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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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666TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THURSDAY

SEPTEMBER 5, 2019

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Peter Riccardella, Chairman, presiding.

COMMITTEE MEMBERS:

PETER RICCARDELLA, Chairman

MATTHEW W. SUNSERI, Vice Chairman

JOY L. REMPE, Member-at-Large

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR., Member

MICHAEL L. CORRADINI, Member

VESNA B. DIMITRIJEVIC, Member

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member*

DAVID PETTI, Member

HAROLD B. RAY, Member

DESIGNATED FEDERAL OFFICIAL:

ZENA ABDULLAHI

MIKE SNODDERLY

*Present via telephone

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

(8:30 a.m.)

CHAIRMAN RICCARDELLA: Good morning. The meeting will come to order.

This is the second day of the 666th meeting of the Advisory Committee on Reactor Safeguards. I am Pete Riccardella, ACRS Chairman.

The ACRS was established by the Atomic Energy Act and is governed by the Federal Advisory Committee Act, FACA.

The ACRS section of the U.S. NRC public website provides information about the history of the ACRS and provides FACA-related documents, such as our charter, bylaws, Federal Register Notices for meetings, letter reports, and transcripts of all full and subcommittee meetings, including all slides presented at the meetings.

The committee provides advice on safety matters to the Commission through its publicly available letter reports. The Federal Register Notice announcing the meeting was published on August 6th and provided an agenda and instructions for interested parties to provide written documents and request opportunities to address the committee, as required by FACA.

In accordance with FACA, there is a

Designated Federal Official. At today's meeting, the DFO is Ms. Zena Abdullahi.

During today's meeting, the committee will consider the following: Westinghouse Topical Report, WCAP-17794, Related to New D5 CPR Correlation for SVEA-96 Optima-3 Fuel Design; and, two, Topical Report 0716-50351, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces; and also Preparation of ACRS Reports.

As reflected in the agenda, portions of the sessions on both of these topical reports may be closed in order to discuss and protect information designated as sensitive or proprietary.

There is a phone bridge line. To prevent interruption of the meeting, the phone will be placed in listen-only mode during the presentations and committee discussion.

We have received no written comments or requests to make statements from members of the public regarding today's sessions. There will be an opportunity for public comment, as we have set aside 10 minutes in the agenda for comments from the members of the public attending or listening to our meeting.

Written comments may be forwarded to

Ms. Abdullahi, the Designated Federal Official.

A transcript of open portions of the meeting is being kept, and it is requested that the speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume, so that they can be readily heard.

And with that, I will request that everybody silence their cell phones or other devices, and we will proceed.

So I turn the meeting over to Member-at-Large Rempe.

MEMBER REMPE: Thank you. So on October 21st of this year, our Thermal Hydraulics Subcommittee completed our review of the Westinghouse Electric Company Topical Report WCAP-17794, which describes the new D5 CPR correlation for SVEA-96 fuel, Optima-3 fuel.

And at the end of our subcommittee meeting, we recommended that this topic be brought to the full committee. And today we are going to hear from the staff on this topic, but my understanding is that there are Westinghouse staff members available on the phone line to respond to any member questions if the staff can't respond to such questions.

I would note that the staff is going to be giving two presentations. This first presentation is an open presentation, and at the end of it we will call for public comments, if there are any, and then we're going to close the meeting and the staff will give a second presentation.

And after that, there is a letter, and Jose March-Leuba, who is on the line because of the hurricane instead of being here, has drafted that letter. And I'm just acting for him, but I will read it for him. And if there are difficult questions, I'll rely on Jose to answer those questions, too, assuming his phone line stays connected.

So with that, I will turn it over to Josh.

MEMBER KIRCHNER: Just one correction for the record. It was August, the subcommittee meeting.

MEMBER REMPE: Did I say something other than August?

MEMBER KIRCHNER: October.

MEMBER REMPE: Oh. Excuse me. Thank you. I misread it.

MEMBER KIRCHNER: Just for the record.

MEMBER REMPE: Brain failure there. Thank you.

MR. KAIZER: Thank you very much. Good morning. My name is Joshua Kaizer, along with Reed

Anzalon. We will be presenting today the safety evaluation for the D5.

Can you go to the next slide, Reed?

This is a very -- it's a unique safety evaluation for the NRC. We have done about 40 of these safety evaluations for critical heat flux and critical power models in the past. We are very used to those.

But this safety evaluation had the unique -- the experience that happened at KKL where they had a single fuel failure and a whole bunch of indications made the staff go back and look at the possibility that the experimental data was not actually capturing the phenomenon occurring in the reactor. And that is why we have had so much attention on this SE and this review.

Here I have just kind of shown that we have three authors of the SE -- myself, Reed, and Josh Whitman. We have three reviewers -- John Lehning, Ben Parks, Paul Clifford. None of those are junior people. I would say they are all very experienced. This is extremely unusual. In every other case, I think we have looked at three or four SEs that have been similar to this, reviews that have been similar to this over the past couple of years.

It has been either I do the review and Reed is the peer reviewer, or Reed does the review and I am the peer reviewer. So to have this many people, and it was solely because we are wondering, okay, does the evidence that we saw in KKL, did that say that there was an issue with the experiments and the correlations in general?

MR. ANZALON: Or with the fuel design.

MR. KAIZER: Yeah. So that was -- that was the heightened, and that was one of the reasons that I think that this topical report was brought to the attention of ACRS. I mean, obviously, you guys are able to look at anything you guys want to, but this was especially, hey, we have something new and unique here, and those are of special interest to the ACRS.

So the safety evaluation focuses on normally three, and this time four, main areas. The first area was ensuring the experimental data supporting the model is appropriate. This is a data-driven model. It's only as good as the experimental data that is used to generate it.

The second was ensuring the model is physically and mathematically appropriate. Here you are just basically looking at, hey, does the form of it make sense mathematically? Am I going to see any areas where it divides by zero, or is it well-behaved?

And third is ensuring that the model has sufficient validation. These models live and die by how well they can predict experiment, and so we've put a lot of emphasis on ensuring that this correlation form can predict the experimental data because that's ultimately the reason why we trust it.

The fourth was whether Optima-2 issues that occurred at KKL were related to the D5 correlation at all and critical power in general, and that was I think a good third to potentially half of the safety evaluation. I don't remember the exact numbers. That's not normally a consideration, but that is, again, why we had all of this attention.

Next slide?

