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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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MONDAY

APRIL 16, 2018

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 1:01 p.m., Ronald G. Ballinger, Chairman, presiding.

COMMITTEE MEMBERS:

RONALD G. BALLINGER, Chairman

DENNIS BLEY, Member*

MICHAEL CORRADINI, Member

JOY REMPE, Member

GORDON R. SKILLMAN, Member
MATTHEW W. SUNSERI, Member

ACRS CONSULTANT:
STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:
MICHAEL SNODDERLY

ALSO PRESENT:
PAUL CLIFFORD, NRR
SARAH FIELDS, Public Participant*
VICTOR HATMAN, Framatome
NICHOLAS KLYMYSHYN, PNNL
BRETT MATTHEWS, Framatome
JONATHAN ROWLEY, NRR

*Present via telephone

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P R O C E E D I N G S

1:01 p.m.

CHAIRMAN BALLINGER: This meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, NuScale Subcommittee. I'm Ron Ballinger, aka Roland, chairman for today's subcommittee meeting.

Members in attendance today are Dick Skillman, Mike Corradini, Matt Sunseri, Joy Rempe, and our consultant, Steve Schultz. And I think that Dennis Bley is on the phone. And we may --

MEMBER BLEY: Yes, he is.

CHAIRMAN BALLINGER: Very good. And we may have one other member, Pete Riccardella, if he doesn't get chosen for jury duty.

The ACRS was -- the subcommittee will receive an informational briefing to prepare to review the staff's evaluation of NuScale's topical report, TR-0716-50351-P, NuScale applicability of AREVA method for the evaluation of fuel assembly structural response to externally applied forces. Today we have members from the NRC, our staff, and Framatome to brief the subcommittee.

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

That means that the Committee can only speak to through its published letter reports. We hold meetings to gather information to support our deliberations.

Interested parties who wish to provide comments can contact our office requesting time after the meeting announcement is published in the Federal Register. That said, we set aside ten minutes for comments from members of the public attending our listening in our meetings.

Though I should remember that Mike Snodderly is the federally designated official for this meeting. The ACRS section of the US NRC public website provides our charter bylaws, letter reports, and full transcripts of all full and subcommittee meetings, including slides presented there.

The rules for participation in today's meeting were announced in the Federal Register on April 13th, 2018. The meeting was announced and is an open and closed meeting. We will close the meeting after the open portion to discuss proprietary material, and presenters can defer questions that should not be answered in the public session at that time --- to that time. No statement or request for making an oral statement to the Subcommittee has been received from the public concerning this meeting.

Our transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. Therefore, we request that participants in this meeting use the microphones. That means make sure the little green light is on when you speak and off when you're not speaking. Participants should first identify themselves and speak with sufficient clarity and volume so they can be readily heard.

We have a bridge line established for the public to listen to the meeting. We also have another bridge line established for Framatome and ACRS people. To avoid disturbance, I request that attendants put their electronic devices like cell phones in the off or noise free mode.

We will now proceed with the meeting. I will call on, let's see --

MEMBER REMPE: Ron, before we start, do we have hard copies of the slides?

MR. SNODDERLY: Yes, sorry.

MEMBER REMPE: Okay, ha, ha, ha.

CHAIRMAN BALLINGER: I'm just so used to having things electronically, that I just don't ---

MEMBER REMPE: Yes. Well, that situation

with the slides, I'd like copies of all of them today. I do get them, but yes.

MR. SNODDERLY: And then, Ron, one other thing before we get started, can we confirm that Framatome is on the phone line?

CHAIRMAN BALLINGER: Yes.

(Off microphone comments.)

MR. SNODDERLY: Oh, is there anyone from NuScale on the line?

CHAIRMAN BALLINGER: Well, they don't have to be here.

MR. SNODDERLY: No, they don't have to. I just --- I was curious. Okay, yes, let's --- Paul?

CHAIRMAN BALLINGER: Okay, Paul. I mean, is there anybody in management that would like to make a statement?

MR. ROWLEY: Well, I'm not technically management, project manager is my title, but I'll give opening remarks for the NRC. Thank you for having us today. My name is Jonathan Rowley. I'm the project manager for Framatome activities that come into the NRC.

Today, myself, Nick Klymyshyn, and Paul Clifford will give you some information on our review of ANP-10337. We know this is important to you to assist you with your review of the NuScale. So hopefully the information you find today will be sufficient to help you with that. So with that, I'll turn it over to Paul Clifford for the NRC's presentation.

MEMBER REMPE: So I have another question. I'm just full of them, or something, ha, ha. But we won't go there on that. But okay, so the materials we were given for this do not include the staff SE of this ANP document.

MR. ROWLEY: They do not, ma'am.

MEMBER REMPE: Pardon?

MR. ROWLEY: No, they do not.

MEMBER REMPE: So the ground rules are a bit strange, because we're supposed to, in the future, review NuScale's topical on the applicability of this fuel for their reactor. We can see the ANP document from Framatome, but we can't see the staff SE and their evaluation of it apparently. Is that the ground rules, and there was some agreement made on that?

