

## 12. RADIATION PROTECTION

### 12.1 Introduction

In the AP1000 Design Control Document (DCD) Tier 2, Chapter 12, "Radiation Protection," Revisions 16 and 17 contain changes to the descriptions of the commitments pertaining to the radiation protection measures and programs of the AP1000 design, as described in NUREG-1793, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design" (FSER), issued September 2004. As such, this supplemental document to NUREG-1793 must be used in concert with the original issue of NUREG-1793 to completely understand the full evaluation of the AP1000 standard design.

In the AP1000 design certification amendment, Westinghouse provided additional information related to the Radiation Protection Program and the design features that will ensure that occupational radiation exposures are as low as is reasonably achievable (ALARA). It also provided information on related facility design changes submitted in various technical reports potentially affecting the internal and external radiation exposures to station personnel, contractors, and the general population, resulting from plant conditions, including anticipated operational occurrences that will be within regulatory criteria. The staff of the U.S. Nuclear Regulatory Commission (NRC) reviewed the additional and amended information provided by Westinghouse, using the guidance in Chapter 12 of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP), Revision 3, issued March 2007. The NRC developed the original NUREG-1793 using the guidance from Regulatory Guide (RG) 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," Revision 3, issued November 1978. Therefore, this supplement follows the format of the original NUREG-1793.

The scope of this review includes Chapter 12, Sections 12.1 through 12.5, Revision 17 of the AP1000 DCD, Tier 2 and Tier 1, Chapter 3.5, "Radiation Monitoring," which covers the associated inspection, test, analyses, and acceptance criteria (ITAAC).

Each section of this report describes the staff's evaluation and review results of the changes proposed in Chapter 12 of the AP1000 DCD, Revision 17. The staff reviewed Revision 16 upon receipt and after review issued several requests for additional information (RAIs); however the applicant submitted Revision 17 prior to the resolution of these RAIs.

#### 12.1.1 Compliance with Title 10 of the Code of Federal Regulations Part 20, "Standards for Protection Against Radiation"

Westinghouse has submitted several technical reports (TRs) with radiation protection implications that include references to industry standards and other regulatory guidance. The Westinghouse document, TR-98, "AP1000 COL Standard Technical Report Submittal of APP GW-GLN-098, Revision 0, 'Compliance with 10 CFR 20.1406' " (APP-GW-GLR-017), references Title 10 of the *Code of Federal Regulations* (10 CFR) 20.1406, "Minimization of Contamination." The applicant has documented changes to the radwaste building in Westinghouse TR-116, "Additional Liquid Radwaste Monitor Tanks and Radwaste Building Extension" (APP-GW-GLN-116), Revision 0. The applicant documented structural changes in

Westinghouse TR-54, "Spent Fuel Storage Racks Structure/Seismic Analysis" (APP-GW-GLR-033), Revision 0, and a redesign of the reactor vessel (RV) head in Westinghouse TR APP-GW-GLE-016, "Impact of In-Core Instrumentation Grid, Quicklocs and Changes to Integrated Head Package," Revision 0.

#### 12.1.2 Compliance with 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants"

Based upon the discussion in Section 12.1 of NUREG-1793, the standardized power plant designer or combined license (COL) applicant will satisfactorily demonstrate that the radiation protection measures incorporated in the AP1000 program, as documented in the DCD, will offer reasonable assurance that, during all plant operations, the occupational doses will be maintained ALARA and within the limits of 10 CFR Part 20, "Standards for Protection Against Radiation." The following sections present the basis for the staff's conclusions.

### **12.2 Ensuring that Occupational Radiation Exposures Are As Low As Is Reasonably Achievable**

#### 12.2.1 Summary of Technical Information

This section addresses the design, construction, and operations policies to maximize the incorporation of both design and construction engineering practices and industry lessons learned to achieve the desired ALARA objectives.

The applicant revised two areas discussing the COL applicant's management commitment and compliance with 10 CFR Part 20 and RG 1.8, "Qualification and Training of Personnel for Nuclear Power Plants"; RG 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable"; and RG 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable," to reflect the plant's staffing and organizational differences. These changes are editorial in nature and are incorporated in DCD Section 12.1.3 as COL actions requiring the COL applicant to provide such information.

The staff determined that all changes in Revision 17 to DCD Section 12.1 are editorial, with the exception of the following item:

In DCD Section 12.1.2.4, the applicant added statements certifying compliance with 10 CFR 20.1406. These changes are documented in Westinghouse TR-98, "Compliance with 10 CFR 20.1406" (APP-GW-GLN-098), Revision 0.

During its evaluation and confirmation, the staff identified insufficient information relating to the description of design features concerning the compliance with 10 CFR 20.1406. In the process of the staff developing RG 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," issued June 2008 (formerly DG-4012), the applicant submitted TR-98. This report was intended to identify and justify standard changes to be incorporated in the DCD. Revision 17 to the AP1000 DCD has incorporated the information in the various sections of the DCD, including Chapters 9, 11, and 12. The implementation of the regulations in 10 CFR 20.1406 affects other systems, structures, and components described in

the DCD. Even though this information was not described in the other DCD chapters it was referenced in the response to RAI-SRP12.1-CHPB-01.

The evaluation below provides an overview of RAI-SRP12.1-CHPB-01, and discusses the applicant's response and the staff's evaluation of the response.

### 12.2.2 Evaluation

This section of the DCD lists specific equipment, as well as facility layout and general design considerations, for 10 CFR 20.1406. The description is substantial and provides examples of design features or considerations for meeting 10 CFR 20.1406. These design features appeared to be based on the draft guidance issued for public comment in the development of DG-4012. The staff has since published the guidance as RG 4.21, Revision 0.

