

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: ACRS NuScale Subcommittee - Open Session

Docket Number: N/A

Location: Rockville, Maryland

Date: August 24, 2018

Work Order No.: NRC-3862

Pages 1-88

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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2 NUCLEAR REGULATORY COMMISSION

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4 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

5 (ACRS)

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7 NUSCALE SUBCOMMITTEE

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9 OPEN SESSION

10 + + + + +

11 FRIDAY

12 AUGUST 24, 2018

13 + + + + +

14 ROCKVILLE, MARYLAND

15 + + + + +

16 The Subcommittee met at the Nuclear
17 Regulatory Commission, Two White Flint North, Room
18 T2B1, 11545 Rockville Pike, at 8:30 a.m., Walter
19 Kirchner, Chairman, presiding.
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1 COMMITTEE MEMBERS:

2 WALTER L. KIRCHNER, Chairman

3 RONALD G. BALLINGER, Member

4 DENNIS C. BLEY, Member

5 CHARLES H. BROWN, JR. Member

6 MICHAEL L. CORRADINI, Member

7 JOSE MARCH-LEUBA, Member

8 JOY L. REMPE, Member

9 GORDON R. SKILLMAN, Member

10 MATTHEW SUNSERI, Member

11
12 DESIGNATED FEDERAL OFFICIAL:

13 MICHAEL SNODDERLY

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P R O C E E D I N G S

8:33 a.m.

CHAIRMAN KIRCHNER: The meeting will come to order. This is a meeting of the Advisory Committee on Reactors Safeguards, NuScale Subcommittee. I am Walt Kirchner, Chairman for today's Subcommittee meeting.

Members in attendance today are Ron Ballinger, Dennis Bley, Gordon Skillman, Matt Sunseri, Mike Corradini, Joy Rempe, Jose March-Leuba, Charlie Brown. And Mike Snodderly is the Designated Federal Official for this meeting. Thank you, Mike.

The Subcommittee will review the staff's evaluation of Revision 1 to NuScale's topical report, TR-0915-17564P, subchannel analysis methodology. Today we have members of the NRC staff and NuScale to brief the Subcommittee.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act, FACA. That means that the Committee can only speak through its published letter reports. We hold meetings to gather information to support our deliberations. Interested parties who wish to provide comments can contact our office requesting time after the meeting announcement is published in the Federal Register.

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1 That said, we've set aside ten minutes for
2 comments from members of the public attending or
3 listening to our meetings. Written comments are also
4 welcome.

5 The ACRS section of the US NRC public
6 website provides our charter, bylaws, letter reports,
7 and full transcripts of all full and subcommittee
8 meetings, including slides presented there. The rules
9 for participation in today's meeting were announced in
10 the Federal Register on August 13, 2018.

11 The meeting was announced as an
12 open/closed meeting. We plan to close the meeting
13 after the open portion to discuss proprietary
14 material, and presenters can defer questions that
15 should not be answered in the public session to that
16 time. No written statement or request for making an
17 oral statement to the Subcommittee has been received
18 from the public concerning this meeting.

19 A transcript of the meeting is being kept
20 and will be made available, as stated in the Federal
21 Register notice. Therefore, we request that the
22 participants in this meeting use the microphones
23 located throughout the meeting room when addressing
24 the Subcommittee. Participants should first identify
25 themselves and speak with sufficient clarity and

1 volume so that they can be readily heard.

2 We have a bridge line established for the
3 public to listen in to the meeting. To minimize
4 disturbance, the public line will be kept in a listen-
5 in only mode. To avoid disturbance, I further request
6 that attendees put their electronic devices like
7 cellphones in the off or noise-free mode.

8 We'll now proceed with the meeting. And
9 shall I turn to NuScale first or the staff?

10 MEMBER SUNSERI: To Paul.

11 CHAIRMAN KIRCHNER: Okay, Paul, would you
12 please begin. Paul Infanger from NuScale.

13 MR. INFANGER: I'm Paul Infanger, I'm
14 Licensing Project Manager for Chapters 4 and 15, which
15 includes the Subchannel Topical Report. I've been
16 with NuScale for about three and a half years. Prior
17 to that, I worked on the Barakah Plant with the
18 Koreans.

19 And then before that, I was with UniStar
20 new plants with Calvert Cliffs COLA. And before that
21 I was licensing manager at a number of operating
22 plants for about 25 years.

23 My background, I went to Ohio State
24 University. I have degrees in physics and a master's
25 in nuclear engineering. And appreciate the

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1 opportunity today to present technical information in
2 support of the staff. This is the third topical
3 report related to our core methodologies. So we had
4 the nuclear codes and methods and the CHF palpables
5 last month.

6 And so we'll have some presenters here
7 today. Immediately to my left is our lead presenter,
8 is Ken Rooks.

9 MR. ROOKS: My name is Ken Rooks, I've
10 been with NuScale for four and a half years in the
11 Core TH Group within the nuclear fuels organization.
12 Prior to NuScale, I was with AREVA, or former AREVA,
13 now Framatome, for four and a half years in their
14 fuels T/H organization. And prior to that I was
15 graduated from NC State in nuclear engineering.

16 MS. CALLAWAY: My name's Allyson Callaway,
17 I'm the Nuclear Analysis Supervisor. I've been with
18 NuScale doing nuclear analysis for the last eight
19 years.

20 CHAIRMAN KIRCHNER: Do you have other
21 NuScale people now on the line that you want to
22 introduce, or at least confirm they're on?

23 MS. CALLAWAY: Sure. Kenny, Anderson, are
24 you on the line?

25 MR. ANDERSON: Yes.

1 MS. CALLAWAY: Okay, and Kenny Anderson,
2 who's also in the nuclear analysis field.

3 CHAIRMAN KIRCHNER: And what is Kenny's
4 role in NuScale's operation?

5 MS. CALLAWAY: Nuclear analysis and core
6 thermohydraulics.

7 CHAIRMAN KIRCHNER: Thank you.

8 MR. ROOKS: All right, so Ken I will go
9 ahead and get started with the presentation.

10 All right, so today we're going to cover
11 in this session an overview of the topical report, an
12 overview of the safety analysis process, and then a
13 brief introduction to the NuScale SMR. Then we'll
14 discuss the VIPRE subchannel T/H code, and then the
15 additional qualification for NuScale conditions and
16 the overall methodology approach.

17 The purpose of the Subchannel Analysis
18 Topical Report is to obtain NRC approval to evaluate
19 the NuScale core using the VIPRE computer code for
20 steady state and transient analyses. We also
21 illustrate NuScale's use of VIPRE and its compliance
22 with the generic SER conditions. And also approval of
23 the conservative methodology for licensing
24 calculations.

25 So I understand we're --

1 MEMBER CORRADINI: If I might, whoever's
2 on the line, you might want to mute it on your end.
3 That may reduce the crackling.

4 MR. ROOKS: Okay. To understand the
5 objective of subchannel analysis, I've kind of
6 presented a simplified flow chart of the safety
7 analysis process. The four components that generally
8 make up the safety analysis processes are nuclear
9 analysis, fuel performance, system transient analyses,
10 and subchannel analysis.

11 The safety analysis uses the design for
12 input and it's informed by testing, such as CHF.
13 Today we're going to be mostly focused on subchannel
14 analysis. As you can see, this portion's quite
15 integrated, with a lot of input lines that are feeding
16 into it. Nuclear analysis specifically is the core
17 design, core physics provided inputs, which is a topic
18 report that's nearing acceptance that you guys have
19 seen.

20 Fuel performance already has an approved
21 topic, which is the fuel thermal-mechanical methods.
22 And system transient analyses are specifically the
23 non-LOCA events for which the subchannel analyses are
24 applicable for that provide thermohydraulic boundary
25 conditions.

1 MEMBER REMPE: Are you, you mentioned that
2 the neutronics analysis report has been reviewed.
3 What about the system transient analysis? Are you
4 planning to submit a report?

5 MR. ROOKS: That's a good question. It's
6 in review currently. By the staff.

7 MEMBER REMPE: Okay.

8 MR. ROOKS: So as mentioned, we'll focus
9 on the subchannel moving forward. The objective of
10 the subchannel analysis is to evaluate margin to
11 acceptance criteria. The specific criteria are
12 SAFDLs, which are specified acceptable fuel design
13 limits.

14 The fuel design limits evaluated using the
15 methods in this topical report are critical heat flux
16 and fuel center line melting, which correspond to the
17 overheating of cladding and fuel pellets in the
18 standard review plan of Chapter 4. Ultimately, the
19 results of the subchannel analysis are used as inputs
20 to the NuScale FSAR for Chapters 4 and 15.

21 So now a quick summary of the pertinent
22 NuScale reactor conditions. As you know, the NuScale
23 reactor is a natural circulation PWR, which implies
24 the system flow changes with thermal power level, flow
25 rates hydraulically driven by the density gradient

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1 between the core and the steam generator.

2 This illustrates how NuScale is unique by
3 not having pumped driven core flow, but it's also
4 important to note that NuScale's not quite that
5 different from a traditional PWR. Our core is
6 operated to maintain the core average exit as
7 subcooled. These subcooled exit quality conditions
8 occur for normal conditions and all AOOs, for off-
9 normal conditions.

10 These fluid conditions are very similar to
11 traditional large PWRs. Our hot channel exit slightly
12 saturating with an equilibrium quality greater than
13 zero, but that's due to our conservative methodology
14 that we're implemented.

15 MEMBER MARCH-LEUBA: Can you repeat that?
16 Go back to the hot channel quality is greater than
17 zero because?

18 MR. ROOKS: Because of our conservative
19 methodology, the way we modeled --

20 MEMBER MARCH-LEUBA: So it really is not,
21 you don't expect it to be greater than zero.

22 MR. ROOKS: That's correct.

23 MEMBER MARCH-LEUBA: But the calculations,
24 because of your uncertainty, conservative assumptions.

25 MR. ROOKS: That's correct. So NuScale is

1 using the VIPRE-01 subchannel analysis tool, which was
2 developed by EPRI. And it's maintained by Zachry.
3 It's a finite volume code capable of determining three
4 dimensional core flow and distribution for single and
5 two-phase conditions.

6 It uses the three equation homogenous
7 equilibrium model and has empirical models to
8 incorporate it for simple boiling and void quality
9 relationships.

10 From the picture you can see the
11 flexibility in the discretization (phonetic) the VIPRE
12 can handle, from modeling an entire core, which is 37
13 assemblies, all the way down to a single volume within
14 the subchannel. VIPER-01 has a strong user and
15 licensing base in the traditional PWR fleet.

