

# Proposed - For Interim Use and Comment



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

### 3.5.2 STRUCTURES, SYSTEMS, AND COMPONENTS TO BE PROTECTED FROM EXTERNALLY-GENERATED MISSILES

#### REVIEW RESPONSIBILITIES

**Primary -** Organization responsible for the review of plant design for protection of structures, systems, and components from internal and external hazards

**Secondary -** None

#### I. AREAS OF REVIEW

10 CFR 50, Appendix A, General Design Criterion (GDC) 2, "Design bases for protection against natural phenomena," requires that structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as tornadoes and hurricanes without loss of capability to perform their safety functions. GDC 4, "Environmental and dynamic effects design bases," requires that structures, systems, and components (SSCs) important to safety be appropriately protected against the effects of missiles that may result from events and conditions outside the nuclear power unit.

The review of the SSCs to be protected from externally-generated missiles includes all plant site safety-related and risk significant SSCs supporting the reactor facility, such elements as essential service water intakes, buried components (e.g., essential service water piping, storage tanks), and structure access openings and penetrations.

The mPower™ integral pressurized-water reactor (iPWR) includes a deeply embedded concrete reactor building, underground steel containment, and fully protected spent fuel pool below the grade level. The safety-related and risk-significant SSCs inside these structures are generally protected from direct hit of missiles. Although the direct hit probability is reduced, the review cannot be eliminated. All safety-related and certain risk-significant SSCs located above ground must be protected from missiles. An SSC may be classified as:

- 1) Safety-related risk-significant;
- 2) Safety-related nonrisk-significant;
- 3) Nonsafety-related risk-significant; or
- 4) Nonsafety-related non-risk significant.

The mPower™ application will include the classification of SSCs, a list of risk-significant SSCs, and a list of regulatory treatment of non-safety systems (RTNSS) equipment. Based on this information, the staff's review will use DSRs Section 3.2, SRP Sections 17.4 and 19.3 to confirm the determination of the safety-related and risk-significant SSCs. If the SSC belongs in the first two classifications above or if it is determined as part of the SRP 19.3 "Augmented Design Standard" review that the SSC is RTNSS

“B”, the review described in this DSRS Section 3.5.2 is applied (see Review Procedure 2 below). For the purpose of brevity in this section, the first two categories above and the RTNSS “B” SSCs will be designated as “SSCs subject to missile protection.” SSCs in the 4<sup>th</sup> classification above are not subject to missile protection.

The specific areas of review are as follow:

1. The functional operations or performance requirements for SSCs are reviewed for compliance with 10 CFR 50, Appendix A, General Design Criteria (GDCs) 2 and 4 and SSCs necessary for the safe shutdown of the reactor facility and SSCs, the failure of which could result in a significant release of radioactivity, must be identified.
2. SSCs subject to missile protection are reviewed for their capability to perform functions required to attain and maintain safe shutdown conditions during normal or accident conditions, mitigating the consequences of an accident, or preventing the occurrence of an accident, assuming impact from externally-generated missiles.
3. If the turbine is not properly oriented, the protection of SSCs from the effects of turbine missiles is reviewed. Based on their relation to safety, structures or areas of structures, systems or portions of systems, and components require protection from externally-generated missiles if they could prevent an intended safety function or if, missile impact on a nonsafety-related SSC could affect the intended safety function of SSCs subject to missile protection.
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 SRP section in accordance with 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 SRP 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 SRP Section 14.3.
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 Standard Review Plan (SRP) or DSRS sections interface with this section as follows:

1. Review of specific missile sources and the protection needed is performed under DSRS sections 3.5.1.4, 3.5.1.5, and 3.5.1.6.

2. Review of the acceptability of barriers and structures designed to withstand externally-generated missiles is performed under DSRS section 3.5.3.
3. Review of RTNSS is performed under (SRP) Section 19.3 as related to augmented design standards of missile protection for nonsafety-related risk significant SSCs.

