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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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NUSCALE DESIGN-CENTERED REVIEW SUBCOMMITTEE

(OPEN)

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TUESDAY

MARCH 4, 2025

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The Subcommittee met via Video Teleconference, at 9:30 a.m. EST, Walter L. Kirchner, Chair, presiding.

SUBCOMMITTEE MEMBERS:

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STEVE SHULTZ

DESIGNATED FEDERAL OFFICIAL:
MICHAEL SNODDERLY

AGENDA

I Opening remarks 4

II Discussion of NuScale Non-Loss-of-Coolant-Accident Analysis Methodology Topical Report 9

III Staff's Evaluation of NuScale Non-Loss-of-Coolant-Accident Analysis Methodology Topical Report 36

IV Discussion of NuScale Extended Passive Cooling and Reactivity Control Methodology Topical Report 55

V Staff's Evaluation of NuScale Extended Passive Cooling and Reactivity Control Methodology Topical Report 82

VI Opportunity for Public Comment 102

Adjourn

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

9:30 a.m.

CHAIR KIRCHNER: Okay, the meeting will now come to order. Good morning. This is the meeting of the NuScale Design Centered Review Subcommittee of the Advisory Committee on Reactor Safeguards. I'm Walt Kirchner, Chairman of today's subcommittee meeting.

ACRS members in attendance in person are Ron Ballinger, Vicki Bier, Craig Harrington, Robert Martin, David Petti, Scott Palmtag and Thomas Roberts.

ACRS members in attendance virtually via Teams are Vesna Dimitrijevic, Greg Halnon and Matt Sunseri. We also have two of our consultants participating virtually via Teams, Dennis Bley and Steve Shultz. If I missed anyone, either ACRS members or consultants, please speak up now.

Michael Snodderly of the ACRS staff is the Designated Federal Officer for this meeting. No member of conflicts of interest were identified and I note that we have a quorum.

During today's meeting, the subcommittee will receive a briefing on the staff's evaluation of NuScale Topical Report TR051649416: Proprietary Non-Loss-of-Coolant Accident Analysis Methodology and

TR124587: Extended Passive Cooling and Reactivity Control Methodology.

We previously reviewed the certified NuScale US600 design as documented in our July 29, 2020 letter report on the safety aspects of the NuScale small modular reactor. Like the staff, we are performing a delta review between the two designs including a power uprate from 50 to 77 megawatts electric per module. We are reviewing these chapters and TRs as part of our statutory obligation under Title 10 of the Code of Federal Regulations, Part 52, Subpart E, Section 141, Referrals to the Advisory Committee on Reactor Safeguards.

We report on those portions of the application which concern safety. The ACRS was established by statute and is governed by the Federal Advisory Committee Act or FACA. The NRC implements FACA in accordance with its regulations. Per these regulations and the Committee's bylaws, the ACRS speaks only through its published letter report. All member comments therefore should be regarded as only the individual opinion of that member not a Committee position.

All relevant information related to ACRS activities, such as letters, rules for meeting participation and transcripts, are located on the NRC public website and can easily be found by typing "About us ACRS" in the search field on NRC's home page.

The ACRS, consistent with the agency's value of public transparency and regulation of nuclear facilities, provides opportunity for public input and comment during our proceedings. We have received no written statements or requests to make an oral statement from the public, but we have set aside time at the end of the meeting for such public comments.

Portions of the meeting may be closed to protect sensitive information as required by FACA and the Government in the Sunshine Act. Attendance during the closed portion of the meeting will be limited to the NRC staff and its consultants. Applicants and those individuals in organizations who have entered into an appropriate confidentiality agreement, we will confirm that only eligible individuals are in the closed portion of the meeting later this afternoon.

The ACRS will gather information, analyze relevant issues and facts and formally propose conclusions and recommendation as appropriate for deliberation by the full Committee. A transcript of the meeting is being kept and will be posted on our website. When addressing the Subcommittee, the participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard. If you are not speaking, please mute your computer on Teams or by pressing *6 if you're on your phone.

Please do not use the Teams chat feature to conduct sidebar discussions related to presentations, rather limit the use of the meeting chat function to report IT problems.

For everyone in the room, please put your electronic devices in silent mode and mute your laptop microphone and speakers. In addition, please keep sidebar discussions in the room to a minimum because our ceiling microphones are live.

For presenters, your table microphones are unidirectional and you'll need to speak into the microphone to be heard. Finally, if you have any feedback for the ACRS about today's meeting, we encourage you to fill out the public meeting feedback form on the NRC's website. With that, we will now proceed with the meeting and I will turn first to the NRC staff and to M.J. for opening comments.

MR. JARDANEH: Thank you. Good morning, Chair Kirchner and good morning to the ACRS

Subcommittee Members, NuScale participants, NRC staff and members of the public.

My name is Mahmoud M.J. Jardaneh and I serve as the Branch Chief of the New Reactor Licensing Branch, responsible for the licensing of the NuScale US460 design and the Division of New and Renewed Licenses in NRR. Thank you for the opportunity today for the staff to present their review of the select NuScale US460 Standard Design Approval or SDA, chapters and topical reports.

As you are aware, the staff is reviewing all chapters of the SDA concurrently with staggered completion dates based on the complexity of the chapter and the extent of change from the certified NuScale US600 design. Today, the staff will be presenting on their review of the seventh group of the SDA chapter and topical reports, including on the Non-Loss-of-Coolant Analysis Methodology Topical Report and the Extended Asset Cooling and Reactivity Control Methodology Topical Report.

Previously, the staff presented to the Subcommittee on 16 of the 19 SDA chapters and one of three SDA Topical Reports. The staff is finalizing their review of the remaining three SDA chapters and we will soon share their safety evaluations with the

ACRS.

At today's meeting, the staff will focus on the deltas from the design certifications that the NRC approved and the Committee reviewed in the past. The staff will also discuss two remaining open items, one in each of the topical reports to be presented today.

Once again, thank you for the opportunity and we look forward to a good discussion. Thank you.

CHAIR KIRCHNER: Thank you, M.J. Now, we will turn to NuScale. I believe, Kevin, are you going to kick it off for NuScale?

MR. LYNN: Sure, I can do that. Thank you. Good morning, members of the ACRS, NRC staff and thank you for having us here. We appreciate the opportunity.

My name is Kevin Lynn. I'm a licensing engineer at NuScale and I've been with NuScale for over three years. Prior to my time at NuScale, I was working in the Nuclear Navy. I also worked in Part 52 New Design, New Reactor Design with a different design center and also spent time in an operating plant reactor and also on license renewal for operating plants. I'll allow my colleagues here to introduce themselves as well.

MR. BRISTOL: Good morning, this is Ben Bristol. I'm the manager of the system thermal hydraulics team at NuScale. I've been with NuScale for 13 years now.

MS. MCCLOSKEY: Good morning, my name is Meghan McCloskey. I'm a safety analysis engineer with NuScale and I've been with them for about the past 10 years and prior to that, I was with Westinghouse, always focused on safety analysis methodology development and application for design basis events.

CHAIR KIRCHNER: Thank you all for being here in person. Go ahead.

MR. LYNN: Next slide, please. Before we begin, we'd like to acknowledge that our work at NuScale has been supported by the Department of Energy and so we appreciate their support, but also acknowledge that the views expressed during these presentations are not necessarily those of the DOE. Next slide, please.

During the open session for non-LOCA topical report, we will start by talking about the history of the non-LOCA topical report, talk about the non-LOCA evaluation model, what the purpose is and the acceptance criteria that's used to analyze. We'll talk about the relevant power uprate and the design and operating changes that have the potential to affect the non-LOCA topical report and finish with a summary of the evaluation model applicability assessment and any changes that we've made since the prior revision. Next slide, please.

As was alluded by the ACRS, the non-LOCA topical report was previously reviewed by the staff and the ACRS. It was approved by the NRC in 2020 and that approved revision, which was revision three, was used to support safety analyses performed for the US600 design, which utilized the NPM-160 module. That was submitted as part of the review of that.

That revision contains certain limitations and conditions which restricted its use to the NMP-160 design, so when we began the work on our next design, we realized that we would need to make some modifications to that and so therefore, revision four was submitted in January 2023 and it was submitted at the same time as we submitted our FSAR for the US460 design, which utilizes the NMP-20 module.

Since the time of the submittal in January 2023, we have made some updates and changes to the topical report in response to NRC questions and back and forth with the NRC staff. Revision five will be submitted at some point, which will incorporate all those updates, but it has not been submitted at this time. The hope would be that then revision five would become the Dash A approved version for future use. As indicated by the ACRS, due to the nature of the delta review, our focus of the discussion today is on the changes since the NRC's prior approval in revision three. Next slide.

This slide provides an overview of the non-LOCA topical report and methodology and how it fits in with other methodology that we utilize as part of the safety analysis. On the left, we start with certain input parameters related to the plant design, core design, fuel design and the SSC design and those all provide input to the NRELAP5 code, which is our system thermal-hydraulic code. NRELAP5 is then used to generate primary and secondary pressures that are used to assess acceptance criteria and it's also used to determine the exit of the safety analysis via confirmation that we have a safe, stabilized condition. All of that in that first box is the subject of the non-LOCA topical report.

The NRELAP5 output is also used to provide input to the VIPRE-01 code, which is used for our subchannel analysis to determine acceptance criteria for fuel. That's the subject of separate topical reports for the subchannel which have both been previously approved by the NRC. Lastly, there is the potential that NRELAP5 is used to provide input to the dose analysis in the form of mass and energy released and that analysis is done separate from this, but is also the subject of an approved top-four port.

DR. MARTIN: Question?

MR. LYNN: Yeah.

DR. MARTIN: It's Member Martin. The NRELAP5 we, of course, have had other meetings and talked about NRELAP5 or the specific application non-LOCA. Are there any different packages that are used and so we set that up a little bit more. Some applicants will use the same code but then they are in the process of personalizing it. They'll have an input that says this is for this specific application and then for others, what it does it just creates a different flow through the architecture of the code. For instance, one applicant does both Ps and Bs and they'll have a P or a B in one of the cards up front and it will use a different constituent package.

Do you have anything like that in your code?

MS. MCCLOSKEY: No.

DR. MARTIN: Okay.

MS. MCCLOSKEY: No, we just have the normal, you know, the user options for things like choke flow and --

DR. MARTIN: Sure, sure, nothing that you've added specifically that changes the course of events as a consequence of say a different view of the events that you're studying.

MS. MCCLOSKEY: No. Nothing like that that fundamentally changes the models or the structures.

DR. MARTIN: Right. We've also talked about in the previous meetings that you have changed a version or you've upgraded your version, your 1.7, I believe it's still an open item and I'm sure you're rapidly trying to close, but could you just to the extent that's reasonable in an open meeting like this, just kind of talk about from your perspective what remains to be done to close out any questions related to NRELAP5. Maybe it's just administrative at this point, but --

MR. LYNN: So, the only open item at this point is related to a question related to the particular base model that's in use. We have the version, I think we're pretty squared away on the NRELAP version we're using, but as part of that, we have a base model that's used essentially as a starting point for all the event-specific analyses and we made some updates to that base model. The staff is still reviewing those updates as a delta compared to the previous base model that we used prior to that point. There's been some questions about that but we're rapidly reaching convergence on that.

DR. MARTIN: Oh, so prior to that point are you referring to five years ago or six years ago?

MR. LYNN: No, so actually when we submitted in January 2023, we were using a specific version of the NRELAP code 1.6 and the specific version of the base model and since that time, during the course of the review, we made changes both the NRELAP version and to the base model.

DR. MARTIN: Okay.

MR. LYNN: And so the staff started their review and reviewed the delta essentially from the version we submitted in January 2023 prior to what they approved before and now they are reviewing the delta between what we submitted in January 2023 to the changes that we made during the course of the review.

DR. MARTIN: Okay. Are you saying maybe more focus is on really the model and not so much the code?

MR. LYNN: Correct.

(Simultaneous speaking.)

DR. MARTIN: Right, so --

MR. LYNN: And at this point --

DR. MARTIN: Nodalization and some code?

MS. MCCLOSKEY: It's not nodalization, it's more on factors of how we've modeled things, like the feedwater pump response, during non-LOCA events. We've modeled that more realistically now.

DR. MARTIN: Okay. Okay.

MR. LYNN: Yeah, there was an initial condition focused --

(Simultaneous speaking.)

DR. MARTIN: It's state of the art.

MR. LYNN: Some changes to the DHRS, our decay heat removal system, modeling to make it a little bit more realistic. Previously, we'd neglected some portions of the system conservatively. We added those to be more realistic and that was the change then that the staff wanted to --

(Simultaneous speaking.)

DR. MARTIN: When you say realistic, are you implying that -- and maybe I'm reading too much into it, maybe from testing?

MR. LYNN: No, so just component wise.

For example, the DHRS is --

COURT REPORTER: Excuse me, sorry to interrupt. I'd just like to remind folks to state their name before speaking. I'm having a bit of difficulty determining who is speaking since there is no video feed and everyone is in one room.

MR. LYNN: Okay, this is Kevin Lynn. You threw me off. The DHRS receives steam from the steam system and that piping to the DHRS, is a heat exchanger essentially, that piping that carries steam runs and goes through the heart of the refueling coil or the UHS and so there's some condensation that happens as that piping goes through the water before it gets to the heat exchanger.

So, on one hand you could conservatively ignore that, but it is actual heat transfer that's occurring, so we've modeled some of those features.

DR. MARTIN: Okay.

CHAIR KIRCHNER: Maybe you've talked about it before. You're taking credit now and before you hadn't.

MR. LYNN: Okay.

DR. MARTIN: I remember that conversation previously. All right, thanks. That's all.

MR. LYNN: So, to finish this slide just

to point out that this general picture here and this general scope is consistent with what we had when we were here for prior approval of revision three. Next slide, please.

So, now I'll talk about the power uprate and the design changes from the NMP-160 to the NMP-20. The biggest change was an uprate from 160 megawatts hence the name to 250 megawatts thermal, which is our current design, approximately 70-some megawatts electric which was referenced by the ACRS in the opening.

For the most part in terms of non-LOCA, the module SSC design is essentially maintained. There were some changes to the operating conditions, so the normal primary pressure, normal operating pressure increased from 1,850 to 2,000 PSI and along with that, we increased the design pressure of the primary side from 2,100 to 2,200 and the secondary side has the same design pressure.

With the increase in power, we have a larger delta T across the core because we're natural circulation, but we use a constant T(avg) control and that T(avg) was changed slightly from approximately 545 to 540. There was also a reduction in secondary side feedwater temperature and a reduction in the minimum temperature for criticality during startup.

There were some optimizations made to our module protection system for the US460 design. Some of the set points were adjusted to match the changes that we made to the operating conditions. For example, when we increased the pressure, we had to increase the pressure for the trip rated to pressure.

There was also a new trip added on high T(avg) and that was added specifically to terminate some of our slower reactivity transients earlier, like a rod withdrawal happening from maybe 75 percent power wasn't hitting the high temperature and high power set points, but the high T(avg) could reach that earlier and cause a trip.

Finally, we added some additional DHRS actuations and an isolation of the pressurizer line on low pressurizer pressure. The one thing you won't see on here is some of the discussion of the changes to the ECCS. Those are more pertinent to the LOCA discussion which was held previously, so we're not covering those because they don't come into play in non-LOCA.

There was also a change to add an ECCS supplemental boron system. That's not relevant per se to the non-LOCA but it will come up later today when we talk about the XPC topical report. Next slide, please.

MR. ROBERTS: This is Tom Roberts. Just out of curiosity, why did you pick high T(avg) instead of high T(hot)?

MR. LYNN: This is Kevin. We had an existing high T(hot) trip and in this particular case for these particular transients, they weren't reaching the high T(hot) trip as fast as we would like to mitigate them, so in this particular case, they reach high T(avg) sooner than they reach high T(hot), but the high T(hot) is still active.

MR. ROBERTS: Okay, thank you.

MR. LYNN: Next slide, please. This slide shows a comparison of the US460 to the US600. On the left is the US600 which is our certified design and on the right is US460. This kind of demonstrates the changes that we made to some of the operating conditions. For example, the red line at the top of the box is moved upward because we have that higher operating design pressure and the blue line, which is the normal operating pressure, is moved up as well.

You can see the box that we would like to operate in, in which case our safety analysis starts from, is the box with the dotted black lines with

T(avg) green right in the middle. The size of that box is essentially unchanged between the two designs. Next slide.

CHAIR KIRCHNER: Kevin, since you showed it, could I just ask would you just explain you now have a lower acceptable temperature for going critical, what's the design basis behind that?

MR. LYNN: So, that's to allow startup sooner essentially. To reach a startup condition, we have to heat up the plant. So, we have a module heat up system which adds heat, non-nuclear heat, into the system and in the previous design it was a 420, so you had to do quite a bit of heat up of non-nuclear heat and this change allows us to essentially go critical earlier and heat up the rest of the way with nuclear heat.

CHAIR KIRCHNER: Thank you.

MR. LYNN: It was essentially an improvement in terms of start up of plant. Next slide.

We'll talk about the analytical assumptions used in the non-LOCA analysis. The general approach from the previous revision is maintained. In terms of the scope of the event, we analyzed the design basis events from an event initiation until a safe, stable condition is reached. There's kind of two ways that we can reach a safe, stable condition. One is reactor trip and DHRS operation. We have trends that show the temperature is decreasing and pressure is decreasing, so we're on a safe trajectory.

The other is potentially there are some events where a reactor trip doesn't occur, a minor decrease in feedwater temperature, a minor decrease in feedwater flow we can essentially reach a new steady state condition. So, that's the end of the event in terms of the scope of the event progression. Obviously, in terms of plant operation, the operators would at some point need to restore themselves back to where they want to be operating, but in terms of operator action, there are no operator actions credited during 72 hours after initiate event occurs to achieve the safety functions.

We do look at different loss of power scenarios, power available, loss of AC power, loss of DC power to see what's more limiting for a particular set of events.

We do have non-safety related control systems and those do factor into the non-LOCA analysis, specifically if we have a case where the normal operation of that control system would tend to make the plant transient less severe, then we neglect or ignore that operation. On the other hand, if we have a normal operating control system that would tend to make the plant more severe, we do then assume that that occurs. So, for an example, in the case of a heat up event or a pressurization event, where pressure is increasing, the normal response of the pressure control system would be to actuate or to turn on spray or increase spray to turn that event around. So, if we credit spray, then it makes the event less limiting, so in those particular cases, we neglect spray which allows the pressurization to continue and eventually reach a trip set point.

