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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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FUELS, MATERIALS, AND STRUCTURES SUBCOMMITTEE

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OPEN SESSION

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TUESDAY

APRIL 2, 2024

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The Subcommittee met via hybrid Video Teleconference, at 1:00 p.m. EDT, Ron Ballinger, Chairman, presiding.

COMMITTEE MEMBERS:

RONALD G. BALLINGER, Chair

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THOMAS E. ROBERTS, Member

ACRS CONSULTANT:
DENNIS BLEY*

DESIGNATED FEDERAL OFFICIAL:
ZENA ABDULLAHI
LAWRENCE BURKHART

ALSO PRESENT:
PAUL CLIFFORD, Public Participant*
ZACHARY HARPER, WEC
KEVIN HELLER, NRR
JEFFREY KOBELAK, WEC*
SCOTT KREPEL, NRR
JAMES LAIRD, WEC
JOHN LEHNING, NRR
YUN LONG, WEC
SCOTT MOORE, ACRS*
BENJAMIN PARKS, NRR*
HAROLD SCOTT, Public Participant*
BRANDON WISE, NRR
*Participating remotely

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

1:00 p.m.

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

This is a meeting of the Fuels, Materials, and Structures Subcommittee of the Advisory Committee on Reactor Safeguards.

Today's meeting is a hybrid meeting -- in-person and virtual attendance.

I'm Ron Ballinger, Chairman of the Subcommittee meeting.

ACRS members are Walt Kirchner, Jose March-Leuba, Matt Sunseri, Tom Roberts, Dave Petti, Greg Halnon, Robert Martin, Vicki Bier, and maybe some others will show.

We have online -- and I'm going to mess this up -- I know we have Vesna Dimitrijevic, and I don't know if there are any others. Correct me if I'm wrong, please.

(No response.)

Nobody is correcting. So, I'm assuming I'm okay.

MS. ABDULLAHI: Brown, I think I see him. Yes, I do.

CHAIR BALLINGER: Oh, is Charlie on?

MS. ABDULLAHI: I think so.

CHAIR BALLINGER: Okay, I'll just assume he is.

MS. ABDULLAHI: Yes, he's been accepted.

CHAIR BALLINGER: He's been accepted, but not on.

And I was looking for Dennis. Is he on?

MS. ABDULLAHI: He should be.

MR. BLEY: He is.

CHAIR BALLINGER: Dennis is on. Okay.

MS. ABDULLAHI: Yes.

CHAIR BALLINGER: That should pretty much cover it.

During today's meeting, the Subcommittee will hear from NRC and Westinghouse staff on the review of the Westinghouse Licensing Topical Report WCAP-18446, Revision 0, "Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs."

Today's meeting is an open and closed session. The first part will be open, and then, we'll have a closed session, if need be, with the latter session intended to protect Westinghouse proprietary information.

And we also will have a presentation by

the NRC staff related to a non-concurrence associated with this review.

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When applicable, ACRS issues publicly available Letter Reports that provide the Commission independent technical reviews of NRC staff's Safety Evaluations of licensees' amendments to their operating licenses.

ACRS members will ask questions and at times make statements. However, these statements are individual member opinions and should not be construed as ACRS findings or opinions. ACRS opinions are documented only in our Letter Reports.

The ACRS section of the U.S. NRC public website provides our Charter, Bylaws, agendas, Letter Reports, and transcripts of all open session Subcommittee and full Committee meetings, which include the slides presented.

A transcript of this meeting is being kept, and the open session transcript will be made publicly available.

The meeting notice and the agenda for this meeting are posted.

We have not received written statements or requests to make an oral statement from the public or prior to this meeting, although there is a statement from the member of the public that will be read into the record as part of this meeting.

Today's meeting is hybrid with virtual participation over Microsoft Teams and in-house for ACRS staff, members, NRC staff, and the public. There is also a telephone bridge line and a Microsoft Teams link allowing participation of the public to join all open sessions.

Finally, when addressing the Subcommittee, the participants should, first, identify themselves and speak with sufficient clarity and volume, so that they may be heard and the transcribing folks will understand you.

When not speaking, we request that participants mute their computer microphone, or phone by pressing *6.

I'll now proceed with the meeting and start by calling on -- let's see, who do I need to call on? Scott Krepel.

MR. KREPEL: Hello. I'm Scott Krepel. I'm speaking through a sign language interpreter.

I am the Branch Chief for the Nuclear

Methods and Fuel Analysis Branch.

And obviously, today's material is an issue of great concern for many of you. This is the first time that we have had a discussion about specific licensing activities that relate to decisions going beyond our current license burnup.

There is a certain non-concurrence that we will be discussing, as you mentioned, during this presentation, and we invite your perspectives, your feedback, et cetera, as we go through.

That's really all I have to say in terms of opening. Thank you so much for engaging with us on this Topical Report.

CHAIR BALLINGER: Thank you.

Zach, do you want to say something?

MR. HARPER: Yes. First, I'd like to thank the ACRS Subcommittee for your time today, and I appreciate the review of the Topical Report.

Jeff Kobelak will be the presenter. He's not able to be with us physically today, but he will be the presenter, and I'll be moving through the slides.

Just appreciate your time and we look forward to a good open and engaging discussion.

So, with that, can I turn it over to Jeff to introduce yourself?

MR. KOBELAK: Okay. Thanks, Zach.

I guess, first, can you just confirm, are you able to hear me clearly?

MR. HARPER: Yes.

MR. KOBELAK: Perfect.

All right. Yes, thank you very much for giving us an opportunity to present today on this Topical Report. It's something that we think is very important to Westinghouse's plans, as I'll talk about in a few moments here, and it's something that we worked on for many years before submitting it, and the staff has put many years of their time on as well. So, we do think it's a very important topic that we're covering today.

I work for Westinghouse Electric Company in the Safety Analysis Group. I've been doing analyses and method development for about 21 years now. So, I'll be the primary presenter for the open session, and then, in the closed session, we're going to have a mix of several different people from Westinghouse presenting.

So, I don't know, should I begin with the presentation or are there any other opening remarks?

CHAIR BALLINGER: I think we're all set.

Why don't you start your presentation?

MR. KOBELAK: Okay. Perfect. Thank you very much.

Okay. So, I wanted to start off this presentation just by kind of speaking to how incremental burnup relates to Westinghouse's plans for developing advanced materials and methods, fuel products, et cetera.

So, Westinghouse I think is unique in that we decided to pursue burnup extension as a two-step process. The first step is what we're talking about today. It's the incremental burnup extension. And for the incremental burnup extension, we are allowing rods only in peripheral assemblies to go above the current license burnup limit.

So, if you look at the graphic in the upper left there, that's showing a quarter core for a 4-loop Westinghouse PWR. And all of those locations that are marked in green would be assemblies for which rods could go above the current license burnup limit.

And then, step two, which is a future and entirely separate licensing action, would be to increase the burnup limit for the entire core above 70 gigawatt-days per MTU, coincident with an enrichment increase that's really needed to operate those assemblies to high burnup more economically.

Next slide, please, Zach.

So, this is a roadmap, I'll call it a roadmap of the Westinghouse EnCore fuel, which is our name for accident-tolerant fuel, as well as the High Energy Fuel Program, which is what we refer to as higher enrichment and higher burnup.

And this shows the progression with time. So, if you look at the left side of this figure, the ADOPT fuel pellets and AXIOM cladding, those are materials that have already been reviewed and approved by the NRC. I believe that both of those were presented to the ACRS as those Topical Reports were under review.

Where we're at now, Topicals that are currently under review. So, incremental burnup is what we're discussing today, and then, the Higher Enrichment Topical Report was submitted last year, and I believe there's an audit upcoming for that Topical Report later this month. But that's in the early stages of review right now.

The EPRI alternate licensing strategy, I think that EPRI has presented on this once and is going to be presenting again in June. So, this is an approach to addressing FFRD for higher burnup fuel rods.

And Westinghouse has made a submittal already to the NRC that is intended to support EPRI ALS. And I believe what I'll call the full umbrella submittal from EPRI is expected to go in later on here in April. So, that will imminently be under review.

And then, looking out to the future, we have what I'll call near-term and long-term concepts. So, near term, we're working on chromium-coated cladding, which I think we expect to submit later this year. And the full-core high burnup extension, which is probably still a couple of years out before that's fully submitted, and then, we've also been looking long term at several advanced fuel materials, so uranium nitride pellets and silicon carbide cladding, but I think those are pretty well out into the future right now.

Okay. I wanted to touch on some of the benefits here in the open session. This is really the motivation for why we decided to do the two-step process.

So, the primary benefit, I think at least for the utilities, are these first two main bullets that are shown here. We can get slightly better fuel utilization. So, that saves utilities a little bit of money each operating cycle, and the higher region burnup allows some additional assemblies that would have just been discharged to be used for an additional cycle of operation.

And so, by reducing the number of feed assemblies, that provides some benefit to utilities. It also has a corresponding benefit relative to the back-end cost. So, every assembly that operates, obviously, has to be dealt with after operation is done, and if plants are loading fewer assemblies, then there's less waste being produced. So, there's less that needs to be put into the spent fuel pool, and then, into dry casks, and eventually, to wherever permanent storage will occur.

And I think we also viewed this as a benefit to Westinghouse, in that we do have a fair amount of high burnup data, but, of course, we're always looking for more. And this is a means of being able to operate a number of assemblies and rods to higher burnup, which allows us to continue building upon and developing a more robust database for higher burnup fuel.

And then, we're at a stage right now where we have a number of customers who are, essentially, waiting on this Topical Report. So, we do have commercial contracts for ADOPT fuel AXIOM cladding and incremental burnup, once it's approved.

Okay. Here, I wanted to talk a little bit about the applicability. So, this, essentially, outlines where this Topical Report can be applied. It will be valid for fuel rod burnups above 62-gigawatt-days per MTU. It's not an unlimited we can go to whatever burnup we want. We'll get into a little more detail there in the closed session.

It's limited to the current fuel rod enrichment. So, this does not allow for greater than 5 weight percent enrichment. As I mentioned before, it's limited only to fuel rods and core peripheral assemblies. So, basically, limiting it to lower-power, non-limiting assemblies.

It is applicable to all the currently manufactured Westinghouse and CE fuel designs, and I'll talk more about that in the closed session, as to how that came about.

In terms of cladding materials, it's applicable to our ZIRLO cladding, Optimized ZIRLO cladding, and AXIOM cladding, although I will say I think that there are very few plants that remain on ZIRLO cladding and we might be in a situation where the remaining customers are transitioning to Optimized

ZIRLO. So, practically speaking, we expect that the majority of application would be to those latter two materials.

And then, in the future, we would intend to apply this with chromium-coated cladding. That is outside of the scope of the current submittal.

And finally, in terms of fuel pellets, we would intend this to be applicable to both standard UO2 and ADOPT fuel pellets.

And the graphic here really just shows this is what I would term an umbrella Topical Report. So, rather than being a specific focus, like a fuel rod performance method or a LOCA analysis method, this is a Topical Report that covers the impact of this incremental burnup increase across all the different technical disciplines.

So, I wanted to take a couple of slides here to provide an overall of the content of the Topical Report. We did write this Topical Report with the objective of ensuring efficient implementation. And what I mean by that is we wanted to be very clear on which previously approved Topical Reports have limitations that are being exceeded; what are the limitations that are associated with implementing this Topical Report, and also, what are the licensee actions that are required whenever they go to implement this Topical Report?

And in that last piece, we don't cover 100 percent of every evaluation that needs to be done, but it is a nice roadmap of all the significant new analyses, re-analyses, and evaluations that are required for implementation.

So, this is something that we do really to try to ensure that, when the Topical Report is approved and a utility wants to implement, we ensure that we're doing it aligned with staff expectations of what would need to be done.

So, the remainder of the Topical Report, there's a lot of sections between one and seven. That is, basically, where we go through all the different technical disciplines to address the effect of the burnup extension. And the focus in each of those areas was impacts on codes, methods, and acceptance criteria.

So, the idea is that the Topical Report will cover how the analyses and evaluations need to be done, and then, the execution of them would occur as part of a plant-specific implementation.

So, just in terms of a high-level overview -- and we will get into a little bit more detail in some of these areas in the closed session -- this is kind of in order that they appear in the Topical Report.

So, Section 2 is mechanical design. This is where we talked about the design basis for the fuel assembly, all the different structural components and materials, and what the impact was associated with taking those assemblies up to a higher burnup level.

We, then, move from the assembly more to look at the fuel rods themselves. So, Section 3 is the core and fuel rod performance. That's where we cover fuel rod design and justify the application of PAD5 to this incremental burnup regime. So, PAD5 is our latest Westinghouse fuel rod performance code.

We talk about nuclear design. And the nuclear design section I think is important because that's really one of the primary factors that was driving incremental burnup.

However, in terms of the codes and methods, we had previously submitted PARAGON2 for review and approval, and also, our Alpha/PHOENIX/PARAGON codes were reviewed and approved through the burnup range of interest. So, there was not a large focus on the codes and methods in terms of nuclear design because we had already received approvals for those codes and methods separately.

And then, in the -- sorry, was there a question?

Okay. And then, in the thermal-hydraulic design, the focus was really on our DMB methods and the calculation of the DMB ratio and demonstrating that those remain applicable to these incremental burnup fuel rods, as well as addressing rod bow. So, with higher burnup, there can be more penalizing effect of rod bow. And our approach was to demonstrate that these incremental burnup fuel rods are non-limiting since they reside on the core periphery and operate at low power.

MEMBER HALNON: This is Greg Halnon.

Is there any downside to putting them on the periphery? I mean, you have other failure mechanisms of fuel rods, such as debris capture and vibrations, and other things happening. Is there any downside to putting these things on the periphery?

MR. KOBELAK: So, we don't think so. The actual residence time of the fuel assemblies is not going to be any higher than what we currently have. So, right now, in core designs that we frequently utilize, a number of assemblies will operate a third cycle out on the core periphery. And this method will not increase the burnup limit enough to be able to allow a fourth cycle. So, it just allows more assemblies to operate a third cycle. So, a lot of those failure mechanisms I think are more associated with residence time, and that is not going to change.

MEMBER HALNON: Okay. Thank you.

MR. KOBELAK: You're welcome.

Okay. Next slide, please, Zach.

Okay. So, then, starting with Section 4, 5, and 6, this is where we get more into the safety and radiological analysis sections.

So, Section 4 covers LOCA analysis, and it was focused on the updates required to our codes and methods. They analyze higher burnup fuel rods. And we'll touch on some of the biggest changes in more detail in the closed session.

And then, of course, the other big factor here was addressing the potential for fuel dispersal from the fuel rods and the incremental burnup regime. So, that was one of the primary objectives that we were trying to tackle with this Topical Report specific to this incremental burnup fuel rods.

Section 5 covers the transient and containment analyses. And the biggest action there was really just to assess and update the decay heat modeling to ensure that our decay heat models remain appropriately conservative for those analyses.

And also, with the issuance of Reg Guide 1.236, there was some new phenomena and acceptance criteria that were identified in reactivity insertion accidents. So, we had to account for those findings within our method for incremental burnup.

