U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR NuScale SMR DESIGN

4.6 FUNCTIONAL DESIGN OF CONTROL ROD DRIVE SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of transient and accident analyses

Secondary - Organization responsible for the review of plant design for protection of structures, systems, and components from internal and external hazards

I. AREAS OF REVIEW

The organization responsible for reactor systems reviews the functional performance of the control rod drive mechanism (CRDM) system to confirm that the system can effect safe shutdown, respond within acceptable limits during anticipated operational occurrences, and prevent or mitigate the consequences of postulated accidents. The review of this design specific review standard (DSRS) ensures conformance with the requirements of General Design Criteria (GDC) 4, 23, 25, 26, 27, 28, 29 and Section 50.62 Title 10 of the Code of Federal Regulations (10CFR50.62).

The CRDM system and its components including the motor assembly are located outside the reactor pressure vessel and serve as a reactor coolant pressure boundary. If the the CRDM system interfaces with the RCPB, then that portion of the CRD system is designed according to ASME code

The specific areas of review are as follows:

1. Examination of the CRDM design to identify possible single failures. Identify the components/assemblies which are safety related (required for scram) and non-safety related. Assure that non-safety related components/assemblies do not degrade or disable the safety function of safety related components/assemblies.

2. Evaluation of the CRDM to verify the following:

   A. Essential portions can be isolated from nonessential portions.

   B. The CRDM system meets the design requirements.

   C. The functional tests verify the proper rod insertion, withdrawal, and scram operation times, or that the inspections, tests, analysis, and acceptance criteria (ITAAC) are sufficient to ensure that rod insertion, withdrawal, and scram operation times will operate in accordance with the certification.

ADAMS Accession No. ML15119A111

D. Redundant reactivity control systems are not vulnerable to common mode failures.

3. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this DSRS section in accordance with DSRS Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this DSRS section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with DSRS Section 14.3.

4. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

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

Review Interfaces. The primary technical reviewer should identify and verify that the adequacy of the design, installation, inspection, and testing of all electrical, fluid, and mechanical systems required for proper CRDM operation are appropriately addressed in the other approved DSRS sections.

Other DSRS sections interface with this section as follows:

1. The review encompasses all transients and accidents in Chapter 15 of the DCD that require reactivity control systems to function. The reviewer ascertains that the reactivity and response characteristics of the reactivity control system are conservative with respect to the parameters assumed in the Chapter 15 analyses.

2. Verification of the reactivity control requirements is performed under DSRS Section 4.3.

3. Review of the Chemical and Volume Control System (CVCS) as a defense-in-depth (DID) function, is performed under DSRS Section 9.3.4.

4. Verification of the results of failure modes and effects analyses to ensure that a single failure occurring in the CRDM system, or an operator error, will not result in the loss of capability for safe shutdown is performed under DSRS Section 7.

5. Verification of the adequacy of the control rod drive mechanisms to perform their mechanical functions (e.g., rod insertion and withdrawal, scram operation and time) and to maintain the reactor coolant pressure boundary is performed under DSRS Section 3.9.4. Verification that the design and requirements meet the ASME code, as applicable to the assigned safety class and seismic category, is performed under DSRS Sections 3.2.1 and 3.2.2. Under DSRS Section 3.6.2, postulated piping failures inside

the containment, including their associated locations and dynamic effects, are evaluated, as they relate to the protection of SSCs against such effects.

6. Determination of the acceptability of the design and analyses, procedures, and criteria used to establish the ability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena such as the safe-shutdown earthquake, is performed under DSRS Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5.

7. Verification of the adequacy of the design, installation, inspection, and testing of all electrical systems (sensing, control, and power) required for proper operation is performed under DSRS Section 7.1 and Appendix 7-A and DSRS Section 8.3.1.

