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NUCLEAR REGULATORY COMMISSION

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725TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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OPEN SESSION

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WEDNESDAY

MAY 7, 2025

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The Advisory Committee met via Video Teleconference, at 8:30 a.m. EDT, Walter L. Kirchner, Chair, presiding.

COMMITTEE MEMBERS:

WALTER L. KIRCHNER, Chair

GREGORY H. HALNON, Vice Chair

DAVID A. PETTI, Member-at-Large

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ACRS CONSULTANT:
DENNIS BLEY*
STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:
KENT HOWARD
QUYNH NGUYEN

ALSO PRESENT:
SARAH ABRAMSON, Public Participant
REED ANZALONE, NRR
JONG CHANG, TerraPower
CHRIS FORREST, TerraPower
ZACH GRAN, NRR
MICHELLE HART, NRR
EDWIN LYMAN, Public Participant*
CANDACE DE MESSIERES, NRR
VICTOR E. SAOUMA, University of Colorado
JOE SINODIS, TerraPower
ERIC WILLIAMS, TerraPower
*Present via telephone

CONTENTS

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

8:30 a.m.

CHAIR KIRCHNER: The meeting will now come to order. Good morning all. This is the morning session of the second day of the 725th Meeting of the Advisory Committee on Reactor Safeguards, ACRS. I'm Walt Kirchner, Chairman of the ACRS.

The ACRS Members in attendance, in person, are Ron Ballinger, Vicki Bier, Gregory Halnon, Robert Martin, Scott Palmtag, David Petti, Thomas Roberts, Craig Harrington and Matt Sunseri. ACRS Members in attendance virtually via Teams is MEMBER HARRINGON: Dimitrijevic. Our Consultants participating today virtually are Dennis Bley and Stephen Shultz. If I have missed anyone, either members or consultants, please speak up now.

Kent Howard of the ACRS Staff is the designated federal officer for this morning's full committee meeting. No member conflicts of interest were identified. And I note we have a quorum.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act, or FACA. The NRC implements FACA in accordance with its regulation. Per these regulations, and the Committee's bylaws, the ACRS speaks only through its published letter reports, therefore all member comments should be regarded as only the individual opinion of that member and not the Committee position.

All relevant information to ACRS activity, such as letter, rules for meeting participation and transcripts are located on the NRC public website and can be readily found by typing about us, ACRS, in the search field on the NRC's homepage.

The ACRS, consistent with the Agency's value and public transparency and regulation of nuclear facilities, provides the opportunity for public input and comment during our proceedings. We have received no written statements or requests to make an oral statement from the public. Written statements may be forwarded to today's designated federal officer. And we have also set aside time at the end of this meeting for public comments.

Transcript of the meeting is being kept and will be posted on our website. When addressing the Committee, the participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

If you're not speaking please mute your computer on Teams. If you are participating via phone, press *6 to mute your phone, and *5 to raise your hand on Teams. The Teams chat feature will not be available for use during the meeting.

For everyone in the room, please put all your electronic devices in silent mode, and mute your laptop, computer microphone and speaker. In addition, please keep sidebar discussions in the room to a minimum since the ceiling microphones are live. For the presenters we remind everyone that these microphones are unidirectional and you'll need to speak directly into the front of the microphone to be heard online for the benefit of our court reporter.

Finally, if you have any feedback to the ACRS about today's meeting we encourage you to fill out the public meeting feedback form on the NRC's website.

During this morning's meeting the Committee will consider the following topic. TerraPower Natrium topical report on source term methodology.

As stated in the agenda, portions of this meeting may be closed to protect sensitive information as required by FACA and the government in the Sunshine Act. The attendance during the closed portion of the meeting will be limited to the NRC Staff and its Consultants, Terrestrial Energy and, that's incorrect.

TerraPower. Pardon me. And those individuals and organizations who have entered into appropriate confidentiality agreement. We will confirm that only eligible individuals are in the closed portion of the meeting.

And with that, I will pass this session to Dave Petti and Tom Roberts.

MEMBER PETTI: Okay, good morning, Members. Let's start with Candace de Messieres.

MS. DE MESSIERES: Good morning. And thank you for the opportunity to provide opening remarks today on behalf of the NRC Staff. I am Candace de Messieres, Chief of Advance Reactor Technical Branch II, in the Division of Advanced Reactors and Nonpower Production and Utilization Facilities in the Office of Nuclear Reactor Regulation, or NRR.

We look forward to continued discussion today following the March 19th ACRS TerraPower Subcommittee meeting on TerraPower's radiological source term methodology.

The source term methodology providers for determination of event specific source terms for use in substantive dose analysis. The Staff considered several guidance documents in its review for methodology, including Regulatory Guide 1.183 that articulates technology inclusive attributes of an acceptable access short-term with description of mechanistic source term described in SECY-93-092, information in SECY-18-096 regarding functional containment, and the discussion of mechanistic source term analysis, probabilistic risk analysis element in trial guide 1247.

The Staff's review was also informed by the evaluation model development and assessment process for EMDAP described in Regulatory Guide 1.203 with a focus on modeling of radionuclide transport and retention phenomena to provide mechanistic source terms. Importantly, implementation of the methodology, including specific source term calculations, will be reviewed as part of future licensing applications.

For example, review of source terms is an integral aspect of the Staff's ongoing assessment of the Kemmerer Power Station Unit 1 construction permit application.

In recognition of the importance of confirming adequate source term development implementation, the Staff's draft topical report safety evaluation includes limitations and conditions, ensuring identified activities are completed to a state appropriate for the intended application. This includes aspects such as confirming appropriate use of computer codes, including needs or inputs and assumptions at the construction permit stage, or completion of code verification and validation, and the use of final design information at the operating license stage.

Before turning it over to TerraPower I'll mention that while the NRC Staff are not making a formal presentation today, several staff involved in the review of the topical report, including senior reactor engineer Michelle Hart, reactor scientist Zach Gran, senior engineer, nuclear engineer, Reed Anzalone, and our senior project manager, Mallecia Sutton are present today to support this.

I would like to thank both the Staff and TerraPower for their efforts to prepare for this ACRS Full Committee meeting and express the NRC Staff's appreciation to the ACRS for their review and feedback during the Subcommittee meeting.

We also would like to recognize the ACRS's efforts to realize efficiencies in its review of this and other TerraPower topical reports given synergies between the Lynx topical reports and the ongoing construction permit review. Which will be subject to ACRS review starting later this year.

Thank you again for your time and consideration, and we look forward to the discussion today.

MEMBER PETTI: Thank you, Candace. TerraPower.

MR. WILLIAMS: Good morning, everyone. My name is Eric Williams, I'm a senior vice president from TerraPower and the Natrium project director. Thank you for giving us the opportunity to come and further the discussion on the mechanistic source term methodology.

This is building off of prior discussions and subcommittee. We have chosen to focus today, we're going to cover an overview of the mechanistic source term methodology, but we're going to focus on the functional containment in the context of mechanistic source term. So we'll get into that in a minute.

And then we'll also be reviewing the barriers that go into defining the functional containment. It is an event specific functional containment, so we'll talk about a couple of those scenarios to help with the understanding of that. As well as how we determine the barrier performance criteria that go with the functional containment. We'll also talk about the attributes of the Natrium design that make it, that support the functional containment strategy that we have.

I'm also joined up here today by Chris Forrest, who is a principal radionuclide transport engineer who will start off a presentation. Joe Sinodis, who is a senior safety analysis engineer. And Jong Chang, the manager and consequence safety methods.

So with that I will turn it over to Chris Forrest to begin.

MR. FORREST: Good morning. My name is Chris Forrest, I'm principal engineer of TerraPower. And myself, along with Joe, we'll be presenting on the prepared material for our mechanistic source term methodology.

We hope to accomplish a few key objectives with our presentation this morning. First, this meeting of course is centered around the Staff's review of the Natrium Mechanistic Source Term Methodology Topical Report, or NAT-9392, which includes elements to develop requirements around our mechanistic source term approach used for the Natrium construction permit application, develop assessments to measure its adequacy and develop an evaluation model and assess its adequacy.

Secondly we'll reserve the early part of this presentation to provide an overview of our mechanistic source term approach for an atrium, including an overview of how a functional containment strategy is implemented in the design. These aspects were described at a high level during our subcommittee meeting in March, and we hope that this presentation will add additional clarity and to fill in gaps in these areas.

Following the mechanistic source term and functional containment overviews, Joe will present more details on the evaluation model development and assessment.

Next slide please. Mechanistic source term is described in several different documents and is generally understood to mean event sources, scenario specific source terms where each event considered would have a source, material at risk, which represents a release that is expected to occur from that particular event.

This is fundamentally different than assuming that ever event involving a release from the core is associated with a hypothetical release involving substantial core melt. Or for example, using something like the TID source term, as is typically done.

When a mechanistic source term approach is considered, it is also expected that a good understanding of fuel and core performance and behavior exists to backup a release being postulated. Implementing a mechanistic source term approach is closely associated with developing frequency based event and accident definitions.

In Natrium, a couple examples of this scenario specific source term include decay times and fuel inventories corresponding to the scenario under consideration. For example, an ex-vessel fuel drop event of an assembly which has been stored for a year in the in-vessel spent fuel storage will have a longer time to decay. In particular, for example, a reduced iodine inventory as compared with a fuel drop event that involves an assembly in the core region that has much shorter time to decay after shutdown.

Another example of an event specific aspect of the source term would be our release fractions chosen for a particular event. So release fractions that reflect the thermal hydraulic conditions of the fuel, and of the event. For example, release fractions for metal fuel are fairly well known with low uncertainties in the normal operating condition range around 500 degree Celsius.

And release fractions for metal fuel at much more severe conditions do have higher uncertainties with them. So for example, a fuel event, a fuel drop event involving a fuel assembly that has not undergone any significant transient can reasonably assume release fractions in the 500 degree Celsius temperature range. And an in-vessel transient, however, would use a higher set of release fractions corresponding to the conditions that fuel sees under those, under that transient.

So similarly, a few quick notes on functional containment and the approach. And we will delve into more details later.

This is also referred to in the historical documents as performance-based containment criteria in relation to advance reactor licensing and new licensing frameworks. The functional containment approach was originally considered for designs using multi-layered TRISO fuel particles, and also is inclusive of using plant structures in a confinement capacity rather than a traditional monolithic leak type containment capacity. The functional containment approach was later described as applicable to any non-light water reactor design, as long as the design establishes appropriate performance criteria and demonstrates the design is adequate in meeting that performance.

Next slide please.

MEMBER ROBERTS: I appreciate the perspective on the slide. Question. Maybe it's for you, maybe it's for the Staff. Go back to the previous slide.

That first sub-bullet kind of implies that there is something less conservative or less bounding about the mechanistic source term. But if you look at the development after the TID in the latest revisions to Reg Guide 1.183, the source term does come from a mechanistic analysis. There is the severe accident assessment and there is kind of a hybridization, if you call it that, of all of the different sources that come out of them. But they do come from physical analyses of things that can happen.

But then there is the deterministic assumption that's made the containment will meet its requirements regardless of what the event progression actually predicts. So from that end it seems to me like this approach may actually even be more conservative or, you know, it may be more realistic in terms of what the overall performance is of a system that's severe accident. In other words, you postulate the severe accident in either case, but this actually takes that progression through what will actually happen as opposed to making maybe a somewhat hybridized, but still, you know, mechanistic, I'll use that term, source coupled with an assumption that containment will meet its requirements regardless of whether or not the calculation says it does or doesn't.

I want your perspective on that. It just, it seems like the perspective on this is it might, it might be that this is actually a more conservative release, you know, an analysis that is more closely based to what could happen as opposed to the downing approach may or may not be conservative, depending on how the progression -- I was wondering if you agree with that characterization, have I got that right, or is it something you would add to that?

MR. FORREST: I would say that I think the statement that these event-specific source terms, you know, under, like we are following the ELMP framework do result in more realistic characterization of the event that's occurring and how we expect the plant to respond. So I do agree that it is a more realistic assessment.

MEMBER ROBERTS: And potentially more conservative?

MR. FORREST: Depending on the assumptions taken certain, you know, it can be. Depending on how those assumptions are made it may be judged to be more conservative, but it depends on the event.

MEMBER ROBERTS: I wonder if, Michelle, if you have any comment. If you combine the bounding on that first bullet, which would imply that this is somehow less conservative with the functional containment, the way you define is, however the containment performs in that scenario is what you'll model as opposed to the Reg Guide 1.183 approach. It assumes containment meets its performance without regards of whether or not the analysis predicts that. Michelle, do I have that right?

MS. HART: Yes. This is Michelle Hart from the Staff. It's, I agree with TerraPower that it does depend on the assumptions for the scenario. There are many scenarios that you look at. And for the LMP purposes you're looking at failures of containment functionality, as well as, you know, the functional containment operates as its expected to. And so the DBAs have to assume the functional containment works.

That's where you look at the, it's more equivalent, or it's not equivalent, but it's more like the deterministic analyses we've done in the past. So I think it's difficult to say that, in all cases, that MST would be more conservative. I don't think that that is necessarily true.

But I take your point about the, maybe inconsistent assumptions. The more, you know, the deterministic assumptions. They don't work together, it's not realistic necessarily. The intent is to be bounding, but it's not always necessarily the case for everybody.

MEMBER ROBERTS: Great, thank you. So one aspect of calling it a functional containment may be that you now have the analysis predict its performance as opposed to having some deterministic functions predicting the performance which could be more or less conservative depending on what the accident progression is, but it's going to track what the accident progression is modeled to be as opposed to making an inquiry, an assumption that you meet certain set of metrics. Okay, I think I found the time on that. Thanks.

MS. HART: Thank you.

MR. FORREST: All right, so this slide and the next slide will described how the mechanistic source term analysis interfaces with our PRA, which of course is at the heart of the LMP licensing methodology.

This slide here is a copy of Figure 1-1 from our topical report NAT 9392. And it shows the frequency dependent definitions of event categories. The portion that I would like to specifically point out is right in the middle of the slide with the navy blue bracket showing the licensing basis events, or LBEs, next to the red bracket, which shows the other quantified events, or OQEs.

The LBEs are the frequency range which includes anticipated operational occurrences, or AOOs, design basis events, or DBEs, and beyond design basis events, or BDBEs, design basis accidents, or DBAs, are also a subgroup of LBEs but they do not have a distinct frequency they are derived from the DBEs and deterministically analyzed.

Events falling within the OQE range have frequencies below our lowest BDBE frequency of 5e minus 7 per plant year. These events are retained inside of the PRA analysis to gain insights into defense-in-depth, adequacy and considered cliff edge effects.