And then, finally, in the radiological consequence analysis section, which is Section 6 of the Topical Report, that discusses how we account for these higher burnup fuel rods when we're doing dose analyses.

Okay. So, I did want to touch on fuel fragmentation, relocation, and dispersal because this is, obviously, one of the biggest new phenomena that has been identified and needs to be addressed as we move into high burnup.

And I guess I should maybe say at least the dispersal piece is something new. The fragmentation and relocation is something that we do account for to some extent within existing methods. So, the dispersal is the most significant piece that was new to us.

So, there is a good body of research that has been ongoing over the last decade. It certainly will not stop. As I said, this is just our first kind of incremental step into high burnup. The larger step is that step two that we've actively working on. So, that research and development is certainly going to continue and there will be more updates past this Topical Report.

But there were some safety assessments that were completed specific to LOCA and non-LOCA accidents and transients back in the 2015=2016 timeframe. And a lot of those assessments hinged on the current burnup limit, as well as a number of other factors, precluding any significant amount of dispersal.

And so, that is something that is still in place today and is being relied upon here. We are more focused on the fuel rods that are in this incremental burnup regime, and we will talk about that more throughout the closed presentation.

There was a RIL issued by the NRC, Research Information Letter 2021-13, that provided a conservative interpretation of the much of the FFRD data that was available at the time, or at least as much as was available in the public domain.

And through the RAI process and within the Topical Report, we do speak to a number of the findings within that RIL. And the idea, as you'll see at the end of the later presentations, is that we fully address the potential for dispersal across all accidents and transients as part of the incremental burnup Topical Report.

Okay. And then, I wanted to kind of wrap up here just with a picture of how we got to where we are today. So, this was a Topical Report that Westinghouse submitted for review back in December of 2020, and it was accepted by the NRC in March 2021.

There was also, I guess -- not shown on this slide -- a supplemental voluntary submittal that Westinghouse made shortly after that which provides some additional information to the staff.

The staff provided their first round of RAIs near the end of 2021, and it took us about six months to provide those responses. So, we responded in three different sets of responses, kind of the ones that we could answer the fastest to the ones that took the most time to answer.

There were some remaining questions that the staff had after we submitted those responses. So, there was a second round of RAIs issued in September of 2022. And again, it took approximately six months to provide those responses back to the staff. They were provided in February of 2023.

We received the Draft SER in March of 2024, and that has led us to the ACRS Subcommittee meeting today, and then, tentatively, a Final SER in June of 2024.

So, that covers everything that I wanted to touch on here in the open session. And if there's any other questions, I'd be glad to take them.

CHAIR BALLINGER: Questions from the members or our consultant?

Hearing none, thank you for your presentation.

Is the NRC ready to go? This is the staff. John, you're going to give both presentations?

Who's up?

MR. HELLER: I believe I am up to start this.

CHAIR BALLINGER: Oh, the slides are coming up.

MR. HELLER: Oh, sorry.

CHAIR BALLINGER: Can we make the screen bigger? Whatever people do to that. Of course, I'm fine with it. Oh, here we go. Oh, that's better. All right.

Thank you.

MR. HELLER: So, my name is Kevin Heller. I am with the Nuclear Methods and Fuel Analysis Branch, one of the lead reviewers on this. My associates here with me, this is John Lehning and this is Brandon Wise.

Thank you for the opportunity to come before you and present about our review of the incremental burnup extension provided by Westinghouse.

Next slide, please.

Okay. So, this is just a brief presentation outline kind of just showing the breakdown, just more so for future reference.

Next slide, please.

Okay. So, going into this, I want to provide some background regarding the nature of this methodology and just to serve as a starting point for our discussion.

So, as Westinghouse already alluded to, the WCAP-18446 methodology, it contains a comprehensive evaluation of the capabilities of Westinghouse's analysis methods in order to address fuel in the incremental burnup range.

So, from the staff's perspective, this is, effectively, an umbrella Topical Report that serves two purposes. First, justify extending the approved limits of applicability for a host of Westinghouse's existing codes and methods, and then, also, to define a methodology by which those codes and methods can be applied to analyze core designs within the incremental burnup range. And a key point to this methodology, again, as Westinghouse alluded to, it intends to demonstrate no dispersal for fuel in the incremental burnup range.

Next slide, please.

Okay. So, review timeline. I'll just go over some of the high points here.

So, the initial submittal was in December of 2020. The acceptance review was completed in March of 2021. So, while the staff's initial acceptance review there was sufficient information presented within that submittal to begin a detailed review, the acceptance review identified a set of topics for supplementary information was necessary to support a timely review.

And so, the staff did engage with Westinghouse in an audit, an audit for understanding, and that, ultimately, resulted in the voluntary supplement of May 2021.

Staff ended up issuing one primary round of RAIs and a second followup set later in the review that was focused on clarification and expansion of the information provided within the first round responses. And as Westinghouse also indicated, their RAI responses were provided within several stages.

And then, in May of 2023, Westinghouse provided a voluntary supplement to the Topical Report, providing justification to expand its scope to include AXIOM cladding.

Also, after the completion of the initial Draft SE, non-concurring staff generated a non-concurrence and filed it in December of 2023. So, there is a non-concurrence associated with this review, but that's a topic that will be covered in a separate presentation later.

Next slide, please.

This is a list of the key regulatory requirements and guidance that the staff used during the course of the review. I don't plan to spend too much time here. We've seen a lot of this before. But I'll just briefly point a few out.

So, for fuel and core performance, GDC-10, for the specified acceptable fuel design limits; NUREG-800; the Standard Review Plan, Chapter 4.2, regarding precluding fuel system damage and maintaining core coolability.

Next slide.

For the loss-of-coolant accidents, 10 CFR 50.46, Appendix K, and the guidance in Chapter 15.6.5 of the SRP; Chapter 15.0.2 of the SRP as well, and Reg Guide 1.203 for the transient accident analysis methods.

Next slide, please.

Similarly, for the non-loss-of-coolant accidents and transients, again, the Standard Review Plan, Chapter 15, and Regulatory Guide 1.203.

And then, for the control rod ejection reactivity insertion accident, Regulatory Guide 1.236.

For containment, GDC-50; for radiological dose, Regulatory Guide 1.183.

And with that, I think I'll turn it over to Brandon.

MR. WISE: So, I'll be discussing the fuel assembly mechanical design section, which primarily included three proposals -- those being a set of design criteria to evaluate fuel assemblies up to the higher burnup limit; a method of evaluating against those criteria, and then, the results in a demonstration of the evaluation for a specific design.

The NRC staff determined that the proposed set of design criteria and methods of evaluation were acceptable and don't present any substantial increase in risk of decremation or damage to the fuel assembly structure.

The specific design evaluation was for the 17x17 OFA design. With approval of that, it received generic approval for an incremental burnup extension without any additional review. Other designs can receive the same approval on a generic or plant-specific basis, per LNC1.

Next slide, please.

And I think I'll hand it back to Kevin.

MR. HELLER: All right. Thanks, Brandon.

So, this, again, being an umbrella Topical Report, there's a whole lot of discussion and justification provided for the host of Westinghouse codes and methods.

And so, for the core and fuel rod performance sections, the Topical Report presents it across these three areas: fuel rod performance, nuclear design, and core thermal-hydraulic design.

So, the NRC staff ended up assessing each of these areas in turn during the course of the review, but here in the open session I'm really only going to touch on the first of these, the fuel rod performance, briefly. I'll go into that one in more detail in the closed.

Next slide, please.

So again, just briefly touching on the fuel rod performance, the phenomenological models for the fuel rod performance are contained within the PAD5 fuel performance code, and per Limitation and Condition 7 within the SE, incremental burnup analyses. We will be using this code.

Westinghouse provided justification for the applicability of models that are associated with each of the fuel rod design bases for use in incremental burnups. We've got the list of design bases here. So, the staff ended up going down through and assessing all the models associated with those, and ultimately, ended up finding them acceptable.

Now, the staff concluded that some of the models associated with the fuel rod design bases are applicable to the incremental burnup range only within the scope of the WCAP-18446 methodology. And that's what resulted in Limitation and Condition 4 and, in part, Limitation and Condition 10. The details of those particular models, again, I'll talk about in the closed session.

So, for the nuclear design, Westinghouse proposed to continue using their existing nuclear design codes, which consist of PARAGON or PHOENIX-P. Those are their lattice transport calculation codes. ANC for their two- and three-dimensional nodal calculations. And Westinghouse indicated that these codes are applicable to the increased burnup conditions within the existing enrichment limit.

So, when the NRC staff went through and started assessing these codes, there were two larger areas that they focused on, because there was a consideration that these are likely to be stressed by application of these methods within the incremental burnup range. And that would be the production and depletion of major uranium and plutonium isotopes. That would be the first area. Westinghouse ended up supplying additional validation data via RAI responses, demonstrating those codes' continued applicability in the incremental burnup range.

And the second area that the staff looked at was modeling increased critical boron concentration. And Westinghouse indicated via their RAI responses that there would be no significant changes to this; that their codes have sufficient capabilities to analyze within the expected ranges in the incremental burnup. And after taking into consideration Westinghouse responses, the staff, ultimately, concluded that the codes were performing well there as well.

And then, lastly, the staff did, also, take a look at, an overall assessment of the neutronic codes, facilitated by code-by-code comparisons. You know, sort of a spot-check; let's make sure everything is working.

So, with that, the NRC staff found/finds that Westinghouse nuclear design codes, as I mentioned before, are applicable to core nuclear designs within the scope of the incremental burnup methodology.

So, for the thermal-hydraulic design, Westinghouse proposed no modification were necessary to the existing methods for analyzing departure from nucleate boiling. And I've got a list there of, in particular, the codes and methods. So, their DNBR correlations, their subchannel codes, their revised thermal design procedure.

The NRC staff ended up assessing Westinghouse's justification in each of these areas and concluded that the codes and methods are applicable up to the requested rod average burnup, the incremental burnup.

Furthermore, Westinghouse also indicated they would perform plant-specific analyses to confirm that both departure from nucleate boiling and its propagation are prevented.

MR. LEHNING: Okay. Thank you, Kevin.

And the next slide will be on the loss-of-coolant accident, or LOCA.

And this is John Lehning from the staff that's speaking now.

We just have an introductory slide in this open session. We'll have about a dozen or so slides in the closed presentation and go through in a bit more detail. There also will be some discussion of a non-concurrence and its disposition on this topic to come.

So, just in brief, the objective of the WCAP-18446 methodology was to demonstrate no cladding rupture for fuel rods in the incremental burnup range. And obviously, if that cladding doesn't rupture, whether the fuel fragments or relocates, at least we know it's not exiting the cladding where it started out.

The model that Westinghouse uses to do these calculations is based on the full-spectrum LOCA methodology that was approved by the staff. I think about eight, or ten or so, years ago, the reviews were underway for that.

The codes that are used, the code that is used for that methodology, WCOBRA/TRAC-TF2. And in assessing the applicability of the evaluation model for this application, Westinghouse did evaluate against several PIRTs to look at whether some modeling changes were needed to go to a higher burnup, and that's described in our Safety Evaluation. In Table 1, we step through those models.

There were a couple of updates that Westinghouse implemented as a result of its evaluations, including fuel rod cladding and rupture modeling in decay heat. And we can go through some more of those details in the closed session. And so, we'll just leave it at the introductory level for now and sort of explain a little bit more of the basis for acceptability in the closed session.

So, I'll turn it back over to Kevin.

MR. HELLER: All right. Thanks, John.

So, when it comes to non-loss-of-coolant accidents, transients and accidents, these analysis methods, Westinghouse separated these into two categories of events: those events that are dependent solely upon core average effects and those events that are dependent upon local effects in the fuel rods.

So, for events dependent upon the core

average effects, Westinghouse indicated that these events are analyzed to address core-wide or systemwide criteria, and that the existing codes and methods can readily accommodate any potential impacts the incremental burnup may have. Therefore, the evaluation models remain applicable.

So, the NRC staff went and assessed the potential impacts of the incremental burnup against relevant parameters for these analyses and concluded that, I guess I'll call it the assertion that Westinghouse made, that that is reasonable; that these codes remain applicable.

For the second category events, those that are dependent on the local fuel rod behavior, these methodologies are for events that predict, for example, fuel enthalpy, departure from nucleate boiling ratio, fuel temperature, et cetera.

And so, the NRC -- or excuse me, I'm getting ahead of myself.

Westinghouse did not propose any changes to the acceptance criteria for these events or any changes to the parameters.

So, the NRC staff also went through and looked at those particular codes in light of the justifications provided and concluded that, for these events, the particular codes have been either individually approved already on a generic basis up to the incremental burnup range or they were approved within the scope of the incremental burnup Topical Report. So, for example, PAD5.

And I think that's all I have on that slide. So, next slide, please. We are already there. All right.

So, for the reactivity insertion accidents, Westinghouse discussed its conformance with the fuel cladding failure thresholds in Regulatory Guide 1.236. With regard to that, in particular, the peak radial average fuel enthalpy, the departure from nucleate boiling, heliclad and mechanical interaction, fuel pellet, incipient melting.

Westinghouse proposes to apply its multidimensional kinetics methodology to this event. And so, the NRC staff assessed the discussions provided for conformance with cladding failure thresholds, and also, examined the code applicability. Ultimately, the staff determined that Westinghouse's evaluation of the control rod ejection analyses is acceptable, in part, because of the discussions provided, and then, also, because the codes used to analyze control rod ejection have been shown to maintain adequate predictive capability within the incremental burnup range.

Next slide.

So, Westinghouse also provided some discussion justifying the continued use of their containment integrity analysis methods, and they provided these for both LOCA and main steam line break scenarios.

Because Westinghouse's justifications and the staff's conclusions are largely the same for both of these, I'm going to be speaking to them side-by-side.

So, when it comes to short-term mass and energy releases, again, both LOCA and steam line break, these, typically, involve a duration of 1 to 10 seconds. The results are generally dictated by mass flux at the piping break, and they're really dominated by, more or less, those instantaneous system conditions, not fuel conditions.

So, the NRC conclusion was that changes in core design to allow for changes in cycle length to reach this -- so, is there a question?

So, the NRC conclusion was that, for changes in core design to achieve these incremental burnups, any changes that would result would not impact these analyses. A mass and energy release would be consistent across core designs.

For the long-term releases, the NRC staff concluded that the computer codes and methods approved for these analyses would also remain applicable because of the conservative treatment of decay heat modeling, and any impacts from the burnup increase could be readily accommodated by these codes.

One point to make, though, is the staff did find that the manner in which the decay heat models were implemented in certain instances in these codes necessitated the introduction of limitations and conditions. So, that's what 13 and 14 are about.

MEMBER MARTIN: I apologize. This is Member Martin. I want to back up to the previous slide just for a clarification, really, on the RAI.

The statement "no fuel dispersal permitted in fuel rods in the incremental burnup range," that is like a limitation/condition. And does that stem from like the Westinghouse analysis of where it's located? What would be some of the underlying details behind that statement? I'm just looking for a clarification on what is meant there.