DR. MARTIN: This is Member Martin. To this question of the role of non-safety systems, when you consider with non-LOCA in particular maybe several figures of merit to look at. Some are going to respond conservatively and some will be non-conservative. It really requires a thorough look at these things and not just say attention on maybe the figure of merit with maybe the least amount of margin, right? Because, you know, maybe that one is unaffected or benefits from the role of the non-safety control system, but maybe something else affects the other metrics. Now, obviously you've been working on this for a really long time and I can only imagine how much analysis you've done.

Can you talk a little bit about your approach and this investigation? Is it just kind of brute force, where you kind of evaluated, of course, we kind of know the events, you're more or less a NUREG-0800 you have your own DHRS and all that. But is there a separate kelp file where you just attack this question head-on and identified the events, maybe even a higher level document that, you know, say like a hazards analysis type thing, but one that identifies maybe scenarios from a qualitative standpoint and then those unfortunately seem to matter the most and we go out and determine -- anyway, I'm obviously putting words in your mouth to some extent. Can you briefly go over that about your approach to this sort of thing and how is captured in your QA system or your document control system?

MR. LYNN: This is Kevin. One thing that we do is we do, as you mentioned, we do have experience now using this as this is our second design. So, for the experience we had from the US600, we've leveraged that in terms of generally knowing what transients go where and what types of cases that you need to look at, but certainly as part of the design changes that we made, we looked at wanting to confirm that those behaviors were still true and also see if there were any differences. But for any particular initiating event, we identify first what are the figures of merit for that event, which are most susceptible to that event. For a heat up event, we're not really concerned as much about the fuel response, it's more the pressurization response.

For a cool down event, we're both concerned with the fuel response and also potentially the pressurization. In those cases, where there's more than one acceptance criteria that may be relevant, we're looking at different cases within that analysis to potentially maximize or minimize that particular acceptance criteria. One set of conditions may be worse for the RCS pressure, but a different set of conditions may be worse for minimum critical heat flux, for example. So, within a particular event analysis, there's probably on the order of 50 individual cases, NRELAP cases, that are run to identify different sensitivities to those things. Even that's potentially in the final documentation of that analysis. In most cases, there is a preliminary analysis that's done that looks at a wider range and then identifies that hey, this particular set isn't really that important. We can focus in and go to a finer granularity on a particular area of this analysis domain to try and find that limited case.

DR. MARTIN: Generally speaking, between the US600 and 460, see any real differences coming out of the design, you know, relatively few design changes? Did you see the trends more or less consistent between the two designs? Any surprises?

MR. LYNN: For the most part, things were consistent and I think in our early days, we had some slides in our pre-application meeting comparing the transient progression to show that they were quite similar. One thing that does come to mind is that in terms of the CHF performance, there was a particular nuance of the previous design just the operating domain that we were in that it was sensitive in one direction of biased pressure.

So, I believe a high bias pressure was potentially more limiting for CHF which was a little bit counterintuitive. When we changed our design pressure and increased it, it's one of the changes we made, that particular sensitivity disappeared. As part of that, we've changed our biases to look at both high and low pressure to find which one is more limiting. That was one change that we did identify and the staff asked a question about that and so we made some changes to the top recorded response.

DR. MARTIN: Thank you.

MR. LYNN: Next slide, please.

MR. ROBERTS: Yeah, Kevin.

MR. LYNN: Yes?

MR. ROBERTS: Stop there for a minute, this is Tom Roberts. That last line, the credit for non-safety valves. Where it says related valves failed to trip. Can you explain that a little bit more? It seems like that essentially says single pairs don't happen because there's a back up valve that predominantly actuates.

MR. LYNN: Yes, so for the main steam isolation valves, there's two valves the safety-related valve and the non-safety-related valve. In the event of a single failure of either valve, there's no consequence because the other valve is there to provide that protection. The only noteworthy thing here is instead of two safety-related valves, you have a non-safety and a safety. As part of the review, we did have some questions about that and to demonstrate that it was acceptable to have the second valve be a non-safety-related valve. In terms of their performance, the steam isolation valves are the same. They have the same isolation time and everything. On the feedwater side, the back up, the non-safety-related valve, has a slightly slower closing time. In our analyses where we take a single failure, there is a delta there a little bit of additional flow that can happen in that time delta between the two valves, but we do factor that into our analysis.

MR. ROBERTS: So, what makes a back up valve non-safety? What compromises are made in the quality or something else to not call them safety-related? It sounds like we should just say they're essentially the same valves.

MR. LYNN: They are essentially the same valves. It's really just a QA designation of the additional pedigree. I don't know if you have anything to add, Meghan.

MS. MCCLOSKEY: The regulating valves are going to be different than the isolation valves, but they also have augmented quality requirements applied to them.

MR. LYNN: And the non-safety-related valves are also identified in tech specs and controlled under tech specs and part of the in service testing program, etc., so it's really just a designation.

MR. ROBERTS: Okay, yes, thanks. I guess there was an analogy to the EDAS discussion we've had a couple of meetings ago.

So, that kind of leads to my next question, with is the single-failure assumptions. That's not on this slide but it is in the topical report.

And, there is a specific statement in the topical report that a inadvertent trip of the ECCS valves is not considered a single-failure.

We talked about that in a previous meeting, and I'm just wondering if you've got any more to add on that.

Because it seems like if you've got, say, one of those trip valves out of service, and that's allowed by tech specs that you be down to a single trip valve.

And so a single-failure in the module protective system, would that presumably trip the remaining trip valve and cause the inadvertent actuation.

And, it would seem like that would be a passive electrical failure that you need to consider, which is a, like a trip that's not required or not desired.

It seems to me that's a kind of definite between pass and failure in an electrical system.

And so, I was wondering why you would not include that as a single-failure, or why that would not be rolled up in the single-failure exception that you got previously on the IAB valves. It just seems to me like the same thing.

MR. LYNN: So, one thing to point out here is in particular for this topical report, it's a non-LOCA topical report methodology.

And in our methodology, if we open an ECCS valve, it's no longer a non-LOCA event. So, we don't analyze events with valve openings, with ECCS valve openings, using this methodology.

So from that perspective, the non-LOCA topical report doesn't address valve opening.

But we have heard the concern though and the question before, and we are prepared to discuss that more in detail in the chapter 15 discussion at the next meeting on April 1.

MR. ROBERTS: Okay, thank you.

MR. LYNN: So in terms of the non-LOCA evaluation model, the focus is on the design changes since our prior approval.

In this particular case, those design changes don't have a substantial impact on our event progressions, or the important phenomena.

From a high/low perspective, primary pressure is still protected by lifting of the RSVs if necessary, during an event.

Secondary pressure is protected in two ways. One, the design pressure is equal to the primary pressure, which is unique for our design.

And also, the secondary pressure during an event is limited to the saturation pressure at the maximum T-hot at the primary side.

For minimum critical heat flux, we are limited typically under a high-power or high-temperature condition that might occur during an event like a reactivity insertion event, like a rod withdrawal.

As discussed earlier, we do employ NRELAP version 1.7 now. Previously, we had used version 1.4 and as I mentioned at the start of the review, we used version 1.6 but we're now currently on version 1.7.

We did perform a PIRT previously in the previous revision, in revision 3. And, that PIRT was based on the NPM-160 design.

We did a review and applicability

assessment, and determined that that PIRT remains applicable, and there are no new phenomena that needed to be added or addressed in this revision.

One significant change that we did make is that we performed additional testing for the NRELAP, the validation to specifically on the DHRS performance.

And so, that new testing was added to the assessment basis as part of the overall validation of the code.

In terms of individual events specific analyses methodology, one of the changes we made is to add a little bit more detail on when we need to do additional sensitivity calculations, with an emphasis on the fact that if margin is low for a particular event, more sensitivity is needed.

If you have a lot of margin, you don't need as much sensitivity cases.

DR. MARTIN: Member Martin. Just to ask a question about the PIRT.

What do you do confirm your PIRT? I would imagine do a lot of sensitivity studies particularly, or I mean how formal is that process when you made your initial PIRT over 10 years ago, correct?

And then, subsequent to that do a bunch of sensitivity studies or what? And then for this design, did you just kind of repeat it all?

MS. MCCLOSKEY: For this design, we, so for the, in terms of confirming the PIRT, originally we focused on understanding where the high ranked phenomena had been addressed.

Because the original PIRT that was done was fairly comprehensive in nature, when we focused on the system thermal hydraulic response.

So a number of our phenomena are actually addressed in sub-channel analysis work.

So, recognizing where our methodologies landed at the time for the DCA, was the first part of that.

And then, building on the understanding of the design response I'd say in terms of what was important, was a factor in how we originally assessed the PIRT.

And, we continued that process with the upgraded design and did an applicability assessment that compared the, compared the transient progressions and what was driving our margins to acceptance criteria between the designs, and how that related to the PIRT phenomenon.

I think it, our PIRTs, our PIRT was

initially very detailed I'd say, in terms of the components and the phenomena.

And with the body of work that we've done thus far, especially a non-LOCA space, our margins really come down to fairly simple design limits, which Kevin covered at the beginning of this slide.

DR. MARTIN: That sounds consistent with my own experience. Generally, the PIRT committee will find many more things they consider important, like -- subjectivity to it.

And then, when you get into it, you realize yes, there's really a much smaller set but as the consequence of having your PIRT team, your kind of laden with their conclusions.

And, that you end up treating maybe things that are not as important as, say, the first guess.

So, would you say then that's kind of consistent with what you saw over the last decade?

MS. MCCLOSKEY: I think that's reasonably consistent.

And the other thing that we've noticed is that the original PIRT work that was done, tended to define out like very, very specific phenomena that particularly when it came to the steam generator and the DHRS heat transfer, it's been more, it's been more reasonable for us to treat those things as steam generator heat transfer DHRS heat transfer versus condensation inside.

And then, the convention or boiling on the outside of the tubes and the DHRS kind of takes a look at that system a little more holistically.

DR. MARTIN: Okay, thank you.

MR. LYNN: Again, in terms of methodology changes for event specific analyses, in general we expanded the scope of our analyses to vary parameters, rather than bias in one direction.

I gave an example earlier related to initial pressurizing pressure. So, that's one particular example.

And then, the last three bullets there is we've made some changes to allow options for certain analyses.

So, for the radiological analyses, previously we used direct output from the NRELAP analysis as input for those.

But we've also added an option for a potential to determine using alternate means to terminate bounding input, so that we don't have to directly translate and wait for that output from NRELAP to use as input.

Similarly, for the control rod drop analysis, we have the potential now, we've identified a method where you can bound that analysis so that you don't have to perform event-specific analysis. Instead, you can bound it by the single rod withdrawal.

And then finally for the born dilution event, we have made some changes to allow for the level increase that occurs during that born dilution event, to be used to result in termination of the event, and confirmation of shut down margin.

Overall, in terms of the open session our conclusion is that the evaluation model for non-LOCA remains adequate to evaluate an NPM design.

Next slide.

And, that concludes our open session presentation.

CHAIR KIRCHNER: Thank you, Kevin.

Members, any questions at this point? I assume you're all waiting for the closed session.

Okay, Mike. Do we go next to NRC staff or?

MR. SNODDERLY: Yes, please.

We had a break scheduled on 10:45, and I think we should stick to that, or around that time. But yes, let's let the staff get started.

CHAIR KIRCHNER: Okay. All right, thank you. So, for those listening in, just a brief pause and we'll have the NRC staff present their evaluation.

MR. HAYDEN: Thanks. My name is Tommy Hayden. I'm a project manager in the New Reactor Licensing branch, in the Division of New and Renewed Licenses, in the Office of NRR.

I am the PM for the topical report for non-loss of coolant accident analysis methodology.

Contributors to the staff's review of this topical report are Zhian Lee, Antonio Barrett, Adam Rau, Peter Lien, Ryan Nolan, Sean Piela, Carl Thurston, Dong Zheng, Joshua Miller, Rosie Sugrue, Upendra Rohagti, Andrew Dyzel, and Marvin Smith.

As you'll see, those are from the Methods branch in the Division of Safety Systems, or contractors and consultants to that.

My apologies to my colleagues if I've pronounced those horribly. I've done my best.

Here's one I can do. Tommy Hayden again. I'm the project manager for this, and then Getachew Tesfaye, is the lead for NuScale.

As an overview, NuScale submitted the non-loss of coolant accident evaluation model topical report, rev. 4, on January 5, 2023.

The topical report was formally accepted for review on July 31, 2023.

The NRC conducted an audit of the topical report from March 2023 to August 31, 2024. Within that audit, 49 audit issues were resolved.

And for those not resolved, seven RAIs were generated. One RAI remains open. Kevin and Member Martin discussed that a little bit, and I'll have a slide here shortly.

There are two significant differences between the draft SER submitted to ACRS on February 4, 2025, and the draft SER published on February 26, 2025, to support this meeting.

The open item as discussed previously, relates to RAI non-LOCA.LTR 50. In that issue, staff is working to understand changes made to the base model.

Those modeling changes revolve around DHRS models, and modeling of core flow distribution.

As Kevin alluded to the path forward here, we are converging on an understanding and resolution to this issue.

We continue to discuss the modeling changes and have high confidence the issue will be resolved shortly, with minimal impact to the SECI evaluation.

As noted, the two significant, there were two significant differences from the safety evaluation that we submitted to ACRS early in February, and the SER we submitted just this past week.

Those differences are as follows. In section 3537, NIST-2 steam generator decay heat removal system integral effects test.

The staff expanded their assessment of the NIST-2 DHRS scalability. And that came as a result of a closure of an open item, RAI non-LOCA LTR 3-9 18, 19, 20, 21, and 69.

And section 3-9, quality assurance, and section 4-0, limitations and conditions. Again, as a result of the closure of an open item, the removal of the limitation in condition number 10.

And then the modification to relay a finding in the 3-9 section of reasonable assurance related to implementation of QA controls, consistent with Reg Guide 1.203 for the non-LOCA --

I'll now pass it to Zhian for changes from the LTR rev. 3 to rev. 4.

MR. LI: Thank you, Tommy, for the introduction.

My name is Zhian Li and it's little bit

hard to pronounce, Zhian, but yes.

Good morning, Mr. Chairman, good morning ECRS members, and good morning colleagues. I'm glad to have this opportunity to present to the committee about our review about the non-LOCA topical report.

I'm the team lead. I have a whole bunch of a team -- their education and their support the completion of this review, and I really appreciate you -- see here.

The review, we focused on five areas. Number one, the design change of the reactors from NPM-162 to NPM-20.

The second, we reviewed the phenomena for the identification and the ranking table. And then, seeing quite a bit work on that.

So we try to find to whether there are any design change, or the impact, the PIRT table again.

And the then third one is there change in the methodology, the evaluation methodology for non-LOCA events.

As the NuScale has spoke on that -- go ahead, do you have a question or no?

DR. MARTIN: Well, yes, I do.

MR. LI: Yes, go ahead.

DR. MARTIN: Hide my little green light

here.

Now you were careful with your words, I think. You said you spent a lot of time looking at the PIRT.

Now, I'll ask you kind of the same question that I asked Meghan. Did you do a sensitivity studies or were your, that attention on PIRT more qualitative?

MR. LI: Well, we did not do sensitivity study. We basically looked through, well not a lot of -- really, yes, take that word back.

And we look at detail, put it this way. And that's our first task basically during the review is first to look at yes, what the design change, what the impact, if there are any to the PIRT team.

And then, the team spent time on that and we get details, and we try to see whether compare with the previous revision and to the design change, to see if there are any impact.

DR. MARTIN: And, maybe just to follow up with the PIRT. I can tell from the gray hair you've done this for a while.

MR. LI: Thank you.

DR. MARTIN: And, so you've seen other applications and not every, going way back but not looking at just reply PIRTs, but PIRTs for non-LOCA have been around for at least as long as PIRTs for the most part.

Compared to typical PWRs, does, do those PIRTs more or less cover 80-90 percent of everything that you otherwise see with the NuScale?

What stands out uniquely with NuScale? Now, I would say the role of the DSRS, which of course is getting a lot of attention. Yes, that's an obvious one.

Anything else, and then natural circulation.

MR. LI: Based on our understanding of the design, I think the fundamental difference that, so is not, there's in the primary loop, you don't have a pump to drive.

DR. MARTIN: Right.

MR. LI: Yes, and that the, really the phenomena for the natural circulation, which was also relates to the power density could drive the flow in slightly different way.

It's not well-controlled. In the PWR, you have a pump and you know what is a certain --

(Simultaneous speaking.)

DR. MARTIN: -- are low.

MR. LI: Right, yes, you know exactly what your pump needs, but this one you don't. I think that's more the fundamental difference we see.

DR. MARTIN: Thanks.

MR. LI: And, that's just to mention that the second, the third part of was you look at the change in the method of evaluation, which the NuScale already discussed that.

They have a new methodology for bounding to calculate the bounding radioactive material release if you have a leak in the primary system, more like a CVCS.

But broadly, this is beyond the non-LOCA before that's covered in other topical report for the small LOCA, the small break, or small leak that it would, able to use a bounding source.

Just a estimate how much I can leak and then, what the timing of the leak. And then, they say okay, I was use the bounding number and then -- into the radiological consequence application.

CHAIR KIRCHNER: To that point about bounding assumptions, LOCA and even for NuScale LOCA, you have something like Appendix K.

And non-LOCA, there's certainly more latitude. But historically, they've been deterministic-type approaches.

Pretty well understood about what uncertainties end up being addressed in a bounding sense.

Clear in looking at the evolution of NuScale, that the DHRS has been a particular component, a particular contribution to core cooling that in the earlier version, it was a much more obviously conservative type assumption. They have moved more towards realistic. It's obviously getting plenty of attention.

Has there been anything else kind of like that, that has gotten unique attention with how they're addressing uncertainties that you probed?

MR. LI: Actually, not really in this particular --

(Simultaneous speaking.)

CHAIR KIRCHNER: Application.

MR. LI: -- case -- application. Because NuScale did not provide a specific method or evaluation for the bounding calculation methodology. So, that's one of the limitation, the condition.

Instead, it says the applicant was responding or use, referring to this topical methodology in this topical report with having to do their analysis to determine what's bounding. And then, what would be the certainty.

CHAIR KIRCHNER: Or something like just the uncertainty of a natural circulation itself. You could maybe bound it with low resistance or something.

Did they do anything particular to address uncertainties with the natural circulation phenomenon?

MR. LI: Not in this methodology. You could be wrong, correct. I don't think they really --

(Simultaneous speaking.)

CHAIR KIRCHNER: Relying mostly on test data to support what their --

MR. LI: Yes, basically mostly on their design they say what are the lines, the size of a line. For example, if you have a CVCS line break or something.