16 MEMBER CORRADINI: Maybe it's a little bit
17 off topic, but are you aware of the number of
18 utilities that are using VIPRE as their subchannel
19 analysis tool?

20 MR. ROOKS: I'm not sure of the total
21 number, but I do know that Duke and Dominion are two
22 large ones that use it.

23 MEMBER CORRADINI: I knew about Dominion,
24 I didn't know about Duke. Okay, thank you.

25 MR. ROOKS: So as I mentioned, NuScale is

1 using the as-approved version of VIPRE, which is the
2 common base used throughout the industry. We've made
3 no changes to the main program, only incorporating
4 NuScale proprietary CHF correlations through a dynamic
5 link library.

6 VIPRE-01 is managed internally through
7 NuScale's Appendix B software QA program. VIPRE has
8 a generic SER that contains a list of several
9 conditional criteria which NuScale has demonstrated
10 compliance.

11 With NuScale using the generically
12 approved version of VIPRE, the robust qualification
13 performed by the original co-developers remains
14 applicable. In addition, NuScale performed additional
15 qualification to justify the applicability to NuScale
16 core conditions.

17 The additional qualification consisted of
18 code-to-code comparisons to a different NRC-approved
19 code, additional experimental comparisons to
20 experiments not in the original SER test suite, and
21 then as well parametric and generalized sensitivity
22 studies.

23 These three additional techniques provided
24 a strong holistic basis that VIPRE was applicable for
25 NuScale applications.

1 MEMBER BROWN: And we're going to see
2 those in the closed session?

3 MR. ROOKS: That's correct.

4 MEMBER BROWN: Okay.

5 MR. ROOKS: The analysis methodology we've
6 implemented is premised on the development of a
7 conservative base model using bounding axial power
8 shapes and general radial power distribution. We set
9 the nodalization to accurately capture the hot channel
10 local conditions for evaluating a conservative MCHF.

11 The uncertainties on inputs are applied in
12 a deterministic manner, meaning the biases are applied
13 in a conservative direction. In addition, we have a
14 detailed analyst-completed checklist that's performed
15 on the analysis level that ensures the method was
16 incorporated correctly and the results are acceptable.

17 So in summary, NuScale had developed a
18 conservative subchannel analysis methodology for
19 evaluating steady state and transient conditions. The
20 topical report provides details about NuScale's use of
21 VIPRE and its compliance with all SER conditions, as
22 well as VIPRE's applicability to the NuScale design
23 and a deterministic methodology for, with supplemented
24 sensitivities.

25 The results using this NuScale subchannel

1 analysis methodology are used as inputs to the NuScale
2 final safety analysis report for Chapters 4 and 15.

3 CHAIRMAN KIRCHNER: Since we're in the
4 open session, can you just qualify what family of
5 transients that you used this for versus what you
6 would do the rest of Chapter 15 with?

7 MR. ROOKS: This would apply to heat-up
8 events and cool-down events or control rod reactivity
9 events. It's applicable to most NuScale Chapter 15
10 events, with the exception of LOCA.

11 CHAIRMAN KIRCHNER: Sure, okay, thank you.

12 MEMBER BROWN: So, okay, so if I reverse
13 it, except for LOCA, it's not only just AOOs, but a
14 number of the DBAs would be you'd be using VIPRE as
15 part of your analysis?

16 MR. ROOKS: That's correct.

17 CHAIRMAN KIRCHNER: Okay, at this point
18 then -- yeah, before we do, are there any questions
19 here in the open session? Or I assume people are
20 going to wait for the closed session.

21 MEMBER MARCH-LEUBA: You assume correctly.

22 CHAIRMAN KIRCHNER: Okay, yes, okay, Mike,
23 let's bring up the staff then. Thank you.

24 Okay, now we'll turn to the staff. Bruce.

25 PARTICIPANT: I don't think your mic's on.

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1 CHAIRMAN KIRCHNER: Just pull it closer,
2 please.

3 MR. BAVOL: Good morning, my name is Bruce
4 Bavol, I'm a project manager in the Office of New
5 Reactors. Today's presentation from the NRC is on the
6 subchannel analysis methodology. The NRC technical
7 reviewers that are involved with this morning's
8 presentation, the lead, Syed Haider, who's to my
9 right.

10 Also, we have Matt Thomas, who's on the
11 bridge line. Matt is currently on rotation as a
12 resident inspector at Watts Bar. He's found some time
13 to call in this morning, because Matt was a support in
14 the review of this presentation, or this topical
15 report.

16 And then to my left at the side desk, Tim
17 Drzwiecki, also was a support with this review and is
18 currently Acting Branch Chief and representing
19 Reactors Systems Branch this morning.

20 First, I'd like to point out that your
21 hard copy presentation has the first bullet there, it
22 should be the subchannel analysis Revision 1, not the
23 codes and methods. I changed it on a presentation.
24 February 15, 2017, Revision 1 was submitted for
25 review. In October of 2016, Revision 0 was submitted,

1 but the change from Rev 0 to Rev 1 was a proprietary
2 update of information in the topical report. And so
3 staff is working with Revision 1.

4 The request for additional information,
5 there the following RAIs are listed there. They're
6 mentioned within the safety evaluation, and the
7 responses from NuScale are also, the ML numbers are
8 also listed.

9 There is, I believe, one confirmatory item
10 that we'll be looking for an update in Revision 2 of
11 the document when we complete this process of going
12 through ACRS.

13 We plan to go to full committee on
14 September 6. And staff plans a final safety
15 evaluation late October. And then the dash A we're
16 scheduled for early 2019.

17 MEMBER MARCH-LEUBA: How is that going to
18 work? Are we going to write a letter on a draft SER?

19 MEMBER CORRADINI: The intention is that
20 we're, they're asking for a letter from us based on
21 the documentation we have now.

22 MR. BAVOL: That's correct. So the
23 updates to that, for confirmatory reasons, will be
24 annotated in the safety evaluation as such. It'll
25 just be --

1 MEMBER MARCH-LEUBA: As long as
2 everybody's happy, I'm happy.

3 MEMBER CORRADINI: No, I think so far
4 we've had topical reports that have all the open items
5 closed. There have been confirmatory items.

6 MR. BAVOL: Right.

7 MEMBER CORRADINI: So we're in the same
8 situation here.

9 MR. BAVOL: That's correct. Okay, I'd
10 like to now turn it over to Syed to start the
11 presentation. And just let me know when you want to
12 shift your slides.

13 MR. HAIDER: Thank you, Bruce. Good
14 morning, my name is Syed Haider. I'm the lead
15 technical reviewer at NRO for the NuScale subchannel
16 analysis methodology topical report, Revision 1, that
17 was submitted in February 2017.

18 I would like to acknowledge the
19 contributions made to the review by Matt Thomas, my
20 colleague, who is also on the line, from the Reactor
21 Systems Branch. And Joe Kelly from the Office of
22 Research.

23 While Matt and I performed the topical
24 reviews and wrote the respective SER sections, Joe
25 performed all necessary VIPRE confirmatory analyses

1 that were needed to support the review. Last but not
2 least, thanks to Bruce for handling all of our
3 coordination with NuScale.

4 The staff conducted the review of the
5 NuScale subchannel analysis methodology topical report
6 per General Design Criterion 10 on reactor design from
7 10 CFR Part 50, Appendix A. The related regulatory
8 guidance is stipulated in NuScale design specific
9 standards, Sections 4.4 on thermal and hydraulic
10 design and 10 CFR 53.4.

11 The NuScale subchannel analysis
12 methodology uses the NRC approved VIPRE-01, dash the
13 01, subchannel thermal-hydraulic computer code,
14 Version MOD-02, to conduct the NuScale fuel design
15 subchannel safety analysis. The earlier VIPRE
16 version MOD-01 was approved by the NRC in 1986, which
17 the version MOD-02 that is used in the NuScale
18 methodology was approved in 1993.

19 The NRC approvals of VIPRE-01 MOD-01 and
20 MOD-02 code versions that were developed by EPRI are
21 documented through their respective NRC generic safety
22 evaluation reports. Note through the rest of the open
23 and closed sessions I will be referring to the NuScale
24 subchannel analysis methodology as an acronym, N-S-A-
25 M, or NSAM.

1 This slide also lists the four elements of
2 approval for the NuScale subchannel analysis
3 methodology, or NSAM, that NuScale applied for in the
4 topical report.

5 These four elements required the staff to
6 focus on that VIPRE-01 code's applicability to the
7 NuScale steady state and transient subchannel
8 analyses; how the methodology fulfills the NRC's
9 requirements, as specified in the generic SERs for
10 VIPRE-01 MOD-01 and MOD-02 versions; whether the
11 methodology is independent of any specific CHF
12 correlations; and whether the methodology for
13 treatment of uncertainties in the subchannel's
14 methodology is also appropriate.

15 So the two generic SERs that document the
16 NRC approval of VIPRE-01 versions MOD-01 and MOD-02
17 identify a total of nine conditions that an
18 application of VIPRE code has to meet. These nine
19 conditions that mainly deal with VIPRE modeling
20 assumptions and qualifications provided the technical
21 basis for the staff review of the NSAM topical report.

22 Out of the nine conditions, the first five
23 conditions belong to the 1986 MOD-01 SER. And the
24 later four conditions belong to the MOD-02 SER that
25 got approved in 1993. The review required the staff

1 to focus on several respects of the methodology
2 application and the treatment of uncertainties.

3 Even though generic VIPRE-01
4 qualifications for subchannel analyses had been
5 reviewed as a part of the original MOD-01 and MOD-02
6 approvals, the staff closely looked into certain areas
7 to ensure the VIPRE-01 licensing applicability to the
8 NuScale design.

9 These respects include questions about the
10 NSAM applicability range and any VIPRE-01 code
11 limitation applicable to the NuScale fuel design,
12 NuScale operating conditions, ensuring that the
13 current number criterion is met and numerical solution
14 is stable, inlet boundary condition consistency
15 between the system level and RELAP-5 and VIPRE-01
16 codes, verifying that the VIPRE predictions are not
17 made close to two-phase fluent stability, and
18 qualification of the VIPRE model and assumption,
19 especially the two-phase flow models used in NSAM.

20 In our review, the information the
21 analysis staff considered in addition to NSAM topical
22 report included the responses to RAIs 9080, 9086,
23 9099, and 9129, as well as the documents NuScale
24 provided for the auditor.

