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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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720TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THURSDAY

NOVEMBER 7, 2024

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The Advisory Committee met via teleconference at 8:30 a.m. EST, Walter L. Kirchner, Chair, presiding.

COMMITTEE MEMBERS:

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GREGORY H. HALNON, Vice Chair

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THOMAS E. ROBERTS, Member

ACRS CONSULTANTS:

DENNIS BLEY

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

KENT HOWARD

C-O-N-T-E-N-T-S

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

(8:30 a.m.)

CHAIR KIRCHNER: Good morning. The meeting will now come to order. This is the second day of the 720th meeting of the Advisory Committee on Reactor Safeguards, ACRS. I'm Walt Kirchner, Chair of the ACRS. The ACRS members in attendance in person, are Ron Ballinger, Greg Halnon, Craig Harrington, Bob Martin, Scott Palmtag, Dave Petti, and Tom Roberts.

ACRS members in attendance virtually via Teams are Vesna Dimitrijevic and Vicki Bier, and I believe that Matt Sunseri will join us later this morning or this afternoon.

ACRS consultants Dennis Bley and Steve Schultz are also with us this morning. If I missed anyone, members or consultants, please speak up at this point.

Not hearing anyone, Kent Howard of the ACRS staff is the Designated Federal Officer for this morning's meeting. No member's conflicts of interest were identified for today's meeting. And I know we have a quorum as well.

During our session today, this morning, the Committee will discuss TerraPower, the Natrium Topical Report on Plume Exposure Pathway Emergency

Planning Zone.

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 regulations. Per these regulations and the Committee's bylaws, the ACRS only speaks 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 easily found by typing, about us ACRS, in the search field on the NRC's home page.

The ACRS, consistent with the Agency's value of public transparency in 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 any statement from the public. However, we set aside time at the end of this meeting for any further public comments or input.

A transcript of the meeting is being held 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. This is important for our Court Reporter, who is capturing our proceedings for the record.

If you are not speaking, please mute your computer on Teams. If you are participating by phone, press *6 to mute your phone and *5 to raise your hand on the screens. Please do not use the Teams, Chat feature to conduct sidebar discussions related to the presentations. Rather limit its use to that of reporting IT problems.

For everyone in this room, please put your electronic devices in silent mode and mute your laptop microphone speakers. In addition, please keep sidebar discussions to a minimum since we are working with live ceiling microphones.

For presenters, we just remind you that these table microphones are rather unidirectional and you need to speak into the front of the microphone to be heard online.

And finally, for anyone with feedback for the ACRS about today's meeting, we encourage you to fill out one of the public meeting feedback forms on the NRC website. While not anticipated, portions of

this meeting may be closed to protect sensitive information, as required by FACA and the government in Sun, in the Sunshine Act. Attendance during the closed portion of the meeting will be limited to the applicable NRC staff and its consultants.

And with that, I will now turn this morning's deliberations over to our TerraPower Design-Centered Subcommittee Chair, Tom Roberts. Tom.

MEMBER ROBERTS: Thank you, Walt. Good morning, I'm glad -- good to see the people here in person.

As Walt said this morning, the full committee received a briefing on the Topical Report and the staff draft Safety Evaluation Report from the staff, for the Natrium Topical Report that's entitled Plume Exposure Pathway Emergency Planning Zone Sizing Methodology, which they've numbered NAT-3056.

This Topical Report was reviewed by our Subcommittee, the TerraPower Natrium Design-Centered Subcommittee on September 19th of this year. And I'll provide some brief background regarding the Topical Report. I'll summarize the discussions that we had two months ago in a call on energy staff management to kick off our presentations.

The Emergency Planning Zone, it's called

EPZ, is the area for which emergency planning is needed to ensure prompt and effective actions can be taken to protect the public in the event of radiological incident. Judgment is required to determine what accident scenarios should dictate the size of an EPZ. The bases for these judgments, this judgement rather, dates back to the 1970s and evolved over the years, culminating in a new Regulatory Guide 1.242. It was issued late last year.

This Topical Report is the first use of the new Regulatory Guide. To review allows us to understand the choices made by the Applicant. Why the staff accepted them with the limitations and conditions that they've put on. And determine whether this application of the new reg guide is suitable for the revisions used in the Topical Report, or the reg guide should be considered.

And looking not just at the TerraPower proposal, but also what that means in terms of the usefulness of the Regulatory Guide, and whether some revisions may be warranted.

During our Subcommittee meeting, three issues were identified where both we and the NRC staff concluded further discussion was warranted. These issues included the bases for various accident

frequency values used as part of the screening assessments. Justification for why the ground accelerations used to determine the limiting seismic scenarios were probably conservative. The language in one of the staff's limitations and conditions that did not seem consistent with a non-light-water reactor probabilistic risk assessment standard.

The Applicant and the staff will cover these issues in more detail this morning. It's worth noting that the Applicant has revised the Topical Report since the Subcommittee meeting. And the staff is in the process of revising the Safety Evaluation Report, also based on the discussions that we had back in Subcommittee meeting.

And with that being said, I'll turn this over now to Ms. Candace De Messieres, who is the Branch Chief of Technical Branch 2 and DANU -- I'm not going to attempt to give you what that means -- in the Office of Nuclear Reactor Regulations. Candace.

MS. DE MESSIERES: Thank you very much. And I'll give it a try, I'll give it a try. Thank you, Chair Kirchner and Member Roberts for the opportunity to present today.

As was mentioned, I'm Candance De Messieres, Chief of Advanced Reactor Technical Branch

2 in the Division of Advanced Reactors and Nonpower Production and Utilization Facilities, or DANU in the Office of Reactor Regulation.

So as was already highlighted, during this meeting TerraPower representatives will provide a summary. And NRC staff will discuss its review of the Topical Report describing a risk-informed methodology for determining the Natrium sodium fast reactor plume exposure pathway Emergency Planning Zone or EPZ size.

I'll now highlight a few items related to this review. First, this review is interdisciplinary in nature. Bringing together expertise from across the Agency in areas of emergency preparedness, consequence analysis, and probabilistic risk assessment.

Second, like several other Topical Reports the ACRS has considered in support of Natrium, staff's review has focused on acceptability of the methodology, with reviews to ensure appropriate implementation performed as part of separate licensee actions.

Third, the report incorporates approaches described in alternative emergency preparedness requirements that were effective in December of 2023, colloquially described as the EP for SMR and ONT rule.

Though this Topical Report was originally submitted prior to plan promulgation, it was later revised to incorporate reference to the plan overall.

Finally, also this was mentioned, following the ACRS Subcommittee meeting on this topic, TerraPower submitted a revision of its Topical Report, and the staff revised its Safety Evaluation to further describe and enhance clarity in areas of the selection of the limiting seismic release scenario, hazard scope and uncertainty treatments.

Mallecia Sutton, Michelle Hart and Hanh Phan of the NRC staff will highlight the updated areas in the staff presentation in more detail. Thank you for the opportunity to present today and we look forward to your observations and feedback.

MEMBER ROBERTS: Okay. Thank you, Candace, we'll turn it over to TerraPower.

MR. GUILFORD: Thank you very much, good morning. My name is Ian Guilford, I'm a Senior Manager on the licensing team at TerraPower. And I'm joined here in person by my colleague, Chris.

MR. COURTENAY: Yes, good morning. My name is Chris Courtenay. I'm principal licensing engineer with TerraPower.

MR. GUILFORD: We appreciate the

opportunity to present today to the ACRS full committee. We appreciate staff's time and expertise reviewing the Topical Report and providing valuable feedback during the audit process. And we also appreciate Subcommittee's comments.

As mentioned earlier, we did revise the Topical Report so that new revisions should be available. We believe that that provides additional clarity into the screening process that we use for the events that feed into the EPZ methodology.

Today's presentation will be by John Biersdorf. John Biersdorf is participating remotely. He is a principal engineer at TerraPower. And I'll turn it over to John.

MR. BIERSDORF: Morning, everyone. Can everyone hear me or -- it looked like you could see me for a hot second. When everyone on --

CHAIR KIRCHNER: We can hear you John, just speak up a little bit more.

MR. BIERSDORF: Oh yes. Is this better?

CHAIR KIRCHNER: Yes.

MR. BIERSDORF: Okay. So my name is John Biersdorf. I'm with TerraPower. I'm a PRA engineer. I'm going to turn off my camera just to save bandwidth. All right, so we'll get started. Yes, so

what we're going to do is just kind of lay down the, going through the overview of our EPZ methodology. So kind of high level, we'll just kind of talk a little briefly about the guidance used, some of the methodology. And then kind of go over the conclusions that we have.

We're going to present essentially the same material that we provided for the Subcommittee meeting, except we've added a few additional slides to add some clarification over some of the aspects that needed some additional information from the previous meeting.

So first when we developed this methodology, we used some regulatory guidance. Primarily, the guidance we used was Reg Guide 1.242. And then we developed some of our criteria, using NUREG-0396.

And then for our high-level overview of the EPZ methodology as a whole, we basically start with a compiled list of all our PRA event sequences. We then use some specific selection criteria to parse those events out into non-seismic events and seismic events. As there's specific selection criteria outlined in this presentation that kind of outlines the categorization of both.

And then, from there we'll utilize some additional input we take into account, such as civic meteorological data, and then some of the rad consequence source term information. We quantify our dose results. We'll get our EPZ dose results at a specific distance that we're quantifying.

And then establish an EPZ boundary if all of our EPZ dose criteria is met. And if not, we have like an iterative process outlined where we can kind of reassess the specific events. And then kind of establish the EPZ boundary when our criteria is met.

Next slide, please. So for our non-seismic events, once we have our compiled list of events, and we broke them down to the non-seismic events, we'll have a, essentially we'll look at it. And we'll say, okay, is this event a greater than 1E to the minus seven?

If it is, is it screened, or if the 96th percentile is greater than 1E to the minus seven, it's screened in for evaluation. If it's not, then we'll look at the mean frequency. If it's greater than 1E to the minus eight, we'll then retain it for cliff-edge effects. And if it's neither of those, it'll be screened out.

So this methodology will give us

essentially all DBAs for our analysis. And then a list of events with a 95th percentile greater than 1E to the minus seven, correctly screened in. And then events greater than, with a mean value greater than 1E to the minus eight are screened in for cliff-edge effects.

And then our next slice we kind of walk through some specific examples to try to illustrate that point. So if we had -- and these are just for illustrative purposes -- so if we had a mean frequency of 2E to the minus seven, and the 95th percentile of 6E to the minus seven. So again, we have that 95th percentile greater than 1E to the minus seven. So this would be directly screened into our EPZ evaluation.

Our next example is a mean frequency of 8E to the minus eight. The 95th percentile of 2E to the minus seven. So that mean frequency again is below our cutoff threshold. However, that 95th percentile is above. So again this would be screened into the evaluation.

A third example would be a mean frequency of 2E to the minus eight with a 95th percentile of 6E to the minus eight. So the 95th percentile we've just missed the threshold for our screening into the EPZ

evaluation. However that mean value, we sit at 2E to the minus eight. So we'd screen it in and look for cliff-edge effects.

And then with the final fourth example, we have a mean frequency of 8E to the minus nine, with a 95th percentile 2E to the minus eight. So this one, both the mean frequency and the 95th percentile are below our cutoffs. So we've screened them out of evaluation.

MEMBER ROBERTS: Hey, John, this is Tom Roberts. I wanted to ask about that last case, and I think I'm going to start my question with an excerpt from Reg Guide 1.242 and want your comment on that.

This Section B.3 in Appendix B, it says if based on PRA, the use of a low-frequency cutoff should consider uncertainty. And it goes on to say the PRA results should retain event sequences with frequencies below the cutoff, and analysts should use them to confirm that there are no cliff-edge effects and that there is adequate defense in depth.

So I read that and there are similar words in NEI's 18-04. There's no discretion of a low frequency cutoff for the cliff-edge effect or defense-in-depth determination. There are if you, you know, parse those two sentences carefully, there's three

concepts in those two sentences.

One is uncertainty, the second one is cliff-edge effects, and the third one is defense in depth. And your evaluation would appear to be intended to cover all three.

And when you talk about uncertainty, you know, I could see where you look at things like grammar uncertainty, it makes sense having a limited cutoff, because going much lower wouldn't get you any additional information. Because you already have enough information to reliably capture all the sequences that could possibly exceed 10 to the minus seven from, in America's perspective.