The information presented in DCD Tier 2, Sections 12.1–12.5, Revision 17, identifies some AP1000 general design features that would minimize the contamination of the facility and environment, as well as the generation of radioactive waste. Specifically, DCD Section 12.1.2.4 describes piping and fuel pool design features to comply with 10 CFR 20.1406. However, this information did not address design features that are unique to system designs or their locations in the plant, warranting more technical details, and the applicant did not identify those that should be considered as COL action items. The staff asked the applicant to provide this information in RAI-SRP12.1-CHPB-01. In a letter from R. Sisk to the NRC, dated September 9, 2008 (DCP/NRC2257), Westinghouse described specific features that are incorporated into the AP1000 design to comply with the requirements of 10 CFR 20.1406 or referenced in TR-98, Revision 0, for the systems that were listed in RAI-SRP12.1-CHPB-01 (and for any other plant systems that may generate or transfer radioactive materials or waste).

The staff determined that the analysis provided by Westinghouse is insufficient because Westinghouse's response to RAI-SRP12.1-CHPB-01 and TR-98 failed to address specific information regarding compliance with 10 CFR 20.1406. Chapter 9.4, "Air-Conditioning, Heating, Cooling, and Ventilation System," covers design features for heating, ventilation, and air conditioning systems (HVAC). Additional information is needed concerning design features provided for these systems to prevent or minimize contamination of the environment. For example, are there provisions to monitor and collect condensate that may form at coolers or in HVAC ducts that may contain or potentially contain contamination. The staff issued RAI-SRP12.1-SPCV-01 and RAI-SRP12.1-SPCV-02 to request this information from the applicant. This is identified as **OI-SRP12.1-CHPB-01**.

The staff also asked the applicant to provide information in RAI-TR98-CHPB-01, 02, and 03. In a letter from A. Sterdis to the NRC, dated December 19, 2007 (DCP/NRC2062), Westinghouse described other specific design features that are incorporated into the AP1000 design to comply with the requirements of 10 CFR 20.1406 and that were referenced in TR-98, Revision 0. The applicant has not committed to RG 4.21, Revision 0, but has described the design features in the licensing basis, the referenced TR-98, and in the response to the aforementioned RAIs. In summary, these documents describe the features ensuring that AP1000 meets the 10 CFR 20.1406 requirements.

### 12.2.3 Conclusions

In NUREG-1793 and its Supplement 1, the staff documented its conclusions that the AP1000 design and DCD (up to and including Revision 15) were acceptable and that the Westinghouse application for design certification met the requirements of Subpart B, "Standard Design Certifications," to 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," that are applicable and technically relevant to the AP1000 standard plant design. Based on the information supplied by the applicant, as described above, the staff concluded that the AP1000 design features met the criteria of SRP Section 12.1. These design features are intended to maintain individual doses and total person roentgen equivalent man (rem) to plant workers and to members of the public ALARA, while maintaining individual doses within the regulatory limits of 10 CFR Part 20.

The staff reviewed the applicant's proposed changes to the AP1000 radiation protection section describing activities that ensure that occupational radiation exposures are ALARA, as documented in DCD Section 12.1, Revision 17. The staff finds that the applicant's proposed changes to DCD Section 12.1 to be acceptable.

## 12.3 Radiation Sources

### 12.3.1 Summary of Technical Information

The staff approved the AP1000 DCD, Section 12.2, "Radiation Sources," Revision 15, in the certified design. This review addresses the compliance with 10 CFR Part 20 and General Design Criterion (GDC) 61, "Fuel Storage and Handling and Radioactivity Control," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

In the AP1000 DCD, Revision 17, the applicant proposed the following two technical changes with associated TR changes:

- (1) In DCD Section 11.2, the applicant proposed to increase the overall liquid waste holdup capacity and improve operational flexibility by adding three liquid waste monitor tanks (and associated pumps, piping, instruments, and valves). The applicant proposed to house the additional tanks, 56,775 liters (15,000 gallons) each in the radwaste building. The new tanks are identical to the three existing monitor tanks, which are housed in the auxiliary building. The applicant documented these changes in TR-116, Revision 0.
- (2) In DCD Section 9.1.2.1, the applicant proposed to increase the overall capacity of the spent fuel pool (SFP) from storage locations for 619 fuel assemblies to locations for 884 fuel assemblies. The applicant documented these structural changes in TR-54, Revision 0. The applicant documented the heat loading analysis changes in TR-103, "Fluid System Changes" (APP-GW-GLR-019), Revision 2.

The evaluation below discusses these changes and missing information and provides an overview of the staff's RAI-SRP12.2-CHPB-01 and RAI-SRP12.2-CHPB-02, the applicant's response, and the staff's evaluation of the response.

## 12.3.2 Evaluation

### Liquid Waste Hold-up Tank

The staff reviewed all technical changes to the radiation sources identified in the AP1000 DCD, Revision 17, in accordance with SRP Section 12.2, "Radioactive Sources." In addition, the staff reviewed the entire section to ensure that there was no missing information critical to providing adequate protection to public health and safety.

NUREG-1793 documents the regulatory basis for DCD Section 12.2, Revision 15. The staff has reviewed the proposed changes to DCD Section 12.2 against the applicable acceptance criteria in SRP Section 12.2. The following evaluation discusses the results of the staff's review.

In TR-116, the applicant proposed to add three liquid waste monitor tanks (and associated pumps, piping, instruments, and valves) and to house the additional tanks, 56775 liters (15,000 gallons) each in the radwaste building.