MEMBER CORRADINI: Well, if I might try, so we asked for an information briefing to try to understand the background of the Framatome/AREVA analysis which is being referred to in terms of applicability for the NuScale design. We have no intention nor, I think, it was agreement with the staff that we wanted to write a letter or even entertain a review of the staff's SE, strictly we wanted to get background information for the applicability topical. So the short answer is yes.

MEMBER REMPE: Okay. I don't know. I guess I don't remember this being agreed to by all of ACRS. But if we did, and I've forgotten, I guess I misunderstood the ground rules. Because if I look at what I see in the Framatome document, there're some things that I have questions about, like simulated irradiation.

And I just am kind of curious. Are we allowed to ask questions about their review? Because apparently the staff has approved this ANP document. So are we supposed to say, okay, it's approved. So we only can do the delta on how this approved fuel applies to NuScale, even though we may not fully understand what's meant by some of the things in the ANP document.

MR. ROWLEY: Well, the SE has not been approved yet. We're in the direct SE stage. So that is soon to be issued to Framatome for their review and comment. But our position is not finalized just yet. So we are leaning toward approval, but it's not approved yet.

MEMBER REMPE: So we are allowed to ask questions about what's in the ANP document. Because I just want to make sure. Because I'm going to be asking questions that you probably have in your SE. But I didn't --- I want everyone to understand why I'm going to be asking those questions and if they are allowed before I get into this meeting.

MEMBER CORRADINI: You can ask anything you want.

MEMBER REMPE: Yes.

CHAIRMAN BALLINGER: As always.

MEMBER REMPE: Well, just wanted to understand and make sure you understand that I couldn't see everything to prepare for this meeting.

(Off the record comments)

CHAIRMAN BALLINGER: Make sure you little light is on.

MR. CLIFFORD: It is somewhat of an awkward situation, because you're right. Usually we finish our topical report, we submit it to the ACRS, you have time to review the staff's safety evaluation, then you ask questions on how we did our review.

But this is a little different. I think you're free to ask any questions you want to Framatome to understand their methodology better so that you understand how it will be applied to NuScale. And I'll do my best to answer any questions on our review. But it's still open, so it is a little awkward.

CHAIRMAN BALLINGER: It's an informational meeting.

MEMBER REMPE: Well, are we going to see your SE before we ever get to the final approval of this topical for NuScale? That was the other question. Because I would like to see it. And I was a little puzzled when I was told, no, no, you can't see that. So I'd like to make sure that doesn't happen.

MR. SNODDERLY: Some other background, so this topical, along with a number of other topicals, was presented to the ACRS and the subcommittee chairman for review. And we said that we didn't think it warranted review. So it did not come to P&P, but it was --

MEMBER REMPE: But it was a decision by a subcommittee ---

MR. SNODDERLY: There was a decision that, you know, for operating plants with other workload, who knows why. But that is one reason why, you know, we did have an opportunity. We said we didn't want to review it. But we did want to review the applicable --

MEMBER REMPE: I thought usually those things came to full ACRS for P&P. But anyhow, I guess, whatever.

MR. SNODDERLY: That's my understanding. So we're here, we have a status. I mean, we can --

MEMBER CORRADINI: But let's just clarify what Mike said so there's no confusion. The topical report on the structural thing came up through P&P, and we passed. And in our normal P&P procedures, we passed. We can look back, but it wasn't even this year. It was a couple of years ago.

MEMBER REMPE: Well, I'm a little --- I guess I didn't fully understand that we'd be put in this situation at this meeting. So that's why I just wanted to bring it up on the record. Thank you.

CHAIRMAN BALLINGER: Sure.

MR. SCHULTZ: Paul, what's the approximate time of your completion and interaction with Framatome?

MR. CLIFFORD: Well, the technical staff, we've completed our draft SE. And then it goes to DPR. Do they still call it DPR?

MR. ROWLEY: DOP.

MR. CLIFFORD: Ha, ha, ha. And then they complete the safety evaluation.

MR. ROWLEY: So, Mr. Schultz, let me answer your question. We will have it finished by next month.

MR. SCHULTZ: That's fine. Thank you.

MR. CLIFFORD: Okay. So I'm here today. I've just got ten brief slides just to kind of give you some background of what the regulatory requirements are. And that'll help start the conversation with how AREVA's addressed each of the regulatory requirements in their topical report.

So it's broken into --- first, I'll identify the applicable regulations, and then separately I'll talk about the requirements for the operating basis earthquake, the OBE, the safe shutdown earthquake, SSE. And then we'll be getting into some combined events.

So GDC-2, and it's listed at the bottom here in its entirety on the slide, is all about defense in-depth. And what I mean by that is that safety related system structures and components, including fuel, must be designed to withstand the effects of earthquakes without loss of capability to perform their intended safety functions.

Now, this includes combined effects of both the natural phenomena, in this case the earthquake, in combination with whatever accident-induced loads there are, for each of the components to perform their intended function under those particular accident conditions.

10 CFR 50, Appendix S implements GDC-2 specifically for earthquakes. It establishes the definitions of OBE and SSE and identifies what SSCs are required to perform their functions. Specifically, SSEs are necessary to assure, one, the integrity of the reactor coolant pressure boundary, two, the capability to shut down the reactor and maintain it in safe shutdown conditions, and three, the capability to prevent or mitigate the consequences of accidents that would result in potential offsite exposures. That's directly from the regulation.

