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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

NUSCALE DESIGN-CENTERED SUBCOMMITTEE

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OPEN SESSION

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TUESDAY, FEBRUARY 6, 2024

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The Subcommittee met via hybrid Video Teleconference, at 1:00 p.m. EST, Walt Kirchner, Chairman, presiding.

COMMITTEE MEMBERS:

WALTER L. KIRCHNER, Chair

RONALD G. BALLINGER, Member

VICKI M. BIER, Member

CHARLES H. BROWN, JR., Member

VESNA B. DIMITRIJEVIC, Member

GREGORY H. HALNON, Member

JOSE A. MARCH-LEUBA, Member

ROBERT P. MARTIN, Member

DAVID A. PETTI, Member

THOMAS E. ROBERTS, Member

ACRS CONSULTANT:

DENNIS BLEY

STEVE SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

MICHAEL SNODDERLY

ALSO PRESENT:

ANTONIO BARRETT, NRR

ANDREW BIELEN, RES

ALLYSON CALLAWAY, NuScale

KRIS CUMMINGS, NuScale

SARAH FIELDS, Public Participant

MAHMOUD JARDANEH, NRR

STACY JOSEPH, NRR

JOSHUA KAIZER, NRR

ZHIAN LI, NRR

JEFF LUITJENS, NuScale

KEVIN LYNN, NuScale

SCOTT MOORE, ACRS

REBECCA PATTON, NRR

ADAM RAU, NRR

HAROLD SCOTT, Public Participant

GETACHEW TESFAYE, NRR

SARAH TURMERO, NuScale

TABLE OF CONTENTS

P-R-O-C-E-E-D-I-N-G-S

12:59 p.m.

CHAIR KIRCHNER: The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, NuScale Design-Centered Subcommittee. I'm Walt Kirchner, the lead member for this meeting. Members in attendance today are Ron Ballinger, Jose March-Leuba, Bob Martin, David Petti, Greg Halnon, Thomas Roberts, and Charles Brown.

Do we have anyone listening in?

MR. BLEY: Vesna.

MEMBER DIMITRIJEVIC: Yes, I am here. Hi, good morning.

CHAIR KIRCHNER: Welcome, Vesna. Good afternoon.

MEMBER DIMITRIJEVIC: Good afternoon. Right.

CHAIR KIRCHNER: Mike Snodderly is the Designated Federal Officer for this meeting. The subcommittee will review the staff's evaluation of two NuScale topical reports on subchannel analysis methodology. We are going to review two -- pardon me. Let me find my place again. The subcommittee will review the staff's evaluation of two NuScale topical reports on subchannel analysis methodology and rod

ejection accident methodology.

The committee reviewed and commented on Revision 1 of the subchannel analysis methodology topical report in 2018 and also on Revision 1 of the rod ejection methodology topical report back in 2020. Since that time, NuScale has revised these methodologies to include a statistical subchannel analysis methodology that utilizes an approach, a statistical approach in defining critical heat flux analysis limits. It is NuScale's intent that a statistical treatment of uncertainty in certain areas will reduce some of the conservatisms and treatments with a defendable basis to provide a better representation of the actual core physical response.

One objective of this meeting is to help prepare the full committee for its upcoming review of Chapters 4 reactor and Chapter 15 transient accident analysis of the NuScale standard design approval application that includes a power upgrade from 50 megawatts electric to 77 megawatts electric for each module.

The ACRS was established by statute. It is governed by the Federal Advisory Committee Act (FACA). The NRC implements FACA in accordance with its regulations found in Title 10 of the Code of

Federal Regulations, Part 7. The committee speaks only through its published letter reports. We hold meetings to gather information and perform preparatory work that will support our deliberations at a full committee meeting.

The rules for participation in all ACRS meetings were announced in the Federal Register on June 13th, 2019. The ACRS section of the U.S. NRC public website provides our charter, bylaws, agendas, letter reports, and full transcripts of our full and subcommittee meetings, including the slides presented there. The agenda for this meeting was also posted there. A portion of this meeting will be closed to protect NuScale proprietary and export controlled information pursuant to 5 U.S. Code 552(b)(c)(4).

As stated in the Federal Register notice and in the public meeting notice posted to the website, members of the public who desire to provide written or oral inputs to the subcommittee may do so and should contact the Designated Federal Officer five days prior to the meeting. A communications channel has been opened to allow members of the public to monitor the open portions of this meeting. The ACRS is now inviting members of the public to use the MS Teams link to view slides and other discussion

material during these open sessions. The MS Teams link information was placed in the agenda on the ACRS public website.

We have received one set of written comments from Harold Scott. Those comments have been distributed to the members, and they have been provided to the staff at NuScale for awareness. The comments will be read into the record during the public comment portion of this meeting and attached to the transcript. We have not received any additional requests to make oral statements from members of the public regarding today's session.

Written comments may be forwarded to Michael Snodderly, today's DFO. There will be an opportunity for public comment, as well, and we have set aside ten minutes in the agenda at the conclusion of the open session of this meeting for comments from the public listening to the meeting.

A transcript of the open portions of the meeting is being kept, and it is requested that speakers identify themselves and speak with sufficient clarity and volume so that they can be readily heard. Additionally, participants should mute themselves when not speaking, including their cell phones.

And with all of that, we'll take a breath

and turn to, proceed with the meeting. And I'll call on Kris Cummings of NuScale to begin today's presentations. Kris.

MR. CUMMINGS: Great. Thank you very much. So my name is Kris Cummings. I'm a licensee engineer with NuScale. I have been with NuScale for about four years. Prior to that, I have had roles with test vendors and reactor vendors Holtec and Westinghouse and have been familiar with these particular types of analyses in the past.

I want to thank the ACRS for having us here. This is what I consider, in essence, the kickoff of the ACRS review of the SDA application and the associated methodologies that support that application. So thank you for having us here. It has been a pleasure working with the NRC staff during the review of this process, and I think we've had some good dialogue with them during the process and come to what we feel is a good resolution of the issues and an approved methodology.

I want to note that we took some of the ACRS's comments from the DCA period under advisement, and so we submitted these two topical reports about a year in advance of when we submitted the SDA. So that allows all of us, the NRC, the ACRS, and ourselves, to

get, in essence, a methodology approved, you know, well in advance of the approval of the SDA application. So we took that advice from the DCA time to heart.

So today we're focused in particular on the two methodologies that you mentioned and the changes that we made to those methodologies associated with the revisions were supplement to these topical reports. I want to note we will be back again in front of the ACRS, as you mentioned, for Chapter 4 and Chapter 15. So we're focused, again, today on the methodologies that will support the analysis or do support the analysis in the SDA application.

With that, that is my opening comments, and so what I would like to do is have my colleagues here that are presenting give an introduction of themselves. Yes, an introduction.

MS. TURMERO: Hi. So my name is Sarah Turmero. I'm a licensing engineer for NuScale, and I have been with the company in this position for about a year and a half. And before coming to NuScale, I was a reactor engineer at Waterford 3. And I will be covering the open portion of the statistical subchannel analysis methodology slides.

MEMBER MARCH-LEUBA: The microphones are

extremely sensitive if you are close to them. They are more concerned with minimizing background noise, so do talk into them.

MS. TURMERO: Okay. Thank you.