From a cliff-edge effect perspective and defense in depth for that matter, you're getting into more of a crossover between, you know, probabilistic and deterministic pattern criteria. And if you look at the cliff-edge effects in NEI 18-04 it's not very detailed, but there is a companion document that has a frequently asked question.

And if I could read from that real quick, it talks about, the LMP methodologist has specifically identified whether specific non-LWR design -- I muted myself momentarily, so I'll start over. The LMP methodologist does not specifically identify whether

specific non-LWR design exhibits cliff-edge effects, except to the extent that if it exists, it may be apparent in the results of the PRA in which then provides risk insights, prevents sequence blood and cutoff, for design, beyond design-based events at five to 10 minus seven per plant year.

Yet the existence or lack thereof of cliff-edge effects is really part of the safety characteristics of a nuclear plant. And not merely a property of the PRA models.

So I look at that, my interpretation of that is the real purpose of not screening in the PRA before doing the cliff-edge effects, is because the only reason you're using the PRA is to make sure you haven't missed something. That's more of a completeness check.

There's a sequence that the PRA identifies, even below the cutoff, that says well, maybe my safety margins aren't adequate. And, you know, then they'll want to go look at that. Not necessarily from a safety analysis perspective, but from plant design perspective. But you kind of have a choice of either you do something to increase the safety margin and eliminate the cliff-edge effect concern.

Or you do something else, like you've, maybe in a safety analysis you assume the cliff-edge actually exists, and verify that the design is still adequate, assuming the cliff-edge effect does exist. So it's not really tied to a frequency. It's tied to completeness of the design and adequacy of safety margins.

Then I go on, the third piece of that is defense in depth. And if you look at defense in depth, the NEI standard, you know, at least my opinion, isn't really clear on what you do with sequences below five to 10 minus seven. Because it really focuses on LBEs, licensing basis events and verify you have defense in depth for the LBEs.

But there's another reference, NUREG-1860, which one of our consultants, Dennis Bley, actually was co-author of, back in about 20 years ago. And it describes, if I could please read that briefly. It says uncertainty associated with limitations in knowledge, such as unknown or unforeseen failure mechanisms, or unanticipated physical and chemical interactions among system materials, cannot be identified by PRA.

Defense-in-depth measures to address this type of uncertainty can be established from repeatedly

asking the question, what if this barrier, measure, or safety feature fails? Without a quantitative estimate of the likelihood of such a failure, as well as by ensuring consistency with established defense-in-depth principles. This approach to defense-in-depth invokes specific deterministic provisions to compensate for the unexpected.

So I look at that, and I compare that to the words of the NEI 18-04 standard, it appears somewhat analogous to the cliff-edge, you know, principle. Of course you're not using the PRA so much as to determine the frequency, and say am I adequate, but am I missing something?

You know, is there a barrier that has a very high modeled reliability, such as if I was wrong about it for whatever reason, because I don't really understand all the phenomena that could happen, then what's left in terms of safety?

Kind of a long question, but really it gets down to, when you look at the words in the Reg Guide 1.242, they don't have a lower frequency cutoff for cliff edge and defense in depth, as such, but there seem to be a good reason for that. So I wanted to --

MR. BIERSDORF: Right but --

(Simultaneous speaking.)

MEMBER ROBERTS: -- you know, long kind of, just asking it, so what is the rationale based on that for having low frequency cutoff for cliff-edge effect?

MR. BIERSDORF: So our frequency threshold for cliff-edge effect overall analysis for an LMP, we don't have one. So we actually look at cliff-edge effects down to our truncation threshold. But for the inclusion in the, or to the EPZ analysis, we have the 1E to the minus eight threshold just to try to incorporate essentially looking at events that we understand that, you know, we can make a good assumption on emergency response on.

So we cut, basically made a cutoff where we include events that we feel are adequate representations of how the facility will respond. They are adequately covering the spectrum of events requested in 1.242. And that we weren't inadequately missing anything from our analysis.

So there wasn't anything specifically associated with 1E to the minus eight, other than we wanted to ensure that we were including the events that we, or we were including enough of the events that we have adequate confidence that we will properly

assessed our analysis and that it showed that within our analysis.

So in our LMP, we do have a cliff edge that goes down below that to show that we have adequate defense in depth, but we haven't had those two separate --

(Simultaneous speaking.)

MEMBER ROBERTS: Can I -- so what that seems like is that if you've done the assessment and beyond vague down to, you know, with no threshold, then there are no cliff-edge effects remaining to consider for this criteria. Is that a fair, fair, John? I'm not quite saying how, if you've addressed cliff-edge effects all the way down to, you know, no limit. Then what residual sequences could possibly exist that would screen in for the EPZ determination?

MR. BIERSDORF: I'm sorry, I'm not sure if I caught that.

MEMBER ROBERTS: Well, if you're doing an assessment of cliff-edge effects, with no limit for LMP, then your plant design has already been assessed to either be free of cliff-edge effects or presumably, if you left cliff-edge effect potential in for whatever reason, it would be adequately modeled in the PRA.

So it's just not clear what's left, you know, once you get down beyond pica kinds of effect determination. What could then possibly screen in with or without a de minimis criterion?

MR. BIERSDORF: Yes, it would be just more of that, you know, if we had something that is somewhat on the cliff edge, down in the 1E to the minus 12 from an LMP standpoint, we wouldn't have that included into our EPZ analysis. It would be part of our LMP, but not within the EPZ.

MEMBER ROBERTS: It seems like you would have made a judgment either that you have the adequate safety margin because of the perceived more likelihood or whatever it is. And you choose to leave it in the design, in which case it would then seem like defense-in-depth assessment would have you model that as failed.

Because you, you know there is not as much margin as you would like for that particular, the aspect of design, you've, and because it was such a low frequency, to say that's okay. That would seem like you would maybe in all your models, not just the EPZ, assume nothing is failed. Does that make sense?

MEMBER ROBERTS: I think so.

MEMBER ROBERTS: In power 10 to minus 12,

you'd say, fine. If I got a cliff-edge effect at, I see a 10 to minus 12 frequency path and assuming that cliff edge occurs, and I fall off that cliff. Then that would seem fine.

That's almost, you know, there's intersection between the cliff-edge effect and defense in depth. That would seem like a kind of defense-in-depth measure would be used in that particular, you know, SSC fails. And then, so that on that assumption your model still produces acceptable lower results.

MR. BIERSDORF: Yes, I guess, I'm not, are you basically stating that would be enough and that we should drop the cliff-edge? I'm kind of not following at this point.

MEMBER ROBERTS: It seems like once you've come to the cliff-edge effect determination and you concluded that either there are no cliff-edge effects of concern or if, the cliff-edge, you know, shut itself, the resulting action frequency is still low. You know, below these kind of, your regulatory limits, then that would seem to be adequate.

And I guess, I'm not seeing the scenario that's left that would be in this 10 to the minus eight, to 10 to minus seventh range that would come out, once you've gone through the assessment that the

cliff-edge effects are acceptable.

MR. JOHNSON: Hi, this is Brian Johnson, PRA manager. And I think I'm going to take a crack at this, because I think I agree. We have separately, from the EPZ topical, our LMP application of the PRA. And they are actually parallel. So we don't directly use the LBEs in the EPZ event selection.

They both, you know, come from the same PRA. They are evaluated similarly. When we do the defense-in-depth evaluation of cliff edges, down below the bottom of the PRA and our defense-in-depth report, which is separate from this report, we do evaluate, you know, for large potential releases and other cliff edges.

It is very similar to what's done here for the purposes of the reg guide application for EPZ topical. It is parallel though. So we don't do the one-event selection that LBEs and EPZ events at the same time.

They're done from the same source of the PRA and so, you know, both the EPZ methodology and the LMP methodology consider cliff edges somewhat similarly. And we have the LMP that shows we don't have a cliff edge of concern. And then the EPZ, when looking at what events are in the PRA, does something

similar.

And if there was something large that maybe for some reason the LMP says is acceptable risk but would maybe resize the EPZ. We would include it in our EPZ sizing.

You know, the LMP LBEs are a 30-day dose at site boundary and don't, especially in the BDBE range, have any specific limits. Well, sorry, below the BDBE range, the once you're under 5E minus seven. And so it's a judgment. The dose does go up to a 750 rem at the site boundary at 5E minus seven, which may be causing potential prompt issues.

So that's why we have two different evaluations. They don't have the same acceptance criteria and they aren't the same application of the PRA.

MEMBER ROBERTS: Hey, Dennis you had your hand up a couple minutes ago. I can't see on the screen if you still there, but --

DR. BLEY: I did.

MEMBER ROBERTS: -- do you have a question?

DR. BLEY: I thought your question took care of what I was going to say, but now they've confused me a bit. It seems that if they've handled

it in the LMP part and identified any cliff-edge effects, we should have a record of those to consider when we get to the second evaluation.

I almost understand why they're doing it again, but if they're doing it again, putting a cutoff on the cliff-edge effects, doesn't seem to make sense to me. I don't see any basis for it.

And it would seem, and I don't have the details, so it's not clear, but anything that had surfaced as a remaining cliff-edge effect in the LMP analysis, at least those probably ought to be considered regardless of frequency over here for the very reasons they were just discussing.

That, you know, maybe it doesn't strongly affect overall risk, but it might slightly change the EPZ. But it doesn't seem logically consistent, I think. So do we really --

(Simultaneous speaking.)

MR. JOHNSON: I'm going to maybe one more time. The LMP evaluation of cliff edge is maybe going to accept things that are not problematic, and we evaluate them here as well. This is a more stringent, potentially, limit at the end of the BDBE range and below the BDBE range.

So I do think it's logically consistent of

trying to apply that more stringent evaluation to a reasonable set of events in that low frequency area.

DR. BLEY: I guess the only, I would be more comfortable if you said you were going to this cutoff and you were also looking at any cliff edges that survived in the LMP analysis. I can't imagine anything, I'm kind of like Tom, I can't imagine there's anything that will really make a difference, if that's the case. But that would seem a much more consistent approach to me, but that might just be me.

MEMBER ROBERTS: Yes, thanks Dennis, I tend to agree with you. There's an aspect of this that the EPZ is part of defense in depth. And so when you look at defense in depth, there may be scenarios that you would consider to be low enough frequency to not worry about in LBE space. But maybe you would be concerned in the EPZ space because that's the last layer of defense in depth.

So just seems logical that if you had a low frequency cutoff in either the EPZ or the LMP, will be in the LMP, free EPZ screen. So I agree with Dennis. That seemed to make logical sense to have the low frequency cutoff in the EPZ and yet not in the others. It seems almost backwards.

Vicki, I can't see the screen, but I

understand you have your hand up.

MEMBER BIER: Yes, thank you. I'm going to be brief about this because I went on it, like to bat on it in Subcommittee. I continue to be a little bothered by slides like this that seem to take the mean and the 95th percentile as being of, as kind of equal importance in determining what's screened in and screened out.

And I understand screening is kind of a zero-one choice. It's like they're in or out. But it sort of doesn't make a lot of sense to me. You know, the 95th could have been the 80th or the 99th. And, you know, it would result in a different set of events and seems kind of arbitrary.

I don't think it's a huge safety issue just because there are, you know, it's in a sense conservative that you're screening more things in. But it just seems a little bit illogical from my perspective. But anyway, I don't think it's a reason, you know, that this should not be approved or whatever. But it just seems awkward to me. Anyway, that's my only comment right now.

MEMBER MARTIN: This is Member Martin. I do have a maybe a clarification question, discussing sequences. And in regard to EPZ we were earlier

talking about release scenarios or the consequences that lead to a particular plant-damage state that have similar, you know, release characteristics.

When you talk about these sequences like on this slide, really talk about the probabilities associated with sequence, families. Clearly a branch, you could have multiple branches that have similar plant-damage end states. And otherwise, similar in the sense of the same kind of release characteristics.

It wouldn't be about a particular, you know, non-seismic event sequence. It's likely multiple ones. What are we talking about here? A particular branch in the PRA? Or is there an exercise to identify event sequence families, and that's the metric being used here?

Really, because that relates more to a release scenario than -- which is applicable here.

MR. BIERSDORF: So are you asking if we both consider event sequence families, as well as individual events sequences?