25 Now I'll summarize the applicability of

1 the nine MOD-01, MOD-02 SER conditions to the NSAM and
2 the how applicant met them.

3 Condition 1 requires that the application
4 of VIPRE-01 should be limited to PWR licensing
5 calculations that cover the heat transfer regimes up
6 to the critical heat flux. Any use of VIPRE-01 in
7 boiling water reactor calculations or post-CHF
8 calculations will require a separate analysis.

9 The applicant did not seek the VIPRE
10 approval for both CHF calculations, and rather limited
11 the NuScale VIPRE-01 application up to the point of
12 CHF.

13 MEMBER MARCH-LEUBA: Syed, has VIPRE been
14 approved for BWR after this SER was issued?

15 MR. HAIDER: Yes. I forgot to mention
16 that.

17 MEMBER MARCH-LEUBA: Okay.

18 MR. HAIDER: It's also worth mentioning
19 that Condition 1 is rooted in VIPRE version MOD-01.
20 That was not approved for BWR, while NuScale has
21 rather used the most recent version, MOD-02. That was
22 approved for PWR and BWR. However, the staff closely
23 reviewed the two-phase response of the NuScale boiling
24 transients.

25 In the closed session, I will present

1 additional information on the NuScale two-phase
2 operation conditions to show that Condition 1 is met,
3 and there are no staff concerns regarding the
4 NuScale's PWR, like two-phase flow attributes or VIPRE
5 codes limitation to handle the two-phase regimes
6 encountered.

7 MEMBER MARCH-LEUBA: Maybe I'll wait for
8 the closed session, but I don't 100% agree with what
9 you said about NuScale being a pressurized water
10 reactor all of the time. There is --

11 MR. HAIDER: I think let's wait until
12 closed session.

13 MEMBER MARCH-LEUBA: Maybe we should
14 discuss this in the closed session.

15 MR. HAIDER: Sure. Condition 2 mandated
16 the submittal of a separate topical report for the
17 staff review and approval for an unapproved CHF
18 correlation to be used in the VIPRE application. The
19 staff had to ensure that the methodology is applied
20 within the range of applicability of the CHF
21 correlation, including fuel assembly during design
22 pressure coolant mass velocity and quality.

23 NuScale submitted a separate topical
24 report for approval of the use of NuScale specific NSP
25 CHF correlation applicable to its new fuel STP 2 fuel

1 that is referenced in the NSAM topic report.

2 The applicant used VIPRE-01 to reduce the
3 experimental CHF data to calculate the local fluid
4 parameters to develop the CHF correlation and the
5 MCHFR for the NuScale fuel. The NSP 2 correlation has
6 been approved by the NRC.

7 The NSAM topical report also provides
8 assurance that only approved CHF correlations will be
9 used with VIPRE-01 MOD-02 for the NPM safety analyses
10 when the NSAM PR is referenced in the NuScale DCA.

11 In this regard, the staff has developed a
12 condition as a part of the present SER that requires
13 that an applicant referencing the NSAM topical report
14 in the safety analysis must also reference an approved
15 CHF correlation. So now it's a condition of the
16 current SER.

17 Based on the submittal of a separate TR
18 for the NuScale CHF correlation, and pursuant to the
19 SER condition use, NRC staff finds that the applicant
20 satisfied the generic VIPRE SER Condition 2. And this
21 discussion of the range of applicability of NSAM vis-
22 a-vis the NSP 2 CHF correlation will be covered in the
23 closed session. That is also tied to the question
24 that you had raised.

25 Condition 3 asked for the specifications

1 for using specific modeling assumptions, choice of
2 two-phase flow models, heat transfer correlation,
3 input values of plant-specific data such as turbulent
4 mixing coefficient, two-phase slipper issue and loss
5 coefficient.

6 The applicant met Condition 3 by providing
7 sufficient information in the NSAM topical report, RAI
8 responses, and the audit documents about the factors
9 that are summarized in the present, on the present and
10 the next slides.

11 These factors typically belong to various
12 thermal-hydraulic input parameters, sensitivities,
13 uncertainties, penalties, heat transfer coefficients,
14 VIPRE model geometry and nodalization, and boundary
15 conditions. Some of them are described in detail by
16 the applicant in their presentation.

17 So the staff has presented some
18 confirmatory analyses that the staff performed about
19 the key sensitivities in the closed session to
20 demonstrate that the applicant has provided sufficient
21 information to justify the specific VIPRE models and
22 assumptions so that a Condition 2 is met by NuScale.
23 Next slide please.

24 Condition 4 requires that if a profile fit
25 a subcooled boiling model, which was developed based

1 on steady state data is used in boiling transient,
2 care should be taken in the time step sizing used for
3 transient analysis to avoid a Courant number less than
4 one. A defect is that NSAM indeed uses the existing
5 VIPRE-01 steady state support boiling correlations, so
6 this condition does apply to NSAM.

7 So a Courant number greater than one is
8 required for the convergence of the numerical solution
9 of the mass momentum and energy equations in a VIPRE
10 simulation of boiling transients while using subcooled
11 void correlation that is based on steady state data.

12 MEMBER MARCH-LEUBA: I guess this can be
13 discussed in the open session. That's a very
14 surprising condition, because most of us are used to
15 a Courant number less than one as the stability
16 condition. So you use Courant number greater than one
17 with an implicit method to offer them the solution and
18 converts to the steady state faster and more reliably.
19 And that I can understand.

20 Now, when you want to apply this
21 methodology to transients, where this overdamping is
22 giving you the wrong transient solution, and I realize
23 you didn't review VIPRE, that that was an old SER that
24 this came from. But this looks a little, something is
25 not kosher here.

1 But using a highly damp implicit method,
2 you are not reducing the transient. So when you are
3 ejecting a control rod, you're not getting the proper
4 profile or whatever you're tracking in the subchannel.
5 Have you considered that maybe that condition of
6 Courant less than one was before a steady state, not
7 for transients?

8 MR. HAIDER: Okay, the staff kind of
9 expected this question. And I think they have a
10 detailed slide in the closed section. I'm sorry, the
11 staff expected this question, and there is material in
12 the closed session where we will be discussing this
13 particular issue.

14 CHAIRMAN KIRCHNER: Okay, but I think this
15 is a good point that Jose brought. Because I have to
16 admit, the first few times reading through the
17 material, I went like this -- for the record, I
18 scratched my head. And saying wait a minute, this is,
19 you're forcing a solution.

20 MEMBER MARCH-LEUBA: I thought it was a
21 typo.

22 CHAIRMAN KIRCHNER: I thought it was a
23 typo, and I kept revisiting this each time I tripped
24 over it. So we will look forward to your analysis of
25 this condition in the closed section.

1 MR. HAIDER: Okay, the staff will offer
2 their thoughts.

3 CHAIRMAN KIRCHNER: Okay, thank you.
4 Again, for the record, this is counterintuitive.

5 MR. HAIDER: I think here I would just
6 like to say that the VIPRE uses an implicit scheme.
7 It is inherently--

8 CHAIRMAN KIRCHNER: You're drifting away
9 again.

10 MR. HAIDER: Sorry, the VIPRE uses an
11 implicit numerical scheme, which is inherently
12 instable. So this Courant number criterion emerged
13 out of the special uses of subcooled void correlation
14 under boiling transients. So it should not be looked
15 in the same light that is available in the open
16 literature about Courant number being less than one
17 being a condition for numerical stability.

18 MEMBER MARCH-LEUBA: I propose that we
19 wait.

20 CHAIRMAN KIRCHNER: We can wait, but no,
21 that's a good enough answer now for the record that,
22 why this is being done. And then we can revisit it in
23 the closed session. Okay, thank you.

24 MR. HAIDER: So VIPRE-01 MOD-01 SER
25 describes the quality control requirements. The

1 objective of these requirements, this requirement is
2 to ensure consistency in the development and
3 application of the VIPRE-01 code for safety analysis.

4 This essentially means that only an as-
5 approved version of VIPRE-01 can be used in an
6 application, and any modification to VIPRE-01 is
7 implemented under Quality Control.

8 The applicant used the as-approved VIPRE-
9 01 code, Version MOD-02, and no code modification was
10 made for NSAM applications. Besides, no QA issues or
11 additional Quality Control requirements were reported
12 in the VIPRE-01 MOD-02 SER, beyond what had already
13 been documented in the VIPRE-01 MOD-01 SER, the
14 earlier one.

15 So there were only enhancement made to
16 VIPRE-01 MOD-02 for NSAM application. That was the
17 implementation of the NuScale CHF correlation into
18 VIPRE-01 MOD-02 suite. This was done through a
19 dynamic link library, or the LL file, that allowed
20 using the user program CHF correlation without any
21 modification for the VIPRE-01 source code.

22 The staff has no QA concern about VIPRE-01
23 MOD-02 version use with the NSAM. Therefore,
24 Condition 5 has been met.

25 MEMBER MARCH-LEUBA: And did I understand

1 you correctly that the MOD-02 SER issued in 1993
2 approved it for BWR conditions?

3 MR. HAIDER: That's right.

4 MEMBER MARCH-LEUBA: So the Condition 1
5 was kind of moot after that point, the one that said
6 only applies for pressurized water reactors? Couple
7 of the slides before.

8 MR. HAIDER: That is the staff's
9 understanding, but we still studied, closely studied
10 the two-phase attributes and performed confirmatory
11 analysis.

12 MEMBER MARCH-LEUBA: So MOD-02 is
13 acceptable for both generally subcooled operation and
14 also for relatively high quality conditions?

15 MR. HAIDER: Not the Courant number
16 condition, but the Condition 1. The Courant number
17 condition is Condition 4.

18 MEMBER MARCH-LEUBA: Not Courant, I'm
19 talking now a steady state void quality. If you go
20 back to slide number --

21 MEMBER CORRADINI: I think, if I read the
22 submittal by NuScale, although they're aware that
23 their MOD-02 of VIPRE can do it, they are not asking
24 for approval beyond CHF.

25 MR. HAIDER: That's true, that's true.

1 That part of Condition 1 is met.

2 MEMBER MARCH-LEUBA: Yeah, but they're
3 asking for approval with 50% voids. Whereas, if you
4 go back to slide 6 please. It says, Condition for
5 more one -- now I can read more one, is that you have
6 to be on PWR conditions. But then you see MOD-02,
7 which is approved for boiling water reactor
8 conditions?

9 MR. HAIDER: Yeah, MOD-02 is also
10 applicable --

11 MEMBER MARCH-LEUBA: So this condition
12 really is not applicable to NuScale, because they used
13 MOD-02. It's not just that it's met, it's not
14 applicable.