For our review process, we used criteria that we have used for multiple reviews. We kind of formalized this critical starting -- it was starting a couple of years ago, but we have been working on this safety evaluation for so long that we formalized that stuff in a NUREG, but we actually don't reference this NUREG in this SE because we had the SE written before the NUREG came out.

It's a very formalized framework. It is very structured. It is basically saying if you have a data-driven model, here is all of the things you need to consider. And we just kind of go it piece by piece and say, okay, yes, you've met this, you've met this, you've met this, you've met this, maybe as if you've met all of these things, then your data-driven model is appropriate.

MEMBER REMPE: I'm going to stop you because if Jose were here I'm sure he would do it, too. We were impressed with the criteria, for the members who weren't at the subcommittee meeting during our NuScale review, and we had suggested even in our letter report but during the topic when we were discussing it we emphasized, oh, this ought to be documented. These are always in proprietary reports, and it would make it much easier to facilitate the review process.

And so we were very happy during the subcommittee meeting, especially Jose, to see that you had indeed followed through on that suggestion, because it wasn't a formal recommendation, but it was in our letter report.

MR. KAIZER: Okay. Next slide?

Finally, and this is the last slide for

our open session, our overall conclusions, we reviewed the D5 model with the criteria that we have previously used. We found everything satisfactory.

There were a few minor issues as there are in every review. Things are never exactly as they should be, but we were able to resolve all of these minor issues, most of them just having a very good demonstration that, yes, we can show that this doesn't really matter.

And, finally, we were able to conclude, and I'd say this was the last bullet we were able to write. And it took a very long time to get there, but we did conclude that there is reasonable assurance that the degradation observed at KKL did not result from an error in the D5 model.

Thank you.

MEMBER REMPE: Okay. So with that, I'm going to first ask Jose if he wants to add anything in the open session.

MEMBER MARCH-LEUBA: No. I think we'll just --

MEMBER REMPE: Okay. So --

MEMBER MARCH-LEUBA: -- go into closed.

MEMBER REMPE: Okay. Then let's go ahead and open the line, and we'll ask the audience, first, while we're waiting for the public to become available, if she'd like to make a comment, since there's only one person out there. I guess not.

So we'll wait and give the public an opportunity to make a comment before we go to closed session.

(Pause.)

MEMBER REMPE: So with that, we're going to close the open session, which I think I need to hit the gavel for, right? And we're going to switch to a closed meeting, and we'll ask everyone in the room who is authorized to make sure there is no one here that shouldn't be.

(Whereupon, the above-entitled matter went off the record at 8:41 a.m. and resumed at 12:37 p.m.)

CHAIRMAN RICCARDELLA: Let's get started. The meeting will be regarding the NuScale applicability of the AREVA method for evaluation of fuel assembly structural response to externally applied forces.

And I turn the meeting over to Walt. Do you want to initiate the meeting, or Ron? I don't --

MEMBER KIRCHNER: I think -- Ron, do you want to take over? And I have no formal comments to make, other than --

MEMBER BALLINGER: The Fuels Materials Subcommittee or people from that, and the NuScale Subcommittee, met and had presentations of this topical report in our August 20th -- I was just going to say August subcommittee. And the presentation that they are going to give today is, obviously, a derivative of that.

And in addition to that, we asked them to unpack a few of their seismic numbers for us, which will be done in closed session. But who is doing the -- is it -- Matt, you're doing the presentation, or --

MR. PRESSON: Yes.

MEMBER BALLINGER: So you're on.

MR. PRESSON: All right. Well, thank you, and good afternoon. I am Matthew Presson, licensing specialist with NuScale Power, project manager for this topical report. We are here today to discuss the applicability of the AREVA method for the evaluation of fuel assembly structural response to externally applied forces.

Presenting today will be primarily Brett Matthews, Framatome technical lead for the NuScale fuel design project, supported by myself and licensing, and Larry Linik in fuels engineering, who may be joining us over the phone.

And with that, I will go ahead and pass the presentation over to Brett.

MR. MATTHEWS: All right. So let me start with the agenda, and I won't spend a lot of time here. I'm going to spend a lot of time in the presentation providing the necessary background for us to talk about the applicability of the method, starting with an overview of Framatome's topical ANP-10337. This was the subject of an ACRS meeting about a year and a half back in early 2018.

We'll talk about the scope of generic applicability for that, provide an overview of the NuScale fuel design, which we refer to by its trade name here, NuFuel-HPT2, and then talk about the process that we use to assess applicability, and then the conclusions from that study.

So if we go to the next slide, we'll jump into an overview of ANP-10337. The fundamental focus of this methodology is the evaluation of fuel safety functions during earthquakes and pipe breaks. It's the fuel assembly response, structural response, to external loads, so motions from loss of coolant accident or seismic event.

And we're looking at a PDF here, but this cartoon represents a seven-assembly row taken from the

NuScale analysis that we did. If we were running this in PowerPoint, there is actually an animation to show how that simulation plays out. But I'll stop and point out a couple of things in this cartoon that we can refer back to as we move through the presentation.

The first thing that I want to show -- again, this is representing seven fuel assemblies across the longest row, but I'll draw your attention to the small maroon I guess it is, maroon rectangles on each fuel assembly. These are representing the intermediate spacer grids on the fuel assembly. And spacer grids have a lot of functions, but for what we're talking about today it serves a very important function in that transmits any impact loads between the fuel assemblies.

So as these fuel assemblies are oscillating back and forth under external motion, the fuel is designed such that all contact occurs at those spacer grid locations, and only at those spacer grid locations. So those spacer grids have to be designed to be able to take that load and transfer it down the line.

The other thing that you would see if we were running this simulation is you would see how the fuel assemblies kind of sway back and forth in response to the seismic event. And primarily what you would see is the fuel assemblies oscillating with kind of a C-shaped bow back and forth. That C-shaped bow corresponds to the first mode, frequency response of the fuel, which makes sense because we are simulating a seismic event, which relative to the fuel it's a relatively low frequency event. It's primarily going to excite the fuel in that first mode frequency range.

So what we get out of the simulation, the big things that we're looking at are the impact loads between the fuel assemblies and between the fuel assembly and the baffle plate or reflector, and also the stresses in the fuel assemblies, as a result of not only the impact loads but the deflection shapes that the fuel takes as it's moving back and forth. So we pay close attention to those deflection shapes as well.