In its review of DCD Section 12.2, the staff identified areas in which additional information was necessary to complete its evaluation of the applicant's change (RAI-SRP12.2CHPB-01). In DCD Tier 2, Section 11.2, the staff noted that a potential exists for the quantity of the radionuclides in the radwaste building portion of the liquid waste management system to exceed the  $A_1$  value. The DCD states that, "The monitor tanks in the non-seismic radwaste building are used to store processed water. The radioactivity content of processed water in each tank will be less than the  $A_1$  and  $A_2$  levels of 10 CFR 71, Appendix A, Table A-1 (" $A_1$  and  $A_2$  Values for Radionuclides")."

In 10 CFR Part 71, Subsection 71.4 defines  $A_1$  as the maximum activity of special form radioactive material permitted in a Type A package.  $A_2$  is defined as the maximum activity of radioactive material, other than special form materials, low specific activity, and surface contaminated object material permitted in a Type A package.

The description of the radioactive sources listed for liquid waste tanks included in DCD Section 12.2 did not indicate an increase in volume to approximately 170,325 liters (45,000 gallons) and hence an increase in the overall radioactivity that would thereby be a much larger source of occupational radiation to personnel in the radwaste building.

In Tier 2, Figure 12.3-1 (Sheet 14 of 16), Radiation Zones, Normal Operation/Shutdown Radwaste Building EL 100'-0" indicates that the room (Rm No. 50355) that the tanks will be located in is Plant Radiation Zone 1, which is defined by Figure 12.3-1 (Sheet 1 of 16) in Tier 2, as Very Low or No Radiation Sources: "Inside Controlled Area" and Outside "Restricted Area." This is an area that will result in a dose rate of less than or equal to 2.5 microSieverts per hour ( $\mu\text{Sv/h}$ ) (0.25 millirem per hour (mrem/h)).

The applicant responded to the staff's concerns in a letter from R. Sisk to the NRC, dated September 9, 2008 (DCP/NRC2257). The applicant agreed that the liquid waste tanks could alter the plant radiation zone assignment and that the issue should be re-analyzed. The affected area will be reclassified to a Plant Radiation Zone III. Plant Radiation Zone III is defined in DCD Tier 2, Section 12.3, Figure 12.3-1, as being an area of low-to-moderate radiation sources; limited worker occupancy, with maximum design dose rates less than or

equal to 150  $\mu\text{Sv/h}$  (15.0 mrem/h ). The revised radiation zone reflects the potential increase in volume and hence the increased radioactivity stored in the liquid waste monitor tanks. Given the building design, tank thickness and potential radioactivity stored in the liquid waste monitor tanks, assigning the adjacent area as a Plant Radiation Zone III is appropriate. Based on the evaluation of the DCD information and the applicant's response to the RAI, the staff concluded that the applicant properly identified all design information related to the three additional liquid waste monitor tanks and associated equipment and provided an adequate demonstration that design objectives have been met for the contained source terms described in the DCD as the basis for radiation design shielding calculations and personnel dose assessment.

### Spent Fuel Pool Capacity

In DCD Section 9.1.2.1, "Design Basis," the applicant increased the overall capacity of the spent fuel storage from the proposed storage locations for 619 fuel assemblies to storage locations for 884 fuel assemblies. The staff noted that the additional fuel assemblies were not addressed in DCD Section 12.2.1.2.3, "Spent Fuel," nor included in Table 12.2-25, "Fuel Handling Area Airborne Radioactivity Concentrations." The potential addition of 265 fuel assemblies with 0.25 percent fuel defects would increase the airborne radioactivity. Moreover, Table 12.2-25, did not identify the basis of the parameters included in Table 12.2-24 for the number of fuel assemblies used in its calculations. The staff presented these concerns in RAI-SRP12.2-CHPB-02 and the applicant responded via letter from R. Sisk to the NRC, dated September 9, 2008 (DCP/NRC2257). The air activity was based on a full core offload, with Reactor Vessel Design (RV) head removal at 100 hours after shutdown; completion of core offload was determined to be 10 days (that is, 240 hours after shutdown); and the SFP purification system operating at 946 liters per minute (250 gallons per minute). Table 2.2-25 was based only on the core from the recent full offload and thus not affected by the increase in the number of fuel assemblies in the SFP. However, the applicant stated that it would complete a detailed review and revise the response, if necessary. This is Open Item **OI-SRP-12.2-CHPB-02**.

### 12.3.3 Conclusions

In NUREG-1793 and its Supplement 1, the staff documented its conclusions that the AP1000 design and DCD (up to and including Revision 15 to the DCD) were acceptable and that the Westinghouse application for design certification met the requirements of Subpart B to 10 CFR Part 52 that are applicable and technically relevant to the AP1000 standard plant design.

In its previous evaluations of the AP1000 DCD, Section 12.2, the staff identified acceptance criteria based on the ability of the design to meet the relevant requirements in 10 CFR Part 20, as it relates to limits on doses to occupationally exposed persons in restricted areas, and in the requirements of GDC 61, as it relates to the information about radiation sources provided by the applicant.

The staff considers RAI-SRP12.2-CHPB-01 to be resolved, and it has verified that the appropriate change was incorporated in Revision 17 to DCD Tier 2, Figure 12.3-1, Sheet 14 of 16, room number 50355. Pending resolution of OI-SRP12.2-CHPB-02, the staff concludes that the applicant has committed to follow the guidelines of the RGs and staff positions set forth in SRP Section 12.3.

## **12.4 Radiation Protection Design Features**

### 12.4.1 Summary of Technical Information

The staff approved DCD Section 12.3, "Radiation Protection Design Features," Revision 15, in the certified design. This review addresses system design, performance aspects, and ITAAC only of the radiation protection design features.

The staff-assessment of the revisions listed in Tier 2, Section 12.3 "Radiation Protection Design Features," include changes in Tier 1, Chapter 3.5, "Radiation Monitoring" (ITAAC) and Tier 2, Section 11.5, "Radiation Monitoring." These changes do not affect the ITAAC scope and acceptance criteria.

