems: Water Level (Flood) Design
3.4.1.2 Flood Protection From External Sources	These provisions include: • Walls below flood level designed to withstand hydrostatic loads. • Water stops provided in all expansion and construction joints below flood and groundwater levels. • Waterproofing of below flood and groundwater levels external surfaces. • Water seals at pipe penetrations below flood and groundwater levels. • Roofs designed to prevent pooling of large amounts of water in accordance with RG 1.102. • No exterior access openings below grade. The flood protection measures that are described above are not only for external natural floods but also guard against flooding from on-site storage tank rupture. Such tanks are designed and constructed to minimize the risk of catastrophic failure and are located to allow drainage without damage to site facilities.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
3.4.1.3 Internal Flooding Evaluation Criteria	All safety-related components that affect the safe shutdown of the plant are located in the Reactor Building (RB) and Control Building (CB). Redundant systems and components are physically separated from each other and from nonsafety-related systems. If the failure of a system results in one division being inoperable, a redundant division is available to perform the safe shutdown of the plant. Protective features used to mitigate or eliminate the consequences of internal flooding are: • Structural enclosures or barriers • Curbs and sills • Leakage detection components • Drainage systems Spray damage is avoided by appropriate location of equipment or pipe or by providing protection from water spray. Doors and penetrations rated as 3 hour barriers are assumed to prevent water spray from crossing divisional boundaries
3.4.1.4 Evaluation of Internal Flooding	The RB and CB drain collection system and sumps are designed and separated so that drainage from a flooded compartment containing equipment for a train or division does not flow to compartments containing equipment for another system train or division. Zones that are isolated by watertight doors provide physical separation. Watertight doors between flood divisions have open/close sensors with status indication and alarms in the main control room. The location of the zones prevents two redundant trains from being affected by the flooding at the same time.
3.7	Design of Structures, Components, Equipment, and Systems: Seismic Design
3.7.3.13 Seismic Category I Buried Piping, Conduits and Tunnels	There are no Seismic Category I utilities i.e. piping, conduits, or auxiliary system components that are directly buried underground. There are no Seismic Category I tunnels in the ESBWR design. The access tunnel, which includes walkways between and access to RB, CB, TB, and Electrical Building is classified Seismic Category II. Since Seismic Category II structures are designed to the same criteria as Seismic Category I structures there is no impact to adjacent Seismic Category I structures. The Radwaste Tunnel provides for pipes that transport radioactive waste to the Radwaste Building from RB and TB. The Radwaste Tunnel is classified non-seismic but the structural acceptance criteria are in accordance with RG 1.143 – Safety Class RW-IIa.
3.8	Design of Structures, Components, Equipment, and Systems: Seismic Category I Structures

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
3.8.1.1.1 Concrete Containment	The containment is a low-leakage reinforced concrete structure with an internal steel liner in the drywell and wetwell to serve as a leaktight membrane. The containment and the structures integrated with the containment are constructed of cast-in-place, reinforced concrete.
3.8.1.1.2 Containment Liner Plate	The internal surface of the containment is lined with welded steel plate to form a leaktight barrier. The liner plate is fabricated from carbon steel, except that stainless steel plate or clad is used on wetted surfaces of the wetwell and Gravity-Driven Cooling System (GDCS) pools.
3.8.1.4.1.4 Corrosion Prevention	Type 304L stainless steel or clad carbon steel plate is used for the containment liner in the wetted areas of the suppression pool as protection against any potential pitting and corrosion on all wetted surfaces and at the water-to-air interface area. The suppression pool contains air-saturated, stagnant, high purity water and is designed for a 60-year life. The amount of corrosion is based on the annual temperature profile of suppression pool water for a typical plant in southern states under normal operation. Observations made on suppression pool water quality over a period of several years indicate that periodic pool cleaning such as by underwater vacuuming is required.
3.8.4.2.5 Welding of Pool Liners	All pool liner welds, including the spent fuel pool liner welds, are visually inspected before starting any other NDE method. The visual weld acceptance criteria are defined in AWS Structural Welding Code, D1.1. In accordance with approved procedures, the welded seams of the liner plate are inspected by: • Liquid Penetrant Examinations. To be carried out on all liner plate butt, fillet, corner and tee welds in accordance with ASME, Section V, Article 6 requirements. The acceptance criteria are in accordance with the requirements of ASME Section III, NE-5352. • Helium sniffer test or vacuum box technique in accordance with ASME Section V, Article 10 requirements. Any evidence of leakage is unacceptable.
3.8.6.1 Foundation Waterproofing	The selected waterproofing material for the bottom of the basemat is a chemical crystalline powder that is added to the mud mat mixture forming a waterproof barrier when cured. No membrane waterproofing is used under the foundations in ESBWR.
4.6	Reactor: Functional Design of Reactivity Control System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
4.6.2.1.4 CRD Maintenance	During removal of the lower housing (spool piece) following removal of the position indicator probes and motor unit, the control rod backseats onto the control rod guide tube. This metal-to-metal contact provides the seal that prevents draining of reactor water when the FMCRD is subsequently lowered out of the CRD housing. The control rod normally remains in this backseated condition at all times with the FMCRD out; however, in the unlikely event it also has to be removed, a temporary blind flange is first installed on the end of the CRD housing to prevent draining of reactor water.
5.2	Reactor Coolant System and Connected Systems: Integrity of Reactor Coolant Pressure Boundary
5.2.1.2 Applicable Code Cases	The reactor pressure vessel (RPV) and appurtenances and the RCPB piping and valves are designed, fabricated, and tested in accordance with the applicable edition of the ASME Boiler & Pressure Vessel Code (ASME Code), Section III, including addenda that were mandatory at the order date for the applicable components.
5.2.5.5 Criteria to Evaluate the Adequacy and Margin of Leak Detection System	For process lines that penetrate the containment, at least two different methods are used for detecting and isolating the leakage for the affected system. The instrumentation is designed to initiate alarms at established leakage limits and isolate the affected systems.
5.3	Reactor Coolant System and Connected Systems: Reactor Vessel
5.3.1.2 Special Procedures Used for Manufacturing and Fabrication	The RPV is constructed primarily from low alloy, high strength steel plate and forgings. All fabrication of the RPV is performed in accordance with GEH approved drawings, fabrication procedures, and test procedures. The shells and vessel heads are made from formed plates or forgings, whereas flanges and nozzles are made from forgings. Welding performed to join these vessel components is in accordance with procedures qualified per ASME Code Section III and IX requirements.
5.4	Reactor Coolant System and Connected Systems: Component and Subsystem Design
5.4.8.1.2 System Description	The system piping routed to the main condenser and LWMS is designed with sufficient wall thickness to ensure the stresses are within the stress limits even if subjected to full reactor pressure. Further, the low-pressure portion of the system is protected by the automatic closure of the overboard flow control valve upon detection of high pressure downstream of the pressure control valve. The system piping routed to the LWMS system is also protected from overpressurization by a pressure relief valve that relieves to the piping routed to the main condenser.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
5.4.9.2 Description	A main steamline drain subsystem is provided to drain flooded main steamlines after maintenance, to remove steam condensed during heatup and low power operations, and to provide pressure equalization around the outboard MSIVs during startup. The drain lines are routed to orificed headers, which are connected to the condenser hotwell.
6.1	Engineered Safety Features: Design Basis Accident Engineered Safety Feature Materials
6.1.2.1 Protective Coatings	Consistent with the rationale of RG 1.54, the WW and attendant vertical vents are designated as a Service Level I area. All surfaces and equipment in this area are either uncoated, corrosion resistant stainless steel, or coated in accordance with RG 1.54 and referenced ASTM standards, as applicable. Regardless of service level designation, all field applied epoxy coatings inside containment meet the requirements of RG 1.54 and are qualified using the standard ASTM tests, as applicable to procurement, installation, and maintenance.
6.2	Engineered Safety Features: Containment Systems
6.2.4.2.2 Instrument Lines Penetrating Containment	Sensing instrument lines penetrating the containment follow all the recommendations of RG 1.11, as follows: • Each line includes a 6 mm (¼ inch) diameter orifice such that in the event of a piping or component failure, leakage is reduced to the maximum extent practical consistent with other safety requirements. The rate of coolant loss is within the makeup capability, the integrity and functional performance of secondary containment and associated safety systems is maintained and the potential offsite exposure is substantially below the guidelines of 10 CFR 52.47(a)(2). • Each line is provided with a self-actuated excess flow check valve located outside containment, as close as practical to the containment. These check valves are designed to remain open as long as the flow through the instrument lines is consistent with normal plant operation; however, if the flow rate is increased to a value representative of a loss of piping integrity outside containment, the valves close. These valves reopen automatically when the pressure in the instrument line is reduced. • The instrument lines are designated as Quality Group B up to and including the isolation valve, located and protected to minimize the likelihood of damage, protected or separated to prevent failure of one line from affecting the others, accessible for inspection and not so restrictive that the response time of the connected instrumentation is affected.
6.5	Engineered Safety Features: Atmosphere Cleanup Systems

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
6.5.2.3 Reactor Building	Leakage through the MSIVs is routed through the main steamline drain lines to the main condenser. These large volumes and surface areas are effective mechanisms to hold up and plate out the relatively low leakage flow. The miscellaneous other penetrations that are based within the RB (for example, RWCU/SDC, FAPCS, RCCWS, etc.) are protected from excess leakage by one of the following methods: (1) Water inventories acting as seals to resist leakage and scrub entrained fission products, (2) Redundant automatic isolation valves, or (3) Closed loop piping systems qualified to maintain their pressure boundary function during the event.
6.5.2.4 Radwaste Building	The radwaste building is designed to contain any liquid releases by locating all high activity tanks in water-tight rooms designed to contain the maximum liquid release for that room. Airborne releases are routed by the Radwaste Building HVAC system through a HEPA filter to the radwaste building stack. Under loss of power conditions, the Radwaste Building HVAC system is isolated providing hold up of potential releases.
6.5.2.5 Turbine Building	The condensate filter backwash receiving tank is located in a water-tight room which would contain any liquid release for treatment by the radwaste system. Airborne releases are routed via the TB HVAC system to the TB stack.
9.1	Auxiliary Systems: Fuel Storage and Handling
9.1.2.1 Design Bases	GDC 61 - Compliance with GDC 61 is demonstrated by conformance with applicable provisions of RG 1.13. These include design to control airborne release of radioactive material; design of drains, gates, and weirs to prevent drainage of coolant inventory below an adequate shielding depth; provision of adequate coolant flow to spent fuel racks; and a system for detecting and containing spent fuel pool liner leakage. These design features have been included in accordance with the applicable guidance of RG 1.13 and comply with GDC 61 requirements.
9.1.3.2 Fuel and Auxiliary Pools Cooling System Description	With the exception of the suppression pool suction line, anti-siphoning devices are used on all submerged FAPCS piping to prevent unintended drainage of the pools.
9.1.4.11 Under-Vessel Servicing Equipment	The in-core monitoring seal flushing equipment is designed to prevent leakage of primary coolant from in-core detector housings during detector replacement.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.2	Auxiliary Systems: Water Systems
9.2.2.2 Reactor Component Cooling Water System Description	The RCCWS provides cooling water to nonsafety-related components in the Nuclear Island and provides a barrier against radioactive contamination of the PSWS.
9.2.6.1 Condensate Storage and Transfer System Design Bases	The Condensate Storage and Transfer System is designed to: • Provide an enclosed area to retain any tank overflow or leakage until an appropriate disposal action is taken
9.2.6.2 Condensate Storage and Transfer System Description	Condensate Storage Tank: The tank overflows to the enclosed retention area. A basin surrounding the tank is designed to prevent uncontrolled runoff in the event of a tank failure. The enclosed space is sized to contain the total tank capacity. Tank overflow is also collected in this space. A sump is provided inside the retention area with provisions for sampling collected liquids prior to routing them to the Liquid Waste Management System or the storm sewer as per sampling and release requirements. These design features preclude uncontrolled releases to the environment.
9.2.8.1 Turbine Component Cooling Water System Design Bases	The TCCWS utilizes plate and frame type heat exchangers. This design mitigates cross-contamination between TCCWS and the PSWS.
9.3	Auxiliary Systems: Process Auxiliaries
9.3.2.3 Process Sampling System Safety Evaluation	Safety/relief valves, vented to the drain headers, are provided in the stations for high-pressure process streams.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.3.3.1 Equipment and Floor Drain System Design Bases	The EFDS meets requirements of GDC 60 by providing a design to avoid the transfer of contaminated fluids to a non-contaminated drainage system for disposal. Drainage systems are designed to accommodate the maximum anticipated normal volumes of liquid without overflowing including such inputs as the anticipated water flow from a fire hose and other fire suppression water discharges to the area floor drains without impacting the safety function of any safety-related component or system. Systems are designed and arranged to minimize flooding of multiple compartments.
9.3.3.2 Equipment and Floor Drain System Description	The LCW Drain Subsystem collects liquid wastes from equipment drains in potentially contaminated systems. These liquids gravity drain to sumps located in the drywell and other areas. The drywell LCW drain, which is monitored for activity, is pumped to the LCW collection tank. The drywell LCW sump pump discharge line is provided with redundant containment isolation valves. The liquid wastes collected in the LCW sumps are also pumped to the LCW collection tank. The HCW Drain Subsystem collects liquid wastes from floor drains in potentially contaminated areas. These liquids gravity drain to sumps located in the drywell and other areas. The drywell HCW drain, which is monitored for activity, is pumped to the HCW collection tank. The drywell HCW sump pump discharge line is provided with redundant containment isolation valves. Liquids collected in the HCW sumps are also pumped to the HCW collection tank. The Detergent Drain Subsystem collects potentially contaminated wastes from the personnel decontamination stations, laundry, and shower facility drains and transfers them to the detergent drain collection tank. The Chemical Waste Drain Subsystem collects liquid wastes containing potentially contaminated chemicals and corrosive substances from washdown areas, laboratory drains, hot maintenance shop, and other miscellaneous sources in the plant. These liquid wastes are transferred to the chemical drain collection tank. Dedicated sumps in the EFDS collect vent and drain water from the closed loop RCCWS and direct the water to the Reactor Building Cooling Water Drain Subsystem. The size of this subsystem accommodates the draining of the largest isolable cooling water pipe segment in the Reactor Building. The sump contents are evaluated for radioactivity and water quality. If the cooling water is radioactively contaminated, it is directed to the LWMS, where it can be processed. If not, the cooling water may be recycled through a line tied back to the cooling water system.
9.4	Auxiliary Systems: Heating, Ventilation, and Air Conditioning