Now, how do those regulations then translate to specific types of accidents? We'll start with the OBE. An OBE is not a postulated accident. It's expected to occur during the lifetime of the reactor. Plants are not required to shut down following a seismic event up to OBE ground motion and may restart without NRC involvement and without inspection. And that includes even if they're tripped on other signals, such as a loss of offsite power.

All system structures and components important to continued safe operation, that would be safety related and non-safety related, must remain functional and within their applicable stress rate and deformation limits.

So basically, this is -- an OBE is treated just like any design-basis analysis that you need to do. You have to design each of your components to withstand some of the reactor trips, be capable of dealing with everyday stresses of normal operation. OBE gets lumped into that.

Now we get into safe shutdown earthquake. This is a postulated accident. It's not expected to occur during the life of the plant. And the reactors must shut down following any seismic event beyond OBE ground motion.

When we're talking about fuel assembly components, we deal with the three key safety functions. And that is that the fuel rod cladding maintains a fission product barrier, the spacer grids maintain geometry, and the guide tubes maintain a pathway for control rod movement.

So when we're talking specifically about what are the design requirements for the fuel components themselves, we deal with their safety functions. And they must be capable of maintaining those safety functions.

But what has been kind of the source of confusion are these other concepts that I'm getting into now. There are three concepts on this slide that are all very important.

First of all the first bullet, in getting back to GDC-2, back in the defense in depth requirements, that the system structures and components important to safety must be capable of performing their intended function when exposed to the combined loads of SSE ground motion in combination with the functional and accident loads during the accident for which the SSE is designed to mitigate.

This is kind of a source of confusion, because you can imagine, well, you could logically argue that if you have seismically qualified RCS piping, then why would you need to postulate loads associated with an earthquake in combination with loads associated with a LOCA if, in fact, the systems were designed to withstand the earthquake. In other words, the earthquake doesn't initiate the LOCA.

This goes back to defense and depth. So it's not causal effects, it's not that the earthquake is causing the LOCA, or the earthquake is causing a loss of offsite power. The earthquake is causing any other potential accident. It's just defense in depth. Your safety related components must be designed to withstand these combined effects, even though they're not causal.

MEMBER CORRADINI: I hear what you're saying. I want to make sure though that I appreciate the difference. Because from the standpoint of analysis, it doesn't matter whether it was causal or not. You're saying that you have an additive of ---

MR. CLIFFORD: Yes.

MEMBER CORRADINI: Okay. So it doesn't matter how I got a loss of coolant, it doesn't matter how I had a small break LOCA, it doesn't matter how I had whatever failure it is. I first had the seismic event, and I have this initiator --- something's initiated and I have to show that they can survive both together.

MR. CLIFFORD: Right. You basically take your accelerations that you calculate separately for your seismic, and then your accelerations and loads that you calculate separately for your LOCA, and you combine them.

MR. SCHULTZ: Paul, when you say that this is caused some confusion, do you mean that you just want to make it clear today that this is what the intent of the language is?

MR. CLIFFORD: Yes.

MR. SCHULTZ: Or do you mean that the licensees or vendors have been confused?

MR. CLIFFORD: I think the staff and the industry has been confused. And maybe I can get to it now. I think in the past you designed components. The easiest one to talk about is your grid cage. Grid cages in the past were very rigid structures, parallel, perpendicular strips of metal that were very rigid.

When you applied a load to them, they would just --- they wouldn't experience a significant plastic deformation. They'd be rigid, and then they would rack. And when they racked, that's when you determined that's your critical load, your buckling load, we call it. Because the strut had buckled. And so you would have to make sure that you designed your system so that you wouldn't buckle.

With modern designs and with the introduction of more limiting assumptions in your seismic analysis, that being you've got these design certifications, so you have these new reactors coming in. They want to build one reactor anywhere. So they look at the worst envelope. They take the worst soil conditions, the worst seismic accelerations, and they want to say, well, I can build one assembly cage that will survive the worst of the worst. That way I can market it anywhere in the world. I'm not restricted to where I place this reactor.

And as a result, you're seeing more pipe loads. And you also have new grid cage designs that will experience more --- have more flexibility, more ductility as a component. So they'll absorb more of that energy. They'll start to deform before they buckle. So you have to take that into account.

MEMBER BALLINGER: So what you're saying, again, is that since the calculation doesn't care whether you call it a safe shutdown earthquake or a LOCA, if you add the loads together it's like having loads above and beyond a safe shutdown earthquake.

MR. CLIFFORD: Yes.

MEMBER BALLINGER: So it's, in effect, the same as increasing the safe shutdown earthquake.

MEMBER REMPE: So that philosophy, if you're trying to combine loads, the thing about, like, when you irradiate something, and you cook and look, shouldn't you have a load that's under affluence in addition to an acceleration? I mean, how far do you go with combined loads? If you take it out of the reactor, you're no longer exposing it to the radiation. Do you see what I'm kind of saying? How far do you want to go with combined loads?

MR. CLIFFORD: Okay. I mean, I think we can get into more details of how they run the tests and how they determine what the critical loads are at their defined failure points and then how they verify those loads with their finite element methods, models. Maybe when we get into that, that'll make more sense.

MEMBER REMPE: Yes. I just am kind of wondering though. I mean, that's a combined load too.