The specific acceptance criteria and review procedures are contained in the referenced SRP or 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, "Design bases for protection against natural phenomena," of Appendix A to 10 CFR Part 50, requires that structures, systems, and components (SSCs) important to safety shall be designed to withstand the effects of natural phenomena such as tornadoes and hurricanes without loss of capability to perform their safety functions.
2. GDC 4, "Environmental and dynamic effects design bases," of Appendix A to 10 CFR Part 50, requires that SSCs important to safety be appropriately protected against the effects of missiles that may result from events and conditions outside the nuclear power unit.
3. 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 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.
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 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 above 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.

Acceptance is based on the design meeting the guidelines of Regulatory Guide (RG) 1.13 as to the capability of spent fuel pool systems and structures to withstand the effects of externally-generated missiles and to prevent missiles from contacting stored fuel assemblies; RG 1.27 as to the capability of the ultimate heat sink and connecting conduits to withstand the effects of externally-generated missiles; RG 1.115 as to the protection of SSCs subject to missile protection from the effects of turbine missiles; RG 1.117 as to the protection of SSCs subject to missile protection from the effects of tornado missiles, and RG 1.221 as to the protection of SSCs subject to missile protection. Hurricane missiles may be more damaging than tornado-generated missiles.

### 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 establishes requirements for the capability of SSCs important to safety to withstand natural phenomena without the loss of their safety functions. This criterion applies directly to the assessment of SSCs as to external missiles generated by natural phenomena. Application of GDC 2 determines whether the chosen design basis reflects the importance of the safety functions to be performed. RG 1.13 describes a method acceptable to the NRC staff for protecting spent fuel pool systems and structures from externally-generated missiles and preventing mechanical damage to the spent fuel by designing the facility to prevent externally-generated missiles from contacting the spent fuel within the pool. To properly designate SSCs to be protected from externally-generated missiles, the Applicant should identify the systems and structures that prevent mechanical damage to the spent fuel. RG 1.27 describes a method acceptable to the NRC staff for protecting the ultimate heat sink and its conduits from the effects of externally-generated missiles. The ultimate heat sink constitutes the source of water supply necessary to safely operate, shut down, and cool down a nuclear plant. Because the ultimate heat sink is important to safety, its SSCs subject to missile protection should be identified and their safety functions secured. Protecting the ultimate heat sink SSCs subject to missile protection from externally-generated missiles ensures that the system can perform its safety functions. Protecting SSCs subject to missile protection from externally-generated missiles should secure the following safety functions: maintenance of the integrity of the spent fuel pool, mitigation of the potential release of fission products, and preservation of the capability of the ultimate heat sink to maintain the plant in a safe condition.
2. GDC 4 establishes requirements for the protection of SSCs subject to missile protection from dynamic effects, including the effects of missiles from events and conditions outside the nuclear unit. Dynamic events originating outside the nuclear unit have the potential to generate missiles; therefore, this criterion applies directly to the assessment of SSCs subject to missile protection that may be affected. RG 1.115 describes methods acceptable to the NRC staff for identification and protection of SSCs subject to missile protection from the effects of missiles generated by turbine failure. Cumulative failure data for conventional plants indicate that the protection of SSCs subject to missile protection from the effects of missiles is an appropriate safety consideration. RG 1.117 describes a method acceptable to the NRC staff for determining which SSCs should be protected from external missiles generated by tornados. The selection of SSCs to be protected is made to keep offsite exposures from exceeding an appropriate fraction of

10 CFR Part 100 offsite dose guidelines. Limits based upon an appropriate fraction ensures protection for events not as severe as design-basis events but with a higher probability of occurrence. Protecting SSCs subject to missile protection from externally-generated missiles secures the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a shutdown condition, and the capability to prevent significant uncontrolled release of radioactivity.

### 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. 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 (USIs) and medium- and high-priority generic safety issues (GSIs) 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 SER section.
2. The first step in the review of SSCs requiring protection against externally generated missiles is to ensure the equipment needed to perform a safety-related function or a risk-significant function have been identified as "SSCs subject to missile (externally-generated) protection". RG 1.115, RG 1.117, and SRP Section 19.3 provide guidance for identification of the "SSCs subject to missile (externally generated) protection." RG 1.115 describes methods acceptable to the NRC staff for identification and protection of SSCs subject to missile protection from the effects of missiles generated by turbine failure. RG 1.117 describes a method acceptable to the NRC staff for determining which SSCs should be protected from external missiles generated by tornados. SRP Section 19.3 as related to augmented design standards provides guidance on the identification of the risk-significant SSCs subject to missile protection.
3. The second step in the review is to determine which SSCs or SSC portions require protection against externally-generated missiles. The reviewer uses engineering judgment and the results of failure modes and effects analyses in conjunction with the results of reviews under other DSRS sections for specific SSCs in this determination. Most safety-related systems are located within structures resistant to external missiles by design for other purposes (e.g., primary containment) or because of specific construction to withstand missiles. Systems and components within such structures are considered adequately protected. The reviewer concentrates attention on SSCs subject to missile