8. The evaluation of potential sources of internal flooding and, where applicable, determination that SSCs are adequately protected against the effects of internal flooding or can otherwise function in the event of such flooding, is performed under DSRS Section 3.4.1. The evaluation of potential sources of internally generated missiles and, where applicable, determination that SSCs are adequately protected against the effects of such missiles are performed under DSRS Sections 3.5.1.1 and 3.5.1.2. The verification of the adequacy of specified environments and service conditions for equipment qualification as they relate to the locations of affected equipment and the overall demonstration that systems and components are qualified to perform their function are performed under DSRS Section 3.11.

9. Reviews of fire protection, technical specifications, and quality assurance and maintenance are performed under DSRS Sections 9.5.1 and Chapters 16 and 17, respectively.

10. Review of the seismic qualification of Category I instrumentation and electrical equipment and the environmental qualification of electrical and mechanical equipment is performed under DSRS Sections 3.10 and 3.11, respectively.

11. Evaluation of the adequacy of the design, installation, inspection, and testing of all instrumentation, sensing, and controls required to provide the safety-related and risk-significant functions of the CRDM is performed under DSRS Sections 7.1, 7.6, and Appendix 7A.

12. Review of technical specifications is coordinated and performed under DSRS Section 16.0.

13. Review of the reliability assurance program is coordinated and performed under DSRS Section 17.4.

14. Review of quality assurance is coordinated and performed under DSRS Section 17.5.

15. Review of the Probabilistic Risk Assessment performed under Standard Review Plan (DSCRS) Chapter 19.0 for risk significance of CRDM.

16. Since some components of the system are inside the reactor pressure vessel (RPV), the choice of the material used for the components is critical and review of the material aspects are reviewed under DSRS Section 6.1.1.

II. ACCEPTANCE CRITERIA

Requirements

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

1. General Design Criteria (GDC) 4, Environmental and Dynamic Effects Design Bases.

2. GDC 23, Protection System Failure Modes.

3. GDC 25, Protection System Requirements for Reactivity Control Malfunctions.

4. GDC 26, Reactivity Control System Redundancy and Capability.

5. GDC 27, Combined Reactivity Control Systems Capability

6. GDC 28, Reactivity Limits.

7. GDC 29, Protection Against Anticipated Operational Occurrences.

8. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission's (NRC's) regulations.

9. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

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. To meet the requirements of GDC 4, the CRDM should remain functional and provide reactor shutdown capabilities under adverse environmental conditions and after postulated accidents.

2. To meet the requirements of GDC 23, the CRDM should fail in an acceptable condition, even under adverse conditions, that prevents damage to the fuel cladding and excessive reactivity changes during failure.

3. To meet the requirements of GDC 25, the design of the reactivity control systems should assure that a single malfunction of the CRDM will not result in exceeding acceptable fuel design limits.

4. To meet the requirements of GDC 26, the CRDM should be capable of providing sufficient operational control and reliability during reactivity changes during normal operation and anticipated operational occurrences.

5. To meet the requirements of GDC 27, the combined capability of CRDM and CVCS should reliably control the reactivity changes to assure the capability to cool the core under accident conditions.

6. To meet the requirements of GDC 28, the CRDM should be designed to assure that reactivity accidents do not result in damage to the reactor coolant pressure boundary, or result in sufficient damage to the core or support structures so as to significantly impair coolability.

7. The CRDM should be designed to ensure an extremely high probability of functioning during anticipated operational occurrences to be in conformance with GDC 29.

8. The CRDM system should be designed to meet the requirements of 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.

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. GDC 4 requires that SSCs be designed to accommodate the effects of, and to be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, and be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from external events. The CRDM provides the capability to safely shut down the reactor during normal operations and anticipated operational occurrences and either prevents or mitigates the consequences associated with postulated accident scenarios. The design of the CRDM must ensure that the ability to perform these safety-related functions is not compromised by adverse

environmental conditions. Compliance with GDC 4 ensures that the CRDM will remain functional under adverse postulated environmental conditions and provide essential reactor shutdown capabilities.

