

Draft for Comment



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

14.3.8 RADIATION PROTECTION - INSPECTIONS, TESTS, ANALYSES, AND ACCEPTANCE CRITERIA

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of radiation protection

Secondary - None

I. AREAS OF REVIEW

This Design-Specific Review Standard (DSRS) section addresses inspections, tests, analyses, and acceptance criteria (ITAAC) related to the radiation protection aspects of the design. Such ITAAC are contained in a combined license (COL) application, in the Tier 1 information of the design control document (DCD) of a design certification (DC) application).

The specific areas of review are as follows:

1. Primary review responsibility for area radiation monitoring systems and airborne radioactivity monitoring systems.
2. Primary review responsibility for radiation shielding provided by structures and components for normal and emergency conditions.
3. Primary review responsibility for other design features provided for radiation protection.
4. Secondary review responsibility for all other Tier 1 information and ITAAC which address the plant radiation protection design. These ITAAC include buildings, ventilation and filtration systems, and the process sampling systems.
5. For a DC application:
 - A. The staff reviews the proposed 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, a facility that incorporates the DC has been constructed and will operate in accordance with the DC, the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission's (NRC's) 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.

6. For a COL application:
 - A. The staff reviews the proposed 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 operate in conformity with the COL, the AEA, and the NRC's rules and 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 staff shall verify that the early site permit ITAAC 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 staff shall verify that the DC ITAAC have been properly incorporated into the COL.
7. 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

Systems described in the Technical Submittal may differ from those outlined in the DSRS. The staff should use the following recommended section interfaces as the basis for reviewing other supplemental or complementary information provided in the Technical Submittal for the specific plant design to identify ITAAC for radiation protection design features:

1. Standard Review Plan (SRP) Section 14.3 provides general guidance on review interfaces.
2. Acceptability of ITAAC information regarding the ability of structures, systems, and components (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 reactor systems is reviewed under DSRS Section 14.3.4.
5. Acceptability of ITAAC information for instrumentation and controls is reviewed under DSRS Section 14.3.5.
6. Acceptability of ITAAC information for electrical systems and components is reviewed under DSRS Section 14.3.6.
7. Acceptability of ITAAC information for plant systems, including the heating, ventilation, and air conditioning design, containment isolation, radioactive waste management and radiation monitoring systems, and selected aspects of the containment design is reviewed under DSRS Section 14.3.7.
8. Acceptability of ITAAC information for emergency preparedness is reviewed under SRP Section 14.3.10.
9. Acceptability of ITAAC information for containment systems is reviewed under SRP Section 14.3.11.

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 AEA, and the NRC's 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 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. The reviewer should primarily use the applicable rules and regulations, general design criteria (GDC), regulatory guides (RGs), unresolved safety issues, and generic safety issues in the review of Tier 1 to determine the safety significance of SSCs with respect to the radiation protection for occupational workers and the general public they provide. Other sources include the DSRS and applicable NRC generic correspondence. The reviewer should use the guidance in Appendix C to SRP Section 14.3 as an aid for ensuring the comprehensiveness and consistency of this review.
2. Radiation Protection: The reviewer should ensure that Tier 1 identifies and describes, commensurate with their safety significance or regulatory requirements, those SSCs that provide radiation shielding, confinement or containment of radioactivity, ventilation of airborne contamination, or radiation (or radioactivity concentration) monitoring for normal operations and during accidents. The reviewer should ensure that Tier 1 identifies and describes, commensurate with their safety significance, those SSCs whose functioning maintains the integrity of radiation shielding material. The reviewer should also ensure that Tier 1 identifies and describes the measures that need to be employed during first-of-a-kind engineering to ensure that final design details (i.e., materials and component selection, equipment placement, and pipe routing) are consistent with the radiation protection commitments (including the commitment that radiation exposures will be as low as is reasonably achievable (ALARA)) in the certified design. Tier 1 contains ITAAC that ensure that the identified SSCs will function in a manner consistent with the certified design.