MR. LYNN: My name is Kevin Lynn. I'm a licensing engineer with NuScale. I have been here almost three years. And prior to that, I was working in licensing at an operating plant, a BWR operating plant, and I also have previous licensing experience with new plants, the Japanese designed the U.S. APWR that was in process a few years ago and came to the ACRS several times. So that's my background.

MR. LUITJENS: My name is Jeff Luitjens. I'm in the nuclear fuels group. The last few years, 11 years at NuScale, jumping around from validation, code development, testing. My background, Ph.D. in nuclear engineering, focus on CHF, and today I am here to provide information on the subchannel.

MS. CALLAWAY: My name is Allyson Callaway. I'm the senior manager of nuclear fuels. I have been at NuScale for 13 years in various capacities within the fuels and neutronics organization.

MS. TURMERO: So to kick off, I just want to acknowledge that we are the proud recipient of

financial assistant awards from the U.S. Department of Energy and are thankful to identify their support of our program.

And to get started, we're going to start off with the statistical subchannel analysis methodology topical report. So for the history of the statistical subchannel analysis methodology, it starts with the originally approved subchannel analysis methodology that was approved by the NRC in December of 2018 and previously presented to the ACRS in August and September of 2018. And this was the topical report that was used for the NuScale US600 design that's codified in 10 CFR Part 52, Appendix G.

And so the statistical subchannel analysis methodology was submitted in December of 2021, and it serves as a supplement to the originally-approved methodology. So the staff performed a review and audit of the topical report where there was one request for supplemental information, no requests for additional information and multiple audit questions. The topical report was revised during the review process to address staff feedback and the most recent revision is Revision 4. That was submitted in November of 2023.

So an overview of the previous subchannel

methodology. VIPRE-1 was used for steady state and transient analysis. The methodology fulfilled the requirements of VIPRE-1 generic safety evaluation limitations, and the topical report covered the methodology application and treatment of uncertainties where the objective of the topical report was to provide a methodology to determine fuel thermal margins, such as critical heat flux and fuel center line melt.

And here on the slide, we have an outline of the general methodology approach, and we'll be going over the differences from the original topical report to the statistical method.

So the changes from the original method, of course, the treatment of uncertainties. There's a statistical treatment of uncertainties for a set of parameters instead of a deterministic approach., radial and axial nodalization, and axial domain. And what remains unchanged is the fuel conduction, grade and frictional losses, cross-flow and mixing, and the qualification or the validation and applicability of the topical report.

MEMBER MARCH-LEUBA: Number one, we are going to interrupt you all the time. When you say statistical analysis of the uncertainties, you mean

what is called best estimate plus uncertainty type of approach where we do kind of a Monte Carlo propagation of -- can you explain to a member of the public that doesn't know what you've done what you've done?

MR. LUITJENS: Yes. So we're talking about statistical here. We're focusing just on the CHF analysis limit, not how subchannel talks to, you know, the systems code. So it's not a best estimate plus uncertainty. I would say our overall methodology is still deterministic. It's just in the CHF analysis for subchannel we're talking about statistical treatments.

MEMBER MARCH-LEUBA: In the previous, Revision 2, I don't remember the number, the approved one, we used bounding uncertainties for every single pyramid, whereas here, for the CHF, you do a Monte Carlo type of sampling?

MR. LUITJENS: Yes. For a set of those uncertainties, you know, five or six, we do a Monte Carlo type uncertainty kind of based on what's the uncertainty value and what's the distribution associated with that uncertainty. We do a Monte Carlo --

MEMBER MARCH-LEUBA: The ACRS is here for the public, so you're talking to, somebody is going to

read this transcript, and they need to understand what you're saying. So don't assume you're talking to your professors at university. Assume you're talking to your students.

MEMBER MARTIN: Robert Martin, member. Treatment of uncertainties specific to systems code, my understanding is you run thousands of cases with VIPRE, correct? You can --

MR. LUITJENS: So for the systems codes, those are done deterministically, so we take the bounding, you know, high flow, low flow. Those get fed to the subchannel, and we analyze those and get the limiting value.

MEMBER MARTIN: So those parameters are deterministically treated while the other ones are sampled --

MR. LUITJENS: Correct, yes. So determining the CHF analysis --

MEMBER MARTIN: The deterministic subchannel is the statistical.

MR. LUITJENS: Correct.

MS. TURMERO: Okay. And as Jeff had mentioned, so the statistical subchannel analysis methodology utilizes the statistical approach into finding the CHF analysis limit, whereas many of the

aspects of the methodology still use a deterministic approach. And so our intent of introducing the statistical treatment of uncertainties was to reduce some of the overly conservative treatments with a defendable basis and to provide a better representation of the physical response.

So statistical versus deterministic. For the deterministic approach, the event analysis input uncertainties are biased independently in a limiting direction. And so range of axial and radial power distributions that's allowed by operations are not treated statistically. There are variations that could be from exposure, power, boron concentration, control rod insertion, axial offset. And so in the existing methodology, the radial power distribution is artificially created to preserve the tech spec-allowed measured radial peaking and minimizing the beneficial cross flow, and the axial power distribution is determined for the limiting shape allowed by axial offset.

For the statistical approach, all of the uncertainties associated with both critical heat flux correlation and event analysis inputs are statistically treated and accounted for with a 95-percent probability at the 95-percent confidence level

in order to determine the critical heat flux analysis limit. And the statistical approach still requires the use of a critical heat flux correlation, the approved critical heat flux correlation with a 95/95 design limit.

With that, I'll turn it over to Kevin Lynn.

CHAIR KIRCHNER: Okay. You're going to do a handover. Good. I just want to note the presence of Member Vicki Bier. And, Sarah, since I have my mike on, this is -- your previous slide said actinically created. Perhaps I'm hanging up on the word. What you're really saying is that, when you apply the existing approved methodology, you accurately, not artificially, model what the core radial peaking is such that it's representative of the actual conditions. It's not artificially created. I'm just stumbling over the choice of words there and not what I believe is what you're actually doing.

MR. LUITJENS: Yes, I think that's the correct interpretation of artificially. What we're really trying to capture is what do we allow from the core design aspect to make sure we're capturing what we could possibly see.

CHAIR KIRCHNER: Okay. Artificially

created could give one the wrong impression. You're trying to accurately model what the radial power distributions is when you conduct your analyses.

Okay. Go on.

MEMBER MARCH-LEUBA: By artificial, I guess you mean bounding, right?

MR. LUITJENS: Yes. By artificial, we mean bounding.

MEMBER MARCH-LEUBA: So the tech specs is really what bounds your operation. You may never reach that solution, but you have tech specifics, you going to need to be under that or you'll be shut down.

Since we are the end of this presentation and if you can say it in the open session, will this exercise gain you a 2-percent margin, a 10-percent margin, a 25-percent margin? Was it worth it? I mean, if you get into a factor of 500 percent, I would be worried that you were tweaking too much.

MR. LUITJENS: Yes. If you're talking about the specific application, kind of going back --

MEMBER MARCH-LEUBA: Yes. You also might need to --

MR. LUITJENS: So from a sense, we're actually maintaining the same amount of margin for different designs.

MEMBER MARCH-LEUBA: It's the same core.