So let me move to slide 5. I always like to start with defining kind of the regulatory framework that we're working within, and for this generic topical, 10337, the main components of this regulatory framework are 10 CFR Part 50, Appendix A, which defines the generic design criteria.

There are a handful of those that are relevant to what we are working towards: 10 CFR Part

50, Appendix S, which addresses earthquake engineering or the safety functionality to withstand earthquakes; 10 CFR 50.46, which of course addresses the requirements to be met following a LOCA event pipe break; and then the relevant regulatory guidance in this case comes from the standard review plan, Chapter 4.2, Appendix A.

Appendix A is really focused on this evaluation of the fuel assembly response to external loads. But if we take this framework and kind of boil it down in layman's terms, really, it comes down to three criteria that we set out to satisfy in this evaluation, and that is maintaining coolable geometry in the fuel assembly, maintaining a path for control rod insertion to insure safe shutdown, and then fuel rod integrity, which is both a coolability concern if there is fragmentation of the fuel rod, but also maintaining that barrier -- first barrier to fissile material.

So slide 6, continuing on with the overview, I put this slide in just to give kind of a visual of what we do as part of the core part of this analysis. This analysis is run with what we call time history inputs at the core boundaries, and these are the excitation. These are the external loads that we use to excite the fuel.

What we refer to here as time history inputs are really the core motion history of the core plates, which are the boundaries, fixed boundaries at the top and bottom of the fuel assembly, as well as the motion of the baffle plates or the reflector, since that is also potentially a boundary that the fuel assembly can come into contact with.

Now, these time history inputs are derived from upstream models of the reactor vessel internals. In fact, the analysis that we are doing here is actually at the end of a long line of analyses that is performed, and starting from the definition of the seismic ground motion that we need to be concerned with, the definition of soil structure interaction and how that is propagated to a building structure, how it propagates through the building structure into the reactor, through the reactor vessel internals, and then finally we get to the heart of the reactor, and here we're analyzing the response of the core to those motions.

But, again, we are at the end of a very long line of analyses, and there is a lot of uncertainty and conservatism that builds up as we get down to that core analysis.

Now, before we depart this slide, the other thing that I wanted to point out is I have put a couple of schematics on here -- again, another important visual to take away -- and there are two points to be made here. First of all, you'll notice that there is a lateral schematic and a vertical schematic.

So one of the unique things that we do in this analysis is we analyze the motion of the fuel or the response of the fuel in three independent orthogonal directions. So we'll run an analysis in the X, Z, and Y direction independently. And then at the back end of the analysis we will pull those components together to come up with a three-dimensional load state.

The other thing that I want to point out here is that when you pull back the skin from these models, and you're looking at the skeleton, what we're left with is really a relatively -- or within the world of mechanical engineering it's a fairly basic structural representation of the fuel, where we are using basic elements, themes, and springs, and dampers, and gap elements, to represent the structural response of the fuel.

So continuing on with that thought, on

slide 7 --

CHAIRMAN RICCARDELLA: But the lateral schematic is basically a two-dimensional model, right, that you're running?

MR. MATTHEWS: It is a two-dimensional model, but we will run a row analysis in the X direction and then we will run a separate row analysis in the Z direction.

CHAIRMAN RICCARDELLA: And are they two different models in the --

MR. MATTHEWS: It's the same model.

CHAIRMAN RICCARDELLA: Same model but two different inputs.

MR. MATTHEWS: Yes.

CHAIRMAN RICCARDELLA: Yeah. Got it.

MR. MATTHEWS: Okay. So building on that schematic representation, the point that I wanted to make there is that the fuel is represented using simple and generic structural models. And this is something we are going to draw on when we talk about the applicability of what we do in this method.

Even though there can be a lot of detail in terms of fuel assembly structure, in terms of individual fuel rod connections, the number of guide tubes, we boil that down into a homogenous beam structure. So we really don't care if it's a 14 by 14, or a 17 by 17, number of guide tubes, all of that gets homogenized into a relatively simple and generic structural representation.

What's really important in this model is how we define the numbers to define all of those elements of the model, and so I want to talk for a minute about how we go about defining those model parameters.

And there are really three different sources for the definition of these model parameters. The first really encompasses most of the parameters in the model, and it's the simplest. These are parameters that are based directly on information from design documents, such as engineering drawings, material specifications.

So this would be information, geometric information -- outer diameter of a tube, inner diameter, material properties like Young's modulus. These are things that we can read directly from engineering specifications and put into the model.

The second category of model parameters are slightly more complex in that they can't be read directly off of a design document. These are parameters where we rely on design-specific characterization testing. So, conceptually, what we are characterizing is fairly simple, but it would be things like the lateral stiffness of the bundle or the frequency response of the bundle. These are things you can't get off of the drawing, but we can interrogate a prototypic test assembly to easily process that information.

So ANP-10337 defines a full characterization protocol, full suite of tests that is necessary to define all of these parameters to fully populate the model. I will note that full characterization protocol was applied to NuScale, and I'll stop and pause here and mention also that there was an NRC audit performed during part of that testing as well. NRC was able to come out to our Horn Rapids Road facility in Richland, Washington, and observe some of that testing being performed on a prototypic NuScale assembly.

Now, the third and last category, there are three parameters that account for fluid effects, and this is the one area in the methodology where we have parameters that are defined independent of the design. And these fluid effects are added mass, the coupling mass, and fluid damping.

So there is a little bit of foreshadowing in the presentation here, but this is obviously something that we are going to reflect back on to talk about when we start talking about the applicability of these methods to NuScale. This is an obvious one that we have to challenge.

The key takeaway here, though, is aside from the fluid effects, the modeling is largely transparent to the fuel design. It is set up to be generically applied to a wide range of fuel assembly types.

CHAIRMAN RICCARDELLA: Can I go back to the previous slide? Those -- you have all of those different spring and dashpot elements that I presume each one of those represents a spacer grid?

MR. MATTHEWS: That's correct.

CHAIRMAN RICCARDELLA: And are the springs and -- are they different as you go up that vertical column, or are they all the same? The spring constants, for example.

MR. MATTHEWS: In this case, they are all the same. They would be all the same because the spacer grid is the same -- that is true. So we're going to get to that in a future slide, so the bottom -- it is true, the lower spacer grid is a different type.

CHAIRMAN RICCARDELLA: Okay. Gotcha.

MR. MATTHEWS: But it is not represented in these models, and I'll talk to that.

