U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD for NuScale SMR DESIGN

14.3.5 INSTRUMENTATION AND CONTROLS—INSPECTIONS, TESTS, ANALYSES, AND ACCEPTANCE CRITERIA

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of instrumentation and controls (I&C)

Secondary - None

I. AREAS OF REVIEW

This design-specific review standard (DSRS) section addresses inspections, tests, analyses, and acceptance criteria (ITAAC) related to the I&C systems. ITAAC information is contained in Tier 1 information from the design control document (DCD) of a design certification (DC) application.

The ITAAC review includes a review of the design commitments to be verified by ITAAC inspection. For DC applications, these design commitments also define the scope of the certified design. The design commitments are identified in design descriptions that establish the scope of ITAAC. For DC applications and for combined license (COL) applications that reference a design certification (DC), these design descriptions and ITAAC are contained in the Tier 1 portion of the DCD.

The review of I&C ITAAC should be coordinated with the review of the applicant's I&C systems design as described in Chapter 7 of the DSRS. It is recognized that the review of ITAAC is performed after review of the application against acceptance criteria contained in Chapter 7 of the DSRS. Furthermore, the ITAAC are reviewed to assure that all structures, systems, and components (SSCs) in this area of review are identified and addressed as appropriate.

The specific areas of review are as follows:

1. Tier 1 information on I&C systems involving reactor protection and control, engineered safety features actuation, and other systems using I&C equipment

2. Tier 1 information related to design process of digital I&C systems

3. key interface requirements related to I&C issues

4. functional requirements of Institute of Electrical and Electronics Engineers (IEEE) Std 603-1991 and the general design criteria (GDC) when implementing the safety system

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5. For DC and COL reviews:

   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 plant that incorporates the DC is built and will operate in accordance with the DC, the Atomic Energy Act, and the Commission's rules and 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 DC must have in order to support the in-scope portion of the design. The interface requirements are required to be verified by ITAAC provided in the COL.

Review Interfaces

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

1. SRP Section 14.3 provides general guidance on review interfaces.

2. Acceptability of ITAAC information regarding the ability of SSCs to withstand various natural phenomena is reviewed in SRP Section 14.3.2.

3. Acceptability of ITAAC information for electrical systems and components is reviewed in SRP Section 14.3.6.

4. Acceptability of ITAAC information for plant systems including heating, ventilation, and air conditioning (HVAC) design; containment isolation; and selected aspects of the containment design is reviewed in SRP Section 14.3.7.

5. Acceptability of ITAAC information for reactor systems is reviewed in SRP Section 14.3.4.

6. Acceptability of ITAAC information for radiation protection is reviewed in SRP Section 14.3.8.

7. Acceptability of ITAAC information for human factors is reviewed in SRP Section 14.3.9.

8. Acceptability of ITAAC information for emergency preparedness is reviewed in SRP Section 14.3.10.

9. Acceptability of ITAAC information for containment systems is reviewed in SRP Section 14.3.11.

10. The identification of risk-significant I&C is reviewed in SRP Sections 19.0 and 19.3.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission's rules and 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 Commission'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 COL, the provisions of the Atomic Energy Act, and the Commission's rules and regulations

DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the Commission's rules and regulations identified above are set forth below. The DSRS is not a substitute for the Commission's rules and 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 Commission's rules and regulations that underlie the DSRS acceptance criteria.

1. The methodology for selecting SSCs that will be subject to ITAAC as well as the criteria for establishing the necessary and sufficient ITAAC should be appropriate for and consistently applied to I&C systems.

2. Tier 1 design descriptions should describe the top-level I&C design features and performance characteristics that are significant to safety. For safety systems, Tier 1 design descriptions should include a description of system purpose, safety functions, equipment quality (e.g., meet the functional requirements of IEEE Std. 603-1991 and the digital system life cycle design process), automatic decisionmaking and trip logic functions, manual initiation functions, and design features (e.g., system architecture) provided to achieve high functional reliability.

   The functions and characteristics of other I&C systems important to safety should also be discussed to the extent that the functions and characteristics are necessary to support remote shutdown, support operator actions or assessment of plant conditions and safety system performance, maintain safety systems in a state that assures their

availability during an accident, minimize or mitigate control system failures that would interfere with or cause unnecessary challenges to safety systems, or provide diverse backup to safety systems.

SRP Section 14.3, Appendix A provides additional guidance on the content of Tier 1 information.

3. ITAAC should identify the significant features of the I&C systems on which the staff is relying to ensure compliance with each NRC requirement identified in DSRS Chapter 7. Inspections, tests, analyses, and acceptance criteria associated with each design commitment should, when taken together, be sufficient to provide reasonable assurance that the final as-built I&C system fulfills NRC requirements.

   SRP Section 14.3, Appendix A, provides additional guidance on the expected scope, content, and format of ITAAC.

