

# Draft for Comment



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

### 14.3.7 PLANT SYSTEMS - INSPECTIONS, TESTS, ANALYSES, AND ACCEPTANCE CRITERIA

#### REVIEW RESPONSIBILITIES

**Primary -** Organizations Responsible for the Review of Plant Systems

**Secondary -** None

#### I. AREAS OF REVIEW

This Design Specific Review Standard (DSRS) section addresses inspections, tests, analyses, and acceptance criteria (ITAAC) related to the plant systems. ITAAC are based on information contained in the final safety analysis report (FSAR) of a combined license (COL) application and are provided in a separate part of the COL application. In addition, ITAAC are included in the Tier 1 portion of the design control document (DCD) of a design certification (DC) application.

The specific areas of review are as follows:

1. New and spent fuel handling systems, power generation systems, air systems, cooling water systems, radioactive waste systems, fire protection systems, and heating, ventilation and air conditioning (HVAC) systems. This includes systems, structures and components (SSCs) which may have special considerations for regulatory treatment of non-safety systems (RTNSS) or defense-in-depth functions.
2. Issues which affect multiple SSCs such as equipment qualification and protection from fires, floods, and tornado missiles.
3. For a DC application:
  - A. The staff reviews 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 NRC regulations.
  - B. The staff reviews the Tier 1 interface requirements and the applicant's justification that compliance with the interface requirements is verifiable through inspections, tests, or analysis. The interface requirements define the significant attributes and performance characteristics that the portion of the facility that is outside the scope of the design certification must have in order to support the in-

scope portion of the design. The method to be used for verification of interface requirements must be included as part of the design certification ITAAC.

4. For a COL application:
  - A. The staff reviews the proposed plant-specific ITAAC to ensure that they 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 be operated in conformity with the combined license, the Atomic Energy Act, and the NRC's regulations.
  - B. If the application references an early site permit with ITAAC, the early site permit ITAAC must apply to those aspects of the combined license which are approved in the early site permit, and the staff shall verify they have been properly incorporated into the COL.
  - C. If the application references a standard design certification, the ITAAC contained in the certified design must apply to those portions of the facility design which are approved in the design certification, and the staff shall verify they have been properly incorporated into the COL.
5. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

#### Review Interfaces

Other DSRS/ Standard Review Plan (SRP) sections interface with this section as follows:

1. SRP Section 14.3 provides general guidance on ITAAC information.
2. Acceptability of ITAAC information regarding building structures and structural aspects of major components and the ability of SSCs to withstand various natural phenomena is reviewed under DSRS Section 14.3.2.
3. Acceptability of ITAAC information for piping design is reviewed under SRP Section 14.3.3.
4. Acceptability of ITAAC information for instrumentation and controls is reviewed under DSRS Section 14.3.5.
5. Acceptability of ITAAC information for electrical systems and components is reviewed under DSRS Section 14.3.6.
6. Acceptability of ITAAC information for waste management systems and radiological monitoring systems is reviewed under DSRS Section 14.3.8.

7. Review of ITAAC information for probabilistic risk assessment and applicable risk classification is performed under SRP Section 19.0.
8. Review of RTNSS is performed under SRP Section 19.3.

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

## II. ACCEPTANCE CRITERIA

### Requirements

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

1. 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 rules and regulations.
2. 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 be operated 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. 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. Based on the determination of safety classification and/or risk significance in accordance with SRP Section 19.3 and as documented in Tier 2 of the DC application or in the final safety analysis report (FSAR) of the COL application, the reviewer confirms that the appropriate SSCs have been included in Tier 1 and ITAAC. Other sources include applicable rules and regulations (such as General Design Criteria), Regulatory Guides, NRC generic correspondence, probabilistic risk assessment (PRA) insights from the standard design's safety and severe accident analyses, and operating experience. Tier 1 should be reviewed for consistency with the initial test program described in DCD Tier 2 Chapter 14.2. In particular, the NRC reviewer should perform a consistency review between the Tier 1 preoperational ITAAC and the applicable Tier 2 system preoperational test abstract to confirm that the test acceptance criteria are consistent with the test requirements for the system test. The Tier 1 ITAAC may have specific

numerical test acceptance criteria values while the Tier 2 system test abstract may only have a verbal description of the test acceptance criteria. The NRC technical reviewer would need to confirm that the numerical and verbal description of the test acceptance criteria are the same as the test acceptance criteria information that would need to be verified during the preoperational test phase of the Initial Test Program. The reviewer should also use the review checklists provided in Appendix C to SRP Section 14.3 as an aid for establishing consistency and comprehensiveness in the review of the systems. If applicable, the reviewer should utilize regulatory guidance from the Commission for selected policy and technical issues related to a particular design. Examples of these are contained in SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs." The SRM related to this SECY is dated July 21, 1993.