CHAIRMAN RICCARDELLA: But now if this -- you say transparency with regard to fuel designs. For a conventional reactor in which it's much -- the fuel is much longer, would I -- I presume you'd have more of these little spring --

MR. MATTHEWS: Yes.

CHAIRMAN RICCARDELLA: -- dash elements to make a taller -- a taller fuel bundle?

MR. MATTHEWS: That's correct.

CHAIRMAN RICCARDELLA: Okay.

MR. MATTHEWS: So that's another point that I'm going to -- that's a key point that we have to discuss, and, you know, if we go back -- if you don't mind backing up to slide 4 real quick. I'll just do this very briefly.

So, again, this is -- it's a cartoon representation taken directly from a NuScale simulation, but you'll notice here there are only three spacer grids being represented in this model. That's something we'll talk about, the meaning of that and the significance of that in terms of, is that an adequate representation of the fuel?

MEMBER CORRADINI: Since I wasn't at the meeting, just to clarify, so there are more than three for thermal hydraulic purposes, but for structural support for this external response, we are looking at three.

MR. MATTHEWS: Yes.

MEMBER CORRADINI: Okay. Fine.

CHAIRMAN RICCARDELLA: I guess I don't understand. The schematic that you -- the lateral schematic that you showed showed a lot more than three.

MR. MATTHEWS: Yeah. And so what's going on here, the schematics, these are from an existing PWR design that would have more spacer grids.

CHAIRMAN RICCARDELLA: Okay.

MR. MATTHEWS: So, I'm sorry, it is not a one to one.

CHAIRMAN RICCARDELLA: Okay.

MEMBER CORRADINI: You're showing a cartoon of a full size here.

MR. MATTHEWS: Yeah. This is full size. I apologize for the confusion, but this is not NuScale.

CHAIRMAN RICCARDELLA: If you showed one of these that was specific to NuScale, it would only have three of those things?

MR. MATTHEWS: That's correct.

CHAIRMAN RICCARDELLA: Okay Got it.

MR. MATTHEWS: All right. So I think we're up to slide 8. So continuing that line of thought, though, and talking about the applicability of ANP-10337, the original intent for that topical was for it to be generically applicable to PWR designs.

And we say that for a number of reasons. We talked about the modeling -- how the modeling is really simple and generic to where it can be applied to a wide range of assembly types, and we can do that because PWR fuel designs share the same basic construction, thus allowing that same representation.

Again, we are not necessarily concerned as to whether we're dealing with a 14 by 14 or a 17 by 17 array, or whether we've got five guide tubes or 24, all of that is homogenized into the same simple generic structural representation. It's a pretty versatile representation.

The other thing is that PWR operating environments are all very similar -- similar temperature, similar flow rates -- so it's -- from the fuel assembly perspective, it's hard to tell, you know, the difference between one reactor type and another.

There was one criteria, however, noted for applicability, and that has to do with modeling assumption to represent the impact behavior of the spacer grid. So on one of the previous slides we zeroed in on the little assembly of springs and dampers representing the impact element at the spacer grid locations.

There is a lot of nuance that goes into modeling that. Again, since that is the element that is transmitting all of the energy in the core, and taking the impact load, things can get to be slightly more complicated when we start to talk about the accumulation of deformation in that element, and when we start introducing plastic deformations.

So there is a modeling assumption to represent that impact behavior in ANP-10337. I will note that in the case of NuScale, we're using the exact same spacer grid that we demonstrate in ANP-10337 sample problem. It's the exact same geometry, same hardware. We've just put it on a shorter fuel assembly. So we're applying the same -- we're working within the same range of applicability for NuScale.

Final point here regarding applicability. There were limitations and conditions imposed through the SER, and I guess we'll jump ahead a slide to slide 9. We can walk through those.

We were requested in RAI 9555 to address all of these L&Cs, and I will briefly walk through them here. I do want to say I'm -- I've got text here to describe what the L&Cs are about. I'm just paraphrasing. This is not the exact language, but -- so starting with items 1 and 2, I'm going to lump those together because those L&Cs have to do with, one, demonstrating critical grid behavior in our impact test protocol; and, number two, a limit on the maximum allowable spacer grid deformation.

Much like we said on the previous slide, we're using the exact same component, in this case the same spacer grid that we demonstrated in the sample problem, so we're meeting those L&Cs for NuScale in the same way that we do in the base topical.

Number three refers to defining controls and quality requirements on the engineering software that we use to implement this topical. We use an internal finite element code called CASAC that is proprietary to Framatome. But, again, we are using the same software in the application of NuScale that we do in the sample problem or that we define in the topical. So there is no difference there.

L&C number 4 limits the use of the applications consistent with the operating fleet. So when we were reviewing this with the NRC and we talk about generic applicability, I think we were all on the same page in terms of accepting that. But there was -- the NRC was, you know, alert to the fact that this is a true statement for existing PWRs, but we don't have a crystal ball. We don't know what the next generation of reactor is going to look like, what that environment is going to be like.

So this is an L&C to address that, to make sure that as we extend to things like NuScale that we stop and address the applicability of this method. So I highlighted that because, frankly, this is why we're here today, to discuss that L&C.

L&C number 5 limits the applicability of the lateral damping values to existing fuel designs. Again, we talked about this on a previous slide as well, that in the base topical we define those values independent of fuel designs. And, again, we were willing to accept that definition to existing designs as we know them today, but moving forward, for the next generation of fuel designs, it's something that needs to be questioned.

So, again, this comes into play with

NuScale, and that's something that we're going to address in this applicability topical.

Number 6 requires a fuel rod stress assessment under faulted conditions. This is something that is not described in detail in ANP-10337, so this is just a catch to make sure that we are executing that evaluation. We do that for NuScale in the same way that we do in the sample problem for 10337.

Number 7, this one requires the use of the most limiting stress criteria when a bounding analysis is performed for both rodded and non-rodded locations. What this is boiling down to is making sure that we're using the most limiting criteria on the guide tubes to make sure that we're ensuring control rod insertability. And, again, we do that for NuScale.

L&C number 8 specifies that a 3-D combination of loads should be considered for non-grid components. This is another one that we have already talked about in the way that we run these analyses in three directions. We then recombine that into a three-dimensional state, so we're complying with that for NuScale.

And then number -- I'm sorry.

CHAIRMAN RICCARDELLA: SRSS, is that how you combine?

MR. MATTHEWS: Yes. It's SRSS.