Next slide please. And on the right here we have a copy of Figure 3-2 from NEI 18-04 showing the work flow of PRA and safety analysis as part of the iterative process of LMP.

I understand the text is maybe a little bit small on the screen, but I'll highlight that I have annotated the figure with these green boxes and text to show the interfaces where mechanistic source term analysis happens. The first interface is in Step 3 where the PRA is initially developed, or later updated.

Part of this update includes an update to assigned dose consequences of release category end states. These end states either describe an end state or with no release or describe an end state where a radiological release occurs and therefore a source term and consequence are assigned.

Source terms and associated radiological consequences for all end states with release are assigned in this step. This includes consequences of OQE type events. For example, unprotected events.

Depending on the maturity of the PRA, the consequences assigned in this step, maybe from explicit MST models or from surrogate cases, or surrogate cases would be used to assign bounding consequences with appropriate basis. Certainly with the ultimate goal that explicit MST models are representing each release category end state.

The PRA continues in Step 4 with event selection to identify event families and determine the list of LBEs. These LBEs that come out of Step 4 now have frequencies and event descriptions. Recall that the LBEs coming out of this list in Step 4 are AOOs, are DBEs, are BDBEs, as well as our DBAs, which are derived from the DBEs.

Once the LBE list has been developed, the safety analysis is performed on the LBE list. In Step 7, which has a number of sub-steps, as noted by the dashed box around all of those Step 7 boxes, specifically highlighting the non-DBA mechanistic source term analysis is performed in Step 7A. This is where, from our mechanistic source term methodology and our radiological consequences methodology we would be following a non-DBA type approach and methodology in our analysis.

And then the prescriptive DBA events are analyzed in Step 7D. And again, from our mechanistic source term methodology and our rad consequences methodology, our DBA aspects of those methodologies are used to evaluate those events. And of course assess the results against 10 CFR 50.34 does limits.

And from there you can see that the iterative process continues. We would do design work, update design, and go back up to updating the PRA analysis as necessary and go on through there.

Next slide please.

CHAIR KIRCHNER: Could you give us an example of going through that cycle, what's left in beyond design basis events in Box 4 once you iterated?

Can you give an example what kind of event would be left and analyzed?

MR. FORREST: So you --

CHAIR KIRCHNER: So you used the PRA, you've iterated, you've actually improved the design and then that beyond design basis event category would shrink, right?

And so I'm asking if you could give us an example of an event that still screens in as being analyzed through your mechanistic source term for that category. It would seem to me that category is, if it's AOO and design basis events, then the expectation would be the systems would deal with that and you wouldn't have a release of consequence. But screens in, what's left, what's residual on the beyond design basis event category?

MR. FORREST: Sure. Let me just restate the questions so to make sure I understand. So you're asking, you're curious about what kinds of events end up in the BDBE category.

CHAIR KIRCHNER: Right.

MR. FORREST: You also mentioned the return residual. And if you go back one slide. I just want to clarify that often when we talk about residual we're talking about a residual reach, excuse me, a residual region that's way over to the right and even beyond other quantified events. So I'm going to key in on your question about BDBEs in this orange region here. So if you can go back to the next slide.

So an example of BDBEs would generally be where there is a similar, so an event family may have LBEs that are defined in the BDBE region where everything functions as its designed and performed to do. Generally our BDBE region we have similar LBEs from the same family that would end up in a BDBE region where, you know, a barrier is assumed failed. Or some kind of, you know, some kind of function does not function and therefore there is an LBE for that event and it is likely ending up in the BDBE region.

CHAIR KIRCHNER: Can you give an example of where the Natrium design of what kind of event would still be in that category after you've gone through this process?

Now in the deterministic world, generally you don't include beyond design events you try and bound it. And then that bounding assumption is everything else that's outside of the box, if you will. So I'm just curious to see what kind of events remain --

MR. FORREST: Yes.

CHAIR KIRCHNER: -- in that category for the Natrium design.

MR. FORREST: Sure. So an example, and I'll share what's already described in our public PSAR document. An example would be for an in-vessel, an in-vessel event where we have a one assembly failure in the core where our functional, and we'll talk about our boundaries in a few slides here, but our primary functional containment boundary, which is our reactor enclosure system, is intact and it's credited, and our enveloping barrier, which is our HAA, our head access area, is isolated and so that barrier is credited, that would represent a DBE like scenario.

If we then fail or don't credit the HAA, that would be an example of a BDBE scenario where we still have the performance of the vessel head and the reactor enclosure system, but we do not have the design performance of the enveloping barrier credited.

CHAIR KIRCHNER: Thank you.

MEMBER ROBERTS: Just following on Walt's question. Can you give us a perspective on the other quantified events from the previous figure, presumably though as you have done all the design that you think you need to do to make them, you know, beyond extremely unlikely, whatever the terminology is in the LMP, and yet you're still evaluating them to get really some sort of judgment on the capability of the function containment system.

So how do you pick those events, and is there anything you would plausible do to screen them out?

MR. FORREST: Sure. I guess I'll preface my answer with I am not a PRA person and so the question is getting a little bit into event selection and frequency, but I'll do my best to address the question.

So other quantified events are generally first getting to that category based on a frequency evaluation. So we, so for example, like we're looking at the core and the operation of the core, and the reactor and the response in a, for a given event. Such as like an unprotected event.

Based on the assumptions made in a PRA on the frequency of an initiating event, and the credited functions, or failures of those functions, that event then gets categorized by frequency into either our LBE region or our OQE region. My comment about assigning source terms and consequences for OQEs, so regardless of where that event falls we do, you know, estimate and create mechanistic source term models to represent such events.

So we're going to consider, you know, when we do that on the mechanistic source term side we're going to consider the pool temperatures that we're seeing in that particular event, we're going to consider fuel temperatures that we're seeing in that particular event, we're going to consider appropriate release fractions for that particular event. And then do our mechanistic source term analysis and come up with a consequence that's assigned for it. I don't know if that answered your question.

MEMBER ROBERTS: Yes, I think the short answer is, that's not part of this presentation so I get it.

(Laughter.)

MEMBER ROBERTS: What the plot there is showing is, basically for a very wide range of frequencies if you, I don't know if that's to scale --

MR. FORREST: It's not to scale.

MEMBER ROBERTS: -- you would be looking at what the cliff edge effects and what the defense-in-depth assessment tells you, you know, might have kind of escaped notice of the PRA because of the model, but you got some process to look at that. So I understand that you'll have more discussion at other forums, but appreciate the answer. Thanks.

MR. FORREST: All right. So this slide is on our definitions and background related to functional containment. So we're moving, so we just had our mechanistic source term overview, we're moving into our functional containment overview.

First off, Natrium has adopted our function, the functional containment definition given in SECY 18-0096. And that definition stated here is the barrier, or set of barriers, that effectively limits transport of radionuclide, radioactive material to the environment. As part of our project development and functional containment definition development, we further define some additional terms.

So we have here the terms primary and enveloping. The primary barrier for Natrium is an SSC that performs radionuclide retention and is a function, and performs that function necessary to keep offsite DBA doses within regulatory limits. Or to keep DBE doses from exceeding the FC target curve.

And enveloping barrier is an SSC that provides a backup radionuclide retention function following the failure or breach of an associated primary barrier.

And finally, our source term methodology also establishes performance criteria as a method for establishing performance criteria that's in alignment with SECY 18-096, Enclosure 2.

MEMBER PETTI: Chris?

MR. FORREST: Yes.

MEMBER PETTI: Principally a barrier in one event sequence might be primary but in another could be enveloping?

MR. FORREST: The barriers, the selected barriers are event specific. Generally the way that we've defined our barriers that are either --

MEMBER PETTI: One or the other --

MR. FORREST: -- one or the other.

MEMBER PETTI: So this is where it's a little bit, the cladding.

MR. FORREST: Okay.

MEMBER PETTI: Is at a barrier, the issue. If that were a barrier then the enclosure, the reactor enclosure would be secondary. But in some events the cladding might fail in which case the enclosure is primary and the next barrier beyond, whatever that one is called, is secondary.

So I was struggling because I've seen the cladding described as a barrier sometimes but then other times not. Tom and I have gone kind of back and forth on this and how do I now letter to make sure we're consistent? It's a little gray to me because it may be event specific.

MR. FORREST: Sure. The way that we've addressed that in our source term analysis, for the cladding barrier, is generally that it has failed or not failed. Therefore it doesn't have leakage performance assigned to it like you would for like an LWR containment leakage. Or like for other barriers where we go through the SECY 18-096 and we determine what's the leakage rate that we could tolerate from various primary and enveloping barriers.

So, for our dual centered events it's

either failed or not failed. We're either taking a failure of full assembly, for example --

MEMBER PETTI: Right.

MR. FORREST: -- you know, in the core. Maybe that's failure of one assembly, the rest of the core is not. You know, is intact.

MEMBER PETTI: Okay. So it's not a barrier as defined here. That helps. I --

MR. FORREST: Correct.

MEMBER PETTI: I think we looked at it was like good.

(Laughter.)

DR. BLEY: Dennis Bley, if I can sneak something in here. I kind of like what Dave was saying. It's interesting. I'm not sure it leads to another problem, but in your first bullet for the primary barrier the or bothers me. Because that seems to say we're going to mix up deterministic and probabilistic analysis. Perhaps depending on which answer we like the best I'm a little concerned about that.

Why is it an or instead of an and, and does it imply that you can pick whichever one you want depending on the particular case?

MR. FORREST: Sure. That's a great

question. And I can certainly answer that. So the, this language is very similar to the safety related, how you come to a safety related determination and how that is described in NEI 18-04.

So if you have an SSC, so not just functional containment barriers but any SSC. And this evaluation of SSCs is an integral part of walking through the LMP methodology and the PRA work. So taking SSC as general, again, not just functional containment barriers, if you have an SSC that is required to keep your doses within 10 CFR 50.34 dose limits, it is safety related.

Likewise, if you have an SSC that is required to keep your DBE doses from exceeding the FC target curve, it also becomes safety related. It's not an either or in that you get to choose which one you take. When, in the Natrium experience, when we come down to it and we do this analysis, often times we actually find that needing to keep the DBA dose within the FC target curve is actually more restrictive, in many cases, than meeting the DBA dose limit of, you know, 25 rem at the site boundary from 10 CFR 50.34.

So I would argue that it is not an or that's problematic, but it's an or that is ensuring that you're looking at your SSCs holistically not just judging them against the 10 CFR 50.34 performance or dose limit.

DR. BLEY: Okay. I like that answer. I'm, operationally I wonder how you avoid the choice issue, but I do like your answer. Go ahead.

MR. FORREST: Thank you. Next slide please. So on this, this is a little bit of discussion on setting the performance criteria.

On the right here we have a copy of Figure 3 from Enclosure 2 of SECY 18-096. This shows the relationship of establishing performance criteria using a graded approach according to event category, or according to event categories.

Non-DBA events, such as AOOs, DBEs and BDBEs, have dose targets or goals such as meeting the FC target curve. DBA events have dose limits such as meeting 10 CFR 50.34 dose limits.

The barrier of performance, or leakage rate, is set to meet the most restrictive dose limit, or goal, using the appropriate EM for non-DBA versus DBA events. And that comment really kind of speaks to the answer that I just gave to the question.

The orange box in the far right here, in the diagram, highlights how physical structures, in this example a plant building, may serve other functions separate from radionuclide retention. Some examples of other functions include asset protection, protection from external events or security threats. These other functions are considered outside of the scope of functional containment and are addressed by other design requirements such as external hazards analysis and SSC interactions.

Next slide please. So this is a key slide that describes sort of our basis for adopting a functional containment approach in the first place. And I've gone ahead and termed these prerequisites. I describe these as prerequisites because if we weren't, if we were designing and licensing Natrium and we weren't adhering to these bullets, then it would not, it would not make practical sense to implement a functional containment approach.

So first, and probably most important, is the use of the LMP methodology, or NEI 18-04. Following the LMP methodology and implementing a mechanistic source term approach are likely the two most important prerequisites.

So this ensures that a frequency-based set of event scenarios are developed from the PRA for which scenario specific source terms are developed, as described earlier in the presentation. The quality of the PRA is evaluated against the non-light water reactor PRA standard through peer reviews. And finally, as part of the LMP process, the integrated decision making process panel reviews the final FC target curve results and approves the design adequacy and safety case.

Secondly, is our use of a systems engineering approach to design. And this has been described before as well, but essentially this means that we are setting functional design requirements and safety requirements early in the design and at the system level. So these are, have been considered from very early on in our design process.

Thirdly is the use of the defense line function framework, which incorporates defense-in-depth into our designed steps.

And finally, also an important, an very important point is the reactor technology. So having a reactor technology, which by the selection of fuel, materials and coolant, as inherent and passive safety features, as well as mechanisms which attenuate radionuclides would make Natrium a prime candidate for implementing a functional containment strategy.

Next slide please.

MEMBER PETTI: Hey, Chris, on the FC curve and defense-in-depth adequacy, how do you treat the other quantified events?

Do they have an offsite dose goal or just done for onsite? Because they wouldn't fit on the FC plot, right, they were less than the BDBEs amount?

MR. FORREST: Correct. That is handled wholly within the PRA analysis actually, so I don't think I can actually answer that.

MEMBER PETTI: Well no, but you're including these other quantified events in your mechanistic source term, so presumably if you went through the calculation you could calculate a dose that would be off of the FC curve except it can't be because the FC curve doesn't go that far. So I was just wondering what criteria you use to define success?

MR. FORREST: So it's true that OQEs don't have a dose goal on the FC target curve. And when we do mechanistic source term analysis for OQEs we simply do that analysis and provide a dose to PRA for consideration in their model.

There is sort of quantitative measures that they look at that include both dose and frequency as they're evaluating things like defense-in-depth and cliff edge effects. So that's where I say like, we simply, from mechanist, from the mechanistic source term methodology and model we simply provide PRA dose. And PRA is looking at, it's within the PRA process that they're looking at the quantitative measures.

MEMBER PETTI: Okay. So if you were to come up with a number that would be higher than say the emergency planning zone cutoff for site boundary than somebody else would then figure out what that means, is that what you're saying?

Because you wouldn't necessarily use that as a criterion because the frequency consequence curve says, well that would be okay. So that's another route of discussion is that where your inquiry goes.

MR. FORREST: Yes, that discussion would happen sort of in the context of PRA and EPZ evaluation. And of course like, if there are design changes needed than, you know, more folks would get involved.

MEMBER PETTI: Right. Yes, it's another quantified event which it got there because you already thought the design supported it being a very low frequency, so okay.

MR. FORREST: Okay.

MEMBER PETTI: I guess that will be

further discussion. I'm guessing, and you can tell me if I'm wrong, you don't have any right now that would show up in that space?

