

Draft for Comment



U.S. NUCLEAR REGULATORY COMMISSION DESIGN-SPECIFIC REVIEW STANDARD FOR NuScale SMR DESIGN

3.5.1.4 MISSILES GENERATED BY EXTREME WINDS

REVIEW RESPONSIBILITIES

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

Secondary - Organization responsible for the review of meteorological data

I. AREAS OF REVIEW

Title 10 of the *Code of Federal Regulations* (CFR), Part 50, Appendix A, General Design Criterion (GDC) 2 requires that all 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. At the same time, GDC 4 requires that all 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 specific areas of review are as follows:

1. Assessment of possible hazards attributable to missiles generated by extreme winds, such as tornado, hurricane, and any other high speed winds identified in Section 3.5 of the final safety analysis report (FSAR), to ensure that the applicant has chosen and properly characterized appropriate design-basis missiles, and to ensure that the effects caused by those missiles are acceptable. Currently, missiles generated by design-basis tornadoes and hurricanes are considered in the plant design bases for all plants. Missiles from other high speed winds are considered on a case-by-case basis when they are identified.
2. 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 DSRS 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 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 SRP Section 14.3.
3. COL Information Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL information 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 information items 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 sections interface with this section as follows:

1. Reviews of those SSCs that should be protected against missile impact are performed under DSRS Section 3.5.2, "Structures, Systems, and Components to be Protected from Externally-Generated Missiles", and SRP 19.3 "Regulatory Treatment of Non-Safety Systems for Passive Advanced Light Water Reactors."
2. The acceptability of the design analysis, procedures, and criteria used to establish the ability of seismic Category I structures and/or missile barriers to withstand the effects of tornado and hurricane missiles is reviewed under DSRS Section 3.5.3, "Barrier Design Procedures."
3. The acceptability of the design-basis tornado parameters, as well as maximum tornado and hurricane wind speed is reviewed under Standard Review Plan (SRP) Section 2.3.1, "Regional Climatology."

II. ACCEPTANCE CRITERIA

Requirements

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

1. 10 CFR Part 50, Appendix A, GDC 2 requires, in part, that SSCs important to safety be designed to withstand the effects of natural phenomena such as tornadoes and hurricanes without loss of capability to perform their safety functions.
2. 10 CFR Part 50, Appendix A, GDC 4 requires, in part, 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 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.

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. As an alternative, and as described in more detail below, an applicant may identify the differences between a DSRS section and the design features (DC and COL applications only), analytical techniques, and procedural measures proposed in an application and discuss how the proposed alternative provides an acceptable method of complying with the NRC regulations that underlie the DSRS acceptance criteria.

1. Regulatory Guide (RG) 1.76 describes acceptable design-basis tornado-generated missile spectrum for the design of nuclear power plants.
2. RG 1.221 describes acceptable design-basis hurricane-generated missile spectrum for the design of nuclear power plants.
3. The method of identifying appropriate design-basis missiles generated by natural phenomena shall be consistent with the acceptance criteria defined for the evaluation of potential accidents from external sources in SRP Section 2.2.3, "Evaluation of Potential Accidents." Other methodologies used by licensees and applicants with appropriate rationale may be acceptable on a case-by-case basis.