MR. LUITJENS: It's the same core with a little power upgrade, but we came back and sharpened our pencils on some of the approaches. We had 5 to 10-percent margin last time. We still have that same amount of margin this time. So there's not an order of magnitude change on the margins that we're seeing.

MEMBER MARCH-LEUBA: Let me refresh the question. If you have a core and you are under a license with your method and with the new method, what's the change in margin that you calculate? Is it in the 5-percent range or is it in the 100-percent range?

MR. LUITJENS: Yes, I'd say that's really hard -- it's hard to get that because you don't have a limit that's made for that specific methodology, so it's hard to go back --

MEMBER MARCH-LEUBA: Is it a big difference in your mind?

MR. LUITJENS: I would say it would not be a big difference.

MEMBER MARCH-LEUBA: I'm going to stipulate in the open, this statistical methodology is well developed and used everywhere. There's nothing new here. You're just joining the 21st century, as

opposed to just doing methods --

MR. CUMMINGS: Yes, Kris Cummings. I'd say we came from the 70s to the 90s.

MEMBER MARCH-LEUBA: Yes. Nothing new --

MR. CUMMINGS: Right.

MR. LYNN: Okay Thanks, Sarah. My name is Kevin Lynn. I'll be covering the open session for the rod ejection methodology. Rod ejection accident methodology was previously approved as Revision 1 by the NRC in June 2020, and it was previously presented to the ACRS at the full committee meeting in March and the subcommittee meeting in February of 2020.

The Revision 1, the approved version, was used for the NuScale US600 design, which is codified in 10 CFR 52, Appendix G. Subsequently, we submitted Revision 2 in December 2021, and the NRC staff performed a review and audit of Revision 2. We had no RSIs. We had one RAI with two questions, and then we had multiple audit questions.

So during the course of that interaction with the NRC staff, we ended up making some changes to the methodology throughout the process. And so we submitted Revision 3 in October 2023, which is the current revision.

The previously-approved version, Rev. 1,

provided the methodology for modeling the rod ejection accident, which is the bounding reactivity-initiated accident in accordance with GDC 28. The rod ejection is a bit unique compared to other Chapter 15 events. It has its own phenomenon and time scales that are looked at, very compressed time scales, as well as its own unique acceptance criteria. And that sort of lends itself to having its own special method.

The approved method used a combination of codes and methods, three codes, SIMULATE-3K, NRELAP5, and VIPRE-01, and it also had a adiabatic fuel model which was used to perform the calculation for fuel entropy and temperature using, essentially, a hand calculation.

The acceptance criteria that we used in Revision 1 was based on Regulatory Guide 1.77, which was the reg guide at the time, and also from the SRP in NUREG-0800. And, overall, we provided a justification for the software, the acceptance criteria, the applicability, and the treatment of uncertainties.

When we moved into Rev. 2, what were the changes? Well, the big change was Reg. Guide 1.77 was replaced with Regulatory Guide 1.236, and that was in June 2020. So, essentially, just after the old

methodology was approved, the new reg guide came out. And that new reg guide had a change to the PCMI fuel failure acceptance criteria, so that was sort of the main driver for why we needed to (audio interference).

While we were doing that revision, we looked it up. There's stuff that we can incorporate, and one of the things we identified was that the adiabatic fuel model calculation, the hand calculation, could be removed and, instead, we could use VIPRE to perform those calculations of fuel entropy and temperature.

In addition, as you just heard, we were looking at the statistical analysis for subchannel, so we wanted to incorporate that, as well. So bringing that limit and make any changes that we needed to make to the rod ejection methodology to better talk and interface with that new method. And then, finally, changes that were incorporated during the process were details and justification that we added based on our interaction with the NRC staff.

So we did not change the actual STIMULATE-3K analysis for uncertainty treatment or the overall qualification of the method. So, again, the primary driver was the new regulatory guide. The methodology itself was not really impacted by the design changes

we made going from DCA to SDA, and the increase in power was not really the driver for the change.

As far as a summary for our open session, for the subchannel analysis, the statistical treatment of uncertainties allows for improved results while still maintaining an overall robust analysis approach. And for the rod ejection, we've incorporated changes from the new reg guide and simplified our analysis to better work with VIPRE and the new subchannel method while still maintaining a conservative result.

And as Kris discussed earlier, these methodologies, at this stage we're talking about the methodologies themselves, but those methodologies are ultimately used to produce results that are identified in Chapters 4 and 15 of the NuScale standard design approval application for US460. Those results will obviously be coming back to the ACRS when those chapters are reviewed.

MEMBER MARTIN: You don't get off too easy. NuScale is, fundamentally, a light water reactor and, clearly, you've --

MR. BLEY: Can you use the mike?

MEMBER MARTIN: I'm pretty close to the mike. Fundamentally, you follow NUREG-0800. Early on in the development of your safety case, you would have

had to evaluated unique aspects of your design with respect to NUREG-0800. Is there anything in this section related to reactivity insertion accidents that is unique? Anyway, if I can get my composure back, is there anything unique about reactivity insertion accidents? As an integral PWR, yes, as an integral PWR, it's a little bit different regarding the design in this aspect. I would think it would, in some way, benefit design change might benefit the likelihood of such an event. Does that come into your thinking going into this at all, or you're just pretty much pushing the button like any LWR on this particular event?

MR. LYNN: Well, I think one unique aspect, right, being a smaller core and looking at that certainly factors into it. And I know one interesting thing, when we went from the uprate for the power, actually, the benchmarking that was performed, some of the benchmarking to the SPUR analysis, for example, actually, when we uprated, the power level is actually more in line with some of the experimental data that's out there that was performed.

So sort of one unique aspect of being small and being low power, you know, we're sort of moving up in the power range and actually bring it

maybe more in line a little bit with some of those cases in some of the more operating plants. So that, you know, change, although it is an uprate, you know, it sorts of brings us into line with that, but they're unique aspects.

I know that during the previous ACRS there was some discussion about unique aspects, including the design of our containment, you know, and the containment being closer to the vessel than it is in a operating plant; and, therefore, does that change anything when it came to rod ejection. But, you know, we addressed that previously, and so there's nothing new this time around that would make us revisit that, no changes that we've made that would make that a different scenario than it was before.

MEMBER MARCH-LEUBA: But, I mean, there's no change between the approved design and the new concept, but raw injection can be worse can be worse. What I'm asking, when we're asking the question about NUREG-0800, what could be -- 800 tells you take the worst rod and eject it, right; so, in that case, you have to do that. But, typically, if I remember correctly, rods are a lot heavier than typical PWR; is that correct?

MR. LYNN: I don't have the answer to

that, but I do know that -- Allyson, do you want to --

MS. CALLAWAY: Allyson Callaway. You're asking if the rods are heavier in mass or --

MEMBER MARCH-LEUBA: No, no, in the dollars.

MS. CALLAWAY: Because there's fewer, each ejected rod relative has more worth than a PWR. We preclude fuel failures still, and so that effectively limits how much worth can be ejected, and that's all just controlled through the power-dependent insertion limits. So the effective worth that's being ejected is still low.

MEMBER MARCH-LEUBA: Because of the --

MS. CALLAWAY: Power-dependent insertion.

MEMBER MARCH-LEUBA: -- safety controls over the rods are positioned.

MS. CALLAWAY: Right.

