

Proposed - For Interim Use and Comment



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

9.3.3 EQUIPMENT AND FLOOR DRAINAGE SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of cooling water systems

Secondary - None

I. AREAS OF REVIEW

The equipment and floor drainage system (EFDS) is designed to ensure that waste liquids, valve and pump leak-offs, and tank drains are directed to proper areas for processing or disposal, and that excessive water accumulation and flooding is prevented in accordance with plant design basis. Review of the EFDS includes design features that are necessary for collecting, routing, and disposing of liquid effluents outside containment. This includes piping and pumps from equipment or floor drains to the sumps, drain tanks, devices that are credited with preventing reverse flow, and any additional equipment necessary to route effluents to the drain tanks and then to the liquid waste management system or other points of discharge.

The specific areas of review are as follows:

1. Leakage detection capability that is relied upon for identifying conditions that are adverse to safety, such as excessive leakage that could compromise the capability of structures, systems or components (SSCs) to perform safety functions or could result in uncontrolled release of radioactive material to the environment.
2. System features that are relied upon to prevent flooding due to drain backflow that may result from malfunction of active components, blockage, or the probable maximum flood, which could affect a SSC that is important to safety.
3. System features that are relied upon to prevent an inadvertent transfer of contaminated fluids to non-contaminated drainage systems or to otherwise prevent uncontrolled releases of radioactive material to the environment.
4. System features, a failure or malfunction of which could result in adverse effects on an SSC important to safety, or could result in uncontrolled release of radioactive material to the environment.
5. 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 SSCs related to this design-specific review standard (DSRS) section in accordance with DSRS 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 Section 14.3.

6. 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 standard review plan (SRP) or DSRS sections interface with this section as follows:

1. DSRS Sections 3.2.1 and 3.2.2: review to determine the acceptability of the seismic and quality group classifications for system components.
2. DSRS Sections 3.3.1, 3.3.2, 3.5.3, 3.7.2, and SRP Sections 3.7.1, 3.7.3, 3.7.4, 3.8.4 and 3.8.5: review to determine the acceptability of the design analyses, procedures, and criteria establishing the ability of seismic Category I structures housing the system and supporting systems to withstand the effects of such natural phenomena as the safe-shutdown earthquake (SSE), the probable maximum flood, and tornado missiles.
3. DSRS Section 3.4.1: review of flood protection.
4. DSRS Sections 3.5.1.1, 3.5.1.2 and 3.5.1.3: review of the protection against internally-generated missiles.
5. DSRS Section 3.5.2: review of the SSCs to be protected against externally-generated missiles.
6. SRP Section 3.6.1 and DSRS Section 3.6.2: review of high- and moderate-energy pipe breaks.
7. DSRS Section 3.9.1 and SRP Sections 3.9.2 and 3.9.3: review for whether components, piping, and structures are designed in accordance with applicable codes and standards.
8. DSRS Section 3.9.6: review of the adequacy of the inservice testing program of pumps and valves.
9. DSRS Section 6.2.4: review for whether portions of the drain system penetrating the containment barrier are designed with acceptable isolation features to maintain containment integrity for all operating conditions, including accidents.
10. DSRS Section 6.6: review for whether inservice inspection requirements are met for system components.

11. DSRS Sections 8.3.1 and 8.3.2: review for whether power supplies for EFDS safety-related portions meet criteria appropriate to its safety function.
12. SRP Section 9.5.1: review for fire protection, including drain system design features (1) to accommodate actuation of installed fire suppression systems (gas and water), (2) to accommodate fire-fighting water, and (3) to prevent backflow of combustible liquids to safety-related areas.
13. DSRS Section 11.2: review of the liquid radioactive waste collection system for verification whether the radwaste system can collect, sample, analyze, and process EFDS effluents consistently with the requirements for disposal of radwaste material.
14. DSRS Section 12.3: review for whether the system meets occupational radiation protection criteria.
15. DSRS Section 16.0: review for technical specifications.
16. SRP Chapter 17: review for quality assurance.

The specific acceptance criteria and review procedures are contained in the referenced DSRS sections.

II. ACCEPTANCE CRITERIA

Requirements

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

1. General Design Criterion (GDC) 2, as it relates to the capability of the system to withstand the effects of natural phenomena.
2. GDC 4, as it relates to the capability of the system to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing and postulated accidents, including loss-of-coolant accidents.
3. GDC 60 as to suitable control of the release of radioactive materials in liquid effluent, including anticipated operational occurrences. This criterion applies as the EFDS usually consists of two subsystems, radioactive and nonradioactive. The inadvertent transfer of radioactive wastes to the nonradioactive portion of the system could result in radioactive releases to the environment.
4. Title of 10 of the *Code of Federal Regulations* (CFR), Section 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.
5. 10 CFR 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.