15 MEMBER CORRADINI: I think it's, I guess
16 I'm reading it differently. They're basically, and
17 NuScale can correct me if I'm misunderstanding their
18 submittal, but as long they're below CHF, they're
19 going to use VIPRE. Once they get past CHF, they're
20 not relying upon VIPRE for their calculation.

21 I could have a void fraction much higher
22 than 50% and not be past CHF.

23 MEMBER MARCH-LEUBA: That's correct.

24 MEMBER CORRADINI: They're not linked.

25 MR. HAIDER: That's right, yeah, yeah.

1 MEMBER CORRADINI: It's based on CHF
2 transition that they're not going to use VIPRE beyond.

3 MR. HAIDER: That's true.

4 MEMBER MARCH-LEUBA: Okay.

5 MR. HAIDER: That is true.

6 MEMBER REMPE: So again, stop me if I'm
7 getting into proprietary information, but several
8 times you as well as NuScale have said, We haven't
9 done anything to change VIPRE except for the CHF
10 correlation and how it's implemented.

11 If I read the technical report, it's
12 actually on page 65 of the PDF, but page 54, it talks
13 about that, how they do some comparisons with another
14 code related to thermal conductivity, and they may
15 calibrate VIPRE, if needed. Is that a change to the
16 code, or is that an input?

17 MR. HAIDER: See, the only --

18 MEMBER MARCH-LEUBA: That would be input
19 parameters.

20 MEMBER REMPE: It's an input parameter.
21 That's what I wanted to know, because I --

22 MEMBER MARCH-LEUBA: Well, you need to ask
23 them, but.

24 MEMBER REMPE: It is through input
25 parameters is how you calibrate the code. Because

1 that sure sounds like you're --

2 MEMBER CORRADINI: If you're going to
3 answer, go to a mic.

4 MR. GALIMOV: Azat Galimov, NuScale. If,
5 in case of the calibration, we actually tuned the
6 based model, and it's input parameter.

7 MEMBER REMPE: It is an input parameter,
8 thank you.

9 MR. HAIDER: Okay, and so we are done with
10 Condition 5. So with Condition 5, this concludes all
11 five conditions that were a part of 1986 SER for
12 VIPRE-01 MOD-01. Now I will present the four
13 additional conditions that were identified in the 1993
14 VIPRE-01 MOD-02 SER.

15 Condition 6 requires that the licensing
16 models used in VIPRE-01 MOD-02 should be qualified.
17 Besides, as is stipulated by some other conditions in
18 the two generic SERs for VIPRE MOD-01 and MOD-2,
19 NuScale needed to justify its two-phase modeling and
20 assumptions for using VIPRE over the range of expected
21 two-phase flow conditions expected in the design
22 application.

23 So there is also some overlap in the
24 conditions when it comes to qualifying various
25 modeling assumptions. It's like you would hear two-

1 phase in Condition 1, you'll also hear about two-phase
2 modeling assumptions in Number 6. So there is some
3 overlap, that should be recognized.

4 NSAM does not use the VIPRE user option to
5 specify a slip ratio as an input to the model.
6 Rather, VIPRE formulation is based on a three equation
7 compressible homogenous equilibrium model that solves
8 3D core flow and distributions through raw
9 temperatures and minimum critical heat flux ratio or
10 MCHFR.

11 NSAM uses non-mechanistic empirical two-
12 phase correlations to reflect subcooled boiling non-
13 equilibrium and concurrent vapor liquid phase slip in
14 two-phase flow.

15 So this continues to the next page. The
16 homogenous equilibrium formulation may not be
17 sufficient to apply for cases with a large relative
18 phase velocities typical of transient boiling. Which
19 may raise convergence problems in transient boiling
20 calculations when using the subcooled boiling models
21 and bulk void correlations to account for the phase
22 slip.

23 The applicant also performed a sensitivity
24 study that is presented in the topical report, using
25 the drift flux model. The drift flux model calculates

1 the void fraction by using the physically more
2 realistic conservation of vapor mass generated by wall
3 superheat instead of defining the void simply as a
4 function of flow and quality with an empirical slip
5 formulation.

6 So drift flux model is physically more
7 realistic. The staff audited the applicant's drift
8 flux model sensitivity cases applicable to NuScale
9 conditions and confirmed that the use of drift flux
10 model had a negligible impact on void fractions and
11 CHFRRs at any point along the hot channel.

12 MEMBER CORRADINI: Remind me, what did the
13 staff do to audit it? They used trace?

14 MR. HAIDER: The staff reviewed the
15 documents.

16 MEMBER CORRADINI: They didn't do a
17 calculation.

18 MR. HAIDER: They didn't do the
19 calculations.

20 MEMBER CORRADINI: Did they ask, I guess,
21 well, I'll ask this one. Did you ask NuScale to do
22 some sensitivities for them to look at the effect? In
23 other words, you can put in a phase, you can put in a
24 slip velocity to verify that it has a small effect.
25 Was the audit based on NuScale calculations that staff

1 asked to have additional calculations done?

2 MR. HAIDER: The staff did not ask for
3 additional calculations.

4 MEMBER CORRADINI: Just looking at what
5 was given.

6 MR. HAIDER: Looking at what was given,
7 but for a range of transients, so.

8 The applicant's use the drift flux model
9 to justify its VIPRE-01 two-phase modeling assumptions
10 is appropriate. The staff believes that the Condition
11 6 has been met, but will provide further supporting
12 information in the closed session about the staff's
13 sensitivities studies of the VIPRE two-phase modeling.

14 So Condition 7 from the generic VIPRE-01
15 MOD-02 SER requires the applicant to declare any
16 possible use of the GEXL Correlation with the proposed
17 subchannel analysis methodology. The GEXL Correlation
18 in the only correlation having the NRC approval for
19 using critical power ration CPR calculations for a
20 core containment fuel. This is just one of the
21 conditions.

22 NSAM TR, topical report, states the
23 NuScale does not perform CPR calculations for BWR fuel
24 with VIPRE-01. That essentially means that NuScale
25 will not use the GEXL Correlation with the NSAM VIPRE-

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1 01 application. In addition, the present SER
2 condition bounds NSAM to use only the CHF correlations
3 that are approved by the NuScale, for NuScale
4 application, and GEXL is not one of them. So clearly
5 Condition 7 is met.

6 VIPRE-01 manual identified limitations for
7 VIPRE code Condition 8 requires that users submit
8 information certifying that the code is not being used
9 in violation of these limitations. The VIPRE
10 conservation equations are based on homogenous
11 equilibrium formulation, which is not sufficient to
12 apply to cases with large relative phase velocities.
13 Their countercurrent flows are conditions under which
14 the flow regimes may change radically.

15 VIPRE should not be applied to situations
16 that in damp conditions such as low flow boil-off and
17 overflow phase separation involving a sharp liquid
18 vapor interface for a countercurrent flow.

19 The applicant has provided sufficient
20 information in the topical report, as well as the
21 audit documents, and has appropriately addressed the
22 staff's concerns expressed in RAI 9080 and its
23 supplement about VIPRE-01 code limitations for a
24 NuScale application.

25 RAI 9080 details, and its resolution will

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1 also be discussed in the closed session, will
2 demonstrate that an NSAM VIPRE application is not
3 susceptible to code limitations, and Condition 8 has
4 been met.

5 The generic NRC acceptance of VIPRE-01
6 MOD-01 did not endorse procedures and users of the
7 VIPRE-01 code described in the code manual. So the
8 users are advised that the suggested imports and
9 procedures are only for best estimate.

10 So the user is expected to justify the
11 import selection for licensing applications.
12 Condition 9 about import selections, uncertainties,
13 and sensitivity analyses is fairly generic and
14 overlaps with several other conditions. However, I
15 would like to report two confirmatory analyses the
16 staff performed to look into the import selection and
17 sensitivity studies about the VIPRE code.

18 One such aspect was inlet flow boundary
19 condition consistency between the system level code
20 and the RELAP 5, and VIPRE-01 application in NSAM.
21 The other was potential two-phase flow instability in
22 VIPRE predictions. The staff checked to a
23 confirmatory analysis that I will be presenting.

24 So more details will be provided during
25 the closed session to demonstrate consistency between

1 the VIPRE and RELAP outputs. The staff also performed
2 a sensitivity study to establish that VIPRE did not
3 show any potential for two-phase instability, so
4 Condition 9 has been met with supporting information.

5 CHAIRMAN KIRCHNER: Doesn't the conclusion
6 on two-phase flow instability require some caveat
7 about a range of transient or operating conditions and
8 pressures?

9 MR. HAIDER: Yes, it does.

10 CHAIRMAN KIRCHNER: You just can't say
11 point blank doesn't show any potential for two-phase
12 instability.

13 MR. HAIDER: We conducted the confirmatory
14 analysis for the limiting case for the rod --

15 MEMBER MARCH-LEUBA: Can I suggest that we
16 wait for this discussion for today's closed session?

17 CHAIRMAN KIRCHNER: Speak up so that we
18 heard you last statement. Just finish your, repeat
19 your last statement.

20 MR. HAIDER: Okay, the staff performed the
21 confirmatory study for the limiting case of
22 misoperation, which was to take the single rod
23 withdrawal.

24 CHAIRMAN KIRCHNER: Okay, so that was the
25 two-phase flow instability confirmatory calculation

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1 you did.

2 MR. HAIDER: That's right, that's right.

3 CHAIRMAN KIRCHNER: My only caveat here is
4 that this reads as a much broader validation of the
5 code for two-phase flow applications than is intended
6 in the actual -- we'll hear what the applicant
7 intends. But as I understand it, there are limits as
8 to drawing that conclusion.

9 MR. DRZEWIECKI: This is Tim from the
10 staff. I just wanted to clarify. The staff's SER
11 makes no findings about the stability of the design
12 based on those calculations. Both are just there just
13 for, you know, illustration purposes only.

14 But there was no findings associated with
15 this methodology in terms of stability. That's a
16 separate topical report that's in our review.

17 CHAIRMAN KIRCHNER: Okay.

18 MEMBER MARCH-LEUBA: I just want to put on
19 the record that I want to talk about this in the
20 closed session, because I disagree with most of the
21 conclusions and the analysis itself.