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.4.2.2 Fuel Building HVAC System Description	On detection of high radiation, the Process Radiation Monitoring System provides a signal that trips the FBGAVS and FBFPVS. Each subsystem's supply AHU and exhaust fan shuts down and their associated dampers close. Exhaust air from either subsystem may be manually diverted to the Fuel Building HVAC Purge Exhaust Filter Unit. It is then exhausted to the RB/FB vent stack by the Fuel Building HVAC Purge Exhaust Filter Unit exhaust fan. Normal ventilation for the area is resumed once the area is decontaminated or the source of radioactivity is removed.
9.4.3.1 Radwaste Building Heating, Ventilating and Air Conditioning System Design Bases	• The RWCRVS maintains the control room areas at a slightly positive pressure (design +31 Pa (+0.125"w.g.)) relative to adjacent areas to minimize infiltration of air. • The RWGAVS maintains the Radwaste Building general area at a slight negative pressure (design -31 Pa (-0.125"w.g.)) relative to adjacent areas and outside atmosphere to prevent the exfiltration of air to adjacent areas. The term "Slightly Negative Pressure" is applied hereafter and represents an allowable pressure range from less than zero to -124 Pa (-0.50"w.g.). Adequate exhaust from the trailer bays is provided to maintain inflow of air from the outside when the truck doors are open. • The RWGAVS is comprised of supply and exhaust subsystems to maintain direction of air flow from personnel occupancy areas towards areas of increasing potential contamination. Exhaust hoods are provided at locations where, under normal operation, contaminants could escape to the surrounding areas. • The RWGAVS provides the capability to exhaust air from the radwaste processing systems. • All exhaust air from the RWGA is discharged to the RWB vent stack. • Redundant components are provided as necessary to increase system reliability, availability and maintainability. • The RWGAVS limits the release of airborne radioactive particulates to the atmosphere by HEPA filtration of the exhaust air from the building prior to discharge to the atmosphere. • The exhaust air is monitored for radiation prior to discharge to atmosphere.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.4.4 Turbine Building HVAC System	The ESBWR: • Meets GDC 60 by suitably controlling the release of gaseous radioactive effluents to the environment. The system directs potentially contaminated building exhaust air to the TBVS system filtration units. Exhaust air from low potential contamination areas is exhausted to the TB vent stack, where it is monitored for radioactive contamination. Exhaust air from high potential contamination areas is filtered using High Efficiency Particulate Air (HEPA) filters before being exhausted to the TB vent stack. The HEPA filters assist in ensuring radioactive material entrained in gaseous effluent will not exceed the limits specified in 10 CFR Part 20, for normal operations and anticipated operational occurrences. TBVS high potential contaminated exhaust subsystems are equipped with HEPA filtration units for localized air cleanup prior to mixing with the main ventilation exhaust (TBE). The local HEPA units are designed, tested and maintained in accordance with Regulatory Guide 1.140. The TBE combined ventilation exhaust is monitored for halogens, particulates and noble gas releases. The TB Compartment area and normal ventilation HVAC PRMS subsystems monitor air for gross radiation levels and alarm functions. The TB is maintained at a slight negative pressure to minimize exfiltration. TB equipment rooms are maintained at a negative pressure to minimize potential airborne radioactivity escaping to adjacent areas or to the outside atmosphere during normal operation by exhausting air through filters from the areas in which a significant potential for contamination exists.
9.4.4.1 Turbine Building HVAC System Design Bases	The TBVS: • Minimizes the possibility of exhaust air recirculation into the air intake • Minimizes the escape of potential airborne radioactivity to the outside atmosphere during normal operation
9.4.4.2 Turbine Building HVAC System Description	Exhaust air from potentially high airborne contamination Turbine Building areas or component vents is collected, filtered, and discharged to the atmosphere through the Turbine Building Compartment Exhaust (TBCE) system. Exhaust air from other (low potential airborne contamination) Turbine Building areas and component vents is exhausted to the atmosphere through the Turbine Building Exhaust (TBE) system. Turbine Building exhaust air is directed to the TB vent stack where it is monitored for radiation prior to being discharged to the atmosphere.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.4.8 Drywell Cooling System	The ESBWR: • Meets GDC 60 by suitably controlling the release of gaseous radioactive effluents to the environment. During normal operation, the DCS re-circulates air with no connection to any HVAC system outside containment. Only during DW purge operations, is the containment air connected with the CONAVS subsystem of RBVS. During DW purge operations, the containment purge fan can be used to discharge containment air to the CONAVS subsystem. The CONAVS system has RB HVAC Purge Exhaust Filter Units that are designed, tested and maintained in accordance with Regulatory Guide 1.140.
9.4.8.2 Drywell Cooling System Description	The DCS is a closed loop recirculating air/nitrogen cooling system with no outside air/nitrogen introduced into the system except during refueling.
10.2	Steam and Power Conversion System: Turbine Generator
10.2.3.4 Turbine Design	• The expected reactor water quality exceeds the turbine manufacturer's requirements for steam and condensate purity.
10.3	Steam and Power Conversion System: Turbine Main Steam System
10.3.2.1 Turbine Main Steam System General Description	Accordingly, the TMSS includes connections that provide controlled water drainage from the main steam lines during various modes of operation. A drain line is connected to the low points of each main steam line, both inside and outside the containment. The drain lines are located at low points in the system, routed to a common header and are connected with isolation valves, as required, to allow drainage to the main condenser. Bypass lines with an orifice are provided around the valves to permit continuous draining of collected condensate from the steam line low points. The steam line drains maintain a downward slope from the steam system low points to the condenser. All horizontal runs of the main steam piping are sloped to the low point at the equalizing header with a slope of at least 1/100 of run, with the exception of the piping upstream of the turbine bypass valves which slopes away from the turbine bypass valves towards the steam source with a slope of at least 1/50 of run. Piping between the bypass valves and condenser is sloped toward the condenser. The drain piping is designed and routed such that non-vertical piping is sloped in the direction of flow with a slope of at least 1/100 of run.
10.4	Steam and Power Conversion System: Other Features of Steam and Power Conversion System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
10.4.1.2.3 Main Condenser System Operation	The condenser is also designed to receive relief valve discharges and any necessary venting from MSR vessels, feedwater heater shells, gland seal steam header, steam seal regulator, sampling system and various other steam and liquid supply lines. Spray pipes and baffles are designed to provide protection of the condenser tubes and components from high-energy inputs to the condenser. During normal operation, radioactive leakage to the atmosphere via circulating water does not occur because the main condenser shells operate at a vacuum and air leakage is into the shell side of the main condenser.
10.4.3.3 Turbine Gland Seal System Evaluation	Relief valve(s) on the seal steam header prevent excessive seal steam pressure. The valve(s) discharge to the condenser shell.
10.4.7.3 Condensate and Feedwater System Evaluation	The C&FS is designed to minimize leakage with welded construction utilized where practicable. Relief valve discharges and operating vents are channeled through closed systems. If it is necessary to remove a component from service such as a FW heater, pump, or control valve, continued operation of the system is possible by use of the multi-string arrangement and the provisions for isolating and bypassing selected equipment and sections of the system.
11.1	Radioactive Waste Management: Source Terms
11.1.5 Process Leakage Sources	Process leakage results in potential release of noble gases and other volatile fission products via ventilation systems. Liquid from process leaks is collected and routed to the liquid-solid radwaste system. Leakage of fluids from the process system results in the release of radionuclides into plant buildings. In general, the noble radiogases remain airborne and are released to the atmosphere with little delay via the building ventilation exhaust ducts. Other radionuclides partition between air and water and may plate-out on metal surfaces, concrete, and paint. Radioiodines are found in ventilation air as methyl iodide and as inorganic iodine (particulate, elemental, and hypoiodous acid forms). As a consequence of normal steam and water leakage into the drywell, equilibrium drywell concentrations exist during normal operation. Purging of this activity from the drywell to the environment occurs via the Reactor Building Contaminated Area HVAC Subsystem (CONAVS) as described in Subsection 9.4.6.2.
11.2	Radioactive Waste Management: Liquid Waste Management System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.2.1 Liquid Waste Management System Design Bases	All atmospheric liquid radwaste tanks are provided with an overflow connection at least the size of the largest inlet connection. The overflow is connected below the tank vent and above the high-level alarm setpoint. Each collection tank room is designed to contain the maximum liquid inventory in the event that the tank ruptures. Steel tank cubicle liners are utilized to preclude accidental releases to the environment. The radwaste tank cubical walls are sealed and coated.
11.2.2.2 Liquid Waste Management System Operation	The LWMS is operated at atmospheric and greater pressures. Tanks are vented to the atmosphere via the radwaste ventilation system described in Section 9.4. No condensing vapors are housed to create a vacuum. The vent is also large enough to accommodate the airflow associated with pumping down the tank at a maximum flowrate. Therefore, no adverse conditions are expected.
11.2.2.3.2 Liquid Waste Management System Tanks	All atmospheric liquid radwaste tanks are provided with an overflow connection at least the size of the largest inlet connection. The overflow is connected below the tank vent and above the high-level alarm setpoint. Each collection tank room is designed to contain the maximum liquid inventory in the event that the tank ruptures. Tank cubicles are lined with steel to preclude accidental releases to the environment. Concrete walls are sealed and coated for added protection. Tanks are vented to the radwaste ventilation system.
11.2.4 Liquid Waste Management System Testing and Inspection Requirements	A leak integrity test is performed on the system upon completion. Provisions are made for periodic inspection of major components to ensure capability and integrity of the systems. Process display devices are provided to indicate vital parameters required in routine testing and inspection.
11.3	Radioactive Waste Management: Gaseous Waste Management System
11.3.2.5.10 Offgas System Charcoal Adsorber Bypass	A piping and valving arrangement is provided, which allows isolation and bypass of the charcoal adsorber vessel that may have caught fire or become wetted with water, while continuing to process the offgas flow through the remaining adsorber vessels. The bypass valve arrangement is such that no single valve failure or valve mis-operation would allow total charcoal bypass. The bypass mode of charcoal operation is not normal for power operation. However, it may be used if the resulting activity release is acceptable.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.3.2.6.1 Offgas System Materials	Per RG 1.143 (Reference 11.3-3), Regulatory Position 2, materials for pressure-retaining components of process systems are selected from those covered by the material specifications listed in Section II, Part A of the ASME Boiler and Pressure Vessel Code, except that malleable, wrought or cast-iron materials, and plastic pipe are not allowed in this application. The components satisfy the mandatory requirements of the material specifications with regard to manufacture, examination, repair, testing, identification, and certification.
11.3.2.6.6 Offgas System Valves	No valves controlling the flow of process gas are located in the charcoal adsorber vault. For all valves exposed to process offgas, valve seats are designed to avoid sparks. All valves exposed to process gas have bellows stem seals, double stem seals or equivalent.
11.3.2.6.10 Offgas System Construction of Process Systems	Pressure-retaining components of process systems employ welded construction to the maximum practicable extent. Process piping systems include the first root valve on sample and instrument lines.
11.3.2.6.12 Offgas System Maintenance Access	Design features that reduce leakage and releases of radioactive material include the following: • Extremely stringent leak rate requirements placed upon all equipment, piping and instruments and enforced by requiring helium leak tests of the entire process system as described in Section 11.3.5. • Use of welded joints wherever practicable. • Specification of valve types with extremely low leak rate characteristics (i.e., bellows seal, double stem seal, or equal). • Routing of most drains through loop seals to the main condenser. • Specification of stringent seat-leak characteristics for valves and lines discharging to the environment
11.3.7.1 Radioactive Offgas System Leak or Failure Basis and Assumptions	The system is designed to be detonation resistant, and seismic per Table 3.2-1, and meets all criteria of RG 1.143 (Reference 11.3-3). As such, the failure of a single active component leading to a direct release of radioactive gases to the environment is highly unlikely.
11.4	Radioactive Waste Management: Solid Waste Management System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.4.1 SWMS Design Bases	• The SWMS is designed to prevent the release of significant quantities of radioactive materials to the environment so as to keep the overall exposure to the public within 10 CFR 20 limits and in accordance with the limits specified in 10 CFR 50, Appendix I (Reference 11.4-21). • All atmospheric collection and storage tanks are provided with an overflow connection at least the size of the largest inlet connection. The overflow is connected below the tank vent and above the high-level alarm setpoint. Each tank room is designed to contain the maximum liquid inventory in the event that the tank ruptures.
11.5	Radioactive Waste Management: Process Radiation Monitoring System
11.5.1.1.2 Radiation Monitors Required for Plant Operation	Additional functions include initiation of discharge valve isolation on the offgas or liquid radwaste systems if predetermined release rates would be exceeded, and provision for sampling at certain radiation monitor locations to allow determination of specific radionuclide content.
12.3.1	Radiation Protection: Facility Design Features
12.3.1.1.4 Valves	Valves back seats minimize leakage through the packing. Straight-through valve configurations were selected where practical, over those that exhibit flow discontinuities or internal crevices to minimize crud trapping. Teflon gaskets are not used.
12.3.1.1.7 Floor Drains	Floor drains with appropriately sloped floors are provided in shielded cubicles where the potential for spills exist. Those drain lines having a potential for containing highly radioactive fluids are routed through pipe chases, shielded cubicles, or are embedded in concrete walls and floors. Smooth epoxy-type coatings are employed to facilitate decontamination when a spill does occur.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
12.3.1.2.6 Contamination Control	Contaminated piping systems are welded to the most practical extent to minimize leaks through screwed or flanged fittings. For systems containing highly radioactive fluids, drains are hard piped directly to equipment drain sumps, rather than to allow contaminated fluid to flow across the floor to a floor drain. Certain valves in the main steam line are also provided with leakage drains piped to equipment drain sumps to reduce contamination of the steam tunnel. Pump casing drains are employed on radioactive systems whenever possible to remove fluids from the pump prior to disassembly. In addition, provisions for flushing with condensate, and in especially contaminated systems, for chemically cleaning the equipment prior to maintenance, are provided. Appropriately sloped floor drains are provided in shielded cubicles and other areas where the potential for a spill exists to limit the extent of contamination. Curbs are also provided to limit contamination and simplify washdown operations. A cask decontamination vault is located in the reactor building where the spent fuel cask and other equipment may be cleaned. The CRD maintenance room is used for disassembling control rod drives to reduce the contamination potential. The radwaste building is seismically designed in accordance with Regulatory Guide 1.143, Class RW-IIa. The tank cubicle concrete is provided with a sealant and a tank cubicle steel liner, as described in Subsection 11.2.2.3 to prevent any potential water releases from high activity areas to the environment. The main equipment washed down in the washdown bays is the spent fuel cask and its transporter. The spent fuel cask is decontaminated in the cask pit (room 21P2). After the spent fuel cask is loaded on the transporter, potential surface contamination is monitored and decontaminated in the washdown bays. Other equipment leaving the plant is also decontaminated inside the plant before loaded onto the transporter, monitored, and washed down if required in the washdown bays before leaving the Fuel Building. The washdown bays include the following design features to minimize the spread of contamination: • Walls or curbs located around areas of potential contaminated fluid leakage; • Floor surfaces sloped to drains, and sumps sized for cleanup water flow rate; • Concrete surfaces, including floor surfaces, which have the potential of being flooded or sprayed with radioactive liquid, are protected with a non-porous coating. Epoxy-type wall and floor coverings provide smooth surfaces for ease of decontamination; and • The decontamination fluid is processed through the liquid radwaste system as necessary, per plant operating procedures.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1- Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
12.3.1.4.3 Main Steam System	Providing valve drains that are piped to equipment drain sumps minimizes leakage from selected valves into surrounding areas. Floor drains are provided to minimize the spread of contamination should a leakage occur.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 2: Provide for adequate leak detection capability to provide detection of leakage for any SSC which has the potential for leakage	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
3.8	Design of Structures, Components, Equipment, and Systems: Seismic Category I Structures
3.8.4.2.5 Welding of Pool Liners	After construction is finished, each isolated pool is leak tested. The liner welds for all pools outside of the RCCV, including the spent fuel pool, are backed by leak chase channels and a leak detection system to monitor any leakage during plant operation. The leak chase channels are grouped according to the different pool areas and direct any leakage to area drains. This allows both leak detection and determination of where leaks originate.
5.2	Reactor Coolant System and Connected Systems: Integrity of Reactor Coolant Pressure Boundary
5.2.5.5 Criteria to Evaluate the Adequacy and Margin of Leak Detection System	For process lines that penetrate the containment, at least two different methods are used for detecting and isolating the leakage for the affected system. The instrumentation is designed to initiate alarms at established leakage limits and isolate the affected systems.
9.1	Auxiliary Systems: Fuel Storage and Handling
9.1.2.1 Spent Fuel Storage Design Bases	GDC 61 - Compliance with GDC 61 is demonstrated by conformance with applicable provisions of RG 1.13. These include design to control airborne release of radioactive material; design of drains, gates, and weirs to prevent drainage of coolant inventory below an adequate shielding depth; provision of adequate coolant flow to spent fuel racks; and a system for detecting and containing spent fuel pool liner leakage. These design features have been included in accordance with the applicable guidance of RG 1.13 and comply with GDC 61 requirements.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 2: Provide for adequate leak detection capability to provide detection of leakage for any SSC which has the potential for leakage	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.1.3.2 Fuel and Auxiliary Pools Cooling System Description	The FAPCS is designed to provide for the collection, monitoring, and drainage of pool liner leaks from the spent fuel pools, auxiliary pools, and IC/PCCS pools (refer to Table 9.1-1) to the Liquid Waste Management System. The spent fuel pool is equipped with drainage paths behind the liner welds. These paths are designed to: • Prevent stagnant water buildup behind the liner plate; • Prevent the uncontrolled loss of contaminated pool water; and • Provide liner leak detection and measurement. The reactor well, equipment storage pool, buffer pool, upper and lower fuel transfer pools, cask pool, and IC/PCCS pools are also equipped with stainless steel liners, and shall be equipped with leak detection drains as part of the FAPCS. All leak detection drains are designed to permit free gravity drainage to the Liquid Waste Management System.
9.2	Auxiliary Systems: Water Systems
9.2.1.2 Plant Service Water System Description	Means are provided to detect leakage into the PSWS from the RCCWS, which may contain low levels of radioactivity.
9.2.2.1 RCCWS Design Bases	The RCCWS is designed to limit leakage of radioactive or chemical contamination to the environment.
9.2.6.1 Condensate Storage and Transfer System Design Bases	The Condensate Storage and Transfer System is designed to: • Provide sampling of the retention area sump prior to disposal to determine if the activity of the sump contents is within 10 CFR 20 limits.
11.5	Radioactive Waste Management: Process Radiation Monitoring System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 2: Provide for adequate leak detection capability to provide detection of leakage for any SSC which has the potential for leakage	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.5 Process Radiation Monitoring System	The Process Radiation Monitoring System (PRMS) allows for determining the content of radioactive material in various gaseous and liquid process and effluent streams. The design objective and criteria are based on the following requirements: • Radiation instrumentation required for safety and protection, and • Radiation instrumentation required for monitoring and plant operation. All radioactive release points/paths within the plant are identified and monitored by this system. All other release points/paths of the plant are located in clean areas where radiological monitoring is not required. This system provides continuous monitoring and display of the radiation measurements during normal, abnormal, and accident conditions.
11.5.1.1.1 Radiation Monitors Required for Safety and Protection	The Radiation Monitoring Subsystems initiates appropriate protective actions to limit the potential release of radioactive materials to the environment if predetermined radiation levels are exceeded in major process/effluent streams. Another objective is to provide plant personnel with indication and alarm of the radiation levels in the major process/effluent streams.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 3: Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult or impossible to conduce regular inspections (such as for spent fuel pools, tanks that are in contact with the ground and buried, embedded, or subterranean piping) to avoid release of contamination from undetected leaks and to minimize contamination of the environment.

DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
3.8	Design of Structures, Components, Equipment, and Systems: Seismic Category I Structures
3.8.4.2.5 Welding of Pool Liners	The leak chase channels are grouped according to the different pool areas and direct any leakage to area drains. This allows both leak detection and determination of where leaks originate. The functioning of the leak chase channels are checked prior to completion of the pool liner installation.
5.2	Reactor Coolant System and Connected Systems: Integrity of Reactor Coolant Pressure Boundary
5.2.5.2 Leak Detection Instrumentation and Monitoring	The plant variables monitored for leakage are summarized in Tables 5.2-6 and 5.2-7 for areas within and outside the containment. The automatic LD&IS isolation functions that are provided for detection and isolation of gross leakage within the plant are identified in Table 5.2-6. The leakage parameters of the plant that are monitored and annunciated in the main control room are identified in Table 5.2-7.
5.2.5.5 Criteria to Evaluate the Adequacy and Margin of Leak Detection System	For process lines that penetrate the containment, at least two different methods are used for detecting and isolating the leakage for the affected system. The instrumentation is designed to initiate alarms at established leakage limits and isolate the affected systems.
9.1	Auxiliary Systems: Fuel Storage and Handling
9.1.2.1 Spent Fuel Storage Design Bases	GDC 61 - Compliance with GDC 61 is demonstrated by conformance with applicable provisions of RG 1.13. These include design to control airborne release of radioactive material; design of drains, gates, and weirs to prevent drainage of coolant inventory below an adequate shielding depth; provision of adequate coolant flow to spent fuel racks; and a system for detecting and containing spent fuel pool liner leakage. These design features have been included in accordance with the applicable guidance of RG 1.13 and comply with GDC 61 requirements.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 3: Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult or impossible to conduce regular inspections (such as for spent fuel pools, tanks that are in contact with the ground and buried, embedded, or subterranean piping) to avoid release of contamination from undetected leaks and to minimize contamination of the environment.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
9.1.3.2 Fuel and Auxiliary Pools Cooling System Description	The spent fuel pool is equipped with drainage paths behind the liner welds. These paths are designed to: • Prevent stagnant water buildup behind the liner plate; • Prevent the uncontrolled loss of contaminated pool water; and • Provide liner leak detection and measurement. The reactor well, equipment storage pool, buffer pool, upper and lower fuel transfer pools, cask pool, and IC/PCCS pools are also equipped with stainless steel liners, and shall be equipped with leak detection drains as part of the FAPCS. All leak detection drains are designed to permit free gravity drainage to the Liquid Waste Management System.
9.1.3.5 Fuel and Auxiliary Pools Cooling System Instrumentation and Control	The SFP and IC/PCCS pools contain backup nonsafety-related resistive type level indicators that can be operated using portable onsite power supplies to indicate when the pools have been replenished to their normal water level. All other pools (upper transfer pool, lower fuel transfer pool, cask pool, buffer pool, reactor well, dryer and separator storage pool) have local, nonsafety-related, panel-mounted level transmitters to provide signals for high/low-level alarms in the MCR.
9.2	Auxiliary Systems: Water Systems
9.2.2.5 Reactor Component Cooling Water System Instrumentation Requirements	RCCWS radiation monitors are provided for monitoring radiation levels and alerting the plant operator of abnormal radiation levels.
9.2.6.5 Condensate Storage and Transfer System Instrumentation Requirements	The makeup water control valve level transmitters control the CST water level. An alarm is initiated if the CST level decreases below the level that opens the makeup water valve. An alarm actuates in the MCR if the CST water level increases above the level that isolates makeup water to the tank. This alarm point is lower than the overflow level. CST level indication is provided in the MCR.
9.3	Auxiliary Systems: Process Auxiliaries

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 3: Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult or impossible to conduce regular inspections (such as for spent fuel pools, tanks that are in contact with the ground and buried, embedded, or subterranean piping) to avoid release of contamination from undetected leaks and to minimize contamination of the environment.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
9.3.2.2 Process Sampling System Description	Facilities for grab sampling and special monitoring are provided. Continuous samples are diverted to continuous monitoring equipment. The continuous monitoring equipment transmits signals to the plant computer located in the Main Control Room (MCR). Alarms are provided for indicating off-normal conditions. The sample station's effluents are returned to an appropriate process stream or to the radwaste drain headers through a common return line. ALARA is considered in station layout and design.
9.3.3.5 Equipment and Floor Drain System Instrumentation Requirements	Leaks in the drywell are detected by monitoring the rate of increase of the sump level. This function is provided by the Leak Detection and Isolation System as described in Subsection 5.2.5. Leak detection in other areas is accomplished by monitoring the frequency and duration of sump pump operation.
9.4	Auxiliary Systems: Heating, Ventilation, and Air Conditioning
9.4.4.2 Turbine Building HVAC System Description	The TBCE subsystem has radiation detectors in the exhaust duct to monitor the air for radioactivity prior to its being discharged to the TB vent stack.
9.4.6 Reactor Building HVAC System	The ESBWR: Meets GDC 60 by suitably controlling the release of gaseous radioactive effluents to the environment. The system may direct its exhaust air to the Reactor Building HVAC Purge Exhaust Filter Unit during periods of high radioactivity. The Reactor Building HVAC Purge Exhaust Filter Unit is designed, tested and maintained in accordance with Regulatory Guide 1.140. The RBVS (CONAVS and REPAVS) exhaust subsystems are equipped with control systems to automatically isolate the effluent on indication of a high radiation level. The RB boundary isolation dampers (CONAVS and REPAVS) close on receipt of a high radiation signal, or on a loss of AC power.
10.4	Steam and Power Conversion System: Other Features of Steam and Power Conversion System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 3: Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult or impossible to conduce regular inspections (such as for spent fuel pools, tanks that are in contact with the ground and buried, embedded, or subterranean piping) to avoid release of contamination from undetected leaks and to minimize contamination of the environment.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
10.4.2.2 Main Condenser Evacuation System Description	Process Radiation Monitoring System (PRMS) radiation detectors in the TBCE system and vent stack produce an alarm in the main control room if abnormal radioactivity is detected (Section 11.5). Radiation monitors are provided on the main steam lines, to trip and isolate the mechanical vacuum pump(s) if abnormal radioactivity is detected in the steam being supplied to the condenser.
10.4.3.5.1.4 Turbine Gland Seal System Effluent Monitoring	The TGSS effluents are normally monitored by a system-dedicated radiation monitor installed on the gland steam condenser exhauster blower discharge. High monitor readings are alarmed in the main control room. The system effluents are then discharged to the TBCE subsystem and the vent stack, where further effluent radiation monitoring is performed (Section 12.2 for the radiological analysis of the TGSS effluents).
10.4.5.6 Circulating Water System Flood Protection	Level switches are provided in the Turbine Building to trip the CIRC pumps and close the required valves in case of a CIRC system component failure. The flooding signal initiates from a high water level detection. In the hypothetical situation of a circulating water system pipe or expansion joint failure, if not detected and isolated, the water discharged would cause internal Turbine Building flooding above grade level, with excess water potentially spilling over on site. If a failure occurred within a condensate system (condenser shell side), the resulting flood level would be below grade level due to the relatively small hotwell inventory relative to the Turbine Building capacity.
11.2	Radioactive Waste Management: Liquid Waste Management System
11.2.2.1 Liquid Waste Management System Summary Description	Provisions for sampling at important process points are included. Protection against accidental discharge is provided by detection and alarm of abnormal conditions and by administrative controls.
11.2.3.2 Liquid Waste Management System Radioactive Releases	All radioactive releases will be discharged to the circulating water system. Prior to discharging to the environment, the contents of the tank being released are sampled and analyzed to ensure that the activity concentration is consistent with the discharge criteria of 10 CFR 20 (Reference 11.2-2) and dose commitment in 10 CFR 50, Appendix I (Reference 11.2-6). A radiation monitor provides an automatic closure signal to the discharge line isolation valve.
11.3	Radioactive Waste Management: Gaseous Waste Management System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 3: Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult or impossible to conduce regular inspections (such as for spent fuel pools, tanks that are in contact with the ground and buried, embedded, or subterranean piping) to avoid release of contamination from undetected leaks and to minimize contamination of the environment.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.3.2.5.9 Offgas System Redundancy	Design provisions are incorporated that preclude the uncontrolled release of radioactivity to the environment as a result of a single equipment failure, short of the equipment failure accident described in Subsection 11.3.7. An analysis of single equipment piece malfunctions is provided in Table 11.3-3. Design precautions taken to prevent uncontrolled releases of activity include the following: • All discharge paths to the environment are monitored. The Process Radiation Monitoring System (PRMS) monitors the normal effluent path and the Area Radiation Monitoring System monitors the equipment areas. • Dilution steam flow to the SJAE is monitored and alarmed, and the valving is required to be such that loss of dilution steam cannot occur without coincident closure of the process gas suction valve(s) so that the process gas is sufficiently diluted if it is flowing at all.
11.5	Radioactive Waste Management: Process Radiation Monitoring System
11.5.3.1.2 Reactor Building HVAC Exhaust Radiation Monitoring Subsystem	The detectors are physically located upstream of the ventilation exhaust duct isolation dampers such that closure of the dampers can be accomplished prior to exceeding radioactive effluent limits imposed by 10 CFR 20, Appendix B.
11.5.3.1.6 Isolation Condenser Vent Exhaust	The air space above the pool that contains the isolation condenser is exhausted to atmosphere through large-diameter discharge vents after first passing through a large face area passive-type steam dryer. Moisture removed by the dryer from the boil-off steam is ducted back to the IC pool. Each ventilation path, from the air space above the pool in which the isolation condenser is submerged, is monitored for radioactivity by a series of radiation monitors. Upon detection of radioactivity escaping the pool, as might be the case from a leak from the isolation condenser, the radiation monitors initiate closure of the containment isolation valves for the affected condenser. A closure setpoint is calculated to ensure isolation of the condenser prior to exceeding the applicable offsite regulatory guidelines (Subsections 11.5.4.4 and 11.5.4.5).