2. Tier 1 should be reviewed for treatment of design information proportional to the safety significance and risk significance of the SSC for that system. Many items may be judged to be risk-significant, and thus should be included in Tier 1. The following issues are identified to ensure comprehensive and consistent treatment in Tier 1 based on the safety significance and/or risk significance of the system being reviewed:
  - A. System purpose and functions (including defense-in-depth functions and RTNSS considerations)
  - B. Location of system
  - C. Key design features of the system
  - D. Seismic and ASME code classifications
  - E. System operation in various modes
  - F. Controls, alarms, and displays
  - G. Logic
  - H. Interlocks
  - I. Class 1E electrical power sources and divisions
  - J. Equipment to be qualified for harsh environments
  - K. Interface requirements
  - L. Numeric performance values
  - M. Accuracy and quality of figures
  - N. Functional arrangement
  - O. Valve qualification and operation
3. Specific ITAAC entries should be utilized to verify selected issues, where appropriate. The reviewer should ensure consistent application and treatment of these ITAAC entries including pump net positive suction head, and physical separation for appropriate systems in Tier 1. In particular, the provisions for environmental qualification (EQ) and seismic qualification aspects of SSCs should be reviewed to ensure appropriate treatment in Tier 1.
4. Environmental qualification of safe-shutdown equipment may be verified as part of specific ITAAC for safety-related systems. EQ treatment in the ITAAC would then be discussed in the General Provisions section of Tier 1. Verification may include type tests or a combination of type tests and analyses of Class 1E electrical equipment identified in the Design Description or accompanying figures to show that the equipment can withstand the conditions associated with a design basis accident without loss of safety function for the time that the function is needed.
5. The design features in Tier 1 should be selected to ensure that the integrity of the analyses is preserved in an as-built facility. For example, 3-hour fire boundaries and

divisional separation may be shown in the building figures. Also, flooding features such as structure elevations should be specified in the site parameters, flood doors may be shown on the building figures, and elevations are shown on the buildings to verify that the approximate physical location of components and relative elevations of buildings minimize the effects of flooding. As-built reconciliation reports for fires and floods to ensure consistency with Tier 2 analyses should be required by the appropriate system ITAAC (e.g., fire protection system) and selected building ITAAC, respectively.

6. Other specific issues that should be addressed include heat removal capabilities for design-basis accidents and tornado and missile protection. Heat removal capabilities may be verified through heat removal requirements for core cooling system heat exchangers and interface requirements for site-specific systems. Tornado and missile protection may be provided by inlet and outlet dampers in ventilation systems, and through the structural design of buildings. In addition, water hammer mitigating design features should be addressed.
7. The areas of review for radioactive waste systems include design objectives, design criteria, identification of all expected releases of radioactive effluents, methods of treatment, methods used in calculating effluent source terms and releases of radioactive materials in the environment, and operational programs in controlling and monitoring effluent releases and for assessing associated doses to members of the public. The radioactive waste systems include the liquid waste management system (LWMS), gaseous waste management system (GWMS), and the solid waste management system (SWMS). These systems deal with the management of radioactive wastes, as liquid, wet, and dry solids, produced during normal operation and anticipated operational occurrences. In addition, the review includes an evaluation of the process and effluent radiological monitoring instrumentation and sampling systems (PERMISS) which are used to monitor liquid and gaseous process streams and effluents and solid wastes generated by these systems. The PERMISS includes subsystems used to collect process and effluent samples during normal operation, anticipated operational occurrences, and under post-accident conditions. The lead branch responsible in implementing the review should coordinate the review of these systems and operational programs and receive input on the design and compliance with acceptance criteria listed in DSRS Sections 11.2 to 11.5 from other branches, including, balance of plant, structural, instrumentation and controls, HVAC, quality assurance, technical specifications, and emergency planning.
8. The reviewer should receive inputs on the treatment of issues identified above from other branches such as the structural, electrical and I&C branches. In addition, the secondary review branches specified in SRP Section 14.3 should provide inputs on selected issues. These issues include key insights and assumptions from PRA and severe accident analyses, as well as inputs for issues such as treatment of alarms, displays and controls, and functionality of motor operated valves (MOVs) and air operated valves (AOVs). Cross-references from Tier 2 to Tier 1 for key insights and assumptions from PRA and severe accident analyses should be provided by applicants in Tier 2 together with these analyses.
9. Tier 1 should address and verify at least the minimum inventory of alarms, controls, and indications as derived from the Emergency Procedure Guidelines, the guidance of RG 1.97, and PRA insights. These may be specified in the Main Control Room (MCR) and the Remote Shutdown System (RSS) ITAAC, or addressed in other appropriate ITAAC, and verified to exist. Other controls, indications and alarms should be identified in the system ITAAC based on their safety and/or risk significance. Locations for these should