MEMBER MARTIN: So the clarification I'm looking for is, as you were discussing the slide, you were talking about sequences. You didn't mention sequence families, which is really I think the more important terminology here. You wouldn't want to

have, say, you know, two or more events that, you know, that may be, look like they screen out. But ultimately, they are more or less the same release scenario. Because collectively, it would cross over the threshold.

Do you account, is there an exercise that you look at these event sequences and then consolidate them by the plant-damage end state and ultimately the release scenario. Is that the metric you're using? Or are you just point blank looking at the branches and doing a cutoff exercise from that?

MR. BIERSDORF: So we look at the families that's aggregated it, within the PRA when the events come into the analysis.

MEMBER MARTIN: And do you feel like there's any subjectivity to that exercise? So this is where some of the, another kind of uncertainty weighs into this.

MR. BIERSDORF: You know we have uncertainties associated with particular sequences. But there is a, what do you call it, systemic, just a human contribution to uncertainties, which I've seen hitting the realm of making folks like us more nervous. How methodical, how objective is that process?

MR. BIERSDORF: Well, I mean we follow the PRA standard for, you know, the event sequence analysis. We have all of the, the steps. And we take it into account with the uncertainty and stuff like that as we feed into the events there.

So we obviously know that there's going to be some subjectivity as you combine sequences. But, you know, we try to understand where those uncertainties are coming from. That's why we try to come up with more of a, you know, this conservative approach is where we're trying to capture as many of the events as we can, into the analysis, to ensure that we have a larger breath of scope, if you will.

Just to make sure that we know what these sequences -- or the families of the events and stuff like that we have in the analysis. And that we're properly accounting for all it.

MEMBER MARTIN: So when you consider -- hang with me for a second, right. The domain of all events represents 100 percent of events. With a cutoff of anything, one times 10 to the minus eight, you don't really know whether you're capturing, you know, 50 percent, 90 percent, 99 percent of that domain. Can you tell us what fraction of the domain of events that you are otherwise capturing, using a

cutoff like this?

MR. BIERSDORF: So can I --

MR. JOHNSON: Brian Johnson PRA manager, again. I know for our amount of releases, it's over 99 percent. Our actual PRA integration cutoff studies I believe, depending on which metric we're using, right, because we have different integrated risk metrics including, you know, probably exceeding 100 millirem dose, latent QHO, prompt QHO.

I believe our last study was around 10 minus 12 for total convergence. And 10 minus eight is over 99 percent of all releases. I don't think that convergence study is part of the EPZ topical directly, but of course it would be available from the evaluations of PRA.

And we can look at integrated risk, you know, because we -- our objective is not to split sequences 100 times to make them less frequent. It's to understand how the plant operates and make sure that we are grouping together events that are functionally similar. And have the same dose consequence.

MEMBER MARTIN: So you mention a number like 99 percent coverage. You know, that's, at least to me, more meaningful, right. Had me on various

uncertainties with, you know, risk models. You know, to state a cutoff doesn't really provide any benchmark, any context.

But you come back and say, oh, well, the method actually results in greater than 99 percent or something like that, you start making it plain though that you've covered credible events. But in the context of just a cutoff, you don't have that. It's just a number.

There is some precedent for that. There's the Reg Guide 1.216 related to LWR containment integrity that uses a metric like that. And it might have been something -- I mean this also comes as a question for the staff. That there are other ways to look at this, that, you know, might be a more palatable metric to trying to find, whether it's a compromise or, you know, some kind of definition of where can you stop? That's all.

MEMBER ROBERTS: Yes, Tom here. This seems to be related to a long-term issue that I know that Vesna's been pushing, which is when you look at these events, reactive to their extremely low risk profiles, and is there some criterion that would be, you know, based on the risk profile of that plant and not necessarily based on frequency cutoffs? Because

the frequency cutoff might screen everything out.

So that's really, it's related to that. I think that's probably unrelated to this discussion, because that's, you know, almost more philosophical than this. This does, it's a mighty attractive precedent in terms of using, you know, perceived likelihood as a basis for screening for the EPZ determination.

But then that's certainly associated with something that I think it is being worked and would be related to that. The overall effort of whether the 90 percent of the sequences for example from the particular reactor, becomes that reactor's cutoff because, you know, that's something that makes sense. And that's the theory, really.

I don't see any hands up. Vicki, I saw you had your hand up, but you might have had it up inadvertently. So I'm giving you a chance to speak now if you want to.

MEMBER BIER: Yes, I think my comment has been addressed. I just wanted to expand on Bob Martin's comment that, you know, our, we wouldn't be concerned about so much, two events that collectively exceed the threshold. But more like, you know, 100 or 1000 events. And that's already been discussed. So

I'm fine with where we're at.

MEMBER ROBERTS: Okay. Let's proceed.

MR. BIERSDORF: Okay. So our next -- so we had the non-seismic events. So the evaluation for the seismic events, this is the second bin of the events sequences that we -- event sequence standards that we assess.

What we have is we have two essentially stages for our analysis. We establish our PGA limiting, our limiting PGA value, which I'll discuss in the next slide. But for our CPA portion, what we do is we develop a bounding-seismic-EPZ event that we use as more of a conservative surrogate that would establish, or that would identify whether or not the seismic events would meet the EPZ criteria.

And by the time we have OLA, we'll have a full seismic PRA that can give us those events for those families that we can evaluate against the criteria overall. So the limiting PGA value will carry through. But we'll have two sets of events that assess. So for CPA we have a bounding seismic event. And by OLA we'll have the full gamut of events coming out of the seismic PRA.

Excuse me, so for development of our limiting PGA, we choose the lower of the two. So

either 2x times our GMRS value or 1g. So, again, that's just the lower of the two. So if our 2x GMRS is less than 1g, we would use that. If it's greater than 1g, we use the 1g threshold.

And this just ensures that we have a range of seismic hazards with an incredible range of ground motions. It kind of acknowledges some of the limitations identified within the PRA. And then some of the uncertainties in the emergency response infrastructure.

MEMBER MARTIN: Just a question, real quick, 1g seems actually pretty conservative. You feel like you can do that without kind of overstraining the design or other decision-making aspects? Trying to think, you know, the more limiting size may be half that. Any thoughts on that? It seems pretty high that acceleration and such.

MR. BIERSDORF: Yes, I mean it's pretty high. We just wanted to make sure that, one, we were capturing a level of conservatism within it. So that we were ensuring that we covered the full range when we assessed. And we also have the 2x GMRS, if you just felt, you know. So we're not upper bound at 1g.

So, you know, if our 2 GMRS is lower, then we can use that. And then that would still provide us

with a frequency threshold that provides us some flexibility.

MEMBER MARTIN: And you think that's going to happen more often, then let's say, the 1g threshold?

I see a nod over here, but you obviously don't want to say something.

PARTICIPANT: He'll, he'll let him --

MEMBER MARTIN: I think it's fine. Then more likely than not, what are you looking at, maybe .6 as, is that range or maybe a particular site and Wyoming.

MR. BIERSDORF: Yes, that's, yes, I think that was in our PSAR. So our 2x GMRS in our PSAR was around .6g. So that's kind of where we're expecting our threshold to roughly be around. At least for this site. And then, you know, some sensitivities that we did with just kind of generically, we felt that this threshold was adequate for what we felt we needed for the seismic events.

MEMBER MARTIN: All right. Thank you.

MEMBER ROBERTS: Can you clarify what return frequency you're calculating the GMRS for, 10 minus four, 10 minus six?

MR. BIERSDORF: I couldn't hear that.

MEMBER ROBERTS: The question is, what return frequency are you looking at for this GMRS? Is this a 10,000-year earthquake, 90-year earthquake? Do you know?

MR. BIERSDORF: Yes, that's going to depend on the site, obviously. But I don't think it's, I can't give the specific, but we're looking at, you know, the lower end of the BDBE range for our 2x GMRS.

MEMBER ROBERTS: That might be about 10 to the minus four, then? Okay.

MR. BIERSDORF: Yes, I believe. I don't have the number off the top of my head for our actual GMRS. But our 2x GMRS, we're sitting at that end of the BDBE range.

MEMBER ROBERTS: Okay. So if you were to compare to the lower end of the BDBE range of the hierarchy, you know, intensity of an earthquake, how does the 2x GMRS compare to, say, a 10 to the minus sixth, you know, seismic event?

MR. BIERSDORF: In terms of like magnitude, or impact?

MEMBER ROBERTS: Yes, in terms of, you know, PGA.

MR. BIERSDORF: So you're looking at, like

something like what's the frequency for 1E to the minus four? Is that what you're saying, versus the 1E to the minus six?

MEMBER ROBERTS: Yes, I'm trying to understand the margin of the GMRS. If you're using a BDBE at the lower end, 10 to the minus four. Saying then if you were to look at BDBE at the other end of the range, would 2x GMRS bound that?

MR. BIERSDORF: I believe so, yes. Like because then you'd have a lower seismic, I mean, I don't know -- like we haven't done the full analysis for outside of Kemmerer. So I can't really give you a spectral range of where things land outside of that.

So I can only kind of really tell you where we got from our site specific --

MEMBER ROBERTS: We understand this is all site specific, and we're talking the methodology. Just trying to get a sense of the margins. So it seems like the justification for the margin is really site specific and this would be the methodology.

And as I think, Candace said, during her intro, if you apply the methodology and the application is not conservative, then that would, you know, be a separate discussion. That, but if you agree then that makes sense to me.

MR. BIERSDORF: Right, and I think that was part of the, out of limiting condition, correct?

MEMBER ROBERTS: Right, and Seth will get to that. But they did add a limitation condition that says that. So I think that all ties together, it makes sense to me. I just wanted to make sure I understood it.

MR. BIERSDORF: Okay. Sorry about that. So once we have our event sequences collected -- one second. Sorry, once we have our event sequences collected then we can establish our EPZ sizing based off of the criteria listed here.

So we've developed these specific criterion using the outline in Reg Guide 1.242. So Criterion Alpha is pretty much identical to 1.242, where you're just looking at projected doses from DBAs. And then we use the PAG limits of 1 rem for your mean, and 5 rem for the 95th for a 4-day TEDE.

Criterion Bravo, there in 1.242 they look for most radiological release sequences. What we did is we've made a frequency threshold, so any event that's greater than 1E to the minus six, we'll look at as, again against those PAG limits, which 1 rem for mean, and 5 rem for the 95th percentile, again for that 4-day TEDE.

And then Criterion Charlie, 1.242 is looking at immediately life-threatening doses from the worse-case radiological release sequences. And we used a selection where the frequency would be below 1E to the minus six and greater than 1E to the minus seven. And then this would exceed, it would not exceed a 24-hour, 200 rem red-bone-marrow acute effective dose.

So it just kind of goes over the justification for using the red bone marrow. We used specific sources, so NUREG-0396 identifies it as a good surrogate for acute whole body. And then, you know, the MACCS best practices and technical basis NUREGS that's also identified in there.

And then in NUREG-4214 it kind of identifies the hematopoietic syndrome as the dominant cause of early fatalities, which is based off of the red bone marrow. And so we just felt it was identified as the most limiting and confirmed with some of the sensitivities that we ran for our analysis. And then we also utilized it, as it's available for quantification within our MACCS software.

So then in conclusion, we based, we just want to reiterate that the EPZ size is based off of

the smallest distance from where all or our criteria is met. And then if the criteria is not met at our desired size, the determination is made to make design changes if we're still in that portion of the development stage.

Otherwise, we make refinements to our specific events, our quantification, and evaluate an EPZ size. Otherwise again, we'd have to expand that size out until we meet the specific criteria. And that was identified a few slides prior. So that's the EPZ methodology.

MEMBER ROBERTS: Okay. Vicki.

MEMBER BIER: Yes, a quick question. The discussion about the bone marrow et cetera, makes it sound like this is really being based on avoidance of acute fatalities or acute health effects, whatever. And I think for the, you know, current fleet of large reactors, we have over time, concluded that acute fatalities are really quite unlikely. And should not be the main driver of protective actions.

That we really should be focusing on cancer instead. And I just wanted to get a comment, am I interpreting that correctly? And is this being done because acute fatalities are actually a realistic possible consequence of an accident? Or am I

misunderstanding something in this process? It just seems strange to me that we're coming back to what seems like an emphasis on acute fatalities.