And then, number 9, this is similar to number 1 and number 2 in that it's another limitation on the applicability of the spacer grid impact modeling. Again, our response for that is very similar to what we say for number 1 and 2. We're using the same spacer grid, so we're applying the same range of applicability as demonstrated in the sample problem to the base topical.

All right. So if we can move forward to number -- slide 10. So that summarizes what I wanted to say in terms of the review of ANP-10337, kind of build that foundation to start working with in this presentation. I'm going to shift gears now and talk a little bit for the next couple of slides about the NuScale design and the NuScale fuel design.

So, again, the NuScale fuel design -- trade name is NuFuel-HTP2 -- this design is based on Framatome's existing 17 by 17 PWR technology. So the graphic that we have on the right side of the screen here, if we were to take a cross-section slice of that assembly at any location above the bottom nozzle assembly, you would not be able to distinguish this from our existing 17 by 17 designs.

It's the exact same geometry, same rod

geometry. Spacer grids are same components from the existing 17 by 17 PWR technology, and that's important for a number of reasons. One thing that I want to pause and talk about here is, you know, on a previous slide we talked about how fluid effects are defined independent of design. Two of those were the added mass effect and the coupling mass effect.

If you look at how those values are derived in ANP-10337, they are derived based on the 2-D cross-sectional effects in the assembly. And so if we were to extend that exercise to NuScale, we would be repeating the exact same exercise that we have already done in 10337.

So all of that to say that at least of those two fluid effects, the added mass and the coupling mass, we would arrive at the same answer for NuScale. And those values, as they're defined in 10337, continue to be applicable to the NuScale fuel design because we have that exact same cross-sectional makeup.

And where the differences are in the NuScale design are in the axial layout, obviously. This is a shorter assembly, and we have already touched on this. But this fuel design has a total of five spacer grids.

The lowest-most spacer grid design, as was noted earlier, it is unique from the others. Although it is not unique relative to our existing 17 by 17 design, we used the same HMP -- Iconel 718 HMP spacer at that lower grid location on those designs as well.

So we have an Inconel 718 HMP at the lowermost location, and then the other four spacer grids are a Zirc-4 HTP grid type. So, again, we count the grids, we've got five grids. We represent three of those in our structural modeling.

The reason we do that is because ANP-10337 looks at the uppermost and lowermost grids, which in this case I don't have the exact dimensions. I know we talked about it in the subcommittee meeting, but the spacer grids are about two inches away from the top and bottom nozzle. They are very close to that end condition.

ANP-10337 says that those spacer grids are so close to those fixed end conditions that they don't really have an opportunity to participate much in the dynamic response of the fuel assembly. So what we do is we make a simplification, a modeling assumption, that those end grids get rolled into the fixed end conditions at the top and bottom.

And we only look at rotational degree of freedom at those intermediate spacer grids, which in this case leaves us with three intermediate rotational degrees of freedom in the assembly.

So this is something, again, that we are going to talk about, is that adequate to capture the dynamic response to the fuel assembly? We put some effort into analyzing that and challenging that to make sure that this is adequate.

The other features I won't go into detail, but the guide tubes, the quick disconnect, Alloy M5 fuel rod cladding, all of these are also borrowed from our existing 17 by 17 fuel assembly designs.

All right. So if you will advance to slide 11. So continuing the discussion of how the new fuel HTP2 fuel design compares with existing Framatome 17 by 17 designs, this is presenting a lot of similar -- the same information that we talked about on the previous slide, just comparing key dimensions and features.

As you can see, intentionally there are a lot of numbers that are the same in both columns. And if you were to kind of parse these out, what you're seeing is that the numbers having to do with the cross-sectional properties are exactly the same. They are identical. Again, the only difference is in the axial layout of this fuel design.

And so I've highlighted in blue the key differences, number 1 being the fuel assembly height. We're a little more than half the height of the existing 17 by 17 design. And, again, that begs the question is -- are our methods -- with that shorter assembly, are our methods adequate to capture the dynamic response of the shorter assembly?

The grid span length is a little bit different. It's within a couple of percent of the 17 by 17 design at 20.1 inches. However, outside of our experience with 17 by 17s, it's well within the experience for all of our PWR designs. It's bounded, both on the upper and lower ends.

This is a value, too, that gets modeled directly. When we place the spacer grids in that structural model, this 20.1 inches is reflected directly of course.

If we advance to slide 12, one more item in talking about how NuScale compares to existing 17 by 17 designs, we can compare the operating parameters for NuScale with the typical operating -- typical operating values for existing 17 by 17 designs.

This chart is a little more interesting than the last one because there are a lot more differences in the numbers. However, most of these numbers are really inconsequential for what we are looking at in terms of looking at the structural response of the fuel to external dynamic excitation. So things like thermal power. Pressure is really of secondary importance. A lot of these don't have any consequence on the simulations that we're running.

Core temperature is taken into account directly. So we scale the models to the appropriate core temperature for NuScale. That is reflected directly.

What is of interest in this table and what is of relevance and significance to us is what I've highlighted in blue, which is showing that the NuScale design operates at a much lower -- with a much lower flow rate, lower coolant velocity. And, correspondingly, you see that in the Reynolds number as well.

So this gets back to what we talked about earlier and having to challenge those fluid effects, in particular the damping that is associated with these different environments. So that's something we have to tackle for NuScale.

All right. So advance to slide 13, please.

So now that we've got an understanding, at least high level, of how NuScale, both the fuel and the operating environment, compares with existing PWRs, we can start to talk about assessing the applicability.

And just real briefly, the process that we applied in assessing applicability, we first off started with the regulatory framework. I always like to start there to make sure that we're in the same design space. We're working with the same framework. NuScale is working within the same regulatory framework as ANP-10337. So we're blowing everything down to the same concerns. We need to satisfy coolable geometry, control rod insertability, and fuel rod integrity.

Number two is we performed a comparison of the parameters that are important to the seismic LOCA response, which we just did on the previous three slides. And when we do that, there are three big things that jump out at us as being significant -- the shorter fuel assembly length of the new fuel HTP2 design, the fact that as a result of that shorter length we have fewer spacer grids that get represented in the model, and then also the difference in coolant flow.

And then taking those differences forward, we applied to a detailed review of the ANP-10337 content, including the L&Cs. And if you read the applicability topical, it is literally structured around this process. It is structured around a chapter-by-chapter review of ANP-10337 with consideration to those differences.

All right. Slide 14?