MR. CLIFFORD: Yes. Right. Okay, so the second, I think, key concept is the second bullet here.

I think the capability to perform their function, whether it's a safety related valve that needs to close, or it's a safety related pump that needs to start up and inject borated water, or maybe it's a safety related trip function which has to initiate a reactor trip, or your guide tubes have to stay in a configuration where you can free fall your control rods, the ability for those to perform their intended function is often judged against the performance of the fuel during those accident conditions, and functionality being both capability and timing of the actions.

And this is a critical issue, because a reactor trip is a good example. You have a reactor trip. The purpose of that trip is to ensure that you don't fail the cladding so that you don't have offsite consequences.

Well, what does functionality mean, that you still can drop those rods? I mean, if the rods drop, right now you have an analysis that shows if I get a trip at 0.6 seconds, and I get a trip signal at one second, and I decay the magnets holding up my control rods, that takes 0.6 seconds. And then they fall in in 2.3 seconds. The combined time of that, that 3.1 seconds or whatever, I won't fail rods.

But if I delay, because there is, say, deflection in my guide tubes that causes more friction for my free falling control rods, and that delays the bottoming out of those control rods to, say, instead of 2.3 seconds now it's 3.5 seconds, or 4.5 seconds, that safety related function no longer performed its intended function. The intended function was to prevent exposures. But because it was delayed, it didn't perform its intended function. Do you understand?

So it's timing. It's not just performance function. It's performance function in the time for which the analysis was done.

MEMBER CORRADINI: So I think I hear you, but let me just make sure. But the initiator is superposed regardless of timing, and yet you're worried about timing about the response?

MR. CLIFFORD: Yes.

MEMBER CORRADINI: So that's more conservative than I guess I would have expected. So if I understand your logic with the first bullet, I've got some sort of seismic event, and I have some sort of other initiator. They could happen in some sort of time sequence, but the way the analysis is, those two accelerations and loads are superposed on each other. And then the fuel assembly's got to show survival and the three functions, as you noted on the previous slide.

MR. CLIFFORD: Right.

MR. SCHULTZ: So what you're saying, Paul, is don't just assume you're done when you demonstrate that the rods go in.

MR. CLIFFORD: Right.

MR. SCHULTZ: You have to demonstrate that they go in with sufficient timing to prevent the damage that might occur in the transient.

MR. CLIFFORD: Correct. Because you, I mean, let me get to the next bullet, and I think it kind of wraps it all up.

I think the next bullet --- in the next few slides we're going to start talking about how we combined events, you know, why we combined or how we combined them. So it's important that we introduce this concept that the event combination with the largest combined loads may not necessarily be the most limiting event combination.

It goes back to GDC-2 and Appendix S. You have to show that each system that's important to safety performs its intended function. You've demonstrated somewhere in your licensing basis that each system performs its intended function. And the requirement is under the loads.

So if you have to close a main seam isolation valve, you've designed the main seam isolation valve to close under the loads associated with a steam line break. It has to perform that function under those loads in combination with any loads associated with a safe shutdown requirement. That's the design-basis for that component. It has to perform that function due to defense in depth.

MEMBER CORRADINI: But it might be a different initiator for a different component, that's your point, is what I thought that means.

MR. CLIFFORD: Well, one way to look at it is this. You have your design, this is where I was, you have your functional requirements for each component. And you demonstrate that that component performs its function under its loads. GDC-2 says, well, in addition to that, superimpose loads associated with a safe shutdown requirement.

MEMBER CORRADINI: Okay. Even though the design-basis for each one of those components could be different?

MR. CLIFFORD: It's absolutely different. Each one of them's different. And I think, in the past, the second bullet is a good example here, the last bullet, I mean. What we're saying here is in the past we've always looked at earthquake and then earthquake plus LOCA. That's where we focused our attention.

And that's because you have ground motion associated with earthquake, and you have basically a pipe width or, you know, you have the response of your vessel. The vessel movement is the result of a large steam, I mean, a large water break. So that breaks, the vessel shifts, you can easily see how both of those events separately impose accelerations on your fuel assemblies. And so they're evaluated.

So I think, in the past, people were looking at this and saying, well, what's the limiting event for me? It's going to be, well, which one gives me the highest combination of accelerations? It's going to be LOCA, SSE. And so you evaluate that.

But when you combine those events, what is the design-basis you're trying to demonstrate? It's ECCS, because it's a LOCA. So you look at ECCS, you show that ECCS performs its function. But ECCS is not a very limiting event when it comes to design and fuel performance and the fact that there's no expectation of cladding integrity during a LOCA.

And the real logical consequences are based on extremely bounding assumptions with significant core damage that's unrelated to ECCS performance. So that event, while giving you the maximum accelerations, is not very limiting with respect to the functionality of all the other safety systems that have to be demonstrated with SSE.

MEMBER BALLINGER: So again, so what you're saying is pick the main seam isolation valve, for example.

MR. CLIFFORD: Yes.

MEMBER BALLINGER: It's got a certain design-basis. But you're saying it really doesn't have a design-basis, because the actual design-basis or requirement for operation has to do with multiple loads that are added on top of one another. So in effect, there's an envelope for every SSE important to safety.