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 3: Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult or impossible to conduce regular inspections (such as for spent fuel pools, tanks that are in contact with the ground and buried, embedded, or subterranean piping) to avoid release of contamination from undetected leaks and to minimize contamination of the environment.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
11.5.3.1.9 Containment Purge Exhaust	The detectors are located adjacent to the exhaust ducting upstream of the ventilating system isolation valves. The detectors are physically located upstream of the ventilation exhaust duct isolation dampers such that closure of the dampers can be accomplished prior to exceeding radioactive effluent limits. The subsystem consists of four redundant instrument channels. Each channel consists of a gamma-sensitive detector and a MCR radiation monitor.
11.5.3.2.1 Offgas Pre-treatment	A continuous sample is extracted from the offgas pipe, then passed through a sample chamber and a sample panel before being returned to the suction side of the SJAE. The sample chamber is a stainless steel pipe that is internally polished to minimize plate-out. It can be purged with room air to check detector response to background radiation. Sample line flow is measured and indicated on the sample panel. A gamma-sensitive detector, positioned on the sample chamber, is connected to a local radiation monitor. The radiation level reading can be directly correlated to the concentration of the noble gases in the sample chamber by obtaining a grab sample at the sample panel. The sample is then removed and the sample is analyzed with a multi-channel gamma pulse height analyzer to determine the concentration of the various noble gas radionuclides. A correlation between the observed activity and the monitor reading permits calibration of the monitor.
11.5.3.2.2 Offgas Post-treatment	This subsystem monitors radioactivity for halogens, particulates and noble gas releases during normal and accident conditions in the offgas piping downstream of the OGS charcoal adsorbers and upstream of the OGS discharge valve. A continuous sample is extracted from the OGS piping, passed through two offgas post-treatment samplers for monitoring and sampling, and returned to the OGS piping. One sampler contains provisions for continuous gaseous, particulate and halogen radioactivity monitoring of the offgas post treatment process. The second sampler contains only provisions for continuous gaseous monitoring.

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Design Objective 3: Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult or impossible to conduce regular inspections (such as for spent fuel pools, tanks that are in contact with the ground and buried, embedded, or subterranean piping) to avoid release of contamination from undetected leaks and to minimize contamination of the environment.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
11.5.3.2.4 Turbine Building Combined Ventilation Exhaust	A representative sample is continuously extracted and passed through the sample panel for monitoring and sampling, and then returned to the TB Combined Ventilation Exhaust stream. Sampling is performed in accordance with ANSI/HPS N13.1 (Reference 11.5-13). Automatic compensation for variation in flow is provided to maintain the sample panel flow proportional to the main flow. The radiation detector assembly consists of shielded gas chambers that house gamma-beta sensitive detectors and check sources. A local radiation monitor analyzes and visually displays the measured radiation level. The subsystem has provisions for purging the sample panel with room air to check detector response to background radiation level reading.
11.5.3.2.16 Drywell Sumps LCW/HCW Discharge	This subsystem monitors the gross radiation level in the liquid waste transferred in the drain line from the drywell LCW and HCW sumps to the Radwaste System. Automatic sump pump trips occur if high radiation levels are detected during liquid radwaste transfers.

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Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
3.8	Design of Structures, Components, Equipment, and Systems: Seismic Category I Structures
3.8.4.1.7 Seismic Category I HVAC Ducts and HVAC Duct Supports	HVAC ducts are made of steel sheet metal and are supported at intervals by supports made of hot or cold rolled steel sections.
4.1	Reactor: Summary Description
4.1.2 Reactor Internal Components	Except for the Zircaloy in the reactor core, these reactor internals are stress corrosion-resistant stainless steels or other high alloy steels.
4.2	Reactor: Fuel System Design
4.2.1.1.4 Cladding Corrosion and Corrosion Product Buildup	Zircaloy cladding tubes undergo oxidation at slow rates during normal reactor operation and reactor water corrosion products (crud) are deposited on the cladding outside surface (Reference 4.2-10). The cladding oxidation causes thinning of the cladding tube wall and introduces a resistance to the fuel rod-to-coolant heat transfer. Crud buildup can also introduce a resistance to heat transfer. The expected extent of the oxidation and the buildup of the corrosion products is specifically considered in the fuel rod design analyses. Thus the impacts of the temperature increase, the correspondingly altered material properties and the thinning of the cladding wall resulting from cladding corrosion on fuel rod behavior relative to impacted design criteria (such as fuel temperature and cladding strain) are explicitly addressed.
4.2.4.8 Materials	Materials selected for use in the Marathon control rod components are chosen to minimize the component end-of-life radioactivity in order to reduce personnel exposure during handling on-site, and for final offsite shipping and burial. All Marathon control rod materials are less than 0.03 weight percent cobalt. The average niobium content for the handle and absorber section, less boron carbide and hafnium, is less than 0.1 weight percent.
5	Reactor Coolant System and Connected Systems:
5.1 Summary Description	The RWCU/SDC recirculates a portion of reactor coolant through a demineralizer to remove dissolved impurities with their associated corrosion and fission products from the reactor coolant.

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Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
5.2	Reactor Coolant System and Connected Systems: Integrity of Reactor Coolant Pressure Boundary
5.2.2.2.2 Equipment and Component Description	Each discharge stack has a drain line that drains condensed steam leakage to the suppression pool and is routed to a submerged discharge location in a wetwell vent to suppress any steam discharge.
5.2.3.2 Compatibility with Reactor Coolant	General corrosion and stress corrosion cracking induced by impurities in the reactor coolant can cause failures of the RCPB. The chemistry of the reactor coolant and any additives whose function is to control corrosion are reviewed in Subsections 5.4.8, 9.3.9 and 9.3.10. The compatibility of the materials of construction employed in the RCPB with the reactor coolant, contaminants, or radiolytic products to which the system is exposed has been considered. The extent of the corrosion of ferritic low alloy steels and carbon steels in contact with the reactor coolant has been considered. Similarly, consideration has been given to uses of austenitic stainless steels in the sensitized condition. Special attention has been given to the use of austenitic stainless steels in any condition in BWRs considering the oxygen content of BWR coolant.
5.2.3.2.3 Compatibility of Construction Materials with Reactor Coolant	Contaminants in the reactor coolant are controlled to very low limits. These controls are implemented by limiting contaminant levels of elements (such as halogens, S, Pb) to as low as possible in miscellaneous materials used during fabrication and installation. These materials (such as tapes, penetrants) are completely removed and cleanliness is assured. Lubricant and gasket materials that remain in contact with the coolant during operation are evaluated on that basis. No detrimental effects occur on any of the materials from allowable contaminant levels in the high purity reactor coolant. Expected radiolytic products in the BWR coolant have no adverse effects on the construction materials.
5.2.3.3.2 Control of Welding	Low-alloy steel is used only in RPV and feedwater piping. Other ferritic components in the RCPB are fabricated from carbon steel materials.
5.2.3.4 Fabrication and Processing of Austenitic Stainless Steels	Austenitic stainless steels in a variety of product forms are used for construction of a limited number of pressure-retaining components in the RCPB.
5.3	Reactor Coolant System and Connected Systems: Reactor Vessel
5.3.3.2.1 Summary Description	The cylindrical shell and top and bottom heads of the RPV are fabricated of low alloy steel, the interior of which is clad with stainless steel weld overlay, except for the top head and most nozzles. The main steam nozzles are clad with stainless steel weld overlay. The bottom head is clad with Ni-Cr-Fe alloy.

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DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
5.3.3.2.2 Reactor Vessel Design Data	(In Core Neutron Flux Monitor Housings)The housings are fabricated of low carbon austenitic stainless steel and are designed in accordance with ASME Section III, Subsection NB. The RPV insulation is reflective metal type, constructed entirely of series 300 stainless steel and designed for a 60-year life.
5.4	Reactor Coolant System and Connected Systems: Component and Subsystem Design
5.4.8.1.1 RWCU/SDC Design Bases	The RWCU/SDC system is designed to: • Remove solid and dissolved impurities from the reactor coolant and measure the reactor water conductivity during all modes of reactor operation. This is done in accordance with RG 1.56, "Maintenance of Water Purity in Boiling Water Reactors." • Enable unit operation within the guidelines of EPRI's "BWRVIP-130: BWR Vessel and Internals Project BWR Water Chemistry Guidelines."
5.4.8.1.2 RWCU/SDC System Description	The following RWCU/SDC system piping and components are constructed of stainless steel: • Bottom suction line up to and including the outboard containment isolation valve; • Bottom suction sampling line up to and including the outboard containment isolation valve; • Pump suction lines from pump suction valves up to and including the Demineralizer downstream isolation valve and demineralizer bypass valve; • Pumps; and • Demineralizer. The remainder of the system is constructed of carbon steel. Resin breakthrough to the reactor is prevented by a strainer in the demineralizer outlet line to catch the resin beads. The resin transfer system is designed to prevent resin traps in sluice lines. Consideration is given in the design to avoid resins collecting in valves, low points or stagnant areas. Interlocks are provided to prevent inadvertent opening of the demineralizer resin addition and backflushing valves during normal operation.

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DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
6.1	Engineered Safety Features: Design Basis Accident Engineered Safety Feature Materials
6.1.2.1 Protective Coatings	Consistent with the rationale of RG 1.54, the WW and attendant vertical vents are designated as a Service Level I area. All surfaces and equipment in this area are either uncoated, corrosion resistant stainless steel, or coated in accordance with RG 1.54 and referenced ASTM standards, as applicable. Regardless of service level designation, all field applied epoxy coatings inside containment meet the requirements of RG 1.54 and are qualified using the standard ASTM tests, as applicable to procurement, installation, and maintenance.
6.2	Engineered Safety Features: Containment Systems
6.2.3 Reactor Building Functional Design	During normal plant operation, potentially contaminated areas within the RB are kept at a negative pressure with respect to the environment while clean areas are maintained at positive pressure. The ESBWR does not need, and thus has no filter system that performs a safety-related function following a design basis accident, as discussed in Subsection 6.5.2.3.
6.2.4.3.2.2 Effluent Lines from Containment	Process Radiation Monitoring System - The penetrations for the fission products monitor sampling lines consist of one sampling line and one return line. Each line uses three tandem stop or shutoff valves. One valve is a manual-operated valve used for maintenance and is located close to the containment. The other two valves are pneumatic, solenoid or equivalent power operated valves and are used for isolation. All three valves are located outside the containment for easy access. The piping to these valves is considered an extension of the containment boundary.
6.5	Engineered Safety Features: Atmosphere Cleanup Systems

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Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
6.5.2.3 Reactor Building	Under normal conditions, the contaminated areas (CONAVS and REPAVS subsections) air flow is maintained from clean to potentially contaminated areas and then routed via the respective RB HVAC subsystem to the RB/FB vent stack. The controlled (CONAVS served) area of the RB surrounds most of the containment (except feedwater and MSIV containment penetrations located in the main steam tunnel) and provides a barrier for airborne leakage of fission products resulting from containment leakage including containment penetrations. Toward this end, most penetrations into the containment (with the exception of the main steam lines, the feedwater lines, the ICs, and miscellaneous other penetrations) terminate in this volume. The second isolation valves on all GDC 54 lines (with the exception of the IC containment isolation valves) are found in this volume such that any potential valve leakage as well as penetration leakage collects in here. The CONAVS area of the RB under accident conditions is automatically isolated or passively sealed (for example, water loop seals) to provide a hold up barrier. When isolated, the RB can be serviced by the HEPA and charcoal filtration systems of the RB Purge Exhaust Filter Unit (Subsection 9.4.6). With low leakage and stagnant conditions, hold up mechanisms perform the basic mitigating functions.
9.1	Auxiliary Systems: Fuel Storage and Handling
9.1.1.4 New Fuel Storage Material Considerations	Material used in the fabrication of the new fuel storage racks is limited to the use of stainless steel in accordance with the latest issue of the applicable ASTM specifications at the time of equipment order. The new fuel racks are fabricated from Type 304L stainless steel, which conforms to ASTM A240/A240M. The appropriate weld wire for the Type 304L components (E308L or ER308L) is utilized in the fabrication process. Materials are chosen for their corrosion resistance and their ability to be formed and welded with consistent quality.
9.1.2.4 Spent Fuel Storage Mechanical and Structural Design	The Spent Fuel Pool and buffer pool are reinforced concrete structures with a stainless steel liner. Materials used for construction are specified in accordance with the latest issue of applicable ASTM specifications at the time of equipment order. The racks are constructed in accordance with the quality assurance requirements of 10 CFR 50, Appendix B.