MR. LEHNING: I can speak to that. This is John Lehning.

And so, we believe from the staff side that this was proposed by Westinghouse. And so, it probably would be better if they want to speak to this, especially in open session.

So, I don't know, Jeff, if you are on and want to say something to why, what the motivation was behind that?

MR. KOBELAK: Yes. I mean, in terms of the motivation, we felt that one of the key tenets of incremental burnup would be to demonstrate that there was not the propensity for fuel dispersal from rods in this incremental burnup regime from any accident or transient from a requirements perspective. And so, a lot of the work we did in the limitations in the Topical are designed to do that.

As far as how we specifically achieved it, if it's okay, I would probably prefer to defer to the closed session.

MEMBER MARTIN: Okay. So, from the staff's position, evidence is there that you're satisfied with in their Topical to support that statement, ultimately? Okay. And I'm getting a nod.

MR. HELLER: Yes. This is Kevin with the staff. Yes.

MEMBER HALNON: On this slide -- this is

Greg -- on this slide 17 that you had up there, yes, you mentioned that they found that the codes were okay because of the conservative modeling of the decay heat. I don't want to put words in your mouth, but it sounds like you're saying that they may be wrong, but they're not so wrong that they're going to exceed the conservative margins of the modeling of decay heat. Is that not the right way of looking at this? Are you saying that they're right enough or they're wrong, or they're just a little wrong?

MR. HELLER: I'm going to try to choose my words carefully because I don't want to trip over into proprietary, potentially proprietary material.

MEMBER HALNON: Okay.

MR. HELLER: The decay heat models, overall, are conservative in their application. We recognize that. There are some nuances to -- I'm trying to figure out how to articulate that.

MEMBER HALNON: Well, you just said that the margin in the conservative modeling of decay heat, those models are conservative to pick up the uncertainties. Is that fair to say?

MR. HELLER: That would be reasonable.

MEMBER HALNON: Okay. So, it's not that they're wrong or right? It's just that the uncertainties were picked up by the conservatisms of the decay heat models?

MR. LEHNING: I think that's probably fair to say, and I didn't want to say that they're wrong because I think that I would use intentionally conservative or knowingly conservative. And so, "wrong" would more to me, it wasn't intended to be that way or there's some kind of mistake in that. But I would say that they were intentionally conservative.

MEMBER HALNON: I'm just trying to -- you said that the codes would be made applicable, which tells me that they're either right or they're less wrong.

MR. LEHNING: And if Westinghouse wants to speak to that?

But the way I would say it is that the amount of intentional conservatism that was originally incorporated was enough to continue to cover the small, maybe relatively effective incremental burnup, is sort of the way I might state it.

MEMBER HALNON: They continue to work together adequately?

MEMBER MARCH-LEUBA: This is Jose.

We are already into proprietary, which I guess we'll discuss in an hour.

Would you say that the decay heat, that this is a known in high burnup, and we can calculate it? They calculated it. It's not that it's an unknown. They just chose a conservative approach --

MEMBER HALNON: Okay.

MEMBER MARCH-LEUBA: -- which they rely on.

MEMBER HALNON: Okay. I just wanted to make sure that everything stacks up.

MR. LEHNING: Yes, we will have that discussion.

MEMBER HALNON: Thank you.

MR. LEHNING: Okay. And so, with no other questions, let me move on to give a few slides in the open session about radiological consequence analysis.

So again, this is John Lehning from the staff speaking.

Westinghouse addressed consequences of three different types of accidents, including LOCA, non-LOCA accidents, of which we've exemplified four of these, and a fuel-handling accident as well. We'll give you some general descriptions now and come back with more details in the closed session.

So, for the loss-of-coolant accident, the radiological consequence analyses are typically performed by licensees, per Regulatory Guide 1.183 or 1.195, depending on whether the alternative or traditional source term would be used.

And Westinghouse concluded that the guidance and codes and methods -- or the codes and methods that it uses to conform to that guidance remain applicable for the fuel and incremental burnup range. And we'll explain that a little bit more in the closed session, why they concluded that.

For non-LOCA, it's a similar story, that there was a conclusion that the methods remain applicable.

And Kevin just spoke to a little bit about what types of evaluations they've done for thermal-hydraulics, and so forth, for the fuel, as well as the technical specification activity limits for certain types of events where a coolant leakage and the activity of that coolant might be one of the factors that plays into the radiological dose. That doesn't change as a result of this, just this Topical Report.

For the fuel-handling accident, the impact of fuel dispersal for non-LOCA accidents is not generically addressed in existing regulatory guidance. And so, there is a little bit more of a need here to consider some customized, I guess, or unique methods, as opposed to the generic methods that don't fully cover maybe the situation as well.

So, at a high level, some of the factors that Westinghouse considered in evaluating this event would be the behavior of key short- and long-lived radionuclides, the power history for the fuel in the incremental burnup range, and assumptions about that. And as well, they had to contend with the expected extent of fragmentation and dispersal. So, all of those things are proprietary details which we'll cover later.

But, in the end, licensees would explicitly address this fuel-handling accident consequences in their license amendment requests to implement this Topical Report method, and the staff would review those analyses at that time.

So, unless there are questions about that, I'll turn it back over to Brandon.

MR. WISE: This is Brandon with the NRC staff.

The ADOPT Fuel Pellet Topical Report was approved in 2022 for existing burnup limits. That's within 62-gigawatt-days per MTU. This was included in the original submittal, in the scope of the original submittal of the incremental burnup extension.

Therefore, the entirety of the review considered the inclusion of ADOPT fuel pellets.

The staff reviewed the unique characteristics of the ADOPT fuel pellets and found that they perform acceptably similar to standard UO2 pellets, such that there is no adverse effect on the predictive capability in modeling ADOPT pellets.

So, the staff found that the inclusion of ADOPT pellets within the incremental burnup extension Topical Report was acceptable, and that the conclusions in the Topical Report and SE, throughout the SE, also were applicable to ADOPT pellets.

Next slide, please.

The AXIOM cladding Topical Report was approved in 2023, and in May of the same year, Westinghouse submitted a supplement, to include AXIOM cladding in the scope of the incremental burnup extension.

The staff determined that the existing cladding performance models for AXIOM cladding contained adequate data up to the requested burnup limit, such that the staff could come to a safety determination. Furthermore, AXIOM-clad rods are subject to the same incremental burnup -- or to the same incremental burnup extension burnup limit and the same placement restrictions, and the no-burst criterion, as other cladding designs. They're not given any special treatment.

And the NRC staff also determined that the incremental burnup extension methodology is applicable to AXIOM cladding and that the AXIOM cladding specific models are acceptable at the high burnup limit.

And I think this is John or Kevin.

MR. LEHNING: Okay. I'll speak to this slide. John Lehning.

So, as far as just a couple of the limitations and conditions here that were related to materials applicability that are able to be spoken about in the open session here, Limitation and Condition 2 in the staff's Safety Evaluation identifies that the methodology only applies to fuel products with uranium dioxide or ADOPT fuel pellets or the -- I'm sorry -- and the fuel cladding type ZIRLO, Optimized ZIRLO, or AXIOM, as we have discussed here.

And for Limitation and Condition 3, the methodology applies to unpoisoned fuel, fuel with integral fuel burnup absorbers, or fuel with gadolinia only. But this does not preclude the use of discrete fuel burnup absorbers. And I think both of these were, basically, proposed by Westinghouse, basically, these limitations, because this is the subset of materials that they intend to apply the method to.

MEMBER PETTI: So, the term "unpoisoned fuel" is there's no poison in the fuel itself?

MR. LEHNING: Correct.

MEMBER PETTI: Because, as you read it, it sounds like it excludes the next two.

MR. LEHNING: Okay. So, it's meant to be all-inclusive of all three of those.

MEMBER PETTI: Right.

MR. LEHNING: I'm so sorry if I related that --

MEMBER PETTI: Okay. No, no, I got you.

CHAIR BALLINGER: Well, what would be a poisoned fuel?

MR. LEHNING: The poisoned fuel, like with gadolinia.

CHAIR BALLINGER: But this says fuel, that you can use gadolinia.

MR. LEHNING: Right, it does say that. I'm sorry.

CHAIR BALLINGER: I'm wondering. It's just the English is --

MEMBER MARCH-LEUBA: The presentation is a little confusing.

Can you give me an example of anything that is not covered? What type of fuel --

MR. LEHNING: I think this might have to do more with future, for example, ATF kinds of concepts or other things. So, I'm not sure it necessarily excludes a lot of the existing fuels that are out there for Westinghouse. I don't think they would want to do that. And so, I think they covered existing fuels, but there may be some advanced designs that they might not have to add and they didn't want to get a lot of questions about the supply. Maybe when they're ready, at that point they might apply or expand it to cover those types of things, if they need to. Okay?

MR. KOBELAK: Hey, John, this is Jeff. I apologize. If you don't mind me jumping in for one second?

MR. LEHNING: Please.

MR. KOBELAK: I think you characterized it accurately, and the only other maybe example would be Urbia. That's a burnable absorber that we've used in the past that would be excluded here because we just didn't look at it as part of the incremental burnup extension.

MR. LEHNING: I appreciate that.

And on to slide 25, Kevin.

MR. HELLER: All right. So, this is Kevin again with the staff. Thanks, John.

So, for limitations and conditions, the NRC staff's Draft Safety Evaluation contains 14 limitations and conditions that licensees adopting the methodology need to address. Incorporated within that list are nine limitations and conditions that were actually initially proposed by Westinghouse.

One or two of them modified -- well, actually, several I see listed here, yes, were modified by the NRC staff during the course of the review. So, the essence of their origin would be Westinghouse imposed in nature, but modified during the course by the staff.

The eight limitations and conditions that have been noted in the foregoing presentation, we've alluded to those. Some aspects we haven't been able to speak to because of the proprietary nature of them. And so, we will touch on those aspects in the closed portion, and then, also, the remaining six limitations and conditions that we haven't really discussed will also be discussed in the closed.

MEMBER MARCH-LEUBA: From the presentation point of view, when I hear you say it has 14 limitations, I say, well, the methodology must be bad. But, in reality, the first nine are just you are agreeing with the methodology. I mean, we should start considering agreeing with the methodology is not a limitation, and it sounds much better to have only six, not 14, but from the bounding perspective.

CHAIR BALLINGER: I look at these kinds of limitations and conditions as, basically, administrative rules, something.

MEMBER KIRCHNER: These are they are limiting it to their product. I can agree with Jose's comment, though, in general. Yes, it makes it sound like there's a lot more issue at play than really is, in fact, the case. You're just saying, okay, Westinghouse is only proposing it for these different cladding types, this fuel type, et cetera. And you're agreeing with them, but, as Jose indicates, it sounds --

MR. LEHNING: Yes, I mean, I think at some points in the past vendors had been encouraged to maybe try to identify certain things that could be limitations and conditions to get out in front of what the staff might impose. So, that might be what's behind it.

I agree with the critique that's being

made there. I would just point out, beyond that, that on a few of those nine that they proposed, we did modify a couple of those just a little bit. But, yes, I think the general sense of the comments being made there are exactly correct.

MR. HELLER: All right. So, conclusions then.

So, the staff found that the incremental burnup methodology presented in WCAP-18446 provides an acceptable approach for comprehensively evaluating fuel operation within the requested incremental burnup, the extended burnup range.

It was addressing fuel assembly mechanical design, core and fuel rod performance, non-LOCA and LOCA safety analyses, and the radiological consequences.

The staff's conclusions are predicated upon the methodology being used within its approved range of applicability and licensees acceptably addressing limitations and conditions within Section 4 of the staff's Safety Evaluation.

And with that, I think we're done. If there are any questions?

MEMBER MARTIN: I guess, for the sake of the public record, a simple question -- maybe.

Obviously, Westinghouse has leveraged a lot of the work they've done in the past in all these areas. You know, the elephant in the room is FFRD -- emphasis on the "D".

With the submittal, did Westinghouse provide analyses unique to these sort of methodologies that you would not have necessarily seen before to specifically address dispersal, maybe even define their own acceptance criteria, or what have you -- something that sets it apart from things you've seen before and have approved before?

MR. LEHNING: I think just in the open session what we might say is that they attempted to address that dispersal issue by, I would say, the easy way, and on the slide here we point to preventing cladding rupture. And so, that's something that's pretty well understood. As you alluded to, there are maybe some differences, as we note on this slide, where they attempted to account for the potential for increased burnup to affect that. But that's more of this evolutionary change to existing models and not trying to, or having to, needing to address some of the more novel aspects of what happens outside of the --

MEMBER MARTIN: A lot of that to prevent

cladding rupture. That's been their focus --

MR. LEHNING: Correct.

MEMBER MARTIN: -- and their lead argument.

MR. LEHNING: Correct.

CHAIR BALLINGER: Okay. Other questions from the members?

Okay. Now, we had originally scheduled that the non-concurrence discussion would occur now. That was because we got the slides for this late, actually, yesterday or the day before, evening, or something like that. And they were non-proprietary. So, we said, okay, let's just do the non-proprietary part all first.

But my question to the staff and to Westinghouse is, based on what we've heard so far, should we hear the proprietary session first before the non-concurrence presentation because we think that knowledge from those presentations would be appropriate for the discussion of the non-concurrence? And I don't know the answer to that. So, I'm asking the staff and Westinghouse whether or not the schedule, as written, just do the non-concurrence discussion. It should be done now? Or would it be more profitable to wait until after the closed session?

MR. LEHNING: From the staff side, I think it might be beneficial to get the benefit of the closed presentations first, if the Subcommittee agrees to that.

CHAIR BALLINGER: Well, since you're the authors of the darn thing -- (laughter) -- at least two of you are --

MEMBER MARCH-LEUBA: To the extent that we will have set a time for the public to rejoin us --

CHAIR BALLINGER: Right. And we have to decide a few things first. Okay.

If we've decided that it's best to have the non-concurrence presentation after the closed session, then, now we have to arrange this. And that means that -- I don't know; Larry can correct me -- we need now to have two public comments because the non-concurrence presentation will be afterwards. Is that correct?

MR. BURKHART: Oh, I think if anybody wants to make a -- you can call for public comment now.

CHAIR BALLINGER: We're going to do it now then, but --

MR. BURKHART: But, yes, and then, we

should set a time, as Jose says, when we can come back to the public session. And then, if the public wants to make comments after that, we can do that, too.

CHAIR BALLINGER: And then, the next question is, when do we want to do the read-in?

MR. BURKHART: The read-in of what?

CHAIR BALLINGER: Harold Scott's --

MR. BURKHART: We can do that, we can do that at this one.

CHAIR BALLINGER: We can do that now?

MR. BURKHART: Yes.

CHAIR BALLINGER: Okay. There is a member of the public that would like us -- that sent us a copy, that would like that to be read into the record. And Zena will do that reading now.

Are you ready, Zena?

MR. BURKHART: Zena, we can't hear you. This is Larry Burkhart.

CHAIR BALLINGER: Well, life intervenes, I guess.