The OQE issues you've looked at so far, you wouldn't expect to get, you know, a high enough dose that would challenge a EPZ boundary or is that not known yet?

MR. WILLIAMS: I don't think we can say that, you know, that's something that's looked at when we do our integrated look at defense-in-depth as part of LMP. So the OQE was resolved to get a cliff edge effect or challenging some integrated risk metric of a PRA which show up in that review and then we would recommend a design change for something --

MEMBER PETTI: Okay, thank you.

MEMBER MARTIN: This is Bob Martin. Some things that been mulling in my head, not just with you guys but there are other things going on in the Agency, and even operating plants, that bring up a concern but relate to licensing with a maintenance rule, right?

And maintenance rule that I'm not an expert. But there is, I feel an applied assumption of certain amount of deterministic design in the application of the maintenance rule.

And while I listened to what you're saying and I say, well, from a licensing standpoint maybe there is a pathway. I think about down the road you're operating and something goes wrong and how do you assure the original design basis if you don't have the inherent design margin that comes with a deterministic, or at least safety related enveloping barriers?

And I don't know, actually, I have not brought this up to my colleagues here. It might have played a role in a recent trip we had, but I think there is a problem that when you declare enveloping barriers as non-safety or non-safety, no special treatment, I think it creates a problem down the road for you guys. Or for your customers.

Has that ever popped in your head in considering functional containment the way that you are? Probably not because it's --

(Laughter.)

MEMBER MARTIN: -- sorry to put you on the spot but I have to at some point or --

CHAIR KIRCHNER: State the question or --

MEMBER MARTIN: Well, it's just the relationship between the maintenance rule and their strategy of functional containment. Yes, that's -- my understanding of the maintenance rule is that it really keys in on the original design, deterministic design basis.

Again, thinking of the time frame when the maintenance rule is written, none of this stuff we're thinking here, even stuff like redefinition of LOCA, which we're doing with the operating plants and, you know. I can think about our trip to Boston a few weeks ago. You know, where it probably does apply pretty well in that particular case given their plants.

So I, it may be a path but it's not easy. And, you know, I've said it before, a functional containment topical report, which addresses all these issues, would be useful. But anyway, this is just something that's been percolating and obviously it's percolated to the point where I said something just now.

But I don't know what the answer is but I think it's a tough one, and it's also worth throwing to the Staff here whether they're thought about it. But there may be a licensing path. I'm not sure it was a path from operations standpoint. And you got to think of them both really.

MR. WILLIAMS: Yes. This is Eric

Williams. I agree. We do have to think about that as we're designing and performing the LMP analysis that we're going through with the PRA. It is one, I mean, there is one key aspect that I have noticed going through the integrative decision making panels, this board that we composed based on NEI 18-04's recommended functions includes a strong presence from the operator. So we have operations on the IDPP.

They look at, all that we're doing for defense-in-depth, functional containment approach, the defense lines, and their advising us on areas where, okay, it might meet defense-in-depth, it might meet something extra to make sure that you can operate the plant with a longer term, or that the plant might go through changes during its lifetime that you want to plan for now.

And so, there is that kind of perspective that's being factored into the design that I hope will address that concern down the long-term.

MR. ANZALONE: So if I may. Sorry, this is Reed Anzalone from the Staff. I think this is something that we've been thinking about going through the review.

I mean, if you look at 50.65 and the basis for it, I think a lot of the criteria in there are intended to make sure that you have a maintenance program for safety significant SSCs that are not necessarily safety related. The one thing that LMP does is that it gives you a really clear accounting of what those SSCs are.

So I think actually in some ways it's clearer and better rather than the criteria that were developed in 50.65 based on operating experience for LWRs about what SSCs should be considered for the maintenance program to have it be defined in a way that you do it on your LMP.

MS. DE MESSIERES: Yes. This is Candace de Messieres, NRC Staff. I would also mention again, through our efforts and our policy branch space that, you know, like for example, technology inclusive management safety case, or TIMaSC and TIRICE efforts. So I think that, I mean again, we appreciate the comment. I think it's something that we're thinking about.

As Reed said, I think there are, you know, logically processes and ways to address it, but we appreciate the comment. And we'll definitely keep --

MEMBER MARTIN: It's more than an appreciated comment. I mean, this could be a disaster for an operator down the road, right?

I mean, if there is no margin to work from, you know, they can use, you know, today a plant can apply better methods, you know, based on their situation and still have a strong plan that they maintain the original design basis. But if you design it so tightly, you know, something happens, you know, not an event but a maintenance issue that relates to a, well, particularly a barrier that's being classified as non-safety with no special treatment which, again, appear to be outside the maintenance role --

MR. ANZALONE: Now --

MEMBER MARTIN: -- but --

MR. ANZALONE: -- with no special treatment?

MEMBER MARTIN: With no special treatment.

MR. ANZALONE: With no special treatment.

MEMBER MARTIN: Right. Right.

MR. ANZALONE: But with special, so if you look at the way the safety classification shapes out in practice, there are maybe fewer safety related SSCs but there are a lot of SSCs that fall into that non-safety related with special treatment. And those are, I believe probably most of them would be in scope for the maintenance role. So it's --

MEMBER MARTIN: So you think, but it's never been done. It's never been talked about it --

MS. DE MESSIERES: Yes.

MEMBER MARTIN: -- and it's never, nothing has ever been written down. But I think this is something that elevates to more than just a question that an ACRS --

MR. ANZALONE: Well, but at the same time --

MEMBER MARTIN: -- right?

MR. ANZALONE: -- I guess I would argue that, you know, understanding the margin that's available --

MEMBER MARTIN: Right.

MR. ANZALONE: -- maintaining margin, like our role as the regulator is to ensure that there is, that there are appropriate safety limits out there and that there is an appropriate level of margin maintained there. And if extra margin is needed to account for those kind of scenarios, from an operational standpoint, that's the designer's prerogative. And the operators prerogative.

MEMBER MARTIN: Agree with that. It is always our prerogative. But --

MS. DE MESSIERES: And I --

MEMBER MARTIN: And more complicated it gets. Obviously the more refined, the more detailed, there is benefits but there is also disadvantages. And the disadvantage may be a more complicated response under real situations.

And obviously deterministic approach, more safety related layers, you know, provides a more clearer cut transparent path in dealing with those kind of scenarios. Again, it's not resolved in the ten minutes that we're talking about it. But it needs to be elevated, in my opinion, all member actions needs our opinion. But I think it's very relevant to the whole functional containment in this application in particular.

MEMBER PETTI: David. I just want to note that we are 15 minutes behind. We were supposed to be done 15 minutes ago so let's just keep going.

MR. FORREST: Okay, thank you. So on this slide is a continuation of sort of the Natrium functional containment approach and strategy. This is a three, three bullets that are summarized from Section 1.3.2.1 from our SER.

So first bullet talks about maintaining at least one barrier beyond the fuel cladding that has reliability between the source and the environment.

So the example here, we talked about, you know, is the cladding a barrier or is it not a barrier. But the example that, you know, that can be thought of for this bullet is our reactor enclosure system. Including our reactor vessel and vessel head.

So this boundary serves as the barrier beyond the cladding. And it is safety related. It's a safety related barrier and it's performance is set such, you know, to ensure that our in-vessels DBAs are kept within our dose limits. Or in the dose limits.

Second bullet talks about optimizing the number of barriers. So here this is where we sort of acknowledge and consider the need for additional enveloping barriers around our primary barriers.

However, it, we want to optimize that such that we specify the enveloping barrier performance to meet the dose targets that it is functioning for. However, we also don't want to overburden the design, and the maintenance, by specifying requirements on numbers of subsequent barriers that may or may not really play into the retention of radionuclides.

Of course that puts the onus on the primary barrier and an enveloping barrier, however, there is still, although it is not, you know, additional barriers are generally not credited in the, in the safety analysis because that safety analysis limits it, you know, limits that credit to what is specified with specific performance.

So the optimized meaning that we established performs a number of barriers to provide adequate retention but also not to over strict the design.

And finally, providing a framework for iterations between source term analysis design and PRA. And we've discussed that a bit by example of the LMP process and talking about the IDPP process and panel as well.

Next slide please.

MEMBER BIER: Excuse me --

CHAIR KIRCHNER: Is this the unduly alliance on any one barrier? I think, you know, this has been a very useful exposition because we probably should have done this when we heard your PDCs. Because if we go back to that discussion, here you say, it's almost like you're saying, well, we'll take fuel cladding failure and then we'll rely on the primary system and/or the head envelop, for example, in the case you just pointed to some detail about.

But that was why I think there was perhaps a lot of questions about SAFDLs versus the other terminology for functional containment. So here it looks like though you really are crediting the cladding, which suggests the SAFDL kind of threshold design limit so that you're not just saying, well, the cladding is gone, we're going to rely on the primary envelop and the upper head enclosure. You see where I'm going?

So maybe it's just the way the fuel graph reads to me. But I think you're crediting the fuel cladding. Expect you are. Yes.

MR. FORREST: So for, and again, we're, that's getting at the event specific source term. Or release, or amount of release that we have.

So for example, you know, an in-vessel fuel drop, we would assume that the cladding fuel assembly or an impacted fuel assembly is failed for all pins. We're not taking a failure of all the assemblies in the vessel in that case.

CHAIR KIRCHNER: No, I'm thinking more of power events.

MR. FORREST: Okay.

CHAIR KIRCHNER: Where cladding does provide, you know, has a primary role in mitigating beyond the consequences.

MR. FORREST: So we, and in this case

then, you know, we've used, in previous ACRS meetings, in our DBAs without release we've talked about our time and temperature no failure criteria. And so we're also evaluating like our in-vessel conditions under these at power scenarios and evaluating portions, portions of the reactor core against that criteria to determine appropriate amounts of fuel failure within the vessel.

MEMBER BIER: Quick question. Or comment I guess really. I want to highlight the use of the term optimize because it sounds like that step is really kind of a judgment call. Like I understand the need that you have to balance, you know, how much requirements are you imposing and are you achieving adequate protection.

But it seems like I don't see a way where you know that you end up with a optimal number of barriers you just end up with something that you determined is reasonable. Is there something more behind that step that I'm not seeing or am I just grabbing it barely?

MR. FORREST: I would say that's an accurate characterization. And we've got a couple of pictures coming up that --

MEMBER BIER: Perfect.

MR. FORREST: -- might, will help to, you know, provide a visual.

MEMBER BIER: Thank you.

MR. FORREST: So this and the next slide we'll talk about, you know, some specific barriers and sort of specific phenomena and events.

So as we previously described, we talked about those prerequisites for instituting a functional containment strategy for Natrium. And this is a short bulleted list at the top here that describes some of those aspects of the technology that help us to ensure our aspects of the passive safety features, or inherent safety features, that help us to retain radionuclides as part of the technology. And do make Natrium well suited for the functional containment strategy.

So we've talked about different regions and different barriers. We've illustrated this in the diagram with the blue boxes and the green lines. And I know that we have shared this figure and discussed it in previous meetings as well.

So the functional containment strategy sets performance and leakage rates on physical barriers. And we do leave the mechanistic source term phenomena, such as things like deposition and pool scrubbing, to the mechanistic source term methodology.

So this is where we begin to see how integral functional containment and the mechanistic source term methodology are. But just keep in mind that when we describe functional containments it's generally sort of a piece of the mechanistic source term methodology. And when we talk about functional containment performance where that performance is setting leakage rates on physical barriers. We're not setting a performance of a certain amount of pool scrubbing in that sense, or deposition rate, but that functional containment performance is principally related to the leakage rate of physical barriers.

So, and then this green box over on the right here is just also a step through of some of the various mechanistic source term phenomena that we encounter as we think about a release in the core and transport of those radionuclides out into the environment.

And so here we can begin to think about sort of an in-vessel event happening. We have a release from the fuel matrix and that, inside of the, what's going on inside of the pin, we've got radionuclide redistribution where radionuclides are coming up from the, through power operation the radionuclides come up through the, from the fuel matrix into the gas plenum.

And so, at any given sort of state of our fuel life we have a certain amount of radionuclide that are existing in the plenum, in the gas plenum of the fuel pin, and are available for release. When we go and do a source term release for this event we are generally instantaneously releasing any radionuclides that we have inside of the plenum.

So from there we're releasing those radionuclides. We know that our alkalide metals, like sodium that we're using as our coolant, and cesiums have an affinity for iodine so we anticipate that those chemical bounds are forming and that there is some iodine retention.

There is the possibility as the fuel, as the release happens from the pin that there is a flashing, or vaporization of radionuclides, depending on the conditions of the pool and the fuel itself. With the gas release from the pin certainly we have bubble formation. And those bubbles can entrain radionuclides which would bypass the sodium pool and make their way to the covered gas region.

Within the sodium pool itself we always assume that our noble, our radio -- our noble gases will bypass the pool. They become bubbles and make their way to the cover gas region. Our sodium, our large sodium pool for Natrium does offer a substantial height for decontamination or bubble scrubbing of those radionuclides. And so some of those vapors and aerosols are removed in that process.

And then at the surface of the pool there is vaporization that happens, again, depending on the conditions of the cover gas region, and the pool surface, we could have additional vaporization of radionuclides into the cover gas region.

And then finally, once we get into the cover gas region, and similarly for subsequent compartments, a gas compartment or an air filled compartment, like the head axis area or subsequent buildings, you know, those provide volumes where radionuclide decay and daughtering can happen, as well as the potential for deposition of aerosols. And then of course there is leakage into the next compartment.

So I wanted to highlight some of those aspects of the mechanistic source term phenomena because when you take it, when you take it altogether and we establish functional containment barriers and we establish leakage rates there, one does have to look at it holistically and understand the source term phenomena that are going on, appropriate level of assumptions that are made in terms of if you're looking at a non-DBA type release case or a DBA release case. And all of that is considered when we are establishing leakage rates for these barriers.

For instance, you know, leakage rates would look very differently if you took a source and released it, you know, directly into the environment without consideration for any mechanistic source term phenomena and set a barrier leakage in that situation. That would look very different than taking the mechanistic source term approach that we have.

MEMBER PETTI: So I have two questions. Yes, I like the green box, I think it helps. Kind of looks a lot like my letter.

(Laughter.)

MEMBER PETTI: Structured, I noticed, because it's how I think about it too, which is good. But, you know, if you think about barriers and leakage rates you could decide to have one barrier at one percent leakage, two barriers, each at ten percent, that gives you, from a source term perspective, the same number but two barriers may be more reliable if they're independent and the like.

And that's what I think this optimization that you talk about goes to and help. So you can, you know, you can kind of make, I'm going to say, to reduce some of the requirements by increasing the redundancy, if you will, in a sense.