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. 10 CFR Part 50, Appendix A, GDC 2 establishes requirements for the ability of SSCs important to safety to withstand the effects of natural phenomena without the loss of capability to perform their safety functions. The GDC 2 requirement that SSCs important to safety be designed to withstand the effects of the most severe of the natural phenomena that have been historically reported for the site and surrounding area is accounted for by considering the extreme environmental loads associated with the 10^{-7} per year design-basis tornado and hurricane specified in RG 1.76 and RG 1.221, respectively. Designing a nuclear power plant to withstand the design-basis tornado and hurricane wind speeds and missiles discussed in RG 1.76 and RG 1.221 ensures that SSCs important to safety will be capable of performing their safety function, and there will be no undue risk to the health and safety of the public in the event of extreme wind conditions. Evolutionary reactors should be designed based on regional wind speeds corresponding to strike probability of less than 10^{-7} per year, as explained in RG 1.76 and RG 1.221.
2. 10 CFR Part 50, Appendix A, GDC 4 establishes requirements for the ability of SSCs important to safety to be protected from dynamic effects, including the effects of missiles from events and conditions outside the nuclear unit. Tornadoes and hurricanes are dynamic events originating outside the nuclear unit; therefore, this criterion is applicable to the assessment of any missiles generated by extreme winds such as tornadoes and hurricanes. For safety considerations, nuclear power plant design must consider the impact of direct action of tornado wind and the moving ambient pressure field, as well as the impact of tornado generated missiles. Hurricane effects considered in the design should include combinations of hurricane wind effects and hurricane-generated missile

impact effects. Protection from a spectrum of missiles exemplified by missiles with critical characteristics provides assurance that the necessary SSCs will be available to mitigate the potential effects of a tornado or hurricane on plant safety.

III. REVIEW PROCEDURES

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. Selected Programs and Guidance - In accordance with the guidance in NUREG-0800, "Introduction - Part 2: Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: Integral Pressurized Water Reactor Edition" (NUREG-0800 Intro Part 2) as applied to this DSRS Section, the staff will review the information proposed by the applicant to evaluate whether it meets the acceptance criteria described in Subsection II of this DSRS. As noted in NUREG-0800 Intro Part 2, the NRC requirements that must be met by an SSC do not change under the SMR framework. Using the graded approach described in NUREG-0800 Intro Part 2, the NRC staff may determine that, for certain structures, systems, and components (SSCs), the applicant's basis for compliance with other selected NRC requirements may help demonstrate satisfaction of the applicable acceptance criteria for that SSC in lieu of detailed independent analyses. The design-basis capabilities of specific SSCs would be verified where applicable as part of completion of the applicable ITAAC. The use of the selected programs to augment or replace traditional review procedures is described in Figure 1 of NUREG-0800, Introduction - Part 2. Examples of such programs that may be relevant to the graded approach for these SSCs include:

- 10 CFR Part 50, Appendix A, General Design Criteria (GDC), Overall Requirements, Criteria 1 through 5
- 10 CFR Part 50, Appendix B, Quality Assurance (QA) Program
- 10 CFR 50.49, Environmental Qualification of Electrical Equipment (EQ) Program
- 10 CFR 50.55a, Code Design, Inservice Inspection and Inservice Testing (ISI/IST) Programs
- 10 CFR 50.65, Maintenance Rule requirements
- Reliability Assurance Program (RAP)
- 10 CFR 50.36, Technical Specifications
- Availability Controls for SSCs Subject to Regulatory Treatment of Non-Safety Systems (RTNSS)
- Initial Test Program (ITP)
- Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)

This list of examples is not intended to be all-inclusive. It is the responsibility of the technical reviewers to determine whether the information in the application, including the degree to which the applicant seeks to rely on such selected programs and guidance, demonstrates that all acceptance criteria have been met to support the safety finding for a particular SSC.