But just not, and there was a time you would identify there's a leak, and then their potential was time you --

I think that's the idea how they're trying to determine, rather than go to a detailed NRELAP5 calculation is okay.

With just the estimated total, potential total release, and the maximum time.

CHAIR KIRCHNER: Relying a lot more on

realistic type behaviors, and with some expectation to have margin, reasonable margin.

MR. LI: Right.

CHAIR KIRCHNER: Maybe not so quantified as a, say --

(Simultaneous speaking.)

MR. LI: And deterministic --

(Simultaneous speaking.)

CHAIR KIRCHNER: -- criteria.

MR. LI: Yes.

CHAIR KIRCHNER: But, okay.

MR. BARRETT: This is Antonio Barrett, of the NRC staff. Yes, so like one thing you were asking about the natural circulation.

In their model, they actually --- this is stuff that they already did before. It's not new for this, for what they did now.

But they biased the loss as higher now so natural circulation.

CHAIR KIRCHNER: Okay.

That's why -- threw that out there, yes All right, thanks.

MR. LI: So we'll move on.

The next one actually we're looking into the code updates, and the NuScale during the review, and also in the application they have a 1., I think 1.4.

And then, they move from 1.4 to a new version, 1.7. And then, this is a change during the review. And, we look into the -- the version.

The other one is the change associated with the code bench marking, or we validation. This is all tied to the new tests, and the test result.

Certainly, this one will get into that in the also the update, the CHF correlation for screening the cases sub-channel now.

What NuScale does is they use NRELAP5 to run bunch of cases, identify those steps potential challenge to the system, I think the NCHFR, the minimal critical graphs.

And then, so they identify this case and then throwing into a sub-channel analysis the use of viper code to get a more detailed result, more accurate result.

And, in the previous version, they have a look-up table. I will try to pronounce it. They call it the -- Correlation. It's the look-up table.

And then, they add two more. One is the Correlation. The other one is, yes, well, yes, there's another one. And there are two analytic.

I think this with the new correlation will give them more accurate screening and for the next step average.

So, and also NuScale updates theirs in response to revision 3, they try to revise some of the limitation, the conditions you see.

And, the staff review that limitation condition and with respect the new design. And then, come up with some of the change limitation and condition.

And we will get into that during the closing session, the closed section, which I have a much more detailed discussion why we have this limitation condition.

But next one.

So, we already talk about the revision 1.7, the base model change. And, this two tests and the test result, and which we'll get into the review the scaling.

Whenever you have to code bench marking on validation, you have to test what you have to address the similarity, scalability, and any distortion.

I think that would be discussed more detail in the --

Yes, some of the events may get into

extended, long-time pulling. That would be Howard's in the next topical report, which Antonio and company would present.

Next slide, please.

Here, the limitation and conditions. The number 1, 7, 9 are the new ones. And, the rest are the, from the previous revision of the topical report.

We revised some of the limitation and condition but not major change. But the previous limitation and condition as you clearly see, the first one is really relates to the NPM-20 design, which some unique design features and then you have to address.

And, number 9 is talk about the radiological, using the bounding methodology for radiological analysis.

And, number 7 is really about the code version as you all know. The code version is critical for any change. You change the code, try to address certain phenomena, and then so that's our limitation condition.

I think that's conclude my presentation.

CHAIR KIRCHNER: Yes, thank you, Zhian.

So, in conclusion, while there are some differences between the current and previous revision, the staff found the applicant provided sufficient information to support the staff's safety finding.

The staff found that an applicant that references this topical report with the limitations and conditions, will meet relevant regulatory requirements pending review and approval of that application.

Questions? Members?

CHAIR KIRCHNER: I have one, Tommy, and Zhian.

MR. LI: Yes.

MS. PATTON: And, that is why are you limiting it to NPM-20? Why wouldn't it not work for the certified design as well?

MR. BARRETT: I can --

MR. LI: Antonio, I can speak too and you can supplement. Becky, go ahead.

MS. PATTON: Yes, this is Becky Patton, I'm the supervisor from Reactive Systems.

Yes, so the staff looked at that early on and the way I think that it was requested, it wasn't just backward looking to the NPM-160, but it was also forward looking to other module designs that would have certain features.

And, when we approve a topical report methodology, we don't do the forward looking like if other applicants, other technologies, BWRs and PWRs when they come in.

You have to look at the sort of the technology I want to say family, but that specific design like for BWRs. You'd have BWR 3s, 4s, 5s, right?

And, you come in with the topical report and you say I want to cover these types of designs, but we don't do a forward looking because that would require the staff to look at all kinds of other things that you can do with that design.

So, we looked at that early on and the forward looking thing was sort of off the table, as something that the staff could entertain.

The backward looking was really a practicality of it for the 160, that that would have required all of the RAI responses, all of the considerations and everything to have also considered the 160.

And so, there were some early on engagements at the management level to, the decision was made to take that off the table as well.

It doesn't mean that they couldn't come in at some future time for an applicability. There's certainly that allowance within the limitation and conditions. But it was mostly a practical determination.

CHAIR KIRCHNER: Yes, I wasn't thinking of forward looking, I was just thinking backward to the DCA, and overall I think the methodologies enhanced and obviously using an improved and updated version of NRELAP.

So, my thinking was well, it would work as well for the former design at this point. But I think this is a trend in all your TRs on methodologies, to kind of restrict it to the application at hand.

But it just strikes me that they made some significant improvements in their modeling capability, and that it would be a if they wanted to revisit the previous design that was considered for the DCA, the methodology would be applicable, as well.

So, I guess this is just at this juncture, standard practice to somewhat limit the TRs to the actual application at hand, and --

MS. PATTON: Yes, I wouldn't say that. I wouldn't say it's -- standard.

MR. LI: Definitely it's not.

MS. PATTON: Oh, I'm sorry.

CHAIR KIRCHNER: Yes, go ahead, Becky.

MS. PATTON: Yes, Becky Patton again.

Yes, I wouldn't say it's necessarily standard practice. Like I said, it was a practicality of getting through this review on a predictable timeframe. And not having to do a backward look as well.

Like I said, the condition and limit is written in such a way that you can do a fairly straightforward applicability-type review in the future.

If the backwards look to the 160's designer also for any forward look for a future design, that's also written in there.

So, I wouldn't say that it's our process going forward. We certainly do topical report reviews for the obsolete too, that are sort of stand alone where you're looking at multiple technologies.

This was really a practicality --

(Simultaneous speaking.)

CHAIR KIRCHNER: Okay.

MS. PATTON: -- of this review. That's the effect the decision that was made.

CHAIR KIRCHNER: All right, thank you.

Questions?

So, at this point, is this a good juncture to take a quick break?

MR. SNODDERLY: Perfect, you're right on time.

CHAIR KIRCHNER: Okay.

MR. SNODDERLY: It's 10:40 and we had a break scheduled for 10:45 so -- with you.

CHAIR KIRCHNER: Let's go to 10:55. We'll reconvene at 10:55 Eastern Time and we'll take up an extended, I have a feeling, TR.

Thank you.

(Whereupon, the above-entitled matter went off the record at 10:38 a.m. and resumed at 10:55 a.m.)

CHAIR KIRCHNER: Okay, we are back in session and we are going to turn back to NuScale, and we are taking up now the Extended Passive Cooling Topical Report, and I will turn to Ben Bristol.

MR. BRISTOL: Good morning. This is Ben Bristol. I'm the manager of the System Thermal Hydraulics Group. We'll go through quick introductions and then Tom is going to kick us off.

MR. CASE: Good morning. My name is Tom Case. I'm a licensed engineer with NuScale. I've been with NuScale for about two years and in the nuclear industry for about 14 years, and I'm a licensed professional engineer.

MR. CODDINGTON: Taylor Coddington, Safety Analysis. I've been with NuScale about seven years.

CHAIR KIRCHNER: Just speak up a little more, Taylor.

MR. CODDINGTON: Taylor Coddington. I've been with NuScale about seven years in safety analysis.

CHAIR KIRCHNER: Thank you.

MR. CASE: So, this is the open portion of NuScale's presentation of the Extended Passive Cooling and Reactivity Control Methodology Topical Report. Next slide?

This portion will cover the evaluation model scope, regulations, and acceptance criteria, the NPM design features related to the methodology, phenomena identification and ranking table or PIRT evolution, and the evaluation model structure, validation basis, and adequacy assessment and conclusions. Next slide?

This is a new topical report that was developed to support the 250 MWt NPM design and SDAA submittal, but is applicable to NPMs that meet the design requirements and conditions specified in the topical report.

The scope of the methodology covers

analysis of long-term cooling and reactivity control following the short-term response to required design basis LOCA and non-LOCA events.

The regulations applicable to the topical report include 10 CFR 50.46(b)(4) and (5), and NuScale principal design criterion 35 for long-term ECCS cooling and maintaining a coolable geometry, NuScale PDC 34 for extended DHRS cooling, and GDC 26 and 27 for reactivity control.

The methodology also supports an exemption to GDC 33 for a safety-related system to provide makeup in response to reactor coolant leakage. Next slide?

So, the applicable regulatory requirements translate into three safety objectives, decay and residual heat removal, reactivity control, and maintaining coolable geometry. The methodology uses the following acceptance criteria corresponded to those safety objectives.

The acceptance criteria are collapsed liquid level remains above the top of the core, the reactor core remains subcritical, and boron concentration remains below precipitation limits, and these acceptance criteria need to be met for 72 hours after event initiation and the subcriticality analysis assumes the highest worth control rod remains withdrawn from the core. Next slide?

DR. PALMTAG: I just have a question on the k effective equals one, plus one. For normal shutdown margin calculations, you usually see something like shutdown margin with one percent, so it might be a 0.99 factor plus uncertainties. Can you tell me why it's one here?

MR. CASE: Yeah, so for the long-term cooling analysis and reactivity control, we're looking at post-event initiation subcriticality as an acceptance criteria, and so that's different than shutdown margin as defined by tech specs, which would basically establish initial conditions or ensure initial conditions are maintained during normal operation.

And so, the shutdown margin calculation controlled by tech spec is different than what the long-term cooling analysis is analyzing, and so the k effective less than one is an appropriate acceptance criteria for the long-term reactivity control given the assumptions and conservatisms that are applied to the methodology, and those conservatisms will be discussed in the closed session.

DR. PALMTAG: Okay, so there's no margin

per se on the shutdown. You're assuming all of the conservatism is built into the modeling, I guess?

MR. CASE: Correct, and that shutdown margin calculation in tech specs does include a margin prior to event initiation, whereas the acceptance criteria we're looking at here during the long-term cooling is just k effective less than one. Next slide? And I'll turn it over to Ben Bristol for design features.

MR. BRISTOL: Good morning. This is Ben. So, we wanted to take a minute to just kind of talk through some of the passive cooling features. These have been described to the ACRS previously in other presentations, but specifically with respect to the long-term cooling conditions. So, just as a quick orientation, after a LOCA event or some event where ECCS is required, the function is all about depressurizing the systems.

So, what happens is we have water redistribution from the RCS into containment, a level is established in containment, and the vent valves and the condensation on the containment wall is used to depressurize the system.

Once pressure equilibrium occurs, then recirculation is passively provided based on a level head difference between the liquid inside the containment compared to the liquid level inside the RPV.

Under these conditions, the HRS is also active. However, mostly the steam generator tubes are uncovered. So, inside the RCS, condensation is occurring on the tube, the outer tube walls in addition to the condensation that's occurring in containment itself.

So, the distribution of the reactor coolants is really established based on the pressure drop, the vapor pressure drop, the pressure drop across the vent valves. We've described previously some optimization and the differences between the NPM-160 design and the NPM-20 design.

That included a key feature change, which is the reduction of one of the vent valves, so three vent valves to two vent valves. It's this long-term cooling analysis and behavior that demonstrates the appropriateness of that sizing change and it's really driven by the containment wall heat transfer rates, which we will present on the next slide if you go to that, Wendy?

In the XPC LTR, we consider a variety of different exceptions criteria. One of those looks at biases and conservatisms that maximize the containment heat removal, and another analysis looks at conditions where we minimize the containment heat removal in order to demonstrate that depressurization functions still occur.

Specifically, we look at sensitivities on pool temperature, one of the main drivers, and what we wanted to point out in this slide is the difference between these two figures, so the equilibrium level under the minimum pressure or maximum heat removal conditions.

The equilibrium level is about five feet of margin above the top active fuel, so that's the liquid level inside the RPV compared to the top of the core. In contrast, the figure on the right shows under the maximum temperature conditions and minimum heat removal conditions the overall system pressure remains higher.

The vent valve capacity is not tested as severely and that results in a much higher equilibrium level. So, we reach an equilibrium state of about ten feet or about twice the margin under those conditions.

CHAIR KIRCHNER: Ben, could you go back to your previous picture? Just I wanted to ask you to address the change. One of the changes is your ultimate heat sink pool level.

I don't know if that previous picture, one slide back, if that's to scale, but I don't think that's the level that we're going to see actually in the NPM-20 design. I think your level is significantly lower on the containment vessel.

MR. BRISTOL: Yeah, that's correct. This is a non-scale --

CHAIR KIRCHNER: Schematic.

MR. BRISTOL: -- schematic.

CHAIR KIRCHNER: Yeah.

MR. BRISTOL: The equilibrium level and the DHRs aren't quite scaled here either, but roughly the pool level is around in the pressurizer band I guess I would say.

CHAIR KIRCHNER: Several feet above the DHRS heat exchanger.

MR. BRISTOL: That's correct.

CHAIR KIRCHNER: And that's reflected now going forward to what you were presenting in the maximum temperature conditions because that pool level would have an impact on where you wind up in the long-term.

MR. BRISTOL: Yeah, that's correct. So, if you can consider the condensate, the containment condensing surface area, it's directly proportional to the pool level. The space above the pool has very little heat transfer rate.

It heats up essentially to the steam temperature and it does very little heat transfer work, so reducing the pool level allows us to optimize the thermal hydraulic response under the maximum cooling conditions. Thanks, Wendy.

Okay, so switching gears here a little bit, one of the other topics that we spent a fair amount of review time with in the DCA or NPM-160 design was under the conditions where we were condensing either on the containment wall or on the steam generator walls, tube walls inside the RCS.

The characteristics of boron transport, generally, boron is left behind when the water boils, and therefore, the condensed water is of a deborated state or a zero boron state, pure water in that regard. So, the core can create a little bit of a distilling effect, and the areas where condensate accumulates are therefore diluted relative to the average.

So, one of the concerns was downcomer dilution, whether it be from the recirculation from containment or direct contribution of condensate from the steam generator tube walls. In order to mitigate that more thoroughly in this design, we've included some passive features.

They're simply flow paths, liquid flow paths in the figure here. We have the four sets of holes in the upper riser. Those are there under conditions where we have extended DHR. DHRS cooling can shrink the RCS, and that results in the level dropping out of the pressurizer and up to and including uncovering the riser.

Under these conditions, the four sets of holes allow for continued circulation of the RCS loop to ensure that any condensing that's occurring in the steam generator tubes is overcome by the natural circulation flow paths in order to keep a relatively uniform concentration in the RCS.

Similarly, under ECCS conditions where the upper four sets of holes uncover, you have another set of holes in the lower riser, and these provide the same effect of allowing transport of more highly borated RCS liquid in the core and upper riser region to mix with the condensate that's recirculating, whether it be from the recirc valves in the containment or from the steam generator tube condensation itself. I'll pause for any questions on this. We're going to switch gears again on the next slide. Thanks, Wendy.

Okay, the last design feature that I have to present here is the supplemental boron components that we've added as part of ECCS. So, there's two sets of components here on the diagram. We have -- the way this system works is we've got a dissolver basket or container where we have boric oxide pellets, and those are maintained in containment throughout the core cycle.

In the event of the need for an ECCS, this system passively works to collect condensate, the condensate that's collecting on the containment wall, redirect it through the basket and create liquid boric acid that mixes with the liquid in the containment, which then is recirculated through the recirc valves into the RCS to provide the additional reactivity control and hold down to support the long-term cooling acceptance criteria that Tom described.

So, the features primarily associated with the dissolver basket are those in the upper portion of containment. In addition to that, we have what we call the mixing tubes in containment, and what that does is it redirects pure condensate, so deborated water, from the condensing walls down to the bottom of containment.

What this allows for is any borated accumulation that occurs in the lower containment region to eventually be transported back upward through the combination of convective effects, as well as simple mass turnover that's provided by the tubes that deposit the lower borated water to the bottom of containment, the lower mixing tubes. If there's on questions on that, we'll --

DR. PETTI: Ben?

MR. BRISTOL: Yeah?

DR. PETTI: This is Dave. Just during normal operation, what's the atmosphere in containment? It's evacuated, right?

MR. BRISTOL: Yes, it's evacuated normally around one PSIA.

DR. PETTI: I'm just wondering what happens to the lower boron oxide just sitting there, you know, for a long time, whether there's any potential degradation. The passive pressure of water vapor would be pretty low, I guess, in PSI, okay.

MR. BRISTOL: Yeah, generally, the RPV is quite high under the conditions, so there's some radiative heat transfer that's occurring. Depending on where the components are located, they can be quite hot under normal operating conditions.

Most things attached to the containment wall tend to stay closer to the pool temperature, but there is a heat balance there between the heat loss through the conductive effects and the heat addition through the radiative heat transfer.

DR. PETTI: You check, at least on the first part, every so often.

MR. BRISTOL: Yeah, the qualification of the boron pellets is part of the program.

DR. PETTI: Okay.

DR. BALLINGER: Yeah, this is Ron Ballinger. What's the packing fraction in there? In other words, you've got, I'm assuming, spherical pellets of some kind.

So, you dump them in here, and if the packing fraction is above a certain number, you don't have a continuous flow path through the bed, but if it's low enough, you do have a flow path, a continuous flow path, excuse me, through the bed, and that would avoid this issue that we're sort of dreaming up, I guess, of reconsolidation of these pellets to make a solid mass as opposed to so that fluid can't get through.

PARTICIPANT: That is something that is

addressed in the XPC LTR itself. There's correlations that we found for pellets being dropped, and what configuration they form, and the path factor that they would result in, and demonstrating the environmental qualification of the pellets is something that is being considered.

MR. BRISTOL: Yeah, and specifically, I think we've got some more details in the closed session.

DR. BALLINGER: Okay.

MR. BRISTOL: We can get into that and some of the testing that we did as part of that.

CHAIR KIRCHNER: Ben, what happens during the refueling operation? You don't -- you know, you keep -- that upper part of the containment remains dry, so to speak, or I think --

MR. BRISTOL: Yes.

CHAIR KIRCHNER: -- or it floods and you replace them.

