## 12 RADIATION PROTECTION

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Appendix A, "Design Certification Rule for the U.S. Advanced Boiling Water Reactor," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," constitutes the standard design certification (DC) for the U.S. Advanced Boiling Water Reactor (ABWR) design. To document the U.S. Nuclear Regulatory Commission (NRC) staff's review supporting initial certification of the ABWR, the staff issued a final safety evaluation report (FSER) in NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design," in July 1994 and NUREG-1503, Supplement 1, in May 1997.

The staff is documenting its review of the GE-Hitachi Nuclear Energy (GEH or the applicant) application for renewal of the ABWR DC in Supplement 2 to NUREG-1503. Chapter 1 of this supplemental FSER describes the staff's review process for the ABWR DC renewal. This supplemental FSER section documents the NRC staff's review specifically related to Chapter 12, "Radioactive Protection," Section 12.3, "Radiation Protection Design Features," of the GEH Design Control Document (DCD), Revision 7. Except as modified by this supplement to the FSER, the findings made in NUREG-1503 and its Supplement 1 remain in full effect.

## 12.3 Radiation Protection Design Features

This evaluation documents the staff's review of the applicant's voluntary submittal to demonstrate that the ABWR design meets the requirements of 10 CFR 20.1406(b). Since the requirements of 10 CFR 20.1406, "Minimization of Contamination," were not applicable at the time the initial ABWR was certified, 10 CFR 20.1406 is not required to be addressed for the renewal. However, with the supplemental information provided, the applicant chose to voluntarily comply with 10 CFR 20.1406(b). In addition, combined license (COL) applicants referencing the ABWR design are required to conform with the operational aspects of 10 CFR 20.1406(a) and any site-specific design information is required to address the requirements of 10 CFR 20.1406(a).

The staff notes that the originally certified ABWR design included much of the information that would be necessary to conform to the requirements of 10 CFR 20.1406(b). However, the applicant's supplemental information and proposed ABWR DCD revisions consolidated the information and included new design information consistent with 10 CFR 20.1406(b) and Regulatory Guide (RG) 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning."

### *12.3.1 Regulatory Criteria*

Because the applicant's proposed design changes are voluntary, they are "amendments," as this term is defined in Chapter 1 of this supplement. Therefore, the proposed changes are evaluated using the regulations in effect at renewal. The following regulatory requirement provides the basis for the acceptance criteria for the staff's review:

- 10 CFR 20.1406(b) requires that applicants for standard DCs submitted after August 20, 1997, describe in the application how facility design will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

*12.3.2 Summary of Technical Information*

In a letter dated July 20, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12125A385), the NRC staff identified 28 items for GEH's consideration as part of its application to renew the ABWR DC. In Item No. 5 of the July 20, 2012, letter, the staff requested that GEH include 10 CFR 20.1406 design features to minimize contamination and the generation of reactor waste. In a GEH letter dated August 4, 2015 (ADAMS Accession No. ML15216A311), the applicant provided information describing how the ABWR design minimizes, to the extent practicable, contamination of the facility and the environment; facilitates eventual decommissioning; and minimizes, to the extent practicable, the generation of radioactive waste by following the guidance of RG 4.21; thereby addressing the requirements of 10 CFR 20.1406(b). In a teleconference on January 19, 2016 (ADAMS Accession No. ML16027A283), the staff asked the applicant to address several issues regarding ABWR compliance with 10 CFR 20.1406(b,) that were not fully addressed in the initial submittal, including adding information to the ABWR DCD on the use of embedded piping in the ABWR design and on the use of epoxy coatings. Epoxy coatings minimize the potential spread of contamination and allow for easier cleanup of spills. Embedded piping can increase the potential for undetected leaks, which could be released to the environment or result in unnecessary contamination issues when the plant is eventually decommissioned. In addition, leaks in embedded pipes can be difficult to access and repair.

Therefore, in a letter dated March 16, 2016 (ADAMS Accession No. ML16076A066), the applicant included additional supplemental information on how the ABWR is designed in accordance with 10 CFR 20.1406(b) to address the staff's comments.

*12.3.3 Technical Evaluation*

The following evaluation addresses information provided in the August 4, 2015, GEH proposed design changes, as supplemented and clarified by the March 16, 2016, GEH submittal and the ABWR DCD proposed revisions. The evaluation also discuss some of the information already provided in the DCD, which the NRC staff determined to be acceptable information to demonstrate that the ABWR has been designed in accordance with the requirements of 10 CFR 20.1406(b).