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DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.1.2.6 Spent Fuel Storage Material Considerations	Material used in the fabrication of the spent fuel storage racks is limited to the use of stainless steel in accordance with the latest issue of the applicable ASTM specifications at the time of equipment order. The spent fuel rack ends are fabricated from Type 304L stainless steel, which conforms to ASTM A240/A240M. The appropriate weld wire for the Type 304L components (E308L or ER308L) is utilized in the fabrication process. The interlocking panels that form the fuel element storage matrix are fabricated from Type 304B7 borated stainless steel, which conforms to ASTM A 887 (UNS Designation S30467, Grade B, 1.75-2.25% boron inclusion). There is no welding of borated stainless steel. Fuel rack feet are fabricated from Type 630 (17-4PH) age-hardened stainless steel, which conforms to ASTM A564/A564M. Materials are chosen for their corrosion resistance and their ability to be formed and welded with consistent quality. The storage tube material is permanently marked with identification traceable to the material certifications. The fuel storage tube assembly is compatible with the environment of treated water and provides a design life of 60 years.
9.1.3.2 Fuel and Auxiliary Pools Cooling System Description	Each water treatment unit is equipped with a prefilter, a demineralizer and a post strainer. A bypass line is provided to permit bypass of the water treatment unit, when necessary. To protect demineralizer resin, the water treatment units are bypassed automatically on a high temperature signal. The prefilter and demineralizers of the water treatment units are located in shielding cells so that radiation exposure of plant personnel is within acceptable limits. Proper physical separation is provided between the active components of the two redundant trains to assure operation of one train in the event of failure of the other train. Any leakage of high-pressure coolant through the safety-related check valves is discharged through the pressure relief valve and measured before being sent to the Liquid Waste Management System. Redundant valves are contained in separate fire zones for improved reliability. All FAPCS lines penetrating the containment that do not have a post-accident recovery function are automatically isolated upon receipt of a containment isolation signal from Leak Detection and Isolation System (LD&IS).
9.1.4.7 Servicing Aids	A portable, submersible underwater vacuum cleaner to help remove crud or miscellaneous loose matter from the reactor vessel or storage pools. The required pump and filter is also submersible for extended periods. The filter can be changed remotely and disposed of in standard containers after use for offsite burial.
9.2	Auxiliary Systems: Water Systems

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DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.2.2.2 Reactor Component Cooling Water System Description	The RCCWS provides cooling water to nonsafety-related components in the Nuclear Island and provides a barrier against radioactive contamination of the PSWS.
9.2.6.2 Condensate Storage and Transfer System Description	The CS&TS equipment and associated piping are fabricated from stainless steel to prevent contamination of the system water.
9.2.8.1 Turbine Component Cooling Water System Design Bases	The TCCWS utilizes plate and frame type heat exchangers. This design mitigates cross-contamination between TCCWS and the PSWS.
9.3	Auxiliary Systems: Process Auxiliaries
9.3.2.2 System Description	Sampling lines and associated valves and fittings are fabricated from stainless steel.
9.3.2.3 Safety Evaluation	The sampling stations are closed systems and the grab samples taken at the sampling stations have a chemical fume hood to preclude the exposure of operating personnel to contamination hazards. A constant air velocity is maintained through the working face of the hoods to ensure that airborne contamination does not escape to the room under operating conditions.
9.4	Auxiliary Systems: Heating, Ventilation, and Air Conditioning
9.4.1 Control Building HVAC System	The Control Building does not house any portion of the nuclear steam supply process or other equipment that can act as a source of radioactive material; and therefore has no postulated sources of radioactive materials in either particulate or gaseous form. Therefore, the CB exhaust systems require no filtration or adsorption capability.
9.4.1.1 Control Building HVAC System Design Bases	The CBVS: • Reduces the potential spread of airborne contamination by maintaining airflow from areas of lower potential for contamination to areas of greater potential for contamination. The CRHA is maintained at a higher pressure than surrounding areas except during the isolation and smoke exhaust modes. • Detects and limits the introduction of airborne hazardous materials (radioactivity or smoke) into the CRHA

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DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
9.4.2.1 Fuel Building HVAC System Design Bases	The Fuel Building HVAC System: • Maintains a negative pressure in the building to minimize exfiltration of potentially contaminated air.
9.4.3.1 Radwaste Building HVAC System Design Bases	• The RWCRVS maintains the control room areas at a slightly positive pressure (design +31 Pa (+0.125"w.g.)) relative to adjacent areas to minimize infiltration of air. • The RWGAVS maintains the Radwaste Building general area at a slight negative pressure (design -31 Pa (-0.125"w.g.)) relative to adjacent areas and outside atmosphere to prevent the exfiltration of air to adjacent areas. The term "Slightly Negative Pressure" is applied hereafter and represents an allowable pressure range from less than zero to -124 Pa (-0.50"w.g.). Adequate exhaust from the trailer bays is provided to maintain inflow of air from the outside when the truck doors are open. • The RWGAVS is comprised of supply and exhaust subsystems to maintain direction of air flow from personnel occupancy areas towards areas of increasing potential contamination. Exhaust hoods are provided at locations where, under normal operation, contaminants could escape to the surrounding areas. • The RWGAVS provides the capability to exhaust air from the radwaste processing systems. • All exhaust air from the RWGA is discharged to the RWB vent stack. • Redundant components are provided as necessary to increase system reliability, availability and maintainability. • The RWGAVS limits the release of airborne radioactive particulates to the atmosphere by HEPA filtration of the exhaust air from the building prior to discharge to the atmosphere. • The exhaust air is monitored for radiation prior to discharge to atmosphere.

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DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.4.4 Turbine Building HVAC System	The ESBWR: • Meets GDC 60 by suitably controlling the release of gaseous radioactive effluents to the environment. The system directs potentially contaminated building exhaust air to the TBVS system filtration units. Exhaust air from low potential contamination areas is exhausted to the TB vent stack, where it is monitored for radioactive contamination. Exhaust air from high potential contamination areas is filtered using High Efficiency Particulate Air (HEPA) filters before being exhausted to the TB vent stack. The HEPA filters assist in ensuring radioactive material entrained in gaseous effluent will not exceed the limits specified in 10 CFR Part 20, for normal operations and anticipated operational occurrences. TBVS high potential contaminated exhaust subsystems are equipped with HEPA filtration units for localized air cleanup prior to mixing with the main ventilation exhaust (TBE). The local HEPA units are designed, tested and maintained in accordance with Regulatory Guide 1.140. The TBE combined ventilation exhaust is monitored for halogens, particulates and noble gas releases. The TB Compartment area and normal ventilation HVAC PRMS subsystems monitor air for gross radiation levels and alarm functions. The TB is maintained at a slight negative pressure to minimize exfiltration. TB equipment rooms are maintained at a negative pressure to minimize potential airborne radioactivity escaping to adjacent areas or to the outside atmosphere during normal operation by exhausting air through filters from the areas in which a significant potential for contamination exists.
9.4.4.2 Turbine Building HVAC System Description	The air exhausted from the TBDRE, once filtered, passes through the air filtration unit of TBE subsystem and is finally released to the atmosphere through the TB vent stack.

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DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.4.6.1 Reactor Building HVAC System Design Bases	The RBVS: • Maintains potentially contaminated areas at a negative pressure to minimize exfiltration of potentially contaminated air. • Maintains clean areas of the building, except for the battery rooms, at a positive pressure to minimize infiltration of outside air. • Maintains airflow from areas of lower potential for contamination to areas of greater potential for contamination. The pressure in these areas hereafter called "Slightly Negative Pressure" is a range from less than zero to –124 Pa (-0.50"w.g.). • Shuts down during radiological events and isolates the Reactor Building boundary (CONAVS and REPAVS subsystems) to prevent uncontrolled releases to the outside atmosphere.
9.4.6.2 Reactor Building HVAC System Description	CONAVS: A common supply air duct distributes conditioned air to the potentially contaminated areas of the Reactor Building. Air is exhausted from the potentially contaminated areas of the Reactor Building by the operating exhaust fan and discharged to the RB/FB vent stack. The RB purge exhaust filter units are equipped with pre-filters, HEPA filters, high efficiency filters and carbon filters for mitigating and controlling gaseous effluents from the Reactor Building. REPAVS: During a radiological event, exhaust air from the refueling area may be manually diverted through the Reactor Building HVAC Purge Exhaust Filter Units. The building isolation dampers close and the supply and exhaust fans stop due to high radiation in the exhaust ducts. CLAVS: A mixture of outside and return air is filtered and heated/cooled prior to distribution by the AHU in service. A common supply and return/exhaust air duct system distributes conditioned air to and from the Reactor Building clean areas.

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DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.4.7.1 Electrical Building HVAC System Design Bases	The TSCVS: • Maintains the TSC at a slightly positive pressure with respect to the adjacent rooms and outside environment to minimize the infiltration of air. The pressure hereafter called “Slightly Positive Pressure” is a range from greater than zero to +124 Pa (+0.50” w.g.). The TSCVS automatically switches to the recirculation mode if smoke is detected in the outside intake air. In this case, there may be no differential pressure between the TSC and the surrounding areas. • Detects and limits the introduction of airborne hazardous materials (radioactivity or smoke) into the TSC.
10.2	Steam and Power Conversion System: Turbine Generator
10.2.3.4 Turbine Design	The design of the turbine: • Nuclear Boiler System (NBS) chemistry and thus Turbine Main Steam System (TMSS) chemistry are carefully controlled to minimize the potential effects of pitting and stress corrosion cracking of turbine rotors and blades. Expected ESBWR water quality parameters are provided in Table 5.2-5. The expected reactor water quality exceeds the turbine manufacturer’s requirements for steam and condensate purity.
10.3	Steam and Power Conversion System: Turbine Main Steam System
10.3.2.2 Turbine Main Steam System Component Description	The TMSS lines are made of carbon steel and are sized for a normal steady-state velocity.
10.4	Steam and Power Conversion System: Other Features of Steam and Power Conversion System
10.4.1.2.3 Main Condenser System Operation	The condenser and water boxes are welded carbon steel or low alloy-ferrite steel. The tubes are stainless steel or titanium with compatible stainless steel or titanium clad carbon steel tube sheets depending on circulating water chemistry.
10.4.3.3 Turbine Gland Seal System Evaluation	Relief valve(s) on the seal steam header prevent excessive seal steam pressure. The valve(s) discharge to the condenser shell.

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DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
10.4.6 Condensate Purification System	The Condensate Purification System (CPS) purifies and treats the condensate as required to maintain reactor feedwater purity. The CPS uses filtration to remove suspended solids, including corrosion products, and ion exchange to remove dissolved solids and other impurities.
10.4.6.1.2 Condensate Purification System Non-Safety Power Generation Design Bases	The CPS removes corrosion products from the condensate and from drains returned to the condenser hotwell, to limit accumulation of corrosion products in the cycle.
10.4.6.2.1 Condensate Purification System General Description	The CPS (shown in Figure 10.4-5) consists of high efficiency filters arranged in parallel and operated in conjunction with a normally closed filter bypass. The CPS also includes bead resin ion exchange demineralizer vessels arranged in parallel. The number of filters and demineralizers are indicated in Table 10.4-4. A resin trap is installed downstream of each demineralizer vessel to preclude gross resin leakage into the power cycle in case of vessel resin retention screen failure. The CPS achieves the water quality effluent conditions required for reactor power operation defined in the water quality specification.
10.4.6.3 Condensate Purification System Evaluation	The CPS removes condensate system corrosion products and impurities resulting from condenser tube leakage in addition to some radioactive material, activated corrosion products and fission products that are carried-over from the reactor. The concentration of such radioactive material in the CPS requires shielding (Chapter 12). Wastes from the condensate purification system are collected in controlled areas and sent to the radwaste system for treatment and/or disposal. Chapter 11 describes the activity level and removal of radioactive material from the condensate system. Chemistry threshold limits and administrative actions are established to mitigate chemistry excursions in the condensate system. The COL Applicant will provide threshold values and recommended operator actions for chemistry excursions in the condensate system (COL 10.4-1-A).
10.4.7.2.1 Condensate and Feedwater System General Description	To minimize corrosion product input to the reactor during startup, recirculation lines to the condenser are provided from the high pressure FW heater outlet header. Cleanup is also accomplished by allowing the system to recirculate through the condensate demineralizers for treatment prior to feeding water to the reactor during startup.
11.2	Radioactive Waste Management: Liquid Waste Management System

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DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.2.1 LWMS Design Bases	• Alternate process subsystem cross-ties and adequate storage volumes are included in the LWMS design to provide for operational and anticipated surge waste volumes. • The LWMS is designed so that no potentially radioactive liquids can be discharged to the environment unless they have first been monitored and diluted, as required. • The LWMS is designed to meet the requirements of General Design Criteria (GDC) 60 (Reference 11.2-4) and RG 1.143 (Reference 11.2-1). Regulatory Guide 1.143 provides radioactive waste management systems; structures and components design guidance; and quality group clarification and quality assurance provisions so that liquid waste as result of natural phenomena hazards and external man-induced hazards can be successfully processed.
11.2.2.2.1 Equipment (Low Conductivity) Drain Subsystem	A strainer or filter is provided downstream of the last ion exchanger in series to collect crud and resin fines that may be present.
11.2.2.2.2 Floor (High Conductivity) Drain Subsystem	A strainer or filter is provided downstream of the last ion exchanger in series to collect crud and resin fines that may be present.
11.2.2.3.1 LWMS Pumps	The LWMS process pumps are constructed of materials suitable for their intended service.
11.2.2.3.2 LWMS Tanks	Tanks are sized to accommodate the expected volumes of waste generated in the upstream systems that feed waste into the LWMS for processing. The tanks are constructed of stainless steel to provide a low corrosion rate during normal operation. The tanks are provided with mixing eductors and/or sparger nozzles. The capability exists to sample all LWMS collection and sample tanks. LWMS tanks are vented into the radwaste ventilation system. The LWMS tanks are designed in accordance with the equipment codes listed in Table 11.2-1.