So as I was going through this and trying to make sure that I understood the methodology, because the topical list is abstract, I just had to look at the construction permit and I saw some of the results and I was confused. Almost all the in-vessel events release krypton-88 but there is no krypton-85m and I'm very confused by that. 85m has a four-hour half-life, 88 has a two-hour half-life.

If you're releasing krypton-88 you got to be releasing krypton-85m. So you guys should go back and look whether there is something that wasn't picked up in the code. But I mean, in every reactor the source term that I've looked at, if you get one you get the other. I don't think it's going to make a difference in the dose but it's a perception of completeness and wholeness, if you will, of the methodology.

MR. FORREST: Understood. I appreciate that comment. I assume you, were you looking at the Section 3.2 --

MEMBER PETTI: Yes.

MR. FORREST: -- tables?

MEMBER PETTI: Yes.

MR. FORREST: Thank you. Something to know about those tables is that that is a summary of the dose contributing. Like most dose contributing isotopes. It's not a complete list of --

MEMBER PETTI: Ah.

MR. FORREST: -- what was released --

MEMBER PETTI: Okay.

MR. FORREST: -- from the event. I will certainly take the note and go back and check on 85m.

MEMBER PETTI: What I don't remember is 88 versus 85 from a dose perspective --

MR. FORREST: Sure.

MEMBER PETTI: -- so.

MR. FORREST: But something to know is that those, it is a filtered list of the most dose contributing isotopes so that could be why --

MEMBER PETTI: Yes.

(Simultaneously speaking.)

MEMBER PETTI: -- question, thanks.

MR. FORREST: All right, next slide please. This slide should wrap-up the bulk of the discussion on functional containment overview, but we did feel that it was appropriate and necessary to have some discussion around the actual, you know, the physical barriers and leakage rates that were assigned. And so I will direct your attention to the two diagrams on the right-hand side.

The left diagram, which is in the center of the slide, shows our functional containment barriers and boundaries during our power operations. And the right-hand side shows our barriers and boundaries during our refueling operations. And this is done side-by-side to highlight, in particular, that our primary functional containment boundary, which is our safety related boundary, does change in these two configurations.

So, still, you know, in either case power operations or refueling, this primary functional containment boundary is safety related. It has a strict one percent performance associated with it. But in the refueling condition it does extend, we see that boundary extend up into the reactor building as it encompasses the ex-vessel fuel handling machine.

I'll focus a couple minutes on the power operations configuration. So this orange line that I've already pointed out, the primary functional containment boundary is drawn around our reactor vessel, and our reactor vessel head. And again, this is our safety related boundary as noted in the table here.

We do have enveloping boundaries that are identified in the green outline here. And those enveloping boundaries are labeled as the guard vessel, which surrounds the reactor vessel as well as the head access area. And the head access area is a concrete structure below ground. So sub-grade. And is, and does have the capability of nuclear island HVAC isolation in the head axis area to achieve the ten percent HAA volume per day, leakage performance that we've assigned for the HAA.

And then also noted here in the table, and then by the blue outline, is the reactor building super structure. So this is the above grade portion of the reactor building. And as we've talked about before, about optimizing barriers, about selecting the number of barriers, this is an example of where, you know, for the in-vessel event that was the subject of setting this performance criteria we've established that the necessary performance as one percent on the reactor vessel head, for leakage into the HAA, and then ten percent from the HAA essential, in the analysis space essentially to the environment.

So we're ignoring any benefit for the

reactor building super structure. But again, physically the building is there it's just not credited in the safety analysis.

And then to illustrate the refueling configuration, I had already described that that primary boundary extends up to the EBHM. And so in this case we simply apply and require the one percent leakage on that primary boundary.

And the configuration itself bypasses the HAA so there is no benefit for crediting an HAA leakage here. That leakage that comes from the refueling condition will be sent straight to the environment without credit in the analysis again for the reactor building itself. But again, the building is still standing there, it just doesn't have an established leakage performance assigned to it.

CHAIR KIRCHNER: And then the area around the guard vessel, that's ventilated though because that's your passive decay heat removal?

MR. FORREST: Outside of the guard vessel is the air flowing through the rack. The reactor area. So yes, that is the decay heat.

CHAIR KIRCHNER: So there the reactor building would encompass, it encompasses the upper head area. I'm just looking at how the plant, from memory, is constructed and how this schematic shows it. It seems to me the reactor building does encompass the, all the boundary, the head access area, but does not include the guard vessel. Is that a good characterization?

MR. FORREST: Yes. I think you're remembering and pointing out that there are other sub-grade structures there --

CHAIR KIRCHNER: Okay.

MR. FORREST: -- that are around, you know --

CHAIR KIRCHNER: The head access area.

MR. FORREST: -- the head access area and around the guard vessel, which would include our portions of the rack. They're not pictured here because they don't have any associated performance assigned to them.

CHAIR KIRCHNER: Assigned to them. Okay. Thank you.

MEMBER ROBERTS: I have two things. First, I want to thank you for putting these diagrams in the slide deck here. They're very clear in terms of what you're accomplishing.

Except when I look at this diagram we talk about this a little bit in the closed session last time, and the PDC. This looks a lot like the S-PRISM configuration that was the basis for the PDCs that INL put together back in 2014 which is, reflects historic sodium past reactors.

So when you look at this configuration, the barriers are essentially identically. The only difference is, well two differences. One is, you've calculated the performance requirements based on the mechanistic source term which, you know, that's analysis, that's fine. Because in terms of defense-in-depth though, you still got the same kinds of barriers that SFRs have always have.

Again, it stems from the figure. With the distinction that the enveloping barriers are non-safety with special treatment as opposed to safety related.

So again, I'll draw on the conclusion this isn't that much of a departure, if at all, from previous practice. I was wondering if you had an overall comment on that. Is that still the raw perspective or do I have that kind of right?

MR. FORREST: I will, I do have a comment on that. There are a number of differences between past SFR designs and the Natrium design. One item that's been mentioned before is, you know, setting, you know, the past designs have said it, tight leakage like a one percentage volume on an upper head area or a building area.

In reviewing those designs, one difference here is that Natrium is defining and setting our primary functional containment boundary to be the vessel head and the vessel itself. And we're setting that tight leakage on that safety related boundary there. That's a key difference from past SFR designs that relied more on what we have pictured here as enveloping barriers. More of those building boundaries.

In our, in Natrium's configuration, the performance that we set on the reactor vessel head and the reactor is doing the bulk of the work to retain radionuclides. That boundary is also protected by things like over pressure protection, as well as other design features.

And so I would argue that the comparisons with past SFR designs is not quite, is not relevant because fundamentally the design does look different from Natrium. And our implementation of a mechanistic source term approach, as well as the functional containment approach, is a fundamentally different approach then those ones took in their licensing efforts.

MEMBER ROBERTS: Right. And it just seems like the performance criteria come from the mechanism source terms, and those clearly have a different basis in previous SFRs.

But in terms of defense-in-depth and what the plant, you know, provides in terms of ability to retain radionuclides from the public, it's kind of essentially the same barriers as the previous SFRs. And again, that's just an observation in my part, it seems like it's not ready departure.

You know, a statement that you've got a function containment not a physical containment, for example, what seemed to be not accurate because you've got physical containment, which has the same barriers as previous designs. Just with performance criteria they're calculated using, you know, maybe a little more sophisticated modeling.

So again, it's just an observation from me. If I'm, Robert, I appreciate you telling me that but I don't know if you all call it messaging, but just from an overall view of the containment approach it doesn't seem like that much of a departure. I think I've said enough. Thanks.

MEMBER PETTI: It seems to me though that the information on mechanistic source term, some of those details weren't available when S-PRISM was done. I mean, S-PRISM, as I understood it, used oxide, where there was an oxide option and then they just had some collection factors. Here it's really a look, the argon reports, and rely a lot on this, was a clean look at these things. And the pool scrubbing and the experiments that were done, I mean, those are significant steps forward to technical underpin your leakage performance which is your source term. So to me that's probably and importance difference that has evolved between S-PRISM and today.

We're scheduled for a break. Well, sorry, we were scheduled for a break 12 minutes ago. This looks like maybe a natural breakpoint, or the next slide?

MR. FORREST: Yes. So this slide here is just simply a listing of areas that we've talked to functional containment. Mostly, you know, chapters within our PSAR where a lot of this information is available. And some modeling strategies in Chapter 4, or Section 4 of our topical report.

So this particular slide concludes the mechanistic source term overview and the functional containment overview. At this point we would move to

Joe and he would describe the rest of the evaluation model. It could be a breaking point if that's what you're thinking.

MEMBER PETTI: So yes. Let's take a break till 10 o'clock.

(Off microphone comment.)

MEMBER PETTI: Yes, seven minutes.

(Laughter.)

MEMBER PETTI: So we'll --

PARTICIPANT: Can we have coffee that fast?

MEMBER PETTI: I don't know.

(Off microphone comments.)

(Laughter.)

CHAIR KIRCHNER: Okay, we are recessed until 10 o'clock eastern.

(Whereupon, the above-entitled matter went off the record at 9:53 a.m. and resumed at 10:04 a.m.)

CHAIR KIRCHNER: Okay, we're back in session, and I'll go -- turn it back to Dave Petti.

MEMBER PETTI: Okay, Joe, start talking about the source term.

MR. SINODIS: Yes, thank you. I'm Joe Sinodis with TerraPower in the Consequence Safety Methods and Analysis Group. The rest of the presentation slides here are very similar to what was presented at the subcommittee meeting back in March, so I'll try to go through them fairly quickly, given our time constraints.

So, the Natrium Mechanistic Source Term Evaluation Model, the development of that employs Regulatory Guide 1.203, the framework, insofar as it's applicable to the Natrium design. Now, we're not committing to Reg Guide 1.203 per se, but we're using the EMDAP process as a guideline. There's four elements with 20 steps, as a reminder, establishing the requirements for the EM capability, developing the assessment base, developing the EM itself, and assessing the EM adequacy.

The Source Term EM for Natrium is intended to apply to normal operation scenarios, system leakage scenarios, the whole suite of LBEs and other quantified events, including the AOOs, DBEs, DBAs, and EDBEs like we've talked about. It's also used for emergency planning zone sizing and dose mapping for equipment qualification evaluations.

So, the EM will apply to all transient classes that could result from fuel failure. A phenomena identification ranking table process was conducted to identify and rank key phenomena expected with the mechanistic source term, and that PIRT was performed for three representative events, a fuel handling accident, sodium processing system leak, and an unprotected loss of flow with degraded pump coastdown.

And the figures of merit for that PIRT process were inhalation dose potential and submersion dose potential. And the word, potential, is there basically to indicate that this is for the source term, the dose is actually being, you know, calculated in a downstream evaluation methodology.

As part of the assessment base, we've evaluated existing tests, benchmarks, simple test problems, and legacy plant transient data. Like I mentioned, the PIRT was developed for selected scenarios, and ranking of those phenomena processes were completed.

Some scaling analysis has been performed and qualification efforts have been undertaken for the experimental work related to uncertainty arising from measurement errors or experimental distortions, and wherever there's experimental data lacking or certainty is currently undefined, conservative approaches are outlined in the methodology.

MEMBER MARTIN: This is Bob. I can't help myself, but, you know, I had asked Jong three times during the subcommittee meeting about who are on your PIRT team, obviously he gave the same answer three times. Still think it's very important that you provide transparency with regard to the individuals involved, their expertise as it lays down the foundation of your evaluation model.

I, in my summary report, of course on the different topical report, I did note that the NRC was, you know, fairly clear and, I don't know whether it was a NUREG or what, I can't remember the exact document itself, but I did cite what the NRC states on their position on, you know, the transparency of PIRT. Hope y'all are reconsidering your position, you know, to hold those proprietary even from us.

So, that's more of a comment. If you have changed your mind, I'd be happy to listen in, but it's probably the only location where you mentioned PIRT, so I figured it was --

PARTICIPANT: Had to do it.

MEMBER MARTIN: I had to do it. So anyway, you can comment if you like, or you -- Joe, you could just keep on going.

(Laughter.)

MR. SINODIS: Thank you for the comment.

(Laughter.)

MR. SINODIS: Okay, so with the EM development plan itself, the Source Term EM consists of a group software codes, or packages, where it would take output from upstream software, or EMs, for example the fuel failure with release EM, those are all used as input into the Source Term EM. And then output from the Source Term EM is used as input into the downstream Radiological Consequences EM.

Life cycle and verification validation plans have been developed for the source term software codes being utilized, and any software capability gaps have been identified with plans developed to fill those gaps.

The Topical Report talks about the structure of those individual software codes, defined for the six ingredients for calculational devices. This is listed in Reg Guide 1.203, the systems and components being modeled, constituent phases, you know, being considered the field equations, closure relations, numerics, and any additional features and software that may be deployed.

Also, on a more macro level, the EM structure is defined with the Source Term EM, how it interfaces with the upstream and downstream evaluation models.

And then as far as the closure models, models are incorporated -- and we've talked a little bit about this before for pool scrubbing and aerosol natural deposition, which are the primary mitigating phenomena that are considered in the Source Term EM.

The Topic Report also describes some of the modeling strategies, you know, being undertaken, particularly for sodium chemical reaction modeling, determining the dose-significant radionuclides for input into the calculational devices, talks about modeling strategy for functional containment predicting compartment conditions, determining barrier leakage rates, as well as the radionuclide transport itself and those mitigating phenomena.

An adequacy assessment is underway and has been taken to assess the model's capability of the equations and solutions of the model to represent the processes encountered, simulate the various system components. Code verifications have been conducted for the computer codes used, and code validations have been performed and are ongoing for some of the software. And like I mentioned, any strategy for gaps have been outlined in the Topical Report. And then model prediction biases and uncertainties, you know, will developed as necessary as the -- as the assessment continues.

Also in the Topical Report, we have a comparison of the Natrium Methodology to Reg Guide 1.183, regulatory positions 2.1 through 2.5 for alternative source terms. We've identified potential source list and releases under consideration at a high level, code identification evaluation is performed as part of that adequacy assessment, and code verification against model fidelity and accuracy, and like I mentioned, work is ongoing in this area as we progress.

And then the last slide here, it just talks about the interface with the other EMs, particularly the downstream Radiological Consequences Evaluation Model. So, the output from the Source Term EM is actually a time-dependent matrices of the radionuclide release, inventory that's released to the environment. And the format and periodicity of that output is event-specific and software-dependent, and the data is transferred via controlled electronic files to the downstream radiological consequences EM.

And then in the Topical Report, we do have two sample calculations in the indices demonstrating applications of --

MEMBER PETTI: So, Joe, just a question on the time-dependence. I understand sort of in the transport piece how that would work, but in the release, it's just the release fraction that's instantaneously injected, if you will, into the line? Is that how, let's say the in-vessel stuff is done?

