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DESIGN SPECIFIC REVIEW STANDARD FOR mPOWER^{TM} iPWR

3.3.1 SEVERE WIND LOADING

REVIEW RESPONSIBILITIES

Primary - Organization responsible for structural analysis reviews

Secondary - None

I. AREAS OF REVIEW

All structures, systems, and components (SSCs) important to safety are to be protected from severe wind loading to ensure compliance with 10 CFR 50, Appendix A, General Design Criterion (GDC) 2 requirements. All safety-related and risk-significant SSCs are subject to severe wind load protection. An SSC may be classified as:

Safety-related risk-significant
Safety-related nonrisk-significant
Nonsafety-related risk-significant
Nonsafety-related non-risk significant

If the SSC belongs in one of the first three classifications above, the review described in this Design-Specific Review Standard (DSRS) Section 3.3.1 is applied. For the purpose of brevity in this section, the first three categories above will be designated as “safety-related or risk-significant”.

The specific areas of review are as follows:

1. The design wind speed, its recurrence interval, the speed variation with height, and the applicable gust factors from the standpoint of use in defining the input parameters for the structural design criteria appropriate to account for wind loadings.

2. The procedures that are used to transform the design wind speed into an equivalent pressure applied to structures are reviewed taking into consideration the geometrical configuration and physical characteristics of the structures and the distribution of wind pressure on the structures.

3. 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 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.

4. 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.

5. Wind Load Effects for mPower™ Applications

   The specific areas of review items 1 through 4 discussed above are generally applicable provided that the unique mPower™ containment configurations and layouts (e.g., below ground containment) as described below are adequately accounted for in the review.

   The mPower™ integral pressurized water reactor (iPWR) is a small-size reactor inside a below-grade containment. The refueling water storage tank (RWST) is located inside the containment and a reactor service building sits above the containment structure. The spent fuel pool is below grade and located in the reactor service building. The ultimate heat sink (UHS) tanks for removing decay heat via emergency condensers are outside containment and are also enclosed in the reactor service building. This DSRS section provides guidance for determining pertinent design-basis wind load effects for all seismic Category I structures.

Review Interfaces

Other DSRS sections interface with this section as follows.

1. The adequacy of the most severe regional and local meteorological data used to specify design wind load parameters for SSCs of the nuclear power plant that may be affected by weather phenomena is reviewed in accordance with DSRS Sections 2.3.1 and 2.3.2.

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

2. Review of the description and results of the Probabilistic Risk Assessment is performed under SRP 19.0.

II. ACCEPTANCE CRITERIA

Requirements

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for review described in this DSRS section. 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."

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

1. 10 CFR 50, Appendix A, GDC 2 requires that SSCs important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions as it relates to natural phenomena. The design bases for these SSCs shall reflect appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena.

2. 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 plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations.

3. 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.

iPWR DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this DSRS section. The DSRS is not a substitute for the NRC's regulations, and compliance with it is not required.

However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the DSRS acceptance criteria and evaluate how the proposed alternatives to the DSRS acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. The wind speed used in the design shall be the most severe wind that has been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data have been accumulated.

2. The acceptance criteria for the design wind speed, its recurrence interval, the speed variation with height, the applicable gust factors, and the bases for determining these site-related parameters, are stated in DSRS Sections 2.3.1 and 2.3.2. The approved values of these parameters should serve as basic input to the review and evaluation of the structural design procedures.

   For mPower™ plants, the containment is below the grade level, but there are other structures above ground for which wind loads need to be defined. In particular, this includes assessing the effects of wind loads on the reactor service building and the enclosed ultimate heat sink (UHS) tanks. Since the spent fuel pool (SFP) is below grade and located in the reactor service building and the UHS tanks for removing decay heat via emergency condensers are outside containment and are also enclosed in the reactor service building, the wind loads induced dynamic vibratory effects, including SFP water sloshing effect, as applicable, should be adequately accounted for in the design of spent fuel pools, UHS tanks, as well as other affected seismic Category I SSCs consistent with the provisions of DSRS Sections 3.3, 3.7 and 3.8. This also includes other structures which are defined as those buildings that house the Power Conversion System (PCS), Radiation Waste (both liquid and gaseous), Feedwater, Main Steam, Diesel Generators, and other systems and components that may be determined to be important to safety due to risk significance. as established by a risk-informed and performance-based technical analysis complemented by design-specific PRA information when available.