22 CHAIRMAN KIRCHNER: Okay. Please go on.

23 MR. HAIDER: So as I mentioned early,
24 okay, so as I mentioned early in the backdrop of the
25 CHF discussion, the staff had formulated a position

1 the part of the present the staff CR that an applicant
2 referencing the NSAM topical report in a safety
3 analysis must also reference an approved CHF
4 correlation.

5 Again, the objective of this SER condition
6 is to ensure that only NRC-approved correlations are
7 used with NSAM.

8 MEMBER MARCH-LEUBA: Is your intent that
9 the CHF correlation be developed with VIPRE? I mean,
10 you collect experimental data. You should analyze it
11 with VIPRE to be able to use it on VIPRE, or can you
12 analyze it with something else? You know what I mean?
13 You would, depending on -- because VIPRE uses an
14 number of approximations through the condition for the
15 channel on the electrically heated bundle test. You
16 should really -- with tool you're planning to use for
17 the analysis in the real reactor. Is that the intent
18 of the condition?

19 MR. HAIDER: As a matter of fact, the
20 applicant did ensure that they used consistent model
21 and consistent code origin, both in the CHF
22 development and NSAM.

23 MEMBER MARCH-LEUBA: Yeah, but was that
24 the likely coincidence? In my opinion, the condition
25 should specify that. Because VIPRE is an

1 approximation. I mean it's not, it's close to our
2 best estimate call, but it's not our best estimate
3 call. It uses slip voids and it uses a number of
4 conservative assumptions.

5 The condition should probably be that the
6 CHF correlation you want to use on VIPRE had to be
7 developed using VIPRE on the experimental data.

8 MR. DRZEWIECKI: This is Tim from the
9 staff, I just want to clarify that. Okay, so as far
10 as the NSP-2 and the NSP-4 CHF correlations, which
11 were developed with VIPRE, staff's SER there does have
12 a condition that those CHF correlations with those
13 limits have to be used using this methodology. Which
14 is, you know, which is VIPRE-01 with certain models
15 frozen and certain parameters frozen. So yes, I agree
16 with you completely.

17 MEMBER MARCH-LEUBA: Yeah, what I'm saying
18 is the language in this condition should include, I
19 know you put the condition on the NSP-4 TR. It should
20 be on this TR for completeness.

21 MEMBER REMPE: I second what's he saying,
22 because if someone else could come in, the applicant
23 could come in with a different correlation in the
24 future. And I think he's right.

25 MR. HAIDER: Yeah, so far the staff has

1 not reconciled this condition with the condition in
2 the CFHR SER.

3 MEMBER REMPE: But in the future, NuScale
4 may have a different fuel and come up with a different
5 CHF correlation that was not generated with VIPRE.
6 And so for legal purposes you need to do that, I
7 think. He's right.

8 MEMBER MARCH-LEUBA: Don't be surprised if
9 our letter says that you should put that in your
10 condition.

11 MR. DRZEWIECKI: Okay.

12 MEMBER MARCH-LEUBA: And that's my
13 opinion, not the ACRS opinion.

14 MR. DRZEWIECKI: Okay, just so that we're
15 clear, you would like staff to make this condition a
16 little tighter to make sure that that says that it has
17 to use the CHF correlation that was developed using
18 this precise methodology.

19 MEMBER MARCH-LEUBA: If I was writing, I
20 would say, If the CHF correlation was not developed
21 using VIPRE, its applicability has to be reviewed by
22 the staff.

23 MR. DRZEWIECKI: Okay.

24 CHAIRMAN KIRCHNER: And a caution here,
25 because these are opinions of individual members, not

1 the opinion of the Committee writ large.

2 MEMBER REMPE: Yes.

3 CHAIRMAN KIRCHNER: So.

4 MR. HAIDER: The staff would also like to
5 clarify that NSAM TR uses several example values of
6 input parameters and includes the subchannel analysis
7 just to demonstrate the NSAM application to perform
8 subchannel analyses and enhance the understanding of
9 the analytical methods. The staff SER does not
10 approve the use of any specific example where new
11 inputs or reserves presented in the topical report.

12 The staff would approve the specific input
13 values and ensuing reserves for the reactor core
14 design for this subsequent licensing submittal in DCA,
15 referencing the NSAM topical report. And the staff
16 will review these final design and planned specific
17 input values used in the subchannel analyses as a part
18 of the separate licensing submittals.

19 I'll elaborate further on the example
20 values during the closed session.

21 So here are the staff SER conclusions.
22 The NRC staff has reasonable assurance that the use of
23 the VIPRE-01 MOD-02 code with NSAM as described in the
24 topical report is appropriate for the NuScale fuel
25 thermal-hydraulic design and plant safety analyses,

1 provided that the present SER condition is met.

2 The staff also found that the sufficient
3 information has been presented for the requested
4 elements of approvals, so the staff concludes that
5 VIPRE-01 applies to the NuScale steady state and
6 transient subchannel analyses. NSAM fulfills the
7 NRC's requirements in the SERs for VIPRE-01 MOD-01 and
8 MOD-02.

9 NSAM is independent of any specific CHF
10 correlation and is used for NuScale applications with
11 an NRC-approved NuScale specific CHF correlation.
12 NSAM describes a methodology for the treatment of
13 uncertainties in the NuScale subchannel analysis that
14 is appropriate.

15 So this concludes the open part of my
16 presentation. And now the staff would like to invite
17 any further questions on the staff review of the
18 NuScale subchannel analysis methodology.

19 MEMBER REMPE: Am I misreading your
20 report? I liked the statements in the prior slide
21 because there are several examples where you say we
22 didn't approve the input value and we didn't approve
23 the methods for calculating the uncertainty associated
24 with it.

25 This last sub-bullet where you say they

1 described the methodology for treatment of
2 uncertainties and analysis that's appropriate seems
3 inconsistent with some of the things that I read in
4 your technical or topical report.

5 And we can into the details later, but I
6 guess I'm just wondering what that last sub-bullet
7 meant, because it seems like there's several cases
8 where you bring up areas where you're saying, hey, it
9 doesn't make sense what you've done here, or we
10 couldn't follow the logic, and so we don't approve it.

11 MR. HAIDER: There are several parameters
12 that were used in NSAM to produce the results and
13 conduct the sensitivity analysis. But those
14 parameters are fuel-specific, and they even sometimes
15 there are CHF-correlation-specific.

16 And they may change, and they should
17 ideally be reviewed where they are actually being
18 implemented in the safety analysis, like Chapter 15
19 review or Chapter 4 review. So their review will be
20 performed in the DCA, but their review--

21 MR. THOMAS: Syed?

22 MR. HAIDER: Yes, Matt? You want to?

23 MR. THOMAS: Let me ask a quick question.
24 This is Matt Thomas, Reactor Systems Branch. You
25 perhaps, I think we could probably discuss this in the

1 open portion right now.

2 MR. HAIDER: Okay.

3 MR. THOMAS: Considering it's coming
4 directly from the topical report. Can you point me to
5 a specific example where you see this inconsistency?
6 And that way we can try to work through it and clear
7 up what this even actually means on the slide.

8 MEMBER REMPE: Again, I hope I don't get
9 in trouble for things, but there was a concern about
10 the reflector and core barrel and guide tube
11 instrumentation tube IPLAS (phonetic) flow pin at
12 least that were selected. There was concern about the
13 axial power distribution that was selected.

14 Later in the closed section, you're going
15 to be talking about high impact parameters that had
16 more effect on the methodology. And when I look at
17 what the staff did, some of the concerns were
18 expressed about some of those parameters.

19 And again, I'll admit, maybe I'm just not
20 used to looking at staff SERs approving the
21 methodology. But it seemed like that this last sub-
22 bullet, it's a bit of an overstatement of what was
23 concluded by the staff, if I look at the details.

24 MR. THOMAS: Okay, so let me try to
25 explain. So those certainty values that you allude

1 to, like the penalties bypass flow and things like
2 that, those are specific values that we are not
3 proving that are deemed as example values in the
4 topical report. Not approving.

5 MEMBER REMPE: Yeah, they clearly aren't,
6 I agree with you. They aren't approving that.
7 Likewise with the --

8 MR. THOMAS: Uncertainties in that the
9 applicant has used a deterministic method for applying
10 uncertainties.

11 MR. ROOKS: I think if I could jump in
12 here and help, maybe I can help. This last bullet I
13 think addresses uncertainty methodology in the actual
14 subchannel analysis, the method, not inputs.

15 So things like reconciling a systems code
16 input to inlet core flow rates or bypass is not an
17 uncertainty treatment within the subchannel
18 methodology. That's when I go to the systems analysis
19 and test the validity of the systems code meshing with
20 the subchannel analysis code that's looking at
21 detailed in-core phenomena.

22 MEMBER REMPE: Like that's also true with
23 the axial power distribution and how they've done --

24 MR. ROOKS: And I view axial power as an
25 input parameter.

1 MEMBER REMPE: Okay. This is all fine
2 then.

3 MR. ROOKS: The methodology I think is
4 flexible about how it treats axial power. So I don't
5 see any limitation there.

6 MEMBER REMPE: Okay, that's fine --

7 MR. THOMAS: I would agree with those
8 statements.

9 MEMBER REMPE: Okay.

10 MR. THOMAS: And specifically for this
11 bullet point, it's referring to, that's right, the
12 methodology of the application of uncertainty
13 methodology, i.e., certainties and penalties by
14 biasing the actual parameter in a conservative
15 direction versus --

16 MEMBER REMPE: Okay, that's fine.

17 MR. THOMAS: Of applying uncertainties.

18 MEMBER REMPE: That's fine. I guess I got
19 confused because of all these conditions on using
20 VIPRE and how that there was a lot of concerns raised.
21 So thank you.

22 MR. THOMAS: Yes, understood, thank you.

23 MEMBER MARCH-LEUBA: I have a generic
24 comment. I am a little -- I realize that the approval
25 of this topical report is based on two old SERs, on

1 MOD-01 and MOD-02. And there are a series of
2 limitations and conditions from one and the other.
3 But when you go through that, it confuses a lot to me
4 what are we talking about. Are we talking about MOD-
5 01 or MOD-02?

6 NuScale is requesting that we approve MOD-
7 02 for their use, and the SER doesn't make that clear,
8 I don't think. I mean, by going through so much back
9 and forth between limitations for 01 and 02, it feels
10 as if you're approving both.

11 MR. HAIDER: Again, maybe this is a
12 regulatory documentation issue. Nowhere in the MOD-02
13 generic SER there is a statement that would say that,
14 that will state that the five conditions approved in
15 MOD-02 are superseded.