MR. BURKHART: Well, I did notice that Mr. Scott -- this is Larry Burkhart -- Mr. Scott I believe is on, in case he would want to provide a comment.

MR. SCOTT: I could try to read part of it. Can you hear me? Can you hear me?

MR. BURKHART: Yes, sir. Please go ahead.

MR. SCOTT: Okay. It will take me a minute to get ready. Can anybody else speak or do something else right now? And then, I'll be ready to talk.

Can you hear me okay?

MR. BURKHART: We can hear you, yes.

CHAIR BALLINGER: Why don't we go out, first, while he's getting ready or until we find Zena, to other public comments?

Are there members of the public now that would like to make a comment? If there are, please state your name and make your comment.

Okay. We haven't heard any public comments.

Zena, are you on the line?

Harold, are you ready?

MR. SCOTT: Sorry.

MS. ABDULLAHI: Okay. Can you hear me now?

CHAIR BALLINGER: Oh, there's Zena. Okay.

MS. ABDULLAHI: Yes, I am here.

CHAIR BALLINGER: Okay. All right, Zena, why don't you read in Harold's comment?

MS. ABDULLAHI: Okay. Give me a second to locate it.

Excuse me. I --

(Pause.)

MR. SCOTT: Well --

MS. ABDULLAHI: I'm getting to it. I'm sorry.

MR. SCOTT: Can I go ahead while she's -- can you hear me okay?

CHAIR BALLINGER: We should only have one person talking at once.

MS. ABDULLAHI: Well, Harold can go ahead while I find it. I sent it to Larry and I'm trying to find it now.

MR. BURKHART: Okay. So this is Larry Burkhart. So Harold's on the line.

MS. ABDULLAHI: Okay. Got it.

MR. BURKHART: He's providing a comment.

Mr. Scott, please go ahead.

MR. SCOTT: Another alternative approach in a nonconcurrence document, ML No. -- could have been to recognize the Dr. Mara petition -- that's PRM-50-124, as a basis for setting regulatory limits within existing regulations.

Now this is in red caps. Choose number of allowable rods bursting rather than amount of fuel dispersal. Recall that 2,200 peak clad temperature and 70 percent equipment clad reactors are now known to be wrong. Not exact I should say. That means allowable burst rods does not need to be rigorous. And best estimate plus uncertainty should not have a place for un-allocated perception of conservatism.

CHAIR BALLINGER: That's a lot shorter than the one that was supposed to be read in, but I guess we're okay.

MR. SCOTT: Well, we were just going to read that one sentence. The rest of it people can read if they have the whole email. Or it might be posted in the transcript.

MS. ABDULLAHI: It will be posted in the transcript.

CHAIR BALLINGER: Is that satisfactory?

Harold, is that satisfactory?

MR. SCOTT: Yes, yes, yes, yes.

CHAIR BALLINGER: Okay.

MR. SCOTT: Yes.

CHAIR BALLINGER: All right. Sorry for the confusion and the like. So we've had no -- we have no -- nobody in the public wants to make a comment. So now we need to recess for I would say 10 minutes while we rearrange things and ensure that the room is suitability set up for the closed session. So we're in recess and --

MEMBER MARCH-LEUBA: Should the public be back into this line say at 4:00, let them know if we're -- we're late?

CHAIR BALLINGER: Good question.

MEMBER MARCH-LEUBA: It's two hours from now. If we're done, we join them. If not, we send somebody to tell them to wait.

CHAIR BALLINGER: The nonconcurrence was going to be -- we were going to allow a little bit more time, so that would be --

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: -- Westinghouse and staff closed session, we have it scheduled for two hours?

CHAIR BALLINGER: Yes, two hours.

MEMBER MARCH-LEUBA: So I would -- I will move that we tell the public to come back to this open line at 4:00.

CHAIR BALLINGER: Okay.

MEMBER MARCH-LEUBA: That's roughly two hours. If we are late, somebody will let them know that --

CHAIR BALLINGER: Yes. Can we do that,

Larry?

Okay. So we're going to recess until 2:09. Call it 2:15 or there abouts. And we'll ask that -- huh?

PARTICIPANT: 4:15.

CHAIR BALLINGER: No, no. We're going --

PARTICIPANT: We'll recess until.

CHAIR BALLINGER: We're going into closed session now. So we're going to recess from --

MEMBER BIER: Oh, I see what you're saying. Yes, thank you.

CHAIR BALLINGER: So now it's from 2:10 to 2:20 on that clock while we set up for the closed session. And we'll remind that the public -- hopefully we'll be back in session, open session at 4:00. For the open session.

(Whereupon, the above-entitled matter went off the record at 2:10 p.m. and resumed at 5:00 p.m.)

CHAIR BALLINGER: Okay. Are we all ready to go? Okay.

MR. LEHNING: So this is John Lehning and Kevin Heller, so comment presenting as individual staff at this point. And in the interest of time we're going to go through the slides quickly and maybe cut out some of the material.

And the other thing I would just say before we start there is some related different topics currently with other ongoing processes such as rulemakings or petitions or the PIRT. We may not be able to address all the questions, but ask us and stop us as you have questions and we'll do our best to answer them.

CHAIR BALLINGER: I think the important thing is to focus on the punch line.

MR. LEHNING: Sure. So the punch line here, the summary of nonconcurrence 2, technical staff who did the review of this topical report were unable to concur because of conclusions regarding fuel dispersal. And that was just a narrow part of the topical report of this wide variety of things that were looked at.

And the original safety evaluation that the staff had drafted included a limitation and condition requiring licensees implementing the method to assess the potential for fuel rod -- fuel dispersal from rods with less than 62 gigawatt days per metric ton uranium rod average burnup. And then justify that that amount of dispersal would not result in non-compliance with the 5046 acceptance criteria.

That limitation and condition was removed by the agency management and without that limitation or some alterative to it that would be acceptable the nonconcurring staff concluded that we wouldn't be able to determine that plants implementing the method would comply with the regulatory requirements. And based on a connection I'll explain in the presentation that -- we couldn't conclude that public health and safety would be adequately protected.

So I'll skip over, but just for the record here's some information about us. And again we're just speaking for ourselves.

We wanted to just give a little bit of background here. This isn't the focus of the nonconcurrence. It's on this just specific topical report, but I think this background is a little bit needing to be understood, at least at some level because they have these big generic things that somehow have impacted this very particular review. And understanding why that is I think is important.

And so we start off with a really key question: Is there a valid safety question associated with fuel dispersal? And this is one where the safety evaluation that was modified and the nonconcurring staff disagreed because the safety evaluation that was modified states that fuel dispersal is not a significant safety issue within current burnup limits, but from the nonconcurring staff's point of view there's not a clear basis for that whereas when we look at some pieces of evidence available to us -- and I'll just skim over really quickly -- we see at least a question about whether this could be an issue that could impact compliance.

And the first piece of evidence here is a TopFuel paper from 2014. And this looked at a couple of different plant scenarios for burnups consistent with the current burnup range and it found that it could be -- and again this study was corrected from the original paper, but it found that there could be up to 200 kilograms of dispersed fuel at end of cycle for this particular case that was looked at. And again that's not treated in the safety analysis for plants at this time. So at least there's a question there about that.

When we look at the RIL that we've talked about a few times that summarizes research about fragmentation, relocation, and dispersal, we can see that this pellet average burnup -- and we talked about again that this is pellet average and not rod average. And so it could be potentially 20, 25 percent of the fuel cycle where we could see rods in the operating reactor core that are above this type of a threshold. And again this not saying again there's a problem, but at least it poses the question for these plants of whether there is a dispersal issue there or not.

And the third item here is a paper from last year that was done for a high burnup core. So it's not necessarily characteristic of the operating burnup range. Okay? But still it gives some data point that if the models in the RIL 2021-13 were used here -- and again the authors of the paper believe that the lower value is probably more realistic. This high one may be overconservative.

And I think there's an error on the slide that we gave you here. We'll give you the corrected slides here after the meeting, but that if we look at again a 100 tons of uranium dioxide in the core, that could be something between half and four tons of fuel. Again, maybe gearing more toward the lower estimate that's less conservative. And again that's high-burnup, but one could ask is there a fraction of that that might occur for the current burnup range?

And so that leads us to the key contention here in the nonconcurrence: Is it possible to conclude with a high level of probability that coolable geometry requirement is satisfied and as well as some other requirements when there's no clear safety analysis that's done for what may be hundreds of kilograms or hundreds of pounds of fuel.

And so the nonconcurrence says that this is a well-founded safety question. It's not an assertion that there is a non-compliance or that plants need to take corrective actions, but those are things that should be figured out using existing agency processes and that those questions should be answered perhaps prior to making more fuel burnup increases that could exacerbate the issue.

So again I've made comments about the safety basis for plants. Where is that? That's in the FSAR, Final Safety Analysis Reports. There's a chapter there on LOCA. The staff reviews those things, reviews the evaluation models as well to do those calculations.

And so do those existing calculations address fuel dispersal and its impacts? The answer to that is no, as I've already explained. And the safety evaluation that was modified -- it talks about the need for even -- or assemblies within current burnup limits to satisfy regulatory requirements, but it has -- the last sentence maybe in the one where the nonconcurrent staff would focus on here that licensees may continue to use their currently approved methodologies for this burnup range of the currently licensed burnup range. However, as I've just pointed out, those methods, they don't include fuel dispersal in their evaluation models. The analyses don't include them. So can we get any confidence out of that by just relying on those methods that don't include the phenomena is the question.

MEMBER PETTI: So just a question. You really have a concern with fuel rods even below 62. So you know, licensee comes in with old methods. Right now there's nothing in any of the rules that say they can't just continue to do their usual reload license amendment, right? And this still exists. That's the --

MR. LEHNING: Right. And the limitation and condition we were talking about wouldn't have solve that, but one of the alternatives we talked about was a backfit evaluation for the fleet of plants. And that would have gone to that question and settled it, whether that's acceptable because it's not cost-beneficial or what have you, but at least it would settle the problem. But that's a correct statement that you made.

And so in the end the safety evaluation as modified, it doesn't make a finding about compliance of currently operating reactors with the regulations. The nonconcurrence believes that kind of demonstration is necessary and presses the point that we would need to take some action to make that determination because the existing safety analyses don't address that issue of dispersal. And so again this is just a safety question that should be resolved from the staff's point of view of nonconcurrence.

MEMBER HALNON: John, on the coolable geometry, I mean we don't know what one looks like, but we know what one is the result of. We can keep it cool. Didn't we learn a lot from TMI meltdown that coolable geometries, one, will come in a lot of different configurations; and two, that was coolable given a lot of dispersion and relocation on a fragmentation? We had both melting and chattering. Doesn't it give you any pause to say, well, maybe it's not as crucial as what we're saying here and that we're probably okay in this space?

MR. LEHNING: If I could address that on a few more slides, I think -- I'll show some pictures when we get to the pictures. I think I'd like to respond to that then. But I understand the question.

MEMBER HALNON: Okay.

MR. HELLER: So, John, if you could go back one slide. I'm not sure that you covered -- or at least reasserted. It's that last bullet point. I think that's important. The nonconcurrence does not give us (audio interference) that licensees are definitively out of compliance with the applicable regulations. Rather, it advocates that a well-founded safety question concerning fuel dispersal should be resolved.

MR. LEHNING: Correct. Yes.

CHAIR BALLINGER: Will this likely be resolved by the rulemaking?

MR. LEHNING: Well, we'll kind of talk to that a little bit, too. I think we didn't want to rely on that, just a punch line real quick. It could be, but we don't know for sure. And again it's the timeline and what's going to be the content of that rulemaking. It's not clear at this point.

CHAIR BALLINGER: And respect to the coolable geometry part, I read all of the papers and stuff, and if somebody says there's 200 tons of fuel that's dispersed, that doesn't mean the core is not cool. That just means you've got fuel particles and stuff circulating around the system. And believe it or not, a main cold pump is designed to pump core barrel bolts. So it will pump that stuff.

MR. LEHNING: There might --

CHAIR BALLINGER: That to me was a problem with those papers. It was like crying wolf a little bit.

MR. LEHNING: Well, I guess we'll get to that, but I guess if there's 200 tons of fuel dispersed, then there's probably not a core left. So there may be a fragment --

MEMBER PETTI: You're (audio interference) 200 KGs, not 200 tons.

MR. LEHNING: Okay. So sorry about that. So I'll go onto this line, if that's -- yes. I'll go onto just these slides in the interest of time.

And so I think why has there been a challenge with figuring out whether plants are in compliance? It's because there are large uncertainties in determining the physical phenomena. So how much fuel disperses? Could it be tens of pounds, hundreds? Could it even be in the thousands? Possibly. So that uncertainty may span a few decades of different values.

And then also there's a question here about what the regulatory acceptance criteria would be. And I've heard some comments that -- from the members here that that sort of go to some of the discussions that maybe staff might have here. And so there's -- these two things together have made this a little bit difficult. And I'll touch more on this in a minute.

And so as far as what these uncertainties are, the staff is taking action. The agency is taking action to try to allay these uncertainties. We're continuing, as we have been, sponsoring research on fuel dispersal which may eventually give -- put us in a place where we can make more precise estimates. And we're also developing calculational methods, as in some of the papers we just referenced, that would help us do those calculations. But even lacks of data and such make it hard to validate those models.

And so I think we're a far cry from licensing basis methods that might satisfy this MDAP that I've referenced here from Reg Guide 1.203 in terms of validation at different scales and integral scales and so forth. And that sort of is captured in these uncertainties and these values from some of these journal papers.

And so we come back now to this question of how much fuel dispersal would be acceptable. And I would argue that there's not a clear position on that because when we look back to maybe when the original rule was issued, we're going to argue that maybe the threshold was a pretty low threshold. But if the agency continued to have that perspective, I don't think there would have been an objection to the limitation and condition. I think that would have been, oh, if it's nearly -- it's very little that's dispersed --

(Audio interference.)

CHAIR BALLINGER: I have no idea what's going on.

PARTICIPANT: Cybersecurity issues.

CHAIR BALLINGER: It's no one of you guys, so keep going.

MR. LEHNING: Okay. And so the specific intent of that regulation is important. And so when we consider the historical basis, the thing the staff keeps in mind is that we have the delegated authority to do routine matters, but we can't reinterpret or change regulations. That has to go through the Commission and our public process. And so whatever that regulation meant when it was issued, in the staff's mind here -- again we're not lawyers, but this is our best understanding of what we've been told, that's the meaning of that regulation. So that sets the table for this discussion.

And we pulled this picture. It may have been pulled from a member's LinkedIn blog here that goes through a lot of great information there, so just noting that.

But the Commission, they spoke about what was the purpose of the peak cladding temperature of 2,200 and 17 percent local oxidation? So the purpose of these criteria was to ensure that the cladding would remain sufficiently attached to retain the UO2 fuel in an easily coolable array. And so when we think about that, that's not a coolable pile necessarily, but -- and the Commission then acknowledged that conservative calculations would -- could lead to rupture of fuel rods, but as long as there wasn't too much oxidation, even when the re-flood occurred, there would not be this brittle failure of the entire rod and there would still be an ability to retain uranium dioxide fuel pellets.

