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UNITED STATES NUCLEAR REGULATORY COMMISSION'S ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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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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TUESDAY

AUGUST 20, 2019

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B10, 11545 Rockville Pike, at 1:00 p.m., Walter Kirchner and Ronald Ballinger, Co-Chairs, presiding.

COMMITTEE MEMBERS:

WALTER L. KIRCHNER, Co-Chair

RONALD G. BALLINGER, Co-Chair

JOSE MARCH-LEUBA, Member

PETER RICCARDELLA, Member*

ACRS CONSULTANT:

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

MICHAEL SNODDERLY

ALSO PRESENT:

BRUCE BAVOL, NRO
SARAH FIELDS, Public Participant*
NICHOLAS KLYMYSHYN, PNNL
LARRY LINIK, NuScale
BRETT MATTHEWS, Framatome
SCOTT MOORE, Executive Director, ACRS
MATTHEW PRESSON, NuScale
CHRIS VAN WERT, NRO

*Present via telephone

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P R O C E E D I N G S

(12:59 p.m.)

CO-CHAIR KIRCHNER: This meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, NuScale Subcommittee. I'm Walt Kirchner, chairman of the NuScale Subcommittee. I've succeeded Mike Corradini, who you remember fondly, I'm sure.

I want to interrupt myself here and just thank you, NuScale, for hosting our visit last month. That was very informative. So if you would, pass that on to your team.

Member Ron Ballinger will co-chair this meeting with me today. Members in attendance are Jose March-Leuba and our consultant, Stephen Schultz.

Mike Snodderly is the designated federal official for this meeting.

The subcommittee will review the staff's evaluation of NuScale Topical Report TR0716-50351, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces.

Today we have members of the NRC staff and NuScale to brief the subcommittee.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act, FACA. The NRC implements FACA in accordance with its regulations, found in Title 10 of the Code of Federal Regulations, Part 7.

The committee can only speak to its published letter reports. We hold meetings to gather information and perform preparatory work that will support our deliberations at a full committee meeting. The rules for participation in all ACRS were announced in the Federal Register on June 13, 2019.

The ACRS section of the U.S. NRC public website provides our charter, by-laws, agendas, letter reports, and full transcripts of all full and subcommittee meetings, including slides presented there. The meeting notice and agenda for this meeting were posted there.

Portions of this meeting can be closed, as needed, to protect proprietary information pursuant to 5 U.S.C. 552(b)(c)(4).

As stated in the Federal Register notice and in the public meeting notice posted to the website, members of the public who desire to provide written or oral input to the subcommittee may do so and should contact the designated federal official five days prior to the meeting, as practicable. We have also set aside ten minutes for comments from members of the public attending or listening to our meetings. We have not received written comments or requests for time to make oral statements for members of the public regarding today's meeting.

A transcript of the meeting is being kept and will be made available on the ACRS section of the U.S. NRC public website.

We request that participants in this meeting please use the microphones located throughout the meeting room when addressing the subcommittee. Participants should first identify themselves and speak with enough volume and clarity so that they can be readily heard.

A telephone bridge line has been established for the public to listen to the meeting. To minimize disturbances, the public line will be kept in a listen-in-only mode. To avoid further disturbance, I request that attendees put their electronic devices, like cell phones, in the off or noise-free mode.

We will now proceed with the meeting and I'll call on Matthew Presson of NuScale to begin today's presentations.

And before I ask you to start, Matthew, we also have Pete Riccardella, the chairman of the full committee on the line. And do we have any other members present?

Hearing none, okay, Matthew, can I ask you also to introduce those participants who are on the call-in lines from NuScale and Framatome as well?

MR. PRESSON: Yes.

CO-CHAIR KIRCHNER: Thank you.

MR. PRESSON: I can definitely do that. Thank you, Walt, and good afternoon.

I am Matthew Presson, the licensing project manager for the NuScale AREVA Fuel Seismic Applicability Topical Report. This report covers the applicability of Framatome's methods for fuel located in a NuScale power module and compares those against the approved ANP-10337 Topical Report.

Next slide. Our presenters for today are Larry Linik with NuScale Fuels Engineering and Brett Matthews, the Framatome technical lead for the NuScale Fuel Design Project. We also have listeners with NuScale out in Corvallis and I believe some of the Framatome participants as well.

CO-CHAIR KIRCHNER: Okay, if they join in, then we will ask them to identify themselves.

Okay, thank you.

MR. PRESSON: But the bulk of the presentation will be provided by Brett.

CO-CHAIR KIRCHNER: Excellent, thank you. Proceed.

MR. PRESSON: Yes, next slide. And here, we will pass it over to Brett.

MR. MATTHEWS: Okay. Thank you, Matthew. So to start the presentation, I will review the agenda, what I'm going to go over. And the first thing we'll get to is --

CO-CHAIR KIRCHNER: Brett, can you pull that microphone just closer to you?

MR. MATTHEWS: Sure. Sure, is that better? Okay.

So I'll start with an overview of ANP-10337. So this is Framatome's topical defining the methodology for our evaluation of the fuel response in response to external excitations, external loads, such as seismic LOCA events.

This was the subject. I want to remind everyone this was a subject of an ACRS meeting I think about a year and a half back, March 2018, if I'm not mistaken. So we'll start with that overview and refresh some of the content that we went over in that last meeting. Specifically, I will address the scope of the generic applicability of that topical and then move into a design overview of the NuScale fuel design. The trade name here that we will be using in the presentation IS NuFuel-HTP2. This design overview will highlight some of the key differences between the NuScale fuel design and an existing 17 by 17 PWR fuel design.

With those differences in mind, we'll talk about the process to assess the applicability to NuScale, and then I will jump to the relevant points from that applicability review and discuss what we're doing in response to those items, and then I'll wrap up with some conclusions.

So next slide, please. So to start with the overview of NAP-10337, the fundamental focus of this methodology is the evaluation of the fuel safety functionality in response to or during and post-earthquake and pipe breaks. So unfortunately, we've got a PDF here, so we're not seeing the animation that I built in but I did have this cartoon, which is just a nice visual for us to kind of center our discussion around. There are some things that we can reflect back on to this simple cartoon as we get into the presentation.

What I'm showing here is actually a

representation of a 7-fuel assembly row from the NuScale reactor and the simulation, if we were able to run it, would actually be the animation from an actual simulation that we performed for the NuScale certification.

So some things to point out. First of all, I guess on this screen, they are showing up as kind of a maroon, kind of smaller maroon rectangles. You'll see that each fuel assembly in that row has three of those. Those are representing the intermediate spacer grids on the fuel. And in animation, you'll see these things sway back and forth and start to interact with each other.

These spacer grids -- the spacer grid, of course, is a key component in the fuel assembly design. One of its many functions is to transmit the interactions between fuel assemblies and between the fuel assembly and the baffle or the heavy reflector.

So all interaction -- the fuel assembly is designed for all interactions to occur at those spacer grid locations and that's a key component in this methodology because we really want to focus in on the magnitude of those impact loads and the ability of that component to withstand those impact loads. So that's the first thing that we look at.

The other thing that you would see, if you can imagine the animation here, in response to the seismic motion, you'll see the fuel assemblies begin to kind of sway back and forth. And the deflection shapes that those fuel assemblies take on is another important piece that we extract from this analysis.

So in response to that motion, because a seismic event is a relatively low frequency event, at least relative to the natural frequencies of the fuel assembly, you primarily see a response from the fuel in the first mode. So you would see this C-shaped bow kind of swaying back and forth and, eventually or periodically, there may be interaction between the fuel assemblies. And at those points of interactions, you can have kind of a brief higher mode response from the fuel assembly, as the fuel assembly kind of rings in response to that.

CO-CHAIR BALLINGER: Correct if I'm swaying or straying into proprietary but -- and I meant to reconfirm this before the meeting, but the distance between the spacer grids in this design, how close are they to the distance between spacer grids in the standard PWR AREVA design?

MR. MATTHEWS: I believe that spacing is very similar, if not the same.

CO-CHAIR BALLINGER: I thought it was very similar.

MR. MATTHEWS: Okay, yes. Yes.

CO-CHAIR BALLINGER: Yes, okay. Thanks.

MR. MATTHEWS: So in summary, what this evaluation, at least the lateral portion of this, we -- the big outcome of this -- these simulations that we perform and the evaluation that we do is to evaluate the impact loads at those grid locations and then, also, look at the stresses in the fuel assembly components as a result of those deflections.

Advance to slide 5, please. Back one, slide 5.

Okay, I want to review the regulatory criteria, the regulatory framework for this methodology. So very briefly, the kind of structure that we are operating within, there are a few sections to -- from 10 CFR Part 50 that we should reference; there's Appendix A, which of course gives us the generic design criteria that we have to satisfy; Appendix S, which addresses design for earthquakes, safe-shutdown to earthquakes; and then Part 50.46, which gives us the requirements that we have to satisfy for pipe breaks and LOCA events.

The relevant regulatory guidance that is in play here is the Standard Review Plan, Chapter 4.2, specifically Appendix A. That addresses the necessary guidance for the evaluation of external loads for fuel assembly response in response to external loads.

All of this regulatory framework, though, for what we do basically boils down to three main items that we are trying to check in this evaluation. Number one is that we want to ensure that we maintain a coolable geometry for the fuel assembly, as it's interacting with its neighboring fuel assemblies.

We want to make sure that we maintain control rod insertability so the control rod or the guide tubes in the fuel assembly maintain an insertable path.

And number three is maintaining fuel rod integrity. And this is both the coolability issue, we want to avoid fuel line fragmentation that could create flow blockage, but we also want to protect the structural integrity of that cladding to maintain that barrier to fissile material.

So page 6, please. So continuing on with our overview, this -- a big part of this methodology is actually simulating this dynamic event, simulating the fuel response to these external loads, and we do this by inputting time history inputs at the core boundaries. These are applied as the source of excitation. So the core boundaries that we're talking about in this case would be the upper and lower core plate between which the fuel is sandwiched in-between. So the motion there is going to excite the fuel. And also in the lateral model, the motion of the baffle plates or the reflector, that movement can change interaction with the fuel as well.

These time history inputs, this is really a -- I say time history in quotes here but we're really talking about the core motion history, as it marches through time. That's what we input to this model. Those inputs are derived from upstream models of the reactor vessel internals. So you have to realize that this analysis that we're doing on the fuel, it's at the end of the line of a long stream of analyses that is performed in evaluating the overall plant response to a seismic event, starting with the definition of the ground motion, the definition of the soil structure interaction, and how that propagates to the building. Eventually, this propagates down to the center of the core and we're the last -- we're the last analysis in that long line of events.

The other thing I want to share here, I've got two schematics, a lateral schematic and a vertical schematic of the models that we use. A couple of points I want to make here and our methodology, what's defined in 10337, we separate out and we analyze separately the response of the fuel in the three independent directions. So X, Y, and Z are all analyzed separately and then combined at the end for a 3D combination of the fuel response.

But here, you can see a simple lateral schematic and vertical schematic. But the other thing I wanted to drive home with this graphic is that when you pull the skin away and you look at the skeleton underneath those models, it's a fairly simply structural representation of the fuel. We're using basic elements, beam elements, springs, dampers, and gap elements to build these models.

So moving ahead to slide 7, so kind of building on that thought that the fuel is represented using simple and generic structural models, the models themselves are, like I said, at a very high level. They are simple generic models. What's really important in this methodology is how we define the model parameters that we use to perform those simulations.

And the sources for defining these model parameters comes from one of three places. Most parameters in the model are based directly on information that we would pull from design documents like engineering drawings, specifications. So these are parameters like geometry, the OD and inner diameter of the tubes, fuel rod cladding, guide tubes; material properties like Young's modulus or the yield strength, these are parameters that we can read directly off of a drawing or a material spec and feed directly into the model. That's where most of the parameters come from.

There are some model parameters that we can't read directly from a design document but these are based specifically or they are based directly on design-specific characterization testing. So an example here would be like the stiffness of the assembly, of the completed assembly, the lateral stiffness, or the frequency of that assembly. That's not something that is going to jump out at you from a design document. But we can build a prototype of the assembly. We can test it and we can interrogate it to get that information.

I will note ANP-10337 defines a full characterization protocol to get these parameters to feed the models. That full characterization protocol has been applied to NuScale. And I will make a note here that NRC was able to observe some of that in an audit and actually observed part of that NuScale testing.

The third source of parameters are parameters accounting for fluid effects, specifically three fluid effects: added mass, the coupling mass effect, and fluid damping. These three parameters are unique in that they are defined independent of the design in ANP-10337. And so I am foreshadowing a little bit but this is something we are going to talk about. Because they are defined independent of design, that's something that we are going to have to address in the applicability and I will get to that in future slides.

But largely, the modeling is really largely transparent to the fuel design. That's one of the key takeaways from this is that it's really a fairly simple -- what's at the core of this method is a fairly simple and generic representation of the fuel.

CO-CHAIR BALLINGER: Okay. I've got probably a dumb question but you said that this analysis is at the end point of an overall seismic analysis.

Now in a standard PWR, the vessel is on a concrete pedestal and it's tied directly to the base mat and everything to the plant. In this case, it's not true, right? Because now the vessel is sitting on the bottom of the pool and the ground motion is transmitted to the pool structure itself. And so you're saying that difference between a standard PWR, which is more like hard-wired to the structure and this analysis has been accounted for in developing the input spectrum, which might involve some tilt, some moments and stuff like that, because the vessel is sitting on the bottom of the pool.

MR. LINIK: Yes, that's correct.

CO-CHAIR BALLINGER: Okay.

MR. LINIK: It starts out with the building seismic and they send the boundary conditions from that to the supports of the module. Then they do the module analysis, which gives us the core plate time histories.

And so it's not resting on the base mat. It's supported by corbels up, what, about two-thirds of the way, halfway up?

CO-CHAIR BALLINGER: Yes.

MR. LINIK: And the bottom of the module is constrained in the X-Y direction.

CO-CHAIR BALLINGER: Yes, but was there

any difference between the resulting spectrum to the fuel between what you had to do and a standard PWR?

MR. LINIK: I'll leave that to Brett.

MR. MATTHEWS: I would say in my experience the spectra are a little unique. So the process for how we go from the soil motion to the core, the transfer of functions that are involved there are unique for NuScale and that results in a unique spectrum from what we would typically see in a PWR.

CO-CHAIR KIRCHNER: But not market.

MR. LINIK: Not significantly different. Actually, when we get to the closed session, I've got an example of a spectra that I can share with you.

CO-CHAIR KIRCHNER: Okay.

MEMBER MARCH-LEUBA: Yes but so the question, of course, is the staff's Safety Evaluation Report is approving this methodology. And then if you decide to build NuScale in Hawaii, you have a different response than California. Right? And you have to redo that part of the analysis. You need to make an example for a particular location, right?

MR. LINIK: Yes, that's correct.

Okay.

MR. MATTHEWS: Slide 8. We're ready to

move on.

So a comment about, since we're going to talk about applicabilities in NuScale, I'll take a moment here to talk about the original applicability of the topical and how that was defined.

The Topical ANP-10337 was really created with the intention of being generically applicable to PWR designs. Really the reason why we felt confident in doing that, there are a couple of things to point out, relatively simple concepts. One is that PWR fuel designs share the same basic construction. That's allowing the same general type of representation. So we don't care if -- we don't care about the differences between -- I should say we don't have specific models for 14 by 14 versus a 17 by 17. We do care about the differences and those get translated into the model. But at the end of the day, the representation is the same, regardless of the details of the structure.

The other thing is that the PWR operating environments, they are all very similar, very similar pressures, temperatures, flow rates. When we look at the fleet of PWR reactors out there, there's not a wide range of difference.

One criterion, however, is noted for

applicability in this base method and that has to do with how we represent the impact behavior of the spacer grids. So if you recall back to that graphic, the spacer grids are the main points of contact. So modeling the nuance of how that impact load gets transferred from one fuel assembly to another can sometimes get kind of tricky, particularly when we start to talk about the deformation behavior of the spacer grid. There are going to be some nonlinearities that make their way into that problem.

So --

MEMBER MARCH-LEUBA: What is special with the NuFuel-HTP2 versus a 17 by 17? The same spacers, same lattice?

MR. MATTHEWS: That is correct. It's actually -- so we'll talk about that in an upcoming slide. I think it's one of the next slides. But the spacer grid that is being used for NuScale is actually identical to -- actually, I have it on this slide here, that NuScale uses the exact same spacer grid that is demonstrated in the base topical.

So we'll talk about limitations and conditions regarding spacer grid modeling and this note regarding applicability but we're not doing, in that regard in how we model the impact behavior between fuel assemblies, we're not doing anything different for the NuScale application. And we can do that because we haven't changed the hardware. It's the exact same component.

MEMBER MARCH-LEUBA: Does the model account for the formation of the grids if they actually impact?

MR. MATTHEWS: It does account for some. That's a detail that we can discuss later but there is some accounting of deformation in there.

CO-CHAIR KIRCHNER: This may be something for a close session but what about the difference with your -- I'll try not to go too far -- with your baffle arrangement versus that of a conventional PWR? Because you have a -- I'm trying not to stray into what might be proprietary. You have your reflector, your heavy stainless steel reflector surrounding the core versus baffle plates and a dead water zone in a PWR.

So are there any significant tolerance or other differences there in the mechanical design for the NuScale core versus being the longer, taller core of a PWR?

MR. MATTHEWS: So with respect to how we model those boundaries, there is no difference between what we're doing for NuScale and what we do for a 10337 or the base topical. That is conservatively modeled to be a rigid structure that doesn't have any compliance. So in the way that we model it, we would conservatively model it the same for NuScale or an existing PWR.

CO-CHAIR KIRCHNER: Okay, so Framatome would model it as a rigid boundary condition for a conventional PWR and you are doing the same here for the NuScale core.

MR. MATTHEWS: That is correct.

CO-CHAIR KIRCHNER: Thank you.

MR. MATTHEWS: So the last point here, there are limitations with regards to applicability. There are limitations and conditions that were imposed through the SER. I'm actually going to go through those on the next slide. We'll walk through those.

Slide 9, please. So RAI 9555 requested that these L&Cs be addressed in applicability to NuScale. So I'm paraphrasing these but I'll walk through them very briefly.

The first L&C has to do with a demonstration of critical grid behavior from dynamic impact testing. So as I mentioned on the previous slide, we're using the using the same exact hardware for the spacer grid. The behavior has not changed from the base topical. So that is satisfied with the use of the same hardware.

The same thing for item number two. Item 2 deals with limits on maximum allowable spacer grid deformation. Again, we're not changing the hardware. We're not changing the limits in the application for NuScale.

Number 3 deals with or defines controls and quality requirements on the engineering software that we use to implement this methodology. Again, there's no change for NuScale. We're using the same engineering software that was certified with the base topical.

MR. SCHULTZ: So a software associated with the overall evaluation was not required to be changed in order to implement the NuScale design and the evaluation?

MR. MATTHEWS: No, the hard -- or the software itself, no.

MR. SCHULTZ: All right.

MR. MATTHEWS: There are detail parameters that we'll talk about where we're going to make some adjustments but the software itself remains the same.

MR. SCHULTZ: Okay, thank you.

MR. MATTHEWS: Uh-huh.

So number 4, in the previous slide we talked about our vision for generic applicability of this and the NRC, when they reviewed the topical, they caught this and said yes, we can accept that for the operating fleet because the operating fleet that's out there now is fairly well-defined but, looking forward to tomorrow's reactor, we don't know that it's going to fall in that same category.

So there's L&C number 4 that limits the use of this method to applications consistent with the operating fleet that was in place at the time that this was approved. And this comes into play. This is something that obviously raises a question for the NuScale application, which we're talking about now.

L&C number 5 limits applicability of the lateral damping values to existing fuel designs. You'll recall in a previous slide I mentioned that there are three parameters in the methodology associated with fluid effects. Damping is one those that is defined in the base topical independent of the fuel design. And again, kind of the same thought that you're comfortable with extending that to generic use based on existing fuel designs and the existing fleet that's out there but L&C number 5 limits that applicability to be reviewed for future designs.

So again, this is something we're going to come back and address for NuScale.

So number 4 and 5, in particular, are the two L&Cs that I want to pull out here and we can reflect on later on when we get into the applicability.

Number 6 requires a fuel rod stress assessment under faulty conditions, which we do for NuScale.

Number 7 requires the use of the most limiting stress criteria when bounding analyses are performed for rodded and non-rodded locations. Basically, this says that we're going to verify control rod insertability for those rodded locations, which we do for NuScale.

Number 8 specifies that a 3D combination of load should be considered for non-grid components, which we do. We recombine the X, Y, and Z components to derive a 3D stress state, accounting for all of the deformation and impact loads in those directions.

And number 9is another spacer grid modeling limitation. It's a limitation on the applicability of the spacer grid impact modeling which, again, much like we said for numbers 1 and 2, we're meeting that because we haven't changed the hardware. We're using the same modeling, same hardware as we use in the base topical.

All right, slide 10, please. So now I'd like to shift gears and talk about what is unique in the NuScale design. Again, the trade name here, NuFuel-HTP2. So the NuFuel-HTP2 design is based on Framatome's existing and proven U.S. 17 by 17 PWR technology. It's a design that we have a lot of operating experience behind.

And when you look at the graphic on the right, it doesn't show up too clearly on this screen, but one thing that I will note is that if you were to be able to cut a cross-section of this assembly at any location from the filter plate up to the top of the hold-down spring, you're not going to be able to distinguish this from Framatome's existing 17 by 17 PWR technology. The 2D design is exactly the same. So the dimensions, the spacer grid features, everything is exactly the same as the 17 by 17.

Obviously, where we're different is in the axial layout. This design is a little more than half the length of a standard or existing 17 by 17 design. As a result of that, there are fewer spacer grids on this design. You can see in this figure there are five spacer grids in the fuel design. There are four Zircaloy-4 HTP grids, one at the top most location and then three intermediate locations. And then there is an Inconel 718 lower spacer grid.

Now, I want to pause here and talk about something in the modeling that we use in this methodology. I don't know if you caught this but in the cartoon that I showed on that first slide, you only saw three spacer grids present. There are five grids in the design. We only model three.

Those end grids, the upper most and the lower most end grid in this methodology, because of their proximity to the top nozzle and the bottom nozzle, they get rolled into that boundary, that fixed boundary condition. In reality, these spacer grids, the way they end up getting modeled in our methodology, there is a rotational degree of freedom with some stiffness there at those spacer grid locations. In reality, those end grids are so close to the ends that there's not -- they're really not contributing a lot to the dynamic response of the fuel assembly.

MEMBER MARCH-LEUBA: How tightly are they rolled so touch to the upper and lower plates? I mean are they allowed to slide up and down on this stretch?

MR. MATTHEWS: There is some sliding that can occur between the fuel rods and the spacer grids.

MEMBER MARCH-LEUBA: It can and it does over the cycle.

MR. MATTHEWS: Yes.

MEMBER MARCH-LEUBA: I mean they almost are --

MR. MATTHEWS: And it can change. It will evolve over the cycle. That is true.

MEMBER MARCH-LEUBA: So but that's a tight -- it's more as a perfect coupling. There is no rattle, no --

MR. MATTHEWS: That's correct. It's more complicated than a tight -- yes, a tight coupling.

MEMBER MARCH-LEUBA: And this might be sharpening the pencil too much but does the temperature differences make a difference? Because NuScale fuel runs a lot colder than Westinghouse but the clad is hotter --

MR. MATTHEWS: Yes.

MEMBER MARCH-LEUBA: -- because of the low heat transfer coefficient.

MR. MATTHEWS: Yes.

MEMBER MARCH-LEUBA: So you have a hot M5 and cold UO2. Does it make a difference?

MR. MATTHEWS: Those temperature differences do factor into our modeling when we're setting material properties.

So we do account for those differences in temperature directly.

MEMBER MARCH-LEUBA: Okay, thank you.

MR. SCHULTZ: Brett, you said that those grids are close to the top and bottom nozzles. How close, roughly? It looks like an inch.

MR. MATTHEWS: So I don't have the exact number. Yes, and you're in the right order of magnitude. I think the bottom spacer it's a little more than an inch.

MR. SCHULTZ: Yes, right.

MR. MATTHEWS: And at the top to allow for shoulder gaff, you've probably got two or three inches between that top grid and the top nozzle.

MR. SCHULTZ: And analytical demonstrations of them have shown that -- your statement, they're unaffected. They unaffect the overall response.

MR. MATTHEWS: That is correct, yes.

MR. SCHULTZ: It's been demonstrated by NuScale and by NRC as well.

MR. MATTHEWS: That is correct. And I've

got some -- I'll probably address this again in the closed session. I've got some more details as to what we did to show that.

MR. SCHULTZ: Good. Thank you.

MR. MATTHEWS: Okay. So I think we can move on to slide 11.

So continuing on with the comparison, this is a table just comparing some key parameters between the NuFuel-HTP2 design and the existing Framatome 17 by 17 design. It's a very boring table because, when you go down through the columns, there is not a lot of difference. Like I said on the previous slide, if you were to take a cross-sectional slice through this, you're not going to be able to tell one from the other.

Where you do see differences in this table or in the axial layout. So the overall fuel assembly height, obviously, the NuFuel design, 94 inches versus roughly 160 inches for the existing design. There is a little bit of a difference in the grid span link. So existing 17 by 17 product has a span length of 20.6. We're just a couple of percent off of that for NuScale at 20.1, however, it is within the range of grid span lengths that we evaluated and designed for in other designs.

And that grid span length is fed directly into the model as well. The spacing between the grids is modeled directly.

And then obviously, with the reduction in height of the fuel assembly, the total active fuel stack is different as well.

But what I've highlighted here that I really want to carry forward and talk about applicability is the big difference here, which is the reduction in height. And as we saw on the previous slide, too, reduction in the number of spacer grids.

Moving ahead to slide 12, so when we look at the operating environment for the fuel, we see more differences here than what we see in terms of the fuel that's operating in that environment. I will say most of these parameters, are inconsequential. They don't enter into the simulation that we're performing. So for things like thermal power, that doesn't really make its way into the representation of the fuel in terms of its dynamic response.

We talked about the temperatures. And you can see here that the NuScale, the core temperature is a little bit lower than the operating environment for an existing 17 by 17. That does get directly represented in the model.

The big thing that jumps out at us, though, the big thing that we need to carry forward and talk about is the change in the coolant velocity in the core. NuScale being a natural circulation plant, much lower flow rates, 3.1 feet per second versus 16 feet per second and, correspondingly, the Reynolds number shows that difference as well.

Okay, so slide 13 --

CO-CHAIR BALLINGER: The linear heat rate, that's average, right?

MR. MATTHEWS: Can we go back one slide?

CO-CHAIR BALLINGER: It can't be peak.

MR. LINIK: It's average.

CO-CHAIR BALLINGER: It's average.

MR. MATTHEWS: Yes, that is average.

CO-CHAIR BALLINGER: Thank you.

MR. MATTHEWS: So let me say a few words about the process to assess applicability of this topical to NuScale. So we started the process with a review of the regulatory criteria for NuScale Fuel Design. And this -- we're operating within the same framework as the base topical, as existing PWRs, so, 10 CFR 50 Appendix A, Appendix S, 10 CFR 50.46. The same regulatory guidance applies. So we're working in the same design space here.

The second step is to do what we just did, which is a comparison of the parameters that are important to the seismic LOCA response of the fuel. Like I said, we just went through that exercise. The big thing that jumps out at us that we need to address applicability is the difference in fuel assembly link. What does that mean for the continued validity and application of the modeling that we define in 10337? And along with that, the reduction in the number of spacer grids, since we are reducing the number of rotational degrees of freedom that we have in that model. And then, finally, the coolant flow. It's a different -- slightly different environment from what we're currently operating in.

So with those differences in mind, we take those forward into a detailed review of ANP-10337, including the L&Cs, applying this filter of the differences that we have between the two fuel designs. And I have a note here that we literally structured the applicability topical around this process. It's literally structured around a chapter-by-chapter review of ANP-10337.

So for this presentation, I'm not going to go through that chapter-by-chapter review but I will jump ahead on slide 14 and jump to the three main points that we addressed in this review. So issue number one, the big question that we have to answer or that we do answer in this applicability topical is: Does the model architecture and characterization testing protocol from ANP-10337 adequately represent the NuScale fuel design with its shorter length and fewer spacer grids? And the answer that we arrive at is yes, we can continue to do that and no modifications are needed.

In short, again, we will get into the details -- more details in the closed session but in short, we are able to show that we're still able to accurately capture the dynamic characterization of the fuel, as shown in the testing. We're still able to reproduce that in these models, at least for the content that is important for what we're trying to simulate.

So issue number 2 is that ANP-10337P-A establishes lateral fuel assembly damping parameters. The cooling flow rate is typical for existing PWRs. Are these values valid in the NuScale design? No, they're not.

We end up deriving NuScale-specific damping values for this application that do not credit the presence of flowing coolant. And what that does for the definition of these design -- or the definition of these parameters, it results in a lower damping value, which is generally more conservative. It's going to reflect less energy dissipation due to this mechanism and generally going to lead to more energy reflected in the impact loads between fuel assemblies.

Issue number 3, RAI 9225 questions the need for evaluation of the fuel during refueling, specifically, while it is stored in the reactor flange tool. When we look at this evaluation, we arrived at the conclusion that we needed an explicit analysis to look at the fuel response when it's in this condition. So we add that analysis. It is above and beyond what is defined in or implied with the use of ANP-10337 and we discuss the continued applicability of ANP-10337 for that condition as well.

MEMBER MARCH-LEUBA: So specifically an adjusted driving force or there is any chance -- is just a driving force on the flanges or does that change the input.

MR. MATTHEWS: So it is a different driving force from what is in the ANP because there is a separate analysis --

MEMBER MARCH-LEUBA: Different --

MR. MATTHEWS: -- propagating that motion through this tool. So, it is a unique set of input.

MEMBER MARCH-LEUBA: So you don't consider an empty, partially-loaded fuel and then it could move a lot more maybe?

MR. LINIK: No. In the closed session, we'll have a graphic that displays how the fuel is captured while it's in the RFT. We can discuss it then.

MEMBER MARCH-LEUBA: Okay.

MR. MATTHEWS: Okay. So that brings me to my conclusions.

So ANP-10337 defines a methodology that is applicable to NuScale with two modifications. The first is that we define a NuScale-specific damping value, instead of using the blanket value from ANP-10337. And we add an additional seismic evaluation in which the core is residing in the reactor flange tool, above and beyond what is implied with the ANP-10377.

CO-CHAIR KIRCHNER: Brett, does that -- is that -- does that conclude your presentation?

MR. MATTHEWS: That concludes my --

CO-CHAIR KIRCHNER: Okay.

MR. SCHULTZ: Brett, just to revisit that last conclusion point, the first one of them, the damping values, you mentioned on the previous slide that that pertains to the differences in load characteristics.

MR. MATTHEWS: Right.

MR. SCHULTZ: I thought there was also other testing that was done or other evaluation that was done, mechanical testing evaluations, to get those values, demonstrate those values for the NuScale fuel.

MR. MATTHEWS: That is correct.

MR. SCHULTZ: Okay.

MR. MATTHEWS: There is additional -- and I can shed more like on that in the closed session.

MR. SCHULTZ: Right. But I just wanted to get in this session that that testing and evaluation has been done.

MR. MATTHEWS: Yes, that is correct.

MR. SCHULTZ: Okay, thank you.

MEMBER MARCH-LEUBA: This might show my ignorance. Do you do any spent fuel evaluation, fuel located in the spent fuel pool?

MR. LINIK: That's not done in the fuels group analysis. The dose group analysis does analyze the fuel in the spent fuel pool.

MEMBER MARCH-LEUBA: For seismic?

MR. LINIK: I believe so, yes.

MEMBER MARCH-LEUBA: And they use a different tool?

MR. LINIK: I'm not familiar with that. I haven't been part of that review.

MEMBER MARCH-LEUBA: It would make sense to use the same tool but we'll ask the staff. Maybe they know.

CO-CHAIR BALLINGER: This may be another fine point for the closed session but the issue of irradiation effects on the grids, the difference between unirradiated and irradiated is the spring relaxation that occurs in the grids. And so has that spring relaxation itself been factored into the seismic analysis?

MR. MATTHEWS: Yes.

CO-CHAIR BALLINGER: Okay, so you've gotten that fine. Good. Thank you.

CO-CHAIR KIRCHNER: Brett, what about the dimensional clearance between the outer rows, the fuel assemblies, and the baffle or, in your case, that would be then the reflector? Is that nominally the same? Because it would seem to me that would factor into any transfer of loads laterally and/or damping calculations.

MR. MATTHEWS: So is your question is it

the same as existing --

CO-CHAIR BALLINGER: Yes, PWRs.

MR. MATTHEWS: Like we mentioned earlier, I think those gap dimensions are very similar. I don't have them off the top of my head but I believe it's very similar to existing plants.

MR. LINIK: I don't know the number off the top of my head either, but I would assume it's probably different but not drastically so.

CO-CHAIR KIRCHNER: Okay. And you treat then, that outer boundary condition as a rigid wall, essentially, for any load transfer.

MR. LINIK: That is correct.

CO-CHAIR KIRCHNER: Any further questions?

Okay, with that, then -- yes, Pete, have you --

MR. SNODDERLY: He has been un-muted and I haven't seen an IM from him.

CO-CHAIR KIRCHNER: This is Pete Riccardella.

MR. SNODDERLY: Yes, Pete, so you're unmuted and I haven't seen an IM from you. So Walt is asking if you have any questions. I don't hear him.

CO-CHAIR KIRCHNER: Okay. Well, he can catch up with us after the staff.

So with that, thank you very much and we'll change out, take a -- not a break but just a pause for a moment here and ask the staff to come forward, please.

(Pause.)

CO-CHAIR KIRCHNER: Bruce, if you're ready, please introduce yourself and your team.

MR. BAVOL: Okay. Good afternoon. My name is Bruce Bavol. I am a project manager for the NuScale design for the NRC. This is the portion where the staff is going to be presenting their review of TR-0716-50351, Revision 0.

Next slide, please. The NRC Technical Review Team consists of Becky Karas, Branch Chief of the Reactor Systems Branch. She is not here today. To my left, Chris Van Wert was the primary reviewer for this topical report and with the assistance of Pacific Northwest Laboratories' Nicholas Klymyshyn.

Next slide, please. The staff review time line, I provided a couple of bullets here, the first bullet being the reference to the advanced copy of the safety evaluation for this particular topical report. I also provided the -A reference for the ANP-10337P-A.

The staff plans to brief the Advisory Committee, full committee, on September 5th and issue its final SER, if everything goes well, late October 2019, and then plans to publish the -A approved version early in 2020.

MEMBER MARCH-LEUBA: We can sort of get our plans to finish the whole NuScale SER in December 2019.

MR. BAVOL: Yes.

MEMBER MARCH-LEUBA: You want to publish this afterwards?

MR. BAVOL: Well we figure with once the Advisory Committee final full committee is complete, that is just an administrative process for the safety evaluation, where NuScale has an opportunity to combine all the documents into a final --

MEMBER MARCH-LEUBA: So there is no issue with timing there?

MR. BAVOL: There is no issue with timing.

MEMBER MARCH-LEUBA: Thank you.

MR. BAVOL: You're welcome.

Next slide, please. And with that, I'll turn it over to Chris, where he'll go over the scope of the staff review.

MR. VAN WERT: All right. Well, thank you very much and good afternoon.

A lot of what you hear here is going to be very similar to what you just heard but I wanted to sort out by just kind of giving you an idea of the scope of the staff's review and show you what's included and what's not included within the review.

So what is included? The evaluation includes the comparison of the NuScale design versus the reference methodology, the ANP-10337 that you heard about earlier. So we're looking at fuel design changes. We're also looking at comparison of the conditions limitations on the underlying methodology in comparison with the NuScale design.

We also looked at some modifications that were made to the reference methodology. What this review does not include is the underlying methodology itself but, also, the analysis based on this methodology. That will be covered in the technical report associated with Chapter 4 and you should be hearing about that in October or -- Chapter 4 -- soon. Within a couple months.

So the actual analysis with the results is covered in the Chapter 4 review. Next slide.

So you already heard about it, so I'll try to breeze through this a little bit quickly. But the generic methodology covers things such as radiation effects. It defines acceptance criteria. It talks about horizontal and vertical dynamic loading. And it looks at the evaluation of grid impact forces against the allowable limits, amongst a few others there.

It also is demonstrating compliance with GDC 2 and Appendix S. It does follow -- is consistent with the guidance provided in SRP Section 4.2, Appendix A. And it has nine conditions limitations which are imposed on it in the staff's SE associated with the approved version of the topical report.

Next slide. So, again, high level. The NuFuel fuel design versus the standard Framatome 17 by 17 HTP design is very, very similar. They are all -- they're both using M5 fuel pins, Zirc-4 guide tubes, HTP grids, HMP bottom grid. The two main differences are length and then also the number of grids.

As you already saw, the grid span is slightly different. I think the numbers were shown so, at least I can say them, 206 versus 20.1 grid span difference. Since it is slightly shorter, it goes to the NuScale fuel assembly a little bit stiffer design.

Next slide. So there are a couple of modifications, some of them being pretty obvious. The first one is dealing with the shorter length and the reduced number of grids. Because of that, the model which is presented in the methodology topical report had to be modified to represent NuScale. We looked at that and determined that it was representative of the NuScale fuel design and it was also consistent with development of the model that is in the underlying methodology. Therefore, the staff was fine with that.

We already discussed axial coolant flow damping and that the --

CO-CHAIR KIRCHNER: Chris, can I interrupt here?

MR. BAVOL: Yes, please.

CO-CHAIR KIRCHNER: I want to reflect back on Steve Shultz's question. So basically when you say the model was modified, you're talking about the input deck that goes into the methodology but the actual source code is not modified for the change in length.

MR. VAN WERT: Correct.

CO-CHAIR KIRCHNER: Do you see what I'm saying?

MR. VAN WERT: Yes, kind of --

CO-CHAIR KIRCHNER: So the methodology is generic enough --

MR. VAN WERT: Correct. Correct.

CO-CHAIR KIRCHNER: -- that you just change input deck, essentially.

MR. VAN WERT: But if you look at the

methodology, it does supply graphs of the models. If you look at ANP-10337, you'll see and you can count the number of grids. If you look at the NuScale one, it obviously has fewer grids.

But you are correct.

CO-CHAIR KIRCHNER: All right.

MR. VAN WERT: It's the inputs in the models there.

CO-CHAIR KIRCHNER: Thank you.

MR. VAN WERT: Uh-huh.

And talk a little bit about axial coolant flow. Again, NuScale has a much lower flow rate. And so that's conservatively just ignored for them. But they do specific testing on the new fuel, fuel design, as far as the pluck tests and whatnot that are described in the methodology. They do those specific to the NuScale fuel assembly design and get damping values specific to them.

The staff reviewed that and audited the testing and finds it acceptable.

Next slide. And the last one to discuss is regarding the mode shapes and how they are used.

If you look at the underlying methodology, it says that you must evaluate and characterize the first five mode shapes for the fuel assembly. But then it also states that it only uses the first three within the model.

It was pointed out that for the NuScale fuel assembly, it was just a little bit stiffer. The way the testing would be performed, it was harder to actually measure and characterize the higher mode shapes. However, they could get the first three, which are important for the modeling. Those are the only three that were required by the methodology.

It was also noted that with the shift, due to the stiffness and you compare to, which you'll probably see in the closed session, if you compare it to the amplitude of the different frequencies, it pushed it in a region for modes 4 and 5 in an area that's less important.

Staff -- well, PNNL in the confirmatory, I can't take credit for it but PNNL confirmatory analyses confirmed which modes were important for this analysis. Therefore, the staff was fine with it.

MEMBER MARCH-LEUBA: You said a moment ago that on the original LTR or SER, only three modes are required, not five, but they choose to --

MR. VAN WERT: For the modeling, it's three. For the characterization, it requires -- I don't know if it requires or not but it says to look at five.

MEMBER MARCH-LEUBA: Just curious. Where the computing power has improved from a factor ten or a hundred since the previous SER was issued, why not go with five and don't have to think about it?

MR. VAN WERT: Well, if you look at the importance of them, usually it's the first and third there that have any impact on the results.

MEMBER MARCH-LEUBA: Why not do all five? I mean I just --

MR. KLYMYSHYN: It's more of a testing.

MEMBER MARCH-LEUBA: Put your green light on.

MR. KLYMYSHYN: Yes. Hi, it's more of a testing issue that trying to characterize it with fifth mode might have been impossible or difficult to do or impossible.

MEMBER MARCH-LEUBA: Oh, you mean it's not analytical but --

MR. KLYMYSHYN: It's not an analytical issue. It's a mechanical testing issue.

MEMBER MARCH-LEUBA: Oh.

MR. KLYMYSHYN: The model is a finite element model made of beams and beam elements, and springs, and dampers, and that sort of thing. So the model has the capacity to behave in the fifth mode if it actually occurs.

MEMBER MARCH-LEUBA: So in the computer, you overstate the fifth mode.

MR. KLYMYSHYN: Correct, yes.

MEMBER MARCH-LEUBA: If you were, then it soft.

MR. KLYMYSHYN: Yes.

MEMBER MARCH-LEUBA: It was only experimental. You just can't flex it that way.

MR. KLYMYSHYN: Yes.

MEMBER MARCH-LEUBA: Only makes sense. Make sure it won't do it there.

MR. KLYMYSHYN: Right.

MR. VAN WERT: Next slide. So then here we've -- similar to what Brett just presented, we kind of went one-by-one down through the nine limits -- limitations and conditions. And the staff you know evaluated the disposition provided by NuScale.

So several of these refer to grid behavior and you will get a similar disposition out of it in that it's the same grids. So the first one and the second one are both related to it, either grid behavior or the deformation applicability limits. And for both of those, it's the same grid and so it is applicable.

For the third one, it's related to the code that is used for the analysis. And NuScale uses the same version of CASAC as the underlying methodology. So, therefore, that condition is met.

Number four is related to that it is kind of limited to the current fleet. And that was more or less the purpose of the applicability topical report, to address any of the differences and explain why it's okay. So we reviewed their information. We also had confirmatory -- independent confirmatory analyses and we determined that it was acceptable.

We already talked a little bit about damping. Again, they've provided NuScale-specific tests and results. We reviewed that and we're fine with that. And they also conservatively ignored any flow damping credit.

MEMBER MARCH-LEUBA: Okay, so --

MR. VAN WERT: Yes.

MEMBER MARCH-LEUBA: -- which is it? You make the flow zero or you measure damping and use it?

MR. VAN WERT: What was that?

MEMBER MARCH-LEUBA: I have two things. That you ignore the flow effect on damping --

MR. VAN WERT: Correct.

MEMBER MARCH-LEUBA: -- make it zero. And then I hear something that they used NuScale-specific damping.

MR. VAN WERT: Yes. So there's a couple of different dampings. There's flow damping, which is a credit that you can take but there's also damping that you know you can think of damping in air. If you pluck it in air or if you pluck it in water, you get difference results.

So they do testing --

MEMBER MARCH-LEUBA: So they take credit for the static water --

MR. VAN WERT: Yes.

MEMBER MARCH-LEUBA: -- damping but not for the flowing water.

MR. VAN WERT: Correct. Anything you want to add to that or is that --

MR. KLYMYSHYN: I think that's it. You got it.

MR. VAN WERT: Okay, we can go to the next slide.

So number 6 is related to fuel rod evaluation and NuScale provides the evaluation, as requested. Control rod locations, they used the control rod location stress limits and, therefore, that meets this limit as well.

3D loads, a lot of the limitations, I should say, in our disposition are related to how they implement it, which is kind of tied to the technical report associated with Chapter 4 but we had both of the documents in hand. So, we're seeing how they are addressing it. So we are able to say that they meet these conditions limitations, even though that review is ongoing. I just want to be clear with that.

As far as the grid deformation model, again, it's the same grid and the limit is not exceeded.

Do you have questions on these? Okay. Go on to the next one, then.

So in conclusions -- or in summary, we did conclude that, after evaluating the differences, that the NuScale fuel assembly meets the conditions limitations associated with referenced methodology and also that the modifications that were made are appropriate for the NuScale fuel design.

And in summary, then, the staff finds that the AREVA or Framatome methodology is acceptable for use for NuScale, given the modifications as outlined in their topical report.

Any questions?

CO-CHAIR KIRCHNER: Thank you, Chris.

MR. VAN WERT: Thank you very much.

CO-CHAIR KIRCHNER: Ron, any questions, further questions now?

CO-CHAIR BALLINGER: I'll wait until the proprietary --

CO-CHAIR KIRCHNER: Okay.

CO-CHAIR BALLINGER: I'll wait until the proprietary session.

CO-CHAIR KIRCHNER: Very good. Jose?

MEMBER MARCH-LEUBA: No, I have no further questions.

CO-CHAIR KIRCHNER: Is Pete still there? You can't tell? While we're waiting, Steve.

PARTICIPANT: Peter, are you still there?

MEMBER RICCARDELLA: I am here but I --

MEMBER MARCH-LEUBA: Everybody turn your green lights off.

MEMBER RICCARDELLA: Can everybody hear me?

PARTICIPANT: Yes, now we can.

MEMBER RICCARDELLA: Okay, I've been on for both presentations. There's an echo. Okay?

I'm on. I've been listening to both presentations and I have no comments. And I will dial in for the closed portion of the meeting. I have the slides.

CO-CHAIR KIRCHNER: Thank you, Pete.

Steve.

MR. SCHULTZ: Yes, here, Chris, I just wanted to understand. The evaluations that were done by the staff in terms of confirmatory analyses, was that particularly focused on the limitation number 4 or were there other areas that you would consider? It seemed in the safety evaluation there were two or three different places where you talked about either confirmatory analyses or audits that were performed by the staff that NuScale had done.

MR. VAN WERT: So we did perform them for a couple different reasons. One of them we didn't present in here but it was alluded to in Brett's presentation, in that the RFT location we did have one specific confirmatory run that we had Nick do for that.

But in general, we always -- not always but we often do confirmatory runs to help just inform our RAIs. Do you want to talk a little bit more about like --

MR. KLYMYSHYN: Sure.

MR. VAN WERT: -- about the number and how you did them?

MR. KLYMYSHYN: So Framatome uses the CASAC code. It's a proprietary in-house bionomic code. And PNNL, we used LS-DYNA, a general purpose finite element code.

We essentially recreated their CASAC model in LS-DYNA and ran a few cases just to make sure that we got the same similar kind of results. And when we see that in review, it helps deal with a lot of questions or concerns just having PNNL do it, do our own version of it. And when they line up very well, that gives us a good feeling about how the other pieces of the review are going.

So it kind of had a general purpose analysis. We looked at the horizontal models and the vertical model, and did a comparison to what Framatome came up with, and we agreed fairly well.

MR. SCHULTZ: In the closed, there's going to be some more detailed results presented. And when we look at that, perhaps you can chime in as to what your relative comparisons demonstrated there.

MR. VAN WERT: Okay.

MR. SCHULTZ: In other words, to give us a better feel when you say close is close enough --

MR. VAN WERT: Yes.

MEMBER SKILLMAN: -- what that really means when we look at their detailed -- some of their detailed calculations, not each and every one.

I appreciate that. Thank you.

MR. VAN WERT: Yes, and we'll talk about it more later but, again, for I guess because we're in open session, so people hear, we don't have slides presenting our confirmatory runs against theirs for the closed session here, since that's really tied more to the tech report associated with Chapter 4, but we are able to talk to it.

MR. SCHULTZ: Good. That's what I was looking for. I wasn't looking for the detailed comparisons but I also wanted to appreciate, if you will, who did what. And we'll talk to NuScale and AREVA about who did what there, too.

Thank you, sir.

MR. VAN WERT: Thank you.

MR. BAVOL: And real quick, this is Bruce. I just wanted to mention that Chapter 4, Chris had mentioned it just a moment ago, is due to the members mid-November, tentatively scheduled now for Phase 4 in November.

MEMBER MARCH-LEUBA: That will be the final Chapter 4, right?

MR. BAVOL: That will be the Phase 4 -- well, okay, yes. And the one we're going to have the subsequent subcommittee --

MEMBER MARCH-LEUBA: I just came back from vacation. We're still doing Phase 3, right?

MR. SNODDERLY: No, so we just completed Phase -- this is Mike Snodderly --

MEMBER MARCH-LEUBA: Oh, Phase 4.

MR. SNODDERLY: We just completed Phase 3. And we're just piloting now our Phase 4.5 review with Chapter 17 and Matt Sunseri. And we'll discuss that at the September full committee meeting.

But for Chapter 4, it will come in in November. It will be given to Ron Ballinger. Ron will review it and make a recommendation to the committee about what, if any follow-up items that will be briefed during one of the issue-specific meetings that we plan to conduct in the April/May/June time frame.

MEMBER MARCH-LEUBA: And we still have plans to do a cross-chapter review by methodologies instead of chapter-by-chapter, correct?

MR. SNODDERLY: Correct, that's the plan.

CO-CHAIR BALLINGER: I have a question that I -- it just came up to my mind. Maybe it's a closed session question. But whenever I hear somebody say we ran the same model that they ran and we got very similar results, I am immediately suspicious.

And so the question that I have is: How much uncertainty is there? Is there pretty much good overlap in the uncertainty? In other words, if you deviate a little bit, does something weird happen so that we have a fortuitous, if you want to look at it that way, connection there that everything is fine, when we don't really have a good connection?

MR. KLYMYSHYN: I'd say that in addition to just trying to replicate their results, we also did some limited sensitivity studies, changing damping values to see how significant they were because the damping is different in this case. And what we came up with, it's very -- it doesn't have a lot of consequence.

CO-CHAIR KIRCHNER: Actually, I can read the words. I don't think these are proprietary. The results are not unusually sensitive to the choice of the damping value from the SER.

CO-CHAIR BALLINGER: Yes, but we're talking about the applicability of the method, as opposed to the results, right? So that was my question related to -- so you were able to compare your sensitivity results from Framatome's sensitivity results?

MR. KLYMYSHYN: I think it just compared to their final results.

CO-CHAIR BALLINGER: Okay.

MR. VAN WERT: And I think Brett can probably speak to it a little bit more but, if you go back to the underlying methodology, they covered their entire PWR fleet. And so you can see a little bit how sensitive or insensitive different parameters are, based on the differences between the different plants. NuScale is just one more step along that path.

And I will point to Brett to answer that later.

CO-CHAIR BALLINGER: So you're interpolating and you're not extrapolating.

MR. VAN WERT: Well I imagine, especially for NuScale, their flow rate is going to be outside the bounds of the operating fleet. The stiffness will be more still than the others but that works in their favor a little bit.

I'm trying to think of any other important parameters, as far as whether or not its interpolated.

Temperatures within general parameters, the grid is identical.

CO-CHAIR BALLINGER: Okay.

MR. VAN WERT: I think for the most part -- you know I would say the stiffer assembly due to the shortness and then also the flow rates are outside of the normal bounds but they handled the -- the stiffness gives it a little bit conservative. And then the lack of use of flow damping conservatively takes care of that issue.

CO-CHAIR BALLINGER: Now one last question, at least for me. With respect to now allowing -- not accounting for flow, that's a conservative assumption. Do you know how much of a conservative assumption that actually is?

MR. VAN WERT: It's not much.

CO-CHAIR BALLINGER: That's what I -- I didn't think it was going to be a heck of a lot.

MR. VAN WERT: When you're looking at three point -- no, no, it's not much. But instead of them trying take credit for it and us trying to figure out how certain do they know the values, they just --

CO-CHAIR BALLINGER: But it would be more significant for a standard PWR or something like that.

MR. VAN WERT: Yes, if there was a reactor coolant pump, it would be significant.

MR. SCHULTZ: And Nicholas, you said that the confirmatory analysis you did was not CASAC. It was a different method that was employed.

MR. KLYMYSHYN: Yes. Yes, we used the commercial finite element software LS-DYNA.

MR. SCHULTZ: Thank you.

MEMBER MARCH-LEUBA: And speaking -- some of this becomes important when uncertainties start to pop up. And there may not be such a thing as a typical safe-shutdown earthquake but for a typical safe-shutdown earthquake, how much margin do you have to limit? I mean are we this close to limiting in which there are certain indicators or are we that close to limiting? Or we can wait until --

MR. VAN WERT: Since that gets towards numbers, that might be a better one for closed session and that would give me time to look at the report.

MEMBER MARCH-LEUBA: But in their position, you can see a lot or very little.

MR. KLYMYSHYN: There was a lot of margin.

MEMBER MARCH-LEUBA: That's a good answer.

MR. KLYMYSHYN: Okay.

MEMBER MARCH-LEUBA: But if you have so much margin, then the uncertainty is -- don't really make any sense.

CO-CHAIR KIRCHNER: Okay, let us turn to

public comment.

Let me look in the audience. Anyone from the public wish to make a comment? Seeing no one present wishing to make a comment, we are going to connect the bridge line.

MR. SNODDERLY: Is there anyone from the public on the bridge line?

MS. FIELDS: Yes.

MR. SNODDERLY: Hello. Is that Sarah Fields?

MS. FIELDS: Yes, it is.

MR. SNODDERLY: Okay. Does anyone on the bridge line want to make a comment?

MS. FIELDS: Yes, I do. This is more a generic comment on the whole retail application in NRC and ACRS review process.

The design certification is built for a cross-unit reactor that would produce 50 megawatts of energy per unit, for a total of 600 megawatts energy. However, from statements made by NuScale and the Utah Associated Municipal Power System, or UAMPS, which is the entity that is expected to submit, so a new application using the NuScale. The intent is to manufacture, construct, and operate a reactor with a 20 percent power uprate. Rather, it would be 60 megawatts of energy per unit, for a total of 720.

I don't know how this 20 percent power uprate will -- would affect this current design and how it would affect NRC staff and ACRS' review of that design. But the clear intent is to have that 20 percent power uprate by the time that manufacturing and construction, and operation.

NuScale and UAMPS have not been forthright with respect to how they would obtain a 20 percent power uprate, whether it would be to a NuScale application for certification, amended application, or whether it would be part of the COL application. My understanding is the NRC has never approved a 20 percent power uprate at the initial COL stage.

But I just wanted to put that out there because I'm concerned at the lack of forthrightness on the part of NuScale and UAMPS as to how they would obtain that power uprate and the fact that they strictly, in a number of public statements, state that it will be a 720-megawatt energy reactor.

Thank you.

CO-CHAIR KIRCHNER: Thank you for your comment.

Bruce? All right, this is Bruce Bavol from the NRO.

MR. BAVOL: Hi, Ms. Fields, this is Bruce Bavol, project manager for the NRC. I'd like to direct you to the public website. On September 25th, there's going to be a public meeting scheduled that will go over future plans for the increased power for this design. So that might be a good starting place for your question.

CO-CHAIR KIRCHNER: Bruce, one more time, the date for that public hearing?

MR. BAVOL: That was September 25th of this year.

CO-CHAIR KIRCHNER: September 25th. And that would be here at the NRC.

MR. BAVOL: That's correct. It will be a bridge line public meeting.

CO-CHAIR KIRCHNER: Thank you.

MS. FIELDS: And are there going to be any public meetings in Utah?

MR. BAVOL: The public meeting bridge line is really a kickoff for NuScale and the NRC to discuss this power increase that you're talking about.

And everybody is welcome to join in. That bridge line information is available on the NRC website.

MS. FIELDS: Thank you.

MR. BAVOL: You're welcome.

CO-CHAIR KIRCHNER: Thank you for your comment.

Any further comments from the public?

Hearing none, we will close the bridge line and we will go to a closed session.

So we are going to take a break at this point. And we have a new clock. We would like everyone back at 2:30.

(Whereupon, the above-entitled matter went off the record at 2:15 p.m.)

LO-0819-66641

August 15, 2019

Docket No. PROJ0769

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

SUBJECT: NuScale Power, LLC Submittal of Presentation Materials Titled "ACRS NuScale Subcommittee Presentation: NuScale Topical Report, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces," PM-0819-66620, Revision 0

The purpose of this submittal is to provide presentation materials to the NRC for use during the upcoming Advisory Committee on reactor Safeguards (ACRS) NuScale Subcommittee Meeting open session on August 20, 2019. The materials support NuScale's presentation of Topical Report, "NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces."

The enclosure to this letter is the non proprietary version of the presentation titled "ACRS NuScale SubCommittee Presentation: NuScale Topical Report, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces," PM-0819-66620, Revision 0.

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

If you have any questions, please contact Matthew Presson at 541-452-7531 or at mpresson@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
NuScale Power, LLC

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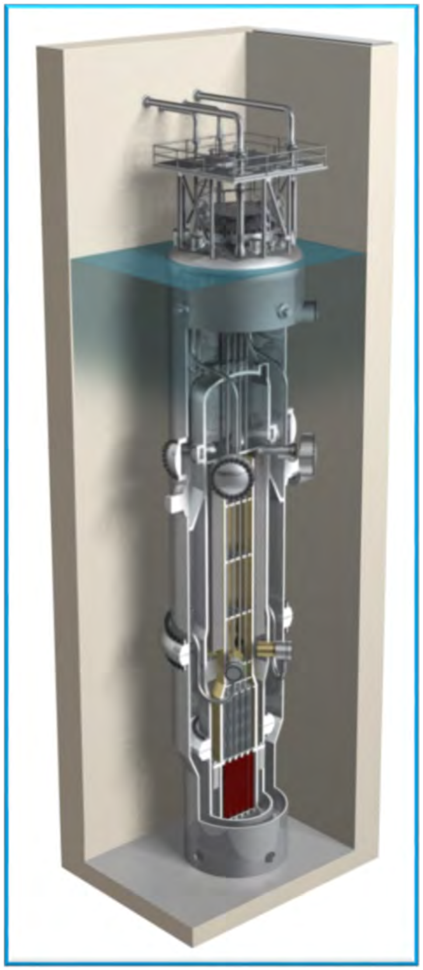
Enclosure: "ACRS NuScale Subcommittee Presentation: NuScale Topical Report, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces," PM-0819-66620, Revision 0

Enclosure:

"ACRS NuScale Subcommittee Presentation: NuScale Topical Report, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces," PM-0819-66620, Revision 0

ACRS Subcommittee Presentation



NuScale Topical Report

NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces

OPEN SESSION

August 20, 2019

PM-0819-66620
Revision: 0

Template #: 0000-21727-F01 R5

Presenters

Larry Linik
Fuels Engineer

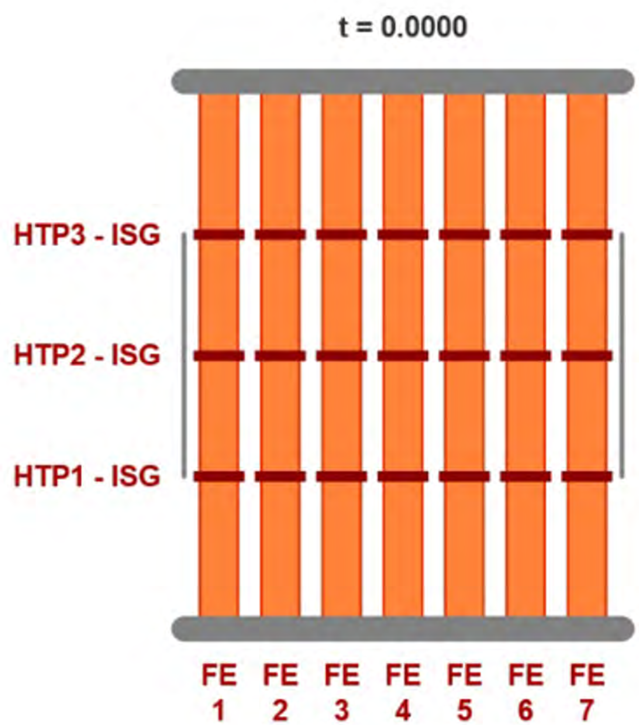
Brett Matthews
Framatome Technical Lead for
NuScale Fuel Design Project

Agenda

- Overview of ANP-10337PA
- Scope of Generic Applicability of ANP-10337PA
- NuFuel-HTP2™ Design Overview
- Process to Assess Applicability to NuScale
- Relevant Points from NuScale Applicability Review
- Conclusions

Overview of ANP-10337PA

- Fundamental Focus: Evaluation of fuel safety functions during earthquakes and pipe breaks.



Note: Deflections from this simulation were amplified for this animation.

- Simulations evaluate impact loads at grid locations and stresses in fuel assembly components.

Overview of ANP-10337PA

Regulatory Criteria and Guidance

Regulatory Criteria (10 CFR)
- 10 CFR Part 50, Appendix A
- 10 CFR Part 50, Appendix S
- 10 CFR Part 50.46

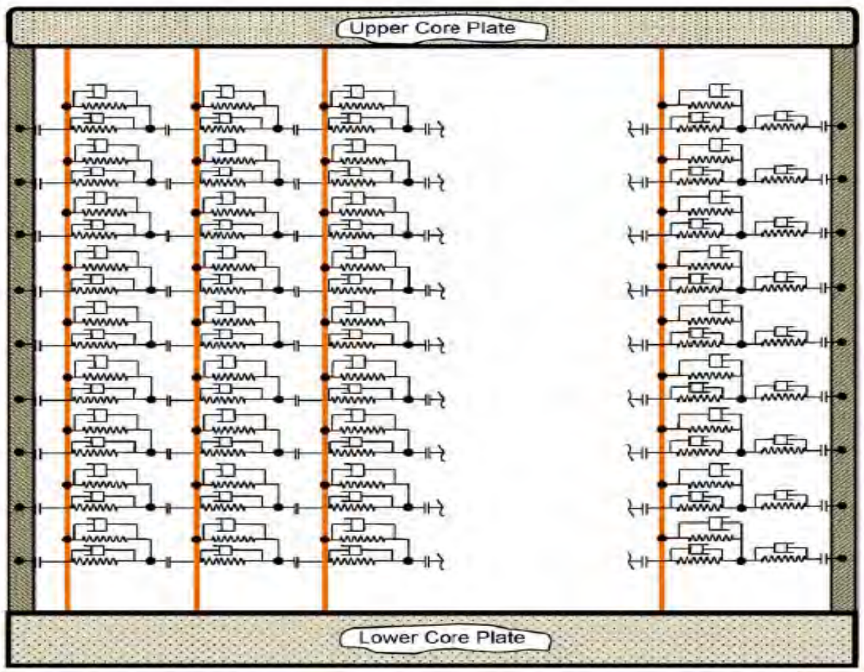
Regulatory Guidance
- SRP 4.2, Appendix A

1) **Coolable Geometry**
2) **Control Rod Insertability**
3) **Fuel Rod Integrity**

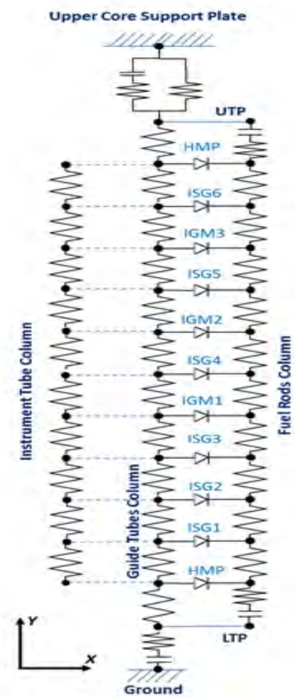
Overview of ANP-10337PA

- "Time History" inputs at the core boundaries are applied as sources of excitation
  - Derived from upstream models of reactor vessel internals

Lateral Schematic



Vertical Schematic



Overview of ANP-10337PA

- Fuel is represented using simple and generic structural models.
- Model parameters definition:
  - Most parameters are based directly on information from design documents (geometry, material properties, etc.)
  - Some model parameters are based on design-specific characterization testing
    - The full ANP-10337PA characterization protocol has been applied to NuScale
    - An NRC audit was performed during part of the NuScale testing
  - Parameters accounting for fluid effects (added mass, coupling mass, and fluid damping) are defined independent of design

Modeling is Largely Transparent to Fuel Designs

Overview of ANP-10337PA

Original Applicability

- Intended to be generically applicable to PWR designs
  - PWR fuel designs share the same basic construction, thus allowing a simple, generic, structural representation
  - PWR operating environments are all very similar
- One criteria is noted for applicability
  - Verification of modeling assumption to represent the impact behavior of spacer grids
    - NuScale uses the exact same spacer grid demonstrated in the ANP-10337PA sample problem
- Limitations & Conditions were imposed through the SER and these will be reviewed later

Requests for Additional Information

- RAI 9555 requests that L&Cs from ANP-10337PA be addressed
- The SER for ANP-10337PA imposes nine L&Cs:

  #1: Demonstration of critical grid behavior from dynamic impact testing.

  #2: Limits on maximum allowable spacer grid deformation.

  #3: Defines controls and quality requirements on engineering software used to implement ANP-10337PA.

  #4: Limits use to applications consistent with operating fleet.

  #5: Limits applicability of lateral damping values to existing fuel designs.

  #6: Requires a fuel rod stress assessment under faulted conditions.

  #7: Requires the use of most limiting stress criteria when bounding analyses are performed for rodded and non-rodded core locations.

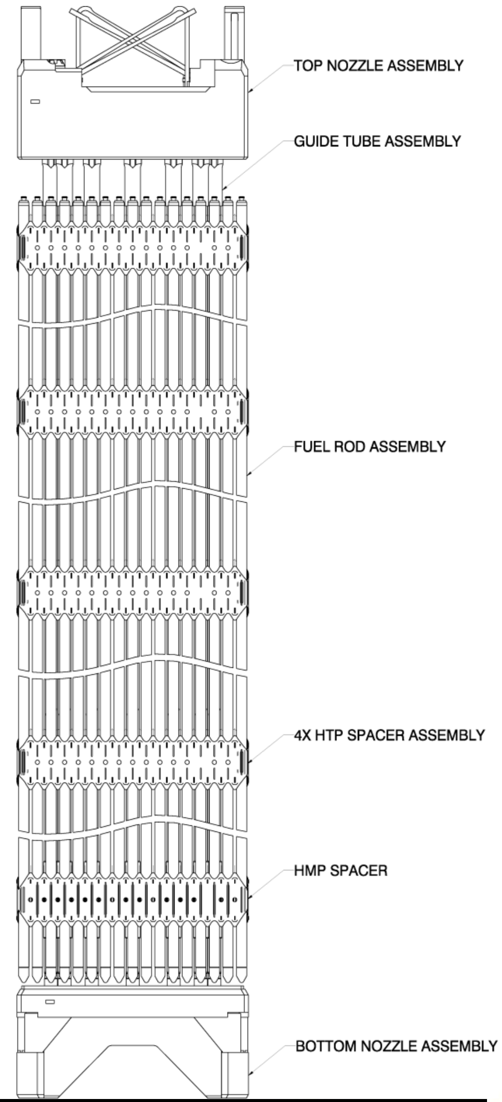
  #8: Specifies that a 3-D combination of loads should be considered for non-grid components.

  #9: Limitation in applicability of spacer grid impact modeling.

NuFuel-HTP2™ Design Overview

- NuFuel-HTP2™ based on Framatome's proven US 17x17 PWR technology
- NuFuel-HTP2™ design features
  - Four 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
NuFuel-HTP2™ vs Framatome 17x17

Parameter	NuFuel-HTP2™ Fuel Design	Framatome 17x17 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 Framatome 17x17

Parameter	NuScale Design Value	Framatome 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

Process to Assess Applicability

1) Review regulatory criteria for NuScale fuel design
   – Same framework as ANP-10337PA

2) Comparison of parameters that are important to seismic/LOCA response (NuScale vs. Existing PWRs)
   – Fuel Assembly Length
   – Number of spacer grids
   – Coolant flow

3) Detailed review of ANP-10337PA content, including SER L&Cs, with consideration to differences

*The applicability topical is structured around a chapter-by-chapter review of ANP-10337PA

Relevant Points from the Review

Issue #1: Does the model architecture and characterization testing protocol from ANP-10337PA adequately represent the NuScale fuel design with shorter length and fewer spacer grids?

"Yes. No modifications are needed."

Issue #2: ANP-10337PA establishes lateral fuel assembly damping parameters that credit flow rates typical for existing PWRs. Are these values valid in the NuScale design?

"No. NuScale-specific damping values are derived."

Issue #3: RAI 9225 questions the need for evaluation of the fuel during refueling, specifically, while it is stored in the Reactor Flange Tool (RFT).

"An analysis is performed for the RFT using ANP-10337PA."

Conclusions

ANP-10337PA defines a methodology that is applicable to NuScale with the following modifications:

- Fuel assembly damping values specific to the NuScale design
- An additional seismic evaluation in which the core is residing in the Reactor Flange Tool (RFT)

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Presentation to the ACRS Subcommittee

Staff Review of NuScale Topical Report

TR-0716-50351, REVISION 0

"NUSCALE APPLICABILITY OF AREVA METHOD FOR THE EVALUATION OF FUEL ASSEMBLY STRUCTURAL RESPONSE TO EXTERNALLY APPLIED FORCES"

Presenters:
Chris Van Wert – Senior Reactor Systems Engineer, Office of New Reactors
Bruce Bavol - Project Manager, Office of New Reactors

August 20, 2019

(Open Session)

NRC Technical Review Areas/Contributors

- REACTOR SYSTEMS NUCLEAR PERFORMANCE & CODE REVIEW BRANCH / NRO:
  Rebecca Karas (BC)

- ADVANCED REACTOR TECHNICAL BRANCH / NRO:
  Chris Van Wert

- Pacific Northwest National Laboratory (PNNL):
  Nicholas Klymyshyn

Staff Review Timeline

TR-0716-50351, "NUSCALE APPLICABILITY OF AREVA METHOD FOR THE EVALUATION OF FUEL ASSEMBLY STRUCTURAL RESPONSE TO EXTERNALLY APPLIED FORCES"

- NuScale submitted Topical Report (TR)-0716-50351, "NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces," Revision 0, on September 30, 2016, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16274A469).
- NuScale submitted ANP-10337P-A, "PWR Fuel Assembly Structural Response to Externally Applied Dynamic Excitations," Revision 0, on April 30, 2018 (ADAMS Accession No. ML18144A816)
- Staff plans to brief advisory committee on reactor safeguards (ACRS) full committee on September 5, 2019.
- Staff plans to issue its final SER in late October 2019.
- Staff plans to publish the "-A" (approved) version of the TR in early 2020.

Scope of the Staff Review

- The staff's review included:
  - Evaluation of the NuScale design versus the reference methodology topical report (ANP-10337P-A)
    - Comparison of the NuScale fuel assembly design versus the designs covered by the methodology
    - Evaluation of the limitations and conditions
  - Evaluation of modifications to the referenced methodology

- The staff's review did *not* include:
  - The underlying methodology (covered by topical report ANP-10337P-A)
  - The docketed analysis of the NuScale fuel assembly design (covered by technical report TR-0816-51127-P)

Non-Proprietary

Summary of ANP-10337P-A, "PWR Fuel Assembly Structural Response to Externally Applied Dynamic Excitations"

- Presents a generic methodology to evaluate PWR assembly structural response to externally applied forces
  - Considers irradiation effects
  - Establishes protocol for benchmark testing
  - Defines acceptance criteria
  - Horizontal and vertical dynamic finite element models
  - Structural analysis of limiting 3D deflection
  - Evaluation of grid impact forces against allowable limits

- Used for demonstrating compliance with GDC 2 and 10 CFR Part 50 Appendix S

- Consistent with guidance provided in SRP Section 4.2 Appendix A

- Contains 9 conditions and limitations

NuScale Fuel Design

- Based on Framatome 17 by 17 HTP design
  - M5 fuel pin cladding
  - Zirc-4 guide tubes
  - HTP™ grids
  - HMP™ bottom grid

- Differences
  - ~1/2 length
  - Five grids (vs. seven)

Modifications to Methodology

- ANP-10337P-A fuel assembly model has been modified for the NuScale fuel assembly design
  - Shorter length
  - Fewer grids

  The staff finds that the dimensional modifications to the model from ANP-10337P-A accurately represent the NuScale design and are consistent with the general methodology

- Axial coolant flow damping is ignored
  - ANP-10337 uses fixed generic damping values that credit axial flow damping and require justification on the basis of test data. NuScale modifies the methodology to propose a different set of damping values specific to the NuScale design and are justified with test data.

  The staff finds that by providing test results on the NuScale fuel assembly, NuScale is following the methodology from ANP-10337P-A. Additionally, NuScale ignores any potential flow damping which the staff finds conservative and acceptable.

Modifications to Methodology

- Fuel assembly characterized for the first three mode shapes instead of five
  - The typical mechanical testing protocols defined in ANP-10337P-A were written for typical full length fuel, which would naturally have more relevant flexural mode shapes than a shorter assembly with fewer grid spacers.

The staff finds that the use of three mode shapes for NuScale to be acceptable based on the comparison of the primary mode shapes versus the fuel assembly motion spectrum. The staff also notes that while ANP-10337P-A requires the characterization of the first five mode shapes, only the first three are used in the model.

Limitations and Conditions

L&C #	Topic	Summary of Disposition
1	Grid Behavior	The NuScale grid design is exactly the same grid design used as an example in ANP-10337.
2	Grid Deformation Applicability Limits	The NuScale grid design is exactly the same grid design used as an example in ANP-10337.
3	CASAC	The NuScale evaluation is performed using a version of CASAC that is consistent with this L&C.
4	Current Fleet	The NuScale design is a significant change from the current fleet, but the technical information and analysis documented in reports and RAI responses, as well as PNNL independent confirmatory analysis, addresses all concerns.
5	Damping	NuScale proposed and justified specific horizontal damping values that differ from the generic damping values.

Limitations and Conditions

L&C #	Topic	Summary of Disposition
6	Fuel Rod Evaluation	NuScale performed fuel rod evaluation that meets this L&C.
7	Control Rod Locations	NuScale used the control rod location stress limits to meet this L&C.
8	3D Loads	NuScale performed 3D analysis of loads to meet this L&C.
9	Grid Deformation Model Limits	The NuScale grid design is exactly the same grid design used as an example in ANP-10337. The grid deformation limit on the impact model is not exceeded.

Non-Proprietary

Staff SER Conclusions

- The staff concludes that the NuScale fuel assembly meets the conditions and limitations associated with the referenced methodology topical report ANP-10337P-A

- The staff concludes that the modifications to the approved methodology are appropriate for the NuScale design are acceptable

- The staff finds that the use of ANP-10337P-A is acceptable for NuScale given the modifications outlined in TR-0716-50351-P.

Questions?

Non-Proprietary

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