be shown on system figures if important to system design and function. The ability of these controls, indications, and alarms to function properly should be checked during the functional tests required by the system ITAAC. Because the intent of the ITAAC is to verify the final as-built condition of the plant, the operation of the system during the completion of the functional tests required in the system ITAAC should be conducted from the MCR. Therefore, the verification that the system can be operated from the MCR need not be a separate ITAAC. Also, because the operation of the equipment from the control room demonstrates the control function, continuity checks between the RSS and the equipment demonstrates that the control signal will be received by the component and provides adequate assurance that the equipment can be operated by the RSS. The results of the pre-operational test program may be utilized to demonstrate the ability to operate plant equipment by the RSS.

### 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. Application of 10 CFR 52.47(b)(1), as it relates to ITAAC (for design certification) providing reasonable assurance that the SSCs in this area of review have been constructed and will be operated in conformity with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations.
2. Application of 10 CFR 52.80(a), as it relates to ITAAC (for combined licenses) providing reasonable assurance that the SSCs in this area of review have been constructed and will be operated in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRCs regulations.

### 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 applicants 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. Follow the general procedures for review of Tier 1 contained in the Review Procedures section of SRP Section 14.3. Ensure that the DCD is consistent with Appendix A to SRP Section 14.3.
4. Ensure that all Tier 1 information is consistent with Tier 2 information. Figures and diagrams should be reviewed to ensure that they accurately depict the functional arrangement and requirements of the systems. Reviewers should use the Review Checklists in Appendix C to SRP Section 14.3 as an aid in establishing consistent and comprehensive treatment of issues.
5. Ensure that the plant systems are clearly described in Tier 1, including the key performance characteristics and safety and/or defense-in-depth functions of SSCs based on their safety and risk significance.

6. The reviewer should ensure that appropriate guidance is provided to other branches such that plant systems issues in Tier 1 are treated in a consistent manner among branches.
7. Ensure that the ITAAC entries related to plant systems items are included for the appropriate systems described in the Tier 2 document. In particular, the reviewer should review these ITAAC for verification of environmental qualification and seismic qualification. The reviewer should ensure consistent application and treatment of these ITAAC entries, including for pump net positive suction head and physical separation for appropriate systems in Tier 1.
8. Ensure that design features for the resolution of selected policy and technical issues are adequately addressed in Tier 1, based on safety and risk significance. Ensure that the appropriate Commission guidance, requirements, bases and resolutions for these items are documented clearly in the SER.
9. Ensure that definitions, legends, interface requirements, and site parameters that pertain to plant systems issues are treated consistently and appropriately in Tier 1.
10. 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 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.

In general, 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 or other NRC approvals (e.g., manufacturing license, site suitability report or topical report). However, the scope of this DSRS section only addresses the NuScale DC application and COL applications that reference the NuScale certified design. For a COL application referencing a DC, the COL application addresses COL action items and site-specific information.

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

1. The reviewer verifies that sufficient information has been provided to satisfy SRP Section 14.3 and this DSRS section, and concludes that the ITAAC are acceptable. A finding similar to that in the Evaluation Findings section of SRP Section 14.3 should be provided in a separate section of the SER.
2. For DC and COL reviews, the findings will also summarize the staff's evaluation regarding DC requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this DSRS section.



## 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 52.47, "Contents of applications; technical information."
2. 10 CFR 52.80(a), "Contents of applications; additional technical information."
3. 10 CFR 50.48, "Fire protection."
4. 10 CFR 50.49, "Environmental qualification of electric equipment important to safety for nuclear power plants."
5. RG 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants."
6. RG 1.206, "Combined License Applications for Nuclear Power Plants."

7. RG 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants."
8. RG 1.215, "Guidance for ITAAC Closure Under 10 CFR Part 52."
9. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs" dated April 2, 1993.