MR. BRISTOL: Yeah, so where those are located is below the level of the pool. Obviously, we needed the condensing surface area above over where the basket, the dissolver basket is located, so that was one of the challenges in trying to figure out the design.

So, if part of refueling floods the reactor module up to the pool level before it's unbolted, so the bed will get flooded, it will dissolve from there, and then as part of operations, the upper module goes for inspections in the dry dock, comes back, returns flooded as part of the restart operations, then containment flood and drains are used to drain containment --

CHAIR KIRCHNER: Right.

MR. BRISTOL: -- at which point there's an operation where the pellets are installed and confirmed to be relocated back in the basket, and from that point on, then the containment atmospheric conditions are controlled such that the boron doesn't dissolve from there until ECCS operations is required for some transient.

DR. PALMTAG: Scott Palmtag. Just to confirm though, the way you've installed the dry pellets, they're not flooded.

MR. BRISTOL: That's correct.

DR. PALMTAG: They remain dry --

MR. BRISTOL: Yeah.

DR. PALMTAG: -- until the next refueling.

MR. BRISTOL: That's correct. Okay, Wendy, next slide?

MS. McCLOSKEY: Okay, this is Meghan and I'll pick up here to talk about, first about the PIRT evolution for this topical report. NuScale had previously developed PIRTs for extended ECCS cooling or extended DHRS cooling for the NPM-160 design, but we took that work and reassessed it holistically because we now had different acceptance criteria as well as design changes to consider.

So, we started right back at the beginning in considering what phases and figures of merit were relevant for the phenomenon and that's what's shown on the table at the bottom here for the NPM-160 design on the left and then the updated, the 250 megawatt design that's part of the SDAA on the right. For LOCA, phase two is the same. That's really no different here.

For non-LOCA and extended DHRS operation, with the previous design, we had a couple different extended DHRS phases depending on whether the riser level was above the top of the riser or whether the DHRS cooling had shrunk it to below the top of the riser and you had intermittent or perhaps interrupted natural circulation there.

With the upper riser flow paths that Ben pointed out with the four different levels there that are sized to maintain liquid flow over top of the steam generator during extended DHRS operation, we're really more focused now on phase three and stable natural circulation.

And then with respect to figures of merit, the NPM-160 design, we established different design criteria, particularly in the US PDC 27, where I'm going to get this mixed up with 26, in that 27, the long-term subcriticality was demonstrated with other cold conditions with all rods in, and with the worst rod stuck out condition, we evaluated that low power recriticality and demonstrated that the fuel cladding remained intact by demonstrating margin to the correct heat flux ratios, low pressure, low power recriticality conditions.

So, now with the design criteria to remain subcritical considering worst rod stuck out, our decay heat source long-term is, or our core heat source long-term is decay heat levels, and under that condition, demonstrating core cooling is met by demonstrating that our collapsed liquid level remains above the top of the core and we maintain a coolable geometry, and then subcriticality remains a figure of merit as well as an acceptance criteria here.

So, that really shifted how we were looking at the PIRT and some things became differently important as we went through that process. Next slide?

In terms of the structure, we've got a couple of key pieces. We're continuing to use NRELAP5 as the thermal hydraulic engine that's driving the methodology, and we used the results from the code calculations to demonstrate that the collapsed liquid level is maintained above the top of the fuel and to evaluate the containment response.

That's basically the same as the scope that we had performed for the DCA and essentially the same methodology there, and then NRELAP5 also provides the thermal hydraulic input boundary conditions for the transport analysis.

We used SIMULATE5 for the core reactivity analyses, and that determines the critical boron concentrations as well as the initial starting boron concentrations because we're evaluating a range of operating cycle exposures and operating histories, different shutdown times, and evaluating conditions for a range of thermal hydraulic conditions that could potentially occur during long-term cooling.

And then the boron transport calculations really bring all of the pieces together. We have this currently implemented in MATLAB scripts, but it could be done in other applicable computational tools.

So, the topical report provides the methodology requirements for the transport analysis, and this is where we map the NRELAP5 thermal hydraulic conditions in the context of the different boron transport regions that we're evaluating and the boron loss terms or addition terms from the ESB, and we compare those concentrations to the critical boron concentrations calculated by SIMULATE5 for those thermal hydraulic conditions in order to demonstrate subcriticality.

And the boron transport analysis for precipitation is similar except that we are treating the loss terms differently because it's the opposite directions of conservatism and we're comparing against solubility limits rather than critical boron concentrations.

DR. PETTI: Meghan, just a question on the precipitation. We know the solubility of boric acid, but sometimes in some systems, radiation fields can cause boric precipitation and then, you know, you're a chemical beaker, so it's important to make sure there's good margin. Is there always, you know, good margin relative to --

MS. McCLOSKEY: Yes, yeah, we don't need

a lot of additional boron to maintain subcriticality, and so that's 25 to 30 kilograms, I think, per dissolver inside of containment. So, our source term for boron addition is much smaller than what we typically see in like operating PWRs.

DR. PETTI: Okay.

MS. McCLOSKEY: And so, our concentrations remain commensurately lower.

DR. PETTI: Okay, great.

DR. MARTIN: This is Member Martin. RELAP, the way it models reactivity is not at all like, say, any other reactor physics code, right. You just wouldn't give it a boron concentration and expect it to reflect reality. It's really about the delta, and I expect that you're using a point kinetics model on --

MS. McCLOSKEY: We're not using RELAP's reactivity models at all in the long-term cooling.

DR. MARTIN: Right, okay, so you're not even doing like a delta reactivity --

MS. McCLOSKEY: No, we're --

DR. MARTIN: You track boron.

MS. McCLOSKEY: No, we're not tracking -- we're tracking boron through the MATLAB script.

DR. MARTIN: So, you don't model boron in

NRELAP5?

MS. McCLOSKEY: Correct.

DR. MARTIN: Okay, so this is all outside?

MS. McCLOSKEY: Yes.

DR. MARTIN: All right, I need to think harder about that.

(Laughter.)

DR. MARTIN: All right, thanks.

MS. McCLOSKEY: All right, next slide? So, in terms of the validation basis for the method, our NRELAP5 validation basis is probably pretty familiar to folks at this point. We are continuing to build on the basis established for the LOCA and the non-LOCA EMs, and then we have additional specific long-term cooling testing that was performed at the NIST-2 facility.

Taylor briefly mentioned the boron dissolution testing that was done. That was separate effects testing that we performed to assess the methods for slow-biased or fast-biased dissolution in the dissolver baskets against that test data and confirmed that our methods would bound the measured data in whichever direction is conservative for a particular transient evolution.

SIMULATE5 has an extensive validation

basis and use cases developed for a wide range of other applications, and what we've done particular to this evaluation model is develop a nuclear reliability factor or NRF specifically considering the extended passive cooling conditions, and that is included in the critical boron concentration to account for uncertainties associated with the reactivity balance there.

And then in terms of the boron transport methods and the adequacy basis, a lot of this relies on the thermal hydraulic input, and it also relies on ensuring that we have conservative treatment of the phenomena that are specific to the boron transport of how that boron is being transported within the module. Next slide?

Overall, in the adequacy assessment from the bottom-up perspective, we focused on correlations that are in NRELAP5 and the correlations that we used in the boron dissolution analysis, and we identified some limitations of those correlations there. The top-down assessment also considered what was the numerical features within NRELAP5 and its fundamental governing equations and how it assessed against the NIST-2 tests.

So, we identified some limitations in the models and correlations, particularly as related to NRELAP5 under these types of conditions, and we have identified conservative treatments within the evaluation model in order to address those limitations or we have implemented alternate approaches to confirm that what we're getting from the method is conservative.

And so, we have evaluated the limitations under these types of low pressure conditions predominantly where the code really wasn't originally developed to operate, and we've ensured that we have conservative treatment required by the evaluation model to address those.

So, overall, our conclusion is that for an NPM with design features that are specified in the topical report, the methodology provides a conservative method to demonstrate adequate core cooling and decay heat removal, that the module remains subcritical following design basis events, and that coolable geometry is maintained. Any questions?

CHAIR KIRCHNER: Members? I have a lot of questions, but I think probably I'll hold most of them for the closed session, but just for the public session, it seems to me that in a simple way on this boron issue, you could look at your system and say that, with the assumptions you used, the most were the rod bank stuck out, what the --

And it's probably more a beginning of cycle problem than end of cycle problem. What's the critical boron concentration to be sufficiently below k effective of one? As a figure of merit, is that possible to do? Do you use that in your thinking to kind of do an overall assessment?

You've looked at the boron redistribution and such, and then you look at the effect of your riser holes and so on, and look at how the boron is transported, but you then have a goal, if you will, as the function of burnup for where you are in the cycle. This is how much we can't let the concentration of boron get below this amount. I'm trying to remember what your steady state normal start of the cycle PPM is. It's about 1,000 or something, something in that order without getting into --

MR. CODDINGTON: Yeah, 1,000 is about right for --

CHAIR KIRCHNER: Yeah.

MR. CODDINGTON: -- equilibrium end of cycle.

CHAIR KIRCHNER: So, if you're in the beginning of cycle and you go through these transients and either the extended cool down or the ECCS functions, and you're looking at a figure of merit target for what you don't want the boron concentration to go below X. Is that how you look at your mass balance, so to speak, of how effective your boron dispensers are for the ECCS system and so on? Is that basically your approach?

MR. CODDINGTON: Yeah, yeah, so, you know, depending on what the initial exposure is, you have a different initial boron concentration, and then we do track the boron as it moves throughout the system and compare it back to critical boron concentration that is specifically tied to not only a cycle exposure, but also a specific operating history.

CHAIR KIRCHNER: Right.

MR. CODDINGTON: So, yeah, that, the critical boron concentration floats with time, with the specific transient being evaluated, with the time since reactor scram, so it's a large number of simulated cases effectively.

CHAIR KIRCHNER: And then to deal with uncertainty, because you have no way really to measure local boron concentrations in this system, how do you -- what's the conservatism that you build in to have confidence that, you know, plus or minus 25 PPM or what, you know, what kind of design targets do you have for the functionality of the riser pools doing their job as well as the, in the case of ECCS, the boron dispensers functioning?

MR. CODDINGTON: Yeah, so we do have a fair number of conservatisms in the method. You know, we don't assume that. We do assume the rod is stuck out and it's worth a lot. There are others that go into the analysis methodology, and then we do develop a specific XPC that gets applied at the critical boron concentration, and I don't know exactly how public those numbers are, so I'd probably prefer to save them for closed session.

CHAIR KIRCHNER: Okay, well, I can pursue this in the closed session, but I just wanted to get a sense in the open session how you, you know, you have identified some rather, I don't want to call them gross because that's the wrong word, but some overall figures of merit, like collapsed liquid level obviously is an obvious one.

But the tracking of what the different boron concentrations are in the system is a much more complicated problem and I'm just looking for, you know, what's your designer's figure of merit on boron concentration or do you just condense that with the changes you've made in the design? You've kind of overwhelmed the problem and you will not have a significant inventory of unborated water anywhere in the system?

MS. McCLOSKEY: We won't have a significant inventory of unborated water near the core, which is where we care about it being unborated. I think the other thing is when we're considering a normal operating history, it's only as we get towards the end of the cycle conditions.

You know, if your plant has been operating along at these load conditions for a cycle, it's getting towards the end of cycle conditions where the worth of the highest worth control rod remaining stuck out can be offset by the amount of reactivity feedback that comes along with up to 72 hours of very effective passive cooling conditions and the assumption that the operators aren't doing anything at all to resolve the system, to resolve the issue.

You know, the plant is always going to be initially shutdown, and then it's the later cooling from the ECCS and the slow burnout of xenon worth that rides the critical boron concentration back up, and you can see some of those effects in some of the closed session work.

CHAIR KIRCHNER: Okay, so you also have included the xenon?

MS. McCLOSKEY: Yes, and we --

MR. CASE: Particularly the downcomer resolution is something that we look at more specifically, and the method doesn't require us to stay above the critical concentration, but it's a part of the consideration.

I think it is important that, and this will be evident in the curves, that the end state of the transient is very safe in terms of margin perspective to the critical concentration, so there's really an inflection point.

Meghan was kind of describing the dynamics of the transport behavior and then the xenon and the temperature effects, right? So, all of those create a bit of a pinch point that we look at deterministically, right, to apply margin, but overall in the context of where the transient ends up, it's in a good spot.

The dilution of the containment was not something that we set out to resolve. I think that's a consideration. In the event that we have modules under those conditions, there's certain procedures, and we still have some of that language in the SRs as to the consideration of that during recovery efforts.

MR. CODDINGTON: And I guess I would just add that in this sizing of the ESB, some of our transients that we do evaluate don't result in a diluted downcomer. There's a flow path that is maintained from the core and riser to the downcomer --

CHAIR KIRCHNER: Right.

MR. CODDINGTON: -- if you assume an injection uprate, for instance. Some of the sizing of the ESB and how much boron it needs to hold, you know, the minimum value there is effectively enough to make sure that it would remain shut down even for that type of event where you don't actually concentrate boron in the core very much.

CHAIR KIRCHNER: Okay, well, we can pursue it further in the closed session, okay. Members? And that concludes your presentation, Ben, yes?

MR. BRISTOL: Yes.

CHAIR KIRCHNER: Okay, so for those listening in, we're going to pause for a moment and change out to NRC staff.

MR. DRUCKER: Well, I just want to do a slide check here. Are you guys seeing the full slides?

CHAIR KIRCHNER: Not yet. We're seeing -- can you go to the slide show?

MR. SNODDERLY: Patrick, give us some time. We won't start until we can see the slides, all of us can see the slides, but thank you for asking. Any other comments, Patrick, or things we can do to help with the transcript?

(Pause.)

MR. SNODDERLY: Okay, thank you for the feedback.

MR. TESFAYE: This is Tesfaye. David, can you hear me?

MR. DRUCKER: Yes, I can hear you. We got you.

Am I okay to start?

CHAIR KIRCHNER: Yes, please, but introduce yourself.

MR. DRUCKER: Good day. My name is David Drucker and I'm a Senior Project Manager in the New Reactor Licensing Branch in NRR and the Lead Project Manager for the XPC topical report review.

This slide shows the contributors to the review of the XPC topical report, and I will present a few introductory slides, and Antonio Barrett, the lead reviewer, will present the remainder of the slides.

During the staff's review of the topical report, 25 audit issues were identified and resolved, and eight RAIs were issued. The second to last bullet on this slide says two RAIs remain open. However, since these slides were submitted to ACRS last week, one of the RAIs was closed, so there's only one open RAI.

The significant changes between the draft safety evaluation provided to ACRS on February 4 and the safety evaluation published on February 26 will be discussed in slide 16.

As I mentioned earlier, only one RAI remains open. RAI XPC-6 was recently closed. NRC staff is reviewing a revised response to RAI XPC-21 that was submitted by NuScale on February 27.

A significant change between the draft safety evaluation provided to ACRS on February 4 and the safety evaluation published on February 26 is the addition of limitation and condition number 10 and number 11, which will be discussed in more detail later in this briefing. Next, Antonio Barrett will discuss the staff's review of this topical report in detail.

MR. BARRETT: Thank you, David. My name

is Antonio Barrett of the NRC staff. I work in the new reactor, excuse me, the Nuclear Methods Systems and New Reactors Branch, excuse me. Anyway, so let's -- all right, we're on the first slide.

So, relevant changes from the DCA to the SDAA, in the DCA, they had a long-term tooling and technical report and SR evaluations, and now for the SDAA, we have a new XPC topical report methodology and new design features.

With respect to the criticality evaluations, there were some for the DCA. There were some conditions and events where you could return to power, and now with the new SDAA and using at least the new methodology and the design features now can return to power. Go to the next slide?

Additionally, some of the additional changes are increasing the riser holes which were there to help promote mixing. For the DCA, the RVVs contained in IAB, which would prevent a blowdown on the ECCS signal, now for the SDAA, the RVVs do not contain these IABs, so when you get a valid ECCS signal it won't blowdown. Some of the boron addition that we're going to talk about eventually.

And for the long-term cooling enhancements, there is the new ECCS supplemental boron system, so the combination of the riser holes, this containment boron addition, the containment mixing tubes, they all contribute to the boron transport and redistribution around the system during DHRS and ECCS cooling. Next slide?

And this is just a figure kind of depicting some of the stuff that we already described and I think you've already seen a lot of this stuff already talked about during the NuScale slides. Over here, you see the RVVs that no longer contain the IABs, the containment mixing tubes which promote mixing towards the bottom of the CNV, the riser holes, the upper and lower riser holes which promote mixing between the downcomer and the riser core section, as well as the boron addition source. Next slide?

So, for some of the review highlights, we're going to cover those on the next two slides. So, the XPC topical report is an extension of the short-term LOCA and non-LOCA topical reports. It was built off of those particular evaluation models and the staff reviewed it as such, and the staff used the guidance in Reg Guide 1.203 to perform this review.

And the staff performed their own independent PIRT, Phenomenon Identification and Ranking Table, evaluation, and compared it to

NuScale's that they had performed.

The staff also reviewed the computational tools used. NRELAP5 was used for the thermal hydraulic response only. SIMULATE was used for their neutronics calculations, and then a MATLAB script was used to input all of the calculational framework for their transport methodology, and that's how they transport boron throughout the system.

The staff reviewed the NRELAP5 test assessment basis. This included reinterval effects tests, a long-term cooling test, and LOCA ECCS tests, and then a non-LOCA test which was mainly a DHRS test at the NIST-2 facility, and the staff reviewed the validation and the associated uncertainties as shown through those test comparisons between the NRELAP predicted predictions versus the test data.

So, and the staff also reviewed the construction and development of the long-term cooling thermo-hydraulic model, and that model was based off of the short-term LOCA base model, and then with some adjustments to make it into the long-term cooling model, some things to make it run a little bit smoother, and the validation basis for that comparison that staff review was about.

In the XPC topical report, there's a lower riser hole flow assessment that's required to ensure that you get adequate lower, that you're actually calculating adequate lower riser hole modeling, and the staff reported an evaluation of that as well.

And the staff also reviewed particular events that were considered for collapsed liquid level, heat removal capability, and the boron transport for subcriticality and precipitation.

DR. MARTIN: This is Member Martin. We'll talk about this more in the closed session. The MATLAB model is obviously something a bit different than NRELAP5 and SIMULATE5 because, you know, a lot of history with those other codes. Once you just kind of describe your approach to reviewing that, it's going to require maybe a little bit more intention than the other two.

MR. BARRETT: Yeah, as far as the review, the staff requested disks that contained the RELAP models, as well as the MATLAB scripts that were used, so we got those in-house and we exercised them in detail from the various sensitivity studies.