And so what does that look like? So even if we get these ruptures we end up with a state where we don't have a lot of dispersal for what these two criteria are trying to accomplish here for -- at the hottest node or the hottest rod we're avoiding the failure of this cladding such that we disperse a bunch of pellets. That's the intent at least of these two criteria from the Commission.

Now if we want to look at what did the Commission want to avoid, there are some words about that, too. They wanted to avoid this large mass with insufficient external area that wouldn't be able to remove heat. And there's this interim state about uranium dioxide fuel pellets falling together into a heap that would be difficult to cool. So that's the thing they didn't want to have happen.

And so if we drew a picture of that, what that might look like, the failure of the ECCS. So there's no water in here. The core is gone in this picture. Again it's an idealization just as the previous picture was. And we have this big pile of pellets. It hasn't all fused together yet in this diagram. But that's what the Commission stated that they wanted to avoid by this regulation.

And so now let's consider what does the picture look like with fuel dispersal per this fragmentation mechanism? I mean we see a picture that's not exactly either of those two. It's somewhere I would say in between where we have maybe some very fine particulate here and maybe some of this could escape from the vessel at some point, but we still have a core that's intact here. So this isn't quite what we see with the criteria for peak cladding temperature and local oxidation, what that would ensure, but neither is it the core is completely lost and gone.

And so the staff's concern or the position that the staff was put in here was to try to basically say whether or not this middle case is acceptable, whether that meets the rule. And it's difficult for us to do that again based on our understanding of what the rule as it was issued meant and what the Commission was trying to accomplish. They wanted to put quite a bit of margin between the regulatory acceptance criteria and the point of failure.

And so again whether this middle picture does that or not, it's probably not the role of two working-level staff to figure that out. It probably needs some higher authority to do that. And we didn't want to concur here in part because we didn't feel like we have the ability to say that this middle picture meets this regulation that the Commission when it -- when sort of this picture looks like this left side of the graph. And so we left this sort of as again a safety question that does this meet the regulation or not? That needs to be solved in some more comprehensive way. We need to come up with criteria. We don't have acceptance criteria for how much or whatever this is. And so this makes it difficult to make regulatory decisions at the staff level.

MEMBER HALNON: So when we were going through the GSI-191 stuff, I mean that took what, a decade-and-a-half to work out, we still approved uprates and we still approved containment modifications and we still approved many license amendments that had to deal with inside containment knowing that as we went through this you would minimize your fiber, you would minimize your paint chips, you would minimize all the stuff that could block -- cause blockage. But we still didn't have a definitive are you in compliance because we didn't have all the testing done with the fiber and the fuel assemblies and whatnot.

How is this different that we -- are we going to hold up all approvals of anything on fuel because we don't necessarily think -- I mean, that's a bad generalization. Are we going to hold this up because we don't have enough test data to show definitely that we have -- or we're taking actions to be conservative and make sure that we're at least not making it worse?

MR. LEHNING: So for GSI-191, I worked on that issue for quite a while, and the thing I would say there is those plants started out with very small sump strainers. It could have been on the tens of square foot, into the hundreds maybe. And so before 2008 they had all pretty much replaced these with thousand square foot strainers. And so they had a great argument. Hey, we're a lot better off than we were. We've made the plant a whole lot better, a whole lot safer in this overall sense.

And just to give a counter example, so when we think about leak before break, my understanding is that there were times when approvals for that were paused. For example, pressurized water stress corrosion cracking. So there have been times where we said we don't understand yet this issue and we need to get to work hard and solve it and then we'll continue on. And so again it's not for us here, the staff, to say that --

MEMBER HALNON: Okay.

MR. LEHNING: -- say what needs to happen.

MEMBER HALNON: No, that's fair.

MR. LEHNING: I would advocate that it probably wouldn't take that long to do at least some backfit evaluation or some evaluation of it at least to current knowledge. It may not be the best and most perfect thing, but at least something to say here's our position on this.

MEMBER HALNON: Okay. No, that's fair. I appreciate that.

CHAIR BALLINGER: Let's use another analogy though. Let's say we discover this problem, which we have. And Appendix K was a long time ago. I didn't see the date on the picture, but it was a long time ago. But since that time the technology and the operational procedures, the inspection techniques, all of that stuff has improved orders of magnitude. So the likelihood of having an event occur where this would be an issue has had to have decreased greatly between now -- between then and now. In other words, talk about ALS. So how is that a similar analogy?

MR. LEHNING: So should the Commission decide to pursue a pathway where the regulation -- it becomes instead of postulate breaks up to and including this double-ended guillotine break -- so maybe it would allow some option like that to be used. And that would be the new yardstick that the staff would use to judge against. But as of right now the way the regulation reads -- and again there's some question about what might or might not need to be done to make ALS work per the regulations, but whatever that regulation would change to the staff would then regulate, too.

But in terms of Appendix K to now, it's true that a lot of conservatisms were in that method. Some of them have been taken advantage of with more best estimate methods. And certainly the estimations of break frequency and so forth are a lot more refined and some of those are on the table for this regulatory basis. And they may lead to rule changes just like what you're saying, but for the time being staff is only able to I think regulate to the rules that are on the books right now.

MR. BURKHART: Ron, may I suggest that instead of drawing analogies to other issues, in light of the time, that we hear out the two staff members here hopefully in the next 10 minutes? And then we're going to hear from their management on why it's okay -- why they think it's okay to go ahead with this action, which is documented in the safety evaluation. We do have limited time and we need to hear from Scott Krepel after them.

MEMBER HALNON: Yes, Scott's only got six slides, so we're going to through those quickly.

MR. LEHNING: Okay.

MEMBER HALNON: But back to the TMI. Go back one picture. I mean, that middle picture is TMI. You have a random relocation, some chattering, some -- however you want to put a word picture of array, or that word that you -- that they used back in 1950-something. That is TMI.

And my point was is that even with that we showed that there's a -- it was a coolable geometry. And not a nice -- it was ugly, no doubt, but it was cool. And there was relocation throughout the RCS including piles on top of the seismic gap. And that was coolable and it went sub-critical and everything else.

So it's not that it makes it okay or in compliance, but does it -- it gives us at least a level of certainty that that random relocation and melting and core configuration was coolable.

MR. LEHNING: Yes, and I wouldn't argue with that, but the counter that I will give back to you is that I think that's a good argument for why do we need PCT at 2,200 and local oxidation at 17 percent? We know that if we just completely -- I mean melt two-thirds of the core, let's say, we're still coolable. And if that's where we want to go with rulemakings or things like that, that could be done, but --

MEMBER HALNON: I wasn't trying to say that was an acceptable thing. I'm just trying to give us a level of confidence that we're not making a safety issue to the point where it's going to be a public health and safety --

(Simultaneous speaking.)

MR. LEHNING: Yes, and I get that. And I guess the thing that I think we're trying to say here is that there ought be a consistency. So if on the one hand we're going to say in this left-hand picture we're going to regulate peak cladding temperature and local oxidation to the point where even on the hottest node, the hottest rod we're not going to release pellets and we're going to keep the vessel looking like this on the inside, why would we need to do that if this middle picture is acceptable? And there may be reasons why, but it's not obvious. And perhaps this is something that people high in the agency ought to make their opinions known on and go forward with based on where we are at least at this point. That's all we're advocating here --

MEMBER HALNON: Okay.

MR. LEHNING: -- not trying to --

MEMBER HALNON: No, I get it.

MR. LEHNING: -- argue your point --

MEMBER HALNON: No, I get it.

MR. LEHNING: -- because I think you have a good point.

I'll try to just wrap up a little bit quickly. I'll skip over a little bit. I mean this point was on regulatory compliance, and regulatory compliance is the basis for in general the public health and safety being protected.

And this past history I'll skip over, but this issue was brought up as a generic issue before. It wasn't resolved there. And the staff did try to look at getting a more general resolution of the issue, but it didn't work out with the process the agency was in at that time.

And this question goes to sort of the resolution schedule and we know that increased enrichment and high burnups, some of these efforts are under way to finish or to start being implemented by 2027. And so again this is a question of whether we should maybe in a similar sense trying to get our arms around this operating reactor dispersal question on a similar time scale. But we don't know that there are activities defined to do that at this point.

So I'll just go through -- I'll skip over I think the alternative discussion in general, but let me just go through a few more slides here. I'll try to wrap up in about -- within 10 minutes. Is that enough time? Or five minutes? What do you guys think?

MEMBER MARCH-LEUBA: Five? Two for five minutes.

MR. LEHNING: Five minutes? Okay. So I'll wrap up on five minutes. And so again there are policy issues here. We're not trying to set the policy, but they influenced our decision. And the point here is that the safety evaluation wouldn't as it stands ensure compliance with regulatory requirements.

And let me skip over this slide, but I think that I'll just make a mention here. So why are we concerned? I think even if there's not an increase predicted in dispersal for these higher increased burnup cores, well the last time we increased burnup there were a couple of issues that we didn't recognize at the time, and one of them obviously was this dispersal issue itself. We didn't recognize that, nor did we recognize this thermal conductivity degradation issue, TCD. And so these issues take a long time to resolve. Based on when we're starting from an in-compliance state, we have the time and space needed do to that. But if we don't, then do we still have the ability to really take our time, take the time needed to address the issues?

And so this takes us to where I think I just have -- I'll just go over three more slides then, and these will be the sort of punch line that we'll end with.

So how can the NRC address emergent safety questions? And there are two ways that -- in general that we might use. One would be voluntary forward-looking licensing basis changes. And the other would be mandatory backfits. And let me just explain what those are.

So for the voluntary forward-looking change, when an applicant agrees to -- that basically occurs when an applicant has some application from the staff. They want to get permission to do something. And as a condition for basically being able to do that they implement some measure that might be a safety improvement. For example, this incorporation of PAD-5 could be one example.

And so this would only be effective for licensees that voluntarily implement the topical report, but on the other hand it's a lot easier to do this. There's a burden of proof on the applicant not on the staff like in the backfit case like we'll explain. And so this is often the way that is used to accomplish these types of things in practice because of the backfit approach being difficult to implement.

But there is -- obviously per 10 CFR 50.109 the NRC has statutory authority to require corrective actions under certain conditions on us. And this type of corrective action could be implemented on all operating plants irrespective of whether they implement this topical report, but the burden of proof would be on the staff. And so in the case of regulatory compliance there's also adequate protection and other ways to go about it, but in the case of compliance, which we're focused on here, not only would there be a need to demonstrate that this action is necessary for compliance, but there would also be a cost-benefit justification.

And the staff, who nonconcurred, believe that such an evaluation would be appropriate because of the importance of core coolability to reactor safety and this would give us a valid rationale for either an action we take or inaction, that we don't need to do anything.

And actually let me just do the conclusion slide. I'll skip over all of the alternatives we discussed with management. We had good discussions with them, respectful discussions on a couple of other alternatives. If you want to read those on your own, please do that.

But here's the conclusion slide. Two staff, Kevin and myself, have nonconcurred on a modified draft safety evaluation that deals with increased fuel burnups. And specifically on the topic of fuel dispersal was the issue because the staff concluded that we didn't have a basis to say that plants implementing the method would be in compliance with NRC regulations.

(Audio interference) agency decisions, again not to criticize them, there are a lot of considerations at stake and I think we made the best decisions we can, as always as an agency, but this led us down the pathway where these generic policy issues have come into play in this very specific review to a level where the staff find it difficult to make this regulatory decision because of the high-level policy-type questions that are involved.

And meanwhile, fuel dispersal -- again, this came out of the 1990s, the burnup increases in the 1990s. So it's been out there all that time. We started to recognize it maybe 20 or so I think years ago. It continues on, in the nonconcurring staff's eyes, as an ongoing safety question, not currently -- obviously not in the safety analysis or any operating reactor. If you look at their FSAR, you're not going to find it treated anywhere. The path forward to resolve it again is not clear as we compare -- like we have a clear pathway for going to higher burnup, for instance, but it's not clear how this is going to get resolved. There are some possibilities, but it's not clear how that would be.

And so that's the message I think I would leave off on and open for any other questions, if we have time.

MEMBER KIRCHNER: John, I have one. For the immediate question, or what's on the table right now, there -- you've outlined the much bigger picture, but for the immediate question that's on the table is this methodology. And that's why I was exploring the direction I was going. One way that the staff in its review could address this concern is some -- and I'm not going to align 100 percent what the Westinghouse proposal, but an approach where you introduce a new figure of merit that's not part of the existing regulatory framework. That provides some level of confidence that you avoid the high -- with a high probability you try and avoid the potential for this dispersal.

Now you could argue one way to do that is just don't increase the burnup of the fuel, but you could also run the system less hard, so to speak in terms of thermal limits, which then -- because somewhere along the line that contributes to the mechanism that leads to the eventual dispersal.

In your opinion do you find that the -- obviously we have this nonconcurrence, but is that an approach that they're using -- is that an approach in the interim that could be used to address this bigger open-ended problem of fuel dispersal?

MR. LEHNING: An approach like what you suggested, or what -- I think that Westinghouse might have a thought on that and if they want to speak up -- I had the feeling that maybe Westinghouse believed that there might not be a ready way to do that and that the penalties that might be incurred from that economically might negate the benefit of the method is sort of the impression I got from them.

MEMBER KIRCHNER: Okay.

CHAIR BALLINGER: We need to have time for

Scott.

MR. LEHNING: Thank you.

CHAIR BALLINGER: Thanks again.

So where does -- oh, he's going to go up there.

MR. KREPEL: Testing. Does this microphone work?

PARTICIPANT: Sounds like it does.

MR. BLEY: Yes, works great.

MR. KREPEL: Okay. Are you ready to share the slides?

Hello. Thanks for having me here to present what I call the management perspective, and that's a combined effort from various people including myself, Ben Parks, who did the evaluation for the nonconcurrence. And he is a current senior level advisor in DANU, and I believe he is on listening so he can answer any questions. We also had Vic Cusumano, who approved the nonconcurrence. But I volunteered to provide the briefing on behalf of all the management.

So first off, it's pretty simple. From the technical issues raised by the nonconcurrence, they're all valid issues and the nonconcurrence resolution did not dispute any of them. There are a lot of documentations, discussion, and so forth, but this is not the basis for how we disposed the nonconcurrence.

Next slide, please. For the nonconcurrence from the management perspective there are two critical points. So first is safety significance, which is related to the technical issues themselves and how it impacts the accident consequences. And then the second is the regulatory process issues that link to the regulatory findings within the topical report.

Next slide. This is kind of a key slide for my presentation. It talks about the safety concerns. And right now the agency has already put out their position in SECY 2015 associated with 50.46(c) rule that says that we do not believe that dispersal is a significant issue at this time. And I understand at that time of 50.46(c) had been hung up for three years while the NRC continued to investigate and there was a lot of work that went into FFRD to get into the conclusions of FFRD, and that was documented within the SECY 2015.

