12.3 SHIELDING AND RADIATION PROTECTION

12.3.1 Design Basis

Plant shielding is designed to provide for personnel access to the plant to perform maintenance and carry out operational duties with personnel exposures limited to the dose criteria set forth in the Code of Federal Regulations Title 10 Part 20 (10 CFR 20) and plant procedures, as appropriate. The shielding design requirements for the Reactor, Turbine, and Radwaste Buildings and for the offgas stack for both normal and shutdown conditions are established considering the total activity in the core, coolant, liquid waste, and offgas systems. The shielding and radiation protection design requirements also consider the radiation conditions in the control room following a design basis accident. Within these requirements the plant is shielded to provide work areas for operation and maintenance of the plant and for the control of the plant during the design basis accident.

The original shielding design was based on the following conservative assumptions. Full power operation design conditions assumed that the core would be operated at design power (pre-uprated). At this power level the ^{16}N coolant activity leaving the reactor vessel would be 1.60 x 10^8 microcuries per second per unit (see Subsection 9.5, "Gaseous Radwaste System"). The offgas system shielding was designed for a stack release rate of 350,000 microcuries per second per unit after a 30-minute holdup. Reactor water fission product concentrations and activated corrosion product concentrations were assumed to have maximum values of 7.4 μCi/cc and 0.07 μCi/cc, respectively. These sources were used in determining the maximum shielding requirements in the condensate system filter demineralizers and for the reactor water cleanup system. Evaluations at the uprated power level conclude that the pre-uprate values for activity still bound the uprated values.

12.3.2 Description

The design basis for shielding work areas was based on the expected radiation levels and estimated occupancy times. The plant was divided into zones dependent upon the intensity of radiation within the given area. Zone classifications are listed in Table 12.3-1. The entrances into all zones are marked in accordance with the regulations of 10 CFR 20 for current radiological conditions. Regulated zones are also appropriately identified at the points of access. Barricades restrict entry to controlled zones with dose rates greater than 100 mRem/h. In addition, radiation work permits are required, and health physics surveillance may be necessary before entry to controlled zones.

Entrances to prohibited zones are barred by locked or guarded doors. Access control requirements for prohibited zones are contained in technical specifications and plant procedures. The entrances to the various zones in the buildings as expected in the shielding design are shown on Figures 1.6-1 through 1.6-7 and

Figures 1.6-11 through 1.6-14. For the purposes of this document and plant drawings and implementing procedures, radiation exposure as expressed in units of R/hr and sub-units, thereof, is equivalent to dose (rad) and dose equivalent (rem).

Exposure of personnel to concentrations of radioactive materials in air and water is controlled under 10 CFR 20.

The radiation monitoring systems are described in subsections 7.12, "Process Radiation Monitoring"; 7.13, "Area Radiation Monitoring System"; 7.l4, "Drywell Leak Detection Radiation Monitoring System", and 7.15, "Health Physics Laboratory Radiation Monitoring Equipment."

The design basis accident, which is the loss of coolant, defines the protection required for the plant Main Control Room and is described in Chapter 14. The Main Control Room is located on the top floor of the control bay. The entire control bay is shielded from secondary containment by concrete walls, roof, and floor. The roof is 27 inches thick, the wall separating the control bay and secondary containment is 30 inches thick, the wall between the Turbine Building and the control bay is 18 inches thick, the floor over the steam tunnel is 54 inches thick, and the remainder of the floor is 30 inches thick. Penetrations from the secondary containment enter the control bay on the lower two floors which are separated from the main control room by 8-inch-thick concrete floors.

The control bay shielding was analyzed for normal occupancy in the control bay using the maximum normal sources. The dose rate to people in the control bay was calculated to be less than 0.5 mrem/hr.

The control bay shielding was analyzed for the design basis accident using the source strengths listed in Appendix F of the Units 1 and 2 Design and Analysis Report. The primary containment contribution to the control bay accident dose was found to be less than 2 mrem/hr. The dose from the secondary containment activity was found to be less than 675 mrem in any continuous 8-hour period.

During accident conditions the exit route from the main control room and plant is that of least possible exposure and is determined at the time of the accident.