As part of its submittals, the applicant proposed adding ABWR DCD Tier 2, Table 12.3-8 which identifies the ABWR DCD chapter and sections that discuss implementation of the design objectives. The applicant also proposed creating DCD Tier 2, Section 12.3.1.5, "Minimization of Contamination and Radioactive Waste Generation," to provide information on how the ABWR minimizes contamination and radioactive waste generation and facilitates decommissioning, including a general description of the design and operational objectives and specific information, which are consistent with the guidance of RG 4.21. The applicant provided the following objectives:

- Objective 1 - Minimize leaks and spills and provide containment in areas where such events may 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).

The GEH proposed design changes that show compliance with 10 CFR 20.1406, include many design features consistent with the requirements of 10 CFR 20.1406(b) and the above-mentioned design objectives. The following paragraphs discuss the significant ABWR design features for satisfying 10 CFR 20.1406(b).

Areas where the potential for spills exists contain appropriately sloped floor drains to limit the extent of contamination. To facilitate the cleanup of leaks and spills, and to help prevent the spread of contamination, de-contaminable 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 building (RB) and turbine building (TB), radwaste areas, rooms containing equipment with liquid radioactive sources, floor drain areas, washdown bays, and tunnels containing piping transporting potentially radioactive contaminated liquids. In addition, equipment and floor drain sumps are lined in stainless steel to reduce crud buildup and to provide surfaces that can be easily decontaminated.

Operating experience has shown that effluent discharge piping and other underground piping can be a source of low-level environmental contamination. In particular, operating experience has shown that the following structure, system, and components (SSCs) have experienced underground piping-related events that have resulted in unmonitored, uncontrolled releases of radioactivity to the environment (i.e., condensate storage tank and associated piping, radwaste/effluent discharge piping, and cooling tower blowdown line). To the extent practical, underground piping is avoided in the ABWR design. However, the condensate storage tank (CST) piping, CST retention area drain, radwaste effluent discharge pipeline, and the cooling tower blowdown line are underground and/or contain underground piping segments. The proposed DCD updates indicate that these lines will be kept as short and direct as possible. In addition, the applicant stated that the underground piping associated with these SSCs will be designed to preclude inadvertent or unidentified leakage to the environment. This piping is enclosed within a guard pipe and will be accessible for visual inspections via a trench or tunnel. The applicant stated that threaded or flanged connections for this piping will be kept to a minimum, and other joints will be welded or otherwise permanently bonded (all piping containing radioactive material piping connections are welded to the extent practicable). Furthermore, fittings will be kept to a minimum and no in-line components will be incorporated into these lines. These features will reduce the potential for unmonitored and uncontrolled releases to the environment and are consistent with RG 4.21 and 10 CFR 20.1406(b).

DCD, Tier 2, Section 12.3.1.2 specifies that plant equipment containing radioactive material is designed to minimize the buildup of radioactive material by minimizing the number of “dead legs” and low points. In addition, butt-welded connections are used instead of socket welds, flanged, or screwed connections. Butt-welded connections are stronger and less likely to leak than connection types. To minimize trapping of radioactive crud, the design employs straight-through valve configurations, where practical, instead of valve configurations that exhibit flow discontinuities or internal crevices. Equipment, such as heat exchangers, and piping have provisions for draining, flushing, and decontamination to minimize the generation of radioactive waste and facilitate the removal of radioactivity from crud traps. Piping is designed to have a service life equivalent to the life of the plant. This reduces the likelihood for leaks and also reduces potential worker dose to replace components.

Penetrations through outer walls of a building containing radiation sources are sealed to prevent miscellaneous leaks to the environment, and the process radiation monitoring system will monitor all expected radioactive release points and paths within the plant. This minimizes the potential for unmonitored and untreated leakage from escaping the plant. Additionally, the plant heating, ventilation, and air conditioning systems are designed to minimize airborne radiation exposures to plant personnel and releases to the environment. These systems maintain airflow from areas of lower potential for contamination to areas of greater potential for contamination.