After that the NRC continued to do further research that led to the 2021 RIL, but we revisited the conclusions of the SECY and there were no changes that were made. We still believe that it was not a significant safety concern and it expanded upon why further within the nonconcurrence which had to do with things happening at the end of the cycle. We had conservative estimates and assumptions to figure out how much fuel would disperse. And at the end of the day, even after all of those assumptions, 200 kilograms -- that's about two-third cubic feet of fuel material and you can make sand out of that to scatter within a certain area which would be about the size of this table. So it becomes hard for us to think and come up with a very strong technical reason on why we would believe there would be a problem with coolability and so on.

We know that we do have some gaps in information and although there are gaps it does not prevent us from making a decision at this point. We still continue to investigate further. We know we have industry interested in going to higher burnups, and so a lot of FFRD related to those issues are still being addressed in some way. We have the PIRT to identify those gaps and what gaps need to be looked at. We have the increased enrichment rulemaking and policy issues based on potential new regulatory frameworks that will be a better fit for FFRD-related things.

And I will pause to see if there's any questions before I proceed.

Okay. The next slide. This is related to the nexus of the topical report. You have seen several slides during the closed session, and obviously I will not discuss that, but it kind of sets the framework for the Westinghouse methodology in which the basis for acceptability (audio interference). Westinghouse effectively established a separate basis for acceptability of WCAP-184 (audio interference) acceptable within its range (audio interference) gigawatt days per metric ton.

Today we've discussed the applicability within the range and the bottom line is that management, NRC management does not view the limitation and condition proposed to the -- by the staff to be within the appropriate scope of this topical report. It is basically out of scope for this specific topical report. And so that is how the regulatory process goes.

And last slide. This really just summarizes everything I just said.

MEMBER HALNON: Scott, when you laid out your sand and you -- I got it that it's coolable. You think it's also sub-critical?

PARTICIPANT: And pumpable.

MEMBER HALNON: Well, it's going to be pumpable, but from a neutronics perspective are you still satisfied that that is still not an issue as well?

MR. KREPEL: That is my understanding from the discussion that has gone on in the research that has led to that conclusion, yes.

MEMBER HALNON: Okay. And then when you say it's out of scope of this effort, it's out of scope because -- I'm going to put words in your mouth -- out of scope because it is not a safety issue or because it's just not covered by this issue? In other words, should it be in scope?

MR. KREPEL: So --

PARTICIPANT: I would add or should it be in scope (audio interference)?

MEMBER HALNON: Yes, or should it be in scope?

MR. KREPEL: Yes, you're right. So yes, you are putting words in my mouth.

(Laughter.)

MR. KREPEL: But yes, we think that this issue should be addressed eventually especially as we move to higher burnups, but for this specific topical report, not really.

MEMBER HALNON: Okay.

MEMBER PETTI: So my sense is there's a -- was a fair amount of frustration on the part of the staff. And I read nonconcurrence as, management, get your act together, get this resolved. We got a PIRT. We got a potential rulemaking. Let's get the ducks aligned and get this going. Because the longer you wait -- you don't want this to last as long as GSI-191, for instance. You want a timely resolution. And that may require some more experiments, because I'm not convinced that all the experiments are as relevant as some, which we put in our letter. But that was how I sort of viewed it.

MR. KREPEL: Yes, understood. So I will emphasize, as I did before, and I've mentioned this already, you don't need to have all the data to make a regulatory decision. So here some people might disagree on how much data is sufficient. And that's okay. And that's why we're going through this nonconcurrence process.

My staff and I still have a very good relationship and we agree to disagree.

All right. That's it for me. Thank you.

CHAIR BALLINGER: Thank you.

MR. KREPEL: Thanks again, everyone.

MEMBER MARCH-LEUBA: Comment from the public again?

CHAIR BALLINGER: Yes, I'm just asking about more questions from the members first. Any questions from the members?

Okay. One last time, who is that?

PARTICIPANT: That's Harold Scott.

CHAIR BALLINGER: Harold, your forehead looks really nice.

So are there members of the public that would like to make a comment? If there are, please state your name and then make your comment.

MEMBER HALNON: Just call on Paul, Paul Clifford.

CHAIR BALLINGER: Who?

MR. CLIFFORD: Yes, hello.

CHAIR BALLINGER: Oh, Paul Clifford?

MR. CLIFFORD: Yes. Hello, can you hear me?

CHAIR BALLINGER: Yes, we can hear you, Paul.

MR. CLIFFORD: Okay. Thanks for hearing my comment. You know, as a 20-year veteran of the NRC

I feel for the staff. There seems to be a reluctance within NRC management to go into the 5109 backfit process. And in the backfit process you can use risk, safety significance, and even cost to evaluate whether new research findings such as fuel fragmentation needs to be backfit onto the industry. But that's not being done.

So the staff is faced -- and the industry is in a weird situation. If you're saying that there's any dispersal at all, that's a compliance nightmare. It's difficult to show compliance if there's any dispersed fuel. And the research suggests that there may be under 62. It's not risk significance, but it's compliance significant. And when the staff is evaluating the design-basis evaluation by the industry, they're forced in compliance space.

So I feel for the staff. I really do. That's my only comment. Thank you for hearing it.

CHAIR BALLINGER: Thank you.

Other comments from the public?

Hearing none, I think we are --

PARTICIPANT: Harold Scott just raised his hand.

CHAIR BALLINGER: Huh?

PARTICIPANT: Harold Scott just raised his hand.

CHAIR BALLINGER: Oh, Harold?

MR. SCOTT: Can you hear?

CHAIR BALLINGER: Now, yes.

MR. SCOTT: Do I have a second to ask -- make an additional comment?

CHAIR BALLINGER: Make your comment.

MR. SCOTT: Okay. I'm going to read a paragraph from a memo from Myron Wiesenack. I'll give the ML number. By the way, Wiesenack is spelled W-I-E-S-E-N-A-C-K. The ML ADAMS number is ML24024A061. And here's what the paragraph I (audio interference) says:

The benefits of such a rule change would be significant. It would resolve the FFRD issue and appropriately put it in a confirmatory role. It would permit burnup extensions beyond the current de facto limit of 62 and it would eliminate the cladding temperature limit of 2,200 F in the balloon and burst regions of the cladding, a temperature that is difficult to estimate, unnecessarily limiting, and could lead to misguided core designs and developmental efforts.

So we're looking at the wrong figure of

merit when we're looking at temperatures. We go to look at the pressure that causes burst. How many rods do you burst? If you limit those, then they -- you do still come back to the -- how much fuel is in the core. Thank you very much.

CHAIR BALLINGER: Thank you.

I'm not seeing where people are raising their hands. I apologize.

PARTICIPANT: It's the new background on Teams. It doesn't jump out of like it used to.

CHAIR BALLINGER: Yes, it doesn't jump out.

MS. ABDULLAHI: Harold, are you going to send me that one, or I should send the one that you have now?

MR. SCOTT: I read from what you already have.

MS. ABDULLAHI: Okay. Thank you.

MR. SCOTT: Number two.

MS. ABDULLAHI: Okay. Number 2, the one -- okay. Then I will make sure that both statements go into the transcript.

MR. SCOTT: Thank you.

MS. ABDULLAHI: You're welcome.

CHAIR BALLINGER: Okay. Thank you again.

Thank you for the applicant as well as the staff. So I think the time now is for the committee to have discussion related to the path forward. And in compliance with the request of the Chairman, I have put together an outline for a potential paper because we're -- if we decide to write a paper, it will be presented in the May Full Committee.

MEMBER MARCH-LEUBA: You mean letter?

CHAIR BALLINGER: Excuse me. Letter. Full Committee meeting.

So we can either put that up there and scream at me or we can have a discussion right now about what we should do and what should the path forward be.

MR. MOORE: Chair, I don't think you have time.

CHAIR BALLINGER: Well, we have --

MR. MOORE: Ten minutes.

CHAIR BALLINGER: -- 10 minutes. So that's my time limit and I'm sticking to it.

PARTICIPANT: Well, I guess I would just ask what would we write about that we haven't already written on our other letter?

CHAIR BALLINGER: Well, we have to do something about the WCAP.

MEMBER KIRCHNER: Yes, I mean what don't you just outline, Ron, what your thinking is at this point? And that will --

CHAIR BALLINGER: Yes, can you put --

MEMBER KIRCHNER: -- give us --

CHAIR BALLINGER: -- that up here?

MEMBER KIRCHNER: -- focus.

CHAIR BALLINGER: Do we need the court -- the recorder and everything for this?

MR. MOORE: Yes, you don't need the court reporter for the general discussion about what should be in a letter, but then you can't go back to anything else --

CHAIR BALLINGER: Oh, okay.

MR. MOORE: -- in the Subcommittee.

CHAIR BALLINGER: Okay. Again this is the first time I've done this, and so it's -- I think we --

MEMBER MARCH-LEUBA: Wait. Wait. If we put the letter in and you haven't adjourned, we need to put that in the transcript, right?

MR. MOORE: Well, what he's saying will be in the transcript.

MEMBER MARCH-LEUBA: I suggest that we adjourn and then we have committee discussions afterwards.

CHAIR BALLINGER: Is that something we can do?

MR. BURKHART: We're not adjourning because the meeting is still going on. So we can let the court reporter go and end his duty. Then I think you want to just discuss where you think the Subcommittee should go on this with respect to Full Committee, right?

CHAIR BALLINGER: Okay. I think let's just keep going. I would just for now put up the straw man for the conclusions and recommendations. Just keep going.

Okay. There we go. I had conclusions and recommendations related to the WCAP itself. And those are the ones that I'm -- I just wrote them down. And the bottom line is is that they made an adequate case for this. Or, whoops. What happened?

MR. BURKHART: Okay. Yes, Ron, we need to make sure -- I would suggest you talk about topics. And I needed to take the letter of for a reason. So I just wanted to -- there was some information on there that shouldn't have been, so I suggest you just talk about the topics.

CHAIR BALLINGER: Okay. All right.

Sorry.

So I had the basic conclusion was that the WCAP should be issued. And they've supplied enough reasons for that to happen. But there was a set of conclusions and recommendations based on the nonconcurrence. And they were that: (A) it was a very -- to my mind it was a very well-written document. It stated a case which we know exists, but that there is a resolution process in place going forward that will ultimately resolve their concerns. So those are the two main sets of results and conclusions.

MEMBER PETTI: Can we urge them to move posthaste?

CHAIR BALLINGER: Yes. Well, we -- that's true. Well, they are --

MEMBER PETTI: I mean the agency to move forward to resolve this. Just give them all the stakeholder --

CHAIR BALLINGER: I mean this is not a GSI-191 thing.

MEMBER PETTI: Without saying that, yes.

CHAIR BALLINGER: But that's what I would propose, but I don't know -- other members have a different opinion? And we can send that document out to the members.

PARTICIPANT: No, no, not yet.

PARTICIPANT: It needs to be reviewed first.

MEMBER HALNON: Remind me why this was not put in the GS -- in our safety issue process. Does anyone remember?

MEMBER PETTI: It was. The slide said it was supposed to be part of the 50.46(c).

MEMBER HALNON: And then a rulemaking.

MEMBER PETTI: Right. No, no, it screened out of the GSI process.

MEMBER HALNON: That's what --

(Simultaneous speaking.)

MEMBER PETTI: -- a generic safety issue.

MEMBER HALNON: If you have some of the staff calling for a 50.109, it sounds like it could be very easily --

MEMBER PETTI: No. Yes, it was screened out and the argument was because they were going to handle in 50.46(c).

MEMBER HALNON: Oh, okay.

MEMBER PETTI: And they didn't handle it in 50.46(c). And somehow nobody -- that didn't close.

MEMBER HALNON: And now it's hanging?

MEMBER PETTI: Right.

MEMBER HALNON: Do we have an opinion about that then, to find a process to put this in rather than just --

CHAIR BALLINGER: But now we're talking about something that's not the --

(Simultaneous speaking.)

MEMBER PETTI: I'll just give you my comment. We made in a very recent letter on Part 53 a recommendation to get a draft Reg Guide and make it a real Reg Guide. And we didn't get a -- pushing the staff sometimes is like pushing on string, I think. I mean, I didn't think that was like a huge ask. This is a bigger ask, but there's a lot more in the line here.

MEMBER HALNON: Well, I always in my career figured that the best way to get something resolved that is hanging is to make sure it's in the appropriate process and let that process handle it with the -- typically it was the corrective action process for a licensee. You put in the corrective action process and now you know that there's going to be a series of steps. Right now it doesn't feel that way for this.

MEMBER PETTI: Yes, well we didn't hear it in the slides, but the paper had all those different options, right?

MEMBER HALNON: Yes. Right. And all those would have been fleshed out during --

(Simultaneous speaking.)

MEMBER PETTI: Right.

CHAIR BALLINGER: But do we think that the rulemaking process will take care of this?

MEMBER PETTI: This is a process question. This is not us formally. We are not experts on this stuff. My opinion is, as we reiterated in the RIL, we think this is an important issue. It ought to be resolved as expeditiously as possible by whatever process the staff (audio interference).

(Simultaneous speaking.)

MEMBER HALNON: And now we're talking about the FFRD.

CHAIR BALLINGER: Yes.

MEMBER PETTI: Yes. Well then --

MEMBER HALNON: Well, that is the essence of the nonconcurrence. I mean nowhere do they say you applied this incorrectly in the WCAP. This is all about a coolable geometry and the resolution of the FFRD, or at least understanding of that.

CHAIR BALLINGER: Okay. Are we in agreement that a letter is appropriate?

MEMBER PETTI: I think the --

(Simultaneous speaking.)

MEMBER PETTI: Look, we have written letters from other vendors. We have to write a letter here.

CHAIR BALLINGER: Okay.

MEMBER PETTI: I think. I mean it would show some sort of bias that isn't really real.

MEMBER HALNON: Well, I think it also gets -- keeps the pressure on.

MEMBER PETTI: Yes.

MEMBER HALNON: And I think we can't sit back and say, well, we're part of the folks that are just waiting to see.

CHAIR BALLINGER: I mean, my personal opinion as this committee, as a committee this is one way to keep the pressure on. There's another way to keep the pressure on with -- when we get the ALS presentation. We have an opportunity as a committee to keep the pressure on. And I think that's a good thing.

Yes, I wish I could say that I'm looking forward to the letter writing in May.

PARTICIPANT: You have one minute to adjourn, Ron.

CHAIR BALLINGER: Yes. All right. If there aren't any -- I've been properly excoriated. I told you I was going to be excoriated.

MEMBER KIRCHNER: I think you'll do it, but go ahead and say thank you to the staff.

CHAIR BALLINGER: Yes. Yes. Thank you very much --

MEMBER KIRCHNER: -- specifically the presenters today --

CHAIR BALLINGER: -- everybody and --

MEMBER KIRCHNER: -- for bringing this to the fore.

CHAIR BALLINGER: -- I'm sure that May letter writing will be interesting for the staff and the applicants.

So thank you once again for presenting, and we are I think adjourned.

(Whereupon, the above-entitled matter went off the record at 5:59 p.m.)

