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U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER™ iPWR DESIGN

10.4.2 MAIN CONDENSER EVACUATION SYSTEM

REVIEW RESPONSIBILITIES

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

Secondary - None

I. AREAS OF REVIEW

The main condenser evacuation system (MCES) is designed to establish and maintain condenser vacuum and to transfer radioactive gases to the gaseous waste processing system or ventilation exhaust systems. Review of the MCES is focused on the system features incorporated to monitor and control releases of radioactive materials in effluents. This includes the startup system which initially establishes main condenser vacuum and the normal system which maintains condenser vacuum once it has been established.

Specific areas of review are as follows:

1. The design, design objectives, capacity, method of operation, and factors that influence gaseous radioactive material handling, e.g., system interfaces and potential bypass routes. The review includes the system schematics, flow diagrams, and/or piping and instrumentation diagrams (P&IDs).
2. The means provided to detect and measure radioactive leakage into or out of the system, and to preclude accidental release of radioactive material to the environment in amounts in excess of the established limits.
3. If the potential for explosive mixtures exists, design features to preclude the possibility of an explosion which could cause a release of radioactive material to the environment.
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.

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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 the acceptability of the seismic and quality group classifications is performed under DSRS Sections 3.2.1 and 3.2.2.
2. Review of provisions incorporated to detect explosive gas mixtures and manage gaseous effluents collected from the MCEs is performed under DSRS Section 11.3.
3. Review of the radiological monitoring instrumentation in place to monitor gaseous effluents in the MCEs is performed under DSRS Section 11.5.
4. Review of the systems quality assurance programs is performed under SRP Chapter 17.
5. Review of the probabilistic risk assessment is performed under SRP Chapter 19 for potentially risk-significant MCEs elements.
6. Review of initial test plant test, and system inspection, tests, analyses, and acceptance criteria under DSRS Section 14.2 and SRP Section 14.3.

For those areas of review identified above as part of the primary review responsibility of other staff, the acceptance criteria necessary for the review and their methods of application are contained in the referenced DSRS/SRP sections of the corresponding primary reviewers.

II. ACCEPTANCE CRITERIA

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

1. General Design Criterion (GDC) 60 as it relates to the MCEs design for the control releases of radioactive materials to the environment.
2. GDC 64 as it relates to the MCEs design for monitoring of releases of radioactive materials to the environment during normal operation, including anticipated operational occurrences.
3. 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.

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4. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (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 design certification has been constructed and will be operated in conformity with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations.
5. 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 combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

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 60 are met when the MCES design includes provisions to prevent excessive releases of radioactivity to the environment which may result from a failure of a structure, system or component in the main condenser (MC). Acceptance is based on meeting the following:

If there is a potential for explosive mixtures to exist, the MCES is designed to withstand the effects of an explosion and instrumentation is provided to detect and annunciate the buildup of potentially explosive mixtures, dual instrumentation is provided to detect, annunciate, and effect control measures to prevent the buildup of potentially explosive mixtures, as outlined in DSRS Section 11.3, subsection II, "Acceptance Criteria," DSRS Acceptance Criteria.

Such a potential does not exist on systems designed to maintain the steam content above 58% by volume in hydrogen-air mixtures or nitrogen content above 92% by volume in hydrogen-oxygen mixtures in all MCES components. The design pressure and normal operational absolute pressure should be provided for MCES components containing potentially explosive mixtures.

2. The requirements of GDC 64 are met when the MCES design provides means to monitor radioactive effluents in potential discharge pathways to the environment (i.e. pump discharge, ventilation, etc).
3. The requirements of 10 CFR 20.1406 are met when the interconnections between the MCES and other plant systems are designed to preclude MCES contamination of connecting systems,

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or the contamination of MCES by connections with interfacing radioactive systems (i.e. gaseous radwaste system).

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:

Compliance with GDC 60 and GDC 64 requires that provisions be included in the nuclear power unit design to control suitably the release of radioactive materials in gaseous and liquid effluents during normal operation, including anticipated operational occurrences.

GDC 60 is applicable to the design of the MCES, because in mPower iPWRs, radioactive materials are processed in this system if there is a primary-to-secondary steam generator tube leak. Design features are incorporated into the system to ensure that these radioactive materials are controlled and routed appropriately.

GDC 64 is applicable to the design of the MCES, because the MCES may contain radioactive fluids and gases that can potentially be released during normal operation and anticipated operational occurrences, and therefore require monitoring. Compliance with GDC 64 provides a level of assurance that releases of radioactive material to the environment will be detected in a timely manner so that appropriate measures can be taken to minimize the quantity of material released.

Meeting these requirements provide assurance that the release of radioactive materials in gaseous and liquid effluents from the MCES during normal operation, including anticipated operational occurrences, is kept as low as is reasonably achievable, in accordance with 10 CFR Part 50 Appendix I.

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

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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, RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.” and RG 1.182, “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 (Regulatory Guide 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 the review of the MCES, the SAR and P&IDs are reviewed to determine the flow paths of gases through the system, including all bypasses, and the points of release of gaseous wastes to the environment or other systems. This information is used in DSRS Section 11.3 to calculate the quantity of radioactive material released annually in gaseous effluents during normal operations, including anticipated operational occurrences. Review of the system verifies that water from the mechanical vacuum pumps and condensate from the steam jet air ejectors are classified as radioactive liquids and treated accordingly.
 3. If there is a potential that explosive mixtures may exist, The determination is made whether the applicant has designed the MCES to withstand the effects of such an explosion and has provided instrumentation to detect and annunciate or has provided dual instrumentation on redundant MCES trains to detect, annunciate, and effect control measures to prevent the buildup of potentially explosive mixtures. The review will also determine if the applicant's design includes adequate provisions to stop continuous leakage-paths after an explosion.

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 final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR 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 FSAR.

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, SRP 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.

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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 evaluation report. The reviewer also states the bases for those conclusions.

The MCES includes equipment and instruments to establish and maintain condenser vacuum and to prevent an uncontrolled release of radioactive material to the environment. The staff has reviewed the applicant's system descriptions, design criteria, and P&IDs for the components of the MCES.

The staff concludes that the MCES design is acceptable in that the applicant has met:

1. The requirements of GDC 60 with respect to the design features in place to control releases of radioactive materials to the environment and the fact that programmatic requirements will provide assurance that the MCES will be designed, installed, and tested as described in the DCD or technical submittal.
2. The requirements of GDC 64 with respect to the MCES design incorporation of provision for monitoring of potential effluent discharge pathways for radiation release during normal operation, including anticipated operational occurrences.
3. The requirements of 10 CFR 20.1406 by providing for the detection and isolation of radioactive material in the MCES so as to minimize, contamination of the associated systems, facility, and the environment; and facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

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 design certification (DC), or combined license (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 (ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor (SMR) reviews including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for

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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 20.1406, Minimization of Contamination.
2. 10 CFR Part 50, Appendix A, General Design Criterion 60, "Control of Releases of Radioactive Materials to the Environment."
3. 10 CFR Part 50, Appendix A, General Design Criterion 64, "Monitoring Radioactivity Releases."
4. 10 CFR Part 50, Appendix I, "Numerical Guides For Design Objectives and Limiting Conditions For Operation to Meet the Criterion "As Low as is Reasonably Achievable" For Radioactive Material in Light Water Cooled Nuclear Power Reactor Effluents."
5. 10 CFR Part 52 "Early Site Permit; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."