In the AP1000 DCD, Revision 17, the applicant proposed to make the following three technical changes. The staff also identified an additional change related to the density of concrete used for shielding purposes:

- (1) In DCD Section 12.3.2.2.4, "Fuel Handling Area Shielding Design," the applicant decreased the minimum water depth above the active fuel portion of the assembly. Spent fuel removal and transfer operations are performed under borated water to provide radiation protection and maintain subcriticality. Minimum allowable water depths above active fuel in a fuel assembly during fuel handling were 3.05 meters (m) (10 feet (ft)) in the reactor cavity and in the SFP. This limits the dose to personnel on the spent fuel pool handling machine (SFHM) to less than 25  $\mu\text{Sv/h}$  (2.5 mrem/h) for an assembly in a vertical position. Normal water depth above the stored assemblies is about 7 m (23 ft), and for this depth the exposure to plant workers is insignificant. TR-121, "Spent Fuel Pool Water Level and Dose" (APP-GW-GLN-121), Revision 0, documented these changes. During the review of Revision 17 to DCD Tier 2, Section 12.3.2.2.4, the staff observed that the applicant decreased the overall minimum allowable water depth above active fuel in the reactor cavity and SFP to 2.67 m (8.75 ft) during fuel movement.
- (2) In DCD Section 12.3.1.1.2, "Common Facility and Layout Designs for ALARA," and Section 12.3.5.1, "Administrative Controls for Radiological Protection," the applicant added statements certifying compliance with 10 CFR 20.1406. TR-98, Revision 0, documented these changes. In the DCD sections, the applicant described general practices, such as to minimize the use of embedded pipes to the extent possible, consistent with maintaining radiation doses ALARA. In addition, to the extent possible, pipes will be routed in accessible areas, such as dedicated pipe routing tunnels or pipe trenches, which provide good conditions for decommissioning, and the number of passageways (doors) between the radiological controlled area and the environment has been minimized. When such doors are incorporated, systems of drains and floor and exterior concrete sloping are used to prevent (potentially radioactive) fluid from exiting the buildings, as well as to prevent surface water from entering the buildings. Because of the potential for adsorption of contaminated fluids, another feature included minimizing the use of concrete block walls in the radiologically controlled areas of the plant. Where such walls are used, they are fully sealed at the ceiling or top of the block

to prevent liquid incursion. The applicant added two COL information items where the COL applicant will, in accordance with 10 CFR 20.1406, establish a groundwater monitoring program beyond the normal radioactive effluent monitoring program and will establish a program to ensure documentation of operational events deemed to be of interest for decommissioning, beyond that required by 10 CFR 50.75, "Reporting and Recordkeeping for Decommissioning Planning." This or another program will include remediation of any leaks that have the potential to contaminate groundwater.

- (3) In DCD Tier 2, Section 12.3.1.1.1, the applicant proposed changes to the Integrated RV Head Package and Quick-Lock Connectors. The staff noted that the applicant's description included an integrated head package that combines the head lifting rig, control and gray rod drive mechanisms, lift columns, control rod drive mechanism cooling system, and power and instrumentation. In its review of DCD Section 12.3 and 12.4, the staff identified areas that needed additional information to complete its evaluation of the applicant's change including Figure 12.3-1 (sheet 8 of 16), "Radiation Zones, Normal Operation/Shutdown Nuclear Island," EL 135'-3" and Table 12-4-12, "Dose Estimate for Refueling Activities." The description of the change lacked sufficient detail to determine the radiological impact on occupational exposure (RAI-SRP12.3-CHPB-01).
- (4) In DCD Section 12.3.2.2.9, the applicant decreased the overall assumed concrete density used for shielding design purposes in the spent fuel transfer canal and tube shielding from 147 pounds per cubic foot (lb/ft<sup>3</sup>) to 140 lb/ft<sup>3</sup>, without an analysis or description of the potential radiological effects.

#### 12.4.2 Evaluation

The staff reviewed all technical changes to the radiation protection design features identified by change marks in the AP1000 DCD, Revision 17, in accordance with SRP Section 12.3-4, "Radiation Protection Design Features." Descriptions and evaluations of the radiation protection design features in the AP1000 DCD, Revision 15, that were previously approved are not affected by the new changes and were not re-reviewed by the staff. Information presented in the Westinghouse TRs supports all technical changes in this section of the DCD.

The staff reviewed the Tier 1, Chapter 3.5, "Radiation Monitoring," ITAAC. This section remained substantially unchanged, but DCD Revision 17 enhanced the Airborne Radioactivity and Area Radiation Monitors by adding monitors with multiple detectors and revising the title of selected area monitors. No additional technical evaluation was required for Chapter 12.3.4, "Area Radiation and Airborne Radioactivity Monitoring Instrumentation."

NUREG-1793 documents the regulatory basis for the AP1000 DCD, Section 12.3, Revision 15. The staff has reviewed the proposed changes to DCD Section 12.3 against the applicable acceptance criteria of SRP Section 12.3-4. The following evaluation discusses the results of the staff's review.