MEMBER MARCH-LEUBA: Similar to what BWRs do, correct? They're all worth minimizers.

MEMBER ROBERTS: A general question. What I think I heard -- this is Tom Roberts -- at least from Jose is that, for the subchannel analysis, this is basically what many people do. And for the rod ejection, I think what you said is this is following the reg guide revision. So would you characterize

neither of these topical reports as novel in scope or innovative in terms of nuclear safety?

MR. LYNN: Yes, we would agree.

MEMBER ROBERTS: Good. Thank you.

CHAIR KIRCHNER: Other members, any comments, questions --

MEMBER MARCH-LEUBA: Since we're in the open session, I want to put on the record that I concur with your evaluation that this is a small evolution. A few more years of learning and tweaking on the calculations, nothing groundbreaking in my opinion.

CHAIR KIRCHNER: Okay. Then we'll turn to the staff for their presentation in the open session. Thank you. Okay. When you're ready. Stacy, are you leading off? Just pull it closer to you, please.

MS. JOSEPH: I'm going to turn it over to my branch chief, Mahmoud Jardaneh, to give some opening remarks, and then I'll kick off.

MR. JARDANEH: Thank you. Good afternoon, Chair Kirchner, and good afternoon, ACRS subcommittee members. I'm Mahmoud Jardaneh, M.J. for short. And I serve as the branch chief of the New Reactor Licensing Branch in the Division of New and Renewed Licenses in NRR. I recently assumed this position and

look forward to being a member of the team working on the licensing review of the NuScale US460 design and engaging with you in this and future NuScale meetings.

Thank you for the opportunity today for the staff to present their review of the NuScale rod ejection accident and subchannel analysis methodologies topical reports associated with the standard design approval application (SDAA). These two topical reports are the last two of eight topical reports submitted prior to the application. The remaining SDAA topical reports are reviewed as part of the application, and we will inform the ACRS when their safety evaluation reports are available for the ACRS.

In addition to the safety evaluation of these topical reports, we have completed the Phase A, the advanced safety evaluation, without open items for five SDAA chapters, and advanced safety evaluations for them will be available for ACRS in the coming few weeks.

In today's meeting, the staff will focus on the differences from the last time we presented on the previous revisions of these topical reports that supported the now-certified NuScale US600 design. Once again, thank you for the opportunity, and we look

forward to a good discussion. Thank you.

CHAIR KIRCHNER: Thank you. And, Stacy, next.

MS. JOSEPH: Thank you very much. Thank you, M.J., and good afternoon, members of the ACRS, NuScale, colleagues from the NRC, and members of the public. My name is Stacy Joseph, and I'm a project manager for the two licensing topical reports that we're here to discuss today. I'm joined by our lead PM for the NuScale SDAA review, Getachew Tesfaye, as well as the staff members from both the Office of Nuclear Reactor Regulation and the Office of Research, who contributed to the reviews of the statistical subchannel analysis methodology and the rod ejection accident methodology.

A discussion on the statistical subchannel methodology will be led by Joshua Kaizer and Antonio Barrett from NRR; and for rod ejection, Adam Rau and Zhian Li will be leading the discussion from NRR, along with insights from Andrew Bielen from the Office of Research. Andrew will be joining us virtually today on Teams and will be presenting during the closed session.

Thank you to NuScale for giving the overview and the histories of the topical reports that

we'll be discussing. We'll try not to repeat too much of what you've already heard today. So in this open session, I'll quickly run through the time lines for each of the topical reports, the reviews, and then Josh and Adam will walk through the regulatory basis for each of the reports and the conclusions the staff made at the completion of their reviews.

The statistical subchannel methodology was submitted to the NRC in December 2021 and was accepted for review after NuScale addressed the staff's request for supplemental information in April of 2022. The staff conducted an audit between July 2022 and December 2023; and, as NuScale previously mentioned, the topical report was revised during this time period to address staff feedback. NuScale submitted the final revision to the topical report just this past November, and the staff's advanced SER was issued shortly later.

With that, I'll turn it over to Josh Kaizer.

MEMBER MARCH-LEUBA: These four revisions, were they a consequence of deficiencies that the staff identified during the review, where there were points of finding of signs that was not completed and the extra features, or can you explain why we were not

happy with Revision 1?

MR. KAIZER: Sure. That's for the NRC staff. This is my answer to that, and NuScale is free to jump in and correct me. Everyone does quality control of their documents a little bit differently, so, if you're looking at a GE topical report or a Westinghouse topical report, you can generally expect to see Rev. 0, it comes in the door. Maybe if there's a major change to the topical, they might make a Rev. 1. And that is one way to do it.

Other people decide to update the topical report, as information comes in, change the information in the topical report. A lot of times, that information would have been in the RAIs, it would have been in the Dash A version. Everything that we kind of saw here, there were some areas where we said, hey, we need more information, but it's really up to them whether they want to rev the topical, just provide the information and say, okay, we're going to attach it at the end of it. And I thought a lot of this came out of the QA program NuScale uses for its document generation, so there was nothing, I'd say, extra special about this topical report that it required four revisions before it even got there. It was just this is the way they chose to address the

information.

MEMBER MARCH-LEUBA: So there was no major deficiency. It was just tweaking.

MR. KAIZER: Correct. Okay. So I'll give the regulatory basis for the statistical subchannel. It mostly comes from GDC 10 of Appendix A, so, basically, saying, hey, you need SAFDLs. Critical heat flux is a SAFDL. This gets a little bit broken down more in the standard review plan, SRP 4.4, which talks about the 95/95.

I can go into a lot more detail because we actually did a presentation on this to the staff a couple of years ago where we tried to track down where does the 95/95 come from and all that kind of stuff. But suffice to say, there is this 95/95 requirement, well, not requirement, but there's 95/95 in the SRP. Everybody says, yes, we want to satisfy that. And for direct correlations, it's a little bit more straightforward when you start to do statistical stuff. It is a little more challenging, but, like a lot of people have pointed out, this was a concern and a challenge that we have long since resolved. I think the earliest I've seen it used, I thought the topical was, like, sometime from the 1980s, the late 80s. So using 95/95 in the statistical sense is something

we're very familiar with, especially in DMB.

And I wanted to add the staff's conclusions, we found an acceptable method for combining all these uncertainties. We did have two limitations and conditions. The first one was, basically, saying that your correlation has to be approved. This was just a carryover from the original, the NuScale, the subchannel analysis methodology. It's kind of a general statement you'll see a lot of times. Any time you see a CHF methodology, hey, your CHF correlation has to be approved for the fuel you're using, so that's not that really big of a deal.

The next one, a little bit more complex, but we just basically said you have a whole bunch of models in this methodology that NuScale wanted to say we're going to model this, we're going to capture the uncertainty of this parameter. We're not really ready to tell you yet how we're going to do that. And so we kind of looked through it and said, okay, that's reasonable, but, before you actually apply this, you have to tell us how you're going to model this and we have to approve it. And there's a number of ways we can do that. We can either approve the equation or we can approve the direct uncertainty itself. So those

were the two conditions, limitations, on the staff's SER, and that was pretty much the majority of the review.

MEMBER MARCH-LEUBA: Revision number 2 is more a condition from the first --

MR. KAIZER: Yes.