DR. MARTIN: So, it wasn't just a qualitative review?

MR. BARRETT: Correct.

DR. MARTIN: There was some quantitative, okay.

MR. BARRETT: So, we can actually check to see that they actually implemented what they were.

DR. MARTIN: Okay, appreciate that.

MR. BARRETT: Can we go to the next slide? We kind of discussed it already a little bit. We reviewed the boron transport subcriticality methodology concentrating on the thermal hydraulic conditions as well as the mixing model assumptions for assuming.

We also did the critical boron equation, and it's going to operate less than the critical boron concentration which obviously tells you your margin to recriticality.

And similarly, we provided the same sort of review for the boron transport and precipitation methodology analysis, which is very similar to the transport subcriticality methodology except for getting the boron basically in one particular area.

MR. BLEY: Excuse me, this is Dennis Bley. Could you speak a little slower? Coming over Teams, it's blurring a little and it's hard to understand.

CHAIR KIRCHNER: Just pull it closer to you.

MR. BARRETT: Okay, does that sound a

little bit better?

MR. BLEY: It does.

MR. BARRETT: Okay, so the boron transport precipitation methodology was reviewed similarly to how the boron transport subcriticality methodology was reviewed, and some of the similar comments I made earlier to Member Martin, except for the boron precipitation methodology was geared towards collecting all of the boron in one particular location, and so you can compare it back to the solubility limit for precipitation. Can we go to the next slide?

So, Dave mentioned earlier that there were some differences in the safety evaluation between what you saw before and what you were just presented with, one of which was the updated nuclear reliability factor review portion, which is we just got the response.

As Dave stated, we were still under review, and then there were two limitations and conditions added. One was requiring enough boron to account for the integral down powers and pre-transient operational histories to include xenon impacts as well as low decay heats.

And in addition, there is another

limitation and condition that was added, and this one was with respect to boron precipitation, and this was to require that the zero power maximum operational limit for boron concentration will be used as the initial condition in the RPV to help account for some uncertainties. Go to the next slide, Dave?

So, for the limitations and conditions, for limitation and condition one, changes to the short-term LOCA or non-LOCA topical reports will require changes to the XPC topical report, so that would have to be looked at.

For limitation and condition number two, it's applicable only to the US460 and NPM-20 based off of how the review was performed and how the PIRT was performed.

Number three, you have to maintain insignificant non-condensable gas in containment for evaluate the amount of non-condensable gases in containment in your subcriticality methodology.

Number five, the methodology was limited to 72 hours and does not include post-event recovery actions. Limitation and condition number six, the RVV compressible flow qualification is going to have to be a part of the ASME QME-1 qualification in the application.

Limitation and condition number seven, there must be an initial test program, first module only, for dissolution testing so that you can account for the different boron dissolution rates, condensation rates, et cetera.

CHAIR KIRCHNER: Antonio, if I could interrupt there just in the open session, what's your expectation? How will they measure in that initial test program the boron dissolution to your satisfaction?

MR. BARRETT: Yeah, so --

CHAIR KIRCHNER: What are you looking for, for metrics?

MR. BARRETT: Yeah, so it's going to be consistent with the evaluation model. So, they make certain assumptions or predictions about what happens with condensation and condensation flow rates, and they have the different mechanical designs set up to get the condensate, have it go certain places.

So, I would imagine like a steam test over varying conditions that would then validate how much you collect, where it collects, how it's able to dissolve a certain amount of boron, does it or does it not, versus what was assumed in the analysis and then overall, the mixing portion in terms of the vault water container.

CHAIR KIRCHNER: You're seeing these as nuclear driven tests, by which I mean you have nuclear heating tested?

MR. BARRETT: I do not. I think it's -- as long as you get the steam, I think that would be the most important part of the test.

CHAIR KIRCHNER: Okay, so they already would use an auxiliary boiler kind of setup to bring the module up to some temperature where they can safely pull rods, but okay, how are you going to measure this?

MR. BARRETT: Yeah, so it should be just, in my opinion, my view, it would be just a dissolution rate. So, if your collection is setup appropriately, you would collect the amount of condensate per whatever steam rate that you have, and then it would dissolve the boron at a certain rate. And if you're assuming, for example, in the analysis, that you're not getting that dissolution rate, then there would be a mismatch there.

CHAIR KIRCHNER: But the easy part is the dissolution of the actual boron, I shouldn't use the word pellets, whatever their geometric form is in the basket. That's the easy part. Where does the boron go? Is that what you're looking for?

MR. BARRETT: No, so the easy part is definitely, I guess, a main portion of it. The second part would be you have your mixing tubes, and whether or not --

CHAIR KIRCHNER: Right.

MR. BARRETT: -- you're actually getting that sort of mixing. So, what we would think you would do is something similar to like a gradient, concentration gradient. Does it actually -- are you getting that sort of mixing flow through the tubes that you expected?

CHAIR KIRCHNER: So, they would have to design a probe that would be in the downcomer region and/or the containment downcomer region to --

MR. BARRETT: That would be one way. I think that you could do some sampling at different elevations potentially over time, but I think there's a lot of different ways that you can do it, but I don't see it as being overly complex.

CHAIR KIRCHNER: So, let me take it one step further. Would this eventually show up as an ITAC then in a COL application?

MR. BARRETT: Yeah, so right now, I think we asked this question as part of the SDAA design and now it's part of their initial test program.

CHAIR KIRCHNER: Okay.

DR. PALMTAG: This is Scott Palmtag. Just to follow up on that, I'm kind of curious, how would they get steam into the containment vessel? Is that something you imagine doing offline at some facility or doing it actually when they build the first, install the first module?

MR. BARRETT: Yeah, I imagine it's when they actually install the first module, but yeah, like I think Dr. Kirchner was saying, like you could either use the ox boiler if it was able to give you the steam levels that you want. I think probably maybe you might be a little bit more interested in the lower steam levels, but as long as you can get the steam in there somehow, I think that would be good enough.

DR. PALMTAG: How would you do that? I'm just trying to figure out the piping. I mean, I don't know all of the piping, but you have your reactor pressure vessel. You'd have to open those valves to let the steam into the containment or in the --

MR. BARRETT: No, I don't think you actually -- I think that's one way you could do it, but a different way would be you can just put the steam directly in. We're not talking about nuclear heating.

We don't even necessarily need you to simulate an ECCS blow valve per se. You don't necessarily have to, but if you're going to have a way to just put the steam in, I think that that would be one, and so it doesn't have to be overly --

DR. PALMTAG: Just when you have -- we're not talking a special test facility. We're actually talking about the real containment vessel.

MR. BARRETT: Yes.

DR. PALMTAG: Is there -- maybe this is something I can ask NuScale, but is there available piping that they could dump the steam into the containment vessel?

CHAIR KIRCHNER: They have a containment fill and drain system, so my sense would be that would be used. Go ahead.

MR. NOLAN: This is Ryan Nolan from the staff. And so, the staff wasn't too focused on how you get the steam into containment, but our understanding is right now that there's a module heat-up system that they would use to bring the RCS up to pressure and temperature, right.

And so, you would use that system and then you could open the vent valves, which would then create steam inside the containment, or they could scope out a temporary system. We weren't really overly concerned with how you get steam into containment, but as of right now, I believe that's the structure that was proposed with the initial testing.

DR. PALMTAG: Yeah, I understand it's easy to define this, but I'm curious when the NuScale people come back up, I'm kind of curious how they're actually doing this because if you're -- I mean, you're limited by your piping that's in there.

MR. NOLAN: Right, so as of right now, this is part of the initial test program, so Chapter 14 does include Revision 2 of the FSAR will include a test that describes how to perform this.

MR. BARRETT: So, limitation and condition eight is approved for the NRELAP5 Version 1.7 in conjunction with Basemodel Rev. 5 with allowable, you know, change processes, allowable change processes.

Limitation and condition nine, you've got to have a separate approval required for single failures, electric power assumptions, and operator actions, which would be a part of the downstream application. Dave, can you go to the next slide?

And the last two, as we discussed earlier, a limitation and condition to account for integral down powers and xenon low decay heat for subcriticality analyses, and limitation and condition number 11, where you have zero power maximum operational limit, no xenon, at the beginning of cycle where initial conditions warrant more precipitation analyses.

DR. PALMTAG: This is Scott Palmtag again. So, I have some questions about ten and 11. So, in a lot of calculations, your core calculation where you have to do your cycle limits, you have to show that you have shutdown capability for all kinds of other limits. Is this meant to be more of a bounding analysis that you're going to set some limit for the, I guess, minimum boron concentration that's going to handle all cycles or is it something that's going to have to be shown on a cycle by cycle basis?

MR. BARRETT: Yeah, so I think we can get into it a little bit more in the closed session, but I think there will be -- what we envision is there's something that's done -- well, I think it's already -- in response to XPC-6, NuScale already put in like a curve, if you will, that will then be placed into the cooler that will probably generally cover most cycles, but can be updated if you wanted to get more margin like, you know, that considers like your power ascension rate and things of that nature.

DR. PALMTAG: I'm just a little concerned about having some bounding analysis because everything has been done on an equilibrium core, right, so as you know, cycle one is going to be completely different and you never quite get to the equilibrium core. There might be fuel changes and everything that goes along the way.

I'm not sure that there's been enough analysis. The equilibrium core analysis can really cover cores. I would think this would have to be something that would have to be shown for each core design.

MR. BARRETT: Yeah, so currently, it's in the cooler right now, so I assume that it will be done for every core design, but that's a part of their tech spec that they currently presented to us. We can show it maybe later, but, so.

DR. PALMTAG: Yeah, and you probably will not be able to answer this, but you have an operational minimum boron concentration is the way I understand this. Won't this -- maybe it's a small amount, but won't this significantly affect core operations and cycle length?

MR. BARRETT: No, this is just so that you can do your precipitation analysis with additional boron. That's it. So, this is not an actual -- if you're talking about 11, there is not an actual limit on operation or anything of that nature.

We're just saying when you're at zero power, no xenon, boron concentration, you're at a very high boron concentration, you have to deborate to kind of go through your cycle, right? So, we're just saying if you use it as your initial condition just when you do the analysis to add some conservatism, and this is how they already currently do the analysis, then you must have this additional boron to account for uncertainties.

DR. PALMTAG: I guess I'm not really -- I'm not sure I understand that. So, as you deplete your cycle, at the end of the cycle, you're going to be at zero boron, and then, but that won't be sort of sufficient? There's going to have to be an additional boron concentration above that zero boron?

MR. BARRETT: No, so I think maybe I, when I was talking about ten and the limits and whatnot, that's kind of a different thing. So, going down to L&C number 11, only when you perform your boron precipitation analyses, which means that the more boron you have, the worse off you are, the worse, you know, the closer you are to your solubility limit.

DR. PALMTAG: Okay.

MR. BARRETT: So, forgetting about everything else and just putting some boron --

DR. PALMTAG: Okay, this is specifically precipitation?

MR. BARRETT: Correct, yeah.

DR. PALMTAG: All right, thank you.

MR. CODDINGTON: This is Taylor Coddington. So, it's effectively, for the boron precipitation analysis, use a conservative method is effectively finished or the limitation is trying to be established.

DR. PALMTAG: Right, I misunderstood. I didn't realize it was for precipitation. I thought there would be a minimum boron limit in the core for criticality purposes, but we can get into that in the closed session.

MR. BARRETT: All right, Dave, can you go to the next slide? I think that's the end. So, the staff believes the applicant has provided sufficient information to support this safety finding.

The staff found what the applicant represents in this topical report satisfies the limitations and conditions and will meet relevant regulatory requirements pending review and approval of the application. Thank you very much for your time. If there's any more questions, I'll take those.

CHAIR KIRCHNER: Members, questions or you're just saving everything for this afternoon? Okay, all right, with that then, if there are no further questions, let me take this opportunity to see if we have any comments from the public either here in our room or online. Just if you're online, unmute your microphone, state your name and affiliation as appropriate, and make your comment.

In the room here, I think we have all staff and applicant with us, so I am not hearing anyone wishing to make a public comment. We're going to adjourn, not adjourn, but we're going to close the open session and we will return at 1:00 Eastern Time for the closed sessions, and those of you who are authorized will have the Teams link to join us. So, we are recessed until 1:00.

(Whereupon, the above-entitled matter went off the record at 12:03 p.m.)

February 26, 2025 Docket No. 052-050

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 Material Entitled "ACRS Subcommittee Meeting (Open Session) Non-Loss-of-Coolant Accident Topical Report and Extended Passive Cooling and Reactivity Control Methodology Topical Report," PM-179845, Revision 0

The purpose of this submittal is to provide presentation materials for use during the upcoming Advisory Committee on Reactor Safeguards (ACRS) NuScale Subcommittee Meeting on March 4th, 2025. The materials support NuScale's presentation of the subject topical reports for the US460 Standard Design Approval Application.

The enclosure to this letter is the nonproprietary presentation entitled "ACRS Subcommittee Meeting (Open Session) Non-Loss-of-Coolant Accident Topical Report and Extended Passive Cooling and Reactivity Control Methodology Topical Report," PM-179845, Revision 0.

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

If you have any questions, please contact Amanda Bode at 541-452-7971 or at abode@nuscalepower.com.

Sincerely,

Mark W. Shaver

Mark W. Shaver
Director, Regulatory Affairs
NuScale Power, LLC

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David Drucker, Senior Project Manager, NRC

Enclosure 1: ACRS Subcommittee Meeting (Open Session) Non-Loss-of-Coolant Accident Topical Report and Extended Passive Cooling and Reactivity Control Methodology Topical Report," PM-179845, Revision 0, Nonproprietary

Enclosure 1:

ACRS Subcommittee Meeting (Open Session) Non-Loss-of-Coolant Accident Topical Report and Extended Passive Cooling and Reactivity Control Methodology Topical Report,” PM-179845, Revision 0, Nonproprietary

ACRS Subcommittee Meeting

(Open Session)

March 4, 2025

Non-Loss-of-Coolant Accident Topical Report and Extended Passive Cooling and Reactivity Control Methodology Topical Report

ACRS Subcommittee Meeting
(Open Session)

March 4, 2025

Non-Loss-of-Coolant Accident Topical Report

Presenters: Kevin Lynn, Meghan McCloskey, Ben Bristol

Acknowledgement and Disclaimer

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

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Agenda

- Non-loss-of-coolant accident (non-LOCA) topical report history
- Non-LOCA evaluation model (EM) analysis purpose, transient class, acceptance criteria
- Relevant power uprate design and operating changes
- Summary of EM applicability assessment and updates

Non-LOCA Topical Report History

- Non-LOCA topical report Revision 3 was approved by NRC in 2020
- Approved Revision 3 was used in Final Safety Analysis Report (FSAR) analyses for US600 (with NPM-160) design that has been certified
- Approved Revision 3 contained limitations and conditions (L&Cs) restricting use to NPM-160 design
- Revision 4 was submitted in January 2023 along with FSAR for US460 (with NPM-20)
- Updates to Revision 4 have been made since January 2023 in response to NRC questions
- Revision 5 will incorporate these updates, but has not been submitted at this time
- Focus of discussion today is changes since prior NRC approval of Revision 3

Non-LOCA EM: Analysis Purpose, Transient Class, Acceptance Criteria

Plant design, core design, fuel rod design, plant initial conditions, structures, systems, and components (SSC) performance