##### 12.4.2.1 Fuel Handling Area Shielding Design

In DCD Section 12.3.2.2.4, spent fuel removal and transfer operations are performed under borated water to provide radiation protection and maintain subcriticality. According to Revision



15 to DCD Tier 2, Section 12.3.2.24, minimum allowable water depths above active fuel in a fuel assembly during fuel handling are 3.05 m (10 ft) in the reactor cavity and SFP. This limits the

dose to personnel on the SFHM to less than 25  $\mu\text{Sv/h}$  (2.5 mrem/h) for an assembly in a vertical position. Normal SFP water depth above the stored assemblies is approximately 7 m (23 ft); and, for this depth, the exposure to plant workers is insignificant. TR-121, Revision 0, documented several changes, and as a result, the NRC staff questioned the accuracy of the calculated exposure to workers adjacent to the fuel handling area. The response to RAI-SRP12.2-CHPB-02 clarified the issue raised by the NRC staff to show that it was not possible to maintain the original value of 3.05 m (10 ft) of water over the fuel assembly, given the design of the SFP and its handling equipment. The design drawings showed an actual value of 2.59 m (8.5 ft) of water. The changes submitted in TR-121 raised the water level in the SFP by 0.3 m (12 inches) to 2.89 m (9.5 ft), and dose rate calculations showed that the dose to the SFHM operators would be 25  $\mu\text{Sv/h}$  (2.5 mrem/h) or less when moving an irradiated fuel assembly while standing on the SFHM. The applicant documented these changes in TR-121, Revision 0. The applicant also responded to the RAI related to TR-121 in the letter from A. Sterdis to the NRC, dated October 4, 2007 (DCP/NRC2015), and described assumptions used in its calculations for the exposure of workers adjacent to the fuel handling areas (RAI-TR121-CHPB-01, 03, and 04). The applicant described the potential radiological effects and dose estimates associated with the change in the minimum water level over active fuel in the refueling area and the SFP.

During the review of Revision 17 to DCD Tier 2, Section 12.3.2.2.4, the staff observed that the applicant again changed the overall minimum allowable water depth above active fuel in the reactor cavity and SFP from 2.89 m (9.5 ft) to 2.67 m (8.75 ft) during fuel movement. With this change in the water level, the applicant did not identify the basis of its parameters in Section 12.3.2.2.4 or the reason for the change. The staff issued RAI-SRP12.3-CHPB-02 to request an explanation for the Revision 17 changes to the minimum refueling and SFP water depth.

The staff reviewed the shielding calculation, APP-GW-N2C-006, Revision 2, Spent Fuel Shielding Evaluation (Alt Doc # CN-REA-05-55) referenced in the response to staff RAI SRP12.3-CHPB-02. On the basis of this review, the staff has additional questions related to calculations performed for both 2.59 m (102 inches) and 2.67 m (105 inches) above the active portion of the fuel assembly and how the heights of 2.59 m (102 inches) and 2.67 m (105 inches) above the fuel assembly correspond to the minimum required water level in the spent fuel pool (SFP).

The APP-GW-N2C-006 also provided the worst-case source, Case D ( $4.16\text{E}+12$   $\gamma$ -cc/sec) from a single fuel assembly at 2.59 m (8.5 ft) and 2.67 m (8.75 ft) below the water's surface. It appears from the information supplied in the referenced calculation that the source described in Case A ( $4.26\text{E}+12$   $\gamma$ -cc/sec) is more conservative based solely on the dose contribution from the single elevated fuel assembly in the SFP. The staff requested a clarification to determine the basis for selection of Case D vs. Case A, as well as a description of design features/access controls to ensure that the dose to the refueling personnel on the fuel handling bridge deck are maintained ALARA during refueling operations. The staff identified this as **OI-SRP12.3-CHPB-02**.

#### 12.4.2.2 Compliance with 10 CFR 20.1406

During its evaluation of Revision 17 to the DCD, the staff identified insufficient information available on the description of design features concerning its compliance with 10 CFR 20.1406 (RAI-SRP12.1-CHPB-01). The staff was in the process of developing RG 4.21, formerly DG-4012, when the DCD applicant submitted TR-98, Revision 0. The staff intended for its report to identify and justify standard changes to be incorporated in the DCD. Revisions 16 and 17 incorporated the information into the various sections of the DCD, including Chapters 9, 11, and 12. The implementation of 10 CFR 20.1406 affects other systems, structures, and components described in the DCD, but that information was not sufficiently described in the other DCD chapters. The design features discussed in DCD Section 12.3 and the COL information items, added as a result of TR-98, clarify some aspects of the applicant's compliance with 10 CFR 20.1406 but do not provide the description of the program consistent with the guidance in RG 4.21.

In TR-98, Revision 0, the applicant proposed to comply with the regulation by the selection of design technology. Table TR-98-1, "AP1000 Features Applicable to 10 CFR 20.1406," in TR-98 lists specific examples (items 19, 22, 23, 24, 25 and 26 in the table) showing how the AP1000 design complies with the portions of 10 CFR 20.1406 dealing with minimizing the generation of waste. The staff has reviewed the items listed in Table TR-98-1 pertaining to the liquid radwaste system and finds that the applicant addressed the issue of minimization of waste generation in 10 CFR 20.1406. The applicant has not committed to RG 4.21, Revision 0, but has described the design features in the licensing basis for the AP1000 to meet 10 CFR 20.1406 requirements. The staff implemented 10 CFR 20.1406 and issued RG 4.21 after Revision 16 to the DCD but before Revision 17. Therefore, the staff is providing documentation requirements for following this RG in correspondence related to Chapter 12 for COL applicants.

In a letter from R. Sisk to the NRC, dated September 9, 2008 (DCP/NRC2257), Westinghouse described specific features that are incorporated into the AP1000 design to comply with the requirements of 10 CFR 20.1406 or are referenced in TR-98, Revision 0, for the systems that were listed in RAI-SRP-12.1-CHPB-01 (and for any other plant systems that may generate or transfer radioactive materials or waste). Subject to resolution of OI-SRP12.1-CHPB-01 (see section 12.2.2), the analysis is sufficient because the responses to RAI-SRP12.1-CHPB-01, as well as TR-98, provide specific information about compliance with 10 CFR 20.1406, and the staff has determined that the applicant considered the applicable design criteria.