MR. SINODIS: That's correct, yes.

MEMBER PETTI: Okay.

MR. SINODIS: Instantaneous release.

(simultaneous speaking.)

MR. FORREST: So, that's the sort of -- the release-from source is generally instantaneous, and the time-dependency that we see in this handoff between source term and radiological consequences generally can be attributed to leakage rates and, you know, transport from those compartments.

And so that, you know, for a release that happens instantaneously and then does not have much holdup, then everything's released very quickly to the environment. For a release that does credit our functional containment barriers, then we would see, you know, some kind of time-dependent release, if we're crediting a leakage rate that is, you know, retaining those radionuclides.

MEMBER PETTI: Right, but even in terms

of, you know, you've got thermal models of the core, so there might be a delay time before the fuel fails. But in the bigger scheme, is that a -- you know, let's say it takes 35 minutes or something, I mean, is that accounted for? And then the release occurs, you know, 35 minutes from when you say the event starts?

MR. FORREST: It depends on the event, but if we're looking at event that has, you know, an in-vessel event that has a slower heat-up and there may be some time that it takes for fuel to heat up where it gets to a failure point, we would consider that as part of the mechanistic source term development.

MEMBER PETTI: Sure, thanks. My other question is, so is the calculation all inside one code? I get the sense that it's -- in DBA space, it sounds like it's all inside one code. I mean, the release is put in and the transport through the sodium and the cover gas, is that all done in the subsequent all-in-one code? I'm just wondering, how do you do the uncertainty analysis across codes? I've only seen it done, you know, you do Monte Carlo, you know, all inside one code. Crossing codes, it seems like it would conceptually be a little bit difficult.

MR. SINODIS: I would say, generally it's done inside one code --

(simultaneous speaking.)

MEMBER PETTI: One code.

MR. SINODIS: From release from the fuel to, you know, there are other codes that are used to determine, you know, compartment conditions, what not, leakages, that sort of thing --

(simultaneous speaking.)

MEMBER PETTI: Yeah.

MR. SINODIS: But generally --

MEMBER PETTI: So, you got something you can put your arms around that you can do the uncertainty sort of on top of, if you will. Yeah, okay.

MR. SINODIS: Okay, and that was the last slide there. So, sorry I went through that quickly, but any other -- here if there are any other questions.

CHAIR KIRCHNER: So, do you get into any -- in this -- I'm just going back to slide number 15. So, unprotected loss of flow is included in the representative events, do you get to fuel melt there?

(No audible response.)

CHAIR KIRCHNER: In most of the -- the source term that we're talking about is plenum-driven fission gas release, right, not particulate or solid transport?

MR. FORREST: We -- you know, for when we perform --

(Simultaneous speaking.)

CHAIR KIRCHNER: Because, where I'm going with this, that's a breakpoint and that changes the whole suite of physical models that you need to analyze the situation.

So, I'm presuming that by and large we're talking here about, you know, breach of cladding and the source term being driven by instantaneous release, almost, of the accumulated fission products in the plenum area, anything that might be entrained or swept out of the clad with that kind of event. But does the unprotected loss of flow get beyond that where you'd get damage, you start changing geometry and you change -- you know, physics change, too, of course, if you get to melt.

MR. FORREST: Right. I'll comment, in this particular sense that unprotected -- generally, in our unprotected loss of flow case, we see, you know, that that sees a rapid rise in temperature, and we typically would reach a creep rupture point of the cladding, in which case we would instantaneously release, you know the plenum contents.

CHAIR KIRCHNER: Right.

MR. FORREST: We're not -- we're generally not seeing fuel melt in these scenarios.

CHAIR KIRCHNER: And for the other events though, typically then the failure is somewhere in the plenum area, or is it in the active core area and the plenum's venting down and then up?

MR. CHANG: This is Jong Chang. So, typically, like a heat flux or the power is at, like, a high -- near, like, at top of the fuel, so like the --

(Simultaneous speaking.)

MR. CHANG: Yeah, so failure location is typically, like, near the edge of, like, a fuel, like, plenum area --

(Simultaneous speaking.)

CHAIR KIRCHNER: Okay, that's what I would expect. Okay.

MEMBER PETTI: And that's what was seen in my TREAT, right? Weren't there experiments that also validated the failures up at the top? I thought I remembered reading that, when they did the transient overloads --

CHAIR KIRCHNER: I'm just thinking back to the previous analyses of similar systems, including PRISM, yeah. Okay.

MEMBER PETTI: Other questions, Members?

(No audible response.)

MEMBER PETTI: Online, anybody? Dennis or Vesna?

DR. BLEY: Nothing from me, thanks.

MEMBER PETTI: Okay, thanks. Okay.

CHAIR KIRCHNER: Okay, Dave, do you have everything you need for your letter?

MEMBER PETTI: Yeah, 30 seconds I'll have it written.

(Laughter.)

CHAIR KIRCHNER: Okay.

MEMBER PETTI: So, thank you. Let's --

CHAIR KIRCHNER: Yeah, thank you to all the presenters --

(Simultaneous speaking.)

MEMBER PETTI: Oh, yeah, public comment. Someone said we have to do public comment. Yeah, sorry. Let's open up for public comment. If you have a comment please raise your hand on Teams, or if you're in the room, and identify your affiliation and your comment. Yes, thank you. Ed, go ahead.

(No audible response.)

MEMBER PETTI: Ed?

(No audible response.)

MEMBER PETTI: We can't hear you, Ed, if you're making a comment.

(No audible response.)

MEMBER PETTI: We're still trying to get you on here, Ed.

PARTICIPANT: Okay, he's text -- he's chatting. He says his mic wasn't enabled and he's working on it.

MEMBER PETTI: Okay, try now. We think we enabled your mic.

PARTICIPANT: Well, he thinks it's on his end.

MEMBER PETTI: Oh, okay.

MR. LYMAN: Oh, no -- hello? Can you hear me?

MEMBER PETTI: There we go, we can hear you.

MR. LYMAN: Thank you, appreciate it. Sorry about that. Edwin Lyman, Union of Concerned Scientists, and I would just like to reiterate my previous concerns about the functional containment approach and its ability to provide the same level of defense-in-depth as is appropriate or applies to the current fleet.

The flaw here is that the physical containment provides defense and some measure of protection in beyond design-basis events, and it's not clear that the functional containment approach provides that same level of protection.

If you look at the Three Mile Island accident, we know that it -- the containment was overbuilt, perhaps, it was not designed to protect against hydrogen burn, but it was in place, and because of that additional pressure capacity, the hydrogen burn at Three Mile Island did not lead to a larger release of radioactivity. And so, if you -- similarly, if you have new designs where there may be events that you don't anticipate, having an overbuilt physical containment could provide that very important level of defense-in-depth.

And in that context, the other quantified events TerraPower referred to presumably include the types of core disassembly accidents that have been evaluated in the past for fast reactors, that these could lead to significant explosive forces within the reactor and within the core. The beta-type energy for a reactor of this size could be on the order of a ton of TNT, perhaps, and not having a strong physical containment in the event of such an accident could be catastrophic.

So, again, the lack of defense-in-depth here is the missing piece that I'm concerned about. Thank you.

MEMBER PETTI: Thank you. Any other public comments?

(No audible response.)

MEMBER PETTI: Okay, hearing none, turn it back over to you, Walt.

CHAIR KIRCHNER: Okay, well, we've budgeted the rest of this session this morning to letter writing and preparation, so, Dave, we're ready to bring your letter up and read it into the record.

MEMBER PETTI: We need Sandra.

CHAIR KIRCHNER: And we need some time to set that up. So, thank you to the presenters again, thank you for the details that you presented leading into the source term discussion.

And, with that, we'll take -- for those participating virtually, we'll just take a few moments to set up and transition to our letter writing session.

(Whereupon, the above-entitled matter went off the record at 10:23 a.m. and resumed at 1:05 p.m.)

CHAIR KIRCHNER: Good afternoon. This meeting will now come to order.

This is the afternoon of the second day of the 725th meeting of the Advisory Committee on Reactor Safeguards. I'm Walt Kirchner, chairman of the ACRS. ACRS members in attendance in person are Ron Ballinger, Vicki Bier, Gregory Halnon, Craig Harrington, Robert Martin, Scott Palmtag, Dave Petti, Thomas Roberts. And Matt Sunseri has recused himself from this meeting.

Attending virtually is ACRS member Vesna Dimitrijevic. Our consultant, Dennis Bley, is also participating this afternoon with us virtually.

If I missed anyone, either ACRS members or consultants, please speak up now.

DR. SCHULTZ: Steve Schultz is here.

CHAIR KIRCHNER: Ah, Steve, thank you. Thank you, Steve, welcome.

Quynh Nguyen of the ACRS staff is the designated federal officer for this afternoon's full committee meeting. And as I mentioned, Matt Sunseri has recused himself. We have a quorum.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act, or FACA. The NRC implements FACA in accordance with our regulations.

Per these regulations and the Committee's bylaws, the ACRS speaks only through its published letter reports. All member comments, therefore, should be regarded as only the individual opinion of that member and not a Committee position.

All relevant information related to ACRS activities, such as letters, rules for meeting participation, and transcripts are located on the NRC public website and can be readily found by typing about us, ACRS, in the search field on NRC's home page.

The ACRS, consistent with the agency's value of public transparency in regulation of nuclear facilities, provides opportunity for public input and comment during our proceedings. We have received written statements from C-10, who is also going to make a presentation during this session on Seabrook.

Any additional written statements may be forwarded to today's designated federal officer. We have also set time, aside time at the end of this meeting for further public comments.

A transcript of the meeting is being kept and will be posted on our website. When addressing the Committee, the participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard. If you're not speaking, please mute your computer on Teams. If you are participating by phone, press star-6 to mute your phone and star-5 to raise your hand on Teams.

The Teams chat feature will not be available during - for use during the meeting. For everyone in the room, please put all of your electronic devices in silent mode and mute your laptop microphone and speakers. In addition, please keep sidebar discussions in the room to a minimum, since the ceiling microphones are live.

For the presenters, your table microphones are very uni-directional and you'll need to speak directly into the front of the microphone to be heard online and also for the purposes of the court reporter.

Finally, if you have any feedback on the ACRS - about the ACRS and today's meeting, we encourage you to fill out the public meeting feedback form on the NRC's website.

And this afternoon we are taking up the topic of Seabrook Nuclear State Alkali Silica Reaction.

With that, I will pass over the chair to

Greg Halnon, who is the chairman of the our Plant Operations Subcommittee. Greg.

MEMBER HALNON: Thank you, Walt. And Sarah, Dr. Saouma, welcome.

So today, as Walt mentioned, we're going to be talking about ASR that's being experienced at Seabrook. I'm going to go through some points that are very important, so I'd ask everybody to listen carefully as we go through these.

We set some time aside today for this Group C-10, Dr. Saouma, hear from them regarding his white paper report of their assessment of N-I-S-T, NIST, shear wall tests and their relevance for Seabrook Safety Station.

The materials will be presented as part of the record for this meeting. After the presentation and questions from the committee members, we will then have public comment period before the beginning of committee deliberations.

I believe that if members have any questions for NRR or the region, there's members of those organizations online and they'll be available for the Reaction Committee.

Just a reminder, this is a meeting of the ACRS, not a meeting between the ACRS and the public.

It's a meeting for the ACRS and they've invited the C-10 organization to make a presentation.

Also, the ACRS is not and will not act as a surrogate for the ASLB, Atomic Safety Licensing Board. Their 2020 decision stands on its own. The ACRS is an independent committee.

The NIST report was not available at the time of the ASLB proceedings. We are here because we were told that it contains new information impacting the safety of Seabrook Nuclear Station. If this new information could impact the safety of the plant and the plant structures, we want to hear about it.

However, I have to caution you. This is not an end-around on the motion to remove or other reconsiderations of the decision. In fact, the Commission put a really high bar on reconsiderations. They consider it a very extraordinary action. It's not to reexamine the facts or the rationales which had been previously discussed during those proceedings.

So I ask that if items have been previously discussed at ASLB and you're bringing them back up, please be transparent with us.

If you want to have a reconsideration of the ASLB, this is not the venue to do it.

Finally, the ACRS usually requires at

least 30 days in advance for technical papers to be submitted to us for Committee review. We made an exception to this since we received this seven days ago, partially because we already had this discussion scheduled on the publicly noticed meeting.

So we thought since we're not under any urgency to make a conclusion or anything to that effect, that it would be good to hear the information that you have to present, recognizing that your position industry and knowledge base.

So it's important for us to understand that we have not had time to digest this material. Engineering staff of the agency has not had time to digest the material. So we will listen and let you provide the information that you brought to us.

And normally we have a lot more time to prepare, but we have a lot of topics this meeting. So just keep that in mind during the discussions that some of our questions or comments may be just what we haven't had that time we normally. And we will take public comments thereafter, after this meeting.

All these will be entered into the public record. I believe that the papers and presentation that you presented is already in the public domain at this point, so that should not limit you.

So with that, Dr. Saouma, I want to welcome you. We've heard you on the phone several times, it's good to have you in person. We appreciate you attending.

And I'm going to turn it first of all, any number that has a comment or question up front. I don't see any. So I'm going to turn the presentation over to you. So please provide us with your talk.

MR. SAOUMA: Thank you. Thank you, Mr. Chairman. Thank you, ACRS Committee, for giving me the opportunity to present some of the concerns that I have.

I thought it would be easier for me to go through the white paper as it contained most of the details. I was planning to make a presentation of about 10, 15 minutes and give time for question. And of course feel free to interrupt me at any time.

MEMBER HALNON: Yeah, so for a time check, if you keep it to 30 minutes, that would be good. And then that'll give us another minutes, because we usually ask for about a 50%. We have an hour, so let's do a 50% talk and time for questions. Go ahead.

MR. SAOUMA: Yeah, let me saying a problem like what we have here really is clash of two different culture, one of engineering and one of science. And sometimes those two communities not always manage to get along too well.

Everything starts with science, everything starts with fundamental research principle, with the rough methodology, eventually those methods, methodology become well accepted, and they find their way into course, into general practice.

However, when there's a new problem which is particularly complex, it may be that engineering is not enough to solve, address this issue. We have may have also to consider the body of knowledge obtained through science in the last couple of years because it can have a high impact.

And they may occasionally and potentially contradict a finding of engineering. But at the end of the day, having been a professor for 40 years, I like to hope that if there is any doubt, science has to prevail over engineering.

Now, having said that, I started by mentioning that the response of the CEB is dominated by in-plane shear, and that the test which were performed was for so-called out-of-plane shear, which are not at all applicable for a structure like a CEB.