2. GDC 23 requires that the protection system be designed to fail into a safe state in the event of adverse conditions or environments. The CRDM provides the positive core reactivity control through the use of movable control rods. The movable control rods provide reactivity control for all modes of operation, including all plant conditions from the cold shutdown condition to the full-load condition. The CRDM, in conjunction with the protection system, must actuate the control rods to effect safety-related functions when necessary to provide core protection during normal operation, anticipated operational occurrences, and accidents. Meeting the requirements of GDC 23 provides assurance that the protection system in conjunction with the CRDM which may fail in a manner that prevents damage to the fuel cladding by providing positive control and preventing excessive reactivity changes during a failure.

3. GDC 25 requires that the protection system be designed to ensure that specified acceptable fuel design limits are not exceeded for any single malfunction of the reactivity control systems. The CRDM provides the motive force for the moveable control rods providing one functional method for reactivity control. Meeting the requirements of GDC 25 by designing these systems to withstand single failures ensures that a single malfunction of the rod control drive system, such as accidental withdrawal, will not prevent proper control of core reactivity and therefore will not result in exceeding acceptable fuel design limits. Maintaining acceptable fuel design limits enhances plant safety by preventing the occurrence of mechanisms that could result in fuel cladding damage such as severe overheating, excessive cladding strain, or exceeding the thermal margin limits. Preventing excessive cladding damage ensures maintenance of the integrity of the cladding as a fission product barrier.

4. GDC 26 requires the provision of two independent reactivity control systems of different design principles. Each system must have the capability of reliably controlling reactivity changes resulting from normal operation and anticipated operational occurrences. One of the systems shall use control rods and be capable of reliably controlling reactivity changes during anticipated operational occurrences, with appropriate margin for malfunctions such as stuck rods. In addition, one of the systems must be capable of holding the reactor core subcritical under cold conditions. The CRDM provides one of the methods for controlling reactivity changes. The CRDM is designed to control reactivity during both normal operation and anticipated operational occurrences. The CRDM should be capable of rendering a reactor subcritical under conservative conditions with the highest worth control rod fully withdrawn from the core. The conservative conditions include the highest positive reactivity contributions resulting from effects such as temperature and power and the lowest negative reactivity contributions from poisons such as xenon. Meeting the requirements of GDC 26 ensures that the CRDM will be capable of providing sufficient operational control, reliability, and safety during reactivity changes, including those during normal operation and anticipated operational occurrences.

5. GDC 27 requires that the reactivity control systems be designed to have the combined ability, in conjunction with poison addition by the CVCS, to reliably control reactivity

changes under accident conditions such that the capability to cool the core is maintained. The CRDM provides the method for inserting the control rods into the reactor core when monitored plant conditions reach specified safety system setpoints. Insertion of the control rods, in conjunction with the poison addition by the emergency core cooling system, provides the means of inserting negative reactivity to rapidly shut the reactor down and ensure core coolability. Coolability, or coolable geometry, refers to the fuel assembly's ability to retain its geometry with adequate coolant channels to permit removal of residual heat. Loss of coolability can result from cladding embrittlement, violent expulsion of fuel, generalized cladding melting, structural deformation, and flow blockage because of coplanar fuel rod ballooning. Meeting the requirements of GDC 27 for the CRDM in conjunction with the emergency core cooling system enhances plant safety by ensuring that the reactor can be shut down and core coolability can be maintained.

6. GDC 28 requires that the reactivity control systems be designed with appropriate limits on the potential amount and rate of reactivity increase to prevent the adverse effects of postulated reactivity accidents. A postulated failure of the control rod system, such as rod ejection or rod dropout, has the potential to result in a relatively high rate of positive reactivity insertion which, if large enough, it could cause a prompt power excursion. Such a prompt power excursion could cause a fuel rodt rupture, rapid fragmentation of the fuel pellet , and dispersal of fuel and cladding into the coolant. This type of event is accompanied by the conversion of nuclear energy to mechanical energy, which if sufficient, could breach the reactor coolant pressure boundary or impair the coolability of the core. Meeting the requirements of GDC 28 for the CRDM enhances plant safety by limiting the effects of postulated reactivity accidents, thereby mitigating the adverse effects which could result in damage to the reactor coolant pressure boundary or impair the capability to cool the core.