MR. CLIFFORD: Well, every load associated with SSE will get combined with each of the components in their evaluation. And there's a plant. They have to evaluate a steam line break. They evaluate a steam line break, they have a limited number of fuel rods that can fail. And that's tied directly into the offsite dose consequences.

They do that analysis, that mean steam isolation valve has to shut in 2.1 seconds. If it doesn't shut at 2.1 seconds, now there's a return to criticality, and you fail 20 percent of the core, and you don't meet your offsite doses. So the demonstration that the plant is designed for a steam line break, including the response of everyone of the systems, not just the main seam isolation valves, is completed in Chapter 15 of your FSAR.

You look at Chapter 15, you can walk through it, and you can show that each one of those components performed its intended function, and you limited offsite consequences to whatever your licensing basis is. And maybe your licensing basis is no fuel failure. So you've done that. But each one of the component design analyses would verify that each component's capable of performing its function.

MEMBER BALLINGER: So if you pull the string on this you're, in effect, saying that every plant is different. So if I put a plant in Idaho versus a plant in California, the main steam isolation valve will not be --- can't be designed until we know what the SSE is or any other loads that are applied to that.

MR. CLIFFORD: Right. With very different seismic envelopes, you're going to have different ---

MEMBER CORRADINI: But there's nothing new to this regulation.

MR. CLIFFORD: There's nothing new to this. There's nothing new, but it was confusing in the past because of the change that I mentioned earlier. In the past, people would look at it and say, okay, if it's changed now, it's become more important, or it's become a bigger source of confusion. It's because you no longer can use a bounding analysis like you used to use.

You used to say, okay, with my rigid structure, my rigid grid cage structure, I have a maximum load before it racks. So it's the same. I just have to make sure that I don't deform my grid, deformation being the buckling, okay.

Now, if you allow plastic deformation, this is the key, if you allow plastic deformation so you start closing the rod pitch, you start changing the thermal-hydraulic channels, if you start changing, you allow this to happen. Now it becomes very sensitive to what other accident you're trying to verify.

LOCA is not sensitive to this. You can take the entire assembly, and you can squeeze it together. But it's not going to make that big of a difference on your P-clad temperature. But it is going to change your DNBR. And if you have a loss if flow event, you can't survive much of a deformation before you start failing rods which means that all the system structures and components that were designed to prevent you from failing those rods no longer perform their intended function.

MEMBER CORRADINI: So I guess I want you to repeat that. Because I --- so what it comes down to is a way in which the structural design has changed is the reason that we have to be more careful, is what I hear you saying.

MR. CLIFFORD: Yes. It's being driven by two things. The first thing is you have cage designs now that will deform before they buckle.

MEMBER CORRADINI: Versus being robust all the way through the SSE?

MR. CLIFFORD: Robust before they buckled.

MEMBER CORRADINI: Correct. I'm sorry, you said it. I didn't say it correctly.

MR. CLIFFORD: Yes.

MEMBER CORRADINI: And there was a second point?

MR. CLIFFORD: The second one was, I think, what we're seeing in NRO space is there just --- they're taking the worst, of the worst, of the worst, so they getting higher acceleration. So they're getting more loads.

MEMBER CORRADINI: Because they wanted to be applicable across ---

MR. CLIFFORD: If I go back to my days of combustion engineering, you would design a 16 by 16 assembly for Palo Verde. And you would design a different 16 by 16 assembly for SONGS. The one at SONGS would have thicker grid straps.

MEMBER CORRADINI: Because it was ---

MR. CLIFFORD: Because it was in a higher seismic envelope. So you would design the fuel for the seismic envelope. So you would have site specific fuel designs. But now, we're not really doing it, we're moving away from that.

MEMBER CORRADINI: Okay.

MEMBER REMPE: I meant to follow-up on Ron's question. You could still have a bounding seismic envelope. So you don't, like, have a different design requirement for a plant in Idaho versus a plant in Wisconsin, right, as long as you found a seismic characteristic?

MR. CLIFFORD: Right. It depends on how much work you want to do analytically versus how much hardware you want to change.

MEMBER REMPE: Yes.

MEMBER BALLINGER: But that's fine for the fuel, because the fuel comes out. And you can change out the fuel. But that was then, this is now. What about this main steam isolation valve for an existing plant?

MR. CLIFFORD: Oh, it's been designed.

MEMBER BALLINGER: It's been designed in accordance with what you're saying, okay.

MR. CLIFFORD: Absolutely. None of this is new. None of this is new. It's just become more important, because now we're seeing deformation, and I'll get to the deformation, whereas in the past we didn't have deformation, allowable deformation of the grid cage.

So here we get to the combined. You can divide it into two. There's SSE+transients and then SSE+LOCA. And you can divide them because SSE+transients, the accelerations on the fuel is not significantly different than SSE alone. Because a loss of flow doesn't cause the core barrel to move which would then add more acceleration to your existing SSE. But a LOCA would.

So I think that's historically why you've seen SSE+LOCA and then SSE. Now, what we're seeing is, to show the functionality of all of your safety related components, there has to be an SSE+transient requirement. And there has to be a demonstration.

MEMBER CORRADINI: But then just to make sure I'm clear, and the reason you've added that additional review space is because of the way the structural design of these newer fuel assemblies are coming out, such that you could get what I'll call non-linear effects that have to be considered.