So that was the process, and I'm going to jump straight to the conclusion, what fell out of that process. There were three relevant points that came out of our evaluation. Number one is a question that we have hinted at throughout this presentation, which 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 going through all of this is that, yes, it does. We can adequately represent that without any modifications to the existing method.

In short, the reason that we arrive at that conclusion is because we have been able to show that applying the techniques and the protocol direct from 10337, we still arrive at a place where we are accurately capturing the dynamic response of the fuel that is of interest, what we're trying to simulate.

So issue number 2 is that ANP-10337 PA establishes lateral fuel assembly damping parameters that credit flow rates, that are typical for existing PWRs. The question there is, are these values valid in the NuScale design? And the answer that we arrived at is that, no, they are not.

The reason we arrived at that is because ANP-10337 defines damping values that are constructed with three components. There is a structural damping component, which is really the -- it's the level of damping that you would observe just from the fuel assembly oscillating in air. So this is something that we get directly from the characterization tests that we do when we perform pluck tests and force vibration tests. You can measure that directly.

The second component is a component of damping that is going to be present just given the fact that this fuel assembly is trying to oscillate in a dense medium. It's trying to push through this dense coolant.

And then the third component is also related to the fluid, but it's specific to the fact that not only is it oscillating in this dense fluid, but as it deflects laterally it is deflecting into oncoming traffic with flow rushing past it. So as it pushes out, there is going to be a restorative force from the flow rushing past trying to push it back to its neutral plane.

CHAIRMAN RICCARDELLA: So you'd expect as the flow goes up, the damping goes up.

MR. MATTHEWS: Yes. So that final piece is what is not present. Well, it is present, but in a much smaller magnitude for NuScale. So given that, we redefine damping for the NuScale application. And where we ended up with, because we threw out that third component, we end up with a value that is lower than what is defined in 10337.

From the standpoint of running a simulation, that's moving in the direction of conservativism because we're eliminating damping from the system. We're removing a key source of energy dissipation.

The third issue is that RAI 9225 questions the need for the evaluation of the fuel during refueling, specifically while it's stored in the reactor flange tool. And where we arrive at on this issue when we looked into it is that we reached the conclusion that to definitively address the issue, we needed to perform an additional analysis above and beyond what you would get from reading ANP-10337.

So we continue to leverage that methodology for this additional analysis when the fuel was in the RFT.

Okay. So moving to slide 15, that brings me to the conclusions, where we ended up. So ANP-10337 PA defines a methodology that continues to be applicable to NuScale with two modifications.

The first is that we have to redefine fuel assembly damping to be specific to the NuScale application, and the second item is really in addition to what is defined in 10337, we perform an additional seismic evaluation in which the core is residing in that reactor flange tool.

And that's it.

MEMBER BALLINGER: Questions? I think we should just change out with the -- well, actually, I shouldn't say this, we are three minutes ahead of schedule. Thank you.

So if the staff ready to go?

CHAIRMAN RICCARDELLA: So are we going to talk -- we're going to talk more about this in closed session?

MEMBER BALLINGER: Yeah.

CHAIRMAN RICCARDELLA: All right.

(Pause.)

MEMBER BALLINGER: Yes. So, Chris, it looks like you're on the hook.

MR. VAN WERT: Well, I actually have Nick calling in from PNNL, so get him a life line open.

MEMBER BALLINGER: Go ahead when you're ready.

MR. BAVOL: Okay. Good afternoon. My name is Bruce Bavol. I'm a project manager for the new reactors, NRC.

The technical reviewer lead for this particular topical report is Chris Van Wert, to my right, and on the bridge line, Nick Klymyshyn, from Pacific Northwest National Labs.

The staff timeline for this review, I provided two references, the first two bullets, and from here, from the full committee, we will be planning to issue the final safety evaluation in late October, and the dash A or approved version we expect to be early 2020 for administrative purposes.

With that, I will turn it over to Chris for staff review.

MR. VAN WERT: All right. Thank you.

So before we kind of dive into the slides here, I want to just try and describe what the scope of the staff's review included and what was outside of the scope of this review.

So, in particular, the review included an evaluation of the NuScale fuel design versus the reference methodology topical report that we just heard about, 10337. And by that, I mean, we looked at the fuel assembly versus the assemblies that were used in 10337, and looked at the differences.

We also evaluated their presentation of the limitations of conditions and how those were addressed for the NuScale design. Additionally, the staff's review included any modifications to the reference methodology.

The review did not include the underlying methodology itself. As is expected, that was covered under the staff's review of ANP-10337. And it also does not cover the actual application of the methodology to review the NuScale fuel design. That is captured under tech report -- as the number is listed there below, that is captured in the staff's review in Chapter 4 of the NuScale DCD -- or DCA.

So this is pretty much parroting back what you've just heard from Brett, but in general, a quick summary of 10337 is that it presents a generic methodology that is applicable to PWR fuel assemblies and the structural response. It considers things such as irritation effects. It provides a protocol for benchmark testing. It defines the acceptance criteria and a few other things listed here.

It is used for demonstrating compliance with GDC 2, 10 CFR 50 Appendix S. And as mentioned before as well, it does follow generally the guidance provided in SRP 4.2 Appendix A. And it does contain nine conditions and limitations, which anyone referencing that methodology must demonstrate that they meet.

And, again, this is a quick summary for the fuel design itself. It is very similar to the operating fleet, 17 by 17 Framatome fuel design, M5 pins, Zirc-4 guide tubes, HTP grids, HMP bottom grids. The key differences are related to height, so there's half-height, and that results in fewer grids, in this case five versus seven total number of grids.

So in terms of modifications to the methodology, most of them are in relation to the axial height. They are half length and fewer grids, so the model itself had to be changed in order to reflect that. And the staff looked at those modifications and determined that it was consistent with the general methodology and was acceptable.

One other key one that was mentioned just a second ago was related to axial coolant flow. And as you heard, it is much -- it is significantly slower for NuScale, so that one -- that component of the flow damping was -- damping was ignored. It's a conservative assumption, although it's not a very appreciable one.

But beyond that, they did specific testing of the NuScale fuel assembly in the conditions to determine their value. So it does differ from the ANP-10337 value.

The last one is kind of included just to -- I don't know if it's creates more confusion or alleviates it. But in the SE, we talk a little bit about the modification in which the mode shapes that are assumed, both in the -- that are characterized versus that are assumed in the modeling, that there is this difference, that the modeling only uses three but the methodology says that you are supposed to use five.

