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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  
+ + + + +  
MONDAY  
APRIL 16, 2018  
+ + + + +  
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

1 GORDON R. SKILLMAN, Member

2 MATTHEW W. SUNSERI, Member

3

4 ACRS CONSULTANT:

5 STEPHEN SCHULTZ

6

7 DESIGNATED FEDERAL OFFICIAL:

8 MICHAEL SNODDERLY

9

10 ALSO PRESENT:

11 PAUL CLIFFORD, NRR

12 SARAH FIELDS, Public Participant\*

13 VICTOR HATMAN, Framatome

14 NICHOLAS KLYMYSHYN, PNNL

15 BRETT MATTHEWS, Framatome

16 JONATHAN ROWLEY, NRR

17

18 \*Present via telephone

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T-A-B-L-E O-F C-O-N-T-E-N-T-S

Opening Remarks

by Ron Ballinger . . . . . 4

Fuel Seismic/LOCA Regulatory Regulatory Requirements

by Paul Clifford . . . . . 13

Public Comments . . . . . 39

Move to Closed Session . . . . . 41

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

1:01 p.m.

1  
2  
3 CHAIRMAN BALLINGER: This meeting will now  
4 come to order. This is a meeting of the Advisory  
5 Committee on Reactor Safeguards, NuScale Subcommittee.  
6 I'm Ron Ballinger, aka Roland, chairman for today's  
7 subcommittee meeting.

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

12 MEMBER BLEY: Yes, he is.

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

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

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

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

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

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

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

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1 received from the public concerning this meeting.

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

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

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

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

21 MR. SNODDERLY: Yes, sorry.

22 MEMBER REMPE: Okay, ha, ha, ha.

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

25 MEMBER REMPE: Yes. Well, that situation



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

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

6 CHAIRMAN BALLINGER: Yes.  
7 (Off microphone comments.)

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

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

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

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

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

23 Today, myself, Nick Klymyshyn, and Paul  
24 Clifford will give you some information on our review  
25 of ANP-10337. We know this is important to you to

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1 assist you with your review of the NuScale. So  
2 hopefully the information you find today will be  
3 sufficient to help you with that. So with that, I'll  
4 turn it over to Paul Clifford for the NRC's  
5 presentation.

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

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

12 MEMBER REMPE: Pardon?

13 MR. ROWLEY: No, they do not.

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

21 MEMBER CORRADINI: Well, if I might try,  
22 so we asked for an information briefing to try to  
23 understand the background of the Framatome/AREVA  
24 analysis which is being referred to in terms of  
25 applicability for the NuScale design. We have no

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1 intention nor, I think, it was agreement with the  
2 staff that we wanted to write a letter or even  
3 entertain a review of the staff's SE, strictly we  
4 wanted to get background information for the  
5 applicability topical. So the short answer is yes.

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

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

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

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1 approved yet.

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

9 MEMBER CORRADINI: You can ask anything  
10 you want.

11 MEMBER REMPE: Yes.

12 CHAIRMAN BALLINGER: As always.

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

16 (Off the record comments)

17 CHAIRMAN BALLINGER: Make sure your little  
18 light is on.

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

24 But this is a little different. I think  
25 you're free to ask any questions you want to Framatome

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1 to understand their methodology better so that you  
2 understand how it will be applied to NuScale. And  
3 I'll do my best to answer any questions on our review.  
4 But it's still open, so it is a little awkward.

5 CHAIRMAN BALLINGER: It's an informational  
6 meeting.

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

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

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

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

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1 review it. But we did want to review the applicable  
2 --

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

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

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

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

18 CHAIRMAN BALLINGER: Sure.

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

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

25 MR. ROWLEY: DOP.

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

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

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

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

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

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

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

7           10 CFR 50, Appendix S implements GDC-2  
8 specifically for earthquakes. It establishes the  
9 definitions of OBE and SSE and identifies what SSCs  
10 are required to perform their functions.  
11 Specifically, SSEs are necessary to assure, one, the  
12 integrity of the reactor coolant pressure boundary,  
13 two, the capability to shut down the reactor and  
14 maintain it in safe shutdown conditions, and three,  
15 the capability to prevent or mitigate the consequences  
16 of accidents that would result in potential offsite  
17 exposures. That's directly from the regulation.

18           Now, how do those regulations then  
19 translate to specific types of accidents? We'll start  
20 with the OBE. An OBE is not a postulated accident.  
21 It's expected to occur during the lifetime of the  
22 reactor. Plants are not required to shut down  
23 following a seismic event up to OBE ground motion and  
24 may restart without NRC involvement and without  
25 inspection. And that includes even if they're tripped

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1 on other signals, such as a loss of offsite power.

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

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

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

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

24 So when we're talking specifically about  
25 what are the design requirements for the fuel

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1 components themselves, we deal with their safety  
2 functions. And they must be capable of maintaining  
3 those safety functions.