MR. CLIFFORD: Correct. It's certainly non-linear effects that would affect how you do the analysis, but then just having an allowable deformation. In the past, you didn't have the allowance for deformation. It was dumped to form your grid cage.

MEMBER CORRADINI: End of story.

MR. CLIFFORD: End of story. Now there's -- I sense somewhat of a relaxation to allow deformation. But if you want to allow deformation, you just have to account for it.

So when we talk about SSEs+transients, as I mentioned earlier, you've got many different systems that respond to many different types of accidents, your reactor protection system, your ESFAS, is engineered safety features actuation signal, respond, and both have the response and the timing of the response.

And the second half of the sentence is right from Appendix S, "To assure the integrity of the reactor coolant boundary, capability to shut down the reactor and maintain safe shutdown condition, and the capability to prevent or mitigate the consequences of accidents." So applicants must demonstrate that their RPS and ESFAS are capable of performing the intended safety features when exposed to combined loads, as we've been talking about.

And when you get into allowable grid deformation, this is where it gets a little sticky, in a sense. This plot here shows DNBR degradation during a loss of flow. There's a change in DNBR, there's a function of time. DNBR is decreasing with reactor coolant flow, as your pumps coast down. And then it's turned around as your rods start falling.

So it's very -- it's time-dependent. So it takes the actuations of you have to get a trip function that initiates a trip, you've got to drop your rods. And you've got to do this in a certain sequence, in a certain timing. And it's very dependent on that timing.

If there's an allowance for grid deformation, then that grid deformation may alter the local thermal-hydraulic condition such as delay of DNBR degradation changes. Or if you delay your scram insertion time, then you can just see from this figure, you know, where's it going to bottom up and turn around. If you delay this another second, you've decreased DNBR that much more.

So the demonstration of your SSCs, not SSEs, SSCs, must take into account any allowance for grid deformation and the impacts of that grid deformation on local thermal-hydraulic conditions and scram insertion time.

MEMBER CORRADINI: But your second bullet, as you describe it with the example, is more appropriate for the transient AOOs than it is for the LOCA.

MR. CLIFFORD: Correct.

MEMBER CORRADINI: As I understand it.

MR. CLIFFORD: Right.

MEMBER CORRADINI: Okay, okay. Right, right.

MR. CLIFFORD: LOCA also needs to account for any grid deformations, and those grid deformations may be larger for a LOCA, because you have the combined accelerations which could cause further deflection or deformation of your grid cage. Because that's high loads, because you combine two different loads. But they still have to account for it. But at the same time, it may be less sensitive to changes in geometry.

Let me go back to this one more time. So do you all understand you have Chapter 15 of your EFSAR? We've analyzed all of the accidents that you're required to analyze, and you've performed the demonstration analysis where you've demonstrated that using all of these systems that are surveilled in your tech specs, that have set points that are dictated in the licensing basis of the plant, if everything performs as designed, you will meet the requirements of your license.

And every event has a different requirement. And GDC-2 and Appendix S says that all those systems that have to respond to each one of those accidents have to be designed to survive your SSE loads in combination with whatever loads are associated with the accident they're trying to mitigate.

So if you allow something to occur that changes the geometry, the base geometry of your fuel, or changes how the control rods insert, that has to be fed into your Chapter 15 analysis. Otherwise, you don't have a demonstration analysis for your entire plant's design. So whereas 20 years ago or so when we said no deformation, then a loss of flow or a loss of flow with SSE, there was no difference, because there was no deformation.

MEMBER CORRADINI: So I'm sure the applicant who you're reviewing is going to tell us, but from your perspective, what's the benefit in having a flexible grid structure?

MR. CLIFFORD: I would leave that to ---

MEMBER CORRADINI: Because what you're telling --- what I'm hearing you telling me in a very precise but limited way is that I've changed my design philosophy. My design philosophy must account for non-linear effects, I won't say non-linear, will account for effects that have a potential change in geometry which brings in a whole class of transients that would never have to be considered.

MR. CLIFFORD: Correct.

MEMBER CORRADINI: Simply because I could rest assured that the geometry remained the same after the seismic event. That's what I hear you saying.

MR. CLIFFORD: Correct. And designs are changing. And you could say they're probably being driven to improve your thermal-hydraulic performance. You get mixing veins, you get differences to provide enhancements, and heat transfer, and that type of thing.

MEMBER CORRADINI: Okay, thank you.

MR. CLIFFORD: Okay, so that was

SSE+transients. Now we're kind of getting to SSE+LOCA. We all are familiar with this. ECCS is a safety related system to mitigate the consequences of a LOCA. You have to meet 5046 analytical limits to ensure coolable core geometry in accordance with GDC-35.

Applicants must demonstrate that the ECCS is capable of performing its intended safety function when exposed to the combined loads. And that means you have to maintain a coolable geometry, show that fuel rod fragmentation does not occur, you meet the specific analytical requirements of PCT and maximum LOCA oxidation to show that maintained ductility so you don't shatter your fuel upon quench. You maintain material insertion if required, and you remove long term decay heat. And if there is an allowance for grid permanent deformation, that must be accounted for in your ECCS performance demonstration.