At the time we did the review, ANP-10337 did have that requirement that you characterized the first five mode shapes. We wrote that part up, and then after the dash A's came out we realized that 10337 was modified at the end to reduce it down to only three being needed.

So, in the end, they are consistent, but I just wanted to bring it up, since that is covered in the staff's SE.

And so, again, limitations and conditions are a major part of the staff's review. A lot of these, if we look at, say, number one, it's the grid behavior, that's dispositioned by the fact that it is the same grid used both for NuScale as well as the operating fleet.

Similar for the grid deformation applicability limits. Being the same grid, it has the same limits. The same version of the code was used, so limitation condition number 3.

As far as 4 goes, yes, this is a different fleet, a different design than the operating fleet. So the staff's review did focus on that. We were looking heavily at the differences between the reactor designs and the fuel designs. And we also relied on their application, the responses to the RAIs, as well as independent confirmatory analyses, which we had PNNL provide for us.

Limitation number 5 is related to damping, as we already mentioned, that they do differ, although the method that they use to determine their damping is consistent with 10337.

And numbers 6, 7, and 8 are actually in relation to how it is applied. And as I alluded to at the beginning of this presentation, the topical report in front of us does not actually provide the analysis. That's covered in the tech report. So our review -- we had to look at the tech report, which is still under review, but we did determine from looking at that separate document that they do need 6, 7, and 8 here.

And number 9, grid deformation model, since it is the same grids, the limit on the impact model is not exceeded.

So, in conclusion, the staff concludes that the fuel assembly meets the conditions and limitations as provide within the reference methodology ANP-10337. We also conclude that the modifications to the approved methodology are appropriate for NuScale and are also acceptable.

The staff also finds that the use of 10337 is acceptable for NuScale, given the modifications as outlined within the topical report.

Any questions?

MEMBER BALLINGER: Any questions? Questions? Now we're way ahead of schedule. Thank you.

Now we need to go to public comment. So are we getting the line -- I guess we should ask if there is anybody in the room that would like to make a comment. Doesn't look like there is too many public here. Is it open?

MR. SNODDERLY: Is there anyone on the public line? Is there anybody on the public line that would like to make a comment?

MEMBER BALLINGER: It doesn't sound like it, but -- but they're all associated with the -- oh, by -- oh. Oh.

Is there anybody on the public line that would like to make a comment? If there is, please state your name and make your comment.

MR. SNODDERLY: Hearing no one from the open line wants to comment, we're going to -- we're going to now close the line, and we're going to prepare to go into closed session.

MEMBER BALLINGER: So folks that are not --

MR. SNODDERLY: Everyone in the room needs -- yeah, that meets the -- who needs to be here.

(Whereupon, the above-entitled matter went off the record at 1:23 p.m.)

LO-0919-66838

August 29, 2019

Docket No. PROJ0769

U.S. Nuclear Regulatory Commission
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One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Submittal of Presentation Materials Titled "ACRS NuScale Full Committee Presentation: NuScale Topical Report, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces," PM-0919-66837, 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 Full Committee Meeting open session on September 5, 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 Full Committee Presentation: NuScale Topical Report, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces," PM-0919-66837, 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
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Enclosure: "ACRS NuScale Full Committee Presentation: NuScale Topical Report, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces," PM-0919-66837, Revision 0

Enclosure:

"ACRS NuScale Full Committee Presentation: NuScale Topical Report, NuScale Applicability of AREVA Method for the Evaluation of Fuel Assembly Structural Response to Externally Applied Forces," PM-0919-66837, Revision 0

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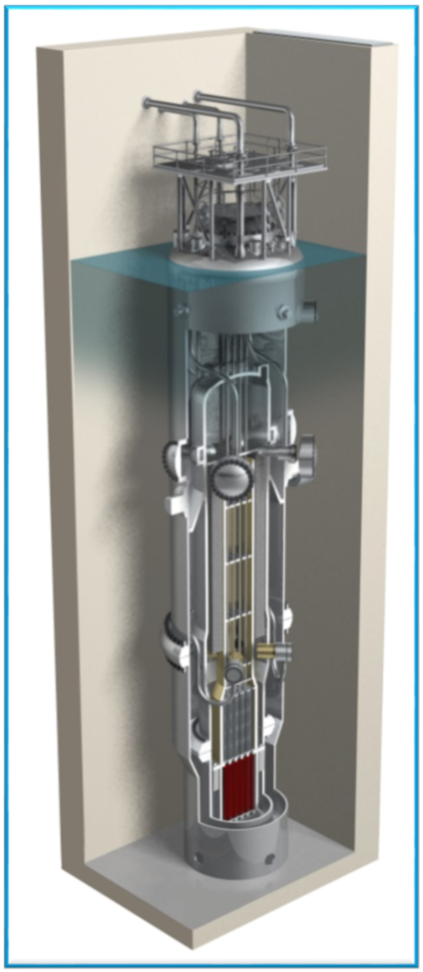
ACRS Full Committee Presentation



NuScale Topical Report

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

OPEN SESSION

September 05, 2019

PM-0919-66837
Revision: 0

Template #: 0000-21727-F01 R5

Presenters

Larry Linik
Fuels Engineer

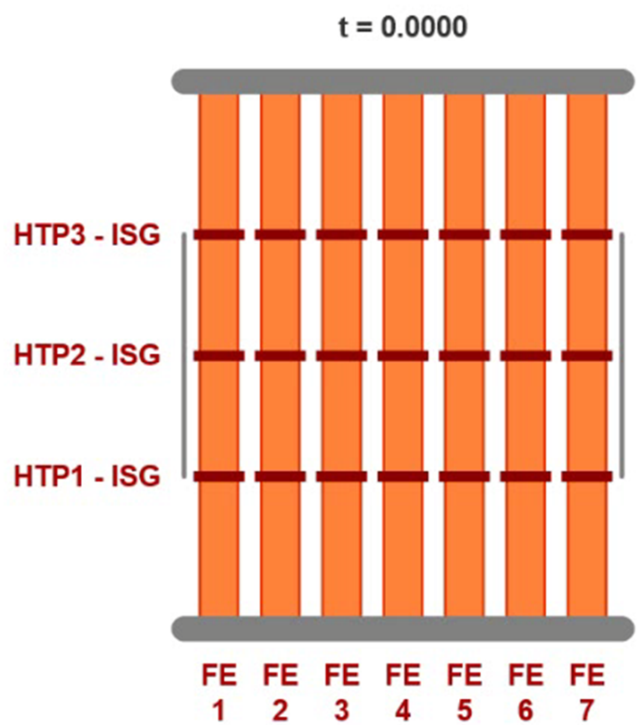
Brett Matthews
Framatome Technical Lead for
NuScale Fuel Design Project