MEMBER MARCH-LEUBA: -- license, and then the second can just --

MR. KAIZER: Correct, yes. And there's a bunch of ways that we can resolve those issues. We're just saying, hey, these have to be reviewed and approved by the staff.

MEMBER MARCH-LEUBA: It's not really limiting.

MR. KAIZER: Correct.

MEMBER MARCH-LEUBA: We need to look at the test at least once.

MR. KAIZER: Yes.

MEMBER MARTIN: With statistical methods, the presentation of information will be a little bit different from a deterministic presentation of information. And there might be a tendency to just kind of globally look at results from thousands of cases in a statistical sense. Do you still expect or require that NuScale present some deterministic

representative type of results of what exists after 95/95, or you'd be satisfied with for just the statistical presentation of information?

MR. KAIZER: I want to ask one clarification on your question because this is something that I get into a lot of conversations about this, and I don't quite understand sometimes when people use -- to me, the deterministic analysis is any analysis where you put in the input and you get out the same output, and a non-deterministic analysis will literally be if I give my computer code three, one time I get the number five, one time I get the number seven.

So I have always viewed that even statistical methodologies are deterministic in nature. It's just what we're doing is we're feeding them, instead of a constant, a random variable, and they're going to give me a different outcome. But if I give it that same initial input, I get the same thing. So I want to clarify that when I hear deterministic in this sense, I'm thinking more of do they have to do, like, the worst-case scenario type thing.

MEMBER MARTIN: No. That's a trick question, and we're aligned on that perspective. Deterministic is a term, because of Chapter 15

accident analysis in the old school, was truly bounding in a sense, and we've evolved to a different approach now.

But, yes, I was just really wondering whether, if an old school reviewer picked it up, would they recognize it?

MR. KAIZER: Well, one of the challenges with statistical CHF is it's been around for so long. I mean, you're talking 1980s, so I took over this position from Tony Attard. I think he started in the NRC in the mid 90s, so, yes, he would have already been familiar with that.

The other thing about statistical subchannel is it's not a replacement method, it's an alternative approach, so we'll talk about their normal subchannel analysis methodology. And I never thought of the statistics in it as giving you, I'd say the major benefit that I feel like you would get from a statistical LOCA where you're like ranging that break size. I mean, normally, what you're doing is you are taking a whole bunch of uncertainties and, instead of just adding them as straight adders, you're saying, okay, we can treat these as random variables and combine their things statistically.

So it is a statistical method, but I don't

think of it as something as far afield from a deterministic one because you're still going to find, I mean, you're treating the uncertainties statistically but not --

MEMBER MARTIN: I think you're overthinking my question.

MR. KAIZER: Okay.

MEMBER MARTIN: An uncertainty is a tendency with statistical methods that kind of present the cloud of results, and that is useful to some extent. But my point about kind of old school approach is people still kind of want to see, you know, plots of behavior because the trends give you a feeling of rate processes and what have you, and, you know, certainly, an expert analyst gets insight. It just doesn't come out of a statistical presentation of, you know, various metrics that might be valuable to measure against acceptance criteria. But to really assess as evidence, which, of course, ultimately, all these analyses are, there needs to be a tangible event. But when you're running thousands of cases, it's difficult to do so, so you're really looking for something representative. In this case, that's something at the 95/95 confidence probability.

As a throwback, I just wouldn't expect it

to kind of look like a traditional analysis. For instance, what's difficult, where this kind of comes from, you know, comparing it to LOCA where they may only run 59, certainly, you can look at a limiting case. But in those limiting cases, the samples themselves, you know, particularly, say, less important than the more dominant ones, they may not look right, you know, because they're in the wrong direction of what might be otherwise considered conservative.

Now, maybe in a case like running thousands of cases, that would be so much of an issue. Truly, a 95 case would capture the more bounding conditions, you know, associated with the major parameters that you are looking at. So, again, it's a simpler question. You know, are there, basically, you know, results that, while they may be, you know, of one representative event, they're still there, just to throw back to the old ways these things were presented in safety analysis reports. I still think that's value in that. That's my point. There's still value, as opposed to statistically presenting information.

MR. KAIZER: Okay. I have just a -- is there a question that I should be answering? The

reason I'm asking is because, like, this, to me, is a very interesting topic, as a lot of times things usually are. And I want to make sure I'm not going into down a rabbit hole that the ACRS, you guys, aren't asking us to go down to answer the question or just accept the comment.

MEMBER MARTIN: It's simply an expectation of content of a safety analysis report. And my expectation is that it truly looked like an analysis, even though there is, of course, the statistical component to it. It should still look like, you know, here's an event and this was the outcome, these were trends, inputs in affect, you know, the transient over time.

MR. KAIZER: I think what I would expect that in the transient analysis that they're performing, but I don't know if I would necessarily expect that in the method they would use to generate the statistical limit.

MEMBER MARTIN: That's fine. That's fine.

MR. KAIZER: Yes, okay.

MEMBER MARTIN: But a reasonable person coming from the outside picks up the safety analysis report. They want more than just a --

MR. KAIZER: Correct.

MEMBER MARTIN: -- statistical presentation of information. They want something that they understand really from kind of a science, engineering basis, as opposed to a math based.

MR. KAIZER: Correct.

CHAIR KIRCHNER: Josh, could you put your limitations and conditions in number two in some perspective, given this is an open meeting? There are numerous equations that are referenced in the submodels and such. What you're really saying is, when it comes to applying this methodology in Chapter 15, we are going to go back and review what?

MR. KAIZER: Sure. So there are a lot of input parameters or input variables that impact your statistical limit, and there's a question of how do you treat the uncertainty of those. When we say how do you treat the uncertainty, what equation are you going to use? Are you going to assume it's normally distributed, uniform distributed? If you are, what are the parameters of that distribution? Are you going to assume there's a linear relationship? There's a whole bunch of questions.

In the initial topical report, NuScale gave examples of how they would treat those uncertainties, but they hadn't finalized that

information yet. So we pretty much said, okay, for these variables, and I think we listed however many there were, there was a handful, okay, that you would have to come in and tell us how you're going to capture that uncertainty. And there's just a bunch of different ways to do it. The one way is, well, we're going to assume a conservatively high or low value. You can do that, but, if it's statistical, you're probably going to say, well, we think that this is going to be normally distributed, and we think this is the way to determine the mean and this is the way to determine the variance. We think that it's best to treat this as a uniform distribution, so here's its lower limit, here's its upper limit. And that is, well, I guess, the further details of that number two.

CHAIR KIRCHNER: Thank you.

MR. KAIZER: If there are no further questions, I'll turn it over to Adam.

MS. JOSEPH: Just quickly. Thanks, Josh. Stacy Joseph again. The time frame for rod ejection topical report is similar to that of subchannel. NuScale submitted Revision 2 of the rod ejection topical report in December 2021. The staff issued an RAI and received NuScale's response in September 2022. The staff performed an audit between April and

September 2023. And following completion of the audit, NuScale revised the topical report to address the feedback from the staff. The staff then completed the review and issued the advanced SER on January 4th, 2024.

Adam.

MR. RAU: All right. Thank you, Stacy. Okay. And so, as NuScale mentioned in their presentation, the regulatory basis for the rod ejection accident is GDC 28. It requires an evaluation of limiting reactivity insertion accidents for the effect on the reactor coolant pressure boundary and for core coolability. In NuScale's case, rod ejection is the limiting accident in their case.