protection outside such structures and on penetrations and access openings in them. Essential service water piping and components, storage tanks, and ultimate heat sink components are examples of SSCs typically outside missile-resistant structures. Such site-specific systems as the ultimate heat sink may be outside the scope of the DC. Detailed review of the site-specific systems that must be protected from missiles is therefore typically deferred until the COL or other site specific review. Depending on the nature and source of the externally-generated missiles, protection may be by missile barriers for individual components, by location of independent redundant subsystems in compartments in missile-protected structures, or by subgrade location at sufficient depth. Physical separation alone is not normally an acceptable method of missile protection for redundant SSCs subject to missile protection as described in RG 1.117.

4. The reviewer determines whether the failure of nonsafety-related SSCs as a result of a missile could prevent SSCs subject to missile protection from externally-generated missiles from completing their safety function. The reviewer also verifies for applicants referring to certified designs whether SSCs outside the design scope might generate external missiles that would prevent SSCs subject to missile protection from performing their intended safety function.
5. 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. 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.

#### IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

The review of SSCs to be protected from externally-generated missiles included all SSCs subject to missile protection supporting the reactor facility. After review of the applicant's proposed design criteria, design bases, and safety classifications for SSCs subject to missile protection, the staff concludes that the SSCs to be protected from externally-generated missiles are in compliance with GDCs 2 and 4. This conclusion is based on the following findings:

The applicant has met the requirements of GDCs 2 and 4 for protection of important to safety SSCs against the effects of externally-generated missiles by:

1. Meeting RG 1.13, Position C.2, "Spent Fuel Storage Facility Design Basis," by preventing missiles generated by tornado winds from causing significant loss of watertight integrity of the fuel storage pool and from contacting fuel within the pool.
2. Meeting RG 1.27, Positions C.2 and C.3, "Ultimate Heat Sink for Nuclear Power Plants," so that the ultimate heat sink is capable of withstanding the effects of external missiles generated by natural phenomena;
3. Meeting RG 1.115, Position C.2, "Protection Against Turbine Missiles," so that essential systems are protected from low-trajectory turbine missiles by either proper turbine orientation or missile barriers;
4. Meeting regulatory Positions C.1, C.2, and C.3 and the Appendix to RG 1.117, "Tornado Design Classification," so that SSCs subject to missile protection are protected from the effects of missiles generated by the design basis tornado by missile barriers for individual components, by location of independent redundant systems or components in missile-protected structures, or by underground locations at depth sufficient to protect against missiles;
5. Demonstrating that the tornado missile is bounding, or that the SSCs are adequately protected from the effects of hurricane-generated missiles; and
6. Identifying all SSCs requiring protection against the effects of externally-generated missiles, including those nonsafety-related SSCs, the failure of which as a result of missiles, may prevent SSCs subject to missile protection from performing their safety functions.

For those applicants referring to a certified design, the reviewer finds that SSCs outside of the DC scope that may cause external missile generation will not prevent SSCs subject to missile protection from performing intended safety functions.

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 SRP 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 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 mPower™-specific DC, or COL 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 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 52.47, "Contents of Application."
4. 10 CFR 52.80, "Contents of Applications; Additional Technical Information."
5. 10 CFR Part 100, "Reactor Site Criteria."
6. Regulatory Guide 1.13, "Spent Fuel Storage Facility Design Basis."
7. Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants."
8. Regulatory Guide 1.115, "Protection Against Turbine Missiles."
9. Regulatory Guide 1.117, "Tornado Design Classification."
10. Regulatory Guide 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants,"