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Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.2.2.3.4 LWMS Equipment Drain RO and Mixed-Bed Demineralizer Processing Subsystem	The equipment drain processing system utilizes filters for removing suspended solid and radioactive particulate material, and charcoal adsorbtion for organic material removal as necessary. Backwash operation for filtration units is performed when the differential pressure across the filter exceeds a preset limit. Filtration backwash waste is discharged to a low activity phase separator or sent directly to a High Integrity Container (HIC). The Equipment Drain Subsystem consists of a filter for removing large particles, a carbon bed for removing organics, as required, a reverse osmosis membrane for removing submicron particulates, and mixed-bed ion exchangers for polishing dissolved ionic compounds. Exhausted resins from a mixed bed ion exchange unit are sluiced to the low activity spent resin holdup tank when an effluent purity parameter (such as conductivity) exceeds a preset limit or upon high differential pressure across the unit. Fine mesh strainers with backwashing connections are provided in the ion exchange vessel discharge and in the downstream piping to limit resin fines from being carried over to the sampling tanks.
11.2.2.3.5 LWMS Floor Drain RO and Mixed-Bed Demineralizer Processing Subsystem	The Floor Drain Subsystem consists of a filter for removing large particles, a carbon bed for removing organics, as required, a reverse osmosis membrane for removing submicron particulates, and mixed-bed ion exchangers for polishing dissolved ionic compounds.
11.3	Radioactive Waste Management: Gaseous Waste Management System
11.3.1 Design Bases	In accordance with IE Bulletin 80-10, May 6, 1980, (Reference 11.3-13), the OGS interconnections between plant systems are designed to minimize the contamination of non-radioactive systems and uncontrolled releases of radioactivity in the environment.
11.3.2.5.7 Offgas System Air Supply	Flow indicators are provided on all air bleed lines to assure that proper air flow is being delivered to the process line or equipment. The air supply is protected from back flow of process gas by two check valves in series in order to comply with Bulletin 80-10, May 6, 1980 (Reference 11.3-13).
11.3.2.6.2 Offgas System Pressure Relief	Radioactive gaseous pressure relief discharge is piped to the main condenser.

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Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.3.2.6.3 Offgas System Equipment Room Ventilation Control	Differential pressure between general areas and equipment cells is sufficient to maintain a flow of air from clean areas into potentially contaminated areas. In addition, the Turbine Building Heating, HVAC System (TBVS) is capable of removing sufficient heat from the process piping, equipment, motors, and instrumentation so as to maintain the environmental temperatures as established. All equipment cell and charcoal vault ventilation air is discharged without passing through occupied areas to the TB compartment exhaust system and the turbine building exhaust ventilation stack, where effluent radiation monitoring is performed. Charcoal vault air conditioning and ventilation equipment are accessible for maintenance during plant operation.
11.3.2.6.5 Offgas System Vents and Drains	OGS drains, depending on source, are routed to either the condenser hotwell or to the radwaste system. All piping is provided with high point vents and low point drains to permit system drainage following the hydrostatic test. A water drain is provided on the process lines just upstream of the charcoal tanks. The process lines through the charcoal adsorbers are sloped so that there are no intervening low spots to act as water traps.
11.3.2.6.7 Offgas System Recombiners	The inlet piping has sufficient drains and moisture separators to prevent liquid water from entering the recombiner vessel. The condensed water in the condenser section is drained to a loop seal that is connected to the main condenser hotwell. Condensed preheater section steam is drained to the above loop seal that is connected to the hotwell. No flow paths above low power operation exist whereby unrecombined offgas can bypass the recombiners.
11.3.2.6.8 Offgas System Charcoal	Channeling in the charcoal adsorbers is prevented by supplying an effective flow distributor on the inlet and by a high bed-to-particle diameter ratio.
11.4	Radioactive Waste Management: Solid Waste Management System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.4.1 SWMS Design Bases	Any resultant gaseous and liquid wastes are routed to other plant sections. Gaseous radionuclides from the SWMS are processed by the monitored radwaste building ventilation system. The monitored ventilation system is described in Section 9.4 and Subsection 12.3.3.2.4. Liquid waste is processed by the monitored LWMS system as described in Section 11.2. Process and effluent radiological monitoring systems are described in Section 11.5. A description of the SWMS design features addressing 10 CFR 20.1406 (Reference 11.4-7) requirements for permanently installed systems is in Section 12.6. The COL Applicant is responsible for including site-specific information describing how the implementation of operating procedures for the SWMS Processing Subsystem will address the requirements of 10 CFR 20.1406 (Reference 11.4-7). Specifically the operational procedures of the SWMS Processing Subsystem should minimize, to the extent practicable, contamination of the facility and the environment, facilitate decommissioning, and minimize the generation of radioactive wastes (COL 11.4-5-A). This information is placed in Section 12.3.1.5.
11.4.2.2.1 SWMS Collection Subsystem	Excess water from holdup tanks is pumped to the equipment drain collection tank or floor drain collection tank. During transfer operations of spent bead resins, and sludges, suspended solids are kept suspended by periodic and recirculation flushing to prevent them from agglomerating and possibly clogging lines.
11.4.2.3.2 SWMS Tanks	The SWMS tanks are sized for normal plant waste volumes with sufficient excess capacity to accommodate equipment downtime and expected maximum volumes that may occur. The tanks are constructed of stainless steel to provide a low corrosion rate during normal operation. They are provided with mixing eductors and/or air spargers. The capability exists to sample all SWMS tanks. All SWMS tanks are vented to radwaste ventilation. The SWMS tanks are designed in accordance with ASME Section III, Class 3, American Petroleum Institute (API) 620, API 650, or AWWA D-100.
11.4.2.3.3 SWMS Piping	Piping used for hydraulic transport of slurries such as ion exchange resins, filter backwash (sludge), and waste tank sludge are specifically designed to assure trouble-free operation. Pipe flow velocities are sufficient to maintain a flow regime appropriate to the slurry being transported (ion exchange resins, filter backwash, RO concentrate, or tank sludge). An adequate water/solids ratio is maintained throughout the transfer. Slurry piping is provided with manual and automatic flushing with a sufficient water volume to flush the pipe clean after each use. Piping codes are in accordance with RG 1.143 for Solid Waste Management Systems. Additionally, piping shielding design features are provided in accordance with RG 8.8, Position 2.

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Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.5	Radioactive Waste Management: Process Radiation Monitoring System
11.5.3.2.5 Liquid Radwaste Discharge	During the discharge, the liquid is extracted from the liquid radwaste discharge process pipe, passed through a liquid sample panel that contains a detection assembly for radiation monitoring, and returned to the process pipe. The sample panel chamber can be drained and flushed to allow assessment of background buildup.
11.5.3.2.7 Radwaste Building Ventilation Exhaust	A sample, continuously extracted, passes through the panel and returns to the exhaust. The subsystem has provisions for purging the sample panel with room air to check detector response to the background radiation level reading.
11.5.3.2.13.1 RB/FB Stack	A sample, continuously extracted from the stack, passes through the panel and returns to the stack exhaust.
11.5.3.2.13.2 TB Stack	A sample, continuously extracted from the stack, passes through the panel and returns to the stack exhaust.
11.5.3.2.13.3 RW Stack	A sample, continuously extracted from the stack, passes through the panel and returns to the stack exhaust.
11.5.6.4 IE Bulletin 80-10 Evaluation	The Process Radiation Monitoring System comprises subsystems that monitor liquid and gaseous effluents that utilize components designed and installed in various ways. A majority of these subsystems are constructed in a way that it is not possible for them to become contaminated due to leakage, spills, errors in valve lineup or other operating conditions as a result of interfacing with radioactive systems. These types of Radiation Monitoring Subsystems are typically purely electrical in nature and do not physically interconnect with the radioactive systems that they are monitoring. In addition, these PRM Subsystems do not interconnect with other non-radioactive systems, thereby eliminating the potential for transfer of radioactive material from a radioactive system to a non-radioactive system.

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Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.5.6.5 Implementation of 10 CFR 20.1406	The PRM Subsystem designs, and procedures used for operation, minimization of facility and environmental contamination, facilitate decommissioning, and minimization of radioactive waste generation, in accordance with 10 CFR 20.1406 includes: • Minimizing contamination by: – Locating radiation detectors outside the process that they monitor, whenever feasible, to avoid the potential of coming in contact with a radioactive process; – Providing atmospheric purging of the internal portion of air sampling skids as necessary; – Providing the ability for liquid flushing of the internal portions of liquid sampling skids as necessary; – Designing the interior portions of liquid and gaseous sampling chambers to minimize the plateout of radioactive material; and – Designing sample extraction points such that they minimize the potential for spillage and contamination of adjacent areas.
12.3.1	Radiation Protection: Facility Design Features

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
12.3.1 Facility Design Features	Carbon steel is used in a large portion of the system piping and equipment outside of the nuclear steam supply system. Carbon steel is typically low in nickel content and contains a very small amount of cobalt impurity. Stainless steel is used in portions of the system, such as the reactor internal components and heat exchanger tubes, where high corrosion resistance is required. The nickel content of the stainless steels is in the 9 to 10.5% range and is controlled in accordance with applicable ASME material specifications. Cobalt content is controlled to less than 0.05% in the XM-19 alloy used in the control rod drives. A previous review of materials certifications indicated average cobalt content of only 0.15% in austenitic stainless steels. Ni-Cr-Fe alloys such as Inconel 600 and Inconel X750, which have high nickel content, are used in some reactor vessel internal components. These materials are used in applications where special requirements (possessing specific thermal expansion characteristics along with adequate corrosion resistance) are necessary, and where no suitable alternative low-nickel material is available. Cobalt content in the Inconel X750 used in the fuel assemblies is limited to 0.05%. Stellite is used for hard facing of components that must be extremely wear resistant. Use of high cobalt alloys such as Stellite is restricted to those applications where no satisfactory alternative material is available. An alternative material (Colmonoy) has been used for some hard facings in the core area. Main condenser tubes and tube sheets are made of stainless steel or titanium alloys to minimize the introduction of foreign material into the reactor system as a result of condenser tube leakage.
12.3.1.1.1 Pumps	Provisions are made for flushing and in certain cases chemically cleaning pumps prior to maintenance. Pump casing drains provide a means for draining pumps to the sumps prior to disassembly, thus reducing the exposure of personnel and decreasing the potential for contamination.
12.3.1.1.2 Instrumentation	Liquid service equipment for systems containing radioactive fluids is provided with vent and backflush provisions. Instrument lines, except those for the reactor vessel, are designed with provisions for backflushing and maintaining a clean fill in the sensing lines. The reactor vessel sensing lines may be flushed with condensate following reactor blowdown.

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Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
12.3.1.1.3 Heat Exchangers	Heat exchangers are constructed of stainless steel or Cu/Ni tubes to minimize the possibility of failure and reduce maintenance requirements. The heat exchanger design allows for the complete drainage of fluids from the exchanger, avoiding pooling effects that could lead to radioactive crud deposition. Connections are available for condensate or demineralized water flushing of the heat exchangers. For the RWCU/SDC, separate connections are also provided for introducing chemical cleaning solutions for decontaminating the heat exchangers. The fuel pool heat exchanger is downstream of the filter/demineralizer and is not subjected to flows containing significant amounts of fission or activation products.
12.3.1.1.4 Valves	Wherever possible, valves in systems containing radioactive fluids are separated from those for "clean" services to reduce the radiation exposure from adjacent valves and piping during maintenance. Flushing and drain provisions are employed in radioactive systems to reduce exposure to personnel during maintenance.
12.3.1.1.5 Piping	Piping was selected to provide a service life equivalent to the design life of the plant, with consideration given to corrosion allowances and environmental conditions. Piping in radioactive systems such as the RWCU/SDC has butt-welded connections, rather than socket welds, to reduce crud traps. Distinction is made between piping conveying radioactive and non radioactive fluids, and separate routing through shielded pipe chases is provided whenever possible.
12.3.1.1.7 Floor Drains	Floor drains with appropriately sloped floors are provided in shielded cubicles where the potential for spills exist. Those drain lines having a potential for containing highly radioactive fluids are routed through pipe chases, shielded cubicles, or are embedded in concrete walls and floors. Smooth epoxy-type coatings are employed to facilitate decontamination when a spill does occur.
12.3.1.2.2 Sample Stations	Sample stations in the plant provide for the routine surveillance of reactor water quality. These sample stations are located in low radiation areas to reduce the exposure to operating personnel. Flushing provisions are included using demineralized water, and pipe drains to plant sumps are provided to minimize the possibility of spills. Fume hoods are employed for airborne contamination control. Both working areas and fume hoods are constructed of polished stainless steel to ease decontamination if a spill does occur. Grab spouts are located above the sink to reduce the possibility of contaminating surrounding areas during the sampling process.

