



# COMMISSION MEETING WITH THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

December 4, 2020



# Agenda

- Matthew W. Sunseri, Chairman, ACRS
  - Overview, Subsequent License Renewals and Transformation activities
- Walter Kirchner, Member-at-large, ACRS
  - NuScale Design Certification Application Review
- Joy Rempe, Vice-Chairman, ACRS
  - Evaluation of the NRC Safety Research Program Including Future Research
- Charles Brown, Member, ACRS
  - Digital Instrumentation and Control Activities

# Overview

Issued 29 reports since the last meeting with the Commission in December 2019:

- NuScale Design Certification and Standard Design Approval Applications
  - Report on the Safety Aspects as required by 10 CFR 52.53 and 52.141
- Research topics
  - Biennial Review and Evaluation of NRC Safety Research Program
  - Quality of selected research projects

# Overview (Cont'd)

- Digital I&C topics
  - Implementation of 50.59 screening for DI&C upgrades
  - BTP 7-19 regarding Diversity and Defense-in-Depth
- Additional review topics
  - Kairos, molten salt cooled reactor
  - BWRX-300, small modular reactor
  - SHINE, medical isotope production facility
- Two subsequent license renewal applications
  - Providing an additional twenty years of operation
  - Expecting to see many more in the coming years

# Subsequent License Renewals

- Peach Bottom Atomic Power Station, Units 2 and 3 was our second SLRA review
- Our final report on the Peach Bottom SLRA was issued December 19, 2019
  - there are no open license renewal issues that would prevent the NRC from renewing the Peach Bottom operating licenses
  - the NRC should approve the Peach Bottom subsequent license renewal application

# Subsequent License Renewals

- Surry Power Station, Units 1 and 2 was our third review
- Differing professional view was heard and considered
- Our final report on the Surry SLRA was issued April 30, 2020
  - there are no open license renewal issues that would prevent the NRC from renewing the Surry operating licenses
  - the NRC should approve the Surry subsequent license renewal application

# ACRS Transformation

- Keeping abreast of Agency actions
  - Met with OEDO representatives early in 2020
  - Interacted frequently on staff changes
- Continuing to focus on safety significant issues
- Realizing operational efficiencies
  - Consolidated Full Committee and Subcommittee meeting weeks, when possible
  - Leveraged virtual meeting capabilities and met our goals
- Identifying additional opportunities
  - Consider virtual meetings for some activities post-pandemic
  - Reduce subcommittee interactions based on complexity of the issues

# **NuScale Design Certification Application (DCA) Review**

Walter Kirchner, Chair  
ACRS NuScale Subcommittee

# NuScale DCA

## NuScale Power Module (NPM)

- Small modular, natural circulation PWRs
- 160 MWt/50 MWe per module, 37 half-length, commercial PWR fuel assemblies
- Reactor core, riser, pressurizer, and two helical-coil steam generators integral to a reactor vessel in a high-strength steel containment vessel
- Passive emergency core coolant system (ECCS) and decay heat removal system (DHRS)
- NPMs immersed in a large reactor building pool that serves as a passive ultimate heat sink