7. GDC 29 requires that the protection and reactivity control systems be designed to ensure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences. The design relies on the CRDM to function in conjunction with the protection systems under anticipated operational occurrences, including loss of power to all reactor coolant pumps, tripping of the turbine generator, isolation of the main condenser, and loss of all offsite power. The CRDM provides an adequate means of inserting sufficient negative reactivity to shut down the reactor and prevent exceeding acceptable fuel design limits during anticipated operational occurrences. Meeting the requirements of GDC 29 for the CRDM prevents occurrence of mechanisms that could result in fuel cladding damage such as severe overheating, excessive cladding strain, or exceeding the thermal margin limits during anticipated operational occurrences. Preventing excessive cladding damage in the event of anticipated transients ensures maintenance of the integrity of the cladding as a fission product barrier.

8. 10 CFR 52.47(b)(1) and 10 CFR 52.80(a) require that ITAAC be identified for DCs and COLs. Because the DC or license approval is being granted before facility construction, there is a potential that the as-built configuration of a facility may not meet the requirements of the DC or COL as granted. The purpose of the ITAAC is to ensure that the as-built facility meets the requirements set forth in the DC or COL.

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 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 evaluates the CRDM design with respect to . As applicable, the reviewer evaluates the CRDM design with respect to electrical fluid, and mechanical systems and possible single failures. The review of the system description includes schematics, layout drawings, process flow diagrams, and descriptive information on essential supporting systems. The review evaluates the technical submittal to ascertain that failure modes and effects analyses have been completed to determine that the CRDM (not the individual drives) is capable of performing its safety-related function following the loss of any active component.

4. The reviewer evaluates the CRDM, system description and schematics, layout drawings, and component descriptions and characteristics to verify that essential portions of the system are correctly identified and are isolable from nonessential portions. The essential portions should be protected from the effects of dynamic conditions (such as high- or moderate-energy line breaks). The reviewer examines layout drawings of the system to ensure that no high- or moderate-energy piping systems are close to the CRDM , or that protection is provided from the effects of high- or moderate-energy pipe breaks. If the dynamic effects of pipe ruptures are proposed to be excluded from the design basis, then the review includes analyses justifying the exclusion. When an essential system or component is designed to perform multiple functions, the review encompasses the additional operating modes to ensure that there can be no adverse impacts on the essential system function. The reviewer should ensure that systems not relied on for safe shutdown cannot impair essential or passive component functions. Where two or more reactivity systems are used, the reviewer evaluates the combined functional performance under accident conditions.

5. The reviewer examines descriptions and drawings to determine that the systems meet the design requirements. The technical submittal should delineate essential equipment. The reviewer of transient and accident analyses confirms by failure modes and effects analysis that the cooling system is capable of maintaining the CRDM temperature below the applicant's maximum temperature criterion. The review performed under DSRS Section 7 confirms that there are sufficient instrumentation and controls available so that the reactor operator in the control room can monitor the CRDM conditions, including the more significant parameters such as coolant flow, temperature, pressure.

6. Reviewers examine the functional tests of the CRDM related to rod insertion and withdrawal and scram operation and time. The reviewers check the elements of the test program to ensure that all required thermal-hydraulic conditions have been included for all postulated operating conditions. The test program should include experimental

verification of system operation where a single failure has been assumed (e.g., stuck rod operation). The reviewers ensure that the system requirements (such as required scram times) are clearly identified and are consistent with the system requirements in the technical specifications and DSRS Sections 14 and 15.

7. The reactivity control systems are evaluated to verify that redundant reactivity control systems are not vulnerable to common mode failures. The review identifies the common mode failures and evaluates transient and accident analyses under DSRS Sections 7 3.9.4, and 9.3.4.

8. 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 technical submittal meets the acceptance criteria. DCs have referred to the technical submittal 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 technical submittal.

