

# Draft for Comment



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

### 10.4.2 MAIN CONDENSER AIR REMOVAL SYSTEM

#### REVIEW RESPONSIBILITIES

**Primary** - Organization responsible for the review of power conversion systems.

**Secondary** - None

#### I. AREAS OF REVIEW

The main condenser air removal system (CAR) is designed to establish and maintain condenser vacuum and to transfer radioactive gases to the gaseous waste processing system or ventilation exhaust systems. Review of the CAR is focused on the system features incorporated to monitor and control releases of radioactive materials in effluents. This includes the startup system which initially establishes main condenser vacuum and the normal system which maintains condenser vacuum once it has been established.

Specific areas of review are as follows:

1. The design, design objectives, capacity, method of operation, and factors that influence gaseous radioactive material handling, e.g., system interfaces and potential bypass routes. The review includes the system schematics, flow diagrams, and/or piping and instrumentation diagrams (P&IDs).
2. The means provided to detect and measure radioactive leakage into or out of the system, and to preclude accidental release of radioactive material to the environment in amounts in excess of the established limits.
3. If the potential for explosive mixtures exists, design features to preclude the possibility of an explosion which could cause a release of radioactive material to the environment.
4. 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 Design Specific Review Standard (DSRS) section in accordance with Standard Review Plan (SRP) Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this DSRS section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.2 and DSRS Section 14.3.7.

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/SRP sections interface with this section as follows:

1. Review of the acceptability of the seismic and quality group classifications is performed under DSRS Sections 3.2.1 and 3.2.2.
2. Review of provisions incorporated to detect explosive gas mixtures and manage gaseous effluents collected from the CAR is performed under DSRS Section 11.3.
3. Review of the radiological monitoring instrumentation in place to monitor gaseous effluents in the CAR is performed under DSRS Section 11.5.
4. Review of the systems quality assurance programs is performed under SRP Chapter 17.
5. Review of the probabilistic risk assessment is performed under SRP Chapter 19 for potentially risk-significant CAR elements.
6. Review of initial plant test and system ITAAC under SRP Section 14.2 and SRP Section 14.3, respectively.

For those areas of review identified above as part of the primary review responsibility of other staff, the acceptance criteria necessary for the review and their methods of application are contained in the referenced DSRS/SRP sections of the corresponding primary reviewers.

## II. ACCEPTANCE CRITERIA

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

1. General Design Criterion (GDC) 60, Control of Releases of Radioactive Materials to the Environment.
2. GDC 64, Monitoring Radioactivity Releases.
3. Title 10 of the *Code of Federal Regulations* (CFR), Section 20.1406, as it relates to the minimization of, to the extent practicable, of contamination of the facility and the environment, designs and procedures to facilitate eventual decommissioning, and to minimize, to the extent practicable, the generation of radioactive waste.
4. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the

inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the DC has been constructed and will be operated in conformity with the DC, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission's (NRC's) rules and regulations.

5. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the AEA, and the NRC's rules and 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 applicant demonstrates how it meets the requirements of GDC 60 as they relate to the CAR design including provisions to prevent excessive releases of radioactivity to the environment, which may result from a failure of a structure, system or component in the main condenser (MC). Acceptance is based on meeting the following:

If there is a potential for explosive mixtures to exist, the CAR is designed to withstand the effects of an explosion and instrumentation is provided to detect and annunciate the buildup of potentially explosive mixtures, dual instrumentation is provided to detect, annunciate, and effect control measures to prevent the buildup of potentially explosive mixtures, as outlined in DSRS Section 11.3, Subsection II, "Acceptance Criteria," DSRS Acceptance Criteria.

Such a potential does not exist on systems designed to maintain the steam content above 58% by volume in hydrogen-air mixtures or nitrogen content above 92% by volume in hydrogen-oxygen mixtures in all CAR components. The design pressure and normal operational absolute pressure should be provided for CAR components containing potentially explosive mixtures.

2. The applicant demonstrates how it meets the requirements of GDC 64 as they relate to the CAR design providing means to monitor radioactive effluents in potential discharge pathways to the environment (i.e., CAR fan discharge and other ventilation systems of the plant, etc.).
3. The applicant demonstrates how it meets the requirements of 10 CFR 20.1406 as they relate to the interconnections between the CAR and other plant systems being designed to preclude CAR contamination of connecting systems, or the contamination of CAR by

connections with interfacing radioactive systems (i.e., gaseous radwaste system).