NRELAP5 system thermal-hydraulic response

Primary pressure, secondary pressure, safe stabilized condition

Non-LOCA topical report TR-0516-49416-P

VIPRE-01 subchannel analysis

Fuel cladding integrity

Subchannel topical reports TR-0915-17564-P-A TR-108601-P-A

Mass & energy release input

Accident radiological analysis

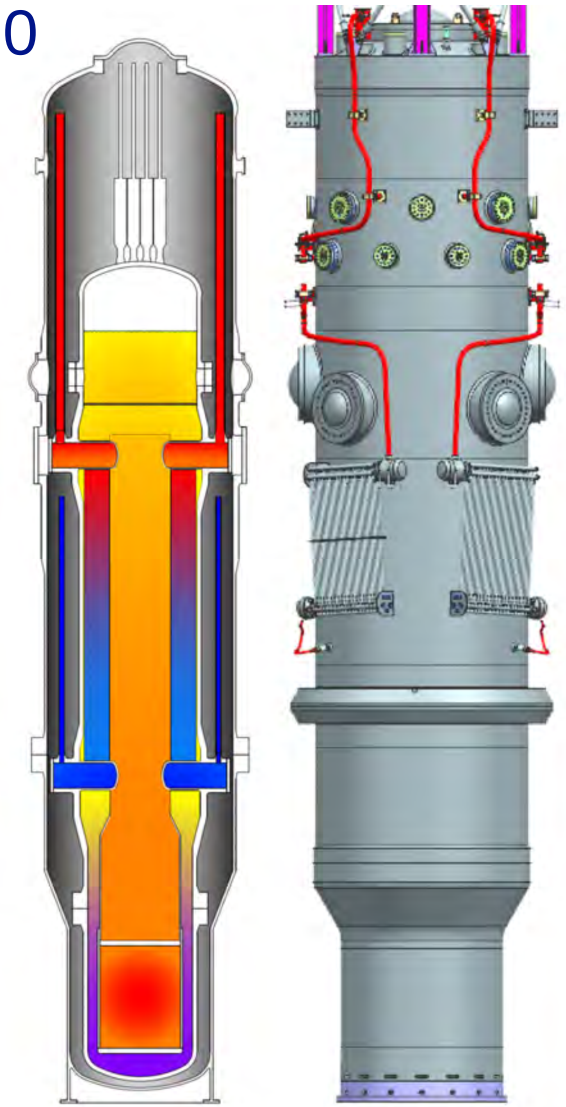
Radiological dose acceptance criteria

Accident source term topical report TR-0915-17565-P-A

→ Scope consistent with the NRC-approved Revision 3

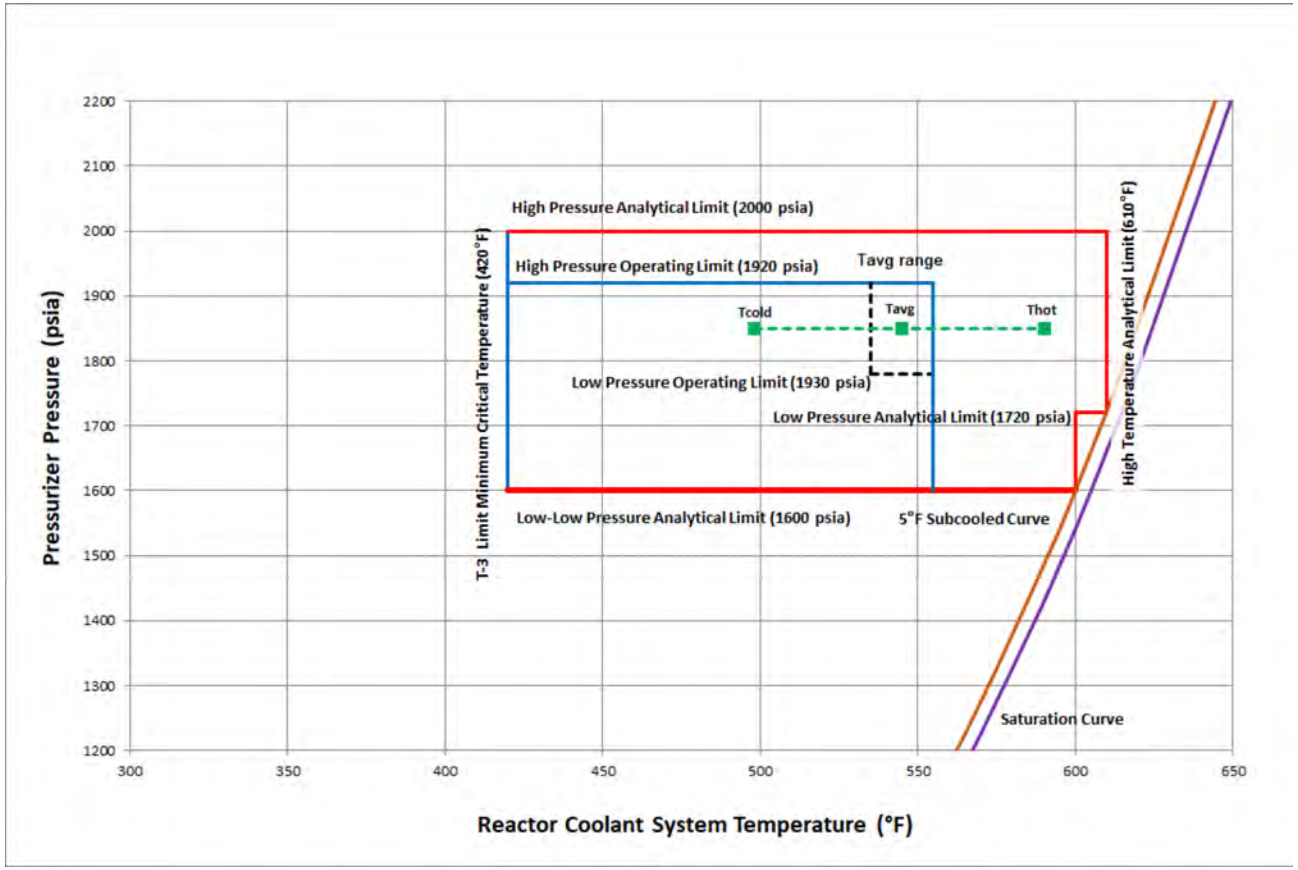
Power Uprate and Design Changes Summary NPM-160 to NPM-20

- Power uprate from 160 MWt to 250 MWt
- Module SSC design essentially maintained
- Operating conditions
  - Increased primary pressure from 1850 psia to 2000 psia
  - Primary and secondary side design pressures increased from 2100 psia to 2200 psia
  - Use T_{avg} control instead of T_{hot} control (T_{avg} changed from ~545°F to 540°F)
  - Decreased secondary side feedwater temperature at 100% power from 300°F to 250°F
  - Reduced minimum temperature for criticality from 420°F to 345°F
- Module protection system (MPS) actuations optimized for US460 design
  - Adjusted to accommodate modified operating conditions
  - Added reactor trip on high T_{avg} to terminate slower reactivity transients earlier (e.g., reactivity transient initiated from lower power)
  - Additional decay heat removal system (DHRS) actuations – for any containment vessel (CNV) isolation signal during power operation
  - Pressurizer line isolation on low pressurizer pressure

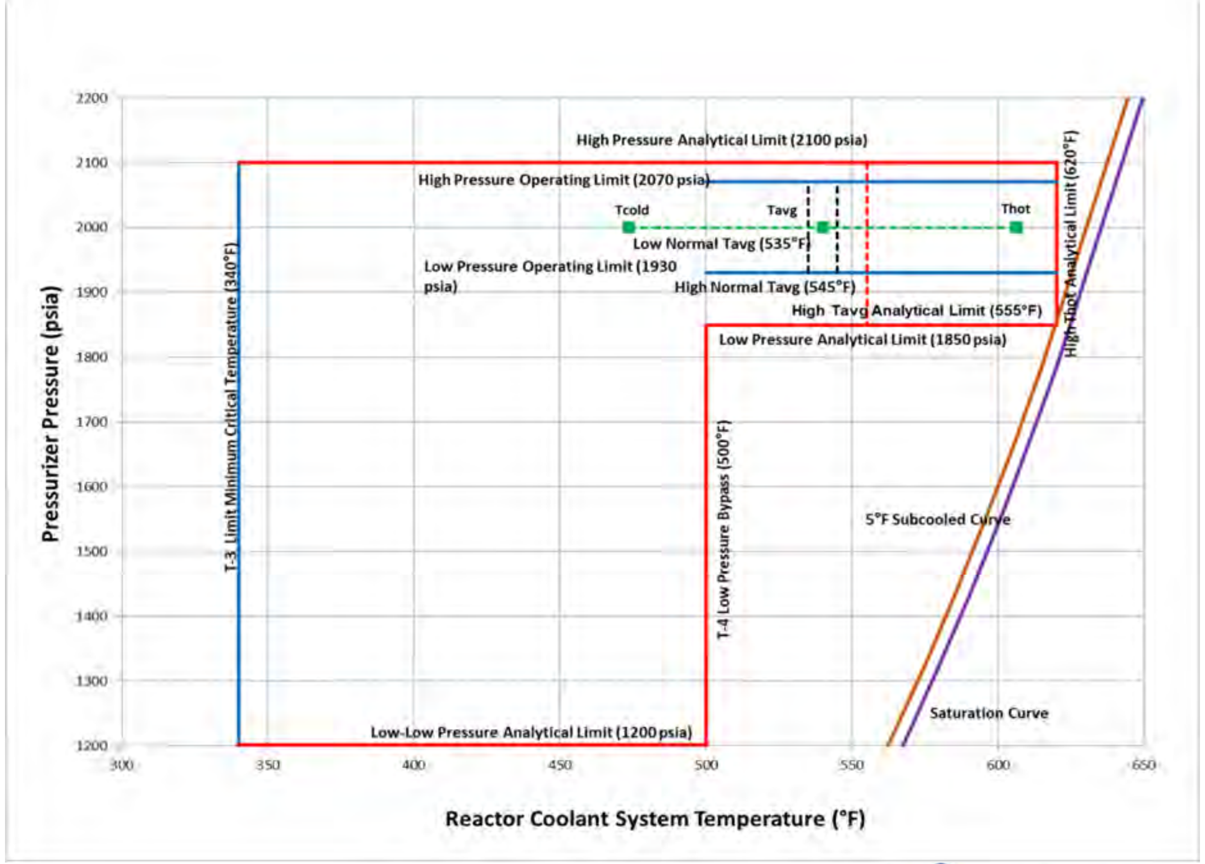


Pressure/Temperature Operation and Limit Changes

US600 (Certified Design)



US460 (Design currently under review)



Analytical Assumptions for Non-LOCA Analysis

Approach from NRC-approved Revision 3 methodology maintained:

Scope of event progression	Safety analyses of design-basis events are performed from event initiation until a safe, stabilized condition is reached
Operator action	No operator actions required to achieve safety functions for 72 hours after an initiating event occurs
Loss of power	Evaluate whether power available, loss of alternating current (AC) power, or loss of AC and direct current (DC) power is more limiting
Nonsafety-related module or plant control systems	• Operation of nonsafety-related control system that leads to a less severe plant response is not credited • Operation of nonsafety-related control system that leads to a more severe plant response is assumed
Nonsafety-related SSC credited	• Nonsafety-related secondary main steam isolation valves (MSIVs) and feedwater (FW) regulating valves serve as backup for safety-related valve single failure • Nonsafety-related check valves in FW piping serve as backup for safety-related check valve failure

Non-LOCA EM Updates

- Design changes have no substantial change in non-LOCA event progressions or important phenomena
  - Reactor pressure vessel (RPV) pressure protected by reactor safety valve (RSV) lift
  - Secondary pressure protected by design pressure equal to RPV design pressure, physically limited to saturation pressure at maximum primary hot side temperature
  - Minimum critical heat flux ratio (MCHFR) limited under high power, high temperature conditions (e.g., reactivity insertion events)
- Non-LOCA phenomena identification and ranking table (PIRT) from NPM-160 remains applicable
- Current EM employs NRELAP5 v1.7 (NRC-approved Revision 3 used NRELAP5 v1.4)
- NRELAP5 assessment basis expanded with NIST-2 steam generator (SG)-DHRS tests
- Methodology changes for event-specific analyses
  - Provided additional detail on when more extensive sensitivity calculations performed
    - Dependent on margin to acceptance criteria – more sensitivity studies needed where margin is smaller
  - Generally expanded scope to vary parameters rather than bias in only one direction
  - Option for radiological analyses to use bounding input rather than transient-specific input
  - Option to demonstrate control rod drop analyses bounded by single rod withdrawal or steady-state conditions
  - Option to use increase in level during boron dilution events to determine shutdown margin at event termination

- Conclusion: EM remains adequate to evaluate an NPM design

Questions?

Acronyms

AC	Alternating current
CNV	Containment vessel
DC	Direct current
DHRS	Decay heat removal system
EM	Evaluation model
FSAR	Final safety analysis report
FW	Feedwater
L&C	Limitation and condition
LOCA	Loss-of-coolant accident
MCHFR	Minimum critical heat flux ratio
MPS	Module protection system
MSIV	Main steam isolation valve
NIST	NuScale Integral System Test Facility
Non-LOCA	Non-loss-of-coolant accident
NPM	NuScale Power Module
PIRT	Phenomena identification and ranking table
RPV	Reactor pressure vessel
RSV	Reactor safety valve
SG	Steam generator
SSC	Structures, systems, and components
T_{avg}	Average temperature
T_{hot}	Hot temperature

ACRS Subcommittee Meeting
(Open Session)

March 4, 2025

Extended Passive Cooling and Reactivity Control Methodology Topical Report

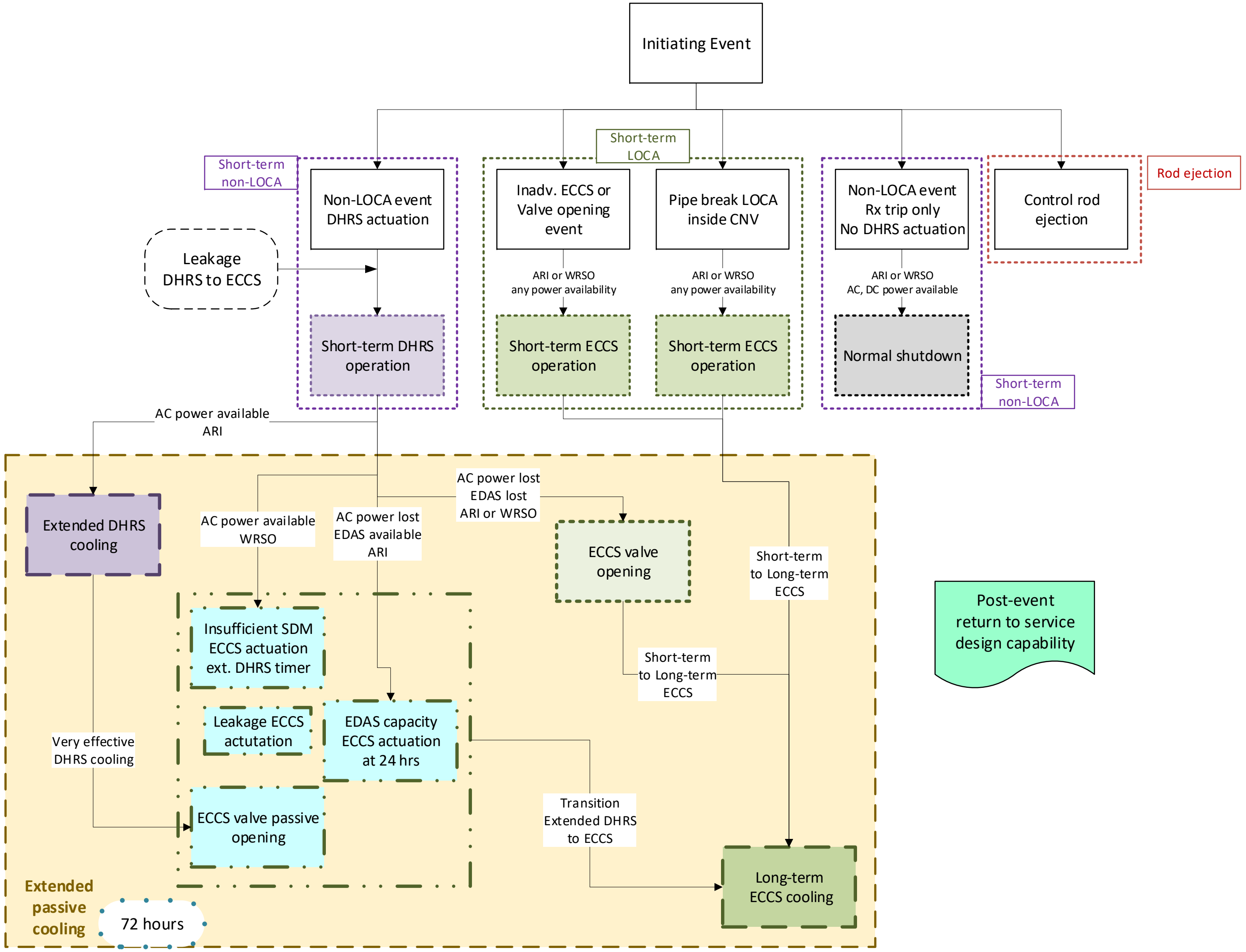
Presenters: Thomas Case, Meghan McCloskey, Ben Bristol

NUSCALE
Power for all humankind

Agenda

- Evaluation model (EM) scope, regulations, acceptance criteria
- NuScale Power Module (NPM) design features
- Phenomena identification and ranking table (PIRT) evolution
- EM structure
- EM validation basis
- EM adequacy assessment and conclusions

NPM Extended Passive Cooling and Reactivity Control Scope



- New topical report to support 250 MWt NPM design and US460 submittal
- Regulations:
  - 10 CFR 50.46(b)(4) and (5)
  - Principal design criterion (PDC) 35 – emergency core cooling
  - PDC 34 – residual heat removal
  - General design criterion (GDC) 26, GDC 27 – reactivity control and subcriticality, normal operation or following anticipated operation occurrences (AOOs) or accidents

  - Supports application exemptions to GDC 33 for system with safety function to provide makeup in response to reactor coolant pressure boundary leakage

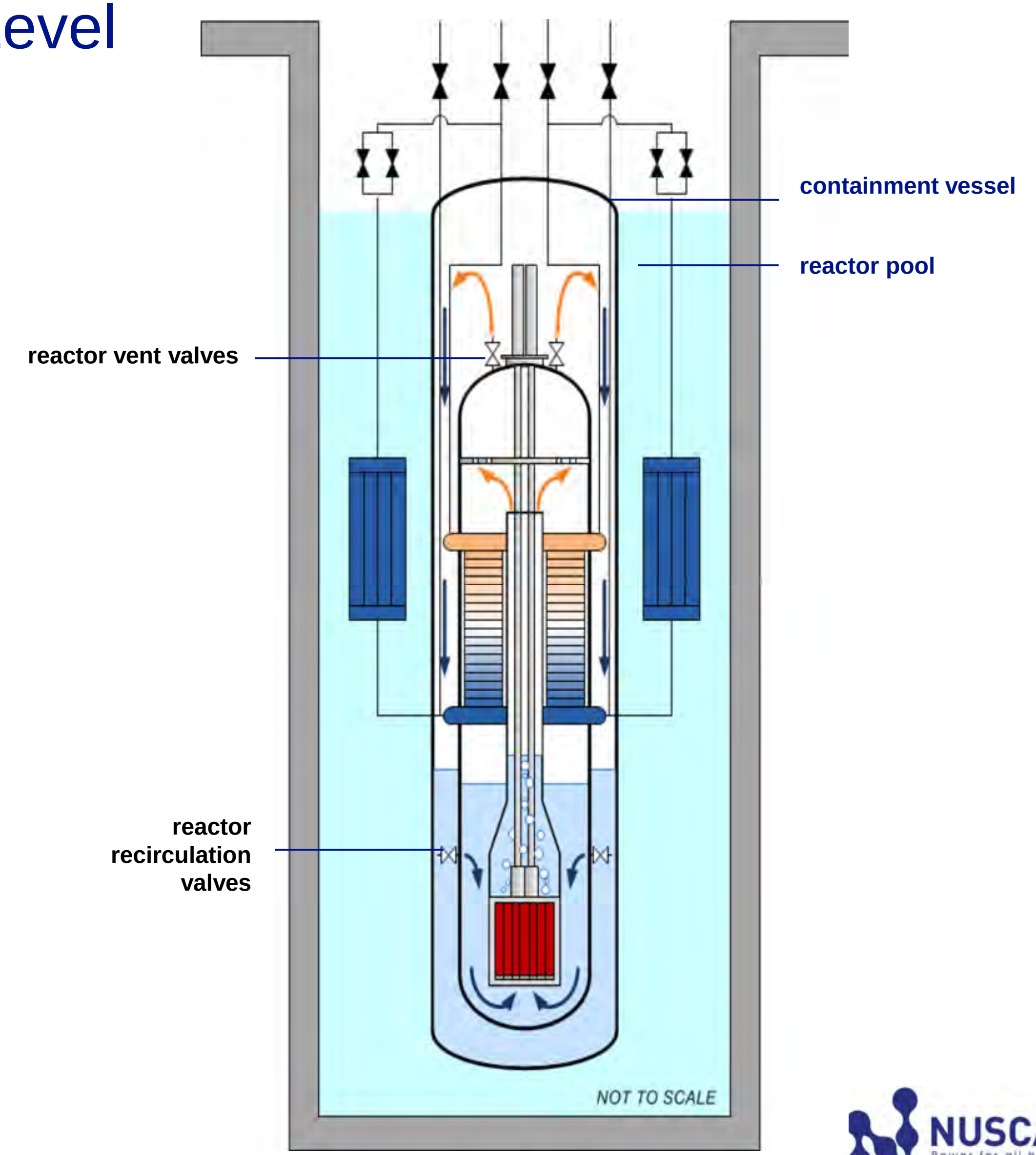
Extended Passive Cooling (XPC) Figures of Merit