Enclosure 2

Westinghouse Open Session Slide Package for the ACRS Subcommittee Meeting on WCAP-18446-P/NP

(Non-Proprietary)

March 2024

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

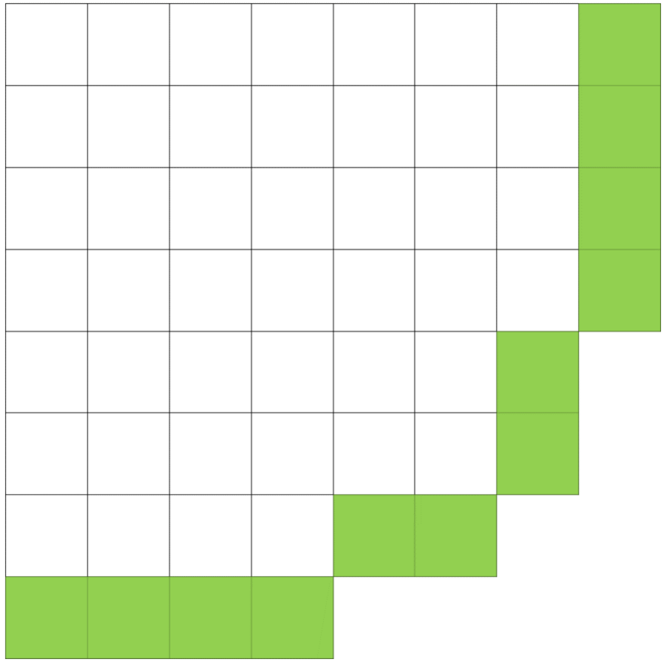
ACRS Fuels, Materials, and Structures Subcommittee Meeting

Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs, Westinghouse Topical Report WCAP-18446-P/NP

Open Session

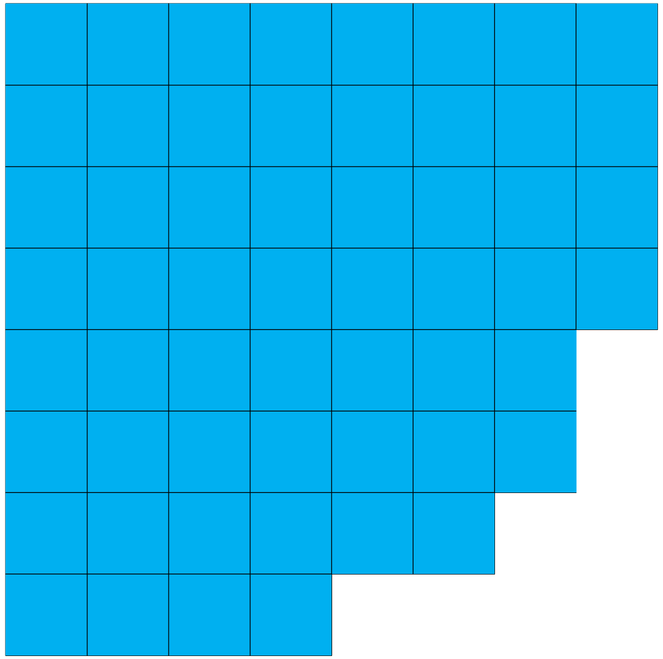
Jeffrey Kobelak
Consulting Engineer, Westinghouse Electric Company
April 2024

Burnup Extension Program as 2-Step Process



Step 1: Increase burnup limit for rods in peripheral assemblies above 62 GWd/MTU

Step 2: Increase burnup limit for entire core to above 70 GWd/MTU with enrichment increase

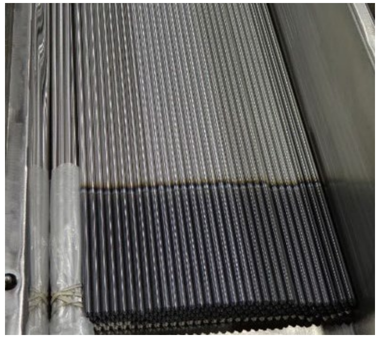


Westinghouse EnCore® Fuel and High Energy Fuel Programs

Timeline of Various Products

Approved 1 → Under Review 2 → Under Development 3 → Long Term 4

AXIOM® Cladding



Chromium-Coated Cladding

Uranium Nitride (UN) Pellets

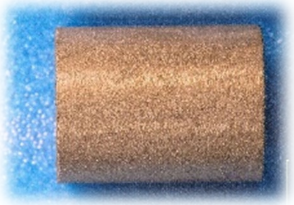
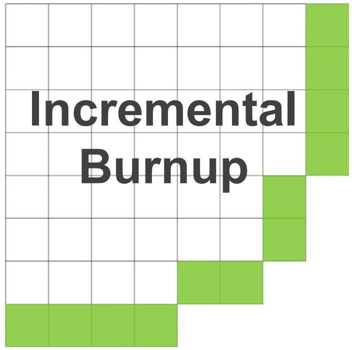


Photo courtesy of Los Alamos National Lab

Product and Methods Evolution

ADOPT™ Pellets

Westinghouse



EPRI
Alternate
Licensing
Strategy

SiGA™ Silicon Carbide (SiC) Composite Cladding

Incremental Burnup Extension Benefits

- Primary benefit is improved fuel utilization
  - Enabling higher region discharge burnup → improved fuel utilization
  - Target is to reduce number of required feed assemblies each reload

- Improved backend cost
  - Optimum utilization of spent fuel pool capacity with higher burnup fuel
  - Lower dry cask storage needs with fewer fuel assemblies
  - Less volume for permanent storage

- Westinghouse has contracted with customers to implement **ADOPT**™ fuel, **AXIOM**® cladding, and the incremental burnup extension (once approved)

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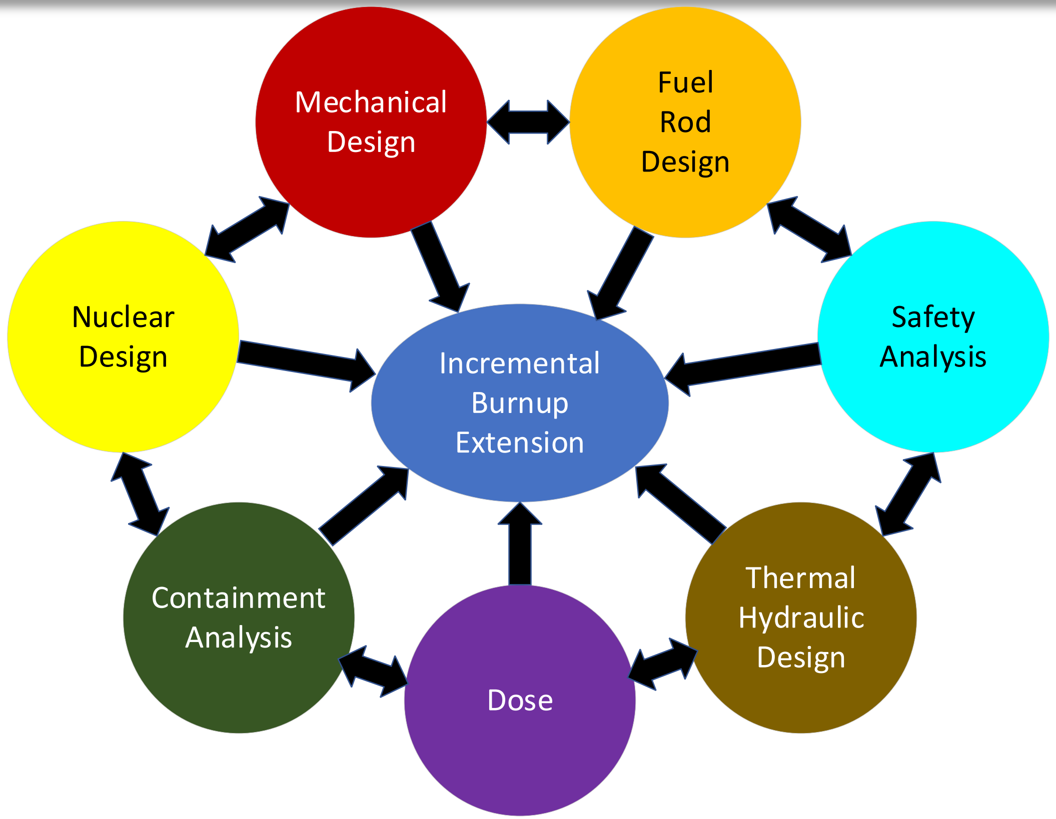
Incremental Burnup Extension Applicability

- Fuel Rod Average Burnup
  - > 62 GWd/MTU
- Fuel Rod Initial Enrichment
  - < 5 w/o enrichment
- Core Location
  - Peripheral Assemblies
- Fuel Assembly Designs
  - All



- Cladding Materials
  - **ZIRLO**®, **Optimized ZIRLO**™, and **AXIOM** cladding
  - Chromium-coated cladding (future)
- Fuel Pellets
  - Standard UO_2 and **ADOPT** fuel pellets

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Incremental Burnup Extension Topical Report Overview

- WCAP-18446-P/NP was written to ensure efficient implementation of the incremental burnup extension
  - Limitations associated with prior topical reports which are superseded are identified in Section 1.4
  - Limitations of applicability clearly defined in Section 7.1
  - Licensee actions for implementation are discussed in Section 7.2

- Impacts of incremental burnup extension addressed functional area-by-functional area
  - Codes
  - Methods
  - Acceptance Criteria

Incremental Burnup Extension Topical Report Overview

- Mechanical Design
  - Fuel assembly design bases
  - Structural components
  - Materials

- Core and Fuel Rod Performance
  - Fuel Rod Design
    - Justify application of PAD5 to incremental burnup regime
  - Nuclear Design
    - Codes are already applicable to incremental burnup regime
  - Thermal-Hydraulic Design
    - DNB methods and determination of DNBR remain applicable to incremental burnup fuel rods
    - Incremental burnup rods are non-limiting for rod bow due to low power

Incremental Burnup Extension Topical Report Overview

- Loss-of-Coolant Accident Analysis
  - Update codes and methods to analyze higher burnup fuel rods
  - Address potential for fuel dispersal from fuel rods in the incremental burnup regime
- Transient and Containment Analysis
  - Assess / update decay heat modeling for analysis of higher burnup fuel rods
  - Address phenomena for high burnup fuel rods related to reactivity insertion accidents
- Radiological Consequence Analysis
  - Account for higher burnup fuel rods in dose analyses

Fuel Fragmentation, Relocation, and Dispersal (FFRD)

- Research regarding FFRD ongoing for the last decade
- Safety assessments were completed for FFRD relative to design basis non-LOCA and LOCA transients and accidents
  - SECY-15-0148: *The experimental results have continued to support the hypothesis that FFRD phenomena are primarily a high burnup fuel issue and that the current licensing limits in the U.S. are adequate to prevent dispersal of large quantities of fine fuel fragments.*
- RIL 2021-13 issued to provide conservative interpretation of subset of FFRD-related data at the time of publication

- **Incremental burnup extension considers potential for dispersal during various accidents and transients**

Incremental Burnup Topical Report Schedule

- Topical Report Submittal — December 2020
- NRC Acceptance Review — March 2021
- First Round of RAIs Issued — December 2021
- Responses to Round 1 RAIs — June 2022
- Second Round of RAIs Issued — September 2022
- Responses to Round 2 RAIs — February 2023
- Draft SER Issued — March 2024
- ACRS Sub Committee — April 2024
- Final SER to be Issued — June 2024

Questions

Acronyms / Codes / Labels

Acronym	Definition
ACRS	Advisory Committee on Reactor Safeguards
ADOPT	Advanced Doped Pellet Technology
ALS	Alternate Licensing Strategy (for FFRD)
DNB	Departure from Nucleate Boiling
DNBR	Departure from Nucleate Boiling Ratio
EPRI	Electric Power Research Institute
FFRD	Fuel Fragmentation, Relocation, and Dispersal
LOCA	Loss-of-Coolant Accident
NRC	Nuclear Regulatory Commission
PAD	Performance Analysis and Design

Acronyms / Codes / Labels (continued)

Acronym	Definition
RAI	Request for Additional Information
RIL	Research Information Letter
SER	Safety Evaluation Report
SiC	Silicon Carbide
UN	Uranium Nitride

NRC Staff's Review of Westinghouse Topical Report WCAP-18446-P, *Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs*

Open Presentation to

Advisory Committee on Reactor Safeguards, Fuels, Materials, and Structures Subcommittee

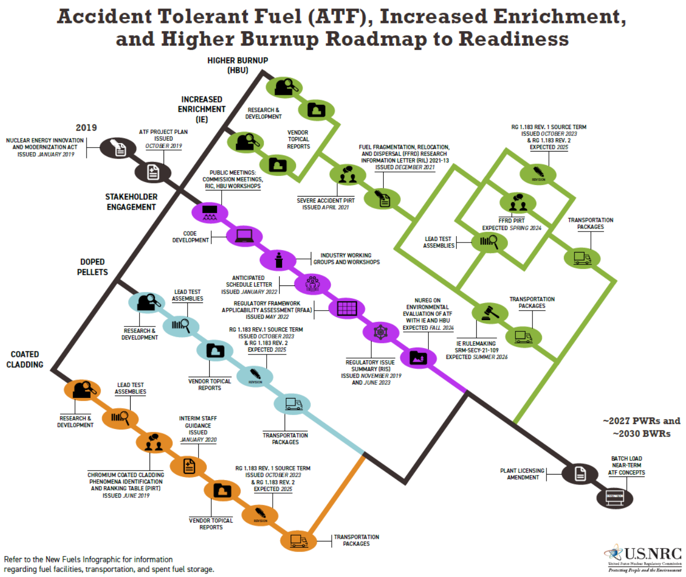
April 2, 2024

K. Heller, U.S. NRC
J. Lehning, U.S. NRC
B. Wise, U.S. NRC

Presentation Outline

Topic	# of Slides
Introduction	3
Review History	1
Requirements and Guidance	4
Technical Evaluation (open portion)	15
• Fuel Assembly Mechanical Design	[1]
• Core and Fuel Rod Performance	[4]
• Loss-of-Coolant Accident Analysis Methods	[1]
• Non-Loss-of-Coolant Accident Analysis Methods	[3]
• Radiological Consequence Analysis	[4]
• Applicability to ADOPT™ Fuel Pellets and AXIOM® Cladding	[2]
Applicability, Limitations and Conditions	2
Conclusions	1
Presentation Total	**26**

Introduction



- Westinghouse proposed WCAP-18446-P/NP to allow an incremental burnup increase beyond currently licensed limits
  - Westinghouse considers proposed incremental burnup limit to be proprietary
- WCAP-18446-P/NP contains a comprehensive evaluation of the capability of Westinghouse’s analysis methods to address fuel in incremental burnup range
- The WCAP-18446-P/NP methodology is intended to demonstrate no dispersal for fuel in incremental burnup range