To facilitate decommissioning and repairs during plant operation, the RB, TB, and radwaste building are designed for large equipment removal, consisting of entry doors from the outside and numerous cubicles with equipment hatches inside the buildings. Wherever possible, piping carrying radioactive fluids is separated from piping carrying nonradioactive fluids. This reduces the potential for the spread of contamination. Embedded piping will be minimized to the extent practicable, which facilitates the dismantlement of systems, reduces the likelihood of undetected leakage of radioactive fluid, and thereby facilitates decommissioning. However, in some cases, piping is embedded, which provides radiation shielding. As discussed above, buried piping will be kept to a minimum, and all buried piping will have features to reduce the potential for unmonitored and uncontrolled releases to the environment.

The ABWR design limits the use of cobalt-bearing materials on moving components that have historically been identified as major sources of reactor coolant contamination. Stainless steel is used in those portions of the system that require high corrosion resistance to minimize the formation of corrosion activation products. In addition, the COL Information Item in DCD, Tier 2, Section 12.3.1.1.2 (summarized in DCD, Tier 2, Section 12.3.7.4) specifies that the COL applicant will address material selection of systems and components exposed to reactor coolant to maintain radiation exposures as low as is reasonably achievable. Therefore, the cobalt content in components in contact with reactor coolant will be minimized, which will reduce plant radiation levels and the potential spread of contamination.

Many additional design features to minimize contamination, facilitate decommissioning, and minimize, to the extent practicable, the generation of radioactive waste are described throughout the ABWR DCD. As discussed above, DCD, Tier 2, Section 12.3, Table 12.3-8, provides a comprehensive crosswalk of applicable DCD chapters and sections which describe design features that address the above-listed RG 4.21 design objectives.

The NRC staff have reviewed the design features and objectives provided in the applicant’s submittals and the information previously provided in the ABWR DCD and finds that these features are designed in accordance with 10 CFR 20.1406(b), and are therefore acceptable.

In addition to the design objectives listed above, RG 4.21 contains the following operational and post-construction objectives associated with the requirements of 10 CFR 20.1406(a):

- Periodically review operational practices to ensure that 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 maintaining 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 aids in the understanding of the interface with environmental systems and the features that will 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.

- Establish and perform an onsite contamination monitoring program along the potential release pathways from the release sources to the receptor points.

As part of the proposed design changes, the applicant proposed adding another COL Information Item in ABWR DCD, Tier 2, Section 12.3.7, “COL License Information,” Section 12.3.7.5, “Requirement of 10 CFR 20.1406,” which states that the COL applicant will address the operational and post-construction objectives of RG 4.21 to meet the requirement of 10 CFR 20.1406. The NRC staff reviewed this COL Information Item and determined that it is appropriate for the COL applicant to address the operational and post-constructive objectives of 10 CFR 20.1406(a). Therefore, this COL Information Item is acceptable.

The NRC staff also verified that the proposed ABWR DCD changes described in the submittals were incorporated into Revision 6 of the ABWR DCD.

*12.3.4 Conclusion*

Based on the above, the staff concludes that the ABWR DCD, Revision 7, complies with the design requirements of 10 CFR 20.1406(b). In addition, in accordance with the COL Information Item in the DCD, Tier 2, Section 12.3.7.5, as discussed above, COL applicants referencing the ABWR design will be required to provide the operational and post-construction aspects of 10 CFR 20.1406(a). As a result, the staff concludes that the ABWR DCD adequately addresses the requirements of 10 CFR 20.1406.

**References**


1. 10 CFR 20.1406, “Minimization of contamination.”

2. 10 CFR Part 52, Appendix A, “Design Certification Rule for the U.S. Advanced Boiling Water Reactor.”

3. NRC, NUREG-1503, “Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design,” July 1994 (ADAMS Accession No. ML080670592).

4. NRC, NUREG-1503, “Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design,” Supplement 1, May 1997 (ADAMS Accession No. ML080710134).

5. NRC, RG 4.21, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning.”

6. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 5, Tier 1 and Tier 2, December 2010 (ADAMS Accession No. ML110040323).

7. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 6, Tier 1 and Tier 2, February 2016 (ADAMS Accession No. ML16214A015).

8. GEH, ABWR Standard Plant Design Certification Renewal Application Design Control Document, Revision 7, Tier 1 and Tier 2, December 2019 (ADAMS Accession No. ML20007E371).