MR. BIERSDORF: It was more essentially just to capture the identified criterion in 1.242 for that Criterion Charlie. And then we just tried to align with some of the stuff that we saw in NEREG-0396 to see if we had the proper effects assessed and that we could evaluate it accordingly.

MEMBER BIER: So would this be a big driver of EPZ selection or just kind of for completeness and compliance purposes?

MR. BIERSDORF: In terms of like evaluation, against Charlie, or specifically the red bone marrow?

MEMBER BIER: I guess I'm not sure which I'm asking. Sorry.

CHAIR KIRCHNER: Vicki, this is Walt. Maybe I could jump in here and say that what we've seen now, TerraPower, we're having a lot of questions because you're the person coming through, implementing.

MR. BIERSDORF: Yes.

CHAIR KIRCHNER: But with another applicant, I just would observe that the Criterion

Charlie sets the distance in terms of the methodology in the analyses we've seen with other applicants. That becomes the limiting factor in setting that distance.

MEMBER BIER: Yes, okay.

CHAIR KIRCHNER: I'm not saying that we're emphasizing --

MEMBER BIER: Great

CHAIR KIRCHNER: - acute exposure, but from the methodology standpoint, what we're seeing is that that Criterion Charlie, is the one that sets the distance when you go through the exercise and look at the other criteria.

MEMBER BIER: Thanks.

MEMBER BALLINGER: This is Ron Ballinger. Just a note, those are not NUREG-CRs.

MR. BIERSDORF: Oh, sorry.

CHAIR KIRCHNER: No, 0396 isn't a --

(Simultaneous speaking.)

MEMBER BALLINGER: 0396 is not, but the others are, have to be CRs.

VICE CHAIR HALNON: The numbers are too high.

MEMBER BALLINGER: Yes, they are too high.

MEMBER ROBERTS: Okay, any more questions,

I guess, and so I'll address Vicki's question that the methodology when applied will determine for this plant, whether or not Criterion Charlie is limiting. I guess, if you don't know, I don't know. But I could make guesses, and it could go either way.

But the -- and Vicki, I think the real answer to your question is in the reg guide. And if, you know, from experience in other work, like Double Tree PRA were to point to a, you know, a need for a different criterion that would really be, you know, a question back to the staff for the reg guide.

It just seems like TerraPower is tracking pretty closely to the reg guide on these criteria. So the reg guide has raised a different question.

Any other questions from members or consultants?

Hearing and seeing none, TerraPower, thank you for the presentation. We'll turn it over to the staff. We're at less than an hour. I guess we'll keep going. If you push the staff presentation, we'll take a break.

So we'll pause for a couple minutes to switch out between the staff, or for the Applicant and staff.

CHAIR KIRCHNER: Tell me when you're

ready.

MS. SUTTON: I'm ready.

CHAIR KIRCHNER: Okay. I'll turn it over to the staff. Mallecia, you're going to start?

MS. SUTTON: Yes.

CHAIR KIRCHNER: Okay. Go ahead. Pull that microphone, Mallecia real close to you, if you would. I know it gets in the way of your notes, but --

MS. SUTTON: Yes, that's fine. Thank you.

CHAIR KIRCHNER: Pull it a little closer, more.

MS. SUTTON: A little bit closer.

CHAIR KIRCHNER: There.

MS. SUTTON: Can everyone hear me now?

CHAIR KIRCHNER: Yes.

MS. SUTTON: Good morning, hello. My name is Mallecia Sutton. I'm a Senior Licensing Project Manager at the NRC and the lead Project Manager for the TerraPower Natrium Project and for the Plume Exposure Pathway Emergency Planning Zone Seismic Methodology, or EPZ.

I'm going forward. With me today for this presentation is Michelle Hart, who is the NRC Senior Nuclear Engineer and our lead technical reviewer for

the TerraPower EPZ Seismic Methodology Topical Report. And Hanh Phan is Senior Reliability and Risk Analyst. One of the principal authors of the SE, Safety Evaluation.

Other technical reviewers that supported and authored the Safety Evaluation are Edward Robinson, Senior Emergency Preparedness Specialist and Kenneth Mott, a Senior Emergency Preparedness Specialist. And they are from the Office of Nuclear Security and Incidence Response, also known as NSIR.

And this slide, it describes the agenda of NRC staff's presentation today. We'll provide the purpose of the staff's review and the staff's review strategy of the Topical Report, provide an overview of the contents of the staff's Safety Evaluation Report, and then summarize the NRC staff's conclusion regarding the TerraPower's EPZ Sizing Methodology Topical Report.

Now, Slide 4. Today we will be presenting the changes made to the Safety Evaluation since September 19, 2024, ACRS Subcommittee meeting. The staff revised a draft to the Safety Evaluation to reflect the Topical Report Revision 3, to clarify the treatment of uncertainties in non-seismic sequence screening, including cliff-edge effects.

Staff imposed a new limitation and condition related to the selection of the seismic release scenario and updated limitation and condition regarding hazards. We also made editorial changes to provide further clarity to the draft Safety Evaluation.

Now, I'll turn the presentation over to Michelle.

MS. HART: Next slide, please. My name is Michelle Hart, I'm a Senior Reactor Engineer in Technical Branch 2.

So the Topical Report's purpose and our review strategy, the purpose of the Topical Report is to provide a methodology and criteria that will be used to establish the site-specific plume exposure pathway Emergency Planning Zone size for the Natrium reactor. And it's a risk-informed approach to determine the Emergency Planning Zone size by meeting criteria in the 10 CFR 50.33(g)(2). Or that's commonly called the alternative EP requirements for SMRs and other new technologies.

The staff's review strategy was to review consistency of the methodology with the technical basis for the alternative EP framework in 10 CFR 50.160 and conformance with the guidance on some

exposure pathway EPZ sizing. And that's Reg Guide 1.242.

We also assess the acceptability of the risk-informed approach and the interaction with overall Natrium licensing approach using the Licensing Modernization Project methodology or LMP.

Next slide, please. Okay. I'll now go over the steps in the methodology in an overview. There are three major portions to the methodology.

The first is accident screening to identify the spectrum events to be used in the plume exposure pathway EPZ sizing analysis. And then there's, they perform a radiological consequence analysis using those accidents that they had screened in. And they determine the plume exposure pathway EPZ size distance based on the sizing criteria with the basis in the regulatory requirement.

In the accident screening, they do compile release sequences from the probabilistic risk assessment for all internal and external initiators. Perform screening of non-seismic release sequences based on frequency, and including uncertainty and screening of seismic release sequences using a unique set of selection criteria.

And in the radiological consequence

analysis, they would use site meteorological data, perform a source term and radiological consequence analysis and evaluate the consequences against the dose-related criteria for Emergency Planning Zone sites.

And so now, the next topic we'll discuss is the accident screening portion and I will turn that over that over to Hanh Phan.

MR. PHAN: Thank you, Michelle. With that, good morning, ladies and gentlemen. My name is Hanh Phan, Senior PRA Analyst in NRR/DANU.

In the next four slides, I will focus on the first step in the TerraPower's proposed methodology for determining the PEP EPZ distance. This step involves identifying the release sequences which will be made under the design and site-specific PRA.

The PRA is --

MEMBER ROBERTS: Hanh, excuse me, please get a little closer to the microphone?

MR. PHAN: Yes, sir.

MEMBER ROBERTS: Thank you.

MR. PHAN: The PRAs will be full scale assessment that covers internal and external hazards, all operational modes, and all sources of radioactive

materials. Previously, the staff has presented to the ACRS a Draft Guide 1413, which outlines the process for identifying licensing events with nuclear power plants, including comprehensive search for initiating events.

However, since this guidance is still in the draft forms, first, it cannot be referenced in the staff's safety evaluation. Therefore, the staff has established and modified a limitation and Condition 2 based on the ACRS comments at the Subcommittee's meetings.

Which states, an Applicant that references this Topical Report, must justify the technical acceptability of the PRAs performed for selected hazards and modes. Prior to the initial fuel load, PRAs supporting this methodology must include all applicable hazards and modes. Next slide, please.

Slide 8, the PRA use for the EPZ sizing calculation will be developed following the requirements in the, provided in the ASME/ANS non-LWR PRA standard. And will undergo peer review.

Key assumptions and sources of uncertainty will be assessed to evaluate their impacts on the calculation. Additionally, a qualitative or quantitative evaluation of security events will be

performed and enclosed in the PEP EPZ size calculation. Next slide, please.

MEMBER MARTIN: Just real quick, Hanh.

MR. PHAN: Yes.

MEMBER MARTIN: So on your previous slide, I assume that kind of answers the question of what does it mean to be a technically justified PRA. Now, you, like that list is comprehensive, the four, or are there others that you've kind of assumed are pretty more minor?

And maybe in knowing what your next slide is, can you kind of lead into the question of cutoffs. And what is, you know, more of a sufficient consideration of events below, you know, the two cutoffs?

Now, would that be included in an acceptance criteria for a technically justified PRA, is kind of what I'm getting at? Is there more and then specifically is there something related to say, what's enough as far as, in cutoffs or, you know, when are we done?

MR. PHAN: Yes, so, yes, I will briefly discuss that. Next slide. And give you at least some confidence why we should -- we -- be doing that, that the cutoff values are acceptable at this stage.

CHAIR KIRCHNER: May I just ask you to elaborate on the last bullet. When you say, security events here including potential sabotage.

MR. PHAN: Yes, sir.

CHAIR KIRCHNER: So, and that would be done qualitatively or quantitatively in addition to the numerical methodology. It's like an overlay, if you will.

MR. PHAN: In addition to the PRA accident sequences.

CHAIR KIRCHNER: Okay.

MR. PHAN: It's like night. Two processes was designed. They screened, they did best release sequences. One for seismic and the others are non-seismic sequences. For non-seismic, these sequences, all sequences and families generated by the PRA will be accepted for inclusion.

The very first screening criterion asks if the mean frequency contributes 1 percent or more to the total frequency. So this is the first criteria to give us the confidence that important sequences and families to be accepted.

If you look at the rate of powers of 10 months, these are, the total frequencies is very low. So one percent of that protects a family of sequences,

of families to be assessed with the policy.

MEMBER MARTIN: So maybe I don't understand, this is Bob Martin, this completely. So I can imagine you could have, say for instance, 100 sequences and families, just to pick a number, okay. And if you kind of think of, this could be an assumption, failure on my part. But, you know, maybe the distribution kind of looks like a power log, so you get more of them on the bottom end.

I could just see a scenario, and we're not necessarily talking about TerraPower or Natrium type of projects, but you can see the results there, but you could have 20 less than one percent. And collectively, they might represent 10 percent of the total. Why is that good enough?

I mean, but, you know, I liked the answer earlier obviously when I asked, is it, you know, Phan, considering, you know, the whole domain is 100 percent. And, you know, we're looking really at more than 99 percent. That's like, provides context, meaning the cutoff doesn't mean anything.

But then, you know, this first gate here seems to open, you know, if it's a general methodology that the NRC is going to accept for other applications, it doesn't necessarily block, you know,

a different design or a different, you know, a different PRA from, you know, from not letting something through, you know.

So I noted the example from Reg Guide 1.216 where it focused in the whole domain and it -- it's, do have navigational rights, the containment, Delta PR containment integrity.

And it looks at what they call more likely, and such. It's a little bit different and their acceptance criteria is 90 percent. Where I think something like here, we're looking at 99 percent of release scenarios that we'd be interested in.

That context I think if somebody else, another applicant is looking at what's being done here and this is of course an open meeting and there might very well be somebody listening. You know, this sets of gates wouldn't necessarily work in every case.

But a, you know, another method such as I think the Reg Guide 1.216 can apply in here. It might very well do that. Do you -- how do you feel about other people looking at this? I know your obvious answer is that well obviously we'll look at everyone case by case, that sort of thing.

But if you communicate that something like this will work in every case, which it's, I mean

you're not, you know, you're not really doing that. But, you know, without having anything more than Slide X and non-proprietary documents, someone else might pick this up and think, okay, I can do it too. And it have -- really be a completely different safety profile.

Now, you all would probably come back and say that's not justified or what have you. But it seems like it might create turn or something might slips by. Okay, anyway.

CHAIR KIRCHNER: Aren't these, these are the wickets from the reg guide.