So those are the regulatory requirements. Any further questions?

MEMBER CORRADINI: If I might, just ask it differently. The anticipation is, with this new design, with this modified design philosophy, that there is potentially not a difference in challenge here as much as there'd be a challenge on the transient side. That's the impression I'm left with in your discussion.

MR. CLIFFORD: You mean from a LOCA perspective?

` MEMBER CORRADINI: Right.

MR. CLIFFORD: It's no different. It's no different.

MEMBER CORRADINI: Right.

MR. CLIFFORD: If you can go to the EFSAR for several plants today, and you'll see a LOCA analysis, and then you'll see a special SSE+LOCA analysis where they've decreased the rod to rod spacing and they've redone their LOCA assessment to show that they're stable at 2,217 percent. But you're not going to see the same in any other event.

MEMBER CORRADINI: Okay. That helped, thank you.

MR. CLIFFORD: Another thing that's important to mention is that it's not just the changes in how NRO, how they use bounding analyses, bounding inputs to their seismic, or the change in grid strap. But there's also, you know, we identified that these irradiation effects have a first order effect on the fuel assembly's response --

So when they take that into account, you know, this new information, they realize that some of their --- maybe their previous assumptions weren't --- I wouldn't say accurate, but just didn't account for the new phenomena. Are we good?

(No audible response)

MR. CLIFFORD: Okay. Next on the agenda is Framatome.

MEMBER BALLINGER: Well, we have a few things we have to do first. Since this is the only open session version, we now need to ask if there are, well, there are no members of the public here. So we need to ask if there is anybody on the public phone line that would like to make a comment. So the line's open, right.

MR. SNODDERLY: Yes. Is Sarah Fields there?

MS. FIELDS: Yes, I am.

MR. SNODDERLY: Okay. Just want to make sure you're there.

MS. FIELDS: Yes. It's a challenge to understand everything and wrap my head around it. So this is just --- I wonder how this is going to affect this NuScale design certification application. In the beginning, you mentioned the topical report, but that wasn't --- I didn't quite catch which topical report that was.

MEMBER CORRADINI: Ms. Fields, you can submit --- we can't answer the questions as we're in the middle of the meeting. But if there's questions you need clarification on, you can send an email to Mike Snodderly, and he will answer your questions.

MR. SNODDERLY: Yes, so Sarah ---

MS. FIELDS: All right. Okay, I'm just supposed to make a comment.

MR. SNODDERLY: Yes, that's ---

MS. FIELDS: Yes. Well, thank you. And I will just send a few questions to Mr. Snodderly.

MEMBER CORRADINI: Right, and ---

MR. SNODDERLY: I'll take an action item, Ms. Fields, to send you the publicly available NuScale report. It won't have the proprietary information. It'll be blacked out. But I think that's what you were asking. And then that report refers to this report, okay.

MS. FIELDS: And I do wonder how this --- this is just a comment --- how the public will be able to review this information and a lot of other information that is not made publicly available in this design certification process and after, you know, as you go on with the rest of your meeting today, which is not going to be available to the public.

Oh, another comment is I hope you will get the transcript for this meeting and the transcript for the previous meeting up on the ACRS website page as soon as possible. Thank you.

MEMBER BALLINGER: Thank you. Are there any other members of the public that would like to make a comment?

(No audible response)

MEMBER BALLINGER: Hearing none, we need to close the line. And we need to go into closed session. And so that means that folks need to verify that there's nobody here that they don't want to be here.

(Whereupon, the above-entitled matter went off the record at 1:46 p.m.)

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UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Regulatory Requirements Associated with Fuel Assembly Performance Under Seismic and LOCA Conditions

ACRS NuScale Subcommittee
March 21, 2018

Paul M. Clifford
Division of Safety Systems
Nuclear Reactor Regulation

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Agenda

1. Applicable Regulations
2. Operating Basis Earthquake (OBE)
3. Safe Shutdown Earthquake (SSE)
4. Combined SSE+Transient
5. Combined SSE+LOCA

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Applicable Regulations

- 10 CFR 50 Appendix A, *General Design Criteria for Nuclear Power Plants* (GDC), Criterion 2, *Design bases for protection against natural phenomena*
  - SSCs important to safety, including reactor fuel, shall be designed to withstand the effects of earthquakes without loss of capability to perform their safety functions
  - combinations of the effects of normal and accident conditions with the effects of the natural phenomena

Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena and (3) the importance of the safety functions to be performed.

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Applicable Regulations (cont)

- 10 CFR 50 Appendix S, *Earthquake Engineering Criteria for Nuclear Power Plants*
  - Establishes definitions for the Operating Basis Earthquake (OBE), Safe Shutdown Earthquake (SSE), and safety requirements for relevant SSCs
  - Implements GDC-2

Operating basis earthquake ground motion (OBE) is the vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public will remain functional.

Safe-shutdown earthquake ground motion (SSE) is the vibratory ground motion for which certain structures, systems, and components must be designed to remain functional.

Structures, systems, and components required to withstand the effects of the safe-shutdown earthquake ground motion or surface deformation are those necessary to assure:

(1) The integrity of the reactor coolant pressure boundary;

(2) The capability to shut down the reactor and maintain it in a safe-shutdown condition; or

(3) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of § 50.34(a)(1).