Safety Objective	Acceptance Criteria
Provide decay and residual heat removal	Collapsed liquid level remains above top of core
Reactivity control	Core remains subcritical
Maintain coolable geometry	Boron concentration remains below precipitation limits

Key assumptions/requirements:
- Demonstrate subcriticality (k_{eff}<1) with highest worth control rod withdrawn from core
- Demonstrate acceptance criteria met for at least 72 hours

NPM Design – Long-term ECCS Collapsed Level

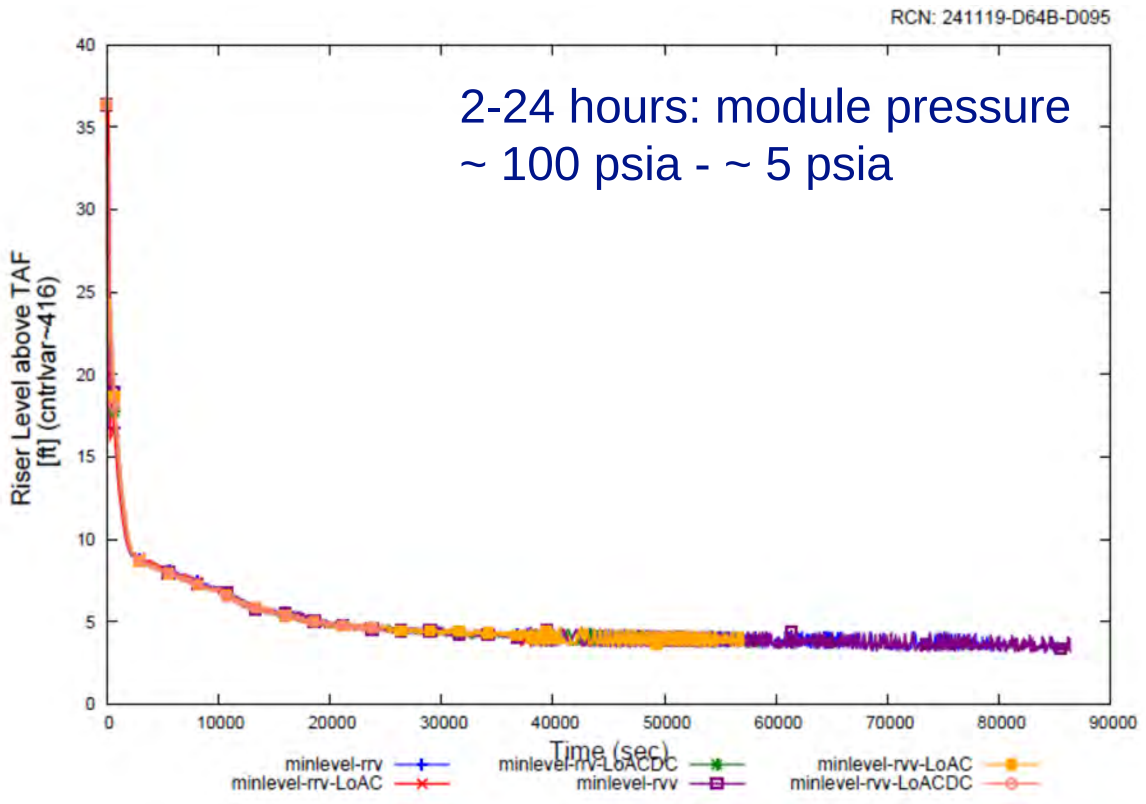
- After emergency core cooling system (ECCS) actuation, decay and residual heat generate vapor and energy transferred to reactor pool ultimate heat sink:
  - ECCS recirculation and condensation on containment wall, heat transfer through vessel wall
  - Steam generator (SG)-decay heat removal system (DHRS) operation with condensation on outside of SG tubes
- During ECCS long-term cooling, reactor coolant distributes between reactor pressure vessel (RPV) and containment vessel (CNV)
- Distribution of reactor coolant depends on
  - ECCS venting capacity and demand
  - Containment heat transfer capacity



NPM Design – Long-term ECCS Collapsed Level

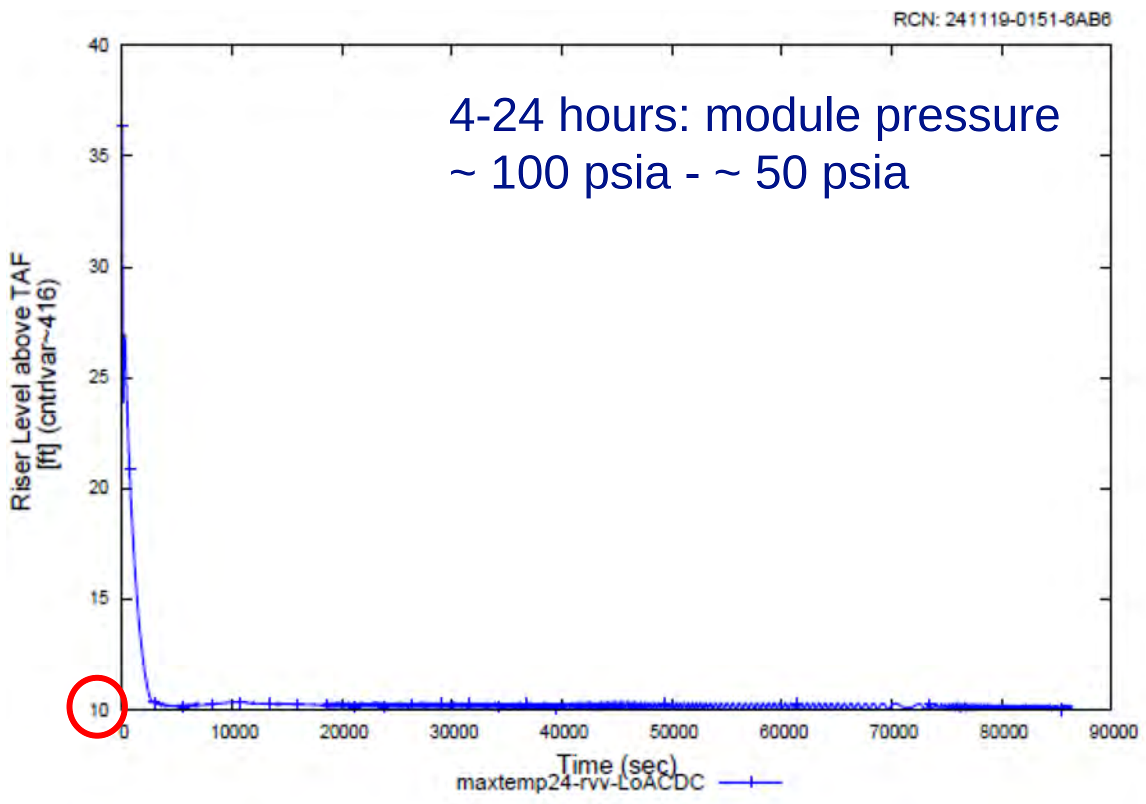
Minimum Level Conditions

High CNV wall heat transfer



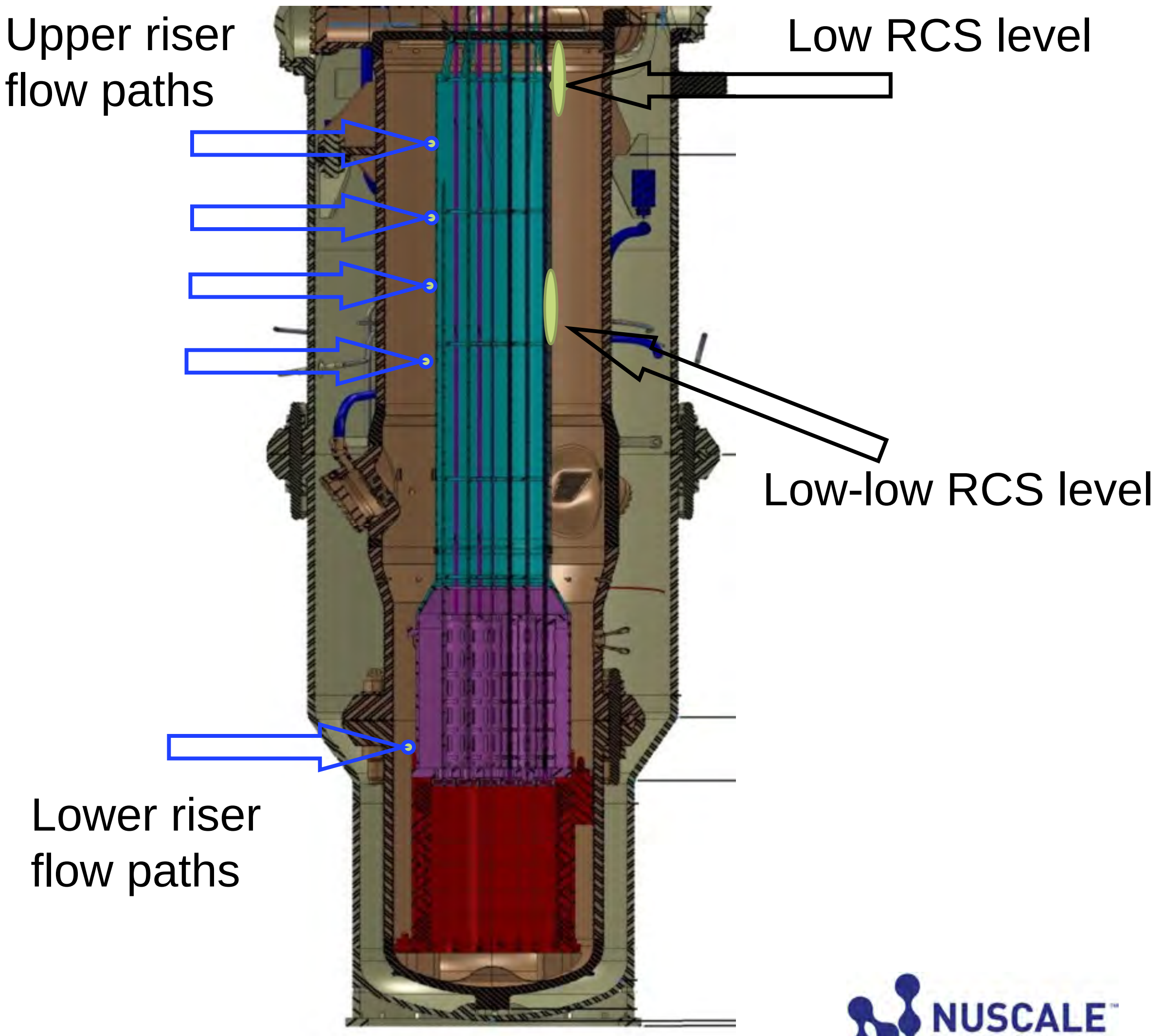
Maximum Temperature Conditions

Low CNV wall heat transfer



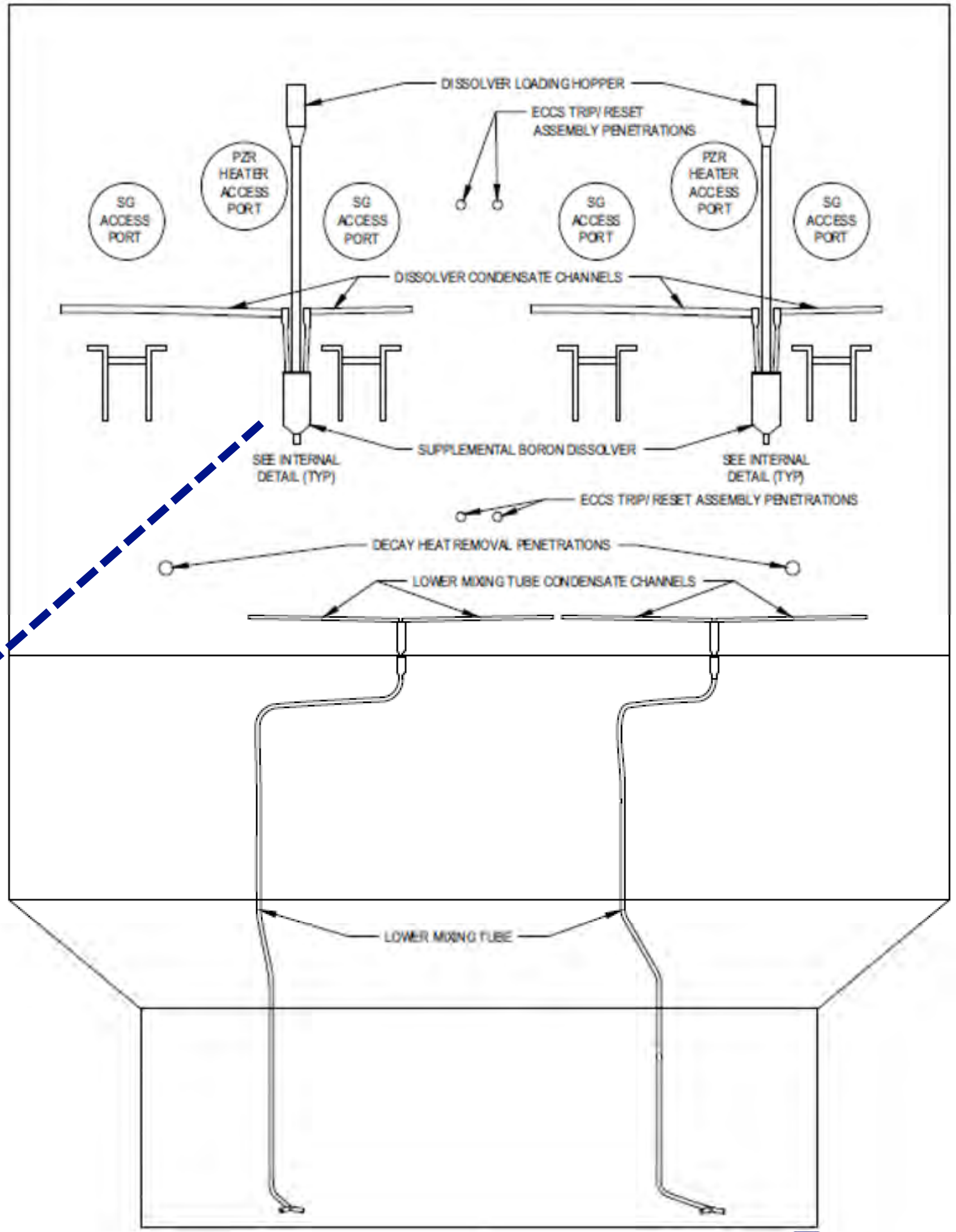
NPM Design Features – Boron Transport Method Applicability

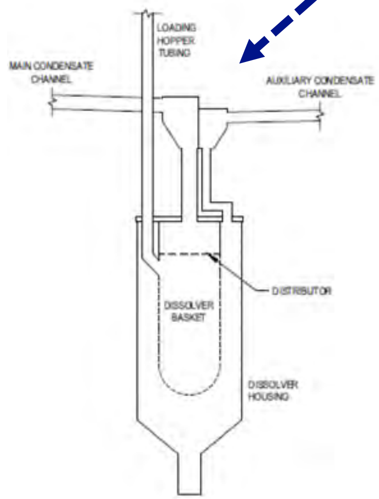
- ECCS actuation designed for core cooling and reactivity control
- Upper riser flow paths between riser and downcomer
  - Sustain liquid flow over the SG for decay heat removal after riser uncovery
  - Maintain boron transport during DHRS operation
- Lower riser flow paths between riser and downcomer
  - Maintain boron transport during ECCS operation



NPM Design Features – Boron Transport Method Applicability (continued)

- ECCS supplemental boron (ESB) feature
  - Passive design feature to maintain subcriticality during design basis extended passive cooling
  - Boron oxide (B_2O_3) pellets in dissolver basket(s)
  - Mixing tube(s) in containment
  - Condensate collection channels to dissolver basket(s) and mixing tube(s)





PIRT Evolution for XPC

- Previously developed PIRTs for NPM-160 long-term ECCS or DHRS cooling were re-assessed holistically, expanded as needed due to
  - ESB design changes
  - Requirement to maintain subcriticality

Design Certification Application (DCA) NPM-160 Design		Standard Design Approval Application (SDAA) CORE250B/NPM-20 Design	
Phase	**Figure of Merit (FOM)**	**Phase**	**FOM**
Loss-of-coolant accident (LOCA) long-term cooling (LTC) Phase 2 Period beginning after reactor recirculation valve (RRV) flow direction reverses and flows from CNV to RPV	Critical heat flux ratio (CHFR); Collapsed liquid level (CLL); Subcriticality	ECCS Phase 2 Period beginning after RRV flow direction reverses and flows from CNV to RPV	CLL; Subcriticality; Coolable geometry
Non-LOCA Phase 3 Stable natural circulation	CHFR; Mixture level (phase 3, 4); Subcriticality	DHRS Phase 3 Stable natural circulation	
Non-LOCA Phase 4 Intermittent natural circulation		n/a	n/a
Non-LOCA Phase 5 Interrupted natural circulation		n/a	n/a

EM Structure

- NRELAP5 thermal-hydraulic analysis
  - Evaluate collapsed liquid level above top of fuel and containment response
    - Minimum level conditions
    - Maximum temperature conditions
  - Provide boundary conditions for boron transport
- SIMULATE5 core reactivity analysis
  - Provide critical boron concentrations
  - Evaluate range of operating cycle exposures, operating histories, thermal-hydraulic conditions
- Boron transport analysis
  - Implemented in MATLAB scripts or other appropriate computational script
  - Map NRELAP5 conditions to critical boron concentration from SIMULATE5 to demonstrate subcriticality
  - Evaluate maximum concentration to demonstrate margin to precipitation concentrations

EM Validation Basis

- NRELAP5 validation
  - Builds on validation basis for LOCA and non-LOCA EMs
  - Additional validation against NIST-2 LTC and LOCA tests
- Boron dissolution validation
  - Separate effects tests performed
  - Methods for slow or fast-biased dissolution assessed against test data
- SIMULATE5
  - Extensive validation basis developed for other applications
  - Nuclear reliability factor (NRF) for XPC conditions evaluated and included in critical boron concentration
- Boron transport
  - Relies on thermal-hydraulic input
  - Conservative treatment of phenomena specific to boron transport

EM Adequacy Assessment and Conclusions

- Adequacy assessment evaluated from bottom-up and top-down perspectives
  - Models and correlations in NRELAP5 or phenomena treatment in boron transport considered
  - Top-down assessments considered NIST-2 integral tests and overall approach/conservatism in the EM
- Adequacy assessment discusses limitations in the models and correlations
- EM requires conservative or bounding approaches to address limitations in models and correlations

Conclusion:

- EM provides conservative method to demonstrate that an NPM, with specified design features, provides adequate core cooling and decay heat removal, remains subcritical following design basis events, and maintains coolable geometry.