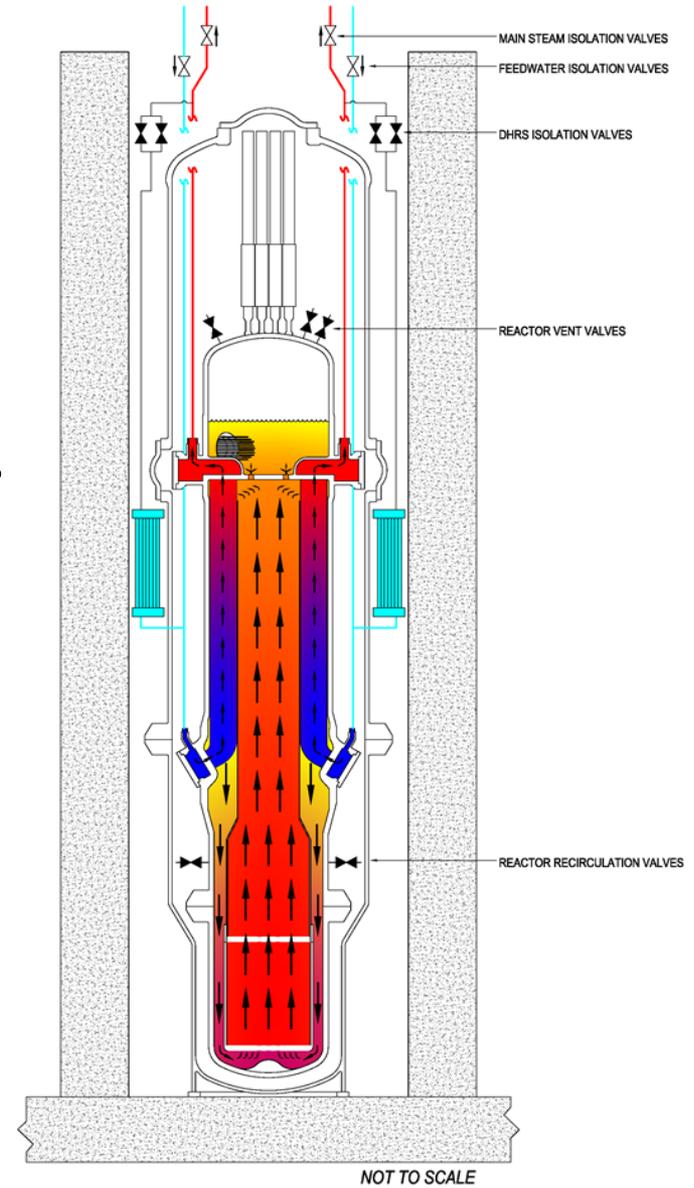


Figure courtesy of NuScale

# ACRS Review of NuScale DCA and SER

- Met Phase 3 review of SER (w/open items) milestone of August 27, 2019
- Identified cross-cutting, safety-focused areas for Phase 5 review of SER (w/no open items) in letter to EDO on September 25, 2019, and supplemented by in-depth technical review of chapters by members
- Issued final ACRS letter report review on DCA prior to July 31, 2020 milestone

# NuScale Final Letter Report

- Reasonable assurance that the NuScale SMR can be constructed and operated without undue risk to the health and safety of the public
- The staff's SER, and the DC and SDA should be issued, subject to staff's exclusions regarding finality of design requirements
- Potentially risk significant items to be reviewed at the COL stage, and updated in the PRA, include:
  - SG integrity
  - ECCS valve performance
  - Combustible gas monitoring
  - Recovery strategies to prevent reactivity insertion accidents associated with boron dilution event sequences

# Helical-Tube Steam Generator (SG) Design

- Different from existing PWR fleet – boiling inside tube banks in parallel channels of different lengths
- NuScale experiments showed unstable flows, density wave oscillations, with potential for tube bundle vibration and accelerated tube wear
- Because of SG integrity issues, staff proposed that the SG design not receive finality – we concur
- In addition to further testing, staff proposed a COL item and ITAAC to address these matters

# ECSS and Valve Performance

- Successful ECSS performance requires one-of-three reactor vent valves and one-of-two reactor recirculation valves open
- However, failures of these hydraulically-operated valve systems are one of the most important risk contributors identified in the NuScale PRA
- Extensive additional qualification testing required by staff should demonstrate reliable performance after extended periods in an operational environment and confirm the PRA failure models

# Source Term

- The post-accident combustible gas monitoring system design will require un-isolating containment and establishing a sizeable flow through non-safety grade piping outside containment
- We concur with the staff that the post-accident combustible gas monitoring system not receive finality
- We expect this design problem to be resolved at the COL stage

# Boron Dilution and Return to Criticality

- Boron dilution can occur in reactor downcomer during cooldown transients and SB-LOCAs when natural circulation is interrupted, and in containment for SB-LOCAs and post-ECCS actuations
- The current fleet addressed similar SB-LOCA scenarios resulting in boron dilution of cold-leg return to reactor vessel (NUREG/CR-2798)
- NuScale incorporated design and setpoint changes to mitigate potential effects of boron dilution in the downcomer for passive cool-down and SB-LOCAs
- However, these changes may not be effective post-ECCS actuation, with downcomer boron concentrations dropping below critical boron concentrations within hours

# Boron Dilution (cont'd)

- An influx of deborated water into the core may result in recriticality, return to power, and the potential for core damage
- Our review of staff analyses suggests more detailed analyses are needed
- COL applicants will need to develop recovery strategies to prevent accidents and potential core damage with a high degree of confidence
- Given the frequent refueling in a NuScale NPP, human errors associated with boron dilution may also be a significant risk contributor (see NUREG/CR-5368)

# Probabilistic Risk Assessment

- The PRA scope and detail were sufficient to inform the DCA design to reduce risk
- Risk measures suggest that the design meets the Commission's Safety Goals with large margins
- However, issues such as boron dilution suggest that these margins need to be substantiated
- We expect to review several other issues at the COL stage:
  - SG integrity, ECCS valve performance, combustible gas monitoring, importance of the CVCS system, and human errors with reactor building crane and refueling operations