6. 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 applicant 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.

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. Protection Against Natural Phenomena. Information that addresses the requirements of GDC 2 regarding the capability of safety-related system portions of the EFDS to withstand the effects of natural phenomena. Acceptance is based on the guidelines of Regulatory Guide (RG) 1.29, Positions C.1 and C.2. Comprehensive compliance with GDC 2 is reviewed under other DSRS sections as specified in Subsection I of this DSRS section. If no portion is safety-related, the EFDS need not meet GDC 2.
2. Environmental and Dynamic Effects. Information that addresses the requirements of GDC 4 regarding the capability to withstand the effects of and to be compatible with the environmental conditions (flooding) of normal operation, maintenance, testing, and postulated accidents (pipe break, tank ruptures) will be considered acceptable if the EFDS is designed to prevent flooding that could affect SSCs important to safety (i.e., necessary for safe-shutdown, accident prevention, or accident mitigation) adversely.
3. Control of Releases of Radioactive Material to the Environment. Information that addresses the requirements of GDC 60 regarding the suitable control of the release of radioactive materials in liquid effluent, including anticipated operational occurrences will be considered acceptable if the EFDS is designed to prevent the inadvertent transfer of contaminated fluids to a noncontaminated drainage system for disposal
4. The requirements of 10 CFR 20.1406 are met when the design and procedures identify provisions to detect contamination that may enter as in-leakage from other systems, identifies potential collection points such as water treatment systems or system low points, and addresses the long-term control of radioactive material in the 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:

1. GDC 2 requires that SSCs important to safety be designed to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods without loss of capability to perform safety functions. EFDS safety-related functions have both active and passive aspects (e.g., flood prevention by such components as check valves, adequate drainage capacity to accommodate unplanned water intrusion in plant areas with SSCs important to safety). Both direct and indirect safety impacts are attributed to EFDS performance during an SSE. RG 1.29 describes an acceptable method of identifying and classifying system portions that should be designed to withstand the effects of an SSE. By adequate drainage capacity EFDS must avert direct effects on safety-related equipment from inundation. Nonsafety-related equipment must be protected if its failure could reduce the functional reliability of safety-related equipment to unacceptable safety levels, or result in incapacitating injury to control room occupants or render the control room uninhabitable.

GDC 2 assures that all EFDS safety-related portions will continue to provide adequate drainage capacity during and following natural phenomena to accommodate postulated flooding events without water accumulation where it could jeopardize continued operability of safety-related equipment. In addition, these regulatory requirements assure that no system component failures will jeopardize the integrity of the reactor coolant pressure boundary, the capability to shut the reactor down and maintain it in a safe-shutdown condition, or the capability to prevent or mitigate the consequences of accidents that could result in offsite radiation exposures.

2. GDC 4 requires that SSCs important to safety be designed to accommodate the effects of and be compatible with the environmental conditions of normal operation, maintenance, surveillance testing, and postulated accidents. For the EFDS, the purpose of GDC 4 is to assure the capability to provide the required drainage capacity to accommodate unanticipated flooding from pipe breaks, tank leaks, discharge from fire suppression systems, and other potential flooding sources. GDC 4 thus requires consideration in the design basis of the EFDS of the entire spectrum of flooding events, from relatively minor, operations-related, or testing-related events to postulated accidents. GDC 4 assures that safety-related equipment functions will not be impacted by undue water accumulations within the plant.
3. GDC 60 requires plants to be designed to control the release of radioactive materials in gaseous and liquid effluents. The EFDS must have sufficient capability and margin to collect and dispose of radioactive and nonradioactive liquid effluents for their controlled and safe processing. As radioactive liquid effluents require a treatment different from that for nonradioactive effluents, the EFDS design typically provides for two separate systems, one for collecting radioactive and the other for collecting non-radioactive effluents. GDC 60 requirements assure containment of radioactive liquid effluents by controlled collection and transfer to appropriate treatment systems.
4. The capability to detect and isolate radioactive material in the EFDS would minimize, to the extent practicable, contamination of the condensate and feedwater systems and the

environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste in accordance with 10 CFR 20.1406.

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.

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, 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, 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 (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. The safety analysis report (SAR) is reviewed for whether the EFDS description section, layout drawings, and piping and instrumentation diagrams (P&IDs) show the EFDS layout and equipment, including pumps and valves necessary for routing effluents, the minimum drain tank capacity system flow requirements, connections to areas with safety-related equipment or to noncontaminated drain systems, and any EFDS leakage detection for safety-related systems.