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OBE Requirements

- OBE is **<u>not</u>** a postulated accident and is expected to occur during the lifetime of the reactor. Plants are **<u>not</u>** required to shut down following a seismic event up to the OBE ground motion, and may restart (without NRC involvement) if tripped on other signals during the event (e.g., loss of switchyard or offsite power).

- SSCs necessary for **continued safe operation** must remain functional and within applicable stress, strain, and deformation limits.
  - All fuel assembly components maintain operational functionality

(I) When subjected to the effects of the Operating Basis Earthquake Ground Motion in combination with normal operating loads, all structures, systems, and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public must remain functional and within applicable stress, strain, and deformation limits.

SSE Requirements

- SSE is a postulated accident and is not expected to occur during the lifetime of the reactor. Plants are required to shut down following a seismic event beyond OBE ground motion.

- With respect to fuel performance, applicant must demonstrate that fuel assembly components are capable of performing their intended safety functions under SSE conditions:
  - Fuel rod cladding maintains fission product barrier
  - Spacer grids maintain geometry of fuel bundle array
  - Guide tubes maintain pathway for control rod movement

(ii) The nuclear power plant must be designed so that, if the Safe Shutdown Earthquake Ground Motion occurs, certain structures, systems, and components will remain functional and within applicable stress, strain, and deformation limits. In addition to seismic loads, applicable concurrent normal operating, functional, and accident-induced loads must be taken into account in the design of these safety-related structures, systems, and components.

SSE Requirements (cont.)

- SSCs important to safety must be capable of performing their intended function when exposed to the **combined loads** of SSE ground motion in combination with functional and accident loads (during the accident for which the SSC is designed to mitigate).

- Capability to perform their intended function often judged against the fuel rod's performance under a wide range of accident conditions
  - Functionality being both capability and timing of action

- Maximum combined loads associated with SSE+LOCA; however, acceptance criteria used for judging functionality of SSCs may be less restrictive under LOCA conditions relative to other transients.
  - For example, during a postulated LOCA there is no expectation of fuel rod cladding integrity and offsite dose calculations are based on bounding assumption of significant core damage

SSE+Transient Requirements

- For AOOs and non-LOCA transients, RPS and ESFAS actions and the timing of these actions are essential to assure the integrity of the reactor coolant boundary, the capability to shut down the reactor and maintain it in a safe-shutdown condition, and the capability to <u>prevent</u> **or** <u>mitigate</u> the consequences of accidents that could result in potential offsite exposures.

- Applicant must demonstrate that RPS and ESFAS are capable of performing their intended safety functions when exposed to the **combined loads** of SSE ground motion in combination with functional and accident loads during the accident for which the SSC is designed to mitigate.

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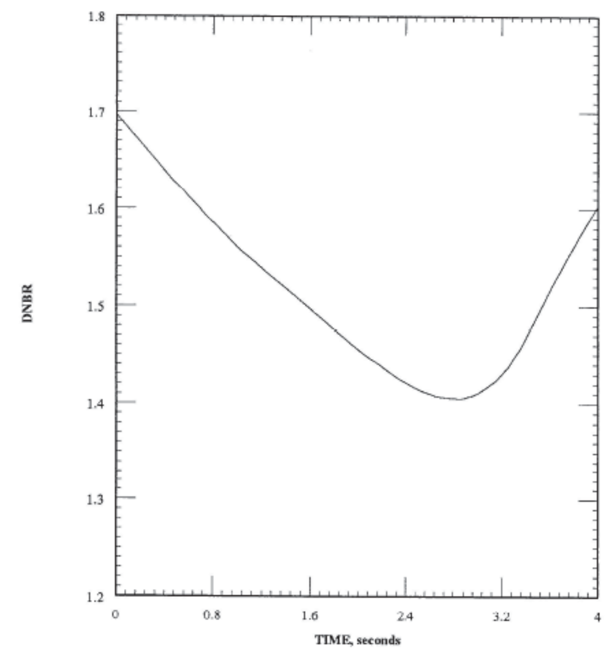
Allowable Grid Deformation

- Spacer grid deformation potentially creates an unanalyzed condition relative to the UFSAR analysis-of-record (performance demonstration)
  - May alter local thermal-hydraulic conditions
  - May delay scram insertion

- The demonstrated performance of SSC's designed to prevent or mitigate the consequences of accidents, including the timing of such actions, would need to account for impacts associated with changes in local TH conditions and scram insertion.



Loss of Forced Flow – MDNBR vs Time

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SSE+LOCA Requirements

- Emergency Core Cooling System (ECCS) is a safety-related system credited to mitigate the consequences of a postulated LOCA.
  - 50.46 analytical limits ensure a coolable core geometry in accordance with GDC-35
- Applicants must demonstrate that ECCS is capable of performing its intended safety function when exposed to the **combined loads** of SSE ground motion in combination with functional and accident loads during a LOCA.
  - Maintain a coolable geometry
    - Fuel rod fragmentation does not occur
    - ECCS performance must satisfy 50.46 requirements
  - Control rod insertability maintained, if required
  - Long-term decay heat removal
- Allowable spacer grid permanent deformation (resulting from combined SSE+LOCA loads) must be accounted for in ECCS performance demonstration.