Table 12.3-18
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Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
12.3.1.2.4 Piping	"Clean" services and radioactive piping are required at times to be routed together in shielded cubicles. In such situations, provisions are made for the valves required for process operations to be controlled remotely, without need for entering the cubicle. Piping configurations are designed to minimize the number of "dead legs" and low points in piping runs to avoid accumulation of radioactive crud and fluids in the line. Drains and flushing provisions are employed whenever feasible to reduce the effect of required "dead legs" and low points. Systems containing radioactive fluids are welded to the most practical extent to reduce leakage through flanged or screwed connections. For highly radioactive systems, butt welds are employed to minimize crud traps. Provisions are also made in radioactive systems for flushing with condensate or chemically cleaning the piping to reduce crud buildup.
12.3.1.2.6 Contamination Control	The HVAC System is designed to limit the extent of airborne contamination by providing airflow patterns from areas of low contamination to more contaminated areas. This, in general, is accomplished by creating negative pressure areas in contaminated cubicles, thus keeping air flow into each cubicle from the corridor area. From these exhaust trunks the exhaust flow is discharged to the RB/FB stack. Penetrations through outer walls of the building containing radiation sources are sealed to prevent miscellaneous leaks into the environment. The equipment drain sump vents that contain airborne contaminants from discharges to the sump are piped directly to their respective building HVAC System. Wet transfer of both the steam dryer and separator also reduces the likelihood of contaminants on this equipment being released into the plant atmosphere. In areas where the reduction of airborne contaminants cannot be eliminated efficiently by HVAC Systems, breathing air provisions are provided, for example, for CRD removal under the reactor pressure vessel and in the CRD maintenance room.
12.3.1.4.2 Fuel and Auxiliary Pools Cooling System	Piping potentially containing resin is continuously sloped downward to the backwash tank.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 4: Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
12.3.1.4.5 Radwaste Building Structure	Design features to minimize occupational exposure include: • Design of equipment with adequate finish or linings to prevent formation and adherence of corrosion products to facilitate decontamination; • Piping design to minimize crud traps and plateout (there are no socket welds in contaminated piping systems); • Provision for remote pipe and equipment flushing; • LWMS and SWMS tanks vent to radwaste building ventilation. The radwaste building process systems area is designed to accommodate modular shield walls to further limit access and reduce radiation levels from waste processing equipment.
12.3.3	Radiation Protection: Ventilation
12.3.3.2 Design Description	In the following subsections, the design features of the various ventilation systems that achieve the radiation control design objectives are discussed. For all areas potentially having airborne radioactivity, the ventilation systems are designed such that during normal and maintenance operations, airflow between areas is always from an area of low potential contamination to an area of higher potential contamination.
12.3.3.2.1 Control Room Ventilation	The EFUs are located in closed rooms that help prevent the spread of any radioactive contamination during maintenance.

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Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 5: Facilitate the decommissioning by (1) minimizing embedded and buried piping, and (2) designing the facility to facilitate the removal of any equipment and/or components that may require removal and/or replacement during facility operation or decommissioning.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
3.8	Design of Structures, Components, Equipment, and Systems: Seismic Category I Structures
3.8.1.1.1 Concrete Containment	The containment is a low-leakage reinforced concrete structure with an internal steel liner in the drywell and wetwell to serve as a leaktight membrane. The containment and the structures integrated with the containment are constructed of cast-in-place, reinforced concrete.
3.8.4 Other Seismic Category I	The ESBWR Standard Plant does not contain underground Seismic Category I pipelines or masonry wall construction. Removable shield blocks consisting of metallic forms filled with grout or concrete designed to Seismic Category II requirements are used. The shield blocks are provided with removable structural steel frame also designed to Seismic Category II requirements to prevent the shielding blocks from sliding or tipping under seismic events
3.8.4.1.1 Reactor Building Structure	These structures are tied together by a system of internal concrete bearing walls and concrete floor slabs. Floor slabs are designed, in general, as composite structures supported by embedded beams during construction
3.8.4.6.5 Special Construction Techniques	Composite construction is used in other Seismic Category I structures.
4.2	Reactor: Fuel System Design
4.2.4.8 Materials	Materials selected for use in the Marathon control rod components are chosen to minimize the component end-of-life radioactivity in order to reduce personnel exposure during handling on-site, and for final offsite shipping and burial. All Marathon control rod materials are less than 0.03 weight percent cobalt. The average niobium content for the handle and absorber section, less boron carbide and hafnium, is less than 0.1 weight percent.
4.6	Reactor: Functional Design of Reactivity Control System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 5: Facilitate the decommissioning by (1) minimizing embedded and buried piping, and (2) designing the facility to facilitate the removal of any equipment and/or components that may require removal and/or replacement during facility operation or decommissioning.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
4.6.2.1.4 CRD Maintenance	The FMCRD design also allows for separate removal of the motor unit, position indicator probe (PIP), separation indicator probe (SIP) and spool piece for maintenance during plant outages without disturbing the upper assembly of the drive. While these FMCRD components are removed for servicing, the associated control rod is maintained in the fully inserted position by one of two mechanical locking devices that prevent rotation of the ball screw and drive shaft.
5.4	Reactor Coolant System and Connected Systems: Component and Subsystem Design
5.4.13.2 Safety and Relief Valves and Depressurization Valves Description	DPVs are designed with flange connections to allow whole valve removal or reinstallation.
6.1	Engineered Safety Features: Design Basis Accident Engineered Safety Feature Materials
6.1	Only metallic insulation is used inside the containment
6.1.2.1 Protective Coatings	Consistent with the rationale of RG 1.54, the WW and attendant vertical vents are designated as a Service Level I area. All surfaces and equipment in this area are either uncoated, corrosion resistant stainless steel, or coated in accordance with RG 1.54 and referenced ASTM standards, as applicable. Regardless of service level designation, all field applied epoxy coatings inside containment meet the requirements of RG 1.54 and are qualified using the standard ASTM tests, as applicable to procurement, installation, and maintenance.
9.1	Auxiliary Systems: Fuel Storage and Handling
9.1.4.7 Servicing Aids	A portable, submersible underwater vacuum cleaner to help remove crud or miscellaneous loose matter from the reactor vessel or storage pools. The required pump and filter is also submersible for extended periods. The filter can be changed remotely and disposed of in standard containers after use for offsite burial.
9.3	Auxiliary Systems: Process Auxiliaries

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Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 5: Facilitate the decommissioning by (1) minimizing embedded and buried piping, and (2) designing the facility to facilitate the removal of any equipment and/or components that may require removal and/or replacement during facility operation or decommissioning.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
9.3.3.4 Equipment and Floor Drain System Testing and Inspection Requirements	The EFDS is designed to permit periodic inspection and testing of important components, such as valves, motor operators, and piping, to verify their integrity and capability. Equipment layout provides easy access for inspection and maintenance. Drainage piping is hydrostatically tested prior to embedment in concrete. Potentially radioactive drainage piping is pressure tested in accordance with ASME B31.1. The EFDS functionality is demonstrated by continuous use during normal plant operation.
9.4	Auxiliary Systems: Heating, Ventilation, and Air Conditioning
9.4.1 Control Building HVAC System	The Control Building does not house any portion of the nuclear steam supply process or other equipment that can act as a source of radioactive material; and therefore has no postulated sources of radioactive materials in either particulate or gaseous form. Therefore, the CB exhaust systems require no filtration or adsorption capability.
9.4.2.1 Fuel Building HVAC System Design Bases	• Is provided with access doors for AHUs, fans, filter sections, and duct-mounted dampers to allow for maintenance as applicable.
11.2	Radioactive Waste Management: Liquid Waste Management System
11.2.2.3.3 Processing Systems	Modular shield walls are provided in the RW to allow shield walls to be constructed to minimize exposure to personnel during operation and routine maintenance.
11.2.2.3.4 Equipment Drain RO and Mixed-Bed Demineralizer Processing Subsystem	The processing system is designed and configured for installation ease and process reconfiguration. In-plant supply and return connections from permanently installed equipment to the processing system are provided for operational flexibility
11.2.2.3.5 Floor Drain RO and Mixed-Bed Demineralizer Processing Subsystem	The processing system is configured for installation ease and process reconfiguration. In-plant supply and return connections from other radwaste equipment to the processing system are provided to ensure operational flexibility.

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Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 5: Facilitate the decommissioning by (1) minimizing embedded and buried piping, and (2) designing the facility to facilitate the removal of any equipment and/or components that may require removal and/or replacement during facility operation or decommissioning.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.4	Radioactive Waste Management: Solid Waste Management System
11.4.2.3.5 SWMS Processing Subsystem	The SWMS Processing Subsystem is designed to be readily replaced. This section includes requirements to be included in the replacement of the process systems throughout the life of the ESBWR.
11.5	Radioactive Waste Management: Process Radiation Monitoring System
11.5.6.5 Implementation of 10 CFR 20.1406	• Facilitating decommissioning by: – Providing equipment, where feasible, that reduces the need for decontamination during the removal and disposal of the equipment.
12.3.1	Radiation Protection: Facility Design Features
12.3.1.1.1 Pumps	Quick-change cartridge-type seals on pumps, and pumps with back pullout features that permit removal of the pump impeller or mechanical seals without disassembly of attached piping are employed to minimize exposure time during pump maintenance.
12.3.1.1.5 Piping	Distinction is made between piping conveying radioactive and non radioactive fluids, and separate routing through shielded pipe chases is provided whenever possible. Piping conveying highly contaminated fluids is usually routed through shielded pipe chases and shielded cubicles. However, when these options are not feasible, the radioactive piping is embedded in concrete walls and floors.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 5: Facilitate the decommissioning by (1) minimizing embedded and buried piping, and (2) designing the facility to facilitate the removal of any equipment and/or components that may require removal and/or replacement during facility operation or decommissioning.	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
12.3.1.2.4 Piping	Piping containing radioactive fluids is routed through shielded pipe chases, shielded equipment cubicles, or embedded in concrete walls and floors, whenever possible. "Clean" services, such as compressed air and demineralized water, are not routed through shielded pipe chases, where possible. For situations in which radioactive piping must be routed through corridors or other low radiation areas, an analysis is conducted to ensure this routing does not compromise the existing radiation zoning. Some piping may be embedded in concrete (e.g., feed-throughs with short sections). Optimization by short sections with embedded piping to the extent practicable facilitates the dismantlement of the systems and the decommissioning of the facility, as required by 10 CFR 20.1406. The radwaste piping gallery between the Turbine Building and the Radwaste Building contains only nonsafety-related electrical cables that are separated from the radwaste piping by a 20 cm shield wall. Cable replacement, though infrequent, is to be performed during shutdown or when no waste transfer operations are occurring in accordance with plant maintenance and radiation protection program procedures that take into account ALARA. During normal operation, the 20 cm concrete shielding minimizes the potential dose to electrical equipment during waste transfer operations.
12.3.1.5.1 Design Considerations	Examples of ESBWR design features that minimize contamination and facilitate decommissioning include the following: • To facilitate decommissioning, the Reactor, Fuel, Turbine, and Radwaste Buildings are designed for large equipment removal, consisting of entry doors from the outside and numerous equipment hatches within the buildings; • To facilitate decommissioning and ease of access, the radwaste process systems are skidmounted and located in the radwaste building to allow truck access, and system skid loading and unloading; • For some piping, feed-throughs with short sections, the piping may be embedded in concrete as discussed in subsection 12.3.1.2.4. Minimization of short sections with embedded piping to the extent practicable facilitates the dismantlement of the systems and the decommissioning;

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Design Objective 6: Minimize the generation and volume of radioactive waste during both operation and during decommissioning (by minimizing the volume of components and structures that become contaminated during plant operation).

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
3.1	Design of Structures, Components, Equipment, and Systems: Conformance With NRC General Design Criteria
3.1.6.1 Criterion 60 — Control of Releases of Radioactive Materials to the Environment	The ESBWR is designed so that releases of radioactive materials, in their gaseous, liquid, and solid form are minimized. Gaseous releases come primarily from the turbine condenser offgas and the ventilation systems. Noble gas and iodine activity that enters the turbine offgas system is held by ambient charcoal beds. Ventilation releases are through multiple plant stacks. The TB, RB/FB and RW stacks and the major streams feeding the plant stacks are monitored by the process radiation monitoring system so that action may be taken to avoid releases in excess of regulatory limits. The radwaste systems process liquid and solid wastes. Processes are provided to treat and package solid wastes, as required by applicable state and federal regulations. In addition, the ESBWR liquid radwaste system can be operated in a mode where non-detergent and nonchemical waste streams are treated to allow maximum recycle to the condensate storage tank. This mode of operation would minimize releases of radioactivity via the liquid or discharge pathway, but would increase solid waste generated. The radwaste system has significant hold-up capacity, both in waste collection tanks and in sample tanks containing processed water. This hold-up or surge capacity provides the plant operator flexibility in operations when deciding when and how to release effluents to the environment.
4.2	Reactor: Fuel System Design
4.2.4.8 Materials	Materials selected for use in the Marathon control rod components are chosen to minimize the component end-of-life radioactivity in order to reduce personnel exposure during handling on-site, and for final offsite shipping and burial. All Marathon control rod materials are less than 0.03 weight percent cobalt. The average niobium content for the handle and absorber section, less boron carbide and hafnium, is less than 0.1 weight percent.
4.6	Reactor: Functional Design of Reactivity Control System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 6: Minimize the generation and volume of radioactive waste during both operation and during decommissioning (by minimizing the volume of components and structures that become contaminated during plant operation).