The ITAAC should require the COL licensee to demonstrate by testing of air flow rates, or by analysis, that airborne radioactivity levels within the plant rooms and areas verify the performance of the design features installed during plant construction. The ITAAC provided should ensure that the plant, as constructed, provides adequate containment and ventilation flow rates to control the concentrations of airborne radioactivity to levels commensurate with the access requirements of areas in the plant. The plant rooms and areas to which the ITAAC apply should be given in figures in Tier 1. The appropriate section of DCD Tier 2, Chapter 12, should include detailed supporting information for the ITAAC.

The ITAAC should require a demonstration by testing or analysis that the radiation shielding (-type, quantity, operational constraints and quality) ensures that (1) the maximum radiation levels in plant areas are commensurate with the areas' operational access requirements, (2) the equipment is qualified, (3) there is access to aid in the mitigation of or the recovery from an accident, and (4) the radiation dose to a member of the public (off site) is a small fraction of the U.S. Environmental Protection Agency's dose limits found at 40 CFR Part 190. The appropriate section of DCD Tier 2, Chapter 12, should include detailed supporting information for the ITAAC.

The ITAAC should require a demonstration by testing or analysis that the as installed airborne monitors provided for radiation protection as specified in the design, are capable of meeting the specified design requirements.

The ITAAC should require a demonstration by testing or analysis that the as installed area radiation monitors provided for radiation protection as specified in the design are capable of meeting the specified design requirements.

3. In accordance with 10 CFR 20.1406(a) and (b) and as relevant to this DSRS section, COL and DC applications must describe how facility design will minimize, to the extent practicable, contamination of the facility and environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste. RG 4.21 describes an acceptable method for demonstrating compliance with design-related requirements of 10 CFR 20.1406. As part of the evaluation, the staff will review the design features of SSCs that are credited in demonstrating compliance with the requirements of Part 20.1406, taking into account the state of technology. First, the review will confirm that the proposed engineering features are adequate and consistent with the objectives of the regulatory requirements. Secondly, the review will confirm that the proposed ITAAC for SSCs used to demonstrate compliance with these NRC regulatory requirements are necessary and sufficient to provide reasonable assurance that if the ITAAC are successfully completed, then the facility has been constructed and will be operated in accordance with these regulatory requirements. As part of this step, the staff may identify the need for additional ITAAC. In evaluating the applicant's justification of the proposed ITAAC or in identifying additional ITAAC, a design certification review will consider interface requirements with other SSC design features, if verifiable through ITAAC, and methods proposed to verify compliance with the interface requirements.
4. 10 CFR 52.47(b)(1) specifies that the application for a DC should contain proposed ITAAC that necessary and sufficient to provide reasonable assurance that plant has been constructed and will operate in accordance with the DC, the AEA, and NRC regulations. 10 CFR 52.97(b) specifies that the COL must identify the ITAAC that are necessary and sufficient to provide reasonable assurance that the facility has been constructed and will be operated in conformity with the license, the AEA, and NRC regulations. SRP Section 14.3 provides guidance for reviewing the ITAAC. The requirements of 10 CFR 52.47(b)(1) and 10 CFR 52.97(b) will be met, in part, by identifying inspections, tests, analyses, and acceptance criteria to verify the top-level design features of radiation protection and components in the DC application and the COL, respectively.

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 DC) providing reasonable assurance that the SSCs in this area of review have been constructed and will operate in accordance with the design certification, the provisions of the AEA, and the NRC's regulations.
2. Application of 10 CFR 52.80(a), as it relates to ITAAC (for COLs) 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 AEA, and the NRC's regulations.