#### 12.4.2.3 Addition of Integrated RV Head Package and Quick-Lock Connectors

In its review of DCD Section 12.3, the staff identified areas that needed additional information to complete an evaluation of the applicant's proposed change (RAI-SRP12.3-CHPB-01). In Tier 2, DCD Section 12.3.1.1.1, the staff noted that the applicant's description now includes an Integrated RV Head Package that combines the head lifting rig, control and gray rod drive mechanisms, lift columns, control rod drive mechanism cooling system, and power and instrumentation cabling. The applicant also replaced the conventional top-mounted instrumentation ports/conoseal thermocouple arrangement with a combination

thermocouple/incore detector system. The description of the change to include the integrated RV Head Package lacks sufficient information to determine if the containment area radiation zones are affected or if the implementation results in an increase or decrease in the refueling dose estimates. The applicant has not yet responded to this RAI. The staff identified this as **OI-SRP12.3-CHPB-01**.

In Revision 17 to DCD Tier 2, Figure 12.3-1 (Sheet 8 of 16), "Radiation Zones, Normal Operation/Shutdown Nuclear Island," EL 135'-3" indicates that the RV head stand area may be a Plant Radiation Zone V [less than or equal to 10mSv/h (1 rem/h)] when the RV head is in the stand, which is defined by Figure 12.3 1 (Sheet 1 of 16). In Revision 15, the same drawing indicated that the area for the RV head stand would be a Plant Radiation Zone II [(less than or equal to 25  $\mu$ Sv/h (2.5 mrem/h)]. There are no supporting calculations to show that the Integrated RV Head Package will result in a dose rate of less than or equal to the original RV head configuration, or to show how this change is ALARA.

Table 12.4-12, "Dose Estimate for Refueling Activities," has not changed as a result of the addition of the design change implementing the Integrated RV Head Package. The use of an integrated RV head, which has been installed at several current generation facilities, minimizes the time necessary to perform disassembly and reassembly of the RV during refueling outages.

#### 12.4.2.4 Concrete Density for Shielding Design

During the review of Revision 17 to DCD Tier 2, Section 2.3.2.2.9, "Spent Fuel Transfer Canal and Tube Shielding," the staff observed that the applicant decreased the assumed overall concrete density for shielding design purposes from 2354.7 kilograms per cubic meter ( $\text{kg/m}^3$ )(147  $\text{lb/ft}^3$ ) to 2242.58  $\text{kg/m}^3$  (140  $\text{lb/ft}^3$ ). The applicant provided no discussion in DCD Chapter 12 (in Revision 17) describing the effect of an approximate 5-percent decrease in the assumed shielding density of the transfer tube on area radiation levels during fuel movement. With the reduction in the concrete density, the applicant did not identify the basis of the parameters included in Section 12.3.2.2.9 or the reason for the change. The applicant did not describe the radiological exposure consequences for occupationally exposed personnel nor discuss the effect on radiation zoning. The staff asked the applicant to address these concerns in RAI-SRP12.3-CHPB-03. The applicant has not yet responded to this RAI. The staff identified this as **OI-SRP12.3-CHPB-03**.

#### 12.4.3 Conclusions

Based on the evaluation of the DCD information and response to RAI-SRP12.1-CHPB-01, and subject to resolution of OI-SRP12.1-CHPB-01 (see section 12.2.2), the staff concluded that the applicant properly identified design information related to its compliance with 10 CFR 20.1406 and provided an adequate demonstration that design objectives for equipment necessary to minimize contamination to the environment have been met, in accordance with 10 CFR Part 20.

Based on the evaluation of the DCD information in the applicant's response to RAI-SRP12.3-CHPB-02, and RAI-SRP12.3-CHPB-03, the staff concluded that the applicant has not properly identified all design information related to its compliance with 10 CFR Part 20 and with GDC 61, nor has it provided an adequate demonstration that design objectives have been met for the spent fuel handling equipment, spent fuel transfer canal, and tube shielding

necessary to minimize exposure to ALARA, in accordance with 10 CFR Part 20. The staff identified these as **OI-SRP12.3-CHPB-02** and **OI-SRP-12.3-CHPB-03**.

Based on the review of the AP1000 design certification amendment and the Westinghouse TR APP-GW-GLE-016, Revision 0, the staff determined that additional information was needed. This report did not describe any changes to Section 12.4 or the dose estimate. In RAI-SRP12.3-CHPB-01, the staff asked the applicant to provide a complete description of how the placement of the Integrated RV Head Package and the revised and associated equipment in the containment building meet the acceptance criteria of SRP Section 12.3.4. The staff identified this as **OI-SRP12.3-CHPB-01**.

The staff determined that the proposed changes in Tier 1, Chapter 3.5, "Radiation Monitoring," in Revision 17 to the DCD enhanced the Airborne Radioactivity and Area Radiation Monitors by adding monitors with multiple detectors and revising the title of selected area monitors.

Upon resolution of the open items, the following conclusions apply.

In NUREG-1793 and its Supplement 1, the staff documented its conclusion that the AP1000 design and DCD (up to and including Revision 15 to the DCD) were acceptable and that the Westinghouse application for design certification met the requirements of Subpart B to 10 CFR Part 52 that are applicable and technically relevant to the AP1000 standard plant design.

In its previous evaluation of the AP1000 DCD, Section 12.3, the staff identified acceptance criteria based on the ability of the applicant's design to meet the relevant requirements in 10 CFR Part 20, as it relates to limits on doses to persons in restricted areas; 10 CFR Part 50, as it relates to the inclusion of sufficient design information to demonstrate the objectives for equipment facility design features, shielding, ventilation, area radiation, and airborne radioactivity monitoring instrumentation; and 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," as it relates to the design of radiation protection features to ensure adequate safety under normal and abnormal operating conditions. The staff reviewed the AP1000 design for compliance with these requirements, as referenced in SRP Section 12.3-4, and determined that the design of the radiation protection features, as documented in the AP1000 DCD, Revision 15, was acceptable because it conformed to all applicable acceptance criteria.