9. 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).

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

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

IV. EVALUATION FINDINGS

The reviewer should state the bases for the conclusions. The reviewer verifies that the applicant has provided sufficient information and that the staff's technical review and analysis, as augmented by the application of programmatic requirements in accordance with the staff's technical review approach in the DSRS Introduction, support conclusions of the following type to be included in the staff's SER.

The staff has reviewed the functional design of the CRDM to confirm that the system has the capability to shut down the reactor with appropriate margin during normal operation, anticipated operational occurrences, and accident conditions, including single failures. The scope of review included process flow diagrams, layout drawings, system description and schematics, and descriptive information for the systems and for the supporting systems essential for operation of the system.

The review has determined the adequacy of the applicant's proposed design criteria, design basis, and safety classification of the CRDM and the requirements for providing a safe shutdown during normal operation, anticipated operational occurrences, and

accident conditions, including single failures. The staff concludes that the design of the CRDM is acceptable and meets the requirements of GDC 4, 23, 25, 26, 27, 28, and 29. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 4 with respect to the design of the system against the adverse effects of missile hazards inside the containment, pipe whipping and jets caused by broken pipes, and adverse environmental conditions resulting from high- and moderate-energy pipe breaks during normal plant operations, anticipated operational occurrences, and accident conditions.

2. The applicant has met the requirements of GDC 23 by demonstrating the ability to insert the control rods upon any failure of the drive mechanism or any induced failure by an outside force (e.g., loss of electric power, instrumentation air, fire, radiation, extreme heat, pressure, cold, water, steam).

3. The applicant has met the requirements of GDC 25 by ensuring that no fuel design limits are exceeded for any single malfunction or rod withdrawal accident.

4. The applicant has met the requirement of GDC 26 by demonstrating the ability to control reactivity changes to ensure that, under normal operation and anticipated operational occurrences with the appropriate margin for malfunction (such as stuck rods), no fuel design limits are exceeded and the reactor can be maintained subcritical under cold conditions.

5. The applicant has met the requirements of GDC 27 by demonstrating the ability to reliably control reactivity changes under accident conditions to ensure that no fuel design limits are exceeded and the reactor can be maintained subcritical under cold conditions.

6. The applicant has met the requirements of GDC 28 by demonstrating the ability to reliably control the amount and rate of reactivity change to ensure that no reactivity accident will damage the reactor coolant pressure boundary or disturb the core or the core’s appurtenances such as to impair coolant flow. The postulated reactivity accidents include rod ejection, rod drop, steamline rupture, coolant temperature changes, pressure changes, and cold water addition.

7. The applicant has met the requirements of GDC 29 by demonstrating a high probability of control rod insertion under anticipated operational occurrences.

For DC and COL reviews, the findings will also summarize the staff’s evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this DSRS section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The 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 50, Appendix A, GDC 23, "Protection System Failure Modes."

2. 10 CFR Part 50, Appendix A, GDC 25, "Protection System Requirements for Reactivity Control Malfunctions."

3. 10 CFR Part 50, Appendix A, GDC 26, “Reactivity Control System Redundancy and Capability.”

4. 10 CFR Part 50, Appendix A, GDC 27, “Combined Reactivity Control Systems Capability.”

5. 10 CFR Part 50, Appendix A, GDC 28, “Reactivity Limits.”

6. 10 CFR Part 50, Appendix A, GDC 29, “Protection Against Anticipated Operational Occurrences.”

7. 10 CFR 50.62, “Requirements for Reduction of Risk from Anticipated Transients Without Scram (ATWS) Event for Light-Water-Cooled Nuclear Power Plants.”

8. RG 1.68, Initial Test Programs for Water-Cooled Nuclear Power Plants.

9. RG1.160, Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.

10. RG 1.182, Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants.

11. RG 1.206, Combined License Applications for Nuclear Power Plants (Light-water Reactor Edition).

12. RG 1.215, Guidance for ITAAC Closure under 10 CFR Part 52.