MEMBER MARTIN: No, the cutoffs. NO, they're cutoffs, 10 to the minus seven, 10 to the minus eight. Those are not the reg guides. And that's their methodology.

CHAIR KIRCHNER: This is the NRC's?

MEMBER MARTIN: No, this is the --

CHAIR KIRCHNER: TerraPower.

MEMBER MARTIN: TerraPower's.

CHAIR KIRCHNER: TerraPower's.

MEMBER MARTIN: Okay.

CHAIR KIRCHNER: You stand corrected. Thank you.

MEMBER MARTIN: So that's it. It's a

unique methodology. And it's their interpretation. But --

CHAIR KIRCHNER: Isn't too different from what we've seen before.

MEMBER MARTIN: Well, we haven't seen any of this before. This is --

CHAIR KIRCHNER: We have.

MEMBER MARTIN: For cutoffs. no.

CHAIR KIRCHNER: Yes, I bet you we have.

MEMBER MARTIN: Cutoffs. Who?

CHAIR KIRCHNER: NuScale. Well, but that's --

(Simultaneous speaking.)

MEMBER MARTIN: Well, that's not relative.

CHAIR KIRCHNER: Similar approach, not the same numbers, but -- yes, thanks, Martin. Go ahead.

MEMBER MARTIN: Okay. Well, like I said it concerns me that it's not a general methodology because it doesn't have context. And I feel like, that, you know, there's precedent in the NRC. I've seen that containment reg guide where, you know, you have the context. It's a little bit more clear where cutoffs are. And, you know, maybe the worst thing that comes out of accepting it, the methodology. It looks like this with cutoffs, is that it creates turn.

But nonetheless, why do that? Why not have a, you know, a deeper discussion about, you know, context with an eye towards what other people might otherwise interpret from what you've got here?

And there's a question in this, I mean, how much were you aware of, say, the other methods like in Reg Guide 1.216? And it might be a new thought, but, you know, so kind of catching it off guard, that's not completely fair.

MR. PHAN: Thank you very much for your concerns and feedback. But this has a big application, because of their implementation of LMP. We believe that when this particular application has been (audio interference) is this figure.

MEMBER MARTIN: Well, like I said, I think the answer I got from TerraPower was an acceptable answer. But at the same time, it's not necessarily something that obviously it comes out of the documentation.

MR. PHAN: Yes.

MEMBER MARTIN: But you know it, but I'm not sure the public would necessarily recognize it.

MR. PHAN: Thank you.

MEMBER ROBERTS: But if I understand what you're asking, maybe I'll give just a kind of a

trivial example. If you had a sequence at 9 times 10 to the minus nine, it was, you know, a thousand times the limit. Then you'd like to have something that says well, yes, I looked at all the scenarios that encompass some fraction of the dose consequence, and so that would screen in this sequence because it has so much more dose than you want to be screened in.

MEMBER MARTIN: Right.

MEMBER ROBERTS: But it all seems like if you take away the low cutoff for the cliff-edge effects and defense in depth, that you'll get a similar, you know, view of things. That you would be looking at those types of sequences and concluding that there may be a cliff edge of sorts.

That just by getting a little bit worse, you get significantly worse cutoffs. And that, you know, came to a cliff edge and that would come out of an assessment like that. So maybe related to the question we asked earlier about why you would have a low cutoff for cliff-edge effects. And it may be another way to get at the same thing that you're concerned about.

MEMBER MARTIN: Well, I think it comes down to transparency really. You know, it seems in the case of TerraPower that, you know, it meets any

kind of, let me say, a safety criteria that, you know, I think we can all accept. But on the surface, it's just not obvious, until you have this conversation.

And then that, it should be a little bit more transparent. I think there are other methods that are more transparent and, you know, we have people from the public online. You know, that call like this and, you know, they're not going to appreciate all the wickets and how they assure, you know, you get adequate protection.

But as you said, in this particular application we're fine. But I'm not so sure going forward, you know. We should, you know, can't say we can't accept methods like this, but we should have an eye towards improving the transparency of the presentation of the information through the methods topical. That's my concern. It's just not obvious.

MEMBER PETTI: Just a clarification, it looks like the realm of cliff-edge effects, those sets of events that are going to be looked at, are frequency limited here, in this chart, right. But then we also heard though that they have sort of a broader cliff-edge in defense in depth evaluation through an LMP, right.

But they're making a judgment here for

EPZ, they're going to limit that broader space based on a frequency cutoff (audio interference), right. Is that how you, that's what I thought I took away from it.

MEMBER ROBERTS: Yes, that's what I heard. You know, whether or not that makes sense to me is a different question than what I heard.

MEMBER PETTI: Oh, yes, yes, okay. Because I'm, yes, I'm always worried about the case that's right out there. You know, I mean, yes, if you go down lower in frequency, doses should be going up, right. And all of a sudden is, as you quoted from that report, you get low enough in frequency, there really are no more values and safety functions. Just you're left with the technology.

And there are characteristics of each of the advanced technologies that show up when you get to those incredibly low values. And those are kind of the inherent hazards that you're designing the plant to prevent, you know, from rearing their ugly heads. Okay, no, I understand that. Thank you.

MR. PHAN: Thank you. The next question is whether the mean frequency is equal to or greater than 1 minus seven per reactor year? If yes, is included. If no, then the next question is whether

the 95 percentile values is equal to or greater than 1 minus seven reactor year?

Again, if yes, it is included. If no, a last question is whether the mean frequency is equal to or greater than 10 to the minus 8 per reactor year? If yes, the sequence or family, it further assesses for any cliff-edge effect. If any identified, the release sequence or family will be included. Otherwise, it will be excluded from the EPZ dose calculation.

Next slide, please. Slide 10. For the seismic release sequences, a limiting peak ground acceleration, PGA, will be used to define seismic events for the PEP EPZ calculation at the CP stage.

This limiting PGA will be set to at least twice the ground motion response spectrum and up to the maximum of 1g. Based on the existing paper for most U.S. sites, (audio interference) GMRS is less than 1.0 g. But in some cases, or some locations, it asks this question.

However, it's up above the cap 1g. So to ensure a conservative approach, the staff established a new limitation and Condition by adding the use of 1g PGA and states, an applicant that references this Topical Report will provide site-specific

justification for the use of the upper bound PGA of 1g when exercising the methodology in the Topical Report Section 3.7, Selection of Seismic Release Sequences.

Additionally, the site-specific scoping level seismic PRA will be performed to provide other insights at the CP stage.

With that, I return to Michelle for continuing with the consequence analysis.

MEMBER PETTI: I just have a broader question. Maybe it's too site specific to answer, but from a probability and a risk perspective, is the approach to seismic similar to the internal hazard approach?

Or do you end up going -- because we don't have data and we're going down to 10 to the minus eight -- so you'd ask yourself, what's the 10 to the minus eight to earthquake? To be consistent, but I know that those aren't 10 to the minus eight, the earthquake measures, they're much higher in frequency, right. So there is this incongruity between external events and the internal events.

Is that -- it's just sort of -- because we're limited in terms of our knowledge, I would imagine on seismic, when you get those really low probabilities. Is that fair to, when you're

calculating?

MR. PHAN: At this stage because the seismic PRA is not deep enough. So we cannot say that 1E minus eight or 1E minus six that is (audio interference) sequence for seismic events. That's why the applicant, they propose using 2x GMRS. Because that's up to PRA during the seismic period. So at the cutoff stage we decided PRA fully completes and perform according to the PRA standard. That would answer what you're asking.

MEMBER PETTI: Thank you.

MR. PHAN: Thank you.

MS. HART: Okay, thanks. So once you determined your events and the families that you're going to include in your radiological consequence analysis, you would pass it on to the radiological consequence analysis step.

And in the EPZ sizing analysis methodology Topical Report, the methodology uses the outputs and methodologies in related Topical Reports which are currently under review. That being the radiological source term Methodology and the radiological release consequences methodology.

The source terms are developed as a part of the safety analysis at PRA and used as input to the

EPZ sizing analysis. In other words, there are no EPZ specific or unique source terms that would be developed, because these are the same scenarios that you're using for your safety analysis and PRA.

Next slide, please. So to estimate the dose, the Topical Report methodology identifies the doses are first estimated at the proposed EPZ distance, and then compared to the three dose-based criteria. And that the plume exposure pathway, EPZ will be established at the furthest distance for which all three criterion are met.

And as TerraPower had described earlier today, there is an iterative risk process to determine the plume exposure pathway, or to establish that in the first place. And if the result of the proposed distance is unacceptable, they will either change the plume exposure pathway EPZ size, or they will make design changes if they're during the design phase.

Next slide, please. So for the dose-based criteria, there are the three criteria for most radiological release sequences. Criterion A, for design-basis accidents and Criterion B, for those sequences and families with a mean release frequency greater than 1 times 10 to the minus six, per reactor year.

You would compare the mean, 96-hour dose for the event, to the lower end of the EPA Protective Action Guide range, that's 1 rem TEDE. And you would compare the 95th percentile, 96-hour dose for the event, to the upper end the EPA PAG range, and that's 5 rem TEDE. And that PAG range is for the early response, or the early phase of radiological incident for things such as evacuation or security measures.

Next slide, please.

VICE CHAIR HALNON: Michelle, this is Greg, just I'm sorry to go backwards. Dose estimation, I think it was Slide 12. I would assume that the expectation is that you're going to see site boundary being that first estimate. Because that's really, if you look at it, the full piece of it is the cliff effects, the cliff-edge financial, if you will, aspect.

If they determine the site boundary is adequate, is it then your expectation that they continue to refine it down to, to get the actual EPZ within the site boundary? Or are you just going to allow them to stop and say okay, we're good at site boundary, if you're good.

MS. HART: So for the purposes of determining a plume exposure pathway EPZ size, it is

about protecting the offsite population. And so once you have control of the area where you're, you know, if you're within the site boundary, there's no reason to have to --

VICE CHAIR HALNON: Okay.

MS. HART: -- refine it further.

VICE CHAIR HALNON: So we'll probably see a lot of site boundaries, I mean you can actually change the site boundary, you can buy more land --

(Simultaneous speaking.)

MS. HART: Correct.

VICE CHAIR HALNON: Instead of just space.

MS. HART: Yes, and that's another refinement that could take, as opposed to refining the facilities.

VICE CHAIR HALNON: Thank you, Michelle.

MS. HART: You know, it's up to them, but yes, I think, you know, certainly the methodology is not saying that this is to determine a site boundary EPZ, but it is a goal that could be accomplished through the use of the methodology.

CHAIR KIRCHNER: And we saw that, Michelle. I'm sure you remember, we saw that with an application for an early site permit.

VICE CHAIR HALNON: Right.

CHAIR KIRCHNER: And they did a plant envelope approach, and then they could show that for one technology selection, they could meet these kind of criterion within the EAB. For another selection it would go a little bit over the EAB in terms of setting the EPZ.

VICE CHAIR HALNON: And this is in effect, an indirect plant envelope determination. So that's why I wanted to see if there was expectation to get down. And there may be a good reason, maybe there's a high factory or something within the site boundary that is using the process heat. You may not want that part of it. So you may want to refine it down. But for us and in most cases, site boundary is really the goal, I think. Thanks.

` MS. HART: So back to, where are we, Slide 4, 14, 15. Yes, 15.

MS. SUTTON: We'll move on, okay. Just want to make sure.

MS. HART: Okay. Oh, no we missed one, 14. I'm sorry, let's go back. Yes.

So for the worst-case radiological release sequences, those are those sequences of the mean release frequency between 10 to the minus seven per reactor year and 10 to the minus six per reactor year.

This is a comparison to a dose metric of 200 rem red marrow acute effective dose for a 24-hour exposure period.

It would generate a dose-distance chart mapping the dose reduction as one moves away from the Emergency Planning Zone boundary. And into the analysis to ensure that the dose drops rapidly beyond the plume exposure pathway EPZ size -- excuse me, plume exposure pathway EPZ to ensure that there's a low probability of early deterministic health effect, which is consistent with what was originally developed in NUREG-0396. And we do reference that kind of dose aggregation evaluation in the guidance in Reg Guide 1.242.

MEMBER ROBERTS: If you can go back one slide. There you go, right there. It says -- chance to -- just to make a comment and then ask a question. The header of this slide says, Criterion A DBAs and Criterion B mean release frequency greater than 10 to the minus six per reactor year.