The staff reviewed the applicant's proposed changes to the AP1000 radiation protection design features as documented in the AP1000 DCD, Revision 17. The staff finds that the applicant's proposed changes do not affect the ability of the AP1000 design features to meet the applicable acceptance criteria. The staff also concluded that the applicant has properly incorporated the design changes into the appropriate sections of the AP1000 DCD, Revision 17. On the basis that the AP1000 radiation protection design features continue to meet all applicable acceptance criteria and that the updated AP1000 DCD properly documents the changes, the staff concluded that all of the changes related to the radiation protection features in the AP1000 system design are acceptable.

## **12.5 Dose Assessment**

### 12.5.1 Summary of Technical Information

The staff approved DCD Section 12.4, "Dose Assessment," in Revision 15 to the certified design. In Revision 17 to the AP1000 DCD there were no technical changes. This review addresses the anticipated occupational radiation exposure from normal operation and anticipated inspections and maintenance.

### 12.5.2 Evaluation

The staff reviewed all changes to the "Dose Assessment" section in accordance with SRP Section 12.3-4. The staff also reviewed all changes in the AP1000 DCD, Revision 17. Information presented in the Westinghouse TRs support all changes in the DCD.

NUREG-1793 documents the regulatory basis for the AP1000 DCD, Section 12.4, Revision 15. The staff has reviewed the proposed changes to DCD Section 12.4 against the applicable acceptance criteria in SRP Section 12.3-4. The following evaluation discusses the results of the staff's review.

#### 12.5.2.1 Summary of Changes

There are no supporting calculations to show that the Integrated RV Head Package will result in a dose rate of less than or equal to the original RV head configuration, or to show how this change is ALARA. Table 12.4-12 does not reflect increased dose (man-rem) as a result of the addition of the design change implementing the integrated RV head package. The use of an integrated head, which has been installed at several current generation facilities, minimizes the time necessary to perform disassembly and reassembly of the RV during refueling outages. The staff asked the applicant to address these issues in RAI-SRP12.3-CHPB-01. This is part of **OI-SRP12.3-CHPB-01**.

### 12.5.3 Conclusions

None of the changes described alter or affect the dose assessment in Revision 15 to the AP1000 DCD. The staff requires no technical evaluation of the changes described in DCD Tier 2, Section 12.4, with the exception of OI-SRP12.3-CHPB-01.

After satisfactory resolution of the Open Item contained in this section, the following conclusion applies.

In NUREG-1793 and its Supplement 1, the staff documented its conclusion that the AP1000 design and DCD (up to and including Revision 15) were acceptable, with the exception of OI-SRP12.3-CHPB-01, and that the Westinghouse application for design certification met the requirements in Subpart B to 10 CFR Part 52 that are applicable and technically relevant to the AP1000 standard plant design. No technical evaluation is required of the changes described in DCD Tier 2, Section 12.4.

The staff concluded that COL Action Item 12.5-1 was not technical in nature and has not changed from DCD Revision 15.

## **12.6 Health Physics Facilities Design**

This section describes the staff's evaluation and findings of the AP1000 DCD, Revisions 16 and 17. The staff originally reviewed Revision 16 and issued several RAIs, but the applicant issued Revision 17 before the staff could close out the RAIs for the previous revision. This review and evaluation, therefore, encompasses both revisions.

### 12.6.1 Summary of Technical Information

The staff approved Section 12.6, "Health Physics Facilities Design," of the AP1000 DCD, Revision 15, in the certified design. In Revision 17 to the AP1000 DCD, the applicant proposed one change, described below, with associated TR changes. This review addressed system design and performance aspects only of the health physics facilities design.

In DCD Tier 2, Section 9.1.2, "Spent Fuel Storage," and Section 9.1.4, "Light Load Handling System," the applicant proposed to increase the minimum allowable water depth above the active fuel region in a fuel assembly to 2.89 m (9.5 ft) when an assembly is being transferred in an SFHM. The applicant stated that the proposed increase in minimum water depth was sufficient to ensure that the personnel radiation exposures would be limited to less than or equal to 25  $\mu\text{Sv/h}$  (2.5 mrem/h) on the SFHM. The applicant has documented these changes in TR-121, Revision 0.

### 12.6.2 Evaluation

The staff reviewed the technical changes to the health physics facilities design, in accordance with SRP Section 12.3-4. The staff reviewed all changes identified by change marks in the AP1000 DCD, Revision 17. The information presented in Westinghouse TRs supports all technical changes in the DCD.

NUREG-1793 documents the regulatory basis for DCD Section 12.5, Revision 15. The staff has reviewed the proposed changes to DCD Section 12.5 against the applicable acceptance criteria of SRP Sections 12.3-4 and 12.5. The following evaluation discusses the results of the staff's review.

#### 12.6.2.1 The Results of Spent Fuel Water Level and Dose

In TR-121, the applicant proposed to change the minimum required depth of water above the active fuel region in a fuel assembly to minimize the exposure from direct radiation to personnel operating equipment on the SFHM. In its review, the staff requested additional information providing the dose rate analysis that was based on an actual increase in the water level from approximately 2.59 m (8.5 ft) to 2.89 m (9.5 ft) above the actual fuel in a fuel assembly when in an SFHM. The applicant responded to the RAI related to TR-121 in a letter from A. Sterdis to the NRC, dated October 4, 2007 (DCP/NRC2015), and described the assumptions used in its calculations for the exposure of workers adjacent to the fuel handling areas (RAI-TR121-CHPB-01, 03, and 04). The applicant described the potential radiological effects

and dose estimates associated with the reduction of the minimum water level over active fuel in the refueling area and the SFP. Revision 16 to the AP1000 DCD incorporated these changes.