3. The procedures used to transform the wind speed into an equivalent pressure to be applied to structures and parts, or portions of structures, as delineated in American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) 7-05, “Minimum Design Loads for Buildings and Other Structures,” are acceptable. In particular, the procedures used are acceptable if found in accordance with the following:

   A. For a design wind speed, V, the basic velocity pressure, q_z, evaluated at height, z, is given by:

   $$q_z = 0.00256\, K_z K_{zt} K_d V^2 I \ (lb/ft^2)$$

   Where:

   K_z = velocity pressure exposure coefficient evaluated at height, z, as defined in ASCE/SEI 7-05, Table 6-3, but not less than 0.87

   K_{zt} = topographic factor equal to 1.0

K_d = wind directionality factor equal to 1.0

V = design wind speed in miles per hour (mi/h) as stated in DSRS Section 2.3.1

I = importance factor equal to 1.15

B. For each wind direction considered, the upwind exposure category should be based on ground surface roughness that is determined from natural topography, vegetation, and constructed facilities. Surface roughness C is defined as open terrain with scattered obstructions having heights generally less than 30 ft. This category includes flat open country, grasslands, and all water surfaces in hurricane prone regions. Because most nuclear power plants are located in relatively open country, K_z values in Table 6-3 should be selected from the Exposure C column. The definition of Exposure C is provided in ASCE/SEI 7-05, Section 6.5.6.3.

C. Design wind loads should be determined in accordance with the following sections in ASCE/SEI 7-05, as applicable.

i. Section 6.5.12 – Design Wind Loads on Enclosed and Partially Enclosed Buildings

ii. Section 6.5.13 - Design Wind Loads on Open Buildings with Monoslope, Pitched, or Troughed Roofs

iii. Section 6.5.14 - Design Wind Loads on Solid Freestanding Walls and Signs

iv. Section 6.5.15 - Design Wind Loads on Other Structures

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. Compliance with GDC 2 requires that nuclear power plant SSCs important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their intended safety functions.

2. The acceptance criteria outlined above include reference to proven industry standards and data for evaluating wind loading on structures. These standards and data have been reviewed by and are acceptable to the staff.

3. Meeting the requirements of GDC 2 provides assurance that SSCs important to safety will withstand the most severe wind loads without loss of capability to perform their intended safety functions.

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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. The site-related parameters described in subsection I.1 are reviewed in accordance with DSRS Sections 2.3.1 and 2.3.2. The staff examines these parameters to ensure that they are consistent with those contained in DSRS Sections 2.3.1 and 2.3.2.

2. After the acceptability of the site-related parameters is established, the reviewer proceeds with the evaluation of the structural aspects of wind design. The procedures used by the applicant to transform wind speeds into equivalent pressures are reviewed and compared with those procedures delineated in subsection II of this DSRS.

3. 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 in the DCD. 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 ESP or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

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

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the 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 applicant has met the requirements of GDC 2 with respect to the capability of the structures to withstand design wind loading so that their design reflects the following:

1. Appropriate consideration for the most severe wind recorded for the site with an appropriate margin;

2. Appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena; and

3. The importance of the safety function to be performed.

The applicant has designed the plant structures with sufficient margin to prevent structural damage during the most severe wind loadings that have been determined appropriate for the site so that the requirements in Item 1 listed above are met. The applicant has used methods provided in ASCE/SEI 7-05, which the staff reviewed and found acceptable, to transform the wind speed into an equivalent pressure on structures and to select pressure coefficients corresponding to the structure's geometry and physical configuration.

The procedures used to determine the loadings on structures induced by the design wind speed specified for the plant are acceptable because these procedures have been used in the design of conventional structures and proven to provide an adequate basis which together with other engineering design considerations ensures that the structures will withstand such environmental forces. In addition, the design of seismic Category 1 structures, as required by Item 2 listed above, has included load combinations of the most severe wind load and the loads resulting from normal and accident conditions.

The use of these procedures provides reasonable assurance that in the event of design basis winds, the structural integrity of the plant structures that must be designed to resist the effects of the design wind speed will not be impaired and, in consequence, safety-related systems and components located within these structures are adequately protected and will perform their intended safety functions if needed, thus satisfying the requirement of Item 3 listed above.

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^{TM}-specific design certification (DC), combined license (COL), or early site permit (ESP) 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^{TM} 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^{TM} -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 revise the DSRS section in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.17 (a)(1)(xii) and 10 CFR 52.79 (a)(41), for ESP and COL applications, respectively.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2,"Design Bases for Protection Against Natural Phenomena."

2. American Society of Civil Engineers/Structural Engineering Institute. "Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-05," American Society of Civil Engineers, Reston, Virginia, 2006.

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