### 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:

Compliance with GDC 60 and GDC 64 requires that provisions be included in the nuclear power unit design to control suitably the release of radioactive materials in gaseous and liquid effluents during normal operation, including anticipated operational occurrences.

GDC 60 is applicable to the design of the CAR, because in NuScale integral pressurized-water reactors (iPWRs), radioactive materials are processed in this system if there is a primary-to-secondary steam generator tube leak. Design features are incorporated into the system to ensure that these radioactive materials are controlled and routed appropriately.

GDC 64 is applicable to the design of the CAR, because the CAR may contain radioactive fluids and gases that can potentially be released during normal operation and anticipated operational occurrences (AOOs), and therefore, require monitoring. Compliance with GDC 64 provides a level of assurance that releases of radioactive material to the environment will be detected in a timely manner so that appropriate measures can be taken to minimize the quantity of material released.

Meeting these requirements provide assurance that the release of radioactive materials in gaseous and liquid effluents from the CAR during normal operation, including AOOs, is kept as low as is reasonably achievable, in accordance with 10 CFR Part 50, Appendix I.

### 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.

Upon request from the reviewer, the interface reviewers will provide input for the areas of review stated in Subsection I. The reviewer obtains and uses such input as required to ensure that this review procedure is complete.

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. In the review of the CAR, the safety analysis report and P&IDs are reviewed to determine the flow paths of gases through the system, including all bypasses, and the points of release of gaseous wastes to the environment or other systems. This information is used in DSRS Section 11.3 to calculate the quantity of radioactive material released annually in gaseous effluents during normal operations, including anticipated operational occurrences. Review of the system verifies that the exhaust fluids from the mechanical vacuum pumps are classified as radioactive fluids and treated accordingly.

4. If there is a potential that explosive mixtures may exist, the determination is made whether the applicant has designed the CAR to withstand the effects of such an explosion and has provided instrumentation to detect and annunciate or has provided dual instrumentation on redundant CAR trains to detect, annunciate, and effect control measures to prevent the buildup of potentially explosive mixtures. The review will also determine if the applicant's design includes adequate provisions to stop continuous leakage-paths after an explosion.

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 design control document (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.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

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

#### IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the staff's technical review and analysis support conclusions of the following type to be included in the staff's evaluation report. The reviewer also states the bases for those conclusions.

The CAR includes equipment and instruments to establish and maintain condenser vacuum and to prevent an uncontrolled release of radioactive material to the environment. The staff has reviewed the applicant's system descriptions, design criteria, and P&IDs for the components of the CAR.

The staff concludes that the CAR design is acceptable in that the applicant has met:

1. The requirements of GDC 60 with respect to the design features in place to control releases of radioactive materials to the environment and the fact that programmatic requirements will provide assurance that the CAR will be designed, installed, and tested as described in the DCD or technical submittal.
2. The requirements of GDC 64 with respect to the CAR design incorporation of provision for monitoring of potential effluent discharge pathways for radiation release during normal operation, including AOOs.
3. The requirements of 10 CFR 20.1406 by providing for the detection and isolation of radioactive material in the CAR so as to minimize, contamination of the associated systems, facility, and the environment; and facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

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 acceptance criteria, as applicable.

## V. IMPLEMENTATION

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

In view of the differences between the designs of SMRs and the designs of large light-water power reactors, the Commission issued SRM- COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (ML102510405) (SRM). In the SRM, the Commission directed the staff to develop risk-informed licensing review plans for each of the SMR design reviews, including plans for the associated pre-application activities. Accordingly, the staff has developed the content of the DSRS as an alternative method for the evaluation of a NuScale-specific application submitted pursuant to 10 CFR Part 52, and the staff has determined that each application may address the DSRS in lieu of addressing the SRP, with specified exceptions. These exceptions include particular review areas in which the DSRS directs reviewers to consult the SRP and others in which the SRP is used for the review. If an applicant chooses to address the DSRS, the application should identify and describe all differences between the design features (DC and COL applications only), analytical techniques, and procedural measures proposed in an application and the guidance of the applicable DSRS section (or SRP section as specified in the DSRS), and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria.

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

## VI. REFERENCES

1. 10 CFR Part 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.”