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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 SUBCOMMITTEE

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OPEN SESSION

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WEDNESDAY

SEPTEMBER 20, 2017

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., Michael Corradini, Chairman, presiding.

COMMITTEE MEMBERS:

MICHAEL CORRADINI, Chairman

RONALD G. BALLINGER, Member

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR., Member

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member

DANA A. POWERS, Member

JOY REMPE, Member

GORDON R. SKILLMAN, Member

JOHN W. STETKAR, Member

MATTHEW W. SUNSERI, Member

ACRS CONSULTANT:

STEPHEN P. SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

MIKE SNODDERLY

ALSO PRESENT:

BRUCE BAVOL, NRO

RICHARD HARNE, AREVA*

JIM HOERNER, AREVA

REBECCA KARAS, NRO

LARRY LOSH, NuScale

JEFFREY SCHMIDT, NRO

GLEN THOMAS, AREVA

TIM THOMAS, AREVA

CHRISTOPHER VAN WERT, NRO

ANDREA D. VEIL, Executive Director, ACRS

*Present via telephone

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P R O C E E D I N G S

8:30 a.m.

MEMBER CORRADINI: This meeting will come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, the NuScale Subcommittee. My name is Mike Corradini, Chairman of the Subcommittee.

Member in attendance are today: Ron Ballinger, Matt Sunseri, Dick Skillman, Dana Powers, Dennis Bley, John Stetkar, Jose March-Leuba, Walt Kirchner, Charles Brown, Joy Rempe, and our consultant is Dr. Steve Schultz. Mike Snodderly is the Designated Federal Official for this meeting.

And the purpose of today's meeting is to discuss the staff's evaluation of the NuScale's topical report entitled "Applicability of AREVA Fuel Methodology for the NuScale Design." Today, we have members of the NRC staff and NuScale Power 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. That said, we set aside ten minutes for extemporaneous comments from members of the public attending or listening to our meetings. Written comments are also welcome.

The ACRS section of the U.S. NRC public website provides charter bylaws, letter reports, full transcripts of all the full and subcommittee meetings, including slides presented here. The rules for participation in today's meeting were announced in the Federal Register on September 18th, 2017. The meeting was announced as an open/closed meeting. We will close the meeting after an open portion to discuss any proprietary matters and presenters can defer questions to that time. And so I'm going to actually go a bit off script and ask NuScale and the staff to alert us if we're straying into something that's got to go into closed session.

No written statement or request for making an oral statement to the Subcommittee has been received from the public concerning this meeting. The transcript of the meeting is being kept and will be made available, as stated in the Federal Register notice. Therefore, we request that participants in this meeting use the microphones located throughout the meeting room when addressing the Subcommittee. Participants should first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We have a bridgeline established for the public to listen to the meeting. To minimize disturbance, the public line will be kept in a listen-in only mode. And to avoid disturbances, I also request that attendees here in the room put their electronic devices, like cell phones, etcetera, in the noise-free mode.

We'll now proceed with the meeting, and I'll call on Becky Karas from the staff to begin today's meeting.

MS. KARAS: This is Becky Karas. I'm Chief of the Reactor Systems Branch in NRO. I just wanted to thank the Committee for its time in looking at this. We think this topical report is fairly straightforward, the review is fairly straightforward for us in comparison to, you know, probably some of the other topical reports that are still under review with the staff. So we hope for a productive meeting and to be able to answer your questions.

MEMBER CORRADINI: Okay. And I think we'll turn it over to NuScale. Larry, will you lead us off?

MR. LOSH: Okay. My name is Larry Losh.

MEMBER CORRADINI: Is your green light on? Push the little button at the very bottom. There you go. You're on.

MR. LOSH: Again, my name is Larry Losh. I'm responsible for fuel at NuScale Power, and, together with Glen Thomas, we'll be presenting the information relative to the applicability of the AREVA fuel methodology for NuScale design.

To accomplish that, I want to walk us through first the relationship that NuScale has with AREVA and how that relates to our overall approach to fuel. Much of the applicability of these topicals is related to the fuel design features and how they compare to existing PWR fuel and how the operating conditions in a NuScale reactor are similar to those of a typical PWR. So --

MEMBER CORRADINI: Larry?

MR. LOSH: -- the presentation will probably cover those items.

MEMBER CORRADINI: Just can you pull your mike a little bit closer? You speak very softly, so we want to make sure we hear every word.

MR. LOSH: I'll try to speak louder, too.

MEMBER CORRADINI: Okay. Thanks.

MR. LOSH: Okay. So what I will cover will be the fuel design features and then a comparison of the fuel design features that are shown on the NuScale design and compare those to a typical PWR fuel assembly, as well as a comparison of the operating conditions. And that really defines our approach to the overall methods of applicability. Glen will cover the details of how that comparison results in a finding that all of those codes and methods are applicable to the NuScale design.

This graphic depicts the relationship that we have with AREVA and how that is considered in this topical. We have contracted with AREVA for fuel design and for fuel fabrication services. The two key elements that we get from that relationship: One, we have access to a proven product for the NuScale plant, something that's in operation today, at least all of the components are and I'll go through those in detail. And, second, it ensures that we have a single design for both the design certification application and for the batch implementation. We're going to show you the design that we want to have approved and the design that we intend to use on a batch basis.

The AREVA support considers the fuel design work following their standard process, which includes a full gamut of prototypic testing, and the analyses are all backed by their approved codes and methods. Now, we've gone to some lengths to ensure that those codes and methods are applicable to the NuScale design, and that's what we're trying to establish and document in the topical report before you today, 2825, Rev. 1.

The graphic here shows the NuScale fuel assembly design, and each of the elements in the design you will see relates back to a proven product from the AREVA catalog. The design incorporates intermediate grids, the HTP grid, and an end grid, the HMP grid, that are identical to that used in current PWR operation in the U.S. We are also using Zircaloy-4 MONOBLOC guide tubes that are identical to that used in the U.S., with the exception of the length.

The quick-disconnect top nozzle is also used in the U.S. The bottom nozzle employs a mesh filter plate that's in use in the U.S. And we are using Alloy M5 fuel rod cladding that is in widespread use worldwide and certainly in the U.S., as well.

MEMBER SKILLMAN: Larry, when would be a good time to ask questions about the design of the fuel assembly itself?

MR. LOSH: Please, go ahead.

MEMBER SKILLMAN: Okay. Your top diameter or your top dimension is 8.406 and your bottom grid is 8.425, so they are different from one another. Why?

MR. LOSH: Glen, I'll let you . . .

MR. G. THOMAS: The question was the difference between the top grid and the bottom grid? Was that the question?

MEMBER SKILLMAN: Yes, the width.

MEMBER CORRADINI: And just, if we're getting into things that should be in closed session, you've got to tell us.

MR. G. THOMAS: That dimension is okay. That follows our standard PWR configuration, so, as Larry mentioned, we're using standard HTP grids at the top locations and an alloy HMP grid at the bottom, and that difference is what use throughout our PWR fleet. Same dimension.

MEMBER SKILLMAN: The reason I ask the question is because this fuel assembly is significantly shorter than a 12-foot.

MR. G. THOMAS: Yes, correct.

MEMBER SKILLMAN: And it could be that the hold-down force is different in the lower grid and the connecting force from the upper grid, from the plenum, is also different. And so my question is really driven by the curiosity does that dimension difference make a difference because of the length and the weight of your fuel assembly? That's a difference, and so I'm curious about whether that difference makes, has any significance at all.

MR. G. THOMAS: Could you repeat the question in terms of --

MEMBER SKILLMAN: Sure.

MR. G. THOMAS: -- the connection between these dimensions and the distribution of --

MEMBER SKILLMAN: You make a good point. You're going to use an AREVA fuel assembly. It's proven technology.

MR. G. THOMAS: Yes.

MEMBER SKILLMAN: Yes, it is, except the fuel assembly that you're going to use is what? Three-fifths?

MR. G. THOMAS: Considerably shorter, yes.

MEMBER SKILLMAN: Okay.

MR. G. THOMAS: Agreed.

MEMBER SKILLMAN: So these end fittings have features of fit into what is the core lower grid and what will be the core plenum.

MR. G. THOMAS: Yes, correct.

MEMBER SKILLMAN: And those intersection forces can be significant, either in terms of the fueling or in terms of fuel assembly lift for flow rate. And so while you're using a proven technology, you actually have a dimension difference that, at least in my judgment, could be significant based on how this smaller assembly is applied in the NuScale reactor design.

MR. G. THOMAS: Okay. A short answer to that question might be the fact that we would expect the forces on the fuel assembly and the plenum to both be less than they are for a PWR because the flow forces from the natural circulation are imposing less lift load, and so we're able to design a hold-down spring system that imposes less compressive load on the bundle. So the forces reacting through the fuel assembly into the lower core plate should be less than they are on a typical PWR. In addition to that, we have less fuel assembly mass because of the shorter fuel stack.

So I think the loads on the assembly, as well as the loads reacting out through the lower core plate, should be less, and in the upper core plate, as well, because of the lower flow forces.

MEMBER SKILLMAN: Thank you.

MR. LOSH: This slide depicts a comparison of the NuScale fuel design and the AREVA 17 x 17 PWR design. As we just discussed, these dimensions are identical, for the most part, except for those having to do with length. You'll notice that the NuScale active fuel stack height is two meters, 78.74 inches, compared to a typical PWR at 12 feet.

The other dimensions that then change are those having to do with the overall fuel assembly height from 160 inches to 94, and the spacer grid span length actually changes slightly. We have a different number of grids on the NuScale fuel assembly design. The resulting fuel assembly span length is 20.1 inches instead of 20.6 typically found in the AREVA PWR design.

Otherwise, the dimensions are the same. The dash pot dimensions, the other guide tube dimensions are identical, and all of the fuel rod internal dimensions having to do with the pellet OD, cladding ID, cladding OD, etcetera, are all identical to the PWR dimensions from AREVA.

MEMBER BALLINGER: I have a question that's probably getting down into the minutia, but the dash pot region, the flow rate up in these bundles in a 17 x 17 standard is about ten times what it is in this bundle because of the natural circulation. So there's cooling flow that goes up into the guide tubes that's based on the flow in a standard 17 x 17 assembly, which should be larger. So in a scram position, does that affect the rod drop timing? Because you've got flow going up that's faster in a PWR assembly than it is in this. Does that affect the rod drop time?

MR. LOSH: It may affect it somewhat. It's in the direction of being less hydraulic resistance and a faster scram time.

MEMBER BALLINGER: Okay.

MR. LOSH: In addition, the NuScale control rod drive line is heavier, which also contributes to a faster drop time.

MEMBER BALLINGER: Okay.

MEMBER REMPE: So I have a process question, and it's similar to, I think, what was brought up last time you guys did this. This is a topical report for using basically a shorter fuel rod, using the AREVA methods for a shorter fuel rod. And you gave us some of the parameters for the reactor but not all, and we have to go to NuScale-specific book or documents to get those other ones. For example, axial peaking factor. And in that particular case, the staff had to assume something.

Now, your reactor, it's fine for using its axial peaking factor with this topical report. But what about, I think John always refers to it Joe's reactor, and he comes in with something that has a very high axial peaking factor, and that's just one example. So there's other conditions that aren't well defined, and how does one deal with Joe's reactor who might want to use the same topical report later?

MEMBER CORRADINI: Can I just, just to clarify, I assume this was specific to NuScale. Is this considered a generic applicability document?

MR. LOSH: No.

MEMBER REMPE: Are you sure? Because the staff in their slide said we don't use anything from NuScale in reviewing this topical report. And when I read the intro to your report, I thought it said that we are just basically wanting to use AREVA methods for a shorter fuel rod, and it didn't really get into the details of the NuScale.

So this is a process question. If you, indeed, are having a topical report for the NuScale reactor, then you're good. But I thought what I read wasn't that way. So Joe's reactor can't come in and use this topical report?

MR. LOSH: This is specific to the NuScale module design.

MEMBER REMPE: Okay. And so if that design changes, I mean, is it tied to a particular version then of the NuScale dimensions and things like that or the axial peaking factor in this particular case?

MEMBER CORRADINI: Can I try something? And maybe staff is going to come in here at this point. But my impression is this is an applicability document for codes and methods already approved, but we have yet to and are not supposed to review how those codes and methods work out for your design. That we're going to see in Chapter 4 of the DCD.

MR. VAN WERT: That's right.

MEMBER CORRADINI: Okay. So that was one thing I want to make sure I'm not misinterpreting, and I'm looking at staff. And the second thing about staff is this is specific just to NuScale, this is not a generic topical? I'm looking at the staff now.

MR. VAN WERT: This is Chris Van Wert from SRSV. Yes, this is specific for NuScale and you will be seeing the actual application of these methodologies in a future meeting in the springtime, probably springtime.

MEMBER CORRADINI: Okay. Thank you.

Just to clarify. So did that help you, Joy?

MEMBER REMPE: No, because I peeked ahead and on slide five you have on your staff's slides, it says the staff review doesn't cover any technical analysis of this plant design based on the AREVA methods. And I know you had to assume an axial peaking factor, which I'm going to be asking later why isn't that a limitation or condition? You basically said we didn't use, we used something typical for a PWR in your topical report or your SER, and so I'm just wondering if there's other things out there that, again, if you are going to assume something for the NuScale design, why didn't you assume their axial peaking factor? Why do you have the statement I used a typical PWR one?

Again, it's a higher-level question, and I'm kind of getting too much into the detail of my example. But I just am curious.

MR. VAN WERT: Right. We were using confirmatory runs using FRAPCON, and we just wanted to kind of come up with a general gut feel of whether or not we had to ask some additional questions. I think the section was, I think this was one we were reviewing, COPERNIC I believe is -- I'm not sure which one you're talking about.

MEMBER REMPE: But we can get to that later with the details. But, again --

MR. VAN WERT: Right. So we were trying to figure out if there was anything unusual that would kind of tell us we had to, it was something that we needed to investigate a little bit further. So we used kind of some standard values and numbers that were --

MEMBER REMPE: Okay. But really your SER is approval based on the axial peaking factor for the NuScale-specific design based in whatever rev of whatever. And even though you assumed this other value, you know it's bounded by this other NuScale --

MR. VAN WERT: Correct. But when we do the technical report review, which we cover in the DCD Section 4.2 presentation, that we will be doing confirmatory runs that are very specific to NuScale's type --

MEMBER REMPE: And if you find out that something doesn't work with this topical report, it will be updated? Because the topical report also doesn't cover all the methods you're going to be having to use, like the thermal hydraulics methods. And so the process will be, oh, well, your design doesn't quite, you can't use some of these methods exactly in this document and your SE would be updated saying there's some more limitations or something would happen?

MR. VAN WERT: Correct. At that time, we will update, if necessary. At this point, we didn't see anything that would indicate that there would be an applicability issue, but we can cover that.

MEMBER REMPE: Okay. Thank you. Sorry.

MR. SCHULTZ: Larry, Steve Schultz on this slide. With regard to the spacer grid span length, you mentioned that as one of the differences, one of the few differences in the design here. Is there any technical design rationale that has set that at a slightly lower span length than for the AREVA design?

MR. G. THOMAS: There's an advantage, and I'll speak to it more in my presentation when we talk about fuel rod bow. Having the shorter spans is an advantage in terms of predicting fuel rod bow performance, so there's an advantage to being slightly smaller than our experience, so we could be bounded by the operational experience of the 17 x 17 --

MR. SCHULTZ: Is it technically significant, the half-inch that you got? Did you design the fuel so that you had that little bit more? I know it's pointed out, and, qualitatively, you might see some advantage but --

MR. G. THOMAS: The key, qualitatively, is that it's less, not that the half-inch is of particular significance. It allows us to say that we're bounded by our operating experience at the 20.6 value. The half-inch in itself is not particularly consequential.

MR. SCHULTZ: I didn't think it would be.

MEMBER CORRADINI: But to get to this point, but all the analysis eventually has to be based on the associated testing that you have to do with this exact fuel design for all the conditions. For example, accident conditions, right?

MR. G. THOMAS: Correct. Testing and analyses, yes.

MEMBER CORRADINI: Okay, fine.

MEMBER REMPE: So is it allowed to ask about will the NuScale design be allowed to load follow? The documentation, or is this something for later, it says we don't plan to, but it doesn't preclude it. Again, that seems important with respect to fuel performance, and I couldn't find a definitive statement saying no load following.

MR. LOSH: Chris, would you like to respond to that?

MEMBER CORRADINI: I was going to wait,

I think the staff has, their one and only limitation is this.

MR. VAN WERT: Right. So this is one of those kind of interfaces between this topical report and then the DCD review, well, the technical report associated with it, as well. The reason you see this limitation here is because, apparently, we're doing the other review, and there was an RAI associated with that DCD review and we requested, you know, some more clarification on whether or not they intend daily load follow use, and in the RAI response they did indicate that they would like to have that.

And so the reason there's limitation on here is we want to make clear that they understood that we cannot find anything in the AREVA topical reports and the staff SE associated with that specifically stating that it was applicable for load follow use. It might be inherent in there. There might be some more stuff that's not, you know, on the docket at this point. I can't weigh in on that at this point, but the NuScale topical saying that the AREVA documents are applicable did not cover it. So we want to make sure that it was clear that any future analysis, namely the DCD review, would include that as part of their scope.

MEMBER REMPE: Okay. Thank you.

MR. LOSH: The next slide looks at a comparison of the operating conditions primarily, but you also will see differences in the overall core configuration. The rated thermal power for the NuScale plant is 160 megawatts thermal compared to a typical PWR of about 3500. We operate at a slightly lower pressure and temperature.

The largest difference you'll see here, of course, will be in regard to the natural circulation flow rates, which produce an average of coolant velocity of about three feet per second compared to a PWR running around 16 feet per second. So we'll end up with core average Reynolds number approximately 80,000, where a PWR will run around 500,000.

MEMBER POWERS: What are the consequences of that?

MR. LOSH: Pardon?

MEMBER POWERS: What are the consequences of that? I mean, it would seem to affect things like mass transport, ability to shear things off the surface of the fuel, things like that.

MR. LOSH: There are a number of things that we will evaluate with respect to the lower Reynolds number in application. But in terms of the applicability of these codes and methods, the only place that it really becomes an element is whether we're in a forced flow convected heat transfer mode for the thermal analysis. And Glen will cover that.

MEMBER POWERS: That has no consequences on the accumulation of material there?

MR. LOSH: Not that we're aware.

MEMBER POWERS: Fine.

MEMBER CORRADINI: You're worried about crud build-up?

MEMBER POWERS: Sure.

MEMBER CORRADINI: Okay. That's where I thought you were going.

MEMBER POWERS: Similarly, on cycle length, a very substantial difference in cycle length here. And so you worry about things, you know, all the things associated with clad corrosion, clad contamination, because of the cycle length, and does it fall outside of our experiential range?

MEMBER CORRADINI: Do you guys have a comment, or do you want to move on? Okay.

MR. SCHULTZ: Larry, with regard to the fuel assembly discharge burnup, here it states that the maximum is less than 50. In various places, there are burnup numbers provided for the assembly. On average, it's listed as 40 gigawatt days per ton. Here it's less than 50. It bothers me that we're not, precise is not the right word but consistent in the discussion of assembly burnup in terms of do we know what the typical application is going to demand for this cycle length and the fuel cycle designs that have been proposed?

MR. LOSH: What we know today is that the equilibrium cycle that's used as a basis for the DCA is a two-year nominal cycle with a 13 fuel assembly feed, and that produces a discharge burnup approximately 40,000. That does not mean that we may not need to design a cycle that has a slightly different burnup, so our expectation is that that 40,000 is typical and the key element is that it's well below what is currently used in PWRs and well below the license limit for the codes that we are using and are applicable to the NuScale design.

MR. SCHULTZ: Okay. It just surprised me that there's so much discussion about, oh, it's 40, and since that's much less than 50, then you've got a case to be made. Here it says less than 50. So I'm trying to understand, again, the consistency and, in some cases, the engineering argument associated with, well, how different is it going to be in application?

MEMBER KIRCHNER: Can I add on here?

MEMBER CORRADINI: Before we start talking about this, are these numbers, I know less than 50 and greater than 50 is open. Is the rest of the discussion in a closed session? Do we want to wait until we're in closed to talk about this? That's a question for you guys to decide.

MR. LOSH: I think we're okay.

MEMBER KIRCHNER: So if I might add on to Steve's points, so these are, when you say maximum fuel assembly discharge burnup, is this averaged over the assembly? And what I'm getting at is peaking factors. To get that kind of push to higher burnups with a shorter core, typically, from a neutronics standpoint, you're going to have a steeper axial profile than you would have in a larger longer-length fuel element in a PWR. So what are you seeing as local peaking in terms of burnup versus average? You see where I'm going with that? These are like average, average numbers for the assembly and the core.

MEMBER CORRADINI: So, once again, I have a feeling we've got to talk about this in closed session.

MEMBER KIRCHNER: Okay. So let me just put a marker down that one aspect I would like to explore is with the shorter core height, what kind of axial peaking factors you have, and what does that mean when you start making these kind of comparisons on burnup and some other matters related to the heat transfer and the performance at lower Reynolds number. Thank you.

MEMBER CORRADINI: Keep on going. I'm watching you guys and the time, if we want time for closed session.

MR. LOSH: Let's see. Oh, we discussed the fact that we had a significantly lower average Reynolds number, and the other element force that's key is that our overall power density, after you consider the shorter height with the smaller number of fuel assemblies and then the lower thermal power, is about 40 percent of that of a typical PWR where we have a linear heat rate of about 2.5 kilowatts per foot average linear heat rate.

And as we just discussed, the overall cycle length, while being longer, due to that lower power density, we see discharge burnups. Here the note was made that it was less than 50. And for our current equilibrium cycle design, it's approximately 40,000 for a discharge burnup.

There are five AREVA topicals that were brought into this one topical discussing applicability of codes and methods. I'll let Glen go through those, but the point that I wanted to make here is that there is a sixth topical associated with AREVA codes and methods, and that's specific to seismic methodology. And that additional methodology topical is the subject of a separate topical report. So this topical, that is 2825, covers the applicability of the five topical reports you see listed here, and we'll be back to you some day later with the seismic one.

With that, Glen, I think this is --

MR. G. THOMAS: Thank you, Larry. So from this part of the presentation, we'll focus more on the actual applicability evaluations that AREVA performed to show that each of these five AREVA topical reports are applicable to the NuScale fuel design and operating conditions. So these first two or three slides are introductory, and then I'll actually march through each of the five topical reports in sequence.

Here, I'll summarize the method of AREVA's evaluation. So we looked at really two key aspects of topical report applicability, the first being the technical applicability of the report which I'll speak to in a little bit further detail down at the bottom of the slide. And the second is the regulatory applicability of each report, which is basically determined by reviewing the SER and TER for each of the topical reports and determining that they didn't have anything that would preclude use or application of that report to NuScale.

The third point there has already been brought up. The rest of the materials and the presentation and the NuScale applicability report do not really deal with the results of these evaluations, so that won't be contained in this evaluation. That's in the DC and in the associated topical report that's part of that DC. So this is really focusing on applicability of the AREVA methods and the AREVA evaluation to show that that, in fact, was the case.

In terms of our technical applicability evaluation, there are really two key factors, and we've already brought them out in Larry's presentation. In each case for each of the five topical reports allowed us to conclude that they were, in fact, applicable to NuScale, the first being the similarity to the fuel design and we'll bring that up one more time in general and then talk about each individual report and then, secondly, the bounding nature of the typical parameters in which AREVA fuel operates in a U.S. PWR.

So I apologize if this table was already presented, but I thought it was really important to emphasize this before I move on with my materials, and that is, again, just the similarity of the designs. And while Larry has walked through some of these parameters, I'll just point out that the three values in red are the only difference are the axial parameters affecting the fuel design. So we're talking about the overall fuel assembly height, the stack length of the fuel, and the grid span which is the space between the spacers. Those are the only three parameters in this list where there's a difference. They're so similar because, as Larry pointed out, we're actually using the same hardware, the same grid, the same parts, the same components for this NuScale design as we used for our own standard 17 x 17 fuel assembly design.

So that comparison, the level of equivalence between NuScale design and AREVA design allows us to conclude in many cases that our methods are, in fact, applicable. So that's point number one.

MEMBER SKILLMAN: Glen, let me ask a question. You mentioned earlier, and please tell me if this is proprietary, you mentioned earlier that the control rod, and I think when you said that you meant the spider plus the elements are heavier, and I think you meant that relatively speaking to a full-length 12-foot core rod.

MR. LOSH: I think I answered it, and my answer was in the context of the total drive line, the translating weight, not just the spider and the elements, but the drive rod above it, which is longer in the NuScale design and, therefore, heavier.

MEMBER SKILLMAN: Okay. So to your point about these fuel assemblies being virtually identical on all aspects, although shorter, you've got the 24 guide tubes that basically carry the impact load from the spider drive line. Has that load-carrying capability been analyzed for the relatively greater impact from the spider in the spring on scram?

MR. LOSH: Good question. The answer to that is yes. We explicitly modeled the additional weight from the lead screw combined with the specific geometry of the shorter fuel assemblies, the shorter guide tubes, and the mass and geometry of the control rod assembly and explicitly modeled the drop to ensure that the load imparted on the fuel assembly was one that would be acceptable in terms of the guide tube structural strength.

MEMBER SKILLMAN: Okay. Thank you.

MR. G. THOMAS: So, again, the key takeaway from this slide is the degree of similarity, and we'll make reference to that through the future slides discussing applicability of each individual report.

Secondly, again, I'm repeating a table, but I just think it's very germane to this applicability argument. So on the last slide, the point of emphasis was the degree of equivalence between the fuel designs. The takeaway from this slide, the key is that, in general, these operating parameters for NuScale listed in the center column are bounded by the operating parameters of AREVA fuel in a typical PWR.

The one exception has already been brought out, and that is the coolant velocity where there are some analyses where a lower coolant velocity would actually be limiting. So when we get to a couple of the topicals where that would be an issue, we'll talk about that specifically.

MEMBER SKILLMAN: Then let me ask this question, perhaps to your favor. Are there any AREVA 17 x 17s that are operating on a 24-month fuel cycle?

MR. G. THOMAS: At this point in time, no.

MEMBER SKILLMAN: No. Okay. Thank you.

MR. G. THOMAS: So the third table here, which is the last of what I consider the introductory slides before I walk through each individual report, simply is a graphic to show on the left the AREVA scope of analysis, in the center column we show the standard review plan applicable criteria, and on the right you can see how our five topical reports are distributed for the work in the AREVA work scope that are used for the project. So it's just to give you a visual as to how these five reports are used and what analyses they cover.

So that is the more general introductory material. We'll start walking through each of the five topical reports and our applicability evaluations.

The first I want to cover is EMF-92-116. It's titled "Generic Mechanical Design Criteria for PWR Fuel Designs." It's a very broadly-used topical within AREVA and defines our industry-approve mechanical design criteria for PWR fuel. It's been used for a number of fuel arrays in both Westinghouse-type plants and CE-type plants. The SER for EMF-92-116 approves its use for fuel up to 62 gigawatt days for measured ton uranium. That's a rod average burnup value. And as we discussed a little bit already, this is bounding relative to the types of burnup values that we're seeing from the NuScale fuel cycles.

92-116 is used in a number of analyses within AREVA, but there are six that are being applied to the NuScale application. So I'll briefly summarize each of those six on this slide and the next.

The first 92-116 section that we're applying to the NuScale design is on internal hydriding. Here the controls are established for fuel rod internal component hydrogen content. Basically, we have a pellet specification that controls the hydrogen content of the pellets. That's how we ensure that we don't introduce an unacceptable amount of hydrogen to the rod interior during operation.

These same controls in terms of this manufacturing specification are going to be imposed in the NuScale fuel design as we used in our standard U02 and gad fuel designs, so the controls would be the same and this criteria will be the same as applied to NuScale fuel as our standard 17 x 17 fuel.

The second section in 92-116 we're applying is on fuel assembly structure normal operation stress analysis. That section of 92-116 directs us to use the ASME code for the stress calculations and the stress limitations for how the stresses are combined. The code equation limits are generic. They're applicable to NuScale because of the things we pointed out at the outset. The operating conditions are similar and generally bounded, and the fuel assembly structural materials, the fuel assembly geometry, with the exception of the length, are the same. And the fact that the length is shorter is actually a benefit in terms of the structural stiffness of the bundle. So these methods for evaluating fuel assembly stresses are applicable to NuScale because of the similarity of their use and the similarity of the design.

The third criteria is on spacer grid fretting wear. The criterion is that no rods are too fret to failure during operation. This is demonstrated through testing, so, for the NuScale program, as Larry mentioned at the outset, we've done full-scale prototypic life and wear testing to show that this fuel is not susceptible to life and wear fretting through the life and wear tests. So this is also an applicable criteria, and the method was also used to demonstrate acceptability.

The fourth area is fuel rod and fuel assembly axial growth. In this analysis, we utilized empirical models to show the rod and assembly end-of-life gaps. For the rod, the key is to show that there's a gap between the rod and the nozzles at the end of life. For the bundle, the key is to show that there's a gap between the top of the nozzle and the core plate at end of life, if there's acceptable gap for axial growth.

So these models and this method is applicable to NuScale because we're utilizing the same structural materials for the fuel assembly and the operating conditions. Typically, burnup is bounded by AREVA U.S. PWR experience.

The last two criteria covered by 92-116 are the fuel lift analysis. There the fuel assembly mass and hold-down are to exceed the hydraulic lift forces, so that's both the method and the criteria for this calculation. The similarity to the fuel design, the geometric similarity, as well as the material similarity, makes the method and criteria applicable to the NuScale application.

MEMBER BALLINGER: Did I read in here that the spring constant is a little different with this fuel than the standard 17 x 17 fuel?

MR. G. THOMAS: It is a little less stiff. A typical AREVA 17 x 17 fuel assembly has a three-leaf spring. This has a two-leaf spring, and the key in understanding that difference is, with natural circulation, we have very low lift forces, and so there is no need for a significant spring load, which can adversely affect fuel assembly --

MEMBER BALLINGER: So your analysis for the regular fuel bounds all this then?

MR. G. THOMAS: Correct, correct. So the last category from 92-116 is the shipping and handling stress analysis. Here the loads from shipping are compared with the ASME allowable limits. This is much like the fuel assembly normal operating stress analysis that I discussed before. ASME code equations and limits are applied. These are generic and applicable to NuScale, given the similarity of the stress conditions and the similarity of the structural materials, the similarity to the shipping conditions.

So in all six of these cases, we concluded that, in the technical evaluation, that these approved 92-116 mechanical design criteria and methods are applicable to the NuScale design. From a regulatory standpoint, there are no SER restrictions that would preclude use to NuScale.

So that's our summary of 92-116. Any questions before I move on to the next topical report? Okay.

The next topical report is 10231. It's the COPERNIC fuel rod computer fuel rod design computer code. This code predicts thermal and mechanical behavior of the fuel under irradiated conditions. It's used for five calculations in the NuScale project: the rod internal pressure analysis, the clad corrosion analysis, the transient clad strain analysis, the fuel and center line melt analysis, and it's used to generate input for the creep collapse analysis which I'll talk about in a separate slide.

MR. SCHULTZ: Glen, remind me and the Committee on the --

MEMBER CORRADINI: You need your green light on.

MR. SCHULTZ: Oh, thank you. If you'd just remind me, the COPERNIC code, the documentation here was issued in 2004. The documentation in the overall description in the design certification application mentions thermal conductivity degradation and that COPERNIC has addressed that. Is that in the 2004 version? Has it been reviewed by the NRC subsequently? The issue has been around a while, but it's also been addressed fairly recently in some applications.

MR. G. THOMAS: Let me ask, if I could, Jim Horner to respond to that question, as he's more familiar with the origins and the review of COPERNIC.

MR. HOERNER: Hello. Is this on?

MEMBER CORRADINI: Yes.

MR. HOERNER: Okay. My name is Jim Horner. That's spelled H-O-E-R-N-E-R. I work at

AREVA in the Thermal Mechanics Department, and I was involved in the original submittal that Steve refers to. And it is a code that's identical to the code which we are using for the NuScale application, and it does include relevant high burnup data that addresses the thermal conductivity degradation issue and it has been reviewed by the NRC. And in subsequent LAR submittals, there have been additional benchmarks to more recent versions of the FRAPCON code, which also includes appropriate thermal conductivity degradation.

MR. SCHULTZ: There hasn't been additional benchmarking or modifications to the code as a result of the high burnup data? You've demonstrated that it does predict the high burnup data well.

MR. HOERNER: I'd say the answer to that is clearly yes. We have done additional benchmarks, but they have not required modifications to the code. So we are currently in the process of developing a next generation fuel performance code. And there are not significant differences with COPERNIC. It's just an increase in the applicability to more AREVA fuel products and more reactor types, PWRs for example. COPERNIC is limited to PWRs.

So we do perform benchmarks against our next generation code, which is under development. None of the benchmarks that have been performed have resulted in anything that makes us think that the COPERNIC has any significant deficiencies that needs to be addressed, particularly in the area of thermal conductivity degradation.

The thermal database in COPERNIC is rather extensive. It goes to high burnup. There's even one data point that goes up to 100 gigawatt days per ton.

MR. SCHULTZ: Thank you.

MEMBER BALLINGER: To be absolutely clear, the COPERNIC code does not have an explicit dependence of burnup, of conductivity on burnup that applies a penalty; is that correct?

MR. HOERNER: That's incorrect. It has an explicit degradation in thermal conductivity with burnup.

MEMBER BALLINGER: That's good. Thanks. That's not what I heard before in previous presentations.

MEMBER CORRADINI: Keep on going.

MR. G. THOMAS: Okay. So COPERNIC applications, COPERNIC code is used for a number of our PWRs. It's used in cores that AREVA supplies fuel to for Westinghouse cores and BWA cores and a number of different configurations. The current COPERNIC ranges of applicability, and I refer to items such as fuel type, cladding material, fuel rod burnup, all bound the NuScale design characteristics and operating conditions.

There's two points I wanted to bring out specific to COPERNIC and the evaluation we performed. The first is that we actually evaluated lower RCS flow rates from natural circulation to determine that the COPERNIC clad-to-coolant heat transfer coefficient predictions were applicable to NuScale at the lower flow velocities; secondly, that the RCS system pressure was used as the rod internal pressure limit for NuScale application. In a typical AREVA PWR, we license above system pressure, but we allow the rod internal pressure to go above the RCS pressure. That was not necessary here, so, as a simplification and conservatism, we created the limit or established the limit to be the system pressure itself.

So our conclusion for COPERNIC is that, based upon AREVA's technical evaluation and regulatory evaluation, that the criteria and methods can be applied to the NuScale design. Again, from a regulatory standpoint, the COPERNIC SER had no restrictions that preclude application to NuScale.

MEMBER CORRADINI: So I have a question.

You mentioned heat transfer, so I have a question. I don't understand you -- now, again, you tell me if we can ask this in public in open session. LOCA initialization. You're choosing not to, at this point, use COPERNIC for LOCA initialization. Do I have that correct?

MR. LOSH: That's correct.

MEMBER CORRADINI: So can you tell me at this point why, or do we wait and tell me why later?

MR. LOSH: I think the NuScale LOCA topical report will address what it uses for thermal conditions to feed into the LOCA analysis that NuScale performs. And it's not --

MEMBER CORRADINI: But can you give me a preview?

MR. LOSH: -- part of this -- I'm not --

MEMBER CORRADINI: Let me state the question a little differently. It seems unusual to me that you're going to use all of this stuff for steady-state analyses and then, when you have to do your safety analysis, this is not the jump-off point for the fuel rod initialization. So treat me as an academic, and it's an academic question. Why? It looks like we have a helper.

MR. SCHMIDT: This is Jeff Schmidt from

the Reactor Systems Branch. There is an RAI currently going through the process that addresses this question. So they don't use COPERNIC directly, but they do do a hand calculation that compares to COPERNIC. So there is some crosstalk between the two of what they use and COPERNIC.

MEMBER CORRADINI: That's good factual information, but why?

MR. SCHMIDT: That I'm going to have to leave to them, but it is a question that is being asked by the staff.

MEMBER CORRADINI: If you want to wait until closed session. This one I -- just call me interested. I want to know why.

MEMBER KIRCHNER: I would amplify on Mike's question. Then the COPERNIC results would not be used for initializing any transient analysis, not just LOCA but any transient analysis?

MEMBER CORRADINI: That isn't how I read it.

MR. LOSH: No, it's specific to LOCA.

MEMBER KIRCHNER: Specific to LOCA.

MR. LOSH: We're not using the AREVA methodology for LOCA. Therefore, we're not using the AREVA methodology for initialization of the LOCA.

MEMBER KIRCHNER: What about AOOs and other transients that you have to analyze?

MR. LOSH: We have other codes that will have their own thermal models in them, but we do use COPERNIC output to benchmark those.

MEMBER KIRCHNER: Now I just second Mike's question why.

MEMBER CORRADINI: So you decide, Larry, if you want to deal with it now or later. Maybe later in closed session?

MR. LOSH: Yes.

MEMBER CORRADINI: Okay.

MEMBER SKILLMAN: Let me ask this question, please. To the second caret under the first bullet, RCS pressure use is rod internal pressure, that suggests to me that you have made a change in your manufacturing process for this fuel and that the fuel will be pre-pressurized to an initial pressure different than your full-length fuel assembly. Is that accurate?

MR. G. THOMAS: The rod internal pressure they're referring to here is there's a prediction of COPERNIC as to how rod internal pressure increases with burnup due to fission gas release. And so what this bullet is communicating is that the limit imposed upon the fuel rod at end of life is that it shall not exceed RCS system pressure, rather than being allowed to go above it as typical AREVA fuel rods would using our typical licensing methodologies. But it does not necessarily reflect a change to manufacturing process or backfill pressure. It's simply we're putting a lower cap on the rod internal pressure buildup over time, and our analyses show that that is acceptable.

MEMBER KIRCHNER: Does that then become a limiting condition or a tech spec on burnup? Because that affects all of your transient analysis, as well.

MEMBER CORRADINI: I have a funny feeling you want to talk about this in closed session.

MR. LOSH: Well, the selection of the criterion for end-of-life and pressure was done by NuScale and was done to be more conservative than what is currently allowed in those plants that have what we call licensed above system pressure where they demonstrate that there is no DNB propagation or other adverse effects from having the fuel rod internal pressure exceed system pressure. We've chosen to use system pressure as the limiting criteria, which is more bounding than allowing the internal rod pressure to go above system pressure.

MEMBER KIRCHNER: But does that imply, as the original question, that you put a lower helium fill?

MR. LOSH: Oh, we do change the manufacturing process to put in a lower helium fill pressure, and it's primarily driven by the fact that we have a lower system pressure.

MEMBER SKILLMAN: Right. And then the answer to the question that I asked earlier is yes?

MR. LOSH: Yes. So I think we were interpreting the question to have to do with the criterion at the end-of-life pressure and not --

MEMBER SKILLMAN: No, I was thinking of the pre-fill to ensure that you don't exceed system pressure at your designated end-of-life MBT.

MEMBER BALLINGER: So, in effect, you have a no lift-off criteria, right?

MR. LOSH: Correct.

MR. G. THOMAS: It ensures you don't get into that region, so it's a simplification and a conservatism both.

MEMBER BALLINGER: From the standpoint of heat transfer, as soon as you lift off, the clad separates from the fuel --

MEMBER CORRADINI: Oh, you're talking about clad pellet --

MEMBER BALLINGER: Yes.

MR. SCHULTZ: Glen, just to clarify, you have a different initial pressurization, but the manufacturing process is the same.

MR. G. THOMAS: I would say the process is identical, yes. That's the other reason I answered that question in that way, but I would say the process is identical to our current fabrication process, but the setting when you fill the chamber is slightly different, yes.

MR. LOSH: The current manufacturing process already allows for that, and you have different internal pressure for different fuel rod designs --

MR. G. THOMAS: That's correct, that's correct. So any other questions on COPERNIC before I move on to the next topical report? Okay. Thank you.

So the third topical we reviewed was 10084, the "Program to Determine In-Reactor Performance of BWFC Fuel Clad and Pre-Collapse," a long title. It's our creep collapse analysis methodology. It ensures that AREVA fuel rods do not collapse during their design lifetimes. It was originally submitted and approved applicable to Zirc-4 cladding. The M5 topical report, BAW-10227, will be discussed a little bit later. That actually extends the application of the creep collapse method and model to M5 cladding, which is what we use for NuScale.

The CROV code and its associated methods are currently used in several PWR licensing applications, like the other two topical reports have already discussed. It's used for fuel AREVA supplies to Westinghouse cores, Babcock and Wilcox cores, and CE cores, and a number of arrays.

There's really a short list of pertinent parameters for the creep collapse prediction, and they're captured there in the left-hand column of the table. The key parameters are clad temperature, pressure differential across the cladding, and what we're referring to there as a pressure differentials is different between the system pressure and the rod internal pressure, and then the fast neutron flux. In each of these three cases, the values for the NuScale application are within the range of existing CROV applications.

The summary for the CROV report, there's one method change that we wanted to call attention to. It's the one method change that's called out in the NuScale applicability topical, and that is the AREVA PWR collapse analysis, what we'd use on a standard 17 x 17 or any PWR design, utilizes fuel performance inputs from an axial elevation of 90 inches. This elevation corresponds in a typical PWR to the worst combination of neutron flux, cladding temperature. Obviously for NuScale, the fuel stack is less than 80 inches in length, so this would make no sense to try to impose this particular aspect of method. So we've developed an alternative method specific to NuScale that creates a conservative set of inputs. If there are questions on that, that's something we could discuss in the closed session, but that is one design difference that the NuScale applicability report calls out as a difference in methodology and it's the only one in the presentations today.

MEMBER REMPE: So I have a question about the AREVA methodology for a typical PWR, if I could ask that in the open session.

MR. G. THOMAS: You can ask it.

MEMBER REMPE: It is a cumulative effect? Like other times when you do creep failure, you have a life fraction rule, and is that they always assume a particular elevation and so they look as the exposure increases and they have a cumulative prediction of creep failure?

MR. G. THOMAS: It is cumulative. The

inputs are generated at a specific axial elevation over time.

MEMBER REMPE: Over time. Okay. And so -- and you can answer this part later, but I want to ask the question now. Is the methodology for the NuScale analysis also a cumulative effect? Because when I was reading this, it sounded like it wasn't, and it would make me feel more comfortable knowing it's still cumulative.

MR. G. THOMAS: The short answer: with time, it is cumulative.

MEMBER REMPE: Okay. And so if you could explain that --

MR. G. THOMAS: And we can explain it further, yes.

MEMBER REMPE: -- in the closed session, I'd like to understand how that's true.

MR. G. THOMAS: We can do that, yes.

MEMBER REMPE: Okay.

MR. G. THOMAS: So our conclusion for the CROV topical 10084 is that, based upon our technical evaluation, it can be applied to the NuScale fuel design. From a regulatory standpoint, there are no SER restrictions in the CROV topical that preclude application in NuScale, and there is the one methodology adjustment, I would call it, that is documented in the report itself.

The next topical report is BAW-10227. It's the "Evaluation of Advanced Cladding and Structural Material in PWR Reactor Fuel." It contains our analysis methodology for M5 fuel rod cladding, and it also calls out the limits we're to apply for fuel rods with M5 cladding. Like the other applications we've discussed to this point, it's approved to a fuel rod average burnup of 62 gigawatt days per metric ton uranium.

For NuScale specifically, there are just two analysis types that the M5 topical BAW-10227 is used for. That's the stress and buckling analysis and the fuel rod cladding fatigue analysis. Similar to the other codes we've talked about, it's used in a number of PWR applications both in Westinghouse plants and B & W plants.

And a table similar to what I showed in the CROV topical report, there's really a short list of critical key parameters for these M5 fuel rod cladding evaluations. They're shown in the left-hand column of this table. Cladding material and radial dimensions, which I've already discussed, are identical for standard PWR design. And cladding temperatures and the pressure differential across the cladding again where the NuScale value is within the range of existing applications for this code.

So the general conclusion here is that the NuScale parameters are within our operating experience for PWRs currently licensed for the M5 topical BAW-10227.

MEMBER CORRADINI: So I have a question here, but it's more educational. This is an average for the bundle, so it's like a per fuel assembly computation where you back-calculate a cumulative for the bundle. Do I have that right?

MR. G. THOMAS: For which analysis does your question refer to?

MEMBER CORRADINI: I'm kind of back on slide 21 where it says approved for PWR licensing applications up to 62 gigawatt days per metric ton uranium for average. Rod average meaning axial length?

MR. G. THOMAS: Averaged across the rod, yes.

MEMBER CORRADINI: So I don't remember if it was Joy or Walt or somebody over here asked the question about shape of the flux and its effect on that number. And, again, we can wait until closed session, but if I have X, which is less than 50, and now we're seeing this is applicable, is the shape of how I get to less than 50 affecting this?

MR. LOSH: I think there was a point that we are probably going to cover in closed session. I think we can go ahead and talk about it now. Relative to axial peaking for the NuScale design compared to a PWR, I think Chapter 4 will cover how any difference of axial peaking will be reflected in setting any safety limits. But in terms of burnup distribution, the axial power distribution burns out. Your axial power distribution from a burnup standpoint is going to represent a ten percent peaking, and that's going to be the same whether it's in the NuScale plant or PWR.

MEMBER CORRADINI: Okay. Thank you. Keep on going. Thank you.

MR. G. THOMAS: Okay. So as I was mentioning in this table, the takeaway from this table is that the NuScale parameters are within our operating experience for PWRs. That leads me to the conclusion --

MR. SCHULTZ: Glen, when you say within, does that mean it's bounded by the upper limits or --

MR. G. THOMAS: Yes. So if I --

MR. SCHULTZ: Within the range seems to

be a very general statement to me.

MR. G. THOMAS: Sure. Let me clarify. So if you look at the table at the key parameters, the dimensional and material parameters are identical because we're using a rod that has identical radial geometry and we're using the same materials. So in that case, we're dealing with the words exactly the same, identical.

For cladding temperatures, the NuScale cladding temperatures are below those of our fuel rods. They're going to create a less limiting stress condition. The pressure differential across the cladding is lower, so we're going to deal again with lower resulting stresses because the load from the pressure are less. Is that clarifying?

MR. SCHULTZ: Yes, it does. Thank you.

MR. G. THOMAS: You're welcome. So just to conclude M5 topical and come back to our primary statement, we concluded in our technical evaluation that BAW-10227 can be applied to NuScale and the SER contains no restrictions that preclude applicability to NuScale.

So the last of the five AREVA topical reports that we evaluated was XN-75-32. That's our computational procedure for evaluating fuel rod bowing and, in particular, Supplements 1 to 4 define the NRC-approved procedure for evaluating fuel rod bow.

Rod bow is influenced primarily by four factors: the slip load of intermediate grid, the force it takes to push a rod through the grid, the span length between the grid which we've talked about a little bit already, the coolant cross flow forces, and the core operating conditions. So the primary concerns with rod bow is that a reduction in the rod-to-rod gap can result in a decrease in DNBR margin, and an increase in the rod-to-rod gap can result in an increase in lower power peaking. So what the rod bow topical does is it provides a method to predict rod bow and then to develop an appropriate fuel performance penalty in the areas of DNB and linear heat rate.

So the application is used broadly within the AREVA fuel types to fuel in Westinghouse plants and CE plants for a number of arrays. Our technical evaluation showed that the design is within our current experience for core operating parameters and slip load and less limiting for spacer grid span length, which we talked about earlier.

So that leads us to the first conclusion that the NuScale fuel is expected to have a lower propensity for fuel rod bow than the AREVA PWR benchmark designs. So that's the first conclusion we drew because the geometric and operating condition similarity. And then, secondly, the CHF penalty that's derived by this method and the linear heat rate penalty derived by this method are acceptable.

MEMBER STETKAR: Glen, I don't do this, so I need some education a little bit. And I don't know whether this is open or closed session. You make an assertion that the expected bow in your fuel assembly is going to be less than a typical PWR fuel assembly, so the gap is going to be larger. The method for assessing the critical heat flux penalty -- and, again, I don't do this, I only understand what I read here -- seems to be based on geometry. It's based on a fraction, the reduced fraction of the spacing between the rods. And the assertion is made that that is not, that that geometry-based penalty is not affected significantly by the coolant flow, which for your core is substantially less than the range of flows that were used to benchmark all of the codes. And I don't know whether we want to talk about this in closed session or whether --

MEMBER CORRADINI: Well, you don't talk numbers. Keep on --

MEMBER STETKAR: I haven't talked about

numbers. It's just substantially less. So can you educate me on why I should have confidence that that empirical correlation that was derived for one set of flow conditions applies to your core with much lower flow? I would expect the propensity to DNBR to be much smaller or a greater propensity to DNBR if your core was that much lower flow.

MR. G. THOMAS: So let me answer that in two steps. One, which you talked about earlier, may not be a key component of your question, but I think it's a significant point. And one is, from geometry, we can conclude confidently that the bow in the NuScale fuel assembly should be limited by our bow experience. So the degree of bowing we would expect to see from NuScale should be --

MEMBER STETKAR: I understand that. But given that degree of bowing.

MR. G. THOMAS: Yes. So given that degree of bowing, now the question is does the CHF penalty still apply for a lower flow rate, given that we're talking about natural circulation? That's the essence of that question?

MEMBER STETKAR: That's the essence of the question. Does that geometrically-based CHF penalty still apply?

MR. G. THOMAS: So from the correlation that we have, we were able to see that there is no adverse trend with a reduction in, an adverse trend for CHF performance with a reduction in flow rate. So for the range that was actually tested --

MEMBER STETKAR: For the range that was tested.

MR. G. THOMAS: For the range that was tested.

MEMBER STETKAR: And, again, tell me when I tread too far.

MR. G. THOMAS: We're still okay.

MEMBER STETKAR: Okay. If I look at, and I didn't go back to the actual AREVA topical report, but in your topical report, there is a plot that shows a trend.

MR. G. THOMAS: Correct.

MEMBER STETKAR: And that trend seems to me to be in the adverse direction for decreasing flow. The plot just shows over the range of flows, but if you kind of draw a line it seems to be going in the wrong direction as you get down toward the flow regime that you have in your core. And I just don't know the, because I don't do this, I just don't know the trade-off in that correlation between some, you know, at some limit, the flow has to start being important.

MR. G. THOMAS: Understood. And --

MEMBER STETKAR: I'd like to know where that limit is. And pressure. But, I mean --

MEMBER KIRCHNER: These basically go back to the Columbia test, don't they?

MR. G. THOMAS: Correct, yes.

MEMBER KIRCHNER: So basically, to summarize those tests, as the pressure goes down and the flow goes down, the margins for DNB go down.

MEMBER STETKAR: Go down, yes.

MEMBER KIRCHNER: And the actual critical heat flux goes down. So you're right in the sense that your instinct is right, but your --

MEMBER STETKAR: I just don't know -- they're asserting that their penalty based on just looking at geometry will hold down through the range of the flows that they --

MEMBER KIRCHNER: Through that range of the experimental data set.

MEMBER STETKAR: Well, but their flows are well beyond the range of the experimental data set.

MEMBER CORRADINI: But they have to do it, I mean, maybe we'll just take this up in closed session, but they have to develop their own data set range for

CHF. That has to be done. I think it's the method once the data set is applied is the question here, and I think that's where John's asking because I'm sure you're going to have to, I know you have to do your own bundle testing at these heights and under these flow and pressure conditions to show approved CHF ratios because it does go up or down. The ratio goes, the ratio goes in such a manner that your CHF actually is going to go down with flow and pressure, as Walt said. So it's more the applicability rather than the --

MEMBER MARCH-LEUBA: Right. But that correlation would be for no bow. We're talking here is the penalty.

MEMBER STETKAR: This is the penalty given a bow, and their assertion is that their amount of bow in this particular assembly ought to be less than the predicted bow for a full-length PWR assembly. But given the amount of bow that you have, whatever that is, it's not going to be zero, is the methodology still justified?

MR. G. THOMAS: And our assertion is that that slight negative trend is within the scatter and the data, so there's no reason to add an additional penalty.

MEMBER STETKAR: I'll give you, the data

is pretty --

MEMBER CORRADINI: Let's wait, let's wait.

MEMBER STETKAR: Okay, all right.

MEMBER CORRADINI: I can see that's not going to satisfy him, so let's wait until closed session.

MR. G. THOMAS: Okay. So the conclusion for the rod bow topical and understanding we'll come back to this some in the closed session for the particular question on CHF, but our conclusion based on our evaluation is that Supplements 1 to 4 can be applied to the NuScale fuel design. The SER for the rod bow topical contains no restrictions that would prevent or preclude application to NuScale.

MEMBER KIRCHNER: For closed session, would you just take a note so I don't forget? You mentioned earlier that you changed the grid spacers. Now, yes, you've shortened up. On one hand, that would let you, I think, make a good argument that it should be stiffer assembly. But aren't you changing the number of contact points versus your normal full-length 17 x 17 fuel --

MR. G. THOMAS: Over the full length of the fuel rod, yes, there are fewer contact points because we've moved from eight grids to five. If that's what you're stating, I would agree with that.

MEMBER KIRCHNER: That and also the grid itself, the spacer, are you changing the number of --

MR. G. THOMAS: Oh, the spacer itself is identical in --

MEMBER KIRCHNER: It is identical.

MR. G. THOMAS: It is identical.

MEMBER KIRCHNER: Okay. Thank you, thank you.

MR. G. THOMAS: It's a line contact spacer design. I'll just go to my concluding slide then. So we've reviewed the five AREVA topical reports we intend to apply to NuScale and demonstrated they apply to NuScale as documented in the TR that's subject to this review.

There is one stated modification in that report, and that is concerning the axial elevation utilized in the pre-collapse analysis. There are no other exceptions or changes to method that we're applying for or noting in the document.

So that concludes the AREVA NuScale presentation. Larry, anything else?

MR. LOSH: No.

MEMBER CORRADINI: Okay. Questions by the Committee? Otherwise, we're going to --

MEMBER KIRCHNER: Just one out of curiosity. Since it was stated that you don't use the COPERNIC for initial conditions for LOCA, do you use that for initializing in your other fuel applications? Or is that a proprietary question?

MEMBER CORRADINI: We can wait. Let's just --

MR. G. THOMAS: I'd rather defer that.

MEMBER CORRADINI: I've got something down that we're going to talk about anyway about COPERNIC so we'll --

MEMBER SKILLMAN: Yes, a general question, Mike, to Glen. My focus in review here is what's different and why is what's different important. To Dana's question about 24-month fuel cycle versus 18-month fuel cycle, the 730 days versus 520 days, what, if any, unique chemistry requirements have you imposed so as to ensure that fouling on the pins is, if you will, within limits, given the very low Reynolds number compared to force flow? It seems that there is a fouling coefficient here that must be taken into consideration because, at least in my view, after some years of experience, I would not expect the fuel clad to be pristine on day 690 on a 24-month fuel cycle. So are there unique chemistry requirements that accompanies the shorter fuel assembly and the lower Reynolds number?

MR. G. THOMAS: So in short, at this point, no. AREVA has not imposed any to ensure that our analyses and analyses' conclusions and methods are valid. We have not.

MEMBER SKILLMAN: Thank you.

MEMBER BALLINGER: But you still have the same limit, and we won't use the number, on the amount of, let's call it non-zirconium alloy stuff on the cladding, right?

MR. G. THOMAS: The analyses assume a limit to that that are the same.

MEMBER BALLINGER: It's the same, yes.

MEMBER CORRADINI: Can you help me? I don't know what you mean, Ron. Can you --

MEMBER BALLINGER: I can't use the number, but in order to not have a deleterious effect on heat transfer during an accident.

MEMBER CORRADINI: There's a fouling --

MEMBER BALLINGER: There's a fouling limit which is X microns, where I can't say what X is.

MEMBER CORRADINI: That's fine.

MEMBER BALLINGER: And it's the same for this fuel, as opposed to the standard 17 x 17 fuel.

MR. LOSH: In terms of chemistry, we have been working with AREVA to ensure that the chemistry we are using is consistent with the chemistry that is representative of the plants from which the data is into the COPERNIC models. So we will be imposing that. No, they're not imposing it, but we are working with AREVA to ensure that our chemistry is consistent with that and we're using the proper chemistry.

As it relates to the potential for crud deposition at these conditions, we don't see anything in the methodology that is an issue. But from an application standpoint, to your point, we have planned for and committed to a fairly aggressive post-irradiation examination campaign to inspect the fuel and do specific lift-off measurements for crud as part of that to ensure that the crud deposition is not an issue at these flow conditions.

MEMBER POWERS: Will the PIE examine borate absorption on the clad surface?

MR. LOSH: Will it examine? I'm sorry.

MEMBER POWERS: Borate absorption rate.

MR. LOSH: We were not planning at this point -- I think the post-irradiation examination was going to be pool side. We didn't have, I think we would be driven by what we see there as to whether we need to take any rods to a hot --

MEMBER POWERS: You won't see it.

MR. LOSH: But the initial was to do strictly pool side, but we were going to do more than just visual. We were planning on doing quantitative measurements.

MEMBER POWERS: Because of the shorter rod, do you have more of a problem with a potential for axial offset?

MR. LOSH: Not a problem. We have a core design with axial offset limits and insertion limits that you would see typically in a PWR, and we work within those. We don't see peaking that's significantly greater than a PWR, but, again, in terms of specific numbers, we can talk in the closed session about that. I believe that information, from the NuScale perspective, is all in the non-proprietary 4.2, 4.3 sections of the SER.

MEMBER CORRADINI: Okay. Other questions? All right. Let's have a change over to the staff. Bruce, you're going to lead us off?

MR. BAVOL: Yes.

MEMBER CORRADINI: Okay, go ahead.

MR. BAVOL: Good morning. My name is Bruce Bavol. I'm the project manager for Licensing

Branch 1 in the Office of New Reactors. I wanted to thank everybody this morning.

This morning, I wanted to just briefly go over my portion of the presentation, some logistics for the time line of the topical report, which was submitted on March 30th, 2016 as Rev. 0. After the staff had an acceptance review, they had some comments. Our Revision 1 was subsequently sent July 1st. That had to do with, and I believe it was mentioned earlier from Larry, the removal of the fuel seismic portion from that topical report.

Staff issued a request for information, RAI 8727. One RAI was generated, and that was responded to by NuScale. And that information was also provided in the safety evaluation.

The safety evaluation, the advanced safety evaluation report was issued by staff July 20th. Following this Subcommittee meeting, we have a full Committee scheduled for October 5th, a quick turnaround. And our plans are to issue a final safety evaluation late October this year, and then the -A approved version would be the follow-up to that in December, mid-December.

The technical reviewers for this particular, Becky Karas had introduced us this morning, was introduced this morning. Jeff Schmidt is also here, and then Christopher Van Wert, the principal technical reviewer for this topical report to my right.

With that, my portion is complete and I'll turn it over to Chris.

MR. VAN WERT: All right. Thank you very much.

MEMBER MARCH-LEUBA: Hey, Bruce, just a question. There was a mention before there was an open RAI still?

MR. BAVOL: No, there's no open RAI. RAI 8727 was just the one, and it was closed.

MEMBER MARCH-LEUBA: It's been closed?

MR. BAVOL: Yes.

MEMBER MARCH-LEUBA: Okay.

MR. VAN WERT: Thank you very much and good morning. My name is Chris Van Wert, and you've heard about, actually AREVA and NuScale covered most of this stuff that I was going to talk about, but here's the slides presenting a listing of the codes and methods that were part of this review.

This was touched on a little bit before, but I just want to make sure it was clear again. The review was an applicability review. The topical was a applicability review, so our focus was applicability of the codes and methods. We did not review the approved AREVA topical reports, and, more specifically, I think of interest here today is that the actual technical analysis using the codes and methods is going to be deferred to the 4.2 review and its associated technical report. That is ongoing. We will be back before you, so any specific analyses using NuScale numbers and getting the results, that will be deferred to that presentation.

MEMBER BALLINGER: So as far as staff is concerned, this review of the topical report is really just setting you up to do the design cert review? Unless you see something there that really conflicts with what's here --

MR. VAN WERT: Correct, correct, yes.

MEMBER BALLINGER: -- you'll just go ahead with the methods that have been done here.

MR. VAN WERT: Our focus now, you know, we did begin kind of focused on this topical report to make sure that the tools were applicable to be used. As summarized before and as we will present here, we didn't see anything that was unusual. Now the focus is in the actual application of it, and that's where we're going to be diving into more specific details really and --

MR. SCHULTZ: Chris, that gets into things like the way in which the methodologies are going to be applied, input assumptions, uncertainties, manufacturing and code uncertainties and otherwise. And we can presume that NuScale and AREVA will be working together and will have to differentiate or determine how that's been done in comparison to how AREVA has applied the methods in the past.

MR. VAN WERT: Correct, yes.

MR. SCHULTZ: That's what you're doing, and we'll get a chance to --

MR. VAN WERT: Yes, that's what we're doing now and for the next few months, but the difficulty was we didn't want to hold up this review by getting into very specifics on uncertainties and whatnot. But we recognize there are certain parameters, flow rate or mass flow rate being one of them that was discussed already in the morning or earlier session. Those types things we wanted to make sure did not derail the applicability of the method, but I'm not going to say today that, once we get into the very specifics of the NuScale design and looking at those analyses, that we don't have to come back and have a question. But everything we've seen today tells us that these codes and methods are applicable for the analysis.

MR. SCHULTZ: Thank you.

MEMBER REMPE: These key parameters, are they protected somehow or listed somehow? I mean, what if things go along -- there's been some changes already in the NuScale design, and how does that interface --

MR. VAN WERT: Right. It's not too unusual during the course of a review for an issue to come up where the staff has question and, maybe through that process, an analysis has to be re-performed with different inputs. If something were to change down the road where -- I'm trying to think of a good example right now, but, off the top of my head, I can't come up with one. But if a key input parameter were to change for NuScale due to a design change during our review of the applicability and the application of this in 4.2, at that point, we would have to come back to this and work with NuScale. They'd have to revise the topical report or potentially, if it were severe enough, they might have to do something with AREVA codes and methods to justify the continued use of it.

MEMBER REMPE: So, again, is there a list somewhere that triggers it? I'm thinking of another design certification where a shielding value changed and it wasn't picked up. So do you guys have a list and say these are the key things that we're going to rely on? And so, I mean, they may change other things and it's determined this isn't important. I mean, how do you track it? Does that make sense or is it a valid question to --

MR. VAN WERT: I did this review, and I'll be doing the next review, so I won't be --

MEMBER REMPE: You've got a list and you know --

MR. VAN WERT: It's not exactly a list, but there won't be a change coming from external unless, and maybe I'm interpreting the question incorrectly and I apologize if that's the case, but I can't think of a, if there's any sort of a fuel design change, which is what this is all related to, that will be under my review. And so I will know, hey, they changed cladding thickness, they changed -- I don't think that would be happening, but I would know that I need to go back and confirm that COPERNIC is okay for evaluation under this new design change.

MEMBER REMPE: Okay. So let's take it further. You decide you want to take a job that pays more someplace else and so the next guy, how will he know that, oh, these are key parameters that are important? I'm just kind of wondering how you --

MR. VAN WERT: They are identified within the topical report that was submitted. So if you look at the topical report that NuScale provided, for each one they might say for fuel rod bowing important parameters are span length, burnup --

MEMBER REMPE: And so let me go back to my axial peaking factor question. That wasn't identified in the topical report.

MR. VAN WERT: Correct, correct.

MEMBER REMPE: But you guys, again, had to assume something. Now, you've said, well, we kind of looked at the design, too, because it wasn't clear to me that this was only going to apply to what's coming later in Chapter 4 of the submittal. But you had to make some assumptions that aren't in the topical report. There's other things, too. Plans for surveillance programs and things like that, and that was something that was raised in an RAI. And so I'm just kind of wondering how you keep track of things like that, and I guess it's not a clear answer.

MR. VAN WERT: The short answer is there's no table that is there. I don't --

MEMBER REMPE: Okay. We just cross our fingers basically.

MR. VAN WERT: I don't want to give you that impression because that's --

MEMBER CORRADINI: I don't think he's saying that. I think he's saying that, currently, he knows what he's going to look at again, and I'm assuming you're going to have to pass it on in some written documented form if you get hit by a bus, when you get hit by a bus.

MR. VAN WERT: I hope no one is plotting anything here. I'm feeling a little uncomfortable with this discussion but, but yes --

MEMBER CORRADINI: I think all Dr. Rempe is trying to get at is she wants to make sure there's a clear designation, if a dime changes, how does it affect --

MR. VAN WERT: Right. And the ones that I feel are important to the design and the applicability of these methods are identified in the NuScale topical report. I'm not trying to say that the axial power shape isn't important, but what we were using that for is to develop our internal calculations on the cladding surface temperature and mid-wall temp. It wasn't to justify an axial shape. And I think we were actually pretty close. I mean, we'll find out in the 4.2 review, but, if I look at the coolant temp that was calculated through that confirmatory run, we were pretty much right on for both AREVA and for NuScale.

MEMBER REMPE: Okay. So, again, there's sometimes, like load following, you put a condition on. Other times axial peaking factor, a surveillance program. You queried them or you made assumptions and, in fact, you can find it in their Chapter 4 submittal what the peaking factor is if you look at the numbers and stuff. But I just am kind of wondering what is and isn't explicitly stated and the traceability of it if you get hit by a bus or something like that. But, again, I guess people will have to just go through and dig through the documentation and the trail if it's not clearly identified is the bottom line.

MR. VAN WERT: We'll be identifying the important parameters in that 4.2 SER, as well.

MEMBER REMPE: Okay.

MR. VAN WERT: But if you're talking about in this topical report SER, you are correct, we don't have a table identifying it.

MEMBER REMPE: Right.

MR. VAN WERT: But there will be discussions on the important parameters within the 4.2 review.

MEMBER REMPE: Okay.

MEMBER KIRCHNER: I think the answer, I guess it's not my place to give you an answer, but how

I would answer Joy's question is I would take the AREVA submittal or the NuScale submittal, correcting myself, and it explicitly states in each of the sections for each of the codes they're going to use the range of validity. And when they step outside that, I would submit that then you would go back and review this SER.

MEMBER REMPE: Well, that was my point, though. They don't have everything. They don't have an axial peaking factor. They don't explicitly state what the surveillance program, even if there is one, in the topical report. So there are things that aren't there.

MEMBER KIRCHNER: No. What I'm saying is they state, they state the range for which the codes have been validated. And we're reviewing the methods, we're not reviewing the core. So that would be my answer to your question is that I would hold them to, you know, the validation program for the codes that they have.

MEMBER REMPE: Well, again, it only applies if it's specific to the NuScale reactor and what's in the Chapter 4. I think it's kind of still fuzzy in my mind, but let's go on.

MR. VAN WERT: Okay, all right. So in this slide, I just did a brief overview without the numbers that were already presented to you, but I just wanted to, again, emphasize some of the similarities between the NuScale design and the AREVA designs, a typical 17 x 17 AREVA design.

As mentioned before, really the only differences in the physical fuel assembly design are associated with the reduced height, so reduced physical overall assembly height, active fuel height, but then also the grid span is now a little bit reduced. Additionally, as discussed before, the rod internal pressure, well, the backfill pressure, I should say, is reduced.

And so, to some extent, this had just been mentioned, but the staff's review was focused on reviewing the conditions or limitations in the referenced AREVA topical reports and seeing if there's any conditions or limitations that would apply to NuScale. We also compared the NuScale fuel system and operational parameters with those used in the development of the AREVA methods, and then we reviewed any specific modifications that NuScale had to make to the AREVA codes and methods. Yes?

MR. SCHULTZ: Chris, I would just augment your second bullet there perhaps to say used to develop benchmark and apply the AREVA methods, rather than just to develop them. I mean, these methods have been --

MR. VAN WERT: Yes, yes.

MR. SCHULTZ: -- developed, benchmarked, and applied, and it's all of those pieces that this particular review is saying are applicability to NuScale.

MR. VAN WERT: But they haven't been applied yet, if that's what --

MR. SCHULTZ: No, no. But I mean this is how, this is what AREVA has done with them.

MR. VAN WERT: Oh, what I was saying here -- I apologize. Maybe this bullet wasn't as clear. So what I was doing is I was comparing the NuScale fuel assembly and operational parameters and compared those with those ranges that were previously presented by AREVA in discussion of each code and method. So if it said that it was --

MR. SCHULTZ: That's fine. Maybe I'm just quibbling with developed versus a more broad description of what methodology is about. So that's fine. I understand what you're saying.

MR. VAN WERT: Okay. Thank you. So we did not present detailed slides on each of the codes and methods. Instead, we focused only on the couple that, through the review, ended up having additional attention. And so you've already heard about these, but I wanted to at least touch on them since these had a little bit more back and forth during the review.

So for the cladding creep collapse methodology, it was already discussed that the initial AREVA method kind of had a hard code 90-inch number in there, and that was not applicable for NuScale fuel design due to the shorter length. And so with that, we submitted an RAI requesting additional information on the methodology that they used to calculate the new height. And through their RAI response, they provided more information and discussed how they were using the maximum flux, regardless of where it was. And the methodology was very similar to what AREVA used in the first place. I think there's going to be some further discussion on that in the closed session, so I'll defer some of that to then. But based on the RAI response information which confirmed the high-level description in the topical report, the staff was able to find that acceptable.

And then the other one that we've already seen some additional discussion on this morning was the fuel rod bow topical report, XN-75-32. The staff of course noted, as mentioned before, that the overall propensity for rod bowing at certain parameters, such as grid span lengths, was more favorable towards NuScale. Additionally, burnup was less. These things would reduce the likelihood of bowing.

And then two other things that we were reviewing as part of this was the penalties that were applied, both the CHF penalty and the linear heat generation rate penalty. So I do understand I think we're going to be talking about this a little bit more in the closed session, but we reviewed the arguments provided to say that these penalties were justified and the staff agreed with the justification provided and concluded that this methodology was applicable for use for NuScale.

MEMBER SKILLMAN: Chris, let me ask you a question. This is, I agree, a snarky question, but let me ask it. So here NuScale says and AREVA says we've got this really neat shorter fuel assembly and we strapped it down really tightly. We've got these five grids that really prevent bowing that is a problem in the 12-foot assemblies. It sounds good. What skepticism did the staff apply to that feature where one might say, yes, that's great, it's nice and strong, it's a stiffer mechanical design, but here's the downside to that degree of stiffness. My question is what skepticism did you apply for that feature?

MR. VAN WERT: The skepticism is kind of split between the review of this topical report and what you'll see in the 4.2 review. Giving a little bit of a preview, we will be looking especially at the inspection program and making sure that they have the ability to confirm that the expected rod growths, any potential bowing, things like that, that can be examined readily in full-size examinations are captured.

It's one of those things where this one kind of straddles the two reviews. So we recognize the data that they provided looked good for the range that it was provided in, but then the one key parameter that was caught was the mass velocity. It's close but not quite down to that NuScale range. I don't remember if the numbers are props --

MEMBER SKILLMAN: We don't care about numbers right now.

MR. VAN WERT: You know, we don't see any trends indicating that we would expect an uptick, but we recognize that there always could be unexpected -- you know, whenever you extrapolate, we always get nervous. So whenever you go slightly outside the ranges, we like to make sure that that's captured in any sort of inspection program.

MEMBER SKILLMAN: Thank you.

MR. VAN WERT: Okay. So really those were the two main ones I just wanted to highlight, the rod bow and -- what was the -- oh, creep collapse because that one had the change in methodology. Those were the two that received additional attention during the review and, at the conclusion, the staff did find that the topical report was acceptable and that AREVA's system design codes and methods are applicable to NuScale. And as was already mentioned before, we did add a -- I will admit this is a little bit of an odd limitation to have on here since they didn't specifically request anything related to it, but we did put a limitation on here regarding load follow because we knew from the 4.2 review that they were wanting to go that route. So, currently, this is the only limitation in the staff's evaluation.

MEMBER CORRADINI: I guess this is more just how you approach it. I kind of sense hidden limitations and conditions that aren't called out in the SER, such as you still have to be good with the methodology, you still have to make sure downstream with the design. Is that just simply because you're going to re-look at all of this in terms of the actual application of the codes and methods to the design?

MR. VAN WERT: Well, those codes and

methods are referenced, so the limitations and conditions that are on those, the staff SER for COPERNIC and you look at those limitations on that, would still carry over. We didn't repeat all the conditions and limitations.

MEMBER CORRADINI: No, I didn't mean, I didn't mean that. I guess I was, I mean, so the one that I'm still not -- well, we'll take it up in closed session, but there was some relative to what will be done for initial conditions, initialization for the LOCA, what really is the limitation for the burnup. It's kind of like, well, it's not going to be here and it's kind of down here, so we're okay. So there's a wide variation there about what is and isn't okay, so I was looking for something there. I was looking for something about initialization for LOCA, so maybe that's just going to follow up in the analysis of the actual fuel design.

MR. VAN WERT: So initialization for LOCA I'll say is handled within the LOCA topical report. So that's kind of outside of the realm of this topical report and the 4.2 review. What was the other -- oh, burnup. The AREVA limits, 62 gigawatt days peak rod average, still apply here. When we're talking about lower values, those are just the NuScale designs.

MEMBER CORRADINI: Sure, sure.

MR. VAN WERT: So if NuScale, for whatever reason, decided they wanted to, in some future date, move up to a higher value, they wanted to go to 62 gigawatt days, they would be able to go through the normal change process and come in for review and approval, depending on the state of approval. I'm making some suppositions here, but they would be able to come in and request the higher burnup and the codes and methods would still apply up to AREVA limits.

MEMBER CORRADINI: But for now they're limited to whatever they have in their current certification application?

MR. VAN WERT: Correct.

MEMBER CORRADINI: Okay. Thank you.

MR. SCHULTZ: Well, that's all pending the evaluations that will be done in support of operation.

MR. VAN WERT: Correct.

MR. SCHULTZ: With the cycle designs and so forth. With regard to this limitation restricted to base load operation, was there one method that drove that in terms of, say, COPERNIC's application to load follow or --

MR. VAN WERT: So what I was looking for --

MR. SCHULTZ: -- was it just a general sense of the matter?

MR. VAN WERT: I looked at a few of them, but COPERNIC was one that I looked at in particular just because I thought that might be where I'd find it. So in the 4.2 part, when we first came up with this question for them and NuScale responded that they would like to request approval for daily load follow, I wanted to make sure that the codes and methods were applicable, in which case then their answer would be a little bit, the scope of their answer would be less.

When I went and started looking, though, I couldn't find any clear indication within the topical and staff's SER to say that it definitely was applicable. I'm not NRR, so I don't want to say that it is not. I'm just saying that I couldn't find any clear indication. So I was using this as a limitation at this point that NuScale, in referencing this, if they want to use daily load follow, they need to provide that additional justification that not only is their plant okay for daily load follow but their methods used to analyze it also are applicable for that purpose.

MR. SCHULTZ: So they'd have to evaluate these methodologies and make that, help you make that determination.

MR. VAN WERT: Correct. I did see, I will look similar towards AREVA's direction, and they can tell me if we need to go to closed session.

MEMBER CORRADINI: Why don't we just wait?

MR. SCHULTZ: That's fine. I appreciate your answer here. Thank you.

MEMBER CORRADINI: Okay. Any other questions by the members? All right. Let me ask if there's folks in the room, we'll go to public comment before we go to closed session, if there's folks in the room that want to make a comment. And the lines should be open. Is there anybody on the line that wants to make a public comment? Assuming the line is open. Okay.

So hearing nothing, let's close the outside line. Let us go into closed -- no. Do we want to?

MEMBER POWERS: No, we do that at the end of the day.

MEMBER CORRADINI: Well, nobody outside can hear our comments after we go into closed session. So are there any comments by the members at this point before we go into closed session? It's a very quiet bunch today.

So a couple of things, just logistically for the recorder, we're now going to go into the closed portion of the meeting. Can I ask AREVA and NuScale, particularly NuScale, to make sure that anybody here is bonafide to be here and can you make sure that the public line is closed off? And with that, we'll take a break since some of the members are starting to care about that. We'll come back at 10:30.

(Whereupon, the above-entitled matter went off the record at 10:15 a.m.)

NuScale Topical Report

Applicability of AREVA Fuel Methodology for the NuScale Design

TR-0116-20825 Rev. 1

Presentation to the ACRS Subcommittee

Larry Losh

NuScale Power

Manager, Nuclear Fuel

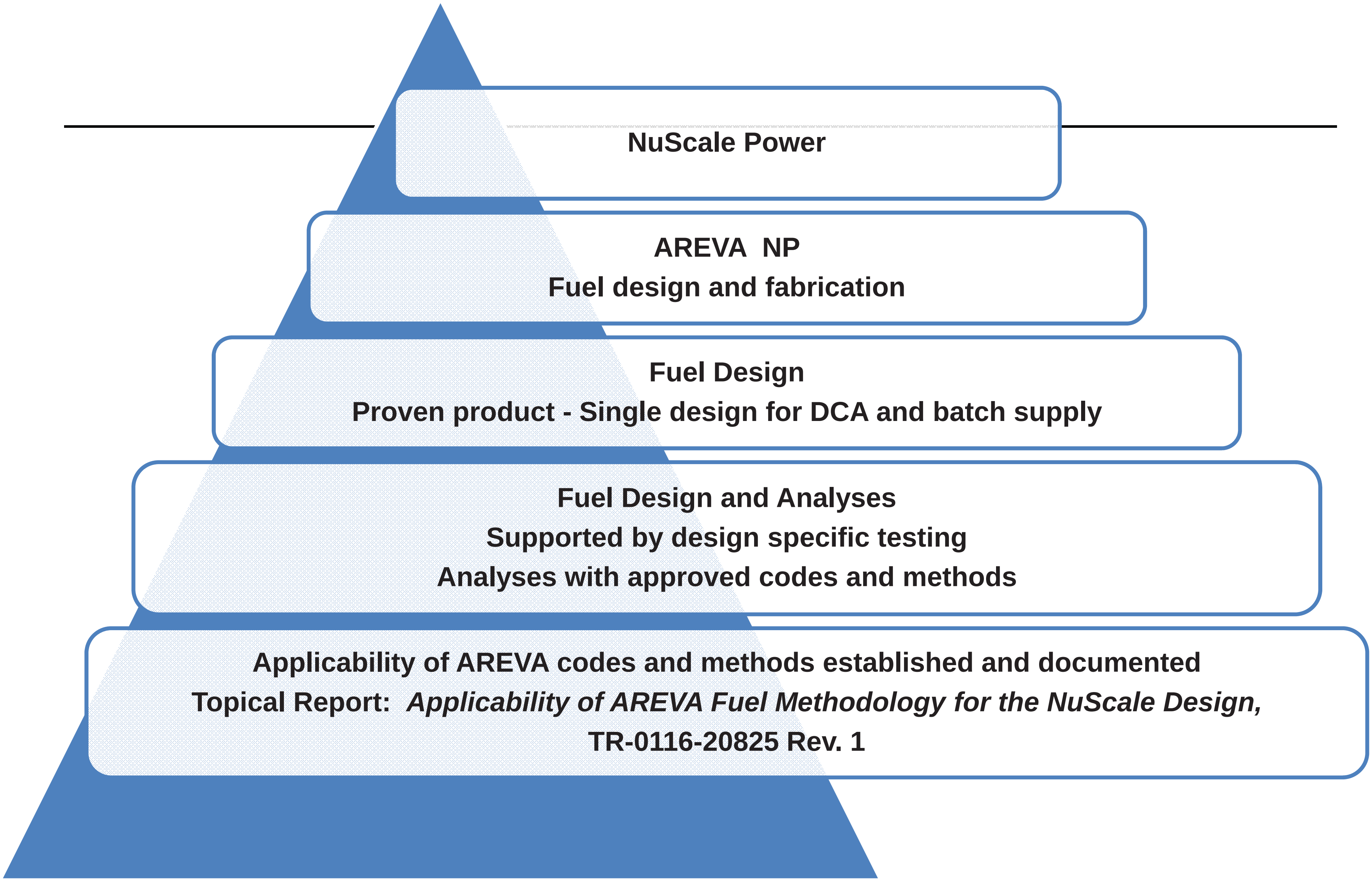
Glen Thomas

AREVA Technical Lead for NuScale Fuel Design Project

September 20, 2017

Agenda

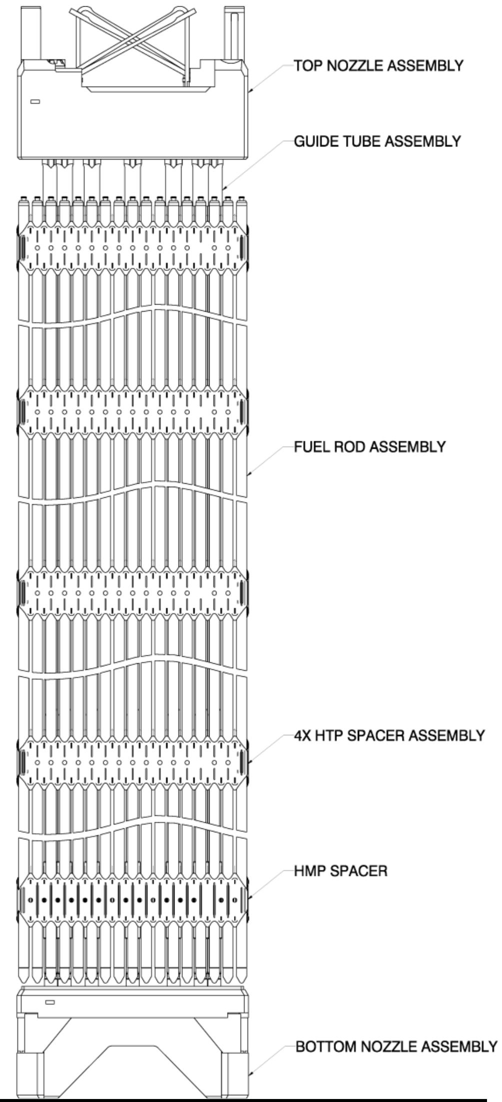
- NuScale Fuel – AREVA relationship
- Fuel Design Features
- Fuel Design and Operating Conditions Comparison
- Approach to Methods Applicability
- NRC approved AREVA Methods Applied to the NuScale Design
- Summary


NuScale Power
AREVA NP
Fuel design and fabrication
Fuel Design
Proven product - Single design for DCA and batch supply
Fuel Design and Analyses
Supported by design specific testing
Analyses with approved codes and methods
Applicability of AREVA codes and methods established and documented
Topical Report: *Applicability of AREVA Fuel Methodology for the NuScale Design,*
TR-0116-20825 Rev. 1

NuScale Fuel Assembly Design

- NuScale design based on AREVA's proven US 17x17 PWR technology
- NuScale design features
  - Zircaloy-4 HTP™ upper and intermediate spacer grids
  - Inconel 718 HMP™ lower spacer grid
  - Mesh filter plate on bottom nozzle
  - Zircaloy-4 MONOBLOC™ guide tubes
  - Quick-disconnect top nozzle
  - Alloy M5® fuel rod cladding

>>Proven features with US Operating Experience



Design Comparison – NuScale vs AREVA 17x17

Parameter	NuScale Fuel Design	AREVA17x17 PWR
Fuel rod array	17 x 17	17 x 17
Fuel rod pitch (inch)	0.496	0.496
Fuel assembly pitch (inch)	8.466	8.466
Fuel assembly height (inch)	94	160
Spacer grid span length (inch)	20.1	20.6
Number of guide tubes per bundle	24	24
Dashpot region ID (inch)	0.397	0.397
Dashpot region OD (inch)	0.482	0.482
ID above transition (inch)	0.450	0.450
OD above transition (inch)	0.482	0.482
Number of fuel rods per bundle	264	264
Cladding OD (inch)	0.374	0.374
Cladding ID (inch)	0.326	0.326
Length of total active fuel stack (inch)	78.74	144
Fuel pellet OD (inch)	0.3195	0.3195
Fuel pellet theoretical density (%)	96	96

Operating Parameter Comparison NuScale vs AREVA 17x17

Parameter	NuScale Design Value	AREVA 17x17 PWR Value
Rated Thermal Power (MWt)	160	3455
System Pressure (psia)	1850	2280
Core Inlet Temperature (F)	503	547
Core Tave (F)	547	584
Average Coolant Velocity (ft/s)	3.1	16
Core Average Re Number	76,000	468,000
Linear Heat Rate (kW/ft)	2.5	5.5
Fuel Assemblies in Core	37	193
Fuel Assembly Loading (KgU)	249	455
Core Loading (KgU)	9,213	87,815
Nominal Cycle Length (EFPD)	694	520
Maximum Fuel Assembly Discharge Burnup (GWd/mtU)	<50	>50

"Applicability of AREVA Fuel Methodology for the NuScale Design" TR-0116-20825 Rev. 1

Addresses applicability of specific AREVA codes and methods:

1. EMF-92-116(P)(A), Revision 0, Generic Mechanical Design Criteria for PWR Fuel Designs
2. BAW-10231P-A, Revision 1, COPERNIC Fuel Rod Design Computer Code
3. BAW-10084P-A, Revision 3, Program to Determine In-Reactor Performance of BWFC Fuel Cladding Creep Collapse
4. BAW-10227P-A, Revision 1, Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel
5. XN-75-32(P)(A), Supplements 1 through 4, Computational Procedure for Evaluating Fuel Rod Bowing

Applicability of AREVA seismic analysis methodology addressed in separate report

– "*NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces,*" TR-0716-50351-P, September 2016

AREVA Methods Applicability

- The applicability of AREVA codes and methods is based on an evaluation of each topical report:
  - Technical applicability to the NuScale fuel design
  - Regulatory limitations per the SER for each topical report
  - TR-0116-20825 Rev. 1 only addresses applicability of methods; results of design-specific analyses are presented in the DCA and the associated technical report
- For each topical report, the technical applicability is based on two factors:
  - Similarity of the NuScale fuel design to AREVA 17x17 PWR fuel designs
  - The bounding nature of the AREVA PWR operating parameters with respect to NuScale operating parameters

Design Comparison – NuScale vs AREVA 17x17

Parameter	NuScale Fuel Design	AREVA17x17 PWR
Fuel rod array	17 x 17	17 x 17
Fuel rod pitch (inch)	0.496	0.496
Fuel assembly pitch (inch)	8.466	8.466
Fuel assembly height (inch)	94	160
Spacer grid span length (inch)	20.1	20.6
Number of guide tubes per bundle	24	24
Dashpot region ID (inch)	0.397	0.397
Dashpot region OD (inch)	0.482	0.482
ID above transition (inch)	0.450	0.450
OD above transition (inch)	0.482	0.482
Number of fuel rods per bundle	264	264
Cladding OD (inch)	0.374	0.374
Cladding ID (inch)	0.326	0.326
Length of total active fuel stack (inch)	78.74	144
Fuel pellet OD (inch)	0.3195	0.3195
Fuel pellet theoretical density (%)	96	96

NuScale fuel design parameters are identical with exception of axial dimensions

Operating Parameter Comparison – NuScale vs AREVA 17x17

Parameter	NuScale Design Value	AREVA 17x17 PWR Value
Rated Thermal Power (MWt)	160	3455
System Pressure (psia)	1850	2280
Core Inlet Temperature (F)	503	547
Core Tave (F)	547	584
Average Coolant Velocity (ft/s)	3.1	16
Core Average Re Number	76,000	468,000
Linear Heat Rate (kW/ft)	2.5	5.5
Fuel Assemblies in Core	37	193
Fuel Assembly Loading (KgU)	249	455
Core Loading (KgU)	9,213	87,815
Nominal Cycle Length (EFPD)	694	520
Maximum Fuel Assembly Discharge Burnup (GWd/mtU)	<50	>50

NuScale operating parameters are generally bounded by AREVA licensing and operating experience

AREVA Methods Addressing SRP Criteria

Analysis using AREVA Methodology	SRP 4.2 Acceptance Criteria	AREVA Topical Report
Shipping And Handling Stress Analysis	1.A.i	EMF-92-116(P)(A)
Fuel Assembly/Component Stress Analysis	1.A.i	
Fretting Wear Assessment	1.A.iii	
Axial Growth (Rod and Assembly)	1.A.v	
Fuel Lift Analysis	1.A.vii	
Internal Hydriding	1.B.i	
Clad Stress Analysis	1.A.i	BAW-10227P-A
Fuel Rod Buckling Analysis	1.A.i	
Clad Fatigue Analysis	1.A.ii	
Clad Corrosion Analysis	1.A.iv	BAW-10231P-A
Fuel Rod Internal Pressure	1.A.vi	
Fuel Centerline Melt Analysis	1.B.iv	
Transient Clad Strain Analysis	1.B.vi	
Clad Creep Collapse Analysis	1.B.ii	BAW-10084P-A BAW-10227P-A
Rod Bow Evaluation	1.A.v	XN-75-32(P)(A)

AREVA applied 5 topical reports to the NuScale fuel design project

EMF-92-116PA Overview

- EMF-92-116PA “Generic Mechanical Design Criteria for PWR Fuel Designs” defines the NRC approved fuel mechanical design criteria (SAFDLs) for AREVA PWR fuel
- EMF-92-116PA has been used to license several PWR fuel designs types in the US:
  - W-type 17x17 and 15x15 fuel
  - CE-type 14x14, 16x16, and 15x15 fuel
- SER approves EMF-92-116PA for PWR licensing applications up to 62 GWd/mtU rod average burnup
  - This limit bounds burnup values from projected NuScale fuel cycle designs

EMF-92-116PA Summary

- The applicable sections of EMF-92-116PA address:
  - Internal hydriding
    - Controls are established for rod internal component hydrogen content
    - Same hydrogen controls and limits will be applied to NuScale fuel
  - Fuel assembly structure normal operation stress analysis
    - Directs use of ASME Code for stress analysis methods and limits
    - ASME Code equations and limits are generic and applicable to NuScale given the similarity of stress conditions to PWR fuel
  - Fretting wear
    - Testing performed to demonstrate fuel fretting resistance
    - Criteria is that fuel rod failures due to fretting shall not occur
    - Fretting tests were performed for prototypic NuScale fuel
  - Fuel rod and fuel assembly axial growth
    - Empirical growth models used to show fuel rod and fuel assembly end-of-life gaps
    - Materials and operating conditions bounded by AREVA US PWR experience

EMF-92-116PA Summary

- Fuel lift analysis
  - Fuel assembly mass and hold-down are to exceed hydraulic lift forces
  - Similarity of fuel design makes method and criteria applicable
- Shipping and handling stress analysis
  - Loads from shipping are compared with ASME allowable limits
  - ASME Code equations and limits are generic and applicable to NuScale given similarity of stress conditions to current PWR fuel

- <u>Conclusion:</u>
  - Based on AREVA's technical evaluation these approved EMF-92-116PA mechanical design criteria and methodologies can be applied to the NuScale fuel design
  - SER contains no restrictions that preclude application to NuScale

BAW-10231PA Overview

- BAW-10231PA, “COPERNIC Fuel Rod Design Computer Code”
  - Predicts the thermal and mechanical behavior of fuel rods under irradiated conditions
    - Rod internal pressure
    - Clad corrosion
    - Transient clad strain
    - Fuel centerline temperature
    - Clad creep collapse initialization data

BAW-10231PA Applications

- The COPERNIC code and its associated methods are currently used in US PWR licensing applications
  - Westinghouse cores fueled with AREVA 17x17 fuel design
  - Babcock and Wilcox cores fueled with AREVA 15x15 fuel design
- Current COPERNIC ranges of applicability (fuel type, cladding material, fuel rod burnup, etc.) bound NuScale design characteristics and operating conditions

BAW-10231PA Summary

- Two points from COPERNIC applicability evaluation:
  - Evaluated lower RCS flow rates from natural circulation and determined that COPERNIC clad-to-coolant heat transfer coefficient predictions were applicable
  - RCS system pressure used as rod internal pressure limit for NuScale application

- <u>Conclusion:</u>
  - Based on AREVA's technical evaluation these approved BAW-10231 criteria and methodologies can be applied to the NuScale fuel design
  - SER contains no restrictions that preclude application to NuScale

BAW-10084PA Overview

- BAW-10084PA, “Program to Determine In-Reactor Performance of BWFC Fuel Cladding Creep Collapse”
  - Documents the AREVA creep collapse methodology to ensure that AREVA fuel rods do not collapse during their design lifetimes
  - BAW-10227PA extends the application of the creep collapse methodology to M5® cladding
- The CROV code and its associated method are currently used in US PWR licensing applications
  - Westinghouse cores fueled with AREVA 17x17 fuel design
  - Babcock and Wilcox cores fueled with AREVA 15x15 fuel design
  - Combustion Engineering cores fueled with AREVA 16x16 fuel design

BAW-10084PA Pertinent Parameters

- Creep ovalization rates and collapse criteria limits are most affected by:

Key Parameter	NuScale Application
Clad temperatures	Within the range of existing CROV applications
Pressure differential across the cladding	Within the range of existing CROV applications
Fast neutron flux	Within the range of existing CROV applications

- NuScale key parameters are within the operating experience of the PWRs currently licensed with BAW-10084PA

BAW-10084PA Summary

- One Method Change
  - AREVA PWR creep collapse analyses utilize fuel performance inputs from an axial elevation of 90 inches - this elevation corresponds to the worst combination of fast neutron flux and cladding temperature in conventional PWRs
  - In contrast, NuScale analysis uses an alternate means to create limiting inputs
- <u>Conclusion:</u>
  - Based on AREVA's technical evaluation BAW-10084 can be applied to the NuScale fuel design
  - SER contains no restrictions that preclude application to NuScale
  - Minor adjustment to the method (limiting axial elevation) is documented in TR-0116-20825 Rev. 1

BAW-10227PA Overview

- BAW-10227PA, “Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel” contains:
  - The analysis methodology used for AREVA M5® fuel rod cladding
  - The M5® fuel rod design limits

- Approved for PWR licensing applications up to 62 GWD/mtU rod average burnup

- BAW-10227PA scope for NuScale is limited to:
  - Fuel rod cladding stress and buckling analyses
  - Fuel rod cladding fatigue analysis

BAW-10227PA Overview

- BAW-10227PA has been used to license various US PWR fuel types
  - Westinghouse cores fueled with AREVA 17x17 fuel design
  - Babcock and Wilcox cores fueled with AREVA 15x15 fuel design

BAW-10227PA Pertinent Parameters

- Fuel rod mechanical analyses (clad stress, fatigue, and buckling) are most influenced by one or more of the following parameters:

Key Parameters	NuScale Application
Cladding material	Identical to existing applications
Cladding radial dimensions	Identical to existing applications
Cladding temperatures	Within the range of existing applications
Pressure differential across cladding	Within the range of existing applications

- NuScale parameters are within the operating experience of the PWRs currently licensed with BAW-10227PA

BAW-10227PA Summary

- Conclusion:
  - Based on AREVA's technical evaluation BAW-10227 can be applied to the NuScale fuel design
  - SER contains no restrictions that preclude application to NuScale

XN-75-32(P)(A) Suppl. 1- 4 Overview

- XN-75-32(P)(A), “Computational Procedure for Evaluating Fuel Rod Bowing,” Supplements 1-4 define the NRC approved procedure for evaluating fuel rod bowing
  - Fuel rod bowing is primarily influenced by
    - Slip load of the intermediate and upper end spacer grids
    - Span length between spacer grids
    - Coolant cross flow forces
    - Core operating conditions
  - Primary Concerns:
    - Reduction in rod-to-rod water gap resulting in decrease in DNBR margin
    - Increase in rod-to-rod water gap resulting in increase in local power peak
  - The rod bow topical report provides a method to predict rod bow and to develop appropriate fuel performance penalties

XN-75-32(P)(A) Suppl. 1- 4 Overview

- XN-75-32(P)(A) Supplements 1- 4 has been used to license most HTP™ PWR fuel designs in the US:
  - W-type 17x17 and 15x15 fuel
  - CE-type 14x14, 16x16, and 15x15 fuel

- The NuScale fuel design is within current experience for core operating parameters and slip load and less limiting for spacer grid span lengths
  - NuScale fuel expected to have lower propensity for fuel rod bowing than the AREVA PWR benchmarked designs
  - Critical Heat Flux penalty method acceptable
  - Linear Heat Rate penalty method acceptable

XN-75-32(P)(A) Suppl. 1- 4 Summary

- Conclusion:
  - Based on AREVA's technical evaluation XN-75-32(P)(A) Supplements 1- 4 can be applied to the NuScale fuel design
  - SER contains no restrictions that preclude application to NuScale

Summary and Conclusion

- Each of the five AREVA topical reports have been demonstrated to apply to NuScale as documented in TR-0116-20825 Rev. 1
  - One stated modification to BAW-10084PA methodology concerning axial elevation of input data

Abbreviations

- ASME – American Society of Mechanical Engineers
- DCA – design certification application
- DNBR – departure from nucleate boiling ratio
- EFPD – effective full power days
- ID – inner diameter
- OD – outer diameter
- PWR – pressurized water reactor
- RCS – reactor coolant system
- SAFDL – specified acceptable fuel design limit
- SER – safety evaluation report
- SRP – standard review plan

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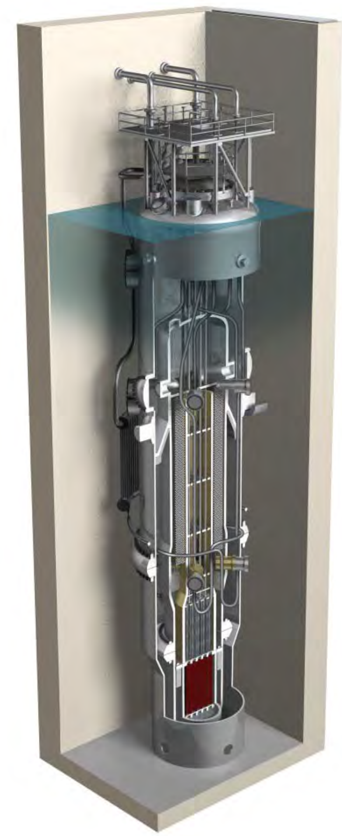

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Presentation to the ACRS Subcommittee

Staff Review of NuScale Topical Report TR-0116-20825-P, Revision 1, "Applicability of AREVA Fuel Methodology for the NuScale Design"

Presenters:

Bruce Bavol - Project Manager, Office of New Reactors

Christopher Van Wert - Senior Reactor Engineer, Office of New Reactors

September 20, 2017

(Open Session)

Staff Review Timeline

- NuScale submitted its topical report (TR) Revision 0, on March 30, 2016
- TR Revision 1 was subsequently sent on July 1, 2016, to incorporate NRC comments
- Staff issued request for additional information (RAI 8727) on February 10, 2017
- NuScale responded to RAI 8727 on March 9, 2017
- Staff issued its safety evaluation report (SER) in July 20, 2017
- Staff plans to brief advisory committee on reactor safeguards (ACRS) full committee in October 5, 2017
- Staff plans to issue its final SER in late October 2017
- Staff plans to publish the "-A" (approved) version of the TR on December 12, 2017

NRC Technical Review Areas/Contributors

- Reactor Systems NRO/DSRA/SRSB:

  Rebecca Karas (BC)

  Jeffrey Schmidt

  Christopher Van Wert

Scope of the Staff Review

The staff's review was limited to the topics presented in topical report TR-0116-20825-P Revision 1 and included the applicability of the following:

- BAW-10084PA, "Program to Determine In-Reactor Performance of BWFC Fuel Cladding Creep Collapse"
- BAW-10227PA, "Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel"
- BAW-10231PA, "COPERNIC Fuel Rod Design Computer Code"
- XN-75-32(P)(A), Supplements 1-4, "Computational Procedure for Evaluating Fuel Rod Bowing"
- EMF-92-116(P)(A), "Generic Mechanical Design Criteria for PWR Fuel Designs"

Scope of the Staff Review (cont)

The staff's review does not cover:

- A technical review of the approved AREVA topical reports
- Any technical analysis of the NuScale plant design based on the AREVA methods
  - NuScale technical report TR-0816-51127-P Revision 1 contains the NuScale fuel system design analysis and is reviewed as part of the DCD Section 4.2 review.

NuScale Fuel Assembly Design Overview

The NuScale fuel assembly design is based on the AREVA 17x17 fuel assembly design and contains many similarities:

- HTP upper and mid grids
- HMP bottom grid
- M5 fuel rod cladding
- Zirc-4 MONOBLOC guide tubes

The differences include:

- Reduced fuel assembly and active fuel stack height
- Reduced grid span height
- Reduced rod internal pressure

Staff Review Approach

The staff reviewed the applicability of each AREVA topical report by:

- Reviewing of the conditions/limitations of the referenced AREVA topical reports
- Comparing of the NuScale system/operational parameters with those used to develop the AREVA methods
- Reviewing any NuScale specific modifications to the AREVA methodology

Staff Technical Review

The staff reviewed the AREVA codes/methods cited in the topical report following the approach presented on the previous slide. Areas that involved additional attention based on the review are detailed below:

- BAW-10084PA (fuel cladding creep collapse)
  - AREVA analysis methodology is performed at a 90 inch elevation based on full-height AREVA fuel designs. NuScale fuel is shorter and required a methodology modification to address the shorter NuScale fuel design.

Staff Technical Review (cont)

- XN-75-32(P)(A) (fuel rod bow)
  - NuScale fuel design has shorter grid span lengths, which reduces the likelihood of bowing
  - The CHF penalty used in the bowing analysis bounds the NuScale fuel assembly design parameters
  - The NuScale parameters important to linear heat generation rate (LHGR) penalties are bounded by the values used in the referenced AREVA topical report to generate the LHGR penalty

Staff SER Conclusions

- The staff concludes that topical report TR-0116-20825 Revision 1 is acceptable and that the cited AREVA fuel system design codes and methods are applicable for use in NuScale fuel system analyses, with the following limitation:
  - Any applicant or licensee referencing this topical report who wishes to operate in modes other than baseload would need to address such operation in their application or license amendment request.

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