# Lessons Learned

- The cross-cutting, focus area approach was effective and should be adopted for reviews of future applications
- Critical methodology topical reports should be submitted early in the review process
- The completeness of proposed new reactor designs should be sufficient to support requested exemptions
- The time period of transient and accident analyses should be continued to the point needed to demonstrate the plant is in a safe, stable condition, with no ongoing degradation
- The staff should develop guidance for the measured application of deterministic and probabilistic tools to provide a more effective licensing framework for advanced reactor design applications and their review

# **Evaluation of the NRC Safety Research Program Including Future Research**

Joy Rempe, Chair  
ACRS Safety Research Subcommittee

# Background

- The Office of Regulatory Research (RES) provides technical advice, tools, and information for meeting NRC's mission, including:
  - resolving safety and security issues
  - making regulatory decisions, and
  - promulgating regulations and guidance

# Background (cont'd)

- Since 1974, ACRS has conducted NRC research reviews. Currently, this activity includes:
  - Reviews of research conducted in support of specific regulatory activities
  - Periodic reviews of important ongoing research
  - Our Biennial Review of NRC's safety research program

# Biennial Research Review

- Review process continues to emphasize 1997 Commission direction:
  - Need, scope, and balance of reactor safety research program
  - Progress of ongoing activities
  - How well RES anticipates research needs and is positioned for changing environment
- 2020 report emphasizes:
  - Prioritization and identification of user needs
  - Long-term planning
  - Follow-up on prior ACRS recommendations

# Biennial Research Review (cont'd)

- Integrated insights from:
  - Initial meeting with Director of RES to obtain overview of program, plans, priorities, and areas of interest
  - Three working group information meetings to discuss research conducted by each RES division: Division of Risk Analysis, Division of Systems Analysis, and Division of Engineering
  - Other ACRS activities (focused reviews of important ongoing projects, etc.)

# Conclusions and Recommendations

- The current user need process satisfactorily meets agency near-term needs for regulatory decisions
- Efforts to initiate “Future-Focused” research with longer-term horizons will help the agency prepare for upcoming challenges, including regulation of advanced technologies and transformation into a modern, risk-informed regulator

# Conclusions and Recommendations (cont'd)

- We support the systematic approach implemented by RES to prioritize research emphasizing enterprise risk in project selection, evaluation, and termination
- Ongoing RES efforts to engage other offices are critical for this approach to be successful

# Conclusions and Recommendations (cont'd)

- As RES continues to leverage resources using international and inter-agency collaborations, it is important that agency priorities be clearly defined and addressed

# Conclusions and Recommendations (cont'd)

- RES contributions are preparing the agency for anticipated non-LWR submittals
- Reference plant evaluations should provide confidence about the adequacy of selected computational tools and identify any remaining data gaps

# Conclusions and Recommendations (cont'd)

- We plan to have additional briefings on several RES activities, such as efforts to address the gap created by the unexpected loss of the Halden test reactor, and the selection and progress of future-focused research projects

# Future Activities

- Several planned RES briefings to address emerging agency needs:
  - Future focused research
  - Halden Gap
  - Non-LWR research
  - Integrated University Programs for Mission-related R&D

# **Digital Instrumentation and Control (DI&C) Activities**

Charles Brown, Chair  
DI&C Systems Subcommittee

# DI&C Letter Reports

- RG 1.187, Rev. 2 & NEI 96-07, Appendix D, Rev. 1 regarding application of 10 CFR 50.59 to Digital I&C Modifications
- BTP 7-19, Rev. 8, Guidance for Defense in Depth and Diversity (D3) due to Latent Defect CCFs in Digital I&C Systems

# RG 1.187 and NEI 96-07, Appendix D

- 10 CFR 50.59 (c)(1) allows licensees to change facilities/procedures in its UFSAR, perform tests or experiments not in its UFSAR without an LAR if:
  - (i) tech spec changes are not required
  - (ii) the change, test or experiment does not meet any of the eight (c)(2)(i) through (viii) criteria

# RG 1.187 and NEI 96-07, Appendix D

- NEI 96-07, Rev. 1 issued November 2000 provided guidance to aid industry in determining if an LAR was required for facility changes based on 10 CFR 50.59
- RG 1.187, Rev. 1 endorsed NEI 96-07 without clarifications or exceptions
- NEI 96-07 applies to all SSCs to address 10 CFR 50.59 requirements
- Use over the next decades resulted in varying opinions and difficulties in applying the guidance to DI&C systems

# RG 1.187 and NEI 96-07, Appendix D

- Difficulty was interpretation of 10 CFR 50.59 (c)(2)(vi) stating that an LAR is needed if the change would:  
“Create a possibility for a malfunction of an SSC important to safety with a ***different result*** than any previously evaluated in the final safety analysis report (as updated)” for DI&C changes
- As a result, NEI developed NEI 96-07, App D to assist licensees in performing 10 CFR 50.59 reviews for digital modifications

# RG 1.187 and NEI 96-07, Appendix D

- Draft RG 1.187, Rev. 2 endorsed App D with an exception which was a point of contention between NRC and NEI relating to the phrase “***different result*** than previously evaluated in the FSAR” in 10 CFR 50.59 Section (c)(2)(vi)

# RG 1.187 and NEI 96-07, Appendix D

- Our letter report of June 20, 2019 agreed that new guidance has been needed, however, we concluded:
  - “There is an opportunity for expanding the use of 10 CFR 50.59 for DI&C modifications by more clearly identifying the significance of *different results* caused by a malfunction of SSCs important to safety as specified in Criterion 6.”

# RG 1.187 and NEI 96-07, Appendix D

- Basically, we urged the staff and NEI to resolve the disagreement
- Subsequently NEI developed a substantially revised Section 4.3.6 in App D Rev. 1 dated May 2020 to resolve the exception
- The revision focused on the “***significance of a different result***” to determine the need for an LAR prior to a DI&C change

# RG 1.187 and NEI 96-07, Appendix D

- Staff agreed and proposed revised draft RG 1.187, Rev. 2 with clarifications only
- During our 674<sup>th</sup> meeting, we reviewed NEI 96-07, App D, Rev. 1 and RG 1.187, Rev. 2
- Our letter report of June 23, 2020 agreed with the resolution and that RG 1.187, Rev. 2 should be issued

# **Branch Technical Position (BTP 7-19), Revision 8, October 2020**

- Provides staff review guidance for evaluating any Defense-in-Depth and Diversity (D3) means credited to address vulnerabilities to CCF
- Applies for any new plant designs or changes to existing plants that require NRC approval
- Does not apply to changes under 10 CFR 50.59

# BTP 7-19

- The revision maintains policy from the SRM to SECY-93-087
- Identifies the need for a well defined DI&C architecture meeting the fundamental design principles to identify D3 needs
- Introduces Safety Significance assessment categories: High, Lower, and Lowest
- Identifies means to eliminate and mitigate CCF, and how some CCF consequences may be acceptable

# BTP 7-19

- Revises guidance on spurious action and diverse manual actions
- Includes use of qualitative assessments per Supplement 1 to RIS 2002-22 for non-reactor protection systems/engineered safety feature actuation systems

# Recommendations

1. BTP 7-19, Rev. 8 should be issued subsequent to incorporation of Recommendations 2 through 3.
2. The BTP discusses the combining or integrating of the RTS and ESFAS and associated communications architectures into a single protection system. This approach challenges two critical D3 elements, redundancy and independence. The BTP should ensure that reviewers verify these fundamental architecture principles are maintained.

# Recommendations

3. The BTP should ensure that interconnections between High Safety Significance systems and those of Lower Safety Significance are one-way, uni-directional digital communication devices rather than bi-directional communication devices (which reduce independence and defense-in-depth) to preclude compromise of High Safety Significance systems

# Acronyms

- ACRS – Advisory Committee on Reactor Safeguards
- BTP – Branch Technical Position
- CCF – Common Cause Failure
- CVCS – Chemical and Volume Control System
- COL – Combined License
- DCA – Design Certification Application
- DHRS – Decay Heat Removal System
- DI&C – Digital Instrumentation and Control
- DID – Defense in Depth
- D3 – Diversity and Defense in Depth
- ECCS – Emergency Core Cooling System
- EDO – Executive Director for Operations
- ESFAS – Engineered Safety Features Actuation System
- ITAAC – Inspections, Tests, Analyses, and Acceptance Criteria
- LAR – License Amendment Request
- LOCA – Loss of Coolant Accident
- LWR – Light Water Reactor
- MWe – Megawatt (electric)
- MWt – Megawatt (thermal)
- NEI – Nuclear Energy Institute
- NPM – NuScale Power Module
- NPP – Nuclear Power Plant
- NRC – U.S. Nuclear Regulatory Commission
- PIRT – Phenomenon Identification and Ranking Table
- PRA – Probabilistic Risk Assessment
- PWR – Pressurized Water Reactor
- RES – Office of Nuclear Regulatory Research
- RG – Regulatory Guide
- RIS – Regulatory Issues Summary
- RTS – Reactor Trip System
- R&D – Research and Development
- SDA – Standard Design Approval
- SG – Steam Generator
- SER – Safety Evaluation Report
- SLRA – Subsequent License Renewal Application
- SMR – Small Modular Reactor
- SRM – Staff Requirements Memorandum
- SSC – Structure, System, or Component
- UFSAR – Updated Final Safety Analysis Report