16 MEMBER MARCH-LEUBA: I'm just looking for
17 regulatory certainty. The SES you say NuScale should
18 use MOD-02 and forget about MOD-01. With this SER,
19 could they run calculations with MOD-01? Not that
20 they want to, but we are approving VIPRE MOD-02 for
21 use in NuScale.

22 MR. HAIDER: But to the best of my
23 knowledge, the five conditions from MOD-01 are also
24 applicable.

25 MEMBER MARCH-LEUBA: And they are

1 applicable.

2 MR. HAIDER: To MOD-01.

3 MEMBER MARCH-LEUBA: Yeah, the limitation
4 conditions are applicable. You can make them
5 applicable and write the new SER. What I'm saying is
6 it's not clear what we are approving.

7 MR. HAIDER: But the staff agrees that
8 there is a nuance, that since MOD-01 was approved only
9 for BWR, while MOD-02 was approved for both BWR and
10 PWR. So the BWR aspect of Condition 1, how much of
11 that applies.

12 MEMBER MARCH-LEUBA: Yeah.

13 MR. HAIDER: So there is uncertainty about
14 that, but the staff tried to look into the two-phase
15 flow conditions that the --

16 MR. HAIDER: I just put my concern on the
17 record. I would like to see more, a clearer language
18 that NuScale plans to use MOD-02 and that's what we're
19 approving.

20 MEMBER CORRADINI: Can I ask the
21 applicant, what's the plan of NuScale? I assumed it
22 was to use MOD-02, which was an approved NRC standard
23 tool, with the limitation that you must use that
24 analysis technique to then develop your CHF
25 correlation, which then must be used in concert with

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1 it. What is the applicant's --

2 MEMBER MARCH-LEUBA: They're not
3 listening. That question is for you.

4 MEMBER CORRADINI: You guys hear the
5 question? Are you planning to use VIPRE MOD-01 or
6 MOD-02 in your analysis?

7 MR. GALIMOV: We installed only MOD-02, so
8 we're going to use only that version.

9 MEMBER CORRADINI: Only MOD-02.

10 CHAIRMAN KIRCHNER: Would you just
11 identify yourself.

12 MR. GALIMOV: Azat Galimov, NuScale.

13 MEMBER CORRADINI: But so your plans are
14 to use MOD-02.

15 MR. GALIMOV: Yes, and in my
16 understanding, MOD-01 is not used by, probably
17 excluded from use from many vendors anyway.

18 MEMBER CORRADINI: Okay, thank you.

19 CHAIRMAN KIRCHNER: Okay, members, any
20 other questions at this point? Then let me turn to
21 the audience and see if there's anyone from the public
22 who wishes to make a statement, please come up and
23 identify yourself and make your comment.

24 Seeing no one, the bridge line is open.

25 OPERATOR: It's open.

1 CHAIRMAN KIRCHNER: If there is anyone
2 from the public who wishes to make a comment, please
3 speak up, identify yourself, then make your comment.

4 Hearing none, let's then take a short
5 recess is the proper thing.

6 MR. SNODDERLY: When would you like to
7 come back?

8 CHAIRMAN KIRCHNER: Let's reconvene at
9 five minutes of ten.

10 MR. SNODDERLY: Five minutes of ten.
11 Okay, with the closed session.

12 CHAIRMAN KIRCHNER: With a closed session.
13 So we are recessed.

14 (Whereupon, the above-entitled matter went
15 off the record at 9:42 a.m.)

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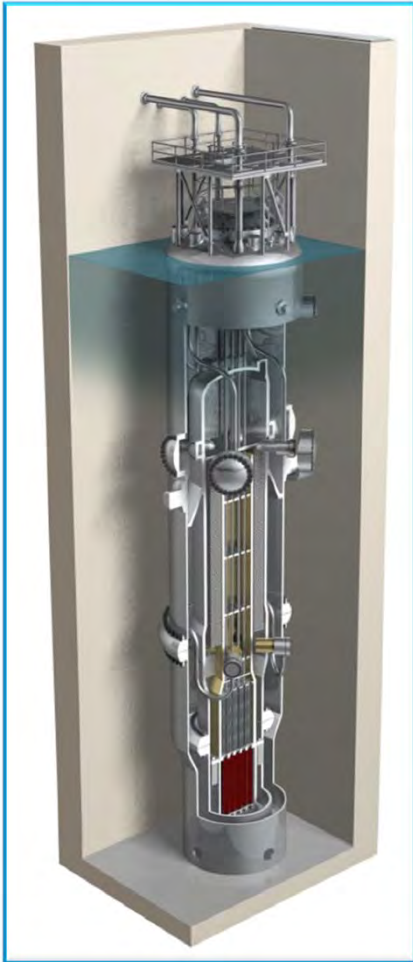
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NuScale Nonproprietary

Subchannel Analysis Methodology TR-0915-17564 ACRS Presentation

Kenneth Rooks

ACRS Open Session – August 24, 2018



PM-0818-61290
Revision: 0

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Acknowledgement & Disclaimer

This material is based upon work supported by the Department of Energy under Award Number DE-NE0000633.

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Agenda

- Overview
- VIPRE-01 Subchannel T/H Code
- Qualification & Methodology Approach

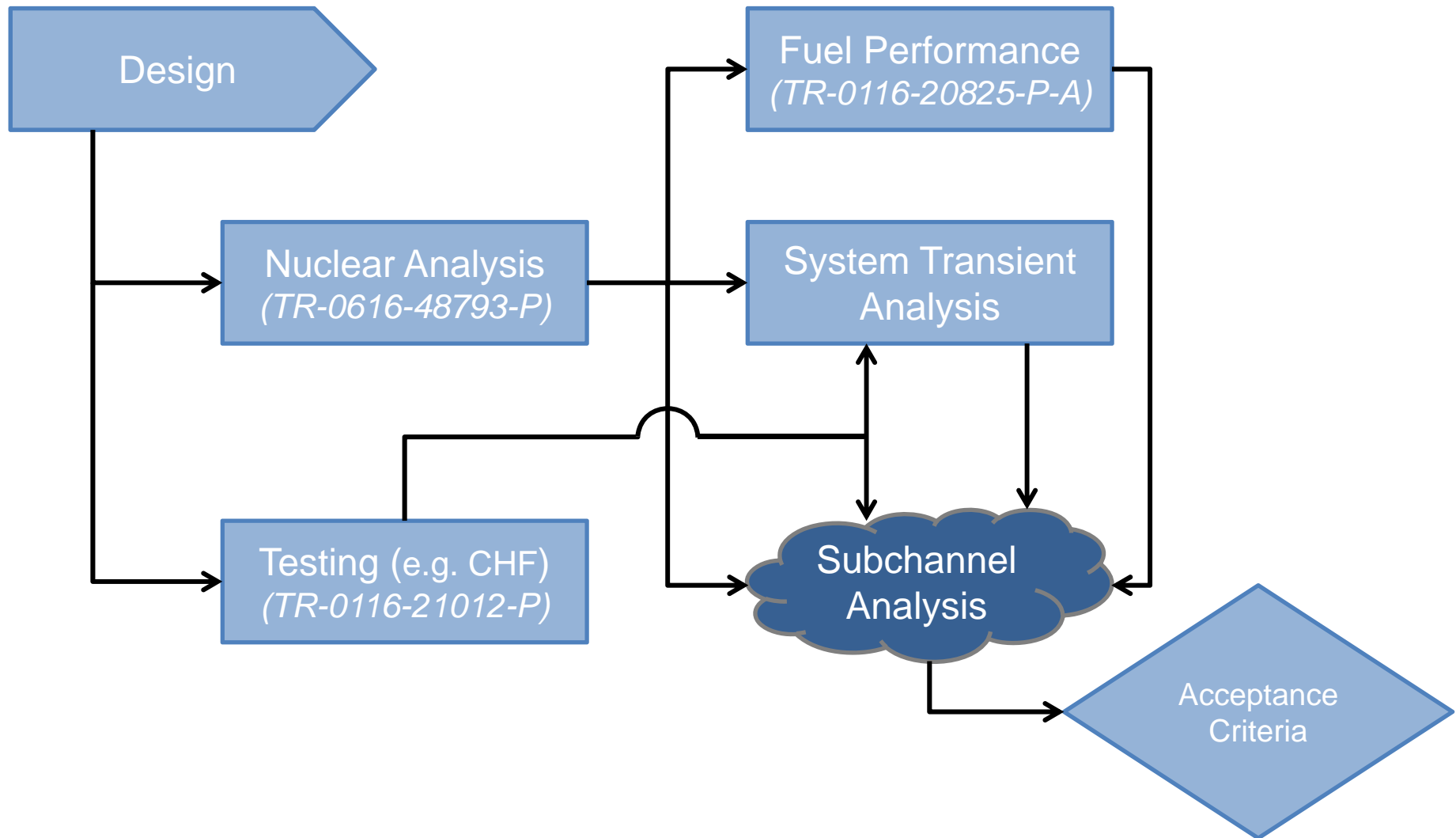
Overview

NuScale seeks approval for:

- VIPRE-01 use for steady-state and transient analysis
- Methodology fulfills requirements of VIPRE-01 generic safety evaluation report (SER) limitations
- Methodology application and treatment of uncertainties