The Reactor Building contains five major shielding structures--the reactor sacrificial shield, the drywell biological shield, the main steampipe tunnel, the fuel pool, and the cleanup demineralizer system equipment rooms. The concrete drywell biological shield with the sacrificial shielding provides the main protection for the area surrounding the reactor vessel, the primary coolant piping, and the recirculation system. Approximately 8 feet of concrete is used to reduce the radiation levels in accessible areas. Entrances to each drywell space are shielded with 5-foot-thick shield plugs in the equipment locks on El. 565 and a 4-foot-thick concrete wall at the personnel airlock. The main steampipe tunnel with its 4-foot 6-inch thick concrete walls is the connecting shielded structure between the Reactor and Turbine Buildings. The spent fuel assemblies are stored inside the spent fuel storage pool. Six-foot-thick concrete walls are provided as shield barriers on all sides of the fuel storage pool approximately up to the top of the fuel storage racks. In addition, the bottom of the storage pool is also provided as a shield barrier and is 6-foot thick. A minimum spent fuel storage pool water level of 21½ feet over the top of irradiated fuel assemblies seated in the spent fuel storage pool racks is maintained to protect plant personnel during movement of irradiated fuel assemblies in the spent fuel storage pool. During movement of fuel assemblies within the Reactor Pressure Vessel (RPV), RPV water level is maintained a minimum of 22 feet above the RPV flange. The reactor water cleanup demineralizer and its associated system are housed in several concrete-shielded rooms surrounding the drywell concrete structure.

Activity enters the Turbine Building with the steam from the reactor. The activity is primarily ^{13}N, ^{16}N, ^{17}N, $^{19}0$, fission product gases, and some carryover of other activity. Approximately 80 percent of the nitrogen activity goes to the offgas system with the other 20 percent going with the condensate. The activity in the condensate is reduced to a negligible value by hotwell holdup and the condensate demineralizers. Shielding is provided around the following Turbine Building areas, and the interior zones are typically classified as shown below.

Equipment Area	Radiation Zone
Main steam lines and valves	Prohibited
Main turbine	Prohibited
Main condenser hotwell area	Controlled
Moisture separators	Prohibited
Reactor feedwater heaters	Prohibited
Reactor feed pump turbines	Controlled
Extraction steam piping	Prohibited
Air ejectors and steam packing exhauster	Prohibited
Condensate demineralizers and backwash equipment	Controlled

Shielding for the radwaste facilities was based on the processing of wastes having concentrations of 7.4 µCi/cc of fission products and 0.07 µCi/cc of corrosion products from the reactor water. Phase-separator tanks hold up activity for decay of essentially all isotopes except the long-lived radionuclides. Shielding is provided around the following Radioactive Waste Building areas and the interior zones are typically classified as shown below.

Equipment Area	Radiation Zone
Cleanup phase-separator tanks	Prohibited
Cleanup sludge pump	Prohibited
Cleanup decant pumps	Regulated
Condensate phase-separator tanks	Prohibited
Condensate phase-separator sludge pumps	Regulated
Condensate phase-separator decant pumps	Regulated
Waste-collector tanks	Controlled
Waste-collector pumps	Regulated
Waste demineralizer	Prohibited
Waste backwash tank	Prohibited
Waste resin tank	Controlled

The shielding design for the plant stack was based on a gaseous fission product release of 350,000 µCi/sec per unit, and the accompanying particulate radioactive daughter products which are collected on the offgas filters. Shielding is provided at the ground level section of the stack. Offgas piping and filters are located in the stack basement in shielded cubicles.

Most areas in the Service Building are designated as unlimited access areas, with dose rates well below 0.5 mrem/hr. The office building is an unlimited access area.

12.3.3 Performance Analysis

The normal construction quality control program assures that there are no major defects or voids in the shielding. After plant startup, both the attenuation provided by the shielding and the integrity with respect to voids and openings will be checked by radiation surveys which will be performed at various reactor power levels and under various operating conditions. Using these surveys and routine health physics monitoring and control, exposure of personnel is expected to be a fraction of the dose criteria set forth in 10 CFR 20.