What that actually says in the reg guide is design basis accidents agree with that. And Criterion B is projected dose for most core melt sequences. So there is some precedent for defining most core melt sequences in these, you know, SMRs and

ONTs as 10 to the minus six per year.

So there's precedent for that but like Bob's been reporting out, that's not in the reg guide. And how you would determine what most core melt sequences means in a particular reactor is something that's kind of left up to the individual Applicant. And so I would tend to agree with Bob.

If it's not in the reg guide, it's not something that, you know, that says how to do it. It's just there's a precedent that TerraPower is following here, and the staff is, you know, accepting based, you know, largely on precedent.

But it leads to a question, there's an NEI document, an NEI 24-05 that was submitted a few months ago, and I think the document is still proprietary, so we can't really ask specific questions about it. Just wondering in general, is this something the staff is in the process of reviewing? And is that review refining any thoughts in terms of evaluating reports like this Topical Report?

MS. HART: So, certainly, yes. We have received that NEI report, and we're in the process of reviewing it, still early in the process. So, you know, a lot of the tenets of this are generally similar to, is that white paper. All of these things

are based on the similar, you know, the previous applications we've gotten, all kind of using the NUREG-0396 as a basis and maybe generalizing it or using it in a less light-water reactor specific way. And maybe bringing it up to date somewhat.

So as we go through that review, there may be some things that we find out. And if, you know, there are some major issues with this methodology, not saying that are, it looks generally consistent at this point, or some refinements that should be made, you know, it may have to -- if it's important enough, we would have to evaluate an implementation of something that uses this methodology. But I don't see a major issue at this point. But like I said, we're still early in the review.

MEMBER ROBERTS: Okay, thank you. Yes, I think I mentioned in the Subcommittee meeting that we're likely interested in, you know, getting briefed where you end up on that document, just to understand what the current views are on that risk in defining that basis. Thank you.

MS. HART: And I did want to mention the quote that you have from the reg guide was, a reference to what's in NUREG-0396. It's not necessarily meant to be generally applicable for non-

light-water reactor designs or even new light-water reactor designs.

You know, these are the core, phrase core-melt sequences. It's not necessarily meant to be generally applicable. But you should do something similar. You know, most release sequences I think is more realistically an equivalent.

MEMBER ROBERTS: Okay. I agree. Thanks for the clarification, Michelle.

MS. HART: Now, back to, where are we? Slide 15. Yes, I think we finally got there. Any more questions about the dose-based criteria?

CHAIR KIRCHNER: Well, just, Michelle, since you'll get several applications in, already have dealt with some -- that last, the previous slide. I hate to, you're right, regress, but previous slide talked about, and it drops off greatly. That was 0396. Is there any in 242, Reg Guide 1.242, is there any definition of that? Or is that something that you just evaluate and put a qualitative judgment on?

MS. HART: So the reg guide does point to the evaluation that was done in Appendix 1 or I, whichever way it's really supposed to be said, to NUREG-0396. So there was that evaluation and you can see it on the chart, that it does drop off rapidly.

And so I think it's more of a qualitative discussion within the reg guide.

And, you know, you kind of have to look at the actual information for the specific site to be able to really tell if you've got a reasonable Emergency Planning Zone size so that you can prepare for the majority of events that go down.

CHAIR KIRCHNER: Thank you.

MS. HART: So, Slide 15. So this is discussing what we were just talking about, the probabilistic dose aggregation and treatment of uncertainty. That last criterion, the low probability of exceeding an early deterministic health-effect criterion considers scenarios with lower frequency than used to determine the licensing basis events with LMP.

Topical Report Section 6.3 does describe the uncertainty and sensitivity analysis methodology for this EPZ sizing analysis. It would go through a Monte Carlo sampling on the PRA event frequencies.

There's source term and consequence analysis uncertainty results are included, and those are determined through the related methodology Topical Reports. So there are, a lot of the outputs of that is uncertainty in both of those.

And the cliff-edge effect evaluations, which we've talked about before, and that's for those events down to what? Between 10 to the minus seven per reactor year and 10 to the minus eight per reactor year.

The primary focus is on single failures that would dramatically change either the risk metrics or the effects of the accident sequences such as timing, plant response, source terms, or end states.

And this is, certainly within this methodology, it's within the context of, would it change your determination of plume exposure pathway EPZ size?

Next slide, please. And then the last criterion is a criterion in the regulation as well. It's the necessity of predetermined prompt protective measures. They would use the radiological release timing to identify if there are any necessary prompt protective measures for the event. Each event is assessed individually and any identified protective measures for those events would inform the emergency plan and procedures.

Next slide, please. So with that that's a description of the staff's review. Our conclusions are that the staff determined that the Topical Report,

subject to the limitations and conditions, provides an acceptable approach for developing analysis to aid in the determination of a site and design-specific plume exposure pathway EPZs for the Natrium reactor.

And accordingly, we conclude that the Topical Report can be used in establishment of a plume exposure pathway EPZ size to support emergency planning and preparedness in compliance with the regulatory requirements as listed.

Are there any further questions?

MEMBER ROBERTS: Thank you, Michelle and Mallecia. Are there any questions from the members here or consultants? Dave.

MEMBER PETTI: Michelle, the Monte Carlo analysis and the cliff-edge analysis, what struck me is you're really just looking for single failures that would cause an increase. And that would tell you that perhaps you don't have also adequate defense in depth.

But these lower, let's talk about the broader set of events we can see, is that we had heard earlier that they're down much lower than 10 to the minus 10, or 10 to the minus 12. Those most likely would require multiple failures.

And so to me I guess that's a big difference in terms of when you think about it from an

EPZ. You're really just looking at, you know, each barrier, if you will, for a simple term, individually and not in its collective sets that would push you down into lower risk. When you look at it through the EPZ lens.

MS. HART: Correct. But yes, this is not intended to refine the design or reduce risk in general. This is trying to determine a reasonable set of events or likely events that you would have to have prepared prompt protective measures ready to go in case you have an event.

And so there's a little bit of a different focus in the goal of what this analysis is trying to do here.

MEMBER PETTI: For me, that's helpful. It puts everything into perspective. Thank you.

MEMBER ROBERTS: Okay. Any other questions from the members in the room or online? I don't see any hands up. So, Vicki, Dennis, anybody else out there with questions for the staff?

MEMBER BIER: Not right now, no.

MEMBER ROBERTS: All right, seeing and hearing none, now is the perfect time to go out for comments from members of the public. So anybody who's been, you know, not been in the room but online, who

would like to make an observation, go ahead and raise your hand. And see Ed Lyman has his hand up and then I'll call you.

Please unmute, state your name and affiliation if appropriate, and then state your comment. Ed.

DR. LYMAN: Yes, thank you. This is Edwin Lyman from the Union of Concerned Scientists. Can you hear me?

MEMBER ROBERTS: Yes.

DR. LYMAN: Yes, right. So, yeah, my comment is that I appreciate the comment, I believe it was Member Martin, about transparency and public understanding of these processes. And from my perspective, I think the most important thing for the public to understand is that any screening process is not cooked up to cherry-pick or to cherry-pick the event sequences to allow the Applicant to get the answer that they want.

And so that's really I think should be front of mind when you think about these processes. And in that context, I'd like to at least go back to the discussion of whether it's appropriate to screen out for frequency events that may have a cliff-edge effect. And I just want to offer one example, since

the discussion was very abstract. I just want to put this forward, for why I think it isn't appropriate to have that screening.

And so let's say you have a flood, a design-basis flood where it's the probable maximum flood height. And the likelihood -- so your defense is, you know, you have flood protection against that flood height.

So if that would, occurs, then the only way that there would be, that would progress to a core-damage accident is if the flood barrier fails. And let's say that's a very low probability event, right, since the flood barrier is presumably very robust. So you might screen that out.

But that's exactly the example where a cliff edge might turn that very low probability event into a very high probability of core damage, if the actual flood height exceeds the probable maximum by a small amount.

So just looking at that example, it does not seem appropriate to do that frequency screening at the first pass, to eliminate those kinds of sequences, where the cliff edge might increase the frequency of core damage by many orders of magnitude. So that's my comment. Thank you.

MEMBER ROBERTS: And thank you, Ed. Any other members of the public out there? I don't see any hands up. Give it another few seconds for somebody to raise their hand or speak up.

Okay, and with that, I thank both the Applicant and the staff and the presentations were very helpful. And with the changes, I think both the Topical Report and the Safety Evaluation will help in terms of a clarity of what's intended and what the additional conditions are intended to do.

And I guess, turn this back to Walt it's the next -- I would recommend we take a break and then go to the --

CHAIR KIRCHNER: Yes, precisely. I agree with you wholeheartedly. So we'll take a break at this point. And we'll come back at 10:35 Eastern time. And we'll proceed with discussion and --

MEMBER PETTI: Do we need a Court Reporter?

CHAIR KIRCHNER: Hold on. We'll come back at 10:35 and we'll proceed to discussion and then letter writing. Tom has a letter drafted on this Topic. And with that, I think we can excuse the Court Reporter for the rest of the day. Is that correct, Larry?

MR. BURKHART: That should be correct, and I shall be in touch, I believe, tomorrow, when you're (audio interference) right?

CHAIR KIRCHNER: Okay. So tomorrow would be, we continue letter writing for which we do not need to make a record, correct?

MR. BURKHART: You are correct.

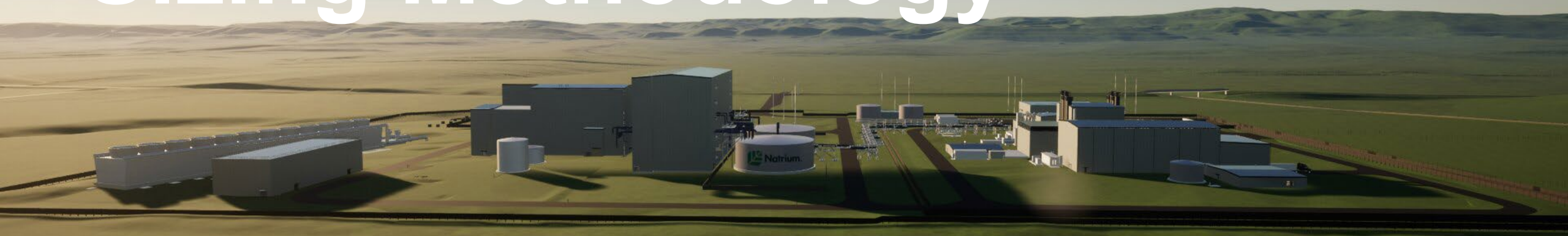
CHAIR KIRCHNER: With that, yes, so thank you -- who's our Court Reporter?

MR. BURKHART: James.

CHAIR KIRCHNER: James, Thank you, James. I think we're finished with your services for this meeting. Thank you. And we are in recess.

(Whereupon, the above-entitled matter went off the record at 10:18 a.m.)