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

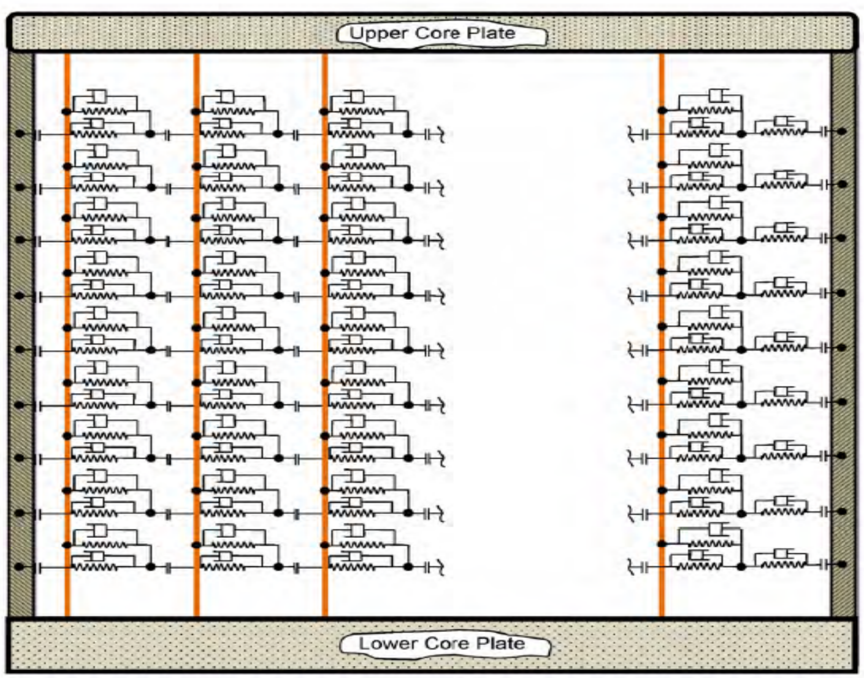
- SRP 4.2, Appendix A

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

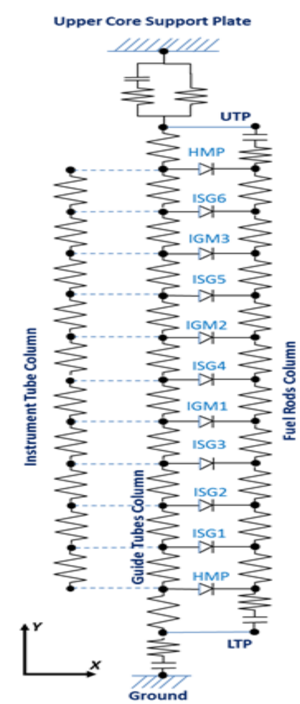
Overview of ANP-10337PA

- "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

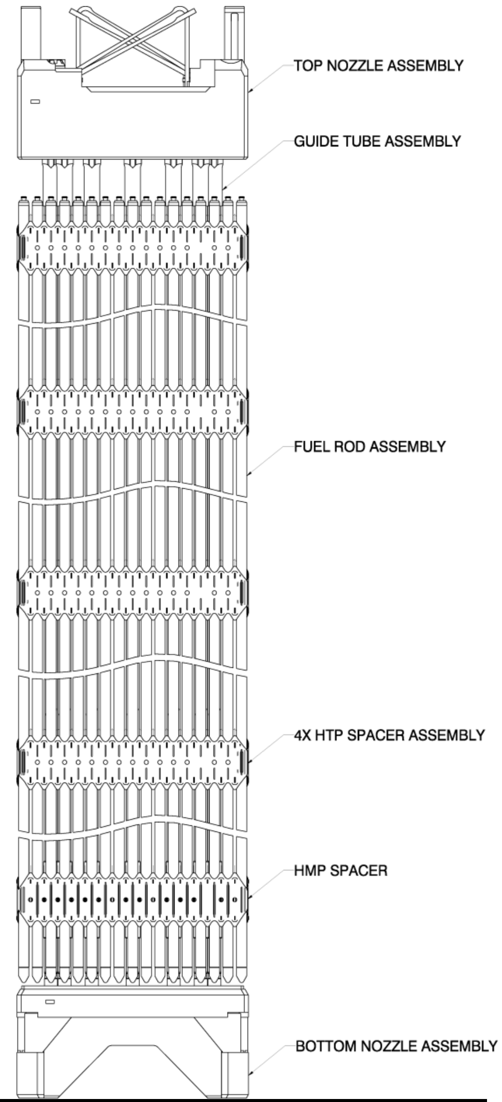
Requests for Additional Information

- 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^{TM} Design Overview

- NuFuel-HTP2^{TM} based on Framatome's proven US 17x17 PWR technology
- NuFuel-HTP2^{TM} 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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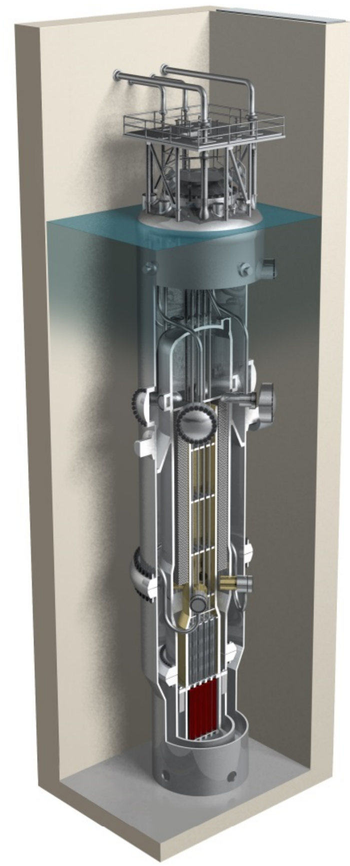

Presentation to the ACRS Full Committee

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

September 5, 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 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)

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

Non-Proprietary

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

NuScale Fuel Design

- Based on Framatome 17 by 17 HTP design
  - M5 fuel pin cladding
  - Zirc-4 guide tubes
  - HTP^{TM} grids
  - HMP^{TM} 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.

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?