4. Tier 1 design descriptions and ITAAC should be based on and consistent with the Tier 2 material.

5. The passive-designed reactors use safety systems that employ passive means (natural forces), such as gravity, natural circulation, condensation and evaporation, and stored energy, for accident mitigation. These designs also include active systems that provide defense-in-depth capabilities for reactor-coolant makeup and decay heat removal. These active systems are the first line of defense to reduce challenges to the passive systems in the event of transients or plant upsets. SECY-95-132, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs (SECY-94-084)," provides certain guidance and positions for ensuring consistent and complete treatment of those systems that might be classified as nonsafety-related by the designer or applicant but are important to safety or otherwise provide defense-in-depth functions.

   Applicable regulatory guidance from the Commission for selected policy and technical issues related to particular design should be followed. For the severe accident analyses, the basis for the staff's review for the evolutionary and passive standard designs was the Commission guidance related to SECY-90-016, "Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements." SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," generically presents guidance and NRC positions on evolutionary and passive light-water reactor (LWR) DC issues. For guidance, positions, and issues related to specific designs, guidance is available in such documents as SECY-97-044, "Policy and Key Technical Issues Pertaining to the Westinghouse AP600 Standardized Passive Reactor Design," or SECY-92-327, "Reviews of Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) for the General Electric (GE) Advanced Boiling Water Reactor (ABWR)."

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. The relevance of the methodology for selecting SSCs that will be subject to ITAAC and the criteria for establishing the necessary and sufficient ITAAC should be considered from the perspective of each type of system within the scope of DC or COL applications. The accepted methodology should be applied consistently to all systems in the scope.

2. Key functions and performance requirements should be identified as a basis for identifying SSCs that should be within the scope of the ITAAC.

3. To confirm that I&C functions have been constructed in accordance with the Commission's rules and regulations, the ITAAC as a whole should address each regulatory requirement. The reviewer should understand the basis for any exceptions to this principle.

4. ITAAC should be consistent with the more complete description of the basis for plant safety.

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 specific 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: Light-Water Small Modular 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 small modular reactor (SMR) framework. Using the graded approach described in NUREG-0800, Intro Part 2, the NRC staff may determine that, for certain 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 completing the applicable ITAAC. The use of the selected programs to augment or replace traditional review procedures is shown in Figure 1 of NUREG-0800, Intro Part 2. Examples of such programs that may be relevant to the graded approach for these SSCs include:

    - 10 CFR Part 50, Appendix A, GDC, Overall Requirements, Criteria 1–5
    - 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 Nonsafety 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 DC or COL applications submitted under 10 CFR 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, "Resolution of Generic Safety Issues," 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 review procedures of SRP Section 14.3. Assure that the Tier 1 information, including ITAAC, are consistent with SRP Section 14.3, Appendix A.

4. Assure that Tier 1 information is consistent with DCD Tier 2 information. Figures and diagrams should be reviewed to assure that they accurately depict the functional arrangement and requirements of the systems. The reviewer should use the requirements listed in DSRS Chapter 7 as an aid in establishing consistent and comprehensive treatment of issues.

In general, each design commitment made to fulfill the technical requirements of 10 CFR Part 50 identified in DSRS Chapter 7 should be included or provide justification with the technical basis for omission. It is permissible to develop general bases (e.g., selection criteria) that provide the basis for multiple omissions.

Note that it is not necessary that the ITAAC explicitly verify each regulatory requirement. In some cases, commitments to design features may address one or more regulatory requirements, and consequently the ITAAC verify the associated requirement by verifying proper implementation of the design feature. For example, a DC application may commit to a specific protection system architecture and demonstrate that the architectural arrangement of functional blocks, channels, and divisions is sufficient to assure compliance with the single failure criterion. Thus, ITAAC that confirm that the functional arrangement of the as-built protection system is as described in the design description provides reasonable assurance that system meets the single-failure criterion. The reviewer should be certain to understand these relationships, but it is not necessary that the ITAAC or referenced Design Descriptions explicitly describe them.

5. Ensure that the I&C systems are clearly described in Tier 1 Design Descriptions and ITAAC. For safety systems, this should include a description of system purpose, safety functions, equipment quality, automatic decisionmaking and trip logic functions, manual initiation functions, and design features (e.g., system architecture) provided to achieve high functional reliability. The functions and characteristics of other I&C systems important to safety should also be discussed to the extent that the functions and characteristics are necessary to support remote shutdown, support required operator actions or assessment of plant conditions or safety system performance, maintain safety systems in a state that assures their availability during an accident, minimize or mitigate control system failures that would interfere with or cause unnecessary challenges to safety systems, or provide diverse backup to protection systems.

6. The reviewer should assure that appropriate guidance is provided to other organizations such that I&C issues in the ITAAC and associated design descriptions are treated in a consistent manner among organizations.

7. The reviewer should assure that standard ITAAC entries in SRP 14.3, Appendix D, related to I&C items, are included in the appropriate systems of the standard design. In particular, the reviewer should assure consistent application and treatment of the standard ITAAC entries for specific ITAAC associated with environmental qualification aspects and for independence for electrical and I&C systems.

