

Proposed - For Interim Use and Comment



U.S. NUCLEAR REGULATORY COMMISSION DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER™ iPWR DESIGN

10.4.5 CIRCULATING WATER SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of power conversion systems.

Secondary - None

I. AREAS OF REVIEW

The mPower™ integral pressurized-water reactor (iPWR) includes a circulating water system (CWS) that provides a continuous supply of cooling water to the main condenser to remove the heat rejected by the turbine cycle and auxiliary systems. The CWS is nonsafety-related and nonrisk-significant.

The specific areas of review are as follows:

1. Review of the performance of the CWS with respect to its functional requirements and the effects of adverse environmental occurrences, anticipated operational occurrences (AOOs), or accident conditions such as loss of offsite power.
2. Review of the CWS and its interfaces with other systems to determine that a malfunction, failure of a component, or failure of a circulating water pipe, including the failure of an expansion joint, do not have unacceptable adverse effects on the functional performance capabilities of safety-related or other risk-significant systems located in the immediate area.
3. Review of the design of the circulating water system with respect to the following:
 - A. The capability to prevent or detect and control flooding of safety-related or other risk-significant areas so that the intended safety function of a safety system or component will not be precluded due to circulating water system leakage.
 - B. Provisions to annunciate abnormal and unsafe operating conditions.
4. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this design-specific review standard (DSRS) section in accordance with Standard Review Plan (SRP) Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this DSRS section.

Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with DSRS Sections 14.2 and 14.3.7.

5. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other DSRS/SRP sections interface with this section as follows:

1. Review of high- and moderate-energy pipe breaks is performed under SRP Section 3.6.1. SRP Section 3.6.1 identifies the circulating water system as a moderate-energy system included in the scope of review.
2. Determination of whether liquid-carrying systems could produce flooding and evaluation of the measures taken to protect safety-related equipment from internal flooding is performed under DSRS Section 3.4.1.
3. Review of the compatibility of the methods proposed for control of water chemistry and of long-term corrosion and organic fouling with system components and piping materials, and assurance that agents used for the control of water chemistry, corrosion, and organic fouling are compatible with the materials of the system is performed (upon request from the primary reviewer) by the organization responsible for reviewing the control of water chemistry, long-term corrosion, and organic fouling in system components and piping materials.
4. Review of the classification of systems quality groups is performed under DSRS Section 3.2.2.
5. Review of the instrumentation and controls, as they may relate to operations that could affect safety-related systems or components is performed under DSRS Chapter 7.
6. Review of the electrical power systems, as they may relate to operations that could affect safety-related systems or components is performed under DSRS Sections 8.3.1 and 8.3.2.
7. Review of the potential for low water conditions (e.g., those associated with drought) that may affect the CWS design is performed under DSRS Section 2.4.11.
8. Review of the probabilistic risk assessment performed under SRP Chapter 19.0 for potential risk significant CWS elements.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations.

1. General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena," as it relates to the failure of the nonsafety-related system or component due to natural phenomena such as earthquakes, tornadoes, hurricanes, and floods should not adversely affect the safety-related structures, systems, or components.
2. GDC 4, "Environmental and Dynamic Effects Design Bases," as it relates to design provisions provided to accommodate the effects of discharging water that may result from a failure of a component or piping in the CWS.
3. Title 10 of the *Code of Federal Regulations* (CFR), Section 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the DC has been constructed and will be operated in conformity with the DC, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission's (NRC's) regulations.
4. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the AEA, and the NRC's regulations.
5. 10 CFR 20.1406, as it relates to the minimization of, to the extent practicable, of contamination of the facility and the environment, designs and procedures to facilitate eventual decommissioning, and to minimize, to the extent practicable, the generation of radioactive waste.

DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified are set forth below. The DSRS is not a substitute for the NRC's regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the intent of 10 CFR 52.47(a)(9), "Contents of applications; technical information." The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41) for COL applications.

1. The requirements of GDC 2 are met when the failure of the CWS due to natural phenomena will not adversely affect the functional performance capabilities of safety-related or risk-significant systems or components.
2. The requirements of GDC 4 are met when the circulating water system design includes provisions to accommodate the effects of discharging water that may result from a failure of a component or piping in the CWS. Acceptance is based on meeting the following:
 - A. Means should be provided to prevent or detect and control flooding of safety-related or other risk-significant areas so that the intended safety function of a system or component will not be precluded due to leakage from the CWS.

- B. Malfunction or a failure of a component or piping of the CWS, including an expansion joint, should not have unacceptable adverse effects on the functional performance capabilities of safety-related or risk-significant systems or components.
- 3. The requirements of 10 CFR 20.1406 are met when the interconnections between the CWS and other plant systems are designed to preclude CWS contamination of connecting systems, or the contamination of the CWS by connections with interfacing radioactive systems.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this DSRS section is discussed in the following paragraphs:

- 1. GDC 2 requires that the failure of the nonsafety-related system or component due to natural phenomena such as earthquakes, tornadoes, hurricanes, and floods should not adversely affect the safety-related structures, systems, or components.
- 2. GDC 4 requires that safety-related or risk-significant SSCs shall be designed to accommodate the effects and be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. Although the CWS is not safety-related, GDCs 2 and 4 establish CWS design limits that will minimize the potential for creating adverse environmental conditions (e.g., flooding of safety-related or risk-significant systems and components).