2. In accordance with 10 CFR 52.47(a)(8),(21), and (22), and 10 CFR 52.79(a)(17), (20) and (37), for design certification or combined 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 which are identified in the version of NUREG-0933 current on the date up to 6 months before the docket date of the application and which 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) for a DC application, and except paragraphs (f)(1)(xii), (f)(2)(ix), (f)(2)(xxv), and (f)(3)(v) for a COL application. 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. DSRS Section 3.5.2, "Structures, Systems, and Components to be Protected from Externally-Generated Missiles" provides guidance on the identification of "SSCs subject to missile (externally-generated) protection."
4. The safety analysis report is reviewed for the identification of the design-basis natural phenomena that could possibly generate missiles. Postulated missiles are reviewed for proper characterization.
5. RG 1.76 provides guidance on the definition and characterization of the design-basis tornado as discussed in Subsection II.
6. RG 1.221 provides guidance on the definition and characterization of the design-basis hurricane as discussed in Subsection II.
7. The design-basis natural phenomena for the site are reviewed with respect to the potential for missile generation. For phenomena with greater potential for missile generation than the design-basis tornado or hurricane (i.e., initiating frequency is 10^{-7} per year or greater), appropriate design-basis missiles are proposed.
8. All plants are required to be designed to protect SSCs subject to missile protection against damage from missiles, which might be generated by the design-basis tornado and hurricane for that plant. The reviewer verifies that the applicant has postulated missiles that include at least (1) a massive high-kinetic-energy missile that deforms on impact, (2) a rigid missile to test penetration resistance, and (3) a small rigid missile of a size sufficient to just pass through any openings in protective barriers. Acceptable missiles and their associated speeds are identified in Table 2 of RG 1.76, and Tables 1 and 2 of RG 1.221.
9. 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 information items. The reviewer may identify additional COL information items; however, to ensure these COL information 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 SER. The reviewer also states the bases for those conclusions.

1. The basis for acceptance in the staff review is the conformance of the applicants' design criteria for the protection from the effects of natural phenomena to the Commission's regulations as set forth in the GDC, and to applicable regulatory guides and national standards.
2. The staff concludes that the assessment of possible hazards attributable to missiles generated by the design-basis tornado and hurricane and other extreme winds is acceptable and conforms to the requirements of GDC 2 and 4. This conclusion is based on the applicant having met the requirements of GDC 2 and 4 by meeting the guidance of RG 1.76, and RG 1.221.

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 information 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 regulations in 10 CFR 52.17(a)(1)(xii), 10 CFR 52.47(a)(9), and 10 CFR 52.79(a)(41) establish requirements for applications for ESPs, DCs, and COLs, respectively. These regulations require the application to include an evaluation of the site (ESP), standard plant design (DC), or facility (COL) against the Standard Review Plan (SRP) revision in effect six months before the docket date of the application. While the SRP provides generic guidance, the staff developed the SRP guidance based on the staff's experience in reviewing applications for construction permits and operating licenses for large light-water nuclear power reactors. The proposed small modular reactor (SMR) designs, however, differ significantly from large light-water nuclear reactor power plant designs.

In view of the differences between the designs of SMRs and the designs of large light-water power reactors, the Commission issued 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) (SRM). In the SRM, the Commission directed the staff to develop risk-informed licensing review plans for each of the SMR design reviews, including plans for the associated pre-application activities. Accordingly, the staff has developed the content of the DSRS as an alternative method for the evaluation of a NuScale-specific application submitted pursuant to 10 CFR Part 52, and the staff has determined that each application may address the DSRS in lieu of addressing the SRP, with specified exceptions. These exceptions include particular review areas in which the DSRS directs reviewers to consult the SRP and others in

which the SRP is used for the review. If an applicant chooses to address the DSRS, the application should identify and describe all differences between the design features (DC and COL applications only), analytical techniques, and procedural measures proposed in an application and the guidance of the applicable DSRS section (or SRP section as specified in the DSRS), and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria.

The staff has accepted the content of the DSRS as an alternative method for evaluating whether an application complies with NRC regulations for NuScale SMR applications, provided that the application does not deviate significantly from the design and siting assumptions made by the NRC staff while preparing the DSRS. If the design or siting assumptions in a NuScale application deviate significantly from the design and siting assumptions the staff used in preparing the DSRS, the staff will use the more general guidance in the SRP as specified in 10 CFR 52.17(a)(1)(xii), 10 CFR 52.47(a)(9), or 10 CFR 52.79(a)(41), depending on the type of application. Alternatively, the staff may supplement the DSRS section by adding appropriate criteria in order to address new design or siting assumptions.

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. RG 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants."
4. RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants."