May 29, 2020 Docket No. 52-048

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Submittal of Presentation Materials Entitled "NRC Public Meeting Presentation: Boron Redistribution and Associated Design and DCA Changes," PM-0620-70336, Revision 0

NuScale Power, LLC (NuScale) has requested a meeting with the NRC technical staff on June 1, 2020, to discuss recent design changes and design certification application (DCA) changes associated with mitigation of postulated boron redistribution events.

The purpose of this submittal is to provide presentation materials to the NRC for use during this meeting.

The enclosure to this letter is the nonproprietary presentation entitled "NRC Public Meeting Presentation: Boron Redistribution and Associated Design and DCA Changes," PM-0620-70336, Revision 0.

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments."

If you have any questions, please contact John Fields at 541-452-7425 or at JFields@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
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Enclosure: "NRC Public Meeting Presentation: Boron Redistribution and Associated Design and DCA Changes," PM-0620-70336, Revision 0

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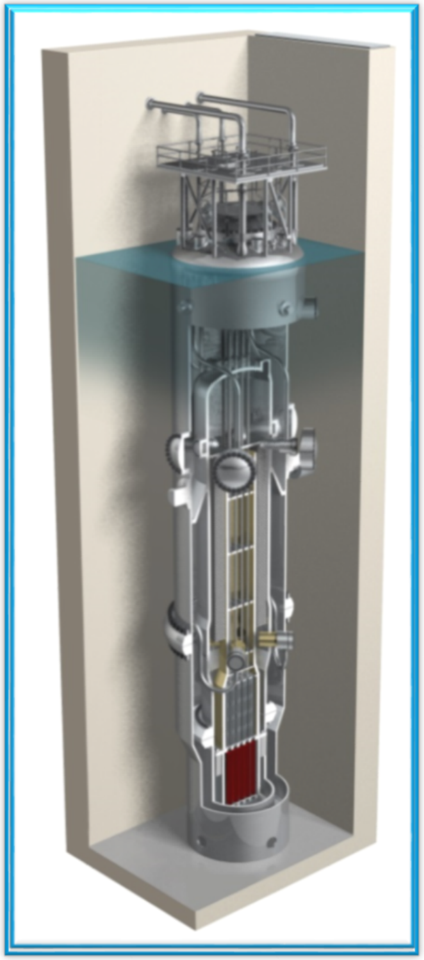

NRC Public Meeting Presentation

Boron Redistribution and Associated Design and DCA Changes

June 1, 2020

PM-0620-70336
Revision: 0

Presenters

Matthew Presson
Licensing Project Manager

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John Fields
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Agenda

- Boron Redistribution Background
- Boron Redistribution Analysis
- Postulated Event Scenarios
- Design Changes
- Safety Analysis
- Mechanical Analysis
- Probabilistic Risk Assessment
- DCA Revision Scope - Design Changes
- DCA Revision Scope – Resulting Analysis Changes
- Conclusions

Boron Redistribution Background

- In February 2020, scenarios were discussed that could lead to dilution of fluid in RPV downcomer
  - Under certain conditions, ECCS actuation or restoration of natural circulation flow could transport diluted coolant to the reactor core
  - Resulting postulated reactivity event could be outside those previously evaluated
    - Return to power (FSAR 15.0.6)
    - Boron dilution (FSAR 15.4.6)
    - Boron redistribution (RAI 8930)
- NuScale initiated an evaluation of the postulated scenarios in accordance with the Corrective Action Program

Boron Dilution Analysis

- NuScale methods use bounding assumptions or assumed perfect mixing
  - Large analysis conservatisms lead to unrealistic, but conservative results
    - Large boron loss term for fluid in containment (CNV) below reactor recirculation valves (RRVs)
    - Boron lost in vapor through reactor vent valves (RVVs) due to volatility
    - No mechanism for boron recovery
  - No methodology approved by the NRC for detailed boron mixing in downcomer or core
- NuScale determined that postulated boron redistribution scenarios could be eliminated through minor design changes
- NRC initiated an audit (ML20059N687) to review these postulated boron redistribution distribution scenarios and NuScale changes to the DCA

Postulated Event Scenarios

- Potential events that were evaluated for boron redistribution
  - LOCAs
    - Condensation of water in CNV from RVVs
    - Condensation of unborated water in downcomer
    - ECCS actuation can transport unborated water to core
  - DHRS operation can shrink RCS inventory below top of riser
    - Condensation of unborated water in downcomer
    - Unborated water can enter core when restoring natural circulation or after ECCS actuation (24-hour timer on loss of AC power)
  - Anticipated Transient Without Scram (ATWS)
    - Condensation of unborated water in downcomer and CNV after RCS fluid lost through reactor safety valves (RSVs)
    - Unborated water can enter core when restoring natural circulation or opening ECCS valves

Design Changes

- Design Considerations
  - Ensure early actuation of ECCS for postulated LOCA events
    - Actuation of ECCS while pressure and level in RPV are higher than CNV establishes flow out of RPV when ECCS valves open
    - After outflow, flow stagnates and slowly reverses through RRVs so that no large influx of unborated water can occur
  - Provide mechanism for boron mixing in the unlikely event that RCS level drops below riser
    - Eliminates potential redistribution from restored natural circulation following analyzed DHRS cooldown scenarios or ATWS events
    - Eliminates potential redistribution from operator action to restore natural circulation or manual ECCS actuation

Design Changes (continued)

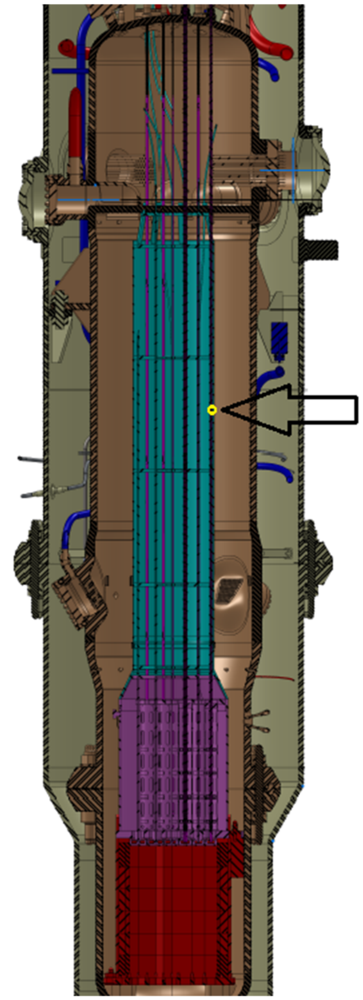
- Addition of ECCS actuation signal on low RCS WR pressure (less than 800 psia +/- 100 psi)
  - ECCS actuation prevented by either of following interlocks
    - CNV pressure less than 1 psia
    - RCS T_{hot} less than 475 ºF
- Interlocks prevent ECCS actuation for Non-LOCA events
  - RCS is subcooled in DHRS cooldown events (lower than 475 ºF) and have no increase in CNV pressure
  - Postulated MSLBs and FWLBs
    - RCS pressure remains above ECCS actuation pressure range during initial transient response
    - RCS is subcooled below 475 ºF T_{hot} interlock before RCS depressurizes to ECCS actuation range

Design Changes (continued)

- Lowered ECCS CNV level actuation setpoint
  - 252 inches (from 282 inches)
  - Level setpoint range remains above RRV
  - Actuates ECCS while RCS level and pressure greater than CNV level and pressure
  - Ensures initial flow out of RPV into CNV
  - Establishes boron mixing before ECCS flow into RPV

Design Changes (continued)

- Diverse flowpaths added to RPV riser
  - Provide a flow path from riser through the downcomer to the core to ensure boron mixing even if level drops below top of riser
  - Four ¾-inch holes located at midpoint of SG
  - Impact to normal operation is minimal
    - Flow through holes is small (~2 kg/s) compared to minimum 100% flow (~535 kg/s)
  - Holes located below RCS contracted level from extended DHRS cooldown
  - Holes are above equilibrium riser level after ECCS actuation (no impact on LOCA cooling)



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Safety Analysis

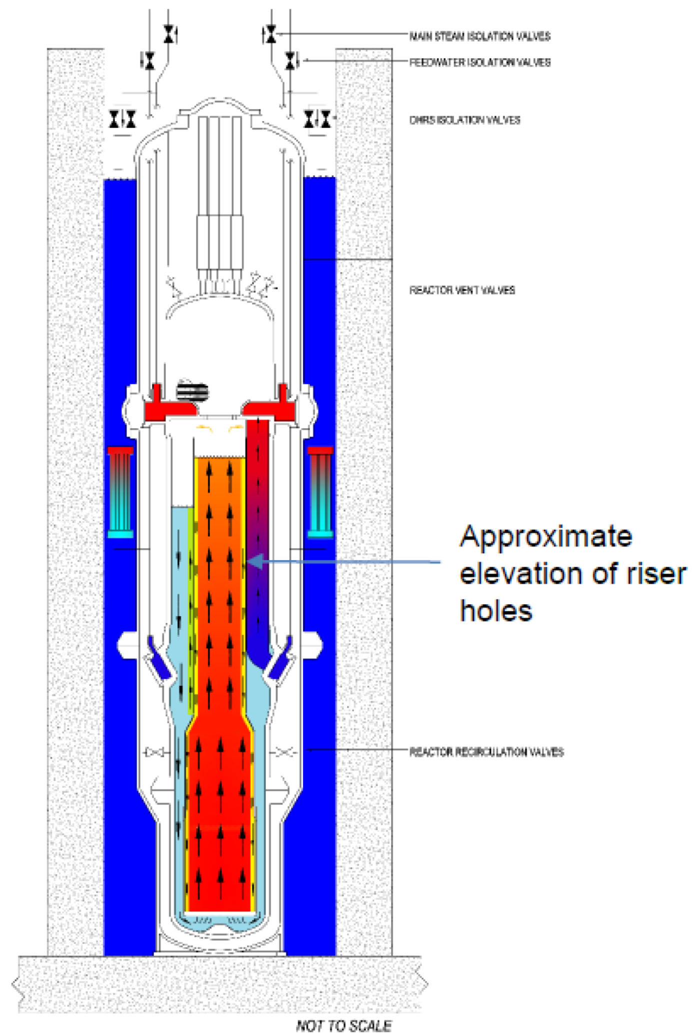
- Return to Power (FSAR 15.0.6)
  - End of cycle conditions remain limiting
  - No impact to the postulated limiting return to power scenario
  - Flow through riser holes maintains downcomer greater than critical boron concentration for events earlier in cycle
- Boron redistribution (RAI 8930)
  - Design Changes maintain assumptions in redistribution analysis
- LOCA (FSAR 15.6.5)
  - Some postulated events would actuate ECCS on low RCS pressure (most steam space LOCAs and some liquid space LOCAs)
  - No change to limiting event MCHFR or collapsed liquid level
  - Minor changes to some non-limiting events

Safety Analysis (continued)

- Inadvertent RPV valve opening (FSAR 15.6.6)
  - No impact to limiting events (Loss of DC power events actuate ECCS on IAB threshold)
  - RVV opening events with power available, remaining ECCS valves open on RCS pressure or low valve ΔP
  - RRV events not affected (remaining valves open on CNV level)
  - RSV events remain bounded by inadvertent ECCS valve opening

Mechanical Analysis

- Mechanical design and analysis impacts of the riser holes
  - Negligible impact on full power RCS flow rate (approximately 0.1 kg/s)
  - Does not introduce structural integrity concerns due to flow-induced vibration
  - No update needed to CVAP Technical Report (TR-0918-60894)
  - Negligible impact to DHRS cooldown



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Mechanical Analysis (Continued)

- Flow Induced Vibration (FIV) Evaluation
  - The riser holes have been evaluated for FIV mechanisms
    - turbulent buffeting (TB)
      - » Holes are small (volume reduction of upper riser approximately 1/26,000) – no impact to riser structural properties and TB evaluations not affected
    - vortex shedding (VS)
      - » No resonance due to flow through the holes
    - Reviewed Operating Experience for fuel pin vibration due to baffle gap cross-flow
      - » Normal flow through holes produces minimal force and no resonance with nearby components

Probabilistic Risk Assessment

- Scope of PRA Evaluations performed
  - Initiating Events
  - System Impact
  - Thermal Hydraulic Evaluation
  - Risk Significance and Metrics Evaluation

Thermal Hydraulic Analysis

- Design changes incorporated into best estimate NRELAP5 PRA thermal hydraulics model
  - riser holes credited for preventing significant boron redistribution (per Chapter 15 analyses)
  - new ECCS actuation logic modeled
- Effects on postulated event progression
  - cycling RSV sequences now reach the new low RCS pressure ECCS actuation
  - DHRS credit to reduce rate of coolant loss of unisolated injection line pipe breaks outside containment mitigated with core flood and drain system (CFDS)

PRA Model Assessment

- Negligible effect on ECCS fault tree model
  - fault tree does not credit all sensors/signals
- Negligible effect on ECCS initiating event
  - requires three sensors to spuriously actuate
- Success criteria
  - RSV cycling
  - DHRS credited to mitigate unisolated injection line pipe break
- Negligible effect on operator actions
  - modeled cues are unchanged

PRA Results

- Internal events
  - negligible change in
    - core damage frequency (CDF) and large release frequency (LRF)
    - conditional containment failure probability (CCFP)
  - no change in
    - candidate risk-significant structures, systems, or components (SSCs)
    - candidate risk-significant initiating events or human actions
    - significant core damage cutsets (FSAR Table 19.1-18)
    - significant large release cutsets (FSAR Table 19.1-26)
- External events
  - negligible effect
- Low power and shutdown operations
  - negligible effect

PRA Summary

- Implementing the design changes had a negligible effect on PRA results and insights
  - Sequences that involve a cycling RSV will now result in ECCS actuation
  - Riser holes credited to prevent significant boron redistribution
- Event tree logic has been updated to reflect the new event progressions for affected sequences

DCA Revision Scope – Design Changes

- Tier 1 Changes
  - Ch 2 – Technical changes to Tables 2.5-2 and 2.5-4 to incorporate ECCS actuation setpoints and ranges
- Tier 2 (FSAR) Changes
  - Ch 3 – Technical change to 3.9 to add the riser holes design change
  - Ch 5 – Technical change to 5.4 to add the riser holes design change
  - Ch 6 – Technical changes to 6.2 and 6.3 to add revised ECCS setpoints and actuation ranges
  - Ch 7 – Technical changes throughout 7.1 to add revised ECCS setpoints and actuation ranges, including associated instrumentation and logic
  - Sect 15.0 – Added ECCS setpoints and actuation range changes to Table 15.0-7
  - Ch 19 – Modified ECCS setpoints and actuation ranges in accident sequences and mitigating systems in 19.1, Table 19.1-8, 19.1-24 and associated event trees, riser hole changes added in Table 19.1-2

DCA Revision Scope – Design Changes

- TS and TS Bases
  - Sections 3.3.1, 3.5.1 – added new operating conditions, required actions and completion times for new instrumentation signals and interlocks
- Technical Reports
  - Instrument Setpoint Methodology (TR-0616-49121) – Added ECCS setpoints and actuation ranges design change to Tables 5-1, 5-2, 6-2, 6-17, 6-23, 6-24 (new), and 7-1
  - NSSS Advanced Sensor (TR-0316-22048) – Added ECCS setpoints and actuation ranges design change to Tables 4-1 and 5-1, and text in Sections 5.2 and 5.4
  - Containment Response (TR-0516-49084) – Added ECCS setpoints and actuation ranges design change to text in Executive Summary, Section 3.3, 5.1, and 6.0; added notes to section 3.2, Tables 3-6, and 3-8
  - Long-Term Cooling Methodology (TR-0916-51299) – Added ECCS setpoints and actuation ranges design change to text in Sections 5.3 and 5.6; added the riser holes design change to text in Section 5.6
  - TS Regulatory Conformance and Development (TR-1116-52011) – Added technical changes to Tables 3-5 and A-1 to incorporate associated TS changes in instrumentation

DCA Revision Scope – Design Changes

- Topical Reports
  - LOCA Methodology (TR-0516-49422)
    - Added ECCS setpoints and actuation ranges design change to text in Section 3.3, Tables 5-3, 5-4, 5-5, A-3, and B-6
    - Added the riser holes design change to text in Section 5.1.
  - Non-LOCA Methodology (TR-0516-49416)
    - Discussed the riser holes design change in Section 1.2

DCA Revision Scope – Resulting Analysis Changes

- Tier 2 (FSAR) Changes
  - Ch 3 – Technical changes to text in 3.9.5 to add structural integrity assessment of riser holes – FIV and acoustic noise
  - Ch 4 – Technical change to text in 4.3 to add boron distribution in LOCA and Non-LOCA events
  - Ch 6 – Material changes to Table 6.2-2 to modify results of limiting LOCA event on containment response
  - Sect 15.0 – Added technical description of boron redistribution during DHRS and LOCA events in Sections 15.0.4, and 15.0.5, and Table 15.0-7
  - Sect 15.6 – Modified sequence of events and analysis results for limiting steam space break, limiting IORV and LOCA events in sections 15.6.5, 15.6.6, and Tables 15.6-12, 15.6-14, 15.6-19, 15.6-20, 15.6-21, 15.6-22, 15.6-23, 15.6-24
  - Ch 16 – Reference change only
  - Ch 17 – Material changes to D-RAP Functions and Categorization in Table 17.4-1
  - Ch 19 – Material changes to System Success Criteria per Event Tree in Table 19.1-7, and Key Assumptions in Table 19.1-22

DCA Revision Scope – Resulting Analysis Changes

- Technical Reports
  - Long-Term Cooling Methodology (TR-0916-51299) – Added statement in Section 5.6 that there is no impact to this analysis from design changes
- Topical Reports
  - LOCA Methodology (TR-0516-49422) – Material text revisions in sections 3.3, 5.1, and B.8, and Tables 5-3, 5-4, 5-5, 9-1, 9-2, A-3, B-6, table notes indicate that there is no impact to this analysis from design changes
  - Non-LOCA Methodology (TR-0516-49416) – paragraph added in Section 1.2 concludes that there is no impact to this analysis from design changes

Summary and Conclusions

- Design changes preclude postulated boron redistribution for postulated design basis and beyond design basis events
- Analyses demonstrate no significant changes to results and that acceptance criteria continue to be met
  - ECCS actuation on low RCS pressure or high CNV level assures initial flow out of RPV precludes influx of unborated water from CNV or downcomer
  - Riser holes assure boron mixing in downcomer and core when:
    - DHRS cools and contracts RCS level below the top of riser
    - for smaller LOCAs/RCS leaks while RCS level is above riser holes
- The evaluation and resolution of this topic involved the evaluation of a broad scope of postulated scenarios, extensive calculations, analyses and related document changes to develop and implement the design changes
- NuScale and the NRC have engaged through numerous technical calls, audit questions, and audit discussions to support NRC SER completion by the end of June 2020 to support ACRS meetings

Acronyms

AC – alternating current
ACRS – Advisory Committee on Reactor Safeguards
AOO – Anticipated Operational Occurrences
ATWS – anticipated transient without scram
CCFP – conditional containment failure probability
CDF - core damage frequency
CFDS – core flood and drain system
CHF – Critical Heat Flux
CNV – containment vessel
COL – Combined License
CVAP – Comprehensive Vibration Assessment Program
CVCS – chemical and volume control system
D-RAP – Design Reliability Assurance Program
DCA – Design Certification Application
DHRS – decay heat removal system
ECCS – emergency core cooling system
EOC – end of cycle
^{o}F – degree Fahrenheit scale
FIV – flow induced vibration
FSAR - Final Safety Analysis Report
FWLB – Feedwater Line Break
GDC – General Design Criteria
IAB – inadvertent actuation block
IORV – Inadvertent operation of and RPV valve
kg - kilogram
kg/s – kilograms per second
LCO – Limiting Condition for Operation
LOCA – loss-of-coolant accident
MCHFR – minimum critical heat flux ratio
MSLB – Main Steam Line Break
NPM – NuScale Power Module
OCRP – overcooling return to power
ΔP – differential pressure
psi –pounds per square inch
psia – pounds per square inch absolute
RAI – Request for Additional Information
RCS – reactor coolant system
RPV – reactor pressure vessel
RRV – reactor recirculation valve
RSV – reactor safety valve
RVV – reactor vent valve
SAFDL – specified acceptable fuel design limits
SDM – shutdown margin
SER – Safety Evaluation Report
SG – steam generator
TB – turbulent buffering
TAF – top of active fuel
TS – Technical Specifications
VS – vortex shedding
WR – wide range

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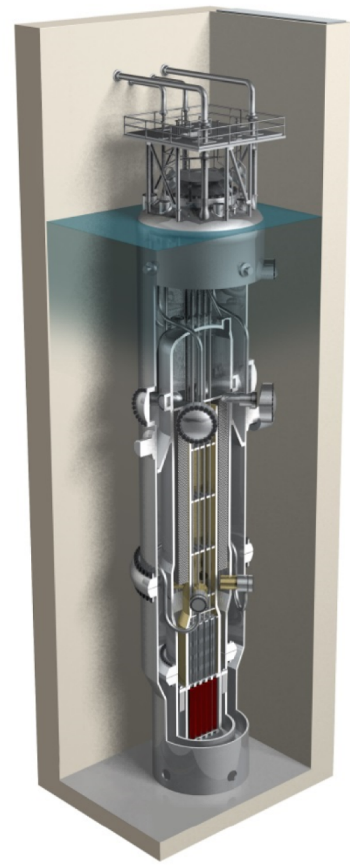

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