Overview – Safety Analysis



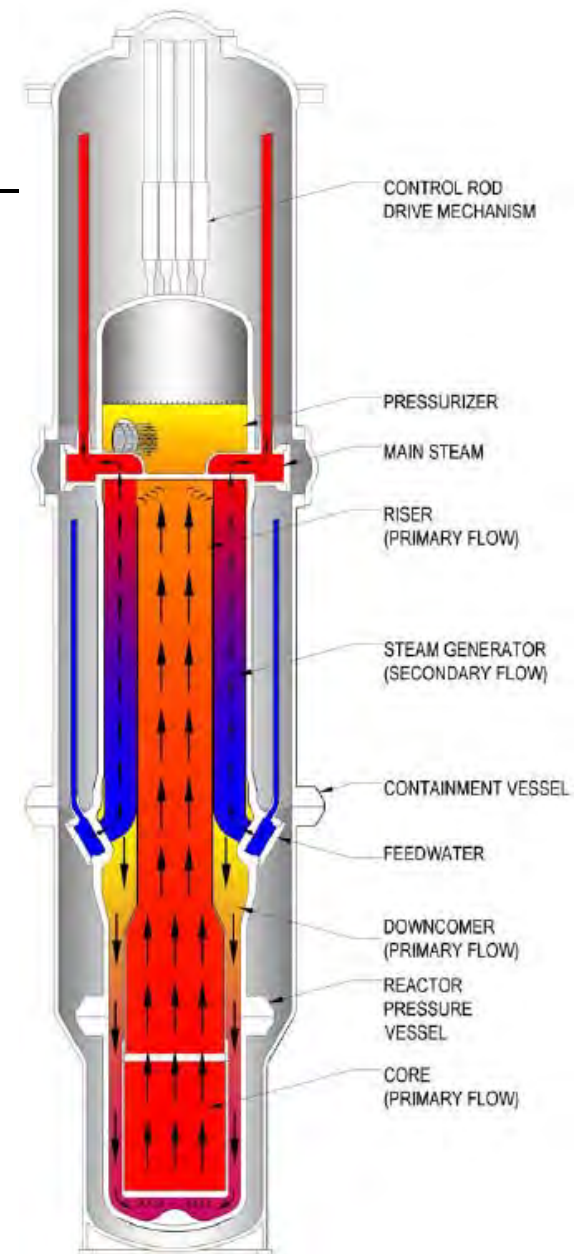
Overview – Subchannel Analysis

- Objective is to determine margin results for:
 - Critical Heat Flux
 - Fuel Centerline Melt
- Regulatory requirements
 - General Design Criterion 10, 10 CFR 50 Appendix A
 - SRP 4.2 – Fuel System Design
 - SRP 4.4 – Thermal & Hydraulic Design

Calculates critical information for FSAR Chapters 4 and 15

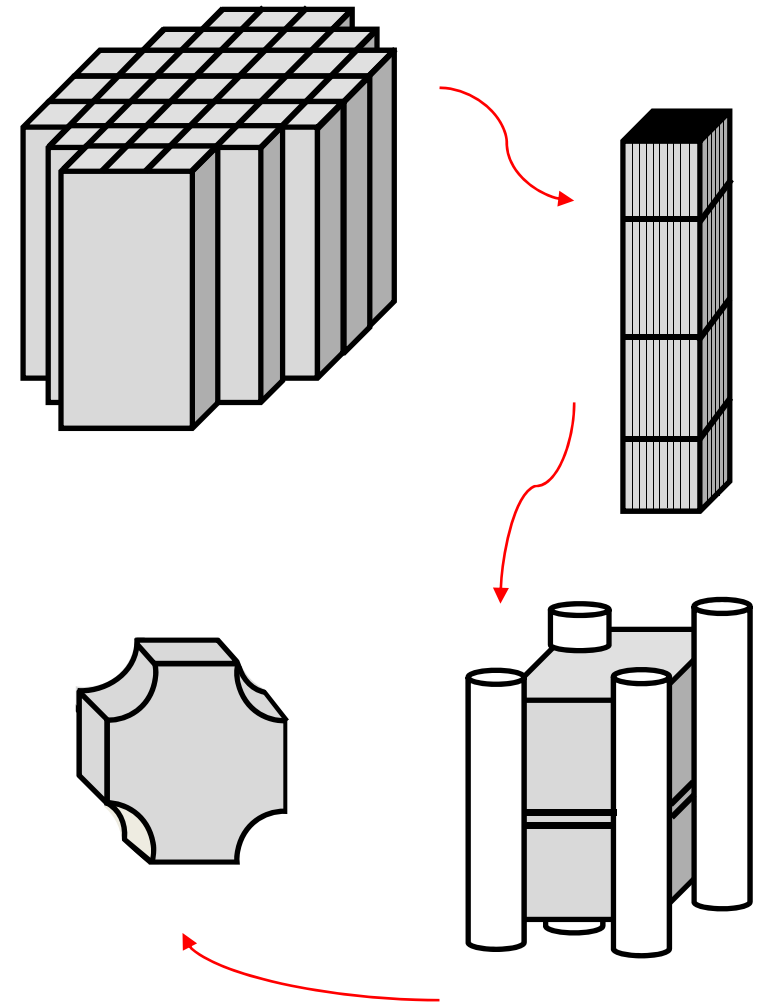
NuScale SMR

- Natural circulation PWR
 - system flow a function of power level
 - flow driven by density gradient between core and steam generator
- Core-average exit fluid conditions remain subcooled
- Hot channel exit quality greater than 0



VIPRE-01 Subchannel T-H Code

- Developed by EPRI and maintained by Zachry
- Finite-volume subchannel analysis code
- Solves 3-D core flow and enthalpy distributions, fuel rod temperatures, and MCHFR
- 3-equation homogeneous equilibrium model (HEM)
- Empirical correlations for two-phase conditions
- Mature PWR licensing history



NuScale Application

- NuScale using the industry-standard, “as-approved” version, no modifications to main program
 - design-specific CHF correlations incorporated through dynamic link library (DLL) (*NSP2 and NSP4 submitted in TR-0116-21012*)
- Managed through NuScale software QA program
- Generic VIPRE-01 SER in EPRI-NP-2511-CCM-A
 - conditional limitations for use
 - NuScale meets SER conditions as demonstrated in topical report

Leverages mature and robust basis for PWR analysis

VIPRE-01 Qualification

- Extensive qualification for PWRs previously performed as part of original approval
- To support SER conditions, NuScale performed additional qualification to ensure VIPRE-01 applicability
 - code-to-code comparison with NRC-approved code
 - additional experimental phenomena comparisons
 - parametric and generalized input sensitivity studies

VIPRE-01 applicable for NuScale conditions

Methodology Approach

- Conservative basemodel development
 - generic cycle-independent radial power distribution
 - bounding axial power shapes
 - detailed radial and axial nodalization evaluations
- Input uncertainties are treated independently; no credit for statistical randomness
- Uncertainties are accounted for as model and acceptance criterion limit biases
- Detailed checklist to ensure compliance with method

Summary

- A conservative subchannel analysis method analyzing steady-state and transient conditions
- Topical report provides details and justification for:
 - how NuScale's use of VIPRE-01 satisfies all SER requirements
 - applicability of VIPRE-01 to the NuScale reactor core
 - deterministic methodology using VIPRE-01
 - appropriate treatment of uncertainties
- Results from NuScale Subchannel Analysis Methodology application provide input to FSAR Chapters 4 and 15

Portland Office

6650 SW Redwood Lane,
Suite 210
Portland, OR 97224
971.371.1592

Corvallis Office

1100 NE Circle Blvd., Suite 200
Corvallis, OR 97330
541.360.0500

Rockville Office

11333 Woodglen Ave., Suite 205
Rockville, MD 20852
301.770.0472

Charlotte Office

2815 Coliseum Centre Drive,
Suite 230
Charlotte, NC 28217
980.349.4804

Richland Office

1933 Jadwin Ave., Suite 130
Richland, WA 99354
541.360.0500

Arlington Office

2300 Clarendon Blvd., Suite 1110
Arlington, VA 22201

London Office

1st Floor Portland House
Bressenden Place
London SW1E 5BH
United Kingdom
+44 (0) 2079 321700

<http://www.nuscalepower.com>

Twitter: @NuScale_Power



Presentation to the ACRS Subcommittee Staff Review of NuScale Topical Report

TR-0915-17564, REVISION 1

“SUBCHANNEL ANALYSIS METHODOLOGY”

Presenters:

Bruce Baval - Project Manager, Office of New Reactors
Syed Haider, Ph.D.- Reactor Systems Engineer, Office of New Reactors
Matt Thomas - Reactor Systems Engineer, Office of New Reactors

August 24, 2018
(Open Session)

NRC Technical Review Areas/Contributors

- Containment and Ventilation Branch
NRO/DSRA/SCVB:
Syed Haider (Lead)
- Reactor Systems NRO/DSRA/SRSB:
Rebecca Karas (BC)
Jeffrey Schmidt
Timothy Drzewiecki
Matt Thomas

Staff Review Timeline

TR-0915-17564, “Subchannel Analysis Methodology”

- NuScale submitted its Topical Report (TR) 0915 17564 P, “Subchannel Analysis Methodology,” Revision 1, on February 15, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17046A333).
- Staff issued the following request for additional information / NuScale provided response:
 - RAI 9080 – 09/11/2017 (ML17254A439) / 11/09/2017 (ML17313B205) & S1 (ML18061A109)
 - RAI 9086 – 09/09/2017 (ML17252A688) / 10/30/2017 (ML17299A973)
 - RAI 9099 – 09/02/2017 (ML17251A368) / 09/13/2017 (ML17251A368)
 - RAI 9129 – 11/17/2017 (ML17321A597) / 01/15/2018 (ML18015A012)
- Staff plans to brief advisory committee on reactor safeguards (ACRS) full committee on September 6, 2018
- Staff plans to issue its final SER in late October 2018.
- Staff plans to publish the “-A” (approved) version of the TR in early 2019.

Scope of the Staff Review (1/2)

- Regulatory Basis
 - General Design Criterion (GDC) 10, “Reactor Design,” in 10 CFR Part 50, Appendix A
 - NuScale DSRS , Section 4.4, “Thermal and Hydraulic Design”
 - 10 CFR 50.34, “Contents of Applications; Technical Information”
- NRC approved VIPRE-01 subchannel analysis code, version MOD-02
- Elements of approval for the NuScale Subchannel Analysis Methodology (NSAM)
 - VIPRE-01 applies to the NuScale steady-state and transient subchannel analyses.
 - Methodology fulfills the NRC’s requirements in the SERs for VIPRE-01, MOD-01 and MOD-02.
 - Methodology is independent of any specific CHF correlation and is used for NuScale applications if the methodology requirements are satisfied and if the NRC approves the CHF correlation.
 - Methodology for treatment of uncertainties in the NuScale subchannel methodology is appropriate.

Scope of the Staff Review (2/2)

- Technical basis for the NRC staff review
 - Nine conditions in the generic SERs for VIPRE-01 MOD-01 and MOD-02
 - VIPRE-01 modelling assumptions and qualifications
- Areas requiring additional review
 - NSAM applicability range and VIPRE-01 code limitations
 - NuScale operating conditions
 - Stability of the numerical scheme
 - Inlet boundary condition consistency
 - Two-phase flow instability verification
 - Qualification of VIPRE-01 MOD-02 models and assumptions
- Information considered by NRC staff
 - NuScale Topical Report, TR-0915-17564, Revision 1, “Subchannel Analysis Methodology”
 - Responses to RAIs 9080, 9086, 9099, 9129
 - Audit documents

1. Post CHF Application Limitation

Summary of the VIPRE-01, MOD-01 SER Condition No. 1

- Application of VIPRE-01 is limited to PWR licensing calculations with heat transfer regimes up to CHF. Any use of VIPRE-01 in boiling-water reactor (BWR) calculations or post-CHF calculations will require prior NRC review and approval.