Incidentally, during the hearing it was mentioned that NextEra plans was never to test the specimen which is representative of the CEB. They made it amply clear that the test they are doing is not to reproduce the failure or make it similar to the one with CEB.

It's of concern because when it comes to shear strengths, why are we concerned about shear strength is because of seismic load. So once you have a letter of excitation, we are concerned about the ability of the structure to reshear at the base. There is no structure which is more prone to shear, potential shear failure than the CEB.

So tunnels, adjacent structure, yes, they might be impacted by earthquake. The shear strength might be mobilized, but nothing close to the CEB.

MEMBER HALNON: Dr. Saouma, the one difference in the CEB other than what you just talked about is that it's a, it's a hoop. Can you explain how that either helps or doesn't help the seismic stresses and the in-plane stresses that you're talking about?

MR. SAOUMA: Yeah, what we are dealing with is a shell, a shell which has a thickness much more than its other dimension. And according to one established procedure, including some of the ASME codes, we treat it as a membrane, a structure which mobilize its membrane effect. That is no bending, pure axial and shear forces.

There might some localized flexure at the juncture where there is discontinuity. But otherwise, as a structure, once it is excited laterally, you look at the potential shear failure of the CEB. Which is why, as far as I know, all the other tests which have performed address ASR in nuclear structure have been using so-called squat shear wall.

Also, many years ago I was first-year graduate student at Cornell. We were having tests done for the NRC where there were shear panel subjected to in-plane shear to test and address the resistance. Of course it was not about ASR, but how is a structure test can replicate a kind of shear failure or kind of failure that you can have in a CEB.

So what I am trying to say is that in no way can we say that the type of tests which were performed is indicative of the type of failure expected to happen in the CEB.

MEMBER HALNON: Okay, now I understand that was part of the ASLB hearing, correct? In representation?

MR. SAOUMA: It was addressed.

MEMBER HALNON: And it was - what was the conclusion?

MR. SAOUMA: I don't come to any towards any specific conclusion saying no, it is --

MEMBER HALNON: Believe it said that it was representative, sufficiently representative for adequate protection. Believe that was the conclusion.

MR. SAOUMA: Okay.

MEMBER HALNON: So why are we talking about --

MR. SAOUMA: Because these studies came and to show that the shear strength is smaller than what had been --

MEMBER HALNON: You made NIST more representative than the beam test?

MR. SAOUMA: Because of the nature of the structure. Because you have a membrane response, which is characterized by the shear failure, which can be only captured experimentally through squat shear walls. Certainly not by beams.

MEMBER HALNON: And recognize I'm not an expert in structures. The squat shear - I can visualize a beam. What is a squat shear wall?

MR. SAOUMA: A squat shear wall is --

MEMBER HALNON: Is there a specific dimension to that?

MR. SAOUMA: Yes, it is a wall, which has to be small height because you want to minimize flexture, and large shear. For instance, this is what was tested at NIST. This was a panel tested in the years before, and these are other tests by Kajima in Japan for reactive shear walls.

MEMBER HALNON: And you're saying that's more representative --

MR. SAOUMA: Of course, no doubt about it. Absolutely no doubt about it.

MEMBER PALMTAG: Can you explain C a little better? What's actually happening?

MR. SAOUMA: Okay, what's happening is we have a wall. They apply a vertical load axle force on it to duplicate the in-situ stresses.

MEMBER PALMTAG: Which one's the wall? The one in the red?

MR. SAOUMA: I'm talking here. This is a wall.

MEMBER PALMTAG: It's not showing up.

(Simultaneous speaking.)

MR. SAOUMA: That's not what it said. So what they do is they apply on top of it a heavy reinforced concrete beam was actuated to apply the compressive force. Because we have to duplicate the in-situ in times of stress for the test to be meaningful, something which is completely absent in the shear bend of the beam by the way.

And then we apply a lateral force to impose - quasi pure shear on the wall so that we have a mechanism of failure, which is identical to the one that you would anticipate in the CEB.

MEMBER PALMTAG: So are you concluding that the ASLB conclusion that it was sufficiently representative is incorrect?

MR. SAOUMA: I'm afraid to answer the question, because if I say yes, you're going to say well, it was adjudicated, so we cannot talk about it.

MEMBER BALLINGER: We want the answer.

MR. SAOUMA: The answer, absolutely incorrect. No doubt about it. I mean, so problem is that none of this has been subjected to external independent peer review.

MEMBER HALNON: Was yours?

MR. SAOUMA: Mine?

MEMBER HALNON: Your white paper, was it a peer review?

MR. SAOUMA: I claim to be an expert, with all due respect.

MEMBER HALNON: I'll take that as a no,

then, it's not peer reviewed.

MR. SAOUMA: No, I have --

MEMBER HALNON: Do you have peers?

MR. SAOUMA: I have peers. I made a presentation to EDF, by the way, with only using publicly available information. And of course they agree with me.

MEMBER HALNON: So it's sort of peer reviewed.

MR. SAOUMA: It's sort of a peer review. But having 20 publications, short courses, books on the subject, well, of course I need to be peer reviewed. But certainly the original proposal --

MEMBER HALNON: Okay.

MR. SAOUMA: Was peer reviewed, which in my opinion was not. In my opinion it was not peer review.

So I don't know exact test configuration answer question that you had.

MEMBER PALMTAG: Okay, that makes sense.

MR. SAOUMA: Yeah, so again, axial force, because there is axial force. And then we shear it. The beam is FLETC. And no way on earth can it duplicate the type of failure that you have on that big shell, the cylindrical shell. That's my point.

And that was highlighted by the NIST and NIST indeed found that the shear strength is about 20% lower than the nominal flex, which incidentally coincidentally is exactly the same amount I found. Because I was also funded by NSF to perform shear test. I found out that the shear strength is about 20% lower.

So the concern here is that yes, it was a test which was performed --

MEMBER PALMTAG: Can you explain that a little better? So you have a wall without ASR, and then you have the same wall with ASR?

MR. SAOUMA: That's correct.

MEMBER PALMTAG: And there's 20%.

MR. SAOUMA: Degrees in strength.

MEMBER PALMTAG: So how did they get ASR?

MR. SAOUMA: At the NRC. Sorry, when you do - you have a concrete mix with is reactive.

MEMBER PALMTAG: So similar to the way they did it in Texas.

MR. SAOUMA: Yeah, because that's only way we can. We try to have a mix which is --

MEMBER PALMTAG: I understand.

MR. SAOUMA: - as close to the origin mix. They put it a, in the environment of high temperature and high humidity. So it accelerates the thermo dynamic process.

MEMBER PALMTAG: Okay.

MR. SAOUMA: So once they reach a certain level of expansion of specimen, they bring it to the lab and test it.

MEMBER PALMTAG: Yeah, so it's just the way they did in Texas, I understand that. So is this wall composition similar to a reactor containment vessel?

MR. SAOUMA: Yes --

MEMBER PALMTAG: -the one at NIST?

MR. SAOUMA: When I read the report, that's what they - when I read the report of NIST, they tried to adhere as fully as possible to have a reactive concrete.

MEMBER PALMTAG: You're going to fight technology issues all through this, don't worry about it. Just keep on working through it.

MR. SAOUMA: Okay.

MEMBER PALMTAG: Just a short, briefly, I have the right rebar in there to represent --

MR. SAOUMA: Yes, to pick it. It's important that you have the rebar so that you maintain as much as possible the low similitude.

MEMBER PALMTAG: It's the same rebar proportions?

MR. SAOUMA: Yes.

MEMBER HALNON: So is all ASRE created equal?

MR. SAOUMA: It's a little bit - no, I mean, you have times when you have a - a aggregate which is more reactive.

MEMBER HALNON: So how can we be assured that the aggregate used in these tests, and I'm not just singling out any one test, is similar to the aggregate used at Seabrook?

MR. SAOUMA: As far as I know, in Texas they have not been able to use the same aggregate. They use a highly reactive aggregate, including something called Texas sand, which is very reactive. And they put alkaline in the mixer in order to --

MEMBER HALNON: Well, as long as the - as long as you get ASR, I mean, the actual reaction it doesn't, I mean.

But I guess the point is, is that in a test situation, wouldn't it be like a very homogeneous mixture of a certain amount of aggregate and a certain amount of cement and a certain of this and be little bit more pure, if you will, as opposed to a random mix that would be done at a nuclear plant?

MR. SAOUMA: Yeah, so problem when you huge structures such as a nuclear reactor plant, CEB or even a dam, you have concrete coming continuously from over time. We cannot say that it is all homogenous. There is certain heterogeneity.

MEMBER HALNON: That's what I meant. But the test is.

MR. SAOUMA: That's because by the virtue of being smaller, it is more homogeneous. It cannot capture the heterogeneity within the context of a test.

MEMBER HALNON: So wouldn't it bias towards the structure at Seabrook being stronger than what the test would show out? Because it's - it doesn't necessarily all have reactive --

MR. SAOUMA: Well, you bring in something which we call size effect. I mean, in other word by that is the equation, where the bigger the specimen, and actually it's the other way around, it's bigger, it is weaker. Because it has more likelihood of having the effects than having in a controlled environment.

MEMBER HALNON: So it's a statistical thing, then.

MR. SAOUMA: Yeah, I think has to do with the bigger model. So if you have many potential weakness in the big structure, you are more likely overall to have a weaker structure than if you have a smaller specimen. That's back to - it's back to mechanics for your --

MEMBER HALNON: Since we've kind of touched on the 20% lower strength, the Table 2 in your paper has two tests that are higher strength, two tests that are lower strength, and one that had no impact.

In my simple mind, tie goes to the runner. It seems to me that that's a bias towards the test. That - I mean, the volume of tests out there show that it's - a tie. But you decided that --

MR. SAOUMA: Puts a tie, because once we're just looking at the test and you examine how it was performed, in my expert opinion, I know that certain tests were conducted much more thoroughly than others. That might be perceived.

MEMBER HALNON: Okay, so from the public documentation, you've seen --

MR. SAOUMA: I was transparent. I provide you with everything. What I have not shown in here is additional tests which were done by another group at

Toronto where they did tests on pure concrete specimen, and they found out oh, there was a reduction in strength.

MEMBER HALNON: But that's not published yet?

MR. SAOUMA: Oh, it is published.

MEMBER HALNON: Why wouldn't you?

MR. SAOUMA: It is not - I mean, I had prepared an additional set of PowerPoint, and --

MEMBER HALNON: It just didn't make it in?

MR. SAOUMA: It didn't make it here, but it is in the literature. The under sensors, Toronto, they did pure shear test on pure concrete, no reinforcement. So they're trying to see whether the ASR is going to weaken the concrete.

We know that ASR is weakening the concrete in tension, in the elastic modelers. And shear was the question. But if you look at something called Mohr's circle, seal and tensile failure are barely written onto each other. Compression, there is some discussion whether it is weakening or not. Yeah, this I'm positive.

So my point is NextEra has performed a test which measure own account. Is not attempting to replicate the CEB tailored model. And yet they went on and applied the same result to all the structure, including the CEB. So then there is a potential issue. Because testing the beam.

See you find it is conveniently stronger. You don't take advantage of the strength, say okay, it does not affect the nominal strength. And they applied to whole structure, including those where the failure mode is entirely different.

Scientifically, this violates all kind of similarity laws. Those similarities include dynamics, pure mechanics. I mean, we know where to satisfy certain --

MEMBER HALNON: I was just wondering, we look at the test data, and they can look at it from different ways. You know, the size of the wall, the type of specimen, the aggregate used and how long did you age it, how did you age it, that sort of stuff.

Yet the most appropriate and most I guess best test that's going on is what they're doing right at Seabrook itself, isn't it? I mean, isn't that doing the actual concrete, the actual core boring and the actual visual test and experiments that they do, isn't that the best set of data we could possibly hope for?

MR. SAOUMA: We're talking about two

different things here. What they're doing is maintenance observation. What I'm looking at, what happened when there's a potential earthquake, how is it going to fare. They are not doing any of that.

They are relying on the finding of the Texas that say the complete strength remains the same.

MEMBER HALNON: Well, they have to extrapolate for something.

MR. SAOUMA: Excuse me?

MEMBER HALNON: You have to extrapolate some data. I mean, you can't subject the plant to a earthquake and say, okay, now we can test it, so.

MR. SAOUMA: No, but that goes at the heart of what we do as structural engineer when we design the structure, when we need to assess or safety of the infrastructure, we need to find out how is it going to fail. So we perform tests in which we have a same failure mechanism as the one anticipated in the prototype.

There is a model and the prototype. If the model does not duplicate the prototype, the test is not applicable. Let's not confuse failure with surface laws. What they are doing now is to think of surface laws.

They are looking at observing crack widths on the surface. You ask me if those are reliable, I would say no, because there is so much infusement on the surface that you won't have any much of cracking on the surface. Once there's a cracking, happens inside.

MEMBER HALNON: And what the bores are for?

MR. SAOUMA: The bores are about how long are they. The wall is four feet, okay. The bore hole are about 20 inches, okay. One would expect the reaction to occur mostly in the zone where there's the highest water content and high temperature. And there is a gradient.

So by the time you come to the surface, the surface is ready to be dry and the surface has heavy reinforcement not too far from it, which is going to inhibit crack opening.

MEMBER HALNON: So other than the original moisture that's in the concrete, how is the moisture getting into the center without it being on the outside?

MR. SAOUMA: There's water everywhere. When you mix concrete, the reason the mix is because it has high water content. However, on the surface it won't dry up. It's exposed outside. In the summer, it's dry, so there's shrinkage. So water evaporates. So you have less water content on the surface than you have the inside.

MEMBER HALNON: I was under the impression the ASR was most predominant in areas where the concrete was wet on the outside, causing additional moisture on the inside. You're saying that this is caused solely from the original - solely from the original moisture?

MR. SAOUMA: Yes, not solely but mostly from the inside. Because when we mix concrete, if we were to look at the amount of water in this for complete hydration, we don't need much water. But we cannot mix it easy, so we put more water.

So by the time we pour the concrete or we place the concrete, there is a pretty high rate of humidity. Anytime it's more than 80%, we are likely to have ASR.

However, with time, the surfaces are going to dry, just when you pour concrete on your driveway, it's going to be dry on the surface. If up here it's going to sink this crack. So I'm talking here about moisture from the inside and not from the outside, that's for sure.

MEMBER HALNON: So why wouldn't we see -

why wouldn't we see it above grade just as predominantly as we see it below grade?

MR. SAOUMA: Why don't we see it above grade? Well, last time I was there in 2019, there was plenty of crack when we went around.

MEMBER HALNON: Well, there was some out, but it wasn't nearly as predominant as it is below grade.