The reviewer uses the following to determine whether EFDS portions are safety-related:

- A. If the system is capable of detecting leaks in safety systems that utilize the drainage system sumps and is the only means for such leakage detection, it is safety-related for this purpose.
- B. If the system can result in the inundation of safety-related areas due to drain backflow from malfunction of active components, blockage, or the probable maximum flood, it is safety-related in this area.
- C. If the system is connected so that an inadvertent transfer of contaminated fluids to noncontaminated drainage systems can occur or cannot be promptly detected, it is safety-related in this area.
- D. If a failure or malfunction in a portion of the system could affect safety-related (i.e., necessary for safe-shutdown, accident prevention, or accident mitigation) SSCs adversely, it is safety-related in this area.

The reviewer applies the above criteria to determine which EFDS portions have safety functions or can adversely affect safety-related systems. These EFDS safety-related portions are then reviewed on the basis of the Subsection II criteria as described in the following paragraphs.

4. The SAR EFDS performance requirements section is reviewed for whether it describes component allowable operational degradation (e.g., drain blockage, sump pump leakage, or failures) for safety-related system portions and the procedures followed to detect and correct these conditions if they become excessive. The reviewer determines whether safety-related system portions can sustain the loss of any active component and meet minimum system requirements. The system P&IDs, layout drawings, and component descriptions and characteristics are then reviewed for whether safety-related EFDS portions are identified correctly and can be isolated from the nonsafety-related portions to the extent required for system performance.
5. The reviewer verifies whether system safety functions will be maintained, as required, in adverse environmental phenomena (e.g., earthquakes) or in certain pipe breaks. The reviewer evaluates the system, using engineering judgment, failure modes and effects analyses, and the results of reviews under other DSRS sections, for whether:
 - A. Failure of nonsafety-related portions of the system or of other systems not designed to seismic Category I standards and located close to safety-related

portions of the system or of nonseismic Category I structures that house, support, or bound safety-related EFDS portions do not preclude operation of safety-related EFDS portions. Reference to SAR Chapter 2 (which describes site features) and the general arrangement and layout drawings is necessary. SAR statements to the effect that the conditions are met are acceptable.

- B. System capability and design features to prevent drain or flood water from backing up in the drainage system into areas housing safety-related equipment is incorporated. SAR statements that this capability is provided are acceptable.
 - C. The system controls and directs the flow of radioactive waste fluids to the radwaste area. The design is acceptable if the system P&IDs and design criteria show that the potential for inadvertent transfer of contaminated fluids to noncontaminated drainage system for disposal is precluded.
- 6. The SAR descriptive information, P&IDs, EFDS drawings, and failure modes and effects analyses are reviewed for whether safety-related system portions can function as required following design-basis accidents, assuming a concurrent failure of a single, active component. The reviewer evaluates the analyses presented in the SAR for assured function of required components, traces the availability of these components on system drawings, and checks that the SAR verifies whether minimum system flow requirements are met for each accident situation for the required time spans. For each case, the design is acceptable if it meets minimum system requirements.
 - 7. Using the guidance provided in RG 4.21, the applicant should address compliance with the requirements of 10 CFR 20.1406.
 - 8. 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).

- 9. 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.

1. The EFDS includes all piping from equipment or floor drains to the sump, the sump pumps, and the pumps and piping network necessary to route effluents to the drain tanks and then to the radwaste system.

The basis for acceptance in the staff review is compliance of the applicant's designs and design criteria for the safety-related EFDS portions and necessary auxiliary supporting systems with NRC regulations as set forth in the GDCs and with applicable RGs, staff technical positions, and industry standards.

The staff concludes that the EFDS design is acceptable and complies with the requirements of GDCs 2, 4, and 60 as to seismic design, environmental conditions, and control of release of radioactive materials. This conclusion is based on the following findings:

- A. The applicant meets GDC 2 requirements by providing the capability of safety-related system portions of the EFDS to withstand the effects of natural phenomena.
- B. The applicant meets GDC 4 requirements for environmental conditions by preventing flooding that could affect safety-related SSCs adversely.
- C. The applicant meets GDC 60 requirements for controlling release of radioactive materials by preventing the inadvertent transfer of contaminated fluids to system portions for noncontaminated drainage.
- D. The applicant meets 10 CFR 20.1406, as it relates to facility design and procedures for operation that 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.

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 design 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, Appendix A, GDC 4, “Environmental and Dynamic Effects Design Bases.”
3. 10 CFR Part 50, Appendix A, GDC 60, “Control of Releases of Radioactive Materials to the Environment.”
4. 10 CFR Part 52, “Licenses, Certifications, and Approvals For Nuclear Power Plants.”
5. 10 CFR 20.1406, “Minimization of Contamination.”
6. RG 1.29, “Seismic Design Classification.”
7. RG 4.21, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning.”