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

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

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

24 This goes back to defense and depth. So  
25 it's not causal effects, it's not that the earthquake

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1 is causing the LOCA, or the earthquake is causing a  
2 loss of offsite power. The earthquake is causing any  
3 other potential accident. It's just defense in depth.  
4 Your safety related components must be designed to  
5 withstand these combined effects, even though they're  
6 not causal.

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

12 MR. CLIFFORD: Yes.

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

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

25 MR. SCHULTZ: Paul, when you say that this

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1 is caused some confusion, do you mean that you just  
2 want to make it clear today that this is what the  
3 intent of the language is?

4 MR. CLIFFORD: Yes.

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

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

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

22 With modern designs and with the  
23 introduction of more limiting assumptions in your  
24 seismic analysis, that being you've got these design  
25 certifications, so you have these new reactors coming

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1 in. They want to build one reactor anywhere. So they  
2 look at the worst envelope. They take the worst soil  
3 conditions, the worst seismic accelerations, and they  
4 want to say, well, I can build one assembly cage that  
5 will survive the worst of the worst. That way I can  
6 market it anywhere in the world. I'm not restricted  
7 to where I place this reactor.

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

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

19 MR. CLIFFORD: Yes.

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

22 MEMBER REMPE: So that philosophy, if  
23 you're trying to combine loads, the thing about, like,  
24 when you irradiate something, and you cook and look,  
25 shouldn't you have a load that's under affluence in

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1 addition to an acceleration? I mean, how far do you  
2 go with combined loads? If you take it out of the  
3 reactor, you're no longer exposing it to the  
4 radiation. Do you see what I'm kind of saying? How  
5 far do you want to go with combined loads?

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

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

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

17 I think the capability to perform their  
18 function, whether it's a safety related valve that  
19 needs to close, or it's a safety related pump that  
20 needs to start up and inject borated water, or maybe  
21 it's a safety related trip function which has to  
22 initiate a reactor trip, or your guide tubes have to  
23 stay in a configuration where you can free fall your  
24 control rods, the ability for those to perform their  
25 intended function is often judged against the

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1 performance of the fuel during those accident  
2 conditions, and functionality being both capability  
3 and timing of the actions.

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

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

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

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1 understand?

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

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

9 MR. CLIFFORD: Yes.

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

20 MR. CLIFFORD: Right.

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

24 MR. CLIFFORD: Right.

25 MR. SCHULTZ: You have to demonstrate that

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1 they go in with sufficient timing to prevent the  
2 damage that might occur in the transient.

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

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

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

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

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1 perform that function due to defense in depth.

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

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

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

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

22 And that's because you have ground motion  
23 associated with earthquake, and you have basically a  
24 pipe width or, you know, you have the response of your  
25 vessel. The vessel movement is the result of a large

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1 steam, I mean, a large water break. So that breaks,  
2 the vessel shifts, you can easily see how both of  
3 those events separately impose accelerations on your  
4 fuel assemblies. And so they're evaluated.

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

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

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

24 MEMBER BALLINGER: So again, so what  
25 you're saying is pick the main seam isolation valve,

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1 for example.

2 MR. CLIFFORD: Yes.

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

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

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

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

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

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

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

21           MR. CLIFFORD: There's nothing new to  
22 this. There's nothing new, but it was confusing in  
23 the past because of the change that I mentioned  
24 earlier. In the past, people would look at it and  
25 say, okay, if it's changed now, it's become more

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1 important, or it's become a bigger source of  
2 confusion. It's because you no longer can use a  
3 bounding analysis like you used to use.

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

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

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

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

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

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

11 MR. CLIFFORD: Robust before they buckled.

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

14 MR. CLIFFORD: Yes.

15 MEMBER CORRADINI: And there was a second  
16 point?

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

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

24 MR. CLIFFORD: If I go back to my days of  
25 combustion engineering, you would design a 16 by 16

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1 assembly for Palo Verde. And you would design a  
2 different 16 by 16 assembly for SONGS. The one at  
3 SONGS would have thicker grid straps.

4 MEMBER CORRADINI: Because it was ---

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

10 MEMBER CORRADINI: Okay.

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

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

20 MEMBER REMPE: Yes.

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

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

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

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

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

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

23 MEMBER CORRADINI: But then just to make  
24 sure I'm clear, and the reason you've added that  
25 additional review space is because of the way the

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1 structural design of these newer fuel assemblies are  
2 coming out, such that you could get what I'll call  
3 non-linear effects that have to be considered.

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

10 MEMBER CORRADINI: End of story.

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

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

22 And the second half of the sentence is  
23 right from Appendix S, "To assure the integrity of the  
24 reactor coolant boundary, capability to shut down the  
25 reactor and maintain safe shutdown condition, and the

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1 capability to prevent or mitigate the consequences of  
2 accidents." So applicants must demonstrate that their  
3 RPS and ESFAS are capable of performing the intended  
4 safety features when exposed to combined loads, as  
5 we've been talking about.