MR. SAOUMA: Than on the - than below grade? Yeah, because below grade, there's no room for it to dry. It might be in contact with the soil moisture on the other side of the wall or the rock. Above grade, it is exposed to the sun, to the air, to the wind, which is going to dry it.

MEMBER HALNON: Does it ever dry out completely?

MR. SAOUMA: Hopefully not. There's always some.

MEMBER BALLINGER: There was an author named Thomas Huxley, who once said that what we have here is the difference between a great hypothesis and an ugly fact. That theoretically, what you're saying nobody can argue.

But as a practical matter, from Seabrook, which is the only experiment we have, given the inhomogeneity of the pour itself, I can't it pour, I have to call it placement, right? Yeah, placement and the fact that the CEB is four feet thick, is it likely that statistically speaking -- we were up there, we saw it.

You have regions where you have ASR and regions where you don't. But that's only from the outside. From the inside, we don't have a clue because of the inhomogeneity of the geology from which the granite came from.

So that's the reality of the situation. So is it appropriate to compare a theoretical calculation for what would happen if you knew everything to the situation where we don't know everything?

In fact, we not only don't know everything, we know that there's a lot of inhomogeneity in the system, and that's the thing that I wrestled with. Because you know, in golf they say that trees are 90% air. Well, in the case of the CEB, it's 90% rebar.

MR. SAOUMA: Except in the middle.

MEMBER BALLINGER: Well, okay.

MR. SAOUMA: And there's no shear reinforcement.

MEMBER BALLINGER: But you're making my point. You're making my point. So that's this, the thing that I struggle with.

MR. SAOUMA: Well, this is same problem in all structures that we live with.

MEMBER BALLINGER: But I'm talking about Seabrook.

MR. SAOUMA: Okay, in dams there's a lot of homogeneity and that we approach it in a certain way, its structure. But Seabrook, if you want to say well, there is some homogeneity, so forget about this science, I'm not sure I can go along with that.

MEMBER BALLINGER: I didn't say we're forgetting about the science. I think I made exactly the point that we do have the science. And if you could adequately characterize everything, in other words, if you knew everything, then you would know the answer. But we don't know everything. In fact, we know - we know we don't know everything.

MR. SAOUMA: As a matter of fact, I happen to have published a paper addressing the inhomogeneity of concrete properties in a dam. So we randomly assigned properties and compared it with what had been the result if everything was homogeneous.

At the end of the day, we have the same

mean, but we're in different standard deviation. It's all paid for in the standard deviation. The mean is more or less the same. When you brought up homogeneity at - and a lot of homogeneity -- and homogenous, you still get the same mean result. The spread is what makes the difference. Something that's, you know.

And again, I've been advocating one to use to a large extent as much as possible, probabilistic-based approach in here. And so of course it's not being done, but that's another story.

MEMBER BALLINGER: So let's say that you do have a big spread, I'll grant you that for sure. But now we're talking about a seismic analysis.

MR. SAOUMA: Okay.

MEMBER BALLINGER: And for a failure to occur, the loads have to be applied in a certain way which we don't understand sometimes. And that load has to be - has to be applied in the region where you have the probability that you have ASR through thickness. So how does that happen?

MR. SAOUMA: Excitation. You have the basic image is excite. The whole structure is being excited, the whole structure. It is not choosing path of least or maximal resistance. The whole structure is being excited. Everything is being stressed, the part which are homogeneous and the part which are inhomogeneous.

MEMBER BALLINGER: Right.

MR. SAOUMA: So unless we do analysis where we model heterogeneity, we're to assume the same mean, the means that we live with, and how is it going to respond.

MEMBER BALLINGER: But that's the assumption we have to make.

MR. SAOUMA: It is an assumption, yes. I mean, what is any better solution? I don't know there is any better solution.

MEMBER BALLINGER: Well, under, in a lot of engineering cases, when you - when you're in the situation that you're in, the solution is to monitor.

MR. SAOUMA: I disagree because a monitor may not capture - you might have a monitor but if you have an earthquake, it might be --

MEMBER BALLINGER: Well, we don't produce earthquakes. What I'm saying is we monitor the structure.

MR. SAOUMA: We produce it in the test bay, which is what NIST did by pushing that wall until failure. So it is duplicating, if you want.

MEMBER BALLINGER: Granted, but that now is what Member Halnon was saying, is we have a very well-characterized specimen, if you will, big as it might be. But that is --

MR. SAOUMA: An idealization?

MEMBER BALLINGER: It's different from the real world. I mean, it's the best we can do, okay, it's the best we can do.

MR. SAOUMA: If I --

MEMBER BALLINGER: But it is different.

MR. SAOUMA: If I hear you correctly, you are trying to say that tests are not - cannot be reliable because we are - everything is homogenous. It does not affect reality, so let's monitor and not worry and not take into account test results.

MEMBER BALLINGER: That's half --

MR. SAOUMA: Which would be, from a structural point of view --

MEMBER BALLINGER: You don't ignore - you don't ignore the test results.

MR. SAOUMA: We don't ignore.

MEMBER BALLINGER: You don't ignore test results. But you do account for the fact that there's a difference between the well-characterized testing and the actual application that we're dealing with, not only in terms of initial characterization, but in terms of evolution of time.

This issue of drying and things like that, the effect of ASR or the shear strength is likely to be a function of time, no?

MR. SAOUMA: When ASR progress with time, and by the way, the criticism that you seem to be making to the shear wall will apply even more to the beam that were tested in Texas, but which we - everything in based in the analysis.

So if it decides one, it also decides --

MEMBER BALLINGER: All I'm saying is this thing I'm struggling with is the relationship between the testing that was done, no matter where it was done. Well-characterized, well thought out, at least in their minds, and the actual application to the structure itself, and the issue related to making that translation to the structure itself. That's what I struggle.

MR. SAOUMA: Indeed, and in order to minimize that potential discrepancy, we need to have a somewhat intelligent test. We need to have a model which capture the same failure mode as the prototype, which is what I'm advocating. Which is what they did at NIST, but did not do at - in Texas.

We need to capture at the very least the same failure mode. If the failure mode does not replicate what we expect to see in the CEB, it's to repeat.

MEMBER HARRINGON: This is Craig. In the full containment structure, if you have an earthquake and the most weakened, most susceptible locations begin to fail, but there, you know, as Greg pointed out, you know, it's not a homogenous concrete structure.

You have local areas that are good, bad, indifferent. How does that failure extend and propagate? Does it - would local areas that are weaker because of ASR or anything else be challenged but cracks don't extend because they're going to encounter a more stable portion of the structure? How does that develop?

MR. SAOUMA: It's called progressive failure.

MEMBER HARRINGON: Okay.

MR. SAOUMA: I mean, just like the World Trade Center, the top beam collapsed, and then it escalated because it was a progressive failure. Here, during an earthquake, what's going to happen, the weakest point is going to fail first. What is it?

Nobody knows. But you know that it is present.

By the time you start failing, it's going to weaken that zone and there'll be redistribution of the stress path, which cause that this failure is going to progress. Over the entire structure? Certainly not. But large enough to be of concern, in my opinion.

So progressive failure, which start as a point of weakest resistance, which we do not know what it is but we know that it is there, somewhere. And that will, again, be to heterogeneity. Of course, it's there, is a very heterogeneous.

If you were to plot the result of the compressive strength of the concrete measured when it was contracted, and true, there is certain spread in there, and we have to account for this heterogeneity. We can intelligently address this complex problem by minimizing the potential error.

Is it perfect? It will never be perfect. But is the best we can do. It's one which can be defended.

MEMBER HARRINGON: And my other question is there's the - is the beam test that was done appropriately representative of a rectangular structure, or are those structures also of concern in your mind as well?

MR. SAOUMA: Well, the beam test, why they chose a beam, I don't know. I mean, I have some suspicions, but it is not representative of what this CB - for of the CEB.

It is representative of the tunnel, because that's where ASR was first observed? I don't know. I doubt because the tunnels are anchored into the rock, so they're not particularly weak in the seismic activity.

It happened to be at least a test for Texas to perform. And at that point, nobody wondered what are we capturing. The failure mode anticipated. During, again, I'm sorry to mention, but during the SNP hearing, it was mentioned that according the SEI code, the only way to test shear is by testing shear beam, which is absolutely wrong.

Because a SEI code has also provision for shear walls and for testing shear walls. That is, in the SEI code. They don't test shear only with beams, they test it also with shear walls, which would have been the appropriate test for a CEB.

MEMBER HARRINGON: But what about the other structure?

MR. SAOUMA: The other structure? You

have to tell me what other structure. It might be representative in some of them.

MEMBER HARRINGON: Well, I mean, in general they're rectangular structures as opposed to cylindrical structures. Does that make a significant difference or not?

MR. SAOUMA: Not as much as with CEB. And the only reason I keep on hammering on the CEB because by far it is the most critical structure in the case of an earthquake. By far it is the most rigid.

I mean, you have a high center of gravity, you have an excitation. It's going to rock back and forth, and it's going to mobilize its shear strengths everywhere. And it's going to find out the weakest point, and that's what would have a localized failure, which may or may not spread.

So in my view, having analyzed the full dynamic analysis of CEBs published in nuclear engineering journals, you know, peer reviewed, this is the most critical one. And failure happens somewhere in between, somewhere over there, if you account for heterogeneity.

And again, I just go repeating myself, heterogeneity is present, always a chance to choose a standard deviation. To me remains the same. I can forward the paper after speaking and to show you that.

That was basically my biggest concern, that they took the results of a test which may not be representative for CEB and applied it blanket over all the entire structure.

MEMBER HARRINGON: I'm kind of going back, kind of like you said, going back to my question. So I appreciate the description the shear test. But the way I look, the way I see it is that shear test is exactly the strength of where the rebar's going to help, right. That's exactly where the rebar is.

MR. SAOUMA: The rebar --

MEMBER PALMTAG: So it's more of a test, I'd almost say it's more of a test of the rebar than a test of the concrete. So that's why I'm concerned --

MR. SAOUMA: Same thing, same thing.

MEMBER PALMTAG: - because does this have the same --

MR. SAOUMA: - same thing with the beam test, by the way. We know the structure is reinforced. We have to be putting the reinforcement. However, the reinforcement which are --

MEMBER PALMTAG: Well, I'm concerned that this NIST test isn't representative.

MR. SAOUMA: It is, certainly more so than the other test because --

MEMBER PALMTAG: How is the scale done?

MR. SAOUMA: Your reinforcement --

MEMBER PALMTAG: - does this have three-inch rebar steel beams in it?

MR. SAOUMA: Same as just scale everything down, of course.

MEMBER PALMTAG: They scaled the NIST test?

MR. SAOUMA: They scaled the test. You need to expect the law simulations. You cannot violation those laws.

MEMBER PALMTAG: That's what I'm, it's a question I'm asking.

MR. SAOUMA: I mean, when I did my --

MEMBER PALMTAG: - does the scale - does this scale hit the Seabrook walls?

MR. SAOUMA: They cannot use - they cannot use No. 18 bars in the lab.

MEMBER PALMTAG: I understand. So is this scaled --

MR. SAOUMA: It is.

MEMBER PALMTAG: Seabrook, okay, that was my question.

MR. SAOUMA: And when I did my own test in Colorado for NRC, everything was not only scaled, but as parted from a specimen, the model taken from the CEB rotated it and put it in our testing machine. And that's how we tested --

MEMBER PALMTAG: The right rebar.

MR. SAOUMA: With the right rebar, yes. But the difference is that yeah, there was no shear reinforcement in these. Neither was there shear reinforcement in the Texas test. There was no shear reinforcement, which is --

MEMBER PALMTAG: There should be in the CEB, correct?

MR. SAOUMA: The CEB does not have shear reinforcement above a certain elevation, as far as I know.

MEMBER PALMTAG: Got a follow-on question. So when we were at Seabrook, we heard some experts, I don't know the name of the consulting firm, but there's a consulting firm, large consulting firm, thousands of - thousand employees --

MR. SAOUMA: NPR?

MEMBER PALMTAG: In Boston, and they run --

MR. SAOUMA: SGH.

MEMBER PALMTAG: I can't remember the exact company.

PARTICIPANT: It's going to the best second one.

MR. SAOUMA: It's not - SGH.

MEMBER PALMTAG: Yeah. So they ran finite element tests, and they don't see the 20%.

MR. SAOUMA: There is no such thing as finite element test.

MEMBER PALMTAG: They ran a finite element analysis.

MR. SAOUMA: Analysis, yeah.

MEMBER PALMTAG: They ran a finite element analysis.

MR. SAOUMA: It all depends, number one, what you feed into its input and the model itself, how are they modeling ASR. As far as I know, they model ASR in the way which was done 20 years ago, they're fitting it as a temperature expansion, homogeneous entire in that structure.

Which is something that people stopped doing many, many years ago because ASR expansion cannot be captured by putting everywhere the same temperature. There is a gradient. It depends on variability, it depends on temperature. What you do in the finite element analysis --

MEMBER PALMTAG: Over a 12 inch by 12 inch, your humidity and temperature are going to be pretty constant?

MR. SAOUMA: Excuse me?

MEMBER PALMTAG: Over a 12-inch sample, which is in between the beams, the humidity and temperature I wouldn't expect a big difference.

MR. SAOUMA: Yes, but I'm not - I'm not sure I prove your point. What I'm trying to say is that the test did not have shear reinforcement. Neither NIST, which is correct.

MEMBER PALMTAG: Why, I'm trying to understand, so why wouldn't the finite element model - I'm sorry, analysis show a 20%?

MR. SAOUMA: It cannot because it all depends on what you put as input. Because when you do a finite element analysis --

MEMBER PALMTAG: Finite element analysis puts in a temperature, so it swells the concrete, right.

MR. SAOUMA: It boosts the temperature, okay. And --

MEMBER PALMTAG: So you get thermal expansion, which is what is - I'm trying to understand, so walk me through this.

MR. SAOUMA: Let me walk you through. I've performed a lot of ASR analysis. The first thing we do is thermal analysis. We look at the variational temperature over a year. We repeat that analysis for five, six years until we have a steady state variation. Because the temperature is thermodynamically fluid.

Then we keep that data and file it. Then we look at the relative humidity. That relative humidity is more or less constant, so we can assume it to be constant. And then we perform the simulation 15 days at a time by increments, 15 days, 15 days, 15 days. It's an analysis which takes time.

And incidentally, it's a non-linear analysis, which everything over there is linear elastic analysis. You cannot perform a linear elastic analysis when you have potential failures. So, and then you simulate that.

And part of your input data is what these elastic models of concrete, how does it interrelate with time? What is the tensile strength of the concrete?