Plume Exposure Pathway Emergency Planning Zone Sizing Methodology



ACRS Full Committee Meeting

November 2024

TP-LIC-PRSNT-0031

TerraPower Natrium

Natrium reactor is a TerraPower & GE Hitachi technology

Table of Contents

- Overview of NAT-3056, TerraPower, LLC (TerraPower) Natrium Topical Report: Plume Exposure Pathway Emergency Planning Zone Sizing Methodology
  - Guidance Used
  - Methodology
  - Conclusion

NAT-3056

Guidance Used

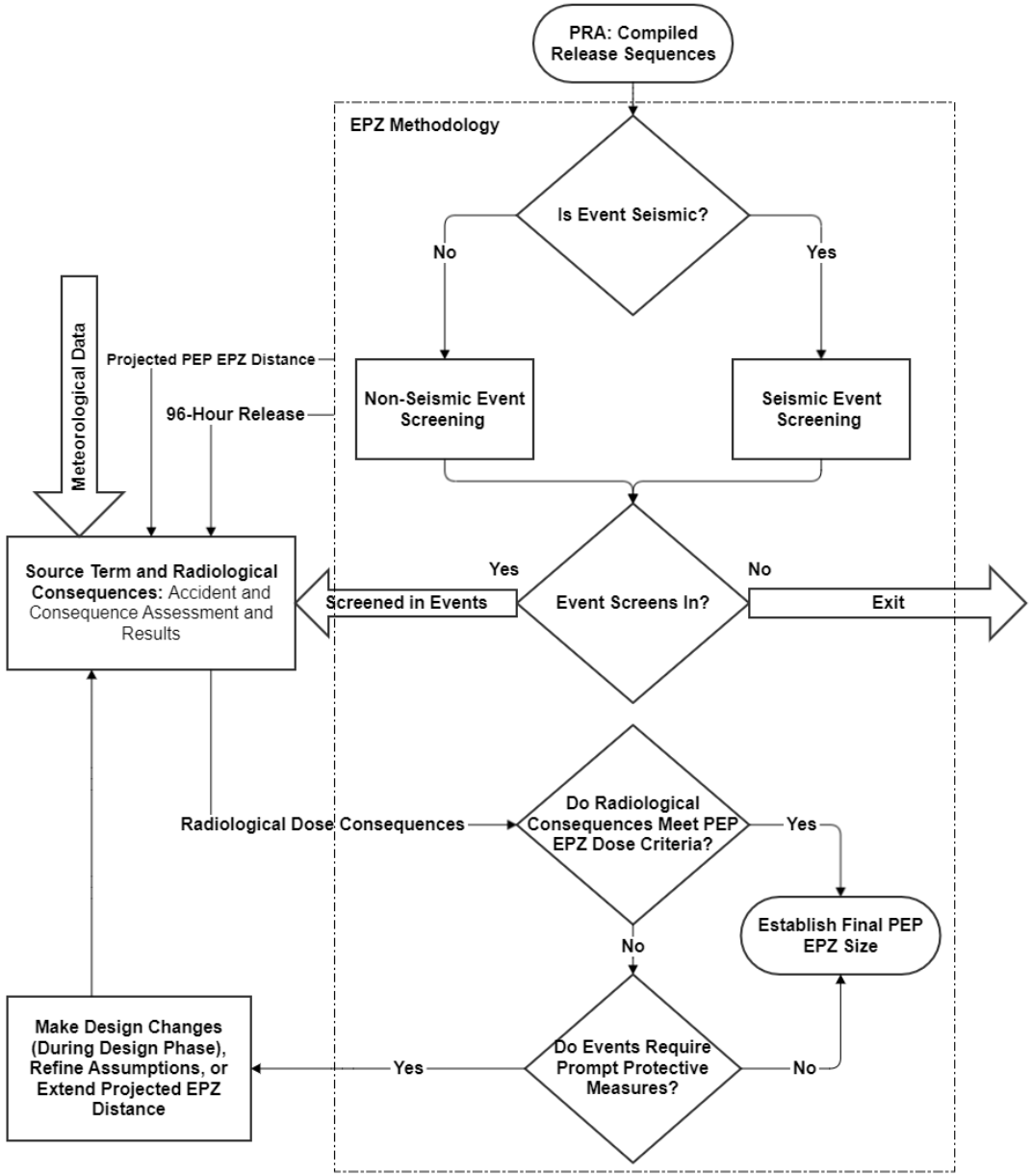
- Regulatory Guide 1.242, *"Performance-Based Emergency Preparedness for Small Modular Reactors, Non Light-Water Reactors, and Non-Power Production or Utilization Facilities"* was utilized in developing the overall methodology.
- Supporting information from NUREG-0396, *"Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants"* was used to assist in the development of the evaluation criteria.

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

NAT-3056

Overall EPZ methodology

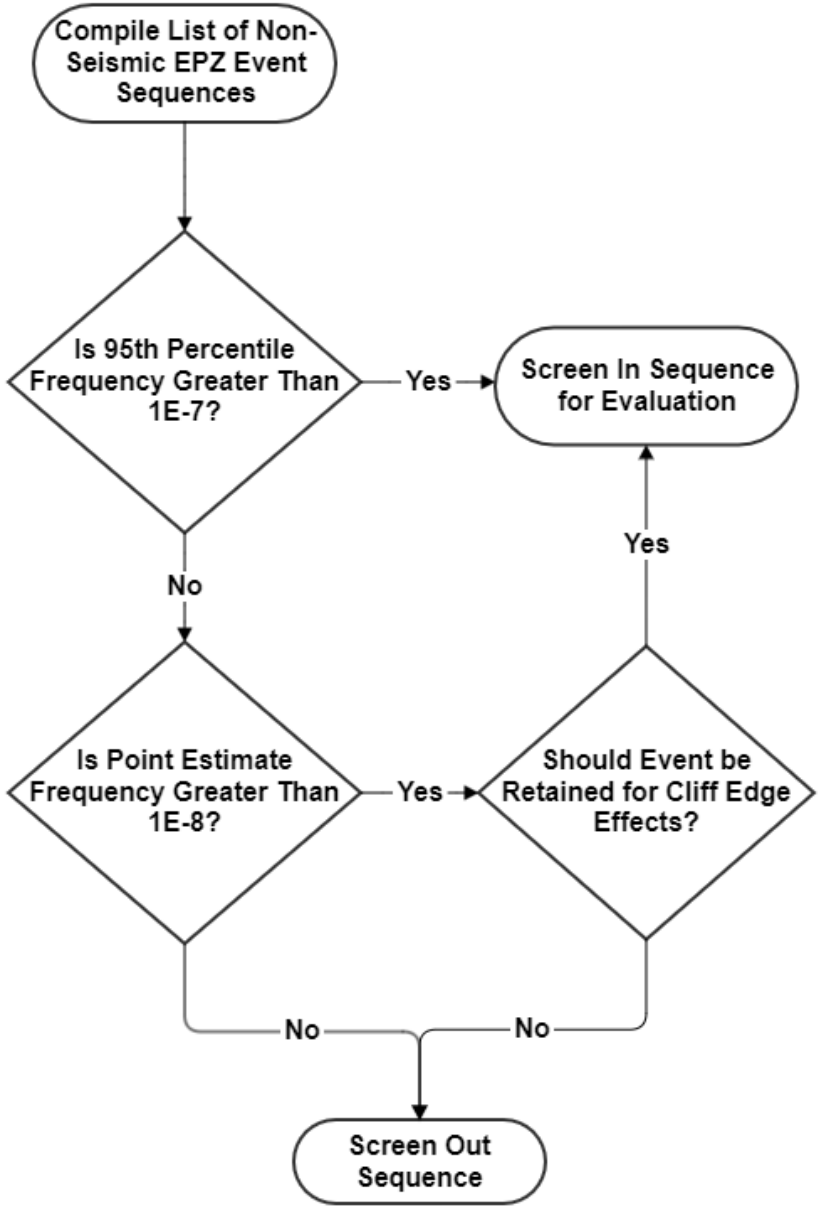
- Assesses all modes and all hazards
- Incorporates site specific meteorological data
- Assesses radiological consequences
- Identifies prompt protective measures
- Establishes final PEP EPZ Size



NAT-3056

Non-seismic Event Selection

- Includes DBAs
- Includes events with a 95th percentile release frequency greater than 1E-7
- Includes events for cliff-edge consideration if they have a release frequency greater than 1E-8



NAT-3056

Non-Seismic Event Selection Example

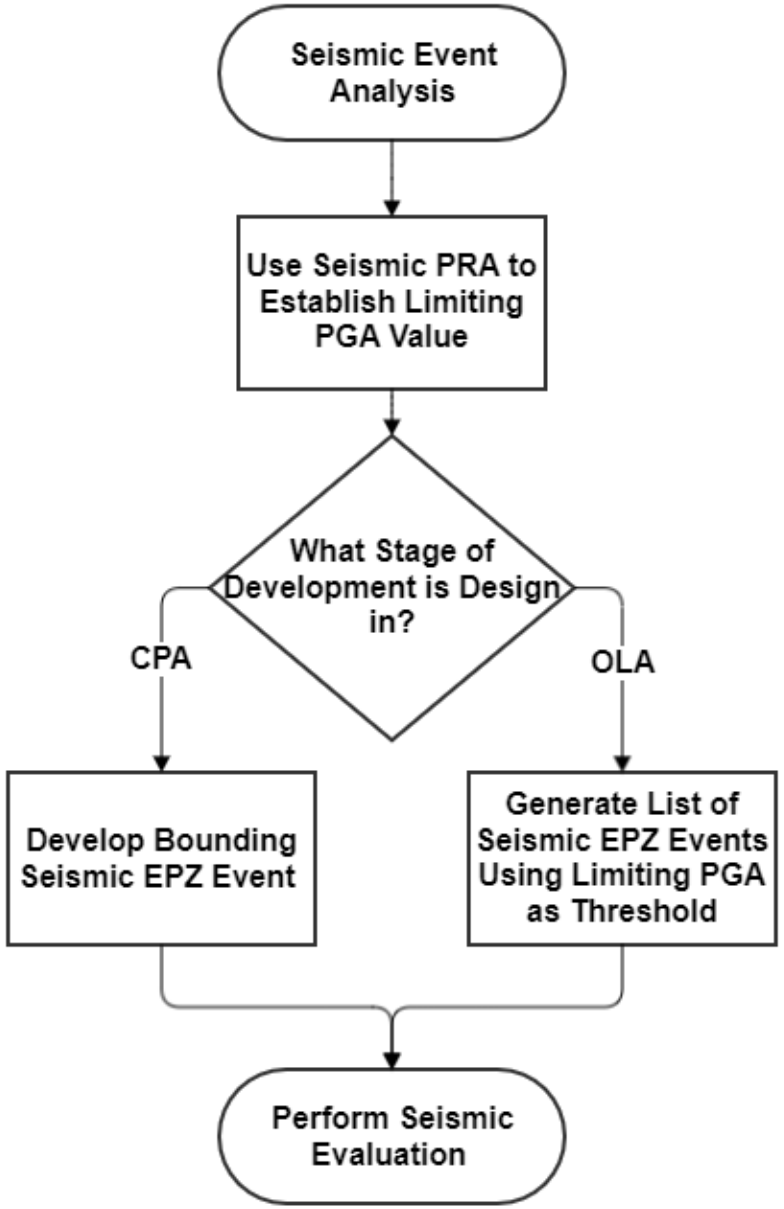
- Mean: 2E-7, 95th percentile: 6E-7 screened into EPZ evaluation
- Mean: 8E-8, 95th percentile: 2E-7 screened into EPZ evaluation
- Mean: 2E-8, 95th percentile: 6E-8 considered for cliff-edge effects
- Mean: 8E-9, 95th percentile: 2E-8 screened out of EPZ evaluation

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

NAT-3056

Seismic Event Selection

- Developed a bounding seismic event for the CPA
- Will generate a list of seismic EPZ events using a limiting PGA as threshold



SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

NAT-3056

Development of Limiting PGA

- Limiting PGA is ***LOWER*** of the two:
  - 2x(GMRS) **OR** 1.0g
- Ensures that range of seismic hazard within credible range of ground motions
- Acknowledges limitations of the SPRA
- Acknowledges uncertainties in the emergency response infrastructure

NAT-3056

Criteria for PEP EPZ Sizing

- Criterion A: Projected doses from the DBAs would not exceed 1 rem mean 4-day TEDE and 5 rem 95th percentile 4-day TEDE.
- Criterion B: Projected doses from most radiological release sequences would not exceed 1 rem mean 4-day TEDE and 5 rem 95th percentile 4-day TEDE.
- Criterion C: Immediate life-threatening doses from the worst-case radiological release sequences would not exceed 24-hour, 200 rem red marrow acute effective dose.

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

NAT-3056

Red Bone Marrow Use

- Supported by guidance
  - NUREG-0396 – Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants
  - NUREG-7009 and NUREG-7161 – MACCS best practices and technical basis in the SOARCA
  - NUREG-4214 – Health Effects Models for Nuclear Power Plant Accident Consequence Analysis
- Identified as most limiting and confirmed by sensitivity analysis
- Available for quantification within MACCS

NAT-3056

Conclusion

- EPZ size is set based on smallest distance criteria are met.
- If the criteria are NOT met at the desired EPZ size, determination is made if design changes or refinements can be made to reduce EPZ size. Otherwise EPZ is expanded to meet the criteria.