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
4.6.2.1.4 CRD Maintenance	The FMCRD design also allows for separate removal of the motor unit, position indicator probe (PIP), separation indicator probe (SIP) and spool piece for maintenance during plant outages without disturbing the upper assembly of the drive. While these FMCRD components are removed for servicing, the associated control rod is maintained in the fully inserted position by one of two mechanical locking devices that prevent rotation of the ball screw and drive shaft.
6.1	Engineered Safety Features: Design Basis Accident Engineered Safety Feature Materials
6.1	Only metallic insulation is used inside the containment
6.1.2.1 Protective Coatings	Consistent with the rationale of RG 1.54, the WW and attendant vertical vents are designated as a Service Level I area. All surfaces and equipment in this area are either uncoated, corrosion resistant stainless steel, or coated in accordance with RG 1.54 and referenced ASTM standards, as applicable. Regardless of service level designation, all field applied epoxy coatings inside containment meet the requirements of RG 1.54 and are qualified using the standard ASTM tests, as applicable to procurement, installation, and maintenance.
9.1	Auxiliary Systems: Fuel Storage and Handling
9.1.4.7 Servicing Aids	A portable, submersible underwater vacuum cleaner to help remove crud or miscellaneous loose matter from the reactor vessel or storage pools. The required pump and filter is also submersible for extended periods. The filter can be changed remotely and disposed of in standard containers after use for offsite burial.
9.2	Auxiliary Systems: Water Systems
9.2.6.2 Condensate Storage and Transfer System Description	The CS&TS equipment and associated piping are fabricated from stainless steel to prevent contamination of the system water.
9.3	Auxiliary Systems: Process Auxiliaries

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 6: Minimize the generation and volume of radioactive waste during both operation and during decommissioning (by minimizing the volume of components and structures that become contaminated during plant operation).	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.3.3.1 Equipment and Floor Drain System Design Bases	The EFDS meets requirements of GDC 60 by providing a design to avoid the transfer of contaminated fluids to a non-contaminated drainage system for disposal. To preclude inadvertent transfer of radioactive liquids to non-radioactive systems, the radioactively contaminated or potentially contaminated liquids are collected by completely separate systems (e.g. no cross connections) from those that collect non-radioactive liquids. Redundant sump pumps are included to increase the reliability, availability, and maintainability of the EFDS.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

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DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
9.3.3.2 Equipment and Floor Drain System Description	The Clean Drain Subsystem collects and transfers liquid wastes by gravity from the clean nonradioactive equipment and floor drains to sumps and pumps these wastes to an appropriate disposal system. The LCW Drain Subsystem collects liquid wastes from equipment drains in potentially contaminated systems. These liquids gravity drain to sumps located in the drywell and other areas. The drywell LCW drain, which is monitored for activity, is pumped to the LCW collection tank. The drywell LCW sump pump discharge line is provided with redundant containment isolation valves. The liquid wastes collected in the LCW sumps are also pumped to the LCW collection tank. The HCW Drain Subsystem collects liquid wastes from floor drains in potentially contaminated areas. These liquids gravity drain to sumps located in the drywell and other areas. The drywell HCW drain, which is monitored for activity, is pumped to the HCW collection tank. The drywell HCW sump pump discharge line is provided with redundant containment isolation valves. Liquids collected in the HCW sumps are also pumped to the HCW collection tank. The Detergent Drain Subsystem collects potentially contaminated wastes from the personnel decontamination stations, laundry, and shower facility drains and transfers them to the detergent drain collection tank. The Chemical Waste Drain Subsystem collects liquid wastes containing potentially contaminated chemicals and corrosive substances from washdown areas, laboratory drains, hot maintenance shop, and other miscellaneous sources in the plant. These liquid wastes are transferred to the chemical drain collection tank. Dedicated sumps in the EFDS collect vent and drain water from the closed loop RCCWS and direct the water to the Reactor Building Cooling Water Drain Subsystem. The size of this subsystem accommodates the draining of the largest isolable cooling water pipe segment in the Reactor Building. The sump contents are evaluated for radioactivity and water quality. If the cooling water is radioactively contaminated, it is directed to the LWMS, where it can be processed. If not, the cooling water may be recycled through a line tied back to the cooling water system. Safety divisions are provided with a separate drain line connecting to the main drainage piping and leading to an appropriate sump in both the Reactor Building and Control Building. Each drain line is provided with a normally closed manual valve, closed to prevent flooding of multiple safety divisions due to backflow. Watertight walls, floors, and doors on safety-related compartments also prevent flooding of multiple safety-related compartments. The collected liquids are discharged to the clean waste system or the Liquid Waste Management System, as appropriate.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 6: Minimize the generation and volume of radioactive waste during both operation and during decommissioning (by minimizing the volume of components and structures that become contaminated during plant operation).	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
9.4	Auxiliary Systems: Heating, Ventilation, and Air Conditioning
9.4.7 Electrical Building HVAC System	• Meets GDC 60 because the EER, TSC and Diesel Building HVAC Systems have no source of radioactive materials in either particulate or gaseous form. The exhaust systems have no provision for filtration or adsorption because these areas are clean.
11.2	Radioactive Waste Management: Liquid Waste Management System
11.2.2.1 Summary Description	The LWMS is divided into several subsystems, so that the liquid wastes from various sources can be segregated and processed separately, based on the most economical and efficient process for each specific type of impurity and chemical content. Cross-connections between subsystems provide additional flexibility in processing the wastes by alternate methods and provide redundancy if one subsystem is inoperative.
11.2.3.2 Radioactive Releases	During liquid processing by the LWMS, radioactive contaminants are removed and the bulk of the liquid is purified and either returned to the condensate storage tank or discharged to the environment. The radioactivity removed from the liquid waste is concentrated on filter media, RO membrane, ion exchange resins, and concentrated waste.
11.3	Radioactive Waste Management: Gaseous Waste Management System
11.3.2.3 Offgas System Process Facility	The facility is located in the TB to minimize piping.
11.4	Radioactive Waste Management: Solid Waste Management System
11.4.2.3.5 SWMS Processing Subsystem	The Processing Subsystem is anticipated to be modernized as more effective technologies are discovered and proven throughout the life of plant operation.
11.5	Radioactive Waste Management: Process Radiation Monitoring System

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 6: Minimize the generation and volume of radioactive waste during both operation and during decommissioning (by minimizing the volume of components and structures that become contaminated during plant operation).	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
11.5.6.5 Implementation of 10 CFR 20.1406	• Minimizing the generation of radioactive waste by: – Directing continuous samples from radioactive processes back to the sampled process; – Utilizing electronic bug sources, where compatible with the subsystem design, in order to minimize the use of radioactive sources; and – Minimizing the amount of a sample that needs to be extracted, consistent with laboratory and sensitivity requirements.
12.3.1	Radiation Protection: Facility Design Features
12.3.1.2.4 Piping	Piping configurations are designed to minimize the number of "dead legs" and low points in piping runs to avoid accumulation of radioactive crud and fluids in the line. Drains and flushing provisions are employed whenever feasible to reduce the effect of required "dead legs" and low points. Systems containing radioactive fluids are welded to the most practical extent to reduce leakage through flanged or screwed connections. For highly radioactive systems, butt welds are employed to minimize crud traps. Provisions are also made in radioactive systems for flushing with condensate or chemically cleaning the piping to reduce crud buildup.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 6: Minimize the generation and volume of radioactive waste during both operation and during decommissioning (by minimizing the volume of components and structures that become contaminated during plant operation).	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
12.3.1.5.1 Design Considerations	Examples of ESBWR design features that minimize the generation of radioactive waste include the following: • The Liquid Waste Management System (LWMS) is divided into several subsystems, so that the liquid wastes from various sources can be segregated and processed separately, based on the most efficient process for each specific type of impurity and chemical content. This segregation allows for efficient processing and minimization of overall liquid waste. • During liquid processing by the LWMS, radioactive contaminants are removed and the bulk of the liquid is purified and either returned to the condensate storage tank or discharged to the environment, minimizing overall liquid waste. The radioactivity removed from the liquid waste is concentrated in filter media ion exchange resins and concentrated waste. The filter sludge, ion exchange resins and concentrated waste are sent to the Solid Waste Management System (SWMS) for further processing. • The SWMS is designed to segregate and package the wet and dry types of radioactive solid waste for off-site shipment and burial. This segregation allows for efficient processing and minimization of overall solid waste. • For management of gaseous radioactive waste, the Offgas System (OGS) minimizes and controls the release of radioactive material into the atmosphere by delaying release of the offgas process stream initially containing radioactive isotopes of krypton, xenon, iodine, nitrogen, and oxygen. Examples of ESBWR design features that minimize the generation of radioactive waste during decommissioning operations include the following: • Reduction of cobalt content in structural and bearing materials; • Minimization of crud buildup in drains by use of stainless steel linings, improving drainage, and facilitating flushing; and • Easing surface decontamination by providing epoxy-type wall and floor coverings.

12.6 MINIMIZATION OF CONTAMINATION AND RADWASTE GENERATIONDeleted

This section discusses how the ESBWR design minimizes contamination of the facility and environment, facilitates decommissioning, and minimizes the generation of radioactive waste, in compliance with 10 CFR 20.1406.

12.6.1 Minimization of Contamination to Facilitate Decommissioning

Examples of ESBWR design features that minimize contamination and facilitate decommissioning include the following:

- Design of equipment to minimize the buildup of radioactive material and to facilitate flushing of crud traps;
- Provisions for design features to plant systems such as the Reactor Water Cleanup/Shutdown Cooling System, liquid and solid radwaste systems and the condensate demineralizer to minimize crud buildup;
- Provisions for draining, flushing, and decontaminating equipment and piping;
- Penetrations through outer walls of a building containing radiation sources are sealed to prevent miscellaneous leaks to the environment;
- Equipment drain sump vents are piped directly to the radwaste HVAC system to remove airborne contaminants evolved from discharges to the sump;
- Appropriately sloped floors around floor drains are provided in areas where the potential for a spill exists to limit the extent of contamination. The floor drains are designed to be of monolithic construction to minimize possibility of liquid penetrating at embedment boundaries. No grout is used in the installation of the floor drains. Periodic visual inspections of the installation around the floor drains is performed to ensure that no bypass exists in these floor drain areas;
- Provisions for decontaminable epoxy-type wall and floor coverings which provide smooth surfaces to ease decontamination. Epoxy-type coatings are applied to both steel surfaces and concrete areas appropriate for contamination control. These areas consist of the walls and floors of the Reactor, Fuel, and Turbine Buildings, radwaste areas, rooms containing equipment with liquid radioactive sources, floor drain areas, washdown bays, and radwaste tunnels;
- Equipment and floor drain sumps are stainless steel lined to reduce crud buildup and to provide surfaces easily decontaminated;
- The radwaste building is seismically designed in accordance with Regulatory Guide 1.143, Class RW-IIa. The tank cubicle concrete is provided with a sealant and a tank cubicle steel liner, as described in Subsection 11.2.2.3 to prevent any potential water releases from high activity areas to the environment;
- For all areas potentially having airborne radioactivity, the ventilation systems are designed such that during normal and maintenance operations, airflow between areas is always from an area of low potential contamination to an area of higher potential contamination;

- The reactor building HVAC system is divided into two major components: the contaminated and clean areas. The clean area system conditions and circulates air through all the clean areas of the reactor building; the contaminated area system conditions and circulates air through the contaminated areas of the building;
- The Fuel and Auxiliary Pools Cooling System (FAPCS), equipped with two independent filter demineralizer units, is designed to reduce pool water radioactive contamination in the major pools in the ESBWR;
- The ESBWR is designed to limit the use of cobalt bearing materials on moving components that have historically been identified as major sources of in-water contamination;
- To facilitate decommissioning, the Reactor, Fuel, Turbine, and Radwaste Buildings are designed for large equipment removal, consisting of entry doors from the outside and numerous equipment hatches within the buildings;
- To facilitate decommissioning and ease of access, the radwaste process systems are skid-mounted and located in the radwaste building to allow truck access, and system skid loading and unloading;
- For some piping, feed-throughs with short sections, the piping may be embedded in concrete as discussed in subsection 12.3.1.2.4. Minimization of short sections with embedded piping to the extent practicable facilitates the dismantlement of the systems and the decommissioning;
- In consideration of minor leaks over long periods of time, the liquid radwaste system (tanks, piping, etc.), Radwaste Building, and the radwaste tunnels are designed to conform to Regulatory Guide 1.143. The spent fuel pool has a leak detection system to monitor any leakage during plant operation, as discussed in Subsection 3.8.4.2.5. The concrete in the underground tunnels containing radwaste piping to and from the Radwaste Building is sealed for ease of decontamination during operation. The tunnels have floor drains to remove any fluid that potentially could leak from the piping. Plant procedures require periodic visual inspection of the radwaste piping in the tunnels; and
- There is no concrete block wall construction in ESBWR. Holes provided for removal of components are filled with interlocking metallic blocks filled with concrete for shielding purposes, as discussed in the last two paragraphs of Subsection 3.8.4. Therefore, there is no exposed porous concrete that could be contaminated, which provides for easier decommissioning.

12.6.2 Minimization of Radioactive Waste Generation

Examples of ESBWR design features that minimize the generation of radioactive waste include the following:

- The Liquid Waste Management System (LWMS) is divided into several subsystems, so that the liquid wastes from various sources can be segregated and processed separately, based on the most efficient process for each specific type of impurity and chemical content. This segregation allows for efficient processing and minimization of overall liquid waste.

- During liquid processing by the LWMS, radioactive contaminants are removed and the bulk of the liquid is purified and either returned to the condensate storage tank or discharged to the environment, minimizing overall liquid waste. The radioactivity removed from the liquid waste is concentrated in filter media ion exchange resins and concentrated waste. The filter sludge, ion exchange resins and concentrated waste are sent to the Solid Waste Management System (SWMS) for further processing.
- The SWMS is designed to segregate and package the wet and dry types of radioactive solid waste for off site shipment and burial. This segregation allows for efficient processing and minimization of overall solid waste.
- For management of gaseous radioactive waste, the Offgas System (OGS) minimizes and controls the release of radioactive material into the atmosphere by delaying release of the offgas process stream initially containing radioactive isotopes of krypton, xenon, iodine, nitrogen, and oxygen.

The LWMS, OGS, and SWMS are discussed and described in more detail in Sections 11.2, 11.3, and 11.4, respectively.

Examples of ESBWR design features that minimize the generation of radioactive waste during decommissioning operations include the following:

- Reduction of cobalt content in structural and bearing materials;
- Minimization of crud buildup in drains by use of stainless steel linings, improving drainage, and facilitating flushing; and
- Easing surface decontamination by providing epoxy-type wall and floor coverings.

12.6.3 COL Information

None

12.6.4 References

None