So the regulatory guidance for this accident is given in, primarily, Reg. Guide 1.236. You know, it was mentioned in their presentation that this is the new guidance that's come out since the previous revision of the topical. There's additional information in SRP 4.2, Appendix B, as well as 15.4.8, as well.

And so the NRC staff conclusions for the evaluation was that the rod ejection accident analysis methodology is a systematic methodology for analyzing this accident. We did place three limitations and

conditions on the topical report that are primarily concerned with, if I could draw a trend between them, I would say articulating the scope of our approval for this, and I think, hopefully, that comes through as a through line through the three limitations and conditions.

So the first is related to the application. So when this is applied, it just states that applicability needs to be demonstrated. So this is, you know, a generic methodology that's applied to a new design that maybe NRC staff hasn't had a chance to look at yet, and that's just a question that would have to be answered at that time.

So limitation and condition number two. I know ACRS members had some questions on this, and, you know, we'll definitely get a chance to talk about the basis in the closed session. Just to try to say a bit about it in the open session, I think the motivation here is that there's a sensitivity to the axial offset in the code, and so the -- well, again, trying not to get into too many details in the open session, we wanted to have a condition reflecting that saying if this is applied to a design that operates with control rods inserted for a long period of time or has a load following scheme that involves this sort

of operation, that this is something that should be addressed and may be outside the scope of staff's approval.

MEMBER MARCH-LEUBA: Your efficient evaluation that if we allowed 1:53:20 operation, the uncertainty of the equation will increase because now you will have the offset, the axial offset, and all that --

MR. RAU: That's right, yes. Not sure if I say uncertainty or bias or conservatism, but one of those, something in that family would --

MEMBER MARCH-LEUBA: Another thing I wanted to place on the open session is, in my mind, there are two extremes. On one extreme, you can provide a link to the control rod position to the grade dispatcher and he controls the power of your reactor at any time he wants. On the other extreme, you have a power plant that is co-located with solar and wind, and you know in the middle of the day you're going to have lower power, and you have a pre-planned hour of shade during the day. And if you're in that way, you can probably control the power with boron, and it wouldn't cause such problems. And that's the most likely one.

So I understand what limitations are

there. And if you decide to do load following, come talk to me and we'll decide if it's okay. Most likely, it will be reprogrammed during the day and many plants are doing that already.

MR. RAU: Yes. And, you know, hopefully, we provided enough in the SE and the condition itself that, you know, if that comes into a future reviewer, they'll understand where we --

MEMBER MARCH-LEUBA: It's good, like, in the SRP in NUREG-0800 you provided hints to the future reviewers, which might be younger 20 years from now to look for. My principle concern is if it's placing an undue burden on NuScale because we are limiting them to bystanders and say, well, we won't bother when maybe you can do it.

MR. RAU: Yes, that makes sense. The third limitation condition is just recognition that the NRC staff considered some of the methodologies cited in the topical report to be integral parts of the methodology, so that particular nuclear analysis methods that were cited, as well as the subchannel methodology, you know, played into our review. And so if these were to, you know, if you were to try to change these out, we would consider this a change to the methodology itself.

With that, I will turn it back over to Stacy.

CHAIR KIRCHNER: Members, further questions, statements, comments? I note for the record I detected Dennis Bley, our consultant, and Steve Schultz also are participating today.

So then thank you. At this juncture, I think we'll change to, turn to public comments. And, with that, we have Harold Scott, I see, on our screen. Good afternoon, Harold. Since you already submitted a comment, do you wish to make any public statement? You have to unmute yourself.

MR. SNODDERLY: Well, I think Harold did request that someone, and I can do it for you --

CHAIR KIRCHNER: We can read it.

MR. SNODDERLY: Yes, that we would read it for Harold, and then we'll follow up and see if --

CHAIR KIRCHNER: Okay. So, Harold, I'm going to ask Mike Snodderly, the Designated Federal Official, to read your comments into the record.

MR. SNODDERLY: Thank you, Chair Kirchner. This is Mike Snodderly. This is an email that we received yesterday, Monday, February 5th, from Harold Scott. It reads as follows: My topic is amount of proprietary marking redaction. Can you or another NRC

staff read out this message during public comment period NuScale meeting? I have trouble speaking. What is it about plots of computer code output that makes them proprietary? I think the public would find value in seeing explicit margins. I would appreciate ACRS members considering if the topic is a concern to be raised with the commissioners. Thanks for listening.

That was the end of the email. This email will also be included in the official transcript.

CHAIR KIRCHNER: Now it's our, not policy but practice, I think, is more accurate to say that the committee doesn't respond in realtime. We address comments raised by the public and usually include them in our considerations for a letter. In this particular case, though, I just would observe that the committee in the past, as a general practice, has encouraged all applicants to make as much material publicly available as supports their safety case, and we've had numerous interactions over the last years with applicants to encourage them to do so.

So, Harold, your comment is duly noted. It is not in our control to decide what is proprietary or not, but it is in our, I think, the committee's interests to encourage all applicants to make as much

of their safety case publicly available, and that would include such detailed plots as you were asking for.

MR. SCOTT: Thank you very much. Thank you. So thank you very much. Thank you.

CHAIR KIRCHNER: Thank you, Harold. Are there any other members of the public or those present here in the room who wish to make a comment? Please come forward or unmute your line and identify yourself and affiliation, as appropriate, and make your comment. Sarah. Okay, Sarah. Go ahead.

MS. FIELDS: Yes, this is Sarah Fields with Uranium Watch in Moab, Utah. To follow up on Mr. Scott's email comment, I found recently that large sections of applications related to so-called advanced reactors and also the NuScale small modular reactor project that you're reviewing now, they're just redacting. You look at an application, you look at a submittal, and most of it is redacted. So I think information that used to be readily available to the public is now being redacted.

So if you're under the illusion that the industry is making everything available possible available to the public, you're mistaken. All this stuff is just missing. Thank you.

CHAIR KIRCHNER: Thank you, Sarah. Any further comments?

MEMBER MARCH-LEUBA: Yes. Mine is related to this, too.

CHAIR KIRCHNER: Okay. This is Member March-Leuba.

MEMBER MARCH-LEUBA: One consideration that we need to have here is the export control is often more restricted on proprietary measures, and all of this, the science, are on export control. And if you release this information, you can go to jail much easier. Proprietary, NuScale can sue you. But if you release export control information, you can go to jail. So people are more careful because of that.

CHAIR KIRCHNER: Thank you. Further comments from the public?

MR. SNODDERLY: Excuse me, Chair Kirchner.

CHAIR KIRCHNER: Yes.

MR. SNODDERLY: If I could add, Ms. Fields, this is Mike Snodderly from the ACRS staff. You might find it interesting, if you look at the recent Revision 1 to the publicly-available non-proprietary version of Chapter 15, accident analysis, and Section 15.4 on the rod ejection accident, there is the description of the sequence of events and

results that may give you, you may find them of interest. So there are more results that are available concerning the rod ejection accident interview he publicly-available FSAR chapter. And if you have trouble finding that, Sarah, you have my email and I can help you find that.