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

Acronym List

CPA – Construction Permit Application
DBA – Design Basis Accident
EPZ – Emergency Planning Zone
GMRS – Ground Motion Response Spectra
MACCS - MELCOR Accident Consequence Code System
PEP – Plume Exposure Pathway
PGA – Peak Ground Acceleration
PRA – Probabilistic Risk Assessment
SOARCA – State-of-the-Art Reactor Consequence Analysis
SPRA – Seismic Probabilistic Risk Assessment
TEDE – Total Effective Dose Equivalent

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

NRC Staff Review of TerraPower Topical Report: "Plume Exposure Pathway Emergency Planning Zone Sizing Methodology"

Office of Nuclear Reactor Regulation (NRR)
Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU)

Office of Nuclear Security and Incident Response (NSIR)
Division of Preparedness and Response (DPR)

ACRS Full Committee Meeting
November 7, 2024

Review Staff

- Michelle Hart, Lead Technical Reviewer - Senior Reactor Engineer, NRR/DANU/UTB2
- Hanh Phan - Senior Reliability and Risk Analyst, NRR/DANU/UTB2
- Edward Robinson - Senior Emergency Preparedness Specialist, NSIR/DPR/RLB
- Kenneth Mott - Emergency Preparedness Specialist, NSIR/DPR/RLB
- Mallecia Sutton - Senior Project Manager, NRR/DANU/UAL1

Agenda

- Topical report (TR) purpose and review strategy
- Safety evaluation (SE) overview
  - Focus on updates since ACRS subcommittee meeting
- Conclusions

Revised Draft SE

Following discussions during the September 19, 2024, ACRS Subcommittee meeting, staff made changes to the draft SE

- Reflected TR revision 3 to clarify the treatment of uncertainties in non-seismic sequence screening, including cliff-edge effects
- Imposed a new limitation and condition related to the selection of the seismic release scenario
- Updated limitation and condition 2 regarding hazards
- Made editorial changes to provide further clarity to SE

TR Purpose and Review Strategy

- Purpose of TR
  - Provide methodology and criteria that will be used to establish the site-specific plume exposure pathway (PEP) Emergency Planning Zone (EPZ) size for the Natrium reactor
  - Risk-informed approach to determine EPZ size by meeting criteria in 10 CFR 50.33(g)(2)
- Review strategy
  - Review consistency with the technical basis for the alternative EP framework in 10 CFR 50.160 and conformance with guidance on PEP EPZ sizing (RG 1.242)
  - Assess acceptability of the risk-informed approach and interaction with overall Natrium licensing approach using the Licensing Modernization Project methodology

Note - 10 CFR 50.160 was issued November 16, 2023. TR Revision 1 made changes to address the proposed final rule and guidance.

TR EPZ Sizing Methodology Steps Overview

- Accident screening to identify spectrum of accidents
  - Compile release sequences from the probabilistic risk assessment (PRA) for all internal and external initiators
  - Perform screening of non-seismic release sequences based on frequency, including uncertainty
  - Perform screening of seismic release sequences with a unique set of selection criteria, including uncertainty
- Radiological consequence analysis
  - Collect meteorological data and incorporate into the radiological consequence analysis
  - Perform source term and radiological consequence analysis
  - Evaluate the radiological consequences against the PEP EPZ dose-related criteria to determine if changes are needed
- Determine PEP EPZ distance based on EPZ sizing criteria

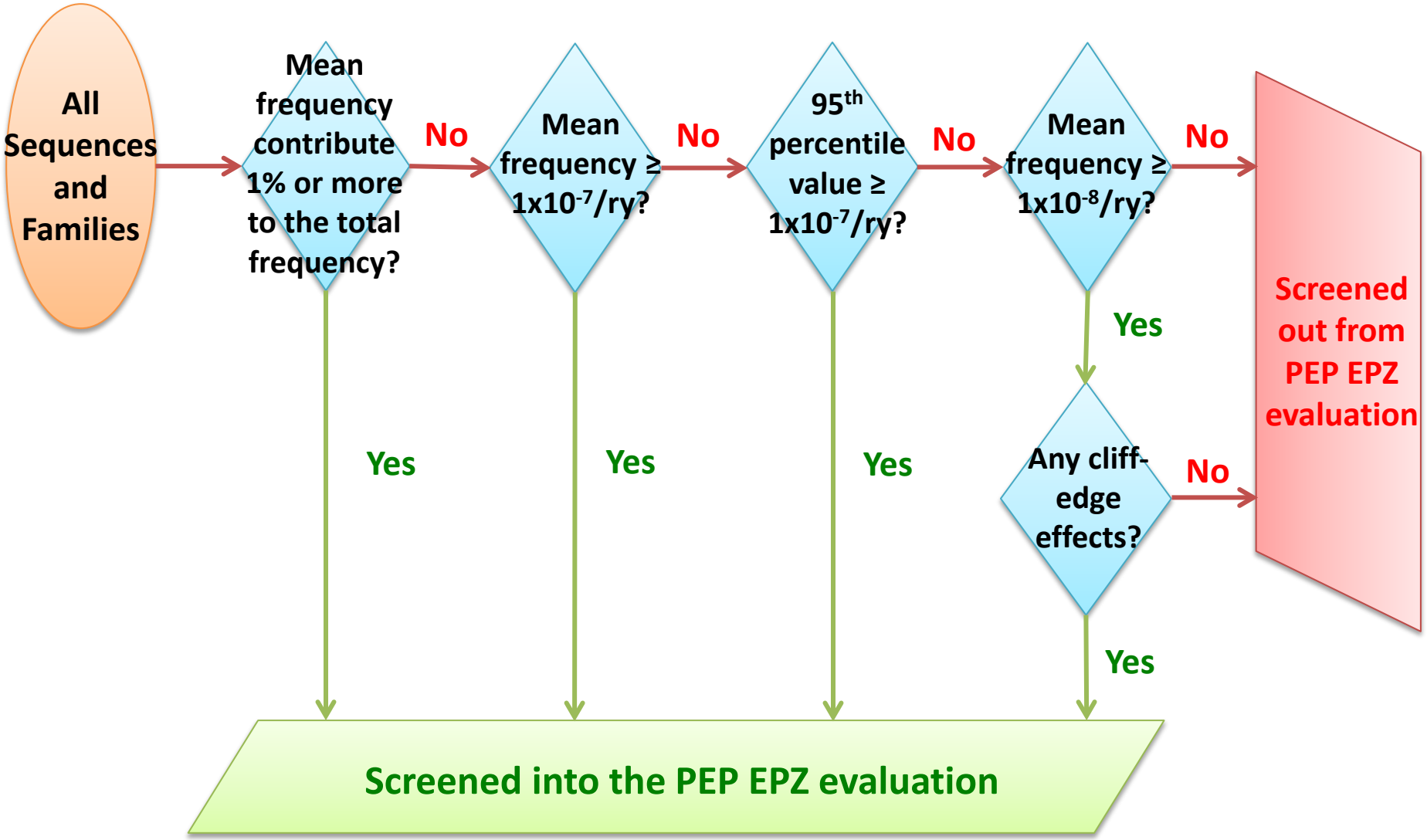
Development and Uses of PRA

- Design- and site-specific PRA will be used to identify release sequences
- The PRA will address internal and external hazards, all modes of operation, and all sources of radioactive material
  - *Updated Limitation and Condition 2: An applicant that references this TR must justify the technical acceptability of the PRAs performed for the selected hazards and modes (e.g., site-specific scoping level PRA). Prior to the initial fuel loading, PRAs supporting this methodology must include all applicable hazards and modes.*

Development and Uses of PRA

- The PRA will be developed in accordance with the guidance provided in the ASME/ANS non-light water reactor (NLWR) PRA standard
- The PRA will undergo a peer review
- Key assumptions and sources of uncertainty will be assessed to determine their impacts on the calculation
- A qualitative or quantitative assessment of security events will be conducted and documented in the size calculation

Selection of Non-Seismic Release Sequences



Selection of Seismic Release Sequences

- A limiting PGA will be used to establish seismic event(s) for use in the PEP EPZ calculation at the CP stage
- The limiting PGA will be two times the ground motion response spectrum (GMRS) or a maximum of 1.0 g
- A new Limitation and Condition was established related the use of 1.0 g PGA:
  - *New Limitation and Condition 5: An applicant that references this TR will provide site-specific justification for the use of the upper bound PGA of 1.0g when exercising the methodology in TR Section 3.7, "Selection of Seismic Release Sequences."*
- The site-specific scoping level seismic PRA (SPRA) will be performed to provide additional insights

Radiological Consequence Analysis to Support EPZ Sizing

- EPZ sizing analysis uses output of methodologies in related TRs under review*
  - Radiological Source Term Methodology
  - Radiological Release Consequences Methodology
- Source terms are developed as part of safety analysis and PRA - used as input to EPZ sizing analysis
  - NRC staff will review the development of source terms as part of its review of a related license application safety analysis report, including the implementation of the related source term TR

* Information on Natrium topical report reviews available at https://www.nrc.gov/reactors/new-reactors/advanced/who-were-working-with/licensing-activities/pre-application-activities/natrium.html

Dose Estimation

- TR methodology identifies that doses are first estimated at a proposed PEP EPZ distance and compared to the three dose-based criteria
  - The PEP EPZ will be established at the furthest distance at which all three criteria are met
- Iterative process to determine PEP EPZ
  - If the result at the proposed distance is unacceptable, change the PEP EPZ size or make design changes (during design phase)

Comparison to Dose-related Criteria for Most Radiological Release Sequences

Criterion A (DBAs) and Criterion B (mean release frequency > 1×10^{-6} per reactor year (/ry))

- Compare mean 96-hour dose for event to lower end of EPA Protective Action Guide (PAG)* range (1 rem TEDE)
- Compare 95th percentile 96-hour dose for event to upper end of EPA PAG range (5 rem TEDE)

*The EPA PAG levels to recommend evacuation or sheltering of the public during the early phase of a radiological incident are 1 to 5 rem (10 to 50 mSv) projected dose over four days (2017 EPA PAG Manual)

Comparison to Dose-related Criterion for Worst-case Radiological Release Sequences

Criterion C (mean release frequency 1×10^{-7}/ry to 1×10^{-6}/ry)

- Compare to dose metric of 200 rem red marrow acute effective dose for a 24-hour exposure period
- Generate dose-distance chart mapping the dose reduction as one moves away from the EPZ
  - Analysis to ensure that the dose drops rapidly beyond the PEP EPZ boundary

Probabilistic Dose Aggregation and Treatment of Uncertainty

- Criterion C considers scenarios with lower frequency than used to determine licensing basis events with LMP
- TR Section 6.3 describes the uncertainty and sensitivity analysis methodology
  - Monte Carlo sampling on PRA event frequencies
  - Source term and consequence analysis uncertainty results are included, as determined in the related methodology TRs
  - Cliff-edge effect evaluations
    - Events with frequencies between 1×10^{-7} /ry and 1×10^{-8} /ry
    - Primary focus on single failures that would dramatically change either risk metrics or the effects of the accident sequences (timing, plant response, source terms, or end states)

Necessity of Predetermined Prompt Protective Measures Criterion

- Radiological release timing used to identify necessity of prompt protective measures
  - Each event assessed individually to determine if timing supports necessity of prompt protective measures
  - Identified protective measures will inform emergency plan and procedures

Conclusions

The NRC staff determined that the TR, subject to the limitations and conditions, provides an approach acceptable to develop analyses to aid in the determination of a site- and design-specific PEP EPZ for the Natrium reactor.

Accordingly, the NRC staff concludes that the TR can be used in establishment of the PEP EPZ size to support emergency planning and preparedness in compliance with the regulatory requirements in 10 CFR 50.33(g) and 10 CFR 50.47(c)(2), as applicable, for prospective TerraPower Natrium reactor CP or operating license applications under 10 CFR Part 50.

Abbreviations

ANS	American Nuclear Society
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
CP	construction permit
DBA	design basis accident
EP	emergency preparedness
EPA	Environmental Protection Agency
EPZ	emergency planning zone
g	gravitational acceleration
GMRS	ground motion response spectrum
L&C	limitation and condition
NLWR	non-light water reactor
PAG	protective action guide
PEP	plume exposure pathway
PGA	peak ground acceleration
PRA	probabilistic risk assessment
RG	regulatory guide
ry	reactor year
SE	safety evaluation
SPRA	seismic probabilistic risk assessment
TEDE	total effective dose equivalent
TR	topical report