Meeting the requirements of these criteria provide a level of assurance that safety-related or risk-significant systems and components will perform their intended safety functions.

- 3. The requirements of 10 CFR 20.1406 are met when the interconnections between the CWS and other plant systems are designed to preclude CWS contamination of connecting systems, or the contamination of CWS by connections with interfacing radioactive systems.

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case. These review procedures are based on the identified DSRS acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

Upon request from the reviewer, the interface reviewers will provide input for the areas of review stated in Subsection I. The reviewer obtains and uses such input as required to ensure that this review procedure is complete.

- 1. Programmatic Requirements — In accordance with the guidance in NUREG-0800 "Introduction," Part 2 as applied to this DSRS section, the staff will review the programs proposed by the applicant to satisfy the following programmatic requirements. If any of the proposed programs satisfies the acceptance criteria described in Subsection II of this DSRS, it can be used to augment or replace some of the review procedures. It should

be noted that the wording of “to augment or replace” applies to nonsafety-related risk-significant SSCs, but “to replace” applies to nonsafety-related nonrisk-significant SSCs according to the “graded approach” discussion in NUREG-0800 “Introduction,” Part 2. Commission regulations and policy mandate programs applicable to SSCs that include:

- A. Maintenance rule, SRP Section 17.6 (DSRS Section 13.4, Table 13.4, Item 17, Regulatory Guide (RG) 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” and RG 1.18, “Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants.”
 - B. Quality Assurance Program, SRP Sections 17.3 and 17.5 (DSRS Section 13.4, Table 13.4, Item 16).
 - C. Technical Specifications (DSRS Section 16.0 and SRP Section 16.1) – including brackets value for DC and COL. Brackets are used to identify information or characteristics that are plant specific or are based on preliminary design information.
 - D. Reliability Assurance Program (SRP Section 17.4).
 - E. Initial Plant Test Program (RG 1.68, “Initial Test Programs for Water-Cooled Nuclear Power Plants,” DSRS Section 14.2, and DSRS Section 13.4, Table 13.4, Item 19).
 - F. ITAAC (DSRS Chapter 14).
2. In accordance with 10 CFR 52.47(a)(8),(21), and (22), for new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues and medium- and high-priority generic safety issues that are identified in the version of NUREG-0933 current on the date 6 months before application and that are technically relevant to the design; (2) demonstrate how the operating experience insights have been incorporated into the plant design; and, (3) provide information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). These cross-cutting review areas should be addressed by the reviewer for each technical subsection and relevant conclusions documented in the corresponding safety evaluation report (SER) section.
 3. Review to determine that safety-related or risk-significant systems and structures are protected from the effects of flooding from a complete failure of the CWS is performed under DSRS Section 3.4.1.
 4. The reviewer analyzes the CWS to verify the capability to detect leaks and to secure the system quickly and effectively.
 5. Based on the information contained in the safety analysis report, the reviewer verifies that the applicant's proposed methods for control of water chemistry and of long-term corrosion and organic fouling, and the chemical agents used for these purposes, are compatible with the system materials.

For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the technical submittal meets the acceptance criteria. DCs have

referred to the technical submittal as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC technical submittal.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, DSRS Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the staff's technical review and analysis support conclusions of the following type to be included in the staff's SER. The reviewer also states the bases for those conclusions.

The circulating water system includes all components and equipment necessary to provide the main condenser with a continuous supply of cooling water. The system is designed to nonnuclear safety, Quality Group D, requirements since it is not necessary for safe shutdown, accident prevention, or accident mitigation and performs no risk-significant functions. Based on the review of the applicant's proposed design criteria and bases for the circulating water system, the staff concludes that the design of the circulating water system is acceptable and meets the requirements of GDCs 2 and 4. This conclusion is based on the following:

The applicant has met the requirements of GDCs 2 and 4 with respect to the effects of discharging water that may result from a failure of a component or piping in the CWS. Acceptance is based on provisions of the design that prevent flooding of safety-related or other risk-significant areas so that the intended safety function of a system or component will not be precluded due to leakage from the CWS; or provisions of the design that detect and control flooding of safety-related or risk-significant areas so that the intended safety function of a system or component will not be precluded due to leakage from the CWS; or provisions of the design such that malfunction of a component or piping of the CWS, including an expansion joint, will not have unacceptable adverse effects on the functional performance capabilities of safety-related or risk-significant systems or components. Also, the fact that programmatic requirements will provide assurance that the CWS will be designed, installed, and tested as described in the DCD or technical submittal.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this DSRS section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower™-specific DC, or COL applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower™ and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM-COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (Agencywide Documents Access and Management System Accession No. ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor reviews, including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower™ -specific DC, COL, or ESP applications submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the Standard Review Plan (SRP) revision in effect 6 months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for complying with 10 CFR 52.47(a)(9), as long as the mPower™ DCD FSAR does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47 (a)(9). Alternatively, the staff may supplement the DSRS section by adding the appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.79 (a)(41), for COL applications.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena."
2. 10 CFR Part 50, GDC 4, "Environmental and Dynamic Effects Design Bases."
3. 10 CFR 20.1406, "Minimization of Contamination."
4. 10 CFR 52.47, "Contents of applications."
5. 10 CFR 52.80(a), "Issuance of combined licenses."