Questions?

Acronyms

AOO	Anticipated operational occurrence
CHFR	Critical heat flux ratio
CLL	Collapsed liquid level
CNV	Containment vessel
DCA	Design certification application
DHRS	Decay heat removal system
ECCS	Emergency core cooling system
EM	Evaluation model
ESB	ECCS supplemental boron
FOM	Figure of merit
GDC	General design criterion/criteria
LOCA	Loss-of-coolant accident
LTC	Long-term cooling
NIST	NuScale Integral System Test Facility
Non-LOCA	Non-loss-of-coolant accident
NPM	NuScale Power Module
NRF	Nuclear reliability factor
PDC	Principal design criterion/criteria
PIRT	Phenomena identification and ranking table
RCS	Reactor coolant system
RPV	Reactor pressure vessel
RRV	Reactor recirculation valve
RVV	Reactor vent valve
SDAA	Standard design approval application
SG	Steam generator
XPC	Extended passive cooling

Presentation to the ACRS Subcommittee Staff Review of NuScale Licensing Topical Reports

TR-0516-49416, Rev. 4, Non-LOCA Analysis Methodology
TR-124587, Rev. 0, XPC Methodology

March 4, 2025

(Open Session)

Presentation to the ACRS Subcommittee of the Staff's Review of NuScale Non-Loss-of-Coolant Accident Analysis Methodology, TR-0516-49416, Rev 4.

March 4, 2025

(Open Session)

NuScale Non-LOCA LTR Review

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Non-Proprietary

NuScale Non-LOCA LTR Review

Overview

- NuScale submitted the Non-Loss-of-Coolant Accident (Non-LOCA) Evaluation Model Topical Report (TR-0516-49416-P), Rev. 4 on January 5, 2023. The topical report was formally accepted for review on July 31, 2023.
- NRC conducted an audit of the topical report from March 2023 to August 31, 2024.
- 49 audit issues were resolved in the audit
- For items not resolved during the audit, 7 RAIs were generated
- 1 RAI remains Open
- There are 2 significant differences between the draft SER submitted to ACRS on February 4, 2025, and the draft SER published on February 26, 2025

NuScale Non-LOCA LTR Review

Open Item(s)

- 1 Open Item remaining
- RAI Non-LOCA.LTR – 50
  - Issue description:
    - Staff is working to understand changes made to NRELAP5 (v1.7) and the NPM basemodel:
      - Modeling changes to DHRS models
      - Modeling of core flow distribution
  - Path forward:
    - NRC and NuScale continue to discuss these modeling changes and have high confidence the issue will be resolved shortly, with minimal impact to the SE

Non-Proprietary

NuScale Non-LOCA LTR Review

Significant differences between previously submitted SER

- 2 significant differences
  - Section 3.5.3.7, "NIST-2 Steam Generator – Decay Heat Removal System (DHRS) Integral Effects Test"
    - Expanded explanation of NIST-2 DHRS scalability
    - Due to closure of Open item RAI NonLOCA.LTR-3,9,18,19,20,21,69
  - Section 3.9, "Quality Assurance" and Section 4.0, "Limitations and Conditions"
    - Removed Limitation and Condition No. 10
    - Inserted finding of reasonable assurance related to the implementation of Quality Assurance controls consistent with RG 1.203 for the Non-LOCA EM

NuScale Non-LOCA LTR Review

Changes from LTR Rev. 3 (NPM-160) to LTR Rev. 4 (NPM-20)

- Considered design changes from NPM-160 to NPM-20
- Applicability of Phenomenon Identification and Ranking to NPM-20
- Use of bounding assumptions for primary coolant release in the radiological analysis instead of calculating primary side mass release
- Updated critical heat flux (CHF) screening for subchannel analyses
- Updated initial conditions and biasing scheme for each Non-LOCA event

NuScale Non-LOCA LTR Review

Changes from LTR Rev. 3 (NPM-160) to LTR Rev. 4 (NPM-20)

- NRELAP5 revised to version 1.7
- NRELAP5 basemodel updated for NPM-20, some system models updated
- Updated DHRS information with new tests (used in Non-LOCA, LOCA, XPC LTRs)
- NIST-2 tests for validation of NRELAP5 for DHRS performance
- Test results and code predictions of oscillation
- Reviewed scaling and distortion
- Long-term progression of non-LOCA events is covered in the XPC LTR

NuScale Non-LOCA LTR Review

Limitations and Conditions

1) Applicable to NPM-20 only
2) Changes to LOCA LTR may require changes to Non-LOCA LTR
3) Types of analyses approved for Non-LOCA EM
4) DHRS heat transfer uncertainty
5) Credit for Non-Safety MSIVs
6) Separate approval required for single failures, electric power assumptions and operator actions
7) Approved for NRELAP5v1.7 in conjunction with NPM-20 basemodel Rev. 5
8) Separate approval required for analytical limits and actuation delays; Applicant must assess for changes to event-specific bias directions
9) Separate approval required for inputs to radiological consequence analysis not derived from transient analyses

NuScale Non-LOCA LTR Review

Conclusions

- While there are some differences between the current and previous revision, the staff found that the applicant provided sufficient information to support the staff's safety finding.
- The staff found that an applicant that references this topical report with the limitations and conditions will meet relevant regulatory requirements pending review and approval of the application.

NuScale Non-LOCA LTR Review

Questions?

Presentation to the ACRS Subcommittee of the Staff’s Review of NuScale’s Extended Passive Cooling and Reactivity Control Methodology (XPC) Topical Report, TR-124587, Revision 0

March 4, 2025

(Open Session)

NuScale XPC LTR Review

Contributors

- **Technical Reviewers**
  - *Antonio Barrett, NRR/DSS/SNRB
  - Dr Rosie Sugrue, NRR/DSS/SNRB
  - Dr John Lehning, NRR/DSS/SNRB
  - Dr Adam Rau, NRR/DSS/SNRB
  - Dr Peter Lien, NRR/DSS/SNRB
  - Carl Thurston, NRR/DSS/SNRB
  - Dr Len Ward, SNRB contractor
  - Marvin Smith, SNRB contractor

  * XPC LTR review lead

  - Chis Boyd, RES/DSA
  - Jason Thompson, RES/DSA/CRAB II
  - Justin Coury, RES/DSA/CRAB II
  - Dr Andrew Bielen, RES/DSA/FSCB
- **Project Managers**
  - David Drucker, PM, NRR/DNRL/NRLB
  - Getachew Tesfaye, Lead PM, NRR/DNRL/NRLB

NuScale XPC LTR Review

Overview

- NuScale submitted the Extended Passive Cooling and Reactivity Control Methodology (XPC) Topical Report, TR-124587, Revision 0 on January 5, 2023. The topical report was formally accepted for review on July 31, 2023.
- NRC conducted an audit of the topical report from March 2023 to August 31, 2024.
- 25 audit issues were resolved in the audit
- For items not resolved during the audit, 8 RAIs were generated
- 2 RAIs remain open
- Significant differences between the draft SER submitted to ACRS on February 4, 2025, and the draft SER published on February 26, 2025, are discussed in Slide 16

Non-Proprietary

NuScale XPC LTR Review

Open Items

- 2 Open Items remaining
- RAI XPC.LTR – 6
  - Issue description:
    - Staff is working to resolve issues with subcriticality considering downpowers and low decay heat
- RAI XPC.LTR – 21
  - Issue description:
    - Staff is working to resolve issues related to the incorporation of Nuclear Reliability Factors
- Path forward:
  - NRC and NuScale continue to discuss both of these issues and have high confidence they will be resolved shortly, with minimal impact to the SE

NuScale XPC LTR Review

Significant differences between previously submitted SER

- Significant difference
  - Sections 4.8.4, “Critical Boron Concentration Evaluation” and 4.8.7, “Boron Precipitation Methodology Assessment,” explain why Limitation and Condition No. 10 and No. 11 respectively were added
  - Section 5, “Limitations and Conditions”
    - Limitation and Condition No. 10 added to require an applicant to provide technical specification controls to ensure adequate boron concentration is maintained
    - Limitation and Condition No. 11 added to require an applicant use a specific initial boron concentration

NuScale XPC LTR Review

Relevant Changes from NPM-160 (DCA) to NPM-20 (SDAA)

- Long Term Cooling and Reactivity Control
  - DCA LTC Technical Report and FSAR Evaluations
  - SDAA New XPC Topical Report Methodology and new design features
- Criticality Evaluations
  - DCA has return to power under some conditions with evaluations
  - SDAA precludes return to power with use of XPC methodology and design features

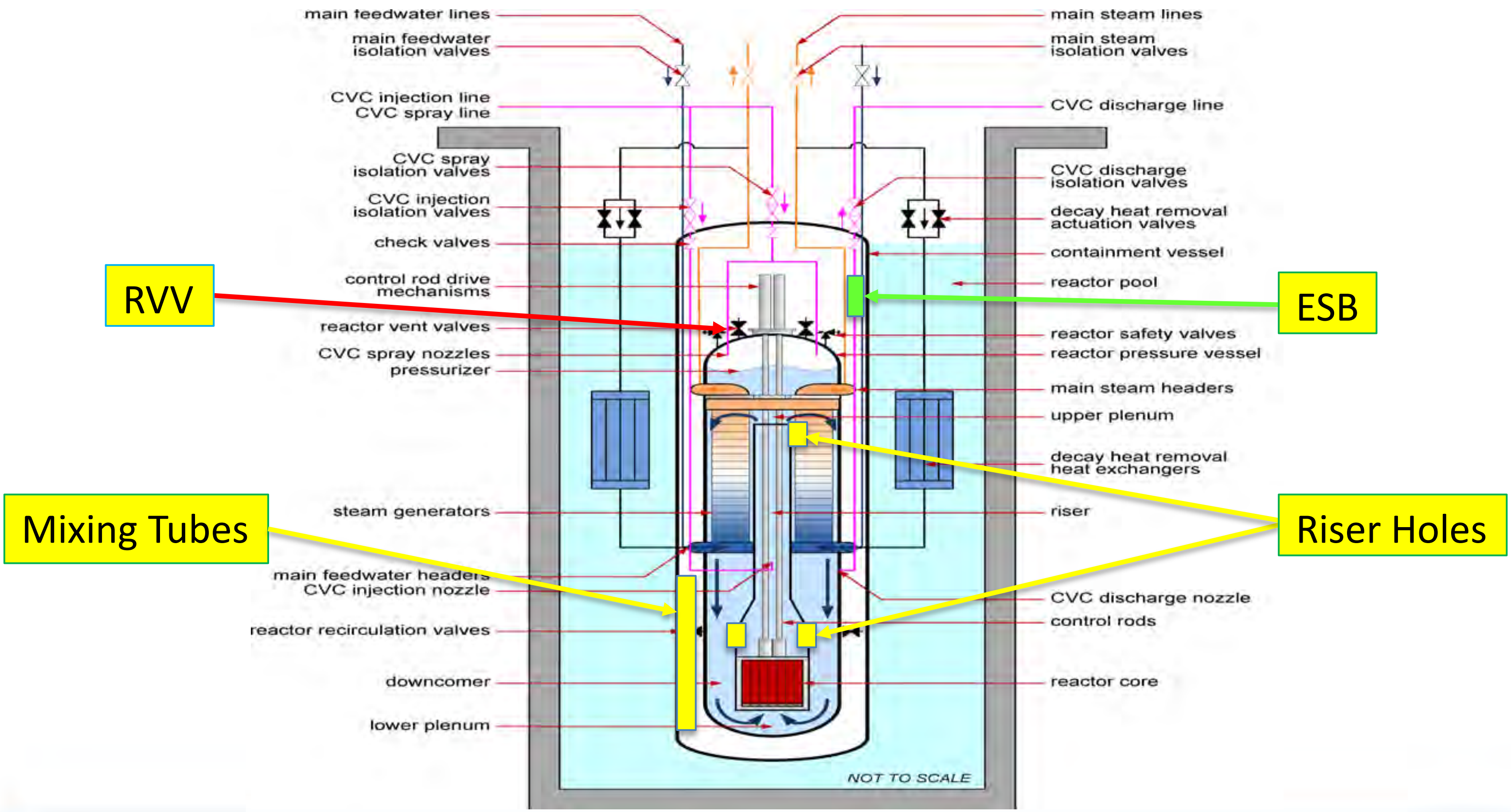
NuScale XPC LTR Review

Relevant Changes from NPM-160 (DCA) to NPM-20 (SDAA)

- Revised Reactor Design
  - Increased number of riser holes to promote mixing between the downcomer and riser to help address potential for recriticality
  - Revised Reactor Vent Valve design
    - NPM-160 RVV with IAB
    - NPM-20 RVV without IAB
  - Long Term Cooling enhancements
    - New ECCS Supplemental Boron System (ESB)
    - Riser holes, containment boron addition and containment mixing tubes contribute to boron redistribution and transport during DHRS and ECCS cooling

NuScale XPC LTR Review

Relevant Design Changes from NPM-160 to NPM-20



NuScale XPC LTR Review

Review Highlights

- XPC TR reviewed as an extension of the LOCA and non-LOCA TRs
- Independent Phenomenon Identification and Ranking Table evaluation
- Reviewed computational tools used - NRELAP5, SIMULATE5 and MATLAB
- Reviewed NRELAP5 Test Assessment Basis
  - NIST-2 LTC, LOCA ECCS, Non-LOCA Tests
  - Reviewed validation and uncertainties
- Reviewed NRELAP5 LTC model used for thermal-hydraulic response
  - Reviewed LTC NRELAP5 model validation vs LOCA base model
- Review and evaluation of lower riser hole flow assessment
- Review of evaluated events for collapsed liquid level, DHRS and ECCS heat removal capabilities and boron transport

Non-Proprietary

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

NuScale XPC LTR Review

Review Highlights

- Review of boron transport subcriticality methodology
  - Thermal hydraulic conditions
  - Boron transport and mixing model assumptions
  - Critical boron concentration and Nuclear Reliability Factors
- Review of boron transport precipitation methodology
  - Thermal hydraulic conditions
  - Boron transport and mixing model assumptions

NuScale XPC LTR Review

Safety Evaluation Report Differences

- Updated Nuclear Reliability Factor review portion
- Add limitation/condition for requiring enough boron to account for integral down powers and xenon impacts for subcriticality analysis applications
- Add limitation/condition to require the zero power maximum operational limit boron concentration (no xenon) at the beginning of cycle is used as an initial condition for precipitation analysis applications

NuScale XPC LTR Review

Limitations and Conditions

1) Changes to LOCA or Non-LOCA LTR may require changes to XPC LTR
2) Applicable US460/NPM-20 only
3) Maintain insignificant non-condensable gas in containment
4) Consider the density difference between the borated and unborated liquid
5) Methodology limited to 72 hours
6) RVV compressible flow qualification
7) Initial test program (first module only) for dissolution testing
8) Approved for NRELAP5v1.7 in conjunction w/NPM-20 Basemodel Rev. 5
9) Separate approval required for single failures, electric power assumptions and operator actions

NuScale XPC LTR Review

Limitations and Conditions

10) Account for integral down powers and xenon for subcriticality
11) Zero power maximum operational limit boron concentration (no xenon) at the beginning of cycle is used as an initial condition for precipitation

NuScale XPC LTR Review

Conclusion

- The staff found that the applicant provided sufficient information to support the staff's safety finding.
- The staff found that an applicant that references this topical report, and satisfies the limitations and conditions, will meet relevant regulatory requirements pending review and approval of the application.

NuScale XPC LTR Review

Questions?

Meeting Title	**Open Session NuScale Subcommittee on Staff's Evaluation of NuScale Non LOCA and Extended Passive Cooling Topical Reports**
Attendee	
Michael Snodderly	ACRS DFO
Stephen Schultz	ACRS
Larry Burkhart	ACRS
Thomas Dashiell	ACRS
Andrea Torres	ACRS
Patrick King	Court Reporter
Christina Antonescu	ACRS
Tammy Skov	ACRS
Shandeth Walton	ACRS
Sandra Walker	ACRS
Erin Whiting	NuScale
Karl Gross	NuScale
Ron Ballinger	ACRS
Kyle Hoover	NuScale
Amanda Bode	NuScale
Kenny Anderson	NuScale
Wendy Reid	NuScale
Derek Widmayer	ACRS
Nathanael Hudson	RES
Matt Sunseri	ACRS
Dennis Bley	ACRS
Hossein Nourbakhsh	ACRS
Getachew Tesfaye	NRR
Greg Halnon	ACRS
Sarah Turmero	NuScale
Lucas Kyriazidis	RES
Stewart Bailey	NRR
Mahmoud -MJ- Jardaneh	NRR
Gene Eckholt	NuScale
Freeda Ahmed	NuScale
Allyson Callaway	NuScale
David Drucker	NRR
Brian Wolf	NuScale
Adam Rau	NRR
Jason Thompson	RES
Gary Becker	NuScale
Tyler Beck	NuScale
Timothy Polich	RoPower
Ben Bristol	NuScale
Stacy Joseph	NRR
River Rohrman	NRR
Stephanie Garland	ACRS
Vesna Dimitrijevic	ACRS

Peter Lien	NRR
Thomas Hayden	NRR
Adam Brigantic	NuScale
Christopher Boyd	RES
Ken Rooks	NuScale
Rick Rosenstein	NuScale
Dan Lassiter	NuScale
Taha Abdelnaeem	Framatome
Hiroaki Sonoyama	
Marvin Smith	
Eric Baker	NuScale
Andrew Deszel	Numark
Kevin Lynn	NuScale
Thomas Case	NuScale
Ben Bristol	NuScale
Taylor Coddington	NuScale
Thomas Griffith	NuScale
Meghan McCloskey	NuScale
Rebecca Patton	NRC
Antonio Barrett	NRC
Len Ward	Consultant
Kris Cummings	NuScale
Zhian Li	NRR
Adam Rau	NRR
Warren Erling	NRR
Sean Piela	NRR
Rosemary Sugrue	NRR
Andrew Bielen	RES
Justin Coury	RES
Carl Thurston	NRR
Joshua Miller	NRR
Dong Zheng	NRR