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

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

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

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1 decreased DNBR that much more.

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

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

11 MR. CLIFFORD: Correct.

12 MEMBER CORRADINI: As I understand it.

13 MR. CLIFFORD: Right.

14 MEMBER CORRADINI: Okay, okay. Right,  
15 right.

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

25 Let me go back to this one more time. So

1 do you all understand you have Chapter 15 of your  
2 EFSAR? We've analyzed all of the accidents that  
3 you're required to analyze, and you've performed the  
4 demonstration analysis where you've demonstrated that  
5 using all of these systems that are surveilled in your  
6 tech specs, that have set points that are dictated in  
7 the licensing basis of the plant, if everything  
8 performs as designed, you will meet the requirements  
9 of your license.

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

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

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

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

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

14                  MR. CLIFFORD:    Correct.

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

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

24                  MEMBER CORRADINI:    Okay, thank you.

25                  MR. CLIFFORD:     Okay, so that was

1 SSE+transients. Now we're kind of getting to  
2 SSE+LOCA. We all are familiar with this. ECCS is a  
3 safety related system to mitigate the consequences of  
4 a LOCA. You have to meet 5046 analytical limits to  
5 ensure coolable core geometry in accordance with GDC-  
6 35.

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

19 So those are the regulatory requirements.  
20 Any further questions?

21 MEMBER CORRADINI: If I might, just ask it  
22 differently. The anticipation is, with this new  
23 design, with this modified design philosophy, that  
24 there is potentially not a difference in challenge  
25 here as much as there'd be a challenge on the

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1 transient side. That's the impression I'm left with  
2 in your discussion.

3 MR. CLIFFORD: You mean from a LOCA  
4 perspective?

5 MEMBER CORRADINI: Right.

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

8 MEMBER CORRADINI: Right.

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

16 MEMBER CORRADINI: Okay. That helped,  
17 thank you.

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

25 So when they take that into account, you

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1 know, this new information, they realize that some of  
2 their --- maybe their previous assumptions weren't ---  
3 I wouldn't say accurate, but just didn't account for  
4 the new phenomena. Are we good?

5 (No audible response)

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

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

15 MR. SNODDERLY: Yes. Is Sarah Fields  
16 there?

17 MS. FIELDS: Yes, I am.

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

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

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1 that was.

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

7 MR. SNODDERLY: Yes, so Sarah ---

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

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

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

13 MEMBER CORRADINI: Right, and ---

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

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

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1 which is not going to be available to the public.

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

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

9 (No audible response)

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

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

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18

19

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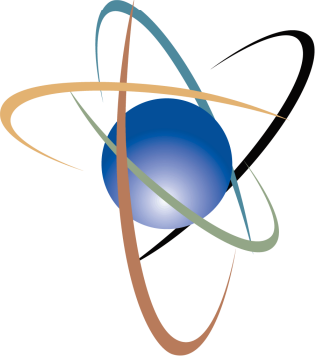
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UNITED STATES NUCLEAR REGULATORY COMMISSION

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

ACRS NuScale Subcommittee

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Nuclear Reactor Regulation



# Agenda

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



# 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, tsunamis, 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.*



# 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).*

# OBE Requirements

- OBE is **not** a postulated accident and is expected to occur during the lifetime of the reactor. Plants are **not** 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
- (1) 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

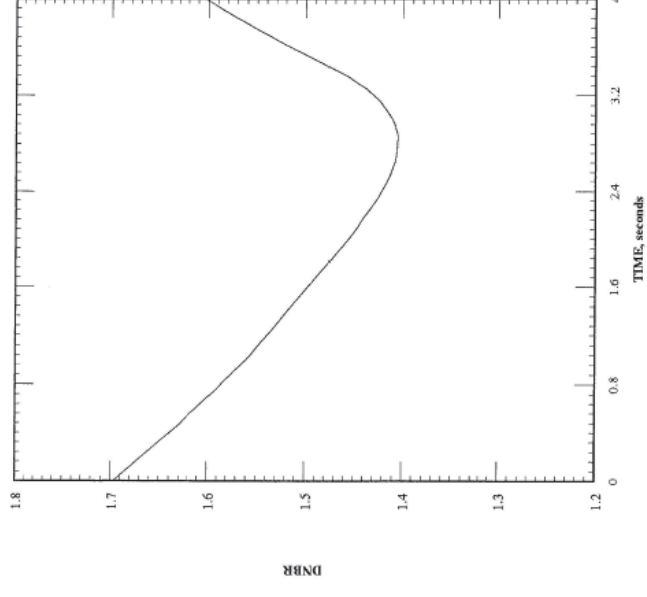


## SSE+Transient Requirements

- 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 prevent or mitigate 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.

# 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.





## 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.