MS. FIELDS: I was talking generally, not specifically about this issue that you're discussing today. I'm talking generally about applications.

MR. SNODDERLY: Okay. Thank you for the clarification.

CHAIR KIRCHNER: Thank you. Not hearing further comments, we are going to take a short break here and go into a closed session with a different Teams link. And those that need to know to participate will have access to that Teams link. And with that, we are on a break for 15 minutes. It is currently five minutes after two. We'll take a break until 2:20 Eastern Time.

(Whereupon, the above-entitled matter went off the record at 2:03 p.m.)

January 25, 2024 Docket No. 52-050

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Submittal of Presentation Materials Entitled "Statistical Subchannel Analysis Methodology and Rod Ejection Accident Methodology Topical Reports, ACRS Open Session," PM-154736, Revision 0 (Open Session)

The purpose of this submittal is to provide presentation materials to the NRC for use during the upcoming Advisory Committee on Reactor Safeguards (ACRS) NuScale Subcommittee Meeting on February 6, 2024. The materials support NuScale's "Statistical Subchannel Analysis Methodology" and "Rod Ejection Accident Methodology" topical reports of the NuScale Standard Design Approval Application.

The enclosure to this letter is the nonproprietary version of the presentation entitled "Statistical Subchannel Analysis Methodology and Rod Ejection Accident Methodology Topical Reports, ACRS Open Session."

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

If you have any questions, please contact Wren Fowler at 541-452-7183 or sfowler@nuscalepower.com.

Sincerely,

Tom Griffith
Manager, Licensing
NuScale Power, LLC

Distribution: Mahmoud Jardaneh, NRC
Getachew Tesfaye, NRC
Mike Snodderly, NRC

Enclosure: "Statistical Subchannel Analysis Methodology and Rod Ejection Accident Methodology Topical Reports, ACRS Open Session," PM-154736, Revision 0 (Open Session)

Enclosure:

"Statistical Subchannel Analysis Methodology and Rod Ejection Accident Methodology Topical Reports, ACRS Open Session," PM-154736, Revision 0 (Open Session)

Statistical Subchannel Analysis Methodology and Rod Ejection Accident Methodology Topical Reports

February 6, 2024

ACRS Open Session

Acknowledgement and Disclaimer

This material is based upon work supported by the Department of Energy under Award Number DE-NE0008928.

Statistical Subchannel Analysis Methodology, TR-108601-P

Supplement 1 to “Subchannel Analysis Methodology,” TR-0915-17564-P-A, Rev. 2

Statistical Subchannel Analysis Methodology – History

- "Subchannel Analysis Methodology," TR-0915-17564-P-A, Rev. 2
  - Approved by NRC in December 2018 and previously presented to ACRS
    - August 24, 2018 subcommittee meeting
    - September 6, 2018 full committee meeting
  - Used for the NuScale US600 design codified in 10 CFR 52 Appendix G
- "Statistical Subchannel Analysis Methodology," TR-108601-P, Rev. 0 submitted in December 2021
  - Serves as a supplement to TR-0915-17564-P-A, Rev. 2
- NRC staff performed review and audit of TR-108601-P
  - One request for supplemental information (RSI)
  - No requests for additional information (RAIs)
  - Multiple audit questions
- TR-108601-P was revised during the review to address NRC staff feedback
- Current revision is TR-108601-P, Rev. 4 – submitted November 2023

Overview of Previous Subchannel Methodology in TR-0915-17564-P-A, Rev. 2

- VIPRE-01 used for steady-state and transient analysis
- Methodology fulfills requirements of VIPRE-01 generic safety evaluation report (SER) limitations
- Methodology application and treatment of uncertainties
- Objective: critical heat flux (CHF) and fuel centerline melt
- General methodology approach:
  - Input uncertainties treated deterministically; no credit for statistical randomness
  - Conservative basemodel development
  - Generic cycle-independent radial power distribution
  - Bounding axial power shapes
  - Detailed radial and axial nodalization evaluations
  - Detailed checklist to ensure compliance with method

Subchannel Methodology Changes in TR-108601-P

- Changes from TR-0915-17564-P-A, Rev 2:
  - Treatment of uncertainties – statistical for a set of parameters instead of deterministic approach
  - Radial nodalization
  - Axial domain
  - Axial nodalization
- Unchanged:
  - Fuel conduction
  - Grid and frictional losses
  - Cross-flow and mixing
  - Qualification (validation and applicability)
- The Statistical Subchannel Analysis Methodology utilizes a statistical approach in defining the CHF analysis limit; but, many aspects of the methodology continue to employ a conservative deterministic approach (e.g., axial and radial power profiles)
- The intent of introducing a statistical treatment of uncertainties in certain areas was to reduce some of the overly conservative treatments with a defendable basis and to provide a better representation of the physical response

Subchannel Methodology: Statistical vs. Deterministic

- **Deterministic:** Event analysis input uncertainties (power distributions, boundary conditions, tolerances, etc.) are biased independently in the limiting direction
  - Range of axial and radial power distributions allowed by operations not treated statistically
  - Variations possible from: exposure, power, boron concentration, control rod insertion, axial offset, etc.
  - As in existing approved methodology:
    - Radial power distribution: Artificially created to preserve measured Technical Specification allowed radial peaking and minimize beneficial cross-flow in analysis
    - Axial power distribution: Search performed for limiting shape allowed by axial offset
- **Statistical:** All uncertainties associated with both CHF correlation and event analysis inputs are statistically treated in order to determine the CHF analysis limit
  - Statistical approach accounts for all uncertainties with a 95% probability at the 95% confidence level
  - Statistical approach continues to require use of an approved CHF correlation with a 95/95 design limit

Rod Ejection Accident Methodology, TR-0716-50350-P

Rod Ejection Accident Methodology – History

- "Rod Ejection Accident Methodology," TR-0716-50350-P-A, Rev. 1
  - Approved by NRC in June 2020
  - Previously presented to ACRS
    - February 19, 2020 subcommittee meeting
    - March 5, 2020 full committee meeting
  - Used for the NuScale US600 design codified in 10 CFR 52 Appendix G
- TR-0716-50350-P, Rev. 2 submitted in December 2021
- NRC staff performed review and audit of TR-0716-50350-P
  - No RSIs
  - One RAI with two questions
  - Multiple audit questions
- TR-0716-50350-P was revised during the review to address NRC staff feedback
- Current revision is TR-0716-50350-P, Rev. 3 – submitted October 2023

Overview of Previous Rod Ejection Methodology in TR-0716-50350-P-A, Rev. 1

- Methodology for modeling rod ejection accident (REA)
- Bounding reactivity initiated accident (RIA) from General Design Criteria (GDC) 28
- REA is unique in comparison to other Chapter 15 events
  - Phenomena, time-scales, acceptance criteria, methods
- Combination of codes and methods:
  - SIMULATE-3K: Transient nuclear physics simulations
  - NRELAP5: Transient systems thermal-hydraulics
  - VIPRE-01: Transient detailed core thermal-hydraulics
  - Adiabatic Fuel Model: Conservative analytical model of fuel enthalpy and temperature
- Unique acceptance criteria from Regulatory Guide (RG) 1.77, NUREG-0800
- Justification for software, acceptance criteria, applicability, and treatment of uncertainties