8. The reviewer should assure that design features from the resolutions of selected technical and policy issues for the design are adequately addressed in Tier 1 material, ITAAC design descriptions, or ITAAC references to the application, based on safety significance. Assure that the appropriate NRC guidance, requirements, bases, and resolutions for these items are documented clearly in the SER.

9. The staff may designate selected information in Tier 2 of the application that, if considered for a change, requires NRC approval prior to implementation. This information is known as “Tier 2*.” The reviewer should assure that Tier 2* material is identified and that appropriate expiration dates are set.

10. Coordinate with the organization responsible for review of reactor systems to confirm that protective, control, display, and interlock functions are consistent with the accident analysis, the operating requirements of the I&C systems, and the requirements of 10 CFR 50, Appendix A, GDC 10, 15, 28, 33, 34, and 35. I&C system ITAAC confirm that the accepted functions are implemented in the as-built design.

11. Coordinate with the organization responsible for the review of plant systems which evaluates the ITAAC for the auxiliary supporting features and other auxiliary features to demonstrate that they satisfy the applicable acceptance criteria including the operating requirements of the supported system and the requirements of GDC 41 and 44. These features include, for example, compressed (instrument) air, cooling water, boration, lighting, heating, and air conditioning.

12. Coordinate with the organization responsible for the review of containment systems which evaluates the ITAAC for the containment ventilation and atmospheric control systems provided to maintain required environmental conditions for I&C equipment located inside containment.

13. Coordinate with the organization responsible for the review of containment and severe accidents which confirms that protective, control, display, and interlock functions associated with containment systems and severe accidents are consistent with the accident analysis, operating requirements, and GDC 16 and 38. I&C system ITAAC confirm that the accepted functions are implemented in the as-built design.

14. Coordinate with the organization responsible for the review of electrical systems which evaluates the ITAAC demonstrating (1) physical separation for cabling and electrical power equipment, (2) power supplied to redundant systems by appropriate redundant sources, and (3) the adequacy of the I&C associated with the proper functioning of the onsite and offsite power systems.

15. Coordinate with the organization responsible for the review of environmental qualification which evaluates the ITAAC relating to environmental qualification of I&C equipment.

16. Coordinate with the organization responsible for the review of seismic qualification which reviews the ITAAC relating to seismic qualification demonstration for I&C equipment.

17. Coordinate with the organization responsible for the review of human-system interfaces which evaluates the ITAAC demonstrating the adequacy of the human factors aspects of the design, such as arrangement and location of I&C equipment, the capabilities of the I&C to support execution of the operating procedures and emergency response guides, and the provision of qualified plant staff and training required to operate I&C equipment.

18. The reviewer should follow the above to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the application meets the acceptance criteria.

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 types to be included in the staff's SER. 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 Tier 1 material, including ITAAC, is acceptable.

2. The findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements) 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 SRP revision in effect 6 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 SMR designs, however, differ significantly from large light-water nuclear 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 Staff Requirements Memorandum (SRM)-COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights To Enhance Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010. 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 preapplication activities. Accordingly, the staff has developed the content of the DSRS as an alternative method for evaluating 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 to address new design or siting assumptions.

VI. REFERENCES

1. *U.S. Code of Federal Regulations*, "General Design Criteria for Nuclear Power Plants," Appendix A, Part 50, Chapter I, Title 10, "Energy."

2. *U.S. Code of Federal Regulations*, "Contents of Applications; Technical Information," Section 47, Part 52, Chapter I, Title 10, "Energy."

3. *U.S. Code of Federal Regulations*, "Contents of Applications; Additional Technical Information," Section 80, Part 52, Chapter I, Title 10, "Energy."

4. Institute of Electrical and Electronics Engineers, IEEE Standard 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," including the correction sheet, January 30, 1995.

5. U.S. Nuclear Regulatory Commission, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," NUREG-0800, March 2007.

6. U.S. Nuclear Regulatory Commission, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs (SECY-94-084)," Commission Paper SECY-95-132, May 22, 1995, Agencywide Documents Access and Management System (ADAMS) Accession No. ML003708005.

7. U.S. Nuclear Regulatory Commission, "Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," Commission Paper SECY-90-016, January 12, 1990, ADAMS Accession No. ML003707849.

8. U.S. Nuclear Regulatory Commission, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs" Commission Paper SECY-93-087, April 2, 1993, ADAMS Accession No. ML003708021.

9. U.S. Nuclear Regulatory Commission, "Policy and Key Technical Issues Pertaining to the Westinghouse AP600 Standardized Passive Reactor Design," Commission Paper SECY-97-044, February 18, 1997, ADAMS Accession No. ML003708316.

10. U.S. Nuclear Regulatory Commission, "Reviews of Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) for the General Electric (GE) Advanced Boiling Water Reactor (ABWR)," Commission Paper SECY-92-327, September 22, 1992, ADAMS Accession No. ML003707916.

11. U.S. Nuclear Regulatory Commission, SRM-COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance Safety Focus of Small Modular Reactor Reviews," August 31, 2010, ADAMS Accession No. ML102510405.