MEMBER PALMTAG: How does the swelling, how do you - how do you model the swelling? From what you said, I didn't.

MR. SAOUMA: The swelling is very often modeled as a sigmoid curve. Because it start in slow, it then accelerate, then it tapers off. So there is a model developed at MIT which basically gives you an equation for that sigmoid curve, which is characterized by something called latency time, characteristic time, and the maximal expansion.

Typically, that's been from so-called acceleration test.

MEMBER PALMTAG: But that gives you a volumetric expansion.

MR. SAOUMA: It would be volumetric expansion, yes. It will give the volume expansion versus time.

MEMBER PALMTAG: You're in between two rebars, which we've seen these rebars. They're just huge rebars.

MR. SAOUMA: Yeah, you.

MEMBER PALMTAG: Ten, 12 inches apart. Wouldn't that give you compression? Wouldn't that make the concrete stronger in between these rebars?

MR. SAOUMA: When we have confined concrete, yes, it is stronger.

MEMBER PALMTAG: But this is confined,

especially in that shear direction.

MR. SAOUMA: Yes, yes.

MEMBER PALMTAG: So you have a wall that's stronger in this direction. So I'm trying to understand.

MR. SAOUMA: What you do is basically you have a fit of the mechanics to capture. So constitutive models are complete, which is a function of the pressure walls, of the confinement. The constitutive models are complete. But constitutive I mean the ways of complete response to stress, to stress or force. How does it respond.

Okay, then we have failure models, more prolonged than models. But I'm not seeing --

MEMBER PALMTAG: We're starting to lose your --

MR. SAOUMA: You cannot see that we have number 18 bars. So that's very strong, nothing in between can move. You have no idea how strong the ASR expansion is. You have no idea what it can do. As a matter of fact, nobody's been able to stop or to prevent it or to slow it down.

Which made me smile a little bit when I saw a presentation a few months ago when they put those little brackets to prevent the wall from expanding. I mean, that's band-aid, that's nothing. Unless you did some very detailed analysis, I mean, this is going to do nothing. It's going to yield within a few weeks. So.

MEMBER PALMTAG: But it doesn't.

MR. SAOUMA: They've not yet installed it.

MEMBER PALMTAG: They've installed bracing, yeah.

MR. SAOUMA: Bracing?

MEMBER PALMTAG: Oh, yeah, there's lots of them.

MR. SAOUMA: Okay, and have they been able to prevent the expansion because of bracing?

MEMBER PALMTAG: I haven't seen the bracing bend.

MR. SAOUMA: Well, we don't see it because of course you don't see it because it's infinitesimal. You have to put string gauges on the bracing to find out what's happening. I don't think they're doing that.

MEMBER PALMTAG: But it does put it in compression if it expands. If you're not seeing to the strength, to the strength of the bracing itself.

MR. SAOUMA: If it is going to stop it or to prevent the expansion, I am extremely doubtful that it can do that, resource bracing.

MEMBER PALMTAG: You don't see that occur and say no to it.

MR. SAOUMA: I have don't think we're reaching a judgment.

MEMBER PALMTAG: That's good.

MR. SAOUMA: And they have few of that. I mean, I've been for 40 years teaching and they have been teaching also. So.

MEMBER PALMTAG: Yeah, I, but from my perspective, at a large company with a thousand employees, they have experience too.

MR. SAOUMA: Actually surprised. You'd be surprised. I mean, this one was the biggest frustration because we spent time teaching finite element on here, finite element.

And you go back to the companies and you find out that what they are doing is absolutely incredible. I mean, to still capture ASR as temperature in 2025. We think that's not been subjected to peer review, that analysis. Only people who review the analysis Idaho National Lab, which was asked only to look at the analysis.

MEMBER PALMTAG: I understand what you're saying, but I'm, from - I've done some finite element.

And I think what the important thing is, though, is that you have the expansion of the concrete. Right, the expansion of the concrete is going to drive the compression, which is going to strength damage. So there may be issues with details, but I don't --

MR. SAOUMA: No, the expansion --

MEMBER PALMTAG: - think what they're doing is wrong.

MR. SAOUMA: The expansion of the concrete is going to weaken the elastic models. It's going to weaken the tensile strength, okay.

When you weaken the elastic models, which is how much information you get when it is subjected to certain axial force, you are more prone to have failure than otherwise because you have weakened the tensile strengths and the elastic models. And that is very well established, very well established.

So if your model does not account for the time that you have an concrete expansion, because if you have straining expansion in one direction, it's going to go in the other direction.

MEMBER PALMTAG: We strained it too- just square or --

MR. SAOUMA: Yes, it's going to go in the direction, out-of-frame direction. And that said, this is all concern because potentially this is what can lead at some point to delamination in the middle of the wall. Well, we have to be careful and not rush to simple conclusion.

So that's pretty much what I had to say about the shear strength. Again, the test, nice test, maybe not so nice because as you know, it cracked in the middle, which was not expected.

But nevertheless, they took the results and applied everywhere in all the structure of Seabrook, where by their our account they say we did not mean those tests to capture the CEB fail. It's in the transcript. And now we are applying it to the CEB. Well, the CEB has a completely different failure mode than a beam. Completely different.

So I am a big fan of capturing similitude, and we need to make sure that if we do a test, it has to be thought intelligently to capture the failure mode. Otherwise it's not representative, simple as that. And it is no surprise that they found a bigger threat because there is this phenomenon called chemical distressing.

I could have predicted even before the test they're going to find the bigger strength. Because the concrete won't expand, there is a rebar, the rebar is like the rubber band preventing it.

So those two surfaces are more in contact, there's more friction between the two surface, and higher shear strength. That's very well established. It's published all over the place.

Chemical distressing is present for the beam. It is not active for the squat shear wall. It is not active in the squat shear, but it's active in the beams. And as a matter of fact, when it's tested at NIST, I mean, they found 20% decrease.

I'd like to say that those people are your neighbor here. The project was overseen by one of your own employees, George Thomas. He knew what he was doing. And yet, you know, 20% decrease, which coincidentally, is the same value of decrease that I found in my own test, which has been - which has been published, peer reviewed. The decrease at about 20% in shear strength.

That's all.

MEMBER HALNON: Is that your predominant - is that the message you wanted to get across?

MR. SAOUMA: That's one of two. The other one is the use of that equation, which relates a complicit - which relates a complicit strength.

MEMBER HALNON: Go ahead and get into

that, because we're at an hour now and I want to make sure that we have some time.

MR. SAOUMA: The other one is that equation here, which is used to relate, Equation 2, which is used to relate the complicit strength in elastic models. So they need to know what those elastic models early on, and they said well, let's use this equation which is in the SEI code.

However, what NIST has shown is that there is quite a bit of spread on figure - in here. You can see on the left are the data from NIST. The equation used by NIST there at the dotted line, and those points appearing not within the 95% or the 105%.

And to confirm, say, if you look at the other curve, so it's a date of something, there's a extracted wall from dams suffering from ASR, those are in blue. The red are resolved ASR. You can see the dispersion that there is in those data points.

Look, all I'm saying is one has to be very careful and in applying this equation. We want to use it, that's fine. But let's find out what is the margin of error. Let's find out what is a margin of error. I mean, there is too much noise in these data. There was too much when they used the calibration in those tests at Texas.

So any test worth its name has to show error bars. That's completely absent. So I'm not saying this is wrong approach. Let's fine - just, give us error bar, tell us how confident are we with that equation.

MEMBER HALNON: Yeah, I get your point. Yeah, we are bound by what is the legal licensing basis of the plant. So the ACI covers the code of record. But I understand what you're talking about, using the uncertainties.

MR. SAOUMA: I'm not saying to not use that equation. I'm saying use that equation by all means.

MEMBER HALNON: Members, any other questions? Okay. Remember, there's also some folks online that, again, because we've only had a couple days to digest this technical information, I think that a clarification to your neighbor, Exelon.

At this point, then, I'm going to open it up for public comment. So I know, Sarah, you're cued up. If you'd like to make a public comment at this point. And just keep in mind again that we don't necessarily respond to public comments, but they are entered into the record and they'll be used in future deliberations.

Keep that microphone real close and wait for the green light.

MR. ABRAMSON: Thank you. My name is Sarah Abramson, I'm Executive Director of the C-10 Research and Education Foundation. We are a community advocacy group. I live near Seabrook Station, as do my constituents, it's about 170-180,000 people living in that ten-mile radius.

MEMBER BALLINGER: I being one of them.

MS. ABRAMSON: Hi, neighbor. I wanted to start in response a bit, the timing is so coincidental. You may know that the recently published quarterly inspection report for Seabrook Station, included a lot of commentary on ASR, including corroboration testing, which Dr. Saouma asked about in the September ACRS meeting.

And we also learned a little bit from the last ACRS meeting. And some of that factors into the timeliness of us providing that white paper report, and of course we always have the goal of obtaining peer review or at least endorsements from similarly qualified scientists. So I just wanted to say that that was in the intent but sometimes timing steals out best intents from us.

I also just want to make a few points

about our perceived importance of the ACRS, especially in our current climate. The ACRS I think is more important than ever before. Political and cultural winds blow, but the body stays the same and the mandate from Congress for you, for you all stayed the same, I appreciate your service, and I know that you all take that seriously.

Recent actions that are important to bring up is a January 20th executive order, Unleashing American Energy, which calls for the heads of federal regulatory agencies, including the NRC, to take a look at improving efficiency and reducing regulatory burdens, which the NRC was already looking at to some extent because of the ADVANCE Act that was passed by Congress last year.

In addition, the March 27 exclusions from federal labor and management relations program executive order eliminated the collective bargaining agreement for a lot of NRC employees, including inspectors that work closely with this ASR issue.

And as an example, this is not an employee who works in Region I, I will say that, but I've spoken to both current and former NRC employees on their opinions of these things and I've tried to talk to the public relations staff, but they haven't been able to give me any official comment.

And there are cases of NRC employees who have at trials at differing public - differing professional opinions, DPOs. And there's an NRC, their own study found that 100% of folks that filed those did experience some form of retaliation.

And in the NRC's official response to Congress on the findings of that report, they cited the union as one of the reasons why not much intervention is needed to improve this problem. Because even if there was this retaliation problem, the union still exists to protect employees in those situations. Well, this no longer exists.

And to tie it back to Seabrook Station specifically, there was a recent occasion where, you know, a safety inspector cited a performance deficiency when NextEra failed to attribute the reactor cavity slab as a Category I seismic structure.

And in the face of that disagreement, and that dissonance between compliance by NextEra and what the NRC staff was expecting in the analysis, NextEra is now trying, they may have successfully recategorized the structure as Seismic Category II, so they no longer have to perform as robust of an analysis.

Despite - without talking about the merits of that decision, I just want to say that I know all of that because I read it in an inspection report because there is a lot of transparency from the inspector staff, which I have come to appreciate and admire. And I worry about those types of things, that candor decreasing or going away.

And it's bodies like this that have access to information that maybe the public wouldn't otherwise, so I would encourage you to please do what you can to encourage candor from staff, even if it is unpopular or inconsistent with the desires of the licensee.

I'll also point to New Hampshire House Bill 1623 that was passed last year, originally called Create Process to Fight Federal Energy Regulation. They renamed it to Relative to Involuntary Retirement or Decommissioning of Electricity Generators.

As a partisan bill that was signed into law last year by the New Hampshire Governor, and the sponsor of the bill said very clearly that it was intended to protect Seabrook Station.

And as somebody who follows this ASR issue, you know, I know that they're coming up on certain structures passing the ASR expansion that's allowed under the current license terms, and a new testing program or more robust enforcement measures might be expected. And when I see laws like this passed, I get worried about holding them -- even about changing any of the license terms right now, just holding them to the ones that exist as they do now.

And part of holding that line and holding that bar for public safety is the ACRS.

Thank you.

MEMBER HALNON: Thank you, Sarah. I don't see anybody else in the room. Is there anybody online that would like to make a public comment? If you do, then raise your hand or unmute yourself and go ahead.

Okay, hearing and seeing none, we're going to give the Committee one last opportunity if any questions came up. Okay.

So as we continue to follow the topic, we'll have another session in an upcoming full Committee meeting where we're going to take this information and then with the staff adjust the white paper a little bit and combine this, their technical assessment of it as well, in addition to the - if we have been in contact with Dr. Thomas. He's, in fact I think he's listening in. So he has current information on the issue.

From there we'll provide a Committee position and letter report. And I'm saying that like that's what the Committee will decide. I'm not sure the Committee decides whether or not to write a letter report to the Commission if we feel like there's a need to transmit information to the Commission from our perspective.

Though we do appreciate the efforts of C-10 and the doctor's engagement. Appreciate the engagement of public advocacy, it's important. Your participation in meetings is important, even if - to give you that new respect in this meeting, which is very extraordinary for us.

Like I said, normally, we require a 30-day front. But we have a need for information and want for information, and appreciate you bringing it to us.

Our mission is --

MR. SAOUMA: Much comments have come in.

PARTICIPANT: Could you use your microphone, please?

MR. SAOUMA: I appreciate very much this invitation. And I don't know what I was going to -. I've been working, looking at this issue for the past seven years. And forgive me for saying that I've been doing entirely pro bono. I'm not paid by C-10. But they is trying to tell me what to do or not to do.

I am a university professor who is a strong believer in science, and Lord knows that science is under attack nowadays. I want it to prevail, even in cases where engineering judgments seem to be it's okay, it's working, why do we need to worry.

That's all.

MEMBER HALNON: Thank you, thank you for that.

You know, our mission as the ACRS and as an agency is clear. We're here to protect the health and safety of the public and enable the safe and secure use of and deployment of civilian nuclear energy through reliable licensing, oversight, and regulation for the benefit of society and the environment.

Given that mission statement, we're going to continue to drive towards that.

With this, I'm going to close the session and turn the meeting back to our chairman. So again, thank you. Walt.

CHAIR KIRCHNER: Thank you, Greg. And thank you again for making the effort to come here in person. And thanks for that presentation, Dr. Saouma.

And thank you again, Sarah, for your comments as well.

We are going to take a break at this point and then we'll return. It's now I believe 2:10. At 2:30, and we'll take back up the NuScale letter report at that time.

MEMBER HALNON: So 2:30?

CHAIR KIRCHNER: Two-thirty, okay.

And for the court reporter, I think we are done with your services for today. We will - Larry, do need him for the rest of the meeting now?

MR. BURKHART: We don't need him for the rest of the meeting.

CHAIR KIRCHNER: Okay, thank you.

So thank you, we won't require further transcription for the rest of this meeting. So thank you again for your service.

Right, thank you. Okay, and with that, we're in recess.

(Whereupon, the above-entitled matter went off the record at 2:11 p.m.)