Rod Ejection Accident Methodology Changes

- Changes from TR-0716-50350-P-A, Rev. 1:
  - Replacement of RG 1.77 with RG 1.236 (issued in June 2020)
  - Change to pellet clad mechanical interaction (PCMI) fuel failure acceptance criteria from RG 1.236
  - Calculation of fuel enthalpy and temperature via VIPRE-01 instead of adiabatic fuel model
  - Subchannel statistical analysis limit
  - Other minor changes to accommodate updated statistical subchannel method
  - Incorporate content from previous RAIs and add new detail, justification, and explanation to address NRC staff questions during review
- Unchanged:
  - SIMULATE-3K analysis and uncertainty treatment
  - Qualification (validation and applicability)
- Primary driver of the revision was the new RG 1.236
- REA method effectively not impacted by design changes
  - Increase in power was not a driver of the changes

Summary and Conclusions

- Subchannel:
  - Statistical treatment of uncertainties allows for improved results while maintaining overall robust analysis approach
- Rod ejection:
  - Incorporate changes from RG 1.236 issuance
  - Simplify analysis structure to use VIPRE-01 for fuel calculations
  - Interface with updated subchannel method
- Improvements in methods while maintaining conservative results
- Results from calculations utilizing these methodologies are contained in Chapters 4 and 15 of the NuScale standard design approval application (SDAA) for the US460 design

Acronyms

ACRS	Advisory Committee on Reactor Safeguards
CFR	Code of Federal Regulation
CHF	Critical Heat Flux
GDC	General Design Criteria
NRC	Nuclear Regulatory Commission
PCMI	Pellet Clad Mechanical Interaction
RAI	Request for Additional Information
REA	Rod Ejection Accident
RG	Regulatory Guide
RIA	Reactivity Initiated Accident
RSI	Request for Supplemental Information
SDAA	Standard Design Approval Application
SER	Safety Evaluation Report

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Presentation to the ACRS Subcommittee
Staff Review of NuScale Topical Reports

TR-108601-P, REV 4,
"STATISTICAL SUBCHANNEL ANALYSIS METHODOLOGY,
SUPPLEMENT 1 TO TR-0915-17564-P-A, REVISION 2,
"SUBCHANNEL ANALYSIS METHODOLOGY""
&
TR-0716-50350-P, REV 3,
"ROD EJECTION ACCIDENT METHODOLOGY"

February 6, 2024

(Open Session)

NRC Technical Review Areas/Contributors

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- **Project Managers**
  - Stacy Joseph, TR PM
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SSAM Staff Review Timeline

- NuScale submitted its Topical Report (TR) TR-108601-P, Rev 0 on December 30, 2021 (ML21364A133) as supplemented by letters dated April 25, 2022 (ML22115A222) and December 13, 2022 (ML22347A314).

- Staff performed an audit between July 13, 2022 and September 27, 2023 (ML23295A001).

- Following the audit, NuScale submitted Revisions 3 and 4 on October 12, 2023 (ML23285A341) and November 6, 2023 (ML23285A341) of the TR.

- Staff issued the Advanced Safety Evaluation Report (SER) on November 6, 2023 (ML23277A007)

SSAM Regulatory Basis

- General Design Criterion 10, “Reactor design,” of Appendix A

  The reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

- Standard Review Plan, Section 4.4, “Thermal and Hydraulic Design”.

  ..*there should be a 95-percent probability at the 95-percent confidence level that the hot [fuel] rod in the core does not experience a DNB [departure from nucleate boiling] or boiling transition condition during normal operation or AOOs.*

SSAM Staff SER Conclusions

- The SSAM is an acceptable methodology to calculate the margin to fuel thermal limits such as the critical heat flux ratio through a statistical combination of the uncertainties.

- There were two limitations and conditions:

1. An applicant referencing [the SSAM] in the safety analysis must also reference an approved CHF correlation which has been demonstrated to be applicable for use with [the NSAM]. (Carry over from NSAM)

2. The SSAM relies on multiple submodels to calculate the statistical critical heat flux analysis limit. While some of these submodels have been reviewed and approved as part of the NRC staff's review and approval of the SSAM, the submodels listed in the SER would need to be reviewed and approved before the application of this methodology for a licensing analysis.

Staff Review Timeline

TR-0716-50350-P, Rev 3
"Rod Ejection Accident Methodology"

- NuScale submitted its Topical Report (TR) TR-0716-50350-P, Rev 2 on December 21, 2021 (ML21351A400).
- NuScale supplemented its submittal by letter dated, September 14, 2022 in response to requests for additional information (RAI), RAI No. 9936 from the NRC staff.
- Staff performed a limited scope audit between April 19, 2023 and September 27, 2023 (ML23295A001).
- Following the audit, NuScale submitted Revision 3 of the TR on October 20, 2023 (ML23293A292)
- Staff issued the Advanced SER on January 4, 2024 (ML23310A166)

Regulatory Basis

- General Design Criterion 28, “Reactivity Limits,” of Appendix A

  Criterion 28—Reactivity limits. The reactivity control systems shall be designed with appropriate limits on the potential amount and rate of reactivity increase to assure that the effects of postulated reactivity accidents can neither (1) result in damage to the reactor coolant pressure boundary greater than limited local yielding nor (2) sufficiently disturb the core, its support structures or other reactor pressure vessel internals to impair significantly the capability to cool the core. These postulated reactivity accidents shall include consideration of rod ejection (unless prevented by positive means), rod dropout, steam line rupture, changes in reactor coolant temperature and pressure, and cold water addition.

- Standard Review Plan Sections 4.2 and 15.4.8 and Regulatory Guide 1.236, “Pressurized-Water Reactor Control Rod Ejection and Boiling-Water Reactor Control Rod Drop Accidents” for reactivity-initiated accidents.

Staff SER Conclusions

- TR-0716-50350 P, Revision 3 provides a systematic methodology for performing rod ejection accident (REA) analysis subject to the following limitations and conditions:

1. An applicant or licensee referencing this report is required to demonstrate the applicability of the REA methodology to the specific NPM design. The use of this methodology for a specific NPM design requires the NRC staff review and approval of the applicant or licensee determination of applicability.
2. The REA methodology is limited to evaluation of REAs for fuel that has not experienced significant depletion with control rods inserted, such as from non-baseload operation.
3. The staff's approval is limited to the use of the rod ejection methodology with TR-0616-48793-P-A, Revision 1 (Reference 14), "Nuclear Analysis Codes and Methods Qualification," and TR-108601-P, Revision 4 (Reference 13), "Statistical Subchannel Analysis Methodology, Supplement 1 to TR-0915-17564-P-A, Revision 2, Subchannel Analysis Methodology."

Questions/comments from members of the public before the closed session starts?

From: Harold Scott
To: Michael Snodderly
Subject: [External_Sender] public comment for 2/6/24 ACRS SC
Date: Monday, February 5, 2024 12:14:24 PM

My Topic is amount of proprietary marking (redaction)

can you or another NRC staff read out this message during
public comment period NuScale meeting ? I have trouble speaking

What is it about plots of computer code output
that makes them proprietary ?

I think the public would find value in seeing the explicit margins

I would appreciate ACRS members considering if the topic is a concern to be raised with the Commissioners.

Thanks for listening