In its review of DCD Section 12.5, the staff identified areas in which the additional information provided by Westinghouse in a letter dated October 4, 2007 determined that the initial depth of water was in error. The SFHM design actually provided 2.59 m (8.5 ft) depth of water over the active fuel in a fuel assembly when initially proposed. In the Westinghouse response provided, the elevation of the top of the active fuel was unchanged since the SFP water level was increased by 0.3 m (12 inches). This was necessary to ensure that the exposure rates on the bridge deck (where operating personnel would normally be located) were less than 25  $\mu\text{Sv/h}$  (2.5 mrem/h). The information provided, and a review of the requisite guidance in SRP Sections 12.3-4 and 12.5, and in RG 1.13, "Spent Fuel Storage Facility Design Basis," Revision 2, allowed the staff to complete its evaluation of the applicant's change.

In DCD Tier 2, Section 9.1.4, the staff noted that a potential exists for the movement of active fuel above the required minimum water depth, if the applicant uses an auxiliary hoist in conjunction with a specialized spent fuel handling tool (SFHT) to reach the approximately 25 percent of the SFP rack spaces that are not accessible using the SFHM. The Westinghouse response to TR-121, RAI-SRP9.1.4-SBPB-04 describes this activity. The applicant's responses to the staff's RAI are discussed below.

Section 9.1.4.3.7 of the DCD states that:

"The three fuel handling devices used to lift spent fuel assemblies are the refueling machine, fuel handling machine, and the spent fuel handling tool. Both the refueling machine and fuel handling machine contain positive stops which prevent the fuel assembly from being raised above a safe shielding height."

DCD Section 9.1.4.3.3 invokes the design of the refueling machine for the SFHM; DCD Section 9.1.4.3.1 states that, because of "mechanical or failure tolerant electrical interlocks or redundant electrical interlocks," the "refueling machine is restricted to raising a fuel assembly or core component to a height at which the water provides a safe radiation shield."

The latter statements imply that, when using the SFHT, there are no positive stops to prevent the fuel assembly from being raised above a safe shielding height. The SFHT with an auxiliary hoist will apparently be used for at least 25 percent of the SFP storage cells, based on the information in TR-121. In TR-121, Revision 0, Westinghouse stated the following:

"due to the radius of the FHM manipulator mast and the proximity to the SFP walls, approximately 25% of the SFP storage cells cannot be serviced by the mast crane. Also, there are instances where fuel inspection and/or fuel repair require the fuel to be moved from the SFP storage racks to the designated fuel inspection or fuel repair workstation. These non-normal fuel transfer operations are performed using the Spent Fuel Handling Tool (SFHT). The SFHT is a long handled tool which latches onto the fuel assembly top nozzle via manually actuated grippers. Lifting of the SFHT and attached fuel assembly is performed using an auxiliary hoist on the FHM."

The DCD does not describe any interlocks related to the movement of fuel assemblies when using the auxiliary hoist.

In a letter from R. Sisk to the NRC, dated June 26, 2008 (DCP/NRC2177), Westinghouse submitted a response to RAI-SRP9.1.4-SBPB-04 on fuel handling equipment. The response stated that the refueling machine and the SFHM will contain positive stops to prevent the fuel assembly from being raised above a safe shielding point. The SFHT will only be used in conjunction with the refueling machine and the SFHM. The applicant's response also stated that it would revise DCD Tier 1 Section 2.1.1, page 2.1.1-1, to limit the lift height of the refueling machine mast and SFHM mast to maintain the minimum required depth of water shielding. DCD Tier 1, Table 2.1.1-1, includes Item 5 of the inspections, tests, analyses, and acceptance criteria to describe the acceptance criteria for this design commitment. This addresses the staff's concern for adequate radiation shielding during spent fuel movement.

#### 12.6.2.2 Documentation of Compliance with 10 CFR Part 20

The staff finds that these changes do not affect the design and performance aspects of the health physics facilities, as previously reviewed in NUREG-1793, Section 12.6.

#### 12.6.3 Conclusions

In NUREG-1793 and its Supplement 1, the staff documented its conclusion that the AP1000 design and DCD (up to and including Revision 15 to the DCD) were acceptable and that the Westinghouse application for design certification met the requirements of Subpart B to 10 CFR Part 52 that are applicable and technically relevant to the AP1000 standard plant design.

In its previous evaluations of the AP1000 DCD, Section 12.5, regarding the health physics facilities design, the staff identified acceptance criteria based on the ability of the design to meet the relevant requirements in 10 CFR 20.1302, "Compliance with Dose Limits for Individual Members of the Public," as it relates to limits on doses to persons in occupied areas, and GDC 61, as it relates to the design of spent fuel storage and handling to ensure adequate safety under normal and postulated accident conditions. The staff reviewed the AP1000 health physics facilities design for compliance with these requirements, as referenced in SRP Section 12.5, and determined that the design of the health physics facilities, as documented in the AP1000 DCD, Revision 15, was acceptable because it conformed to all applicable acceptance criteria.

The staff reviewed the applicant's proposed changes to the AP1000 health physics facilities design as documented in the AP1000 DCD, Revision 17. The staff concluded that the applicant's proposed changes do not affect the ability of the AP1000 health physics facilities design to meet the applicable acceptance criteria. The staff also concluded that the applicant has properly incorporated the design changes into the appropriate sections of the AP1000 DCD, Revision 17. On the basis that the AP1000 health physics facilities design continues to meet all applicable acceptance criteria and the updated AP1000 DCD properly documents the changes, the staff concluded that all of the changes related to the system design of the AP1000 health physics facilities are acceptable.