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, "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. The reviewer should follow the general procedures for review of Tier 1 contained in the Review Procedures section of SRP Section 14.3, and ensure that the DCD is consistent with Appendix A to SRP Section 14.3.
4. The reviewer should 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. The reviewer should ensure that Tier 1 clearly describes the SSCs that provide a significant radiation protection function, including the key performance characteristics and safety functions of SSCs based on their safety significance. In this context, radiation protection function should be understood to include occupational radiation protection, radiation protection for members of the public, and protection of electric equipment relied upon to remain functional during and following Design Basis Events (DBEs), including anticipated operational occurrences (AOOs). The review of the radiation protection function should also consider those tests needed to ensure the operation of equipment necessary to ensure the functionality of radiation protection features (e.g., shielding integrity), such as ventilation for ensuring that the maximum shielding material temperature is not exceeded.
6. The reviewer should ensure that Tier 1 identifies and describes the measures that are to be employed during first-of-a-kind engineering to ensure that final design details (i.e., materials and component selection, equipment placement, and pipe routing) are consistent with the radiation protection commitments in the certified design.
7. The reviewer should ensure that appropriate guidance is provided to other branches so that radiation protection issues in Tier 1 are treated in a consistent manner among branches.
8. The reviewer should ensure that Tier 1 adequately addresses design features from the resolution of selected policy and technical issues on the basis of their safety significance. The reviewer should also ensure that the safety evaluation report (SER) clearly documents the appropriate Commission guidance, requirements, bases, and resolutions for these items.
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 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.

- A. 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).
10. The reviewer should ensure that the guidance contained in the issued final Interim Staff Guidance (ISG) documents associated with applications for new reactors is followed:
- A. ISG on Post-Combined License Commitments (ESP/DC/COL-ISG-15).
11. The reviewer should ensure that Tier 1 adequately addresses design features provided to demonstrate compliance with 10 CFR 20.1406 by considering the design features of SSCs that contain or handle radioactive material as described in Tier 2 of the DCD. Regulatory positions C.1 through C.4 of RG 4.21 describe concepts to be implemented to provide reasonable assurance that inadvertent spills, leaks, and discharges of liquid, gaseous, and solid radioactive effluents are prevented, detected, monitored, and corrected.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the FSAR review and analysis 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 reviewer verifies that sufficient information has been provided to satisfy the regulatory requirements related to ITAAC, and concludes that the proposed 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 Part 20, “Standards for Protection Against Radiation.”
2. 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities.”
3. 10 CFR Part 52, “Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants.”
4. GDC 61, “Fuel Storage and Handling and Radioactivity Control.”
5. GDC 19, “Control Room.”
6. GDC 4, “Environmental and Dynamic Effects Design Bases.”
7. RG 1.7, “Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident.”
8. RG 1.112, “Calculations of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors.”
9. RG 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors.”
10. ANSI/ANS Standard 18.1-1999, “Source Term Specification,” American National Standards Institute/American Nuclear Society.”

11. NUREG-0737, "Clarification of TMI Action Plan Requirements."
12. 40 CFR Part 190, "Environmental Radiation Protection Standards For Nuclear Power Operations."
13. RG 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants."
14. RG 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants."
15. RG 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants."
16. RG 1.29, "Seismic Design Classification."
17. RG 1.117, "Tornado Design Classification."
18. RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."
19. EPRI, "Pressurized Water Reactor Primary Water Chemistry Guidelines."
20. EPRI, "Pressurized Water Reactor Primary Water Zinc Application Guidelines."
21. EPRI, "Advanced Light Water Reactor Utility Requirements Document, Volume III, ALWR Passive Plant."
22. NUREG-1242, "NRC Review of Electric Power Research Institute's Advanced Light Water Reactor Utility Requirements Document, Passive Plant Designs" Volume 3, Part 1 and Volume 3, Part 2 (ADAMS Accession Nos. ML070600372 and ML070600373).
23. EPRI, "Cobalt Reduction Guidelines."
24. RG 8.8, "Information Relevant to Assuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as is Reasonably Achievable."