Applicant's Meeting the Condition in the NSAM

- Limits the VIPRE-01 code to PWRs up to CHF
- VIPRE approval not sought for post-CHF calculations.
- NuScale is a PWR -- the BWR limitation not applicable.
- NSAM meets the post-CHF application/BWR limitation on the use of the VIPRE-01 code for the NuScale design.
- Condition 1 is met.

2. CHF Correlation Requirement

Summary of the VIPRE-01, MOD-01 SER Condition No. 2

- Use of an unapproved CHF correlation will require the submittal of a separate TR for review and approval.
- Application is within the range of applicability of the CHF correlation including fuel assembly geometry, spacer grid design, pressure, coolant mass velocity, quality, etc.,

Applicant's Meeting the Condition in the NSAM

- A separate TR submitted/approved for the NuScale specific NSP2 CHF correlation.
- VIPRE-01 used to reduce the experimental CHF data to calculate the local fluid parameters to develop the NuScale specific CHF correlations/MCHFR.
- NSAM TR provides assurance that only approved CHF correlations will be used with VIPRE-01 for the NuScale safety analyses supporting the NuScale DCA.
- Submittal/approval of a separate TR for the NuScale specific CHF correlation met the present NSAM TR SER Condition 1. So, the generic VIPRE SER Condition 2 has been met.
- Range of applicability of the NSAM is covered in the closed session.

3. VIPRE-01 Models and Assumptions (1/2)

Summary of the VIPRE-01, MOD-01 SER Condition No. 3

Provide justifications for specific modeling assumptions, choice of two-phase flow models, heat transfer/CHF correlations, input values of plant specific data such as turbulent mixing coefficient, slip ratio, and grid loss coefficient, including defaults.

Applicant's Meeting the Condition in the NSAM

The applicant provided sufficient information on:

- Turbulent mixing coefficient
- Grid spacer loss coefficient
- Heat transfer correlations
- Model geometry
- Radial and axial nodalizations
- Bypass flow
- Inlet flow/temperature distributions

3. VIPRE-01 Models and Assumptions (2/2)

Applicant's Meeting the Condition in the NSAM (cont.)

- Radial and axial power distributions
- Rod and assembly bow penalties
- CHF correlation and DNBR limit

Applicant provided sufficient information to justify the specific VIPRE models and assumptions.

Key sensitivities/confirmatory analyses are discussed in the closed session to demonstrate that Condition 3 has been met.

4. Courant Number Criterion

Summary of the VIPRE-01, MOD-01 SER Condition No. 4

If a profile fit subcooled boiling model, which was developed based on steady state data, is used in boiling transients, care should be taken in the time step size used for transient analysis to avoid the Courant number (N_c) less than 1.

Applicant's Meeting the Condition in the NSAM

- A subcooled void correlation based on steady-state data is not suitable for modeling boiling transients in VIPRE with $N_c < 1$. $N_c > 1$ is required for the convergence of the numerical solution of the mass, momentum, and energy equations in VIPRE.
- NSAM uses the VIPRE-01 steady-state subcooled boiling correlations.
- NSAM TR presents results for three design-basis example transients. Transient time step selected on a case-by-case basis for the axial nodalization & coolant velocity, to ensure $N_c > 1$.
- Staff audit showed the condition was met throughout the transients.
- Staff confirmatory calculations showed no numerical stability issues resulting from the transient time step selection for $N_c > 1$.
- Condition No. 4 has been met.

5. Quality Assurance

Summary of the VIPRE-01, MOD-01 SER Condition No. 5

- Quality control requirements, described in Section 2.6 of the VIPRE-01 MOD-01 SER, to ensure consistency in the development and application of the VIPRE-01 code for safety analysis.
- Only an as-approved version of VIPRE-01 is used and any modification to VIPRE-01 is implemented under quality control.

Applicant's Meeting the Condition in the NSAM

- No QA issues or additional quality control requirements reported in the VIPRE-01, MOD-02 SER (1993), beyond the VIPRE-01, MOD-01 SER (1986).
- No modifications were made to VIPRE-01, MOD-02 for NSAM.
- Implementing CHF correlation into VIPRE through a .DLL file allowed using the user-programmed CHF correlation without any VIPRE source code modification.
- No QA concerns about the VIPRE-01, MOD-02 version use with NSAM.
- Condition 5 has been met.

6. Qualification of VIPRE-01 MOD-02 Models (1/2)

Summary of the VIPRE-01, MOD-02 SER Condition No. 1

- The use of VIPRE-01 MOD-02 is contingent upon full qualification of the licensing models.
- Besides, as stipulated by Condition 3 of the SER for VIPRE-01, MOD-01, and Conditions 6 and 8 of the SER for VIPRE-01, MOD-02, to support qualification of the modeling assumptions, NuScale needed to justify its two-phase modeling and the selected parameters for using VIPRE-01 for the design application over the range of expected two-phase flow conditions.

Applicant's Meeting the Condition in the NSAM

- Slip ratio not used as a modeling assumption in NSAM – No slip ratio specified as a VIPRE input.
- VIPRE formulation
 - 3-equation incompressible, homogeneous equilibrium model (HEM)
 - Solves 3-D core flow field and enthalpy distribution, fuel rod temperatures, and MCHFR.
 - Non-mechanistic empirical two-phase correlations used to reflect subcooled boiling non-equilibrium and concurrent vapor/liquid phase slip in two-phase flow

6. Qualification of VIPRE-01 MOD-02 Models (2/2)

Applicant's Meeting the Condition in the NSAM

- The HEM formulation of VIPRE-01 using the subcooled boiling models and bulk void correlations to account for phase slip may not be sufficient for cases with large relative phase velocities.
- Applicant's drift flux model sensitivity study
 - The drift flux model calculates the void fraction by using the physically realistic conservation of vapor mass generated by wall superheat instead of defining the void as a function of flow and quality with an empirical slip correlation.
 - Audited the applicant's drift flux model sensitivity cases applicable to NuScale design conditions. The use of the drift flux model had a negligible impact on void fractions and CHF at any point along the hot channel.
- The applicant's use of the drift flux model to justify its VIPRE-01 two-phase modeling assumptions is appropriate. Condition 6 has been met.

7. GEXL Correlation

Summary of the VIPRE-01, MOD-02 SER Condition No. 2

The GEXL correlation is the only correlation that currently has NRC approval for use in critical power ratio (CPR) calculations of a core containing GE fuels. However, use of the GEXL correlation for other vendors' fuels or use of any other correlation requires a separate submittal for NRC review and approval.

Applicant's Meeting the Condition in the NSAM

- This VIPRE-01, MOD-02 SER condition requires the applicant to declare any possible use of the GEXL correlation with the proposed subchannel analysis methodology.
- NSAM TR states that "NuScale does not perform CPR calculations for BWR fuel with VIPRE-01."
- Condition 7 has been met as the above cited statement means that NuScale will not use the GEXL correlation with the NSAM VIPRE-01 applications.

8. VIPRE-01 Code Limitations

Summary of the VIPRE-01, MOD-02 SER Condition No. 3

- VIPRE-01 manual identifies VIPRE code limitations. Each user, in its documentation for NRC approval, should certify that the code is not being used in violation of these limitations.
- The VIPRE code should not be used to model cases with large relative phase velocities, countercurrent flow, or conditions under which the flow regime changes radically. VIPRE should not be applied to situations that entail conditions such as low-flow boil off, annular flow, phase separation involving a sharp liquid/vapor interface, or countercurrent flow.

Applicant's Meeting the Condition in the NSAM

- The applicant provided sufficient information in the TR, and appropriately addressed the staff's concerns in RAI 9080 about VIPRE-01 code limitations for NuScale application.
- RAI 9080 details will be discussed in the closed session to show that NSAM VIPRE-01 application is not prone to code limitations and Condition 8 is met.

9. Input Selection, Uncertainties and Sensitivity Analyses

Summary of the VIPRE-01, MOD-02 SER Condition No. 4

NRC acceptance of VIPRE-01 MOD-02 does not endorse procedures and uses of VIPRE described in the code manual. Each user is advised to note that values of input recommended by the code developers are for best-estimate use only and do not necessarily incorporate the conservatism appropriate for licensing type analysis. Therefore, the user is expected to justify or qualify the input selections for licensing applications.

Applicant's Meeting the Condition in the NSAM

The staff performed confirmatory analyses to look into the following two aspects of the NuScale VIPRE model:

- Inlet flow boundary condition consistency
- Two-phase flow instability

More details will be provided in the closed session to demonstrate consistency b/w VIPRE inlet flow BC and the system code output. VIPRE results did not show any potential for two-phase instability. Condition 9 has been met.

NSAM TR Conditions & Limitations

Condition No. 1

An applicant referencing the NSAM topical report in a safety analysis must also reference an approved CHF correlation. The basis for this condition is provided in Section 4.1 of the staff SER of the NSAM topical report.

NSAM TR Example Values

- The NSAM TR uses several example values of input parameters and includes the subchannel analysis results just to demonstrate the NSAM applicability to perform subchannel analyses, and enhance the understanding of the analytical methods. The staff SER does not approve the use of any specific example value inputs or results presented in the TR.
- In various subsections of the SER, the staff has documented the review of various input parameters and the determination of the aspects that are approved.
- The staff would approve specific input values and ensuing results for the reactor core design for the subsequent licensing submittals (e.g., DCAs) referencing the NSAM TR. The staff would review these final design- and plant-specific input values used in the subchannel analyses as a part of these separate licensing submittals.

Staff SER Conclusions

- The NRC staff has reasonable assurance that the use of the VIPRE-01, MOD-02 code with the NSAM described in the TR is appropriate for the NuScale fuel thermal-hydraulic design and plant safety analyses, provided that the SER conditions and limitations are met.
- Elements of Approval
 - VIPRE-01 applies to the NuScale steady-state and transient subchannel analysis using the methodology presented.
 - NSAM fulfills the NRC's requirements in the SERs for VIPRE-01, MOD-01 and MOD-02.
 - NSAM is independent of any specific CHF correlation and is used for NuScale applications if the methodology requirements are satisfied and if the NRC approves the CHF correlation as confirmed by Condition 1 of this SER.
 - NSAM describes a methodology for treatment of uncertainties in the NuScale subchannel analysis that is appropriate.

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