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Review Timeline

Westinghouse

- WCAP-18446-P Submitted Dec 2020
- Post-Audit Voluntary Supplement May 2021
- 1st Round RAI Responses #1 Feb, #2 Apr, #3 Jun
- 2nd Round RAI Responses #1 Dec, #2 Feb
- AXIOM Voluntary Supplement May 2023

- Mar 2021 Acceptance Review Complete
- Apr 2021 Audit
- Dec 2021 1st Round RAIs
- Sep 2022 2nd Round RAIs
- Oct 2023 Initial Draft SE
- Dec 2023 Filed Nonconcurrence
- Feb 2024 Response
- Apr SC, May FC ACRS

NRC

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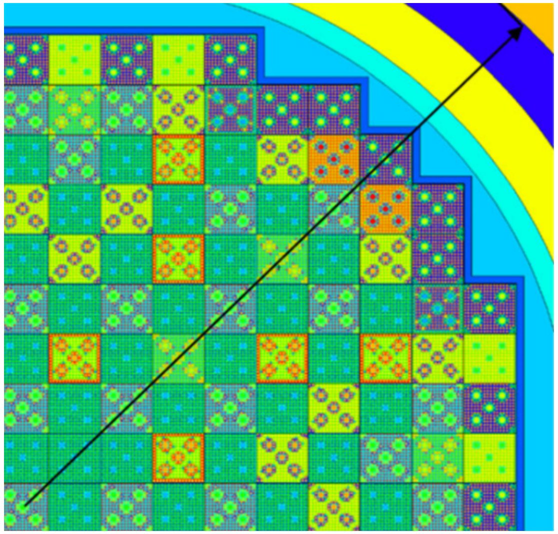
Key Regulatory Requirements and Guidance



- Fuel and Core Performance
  - General Design Criterion 10
    - Specified acceptable fuel design limits to assure cladding integrity for normal operation and anticipated operational occurrences
  - NUREG-0800, Standard Review Plan, Chapter 4.2
    - The fuel system is not damaged due to normal operation and anticipated operational occurrences
    - Fuel system damage is never so severe as to prevent control rod insertion when required
    - The number of fuel rod failures is not underestimated for postulated accidents
    - Core coolability is maintained

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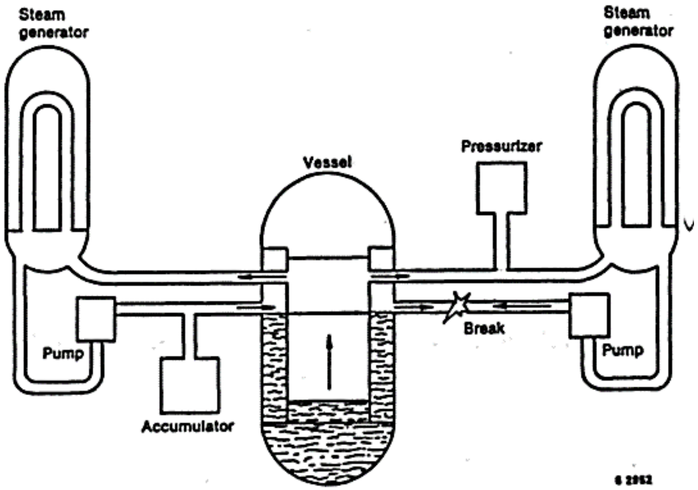
Key Regulatory Requirements and Guidance



- Loss-of-Coolant Accident
  - 10 CFR 50.46
  - General Design Criterion 35
  - Appendix K to 10 CFR 50
  - NUREG-0800, Standard Review Plan
    - Chapter 15.6.5, Loss-of-Coolant Accident
    - Chapter 15.0.2, "Review of Transient and Accident Analysis Methods"
  - Regulatory Guide 1.157, "Best-Estimate Calculations of Emergency Core Cooling System Performance"
  - Regulatory Guide 1.203, "Transient and Accident Analysis Methods"

Key Regulatory Requirements and Guidance

- Non-Loss-of-Coolant Accidents and Transients
  - NUREG-0800, Standard Review Plan, Chapter 15
  - Regulatory Guide 1.203, "Transient and Accident Analysis Methods"
  - General Design Criterion 27
    - Combined reactivity control systems capability
  - General Design Criterion 28
    - Reactivity limits
  - Regulatory Guide 1.236, "Pressurized-Water Reactor Control Rod Ejection and Boiling-Water Reactor Control Rod Drop Accidents"

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Key Regulatory Requirements and Guidance

- Containment
  - General Design Criterion 50, Containment design basis
- Technical Specifications
  - 10 CFR 50.36
- Radiological Dose
  - 10 CFR 100
  - 10 CFR 50.67
  - Regulatory Guide 1.195
  - Regulatory Guide 1.183

Fuel Assembly Mechanical Design

- Westinghouse proposed a methodology for extending the burnup limit for fuel assemblies
  - A set of design criteria
  - A method of evaluating against that criteria
  - The results of the evaluation for a specific design
- The 17x17 OFA design is generically approved for an incremental burnup extension. Other designs can be approved on a generic or plant-specific basis per L&C 1
- Westinghouse determined and the NRC staff found that the proposed assembly design criteria and evaluation methods were acceptable

Core and Fuel Rod Performance

- WCAP-18446-P/NP presents discussions across three separate phenomenological areas of Westinghouse codes and methods to justify extending the rod-average burnup limit:

    1. Fuel rod performance
    2. Nuclear design
    3. Core thermal-hydraulic design

Fuel Rod Performance

- Analyses will use the NRC-approved PAD5 code (L&C 7)
- Westinghouse evaluated the applicability of key models in the extended burnup range for each fuel rod design basis:
  - Fuel rod internal pressure
  - Fuel rod cladding stress
  - Fuel rod cladding strain
  - Pellet-cladding interaction
  - Fuel cladding oxidation and hydriding
  - Fuel temperature
  - Clad free standing
  - Fuel cladding fatigue
  - Fuel cladding flattening
  - Fuel rod axial growth
  - Fuel cladding wear
- NRC staff assessed these models and underlying phenomena and found them acceptable within WCAP-18446-P/NP (L&C 4, L&C 10)

Nuclear Design

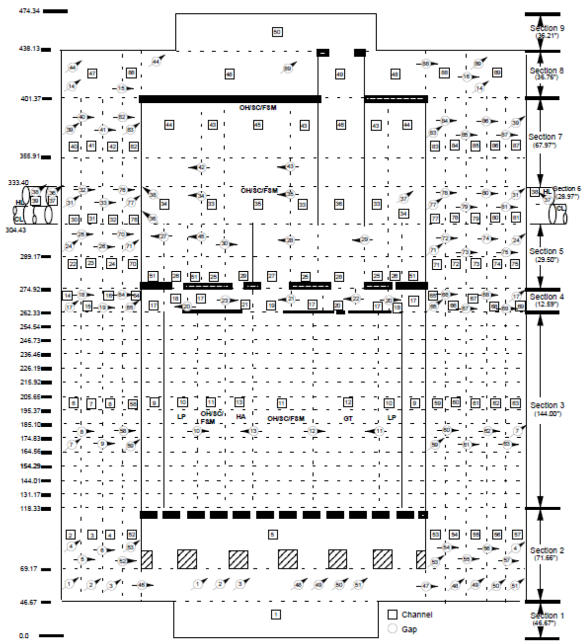
- Westinghouse proposed to continue using existing nuclear design codes
  - PARAGON or PHOENIX-P for lattice transport calculations
  - ANC for two- and three-dimensional nodal calculations
- Westinghouse asserted these codes are applicable to increased burnup conditions within existing 5% enrichment limit
  - Applicability of WCAP-18446-P/NP is limited to 5% enrichment per Limitation and Condition 5
- NRC staff examined two areas most likely to be stressed at an extended burnup range:
  - Production and depletion of major uranium and plutonium isotopes
  - Modeling increased critical boron concentrations
  - Found these areas are acceptable within the scope of WCAP-18446-P/NP

Thermal-Hydraulic Design

- Westinghouse proposed that no modifications are necessary to existing methods for analyzing departure for nucleate boiling
  - DNB correlations
  - VIPRE/W code
  - Revised Thermal Design Procedure, Westinghouse Thermal Design Procedure, etc.
  - DNB propagation
  - Fuel rod bow
- The NRC staff found that the T/H codes and methods are applicable up to the requested rod-average burnup extension limit

Loss-of-Coolant Accident Analysis Methods

- Objective of WCAP-18446-P/NP is to demonstrate no cladding rupture for fuel in incremental burnup range
  - Preventing cladding rupture implies no fuel dispersal
- Model for demonstrating non-rupture is based on FULL SPECTRUM™ LOCA methodology (WCAP-16996-P-A)
  - WCOBRA/TRAC-TF2 code



- Westinghouse evaluated PIRT phenomena for impacts of increased burnup (Table 1 of NRC safety evaluation)
- Key model updates include
  - Fuel rod cladding and rupture
  - Decay heat

Non-Loss-of-Coolant Accident Analysis Methods

- Transient (Anticipated Operational Occurrence) Analysis
  - Westinghouse divided these events into two categories:
    - Events dependent upon core-average effects
    - Events analyzed to assess local fuel rod behavior
  - Westinghouse stated that approved evaluation models remain applicable

Non-Loss-of-Coolant Accident Analysis Methods

- Reactivity Insertion Accidents
  - Westinghouse discussed its conformance with the fuel cladding failure thresholds in RG 1.236:
    - Peak radial average fuel enthalpy (calories per gram)
    - Departure from nucleate boiling
    - Pellet-cladding mechanical interaction
    - Fuel pellet incipient melting
  - Westinghouse proposed to apply its multi-dimensional kinetics methodology (WCAP-15806-P-A) or another approved evaluation model for this event
  - No fuel dispersal permitted for fuel rods in incremental burnup range

Non-Loss-of-Coolant Accident Analysis Methods

- Containment integrity analysis for LOCA and main steam line break (MSLB)
  - Short-term mass and energy release
    - Dominated by system conditions, not fuel conditions
      - E.g., break area, system temperature, pressure
    - Not impacted by incremental burnup extension
  - Long-term mass and energy release
    - Licensed methods for LOCA
      - WCAP-10325-P-A
      - WCAP-17721-P-A
      - CENPD-132P
    - Licensed methods for MSLB
      - LOFTRAN
      - RETRAN
      - SGNIII
  - Conservative modeling of decay heat and other parameters
    - As supported by Limitations and Conditions 13 and 14

Radiological Consequence Analysis

- Westinghouse addressed the radiological consequences of three types of accidents:
  - LOCA
  - Non-LOCA accidents
    - Steam generator tube rupture
    - Main steam line break
    - Reactor coolant pump locked rotor
    - Control rod ejection
  - Fuel handling accident
- General non-proprietary information provided in open presentation

Radiological Consequence Analysis: LOCA

- LOCA radiological consequence analysis typically performed per RG 1.183 or RG 1.195
- Westinghouse concluded that this guidance, and the codes and methods it uses to conform thereto, remain applicable for fuel in the incremental burnup range

Radiological Consequence Analysis: Non-LOCA Accidents

- Westinghouse stated that existing transient and radiological analysis methods for fuel within current burnup limits remain valid for fuel in incremental burnup range
- Existing technical specifications limit activity of primary and secondary systems

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Radiological Consequence Analysis: Fuel Handling Accident

- Impact of fuel dispersal for non-LOCA accidents not generically addressed in existing regulatory guidance
- Westinghouse considered the impacts of key factors, including
  - Behavior of key short- and long-lived radionuclides
  - Expected power history for fuel in incremental burnup range
  - Expected extent of fragmentation and dispersal
- Licensees will explicitly address fuel-handling accident consequences as part of license amendment requests proposing an incremental burnup extension

Applicability to ADOPT Fuel Pellets

- ADOPT fuel pellet topical report (WCAP-18482-P-A) approved in 2022 for existing burnup limits (i.e., within 62 GWd/MTU)
- December 2020 submittal of WCAP-18446-P/NP included consideration of ADOPT fuel pellets as an appendix
- The NRC staff found that ADOPT pellets perform acceptably similarly to standard UO_2 pellets such that the analyses and conclusions throughout the TR and SE remain applicable for ADOPT pellets

Applicability to AXIOM Cladding

- AXIOM cladding topical report (WCAP-18546-P-A) approved in 2023 for existing burnup limits (i.e., within 62 GWd/MTU)
  - Added to WCAP-18446-P/NP review scope by May 2023 voluntary supplement
- Existing cladding performance models contain adequate data up to the requested burnup limit
- AXIOM-clad rods in the incremental burnup range are subject to the same placement restrictions and no-burst criterion as fuel rods with other cladding designs
- The NRC staff determined that WCAP-18446-P/NP methodology applies to AXIOM cladding and the AXIOM specific models are acceptable at the higher burnup limit.

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Material Applicability Conditions

- Per Limitation and Condition 2, WCAP-18446-P/NP is only applicable to fuel products with
  - Uranium dioxide or ADOPT fuel pellets
  - ZIRLO®, Optimized ZIRLO™, or AXIOM cladding
- Per Limitation and Condition 3, WCAP-18446-P/NP is only applicable to
  - Unpoisoned fuel
  - Fuel with integral fuel burnable absorbers
  - Fuel with gadolinia

  (this limitation does not preclude use of discrete burnable absorbers)

Limitations and Conditions

- The NRC staff's draft safety evaluation contains 14 limitations and conditions that licensees adopting the methodology must address
  - Incorporated therein are 9 limitations Westinghouse proposed in WCAP-18446-P/NP or RAI responses
  - NRC staff modified several of the limitations proposed by Westinghouse
- Eight limitations and conditions have been noted in the foregoing presentation
  - The remaining 6 will be discussed during the closed presentation

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Conclusions

- The NRC staff found the WCAP-18446-P/NP incremental burnup methodology provides an acceptable approach for comprehensively evaluating fuel operation within the requested extended burnup limit, addressing
  - Fuel assembly mechanical design
  - Core and fuel rod performance
  - Non-LOCA & LOCA safety analyses
  - Radiological Consequences
- The staff's conclusions are predicated upon
  - The methodology being used within its approved range of applicability
  - Licensees acceptably addressing limitations and conditions in Section 4.0 of the staff's safety evaluation

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Table of Abbreviations

ACRS	Advisory Committee on Reactor Safeguards
10 CFR	Title 10 of the *Code of Federal Regulations*
DNB	Departure for Nucleate Boiling
FC	Advisory Committee on Reactor Safeguards Full Committee
FULL SPECTRUM™ LOCA	WCAP-16996-P-A, Revision 1, 'Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (Full Spectrum LOCA Methodology)
GWd/MTU	Gigawatt-days per Metric Ton of Uranium
L&C	Limitations and Conditions
LOCA	Loss-of-Coolant Accident
NRC	U. S. Nuclear Regulatory Commission
OFA	Optimized Fuel Assembly
PAD5	Performance Analysis and Design Mode

Table of Abbreviations (Contd.)

RAIs	Requests for Additional Information
RG	Regulatory Guide
RG 1.183	Regulatory Guide 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors”
RG 1.195	Regulatory Guide 1.195, “Methods And Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactors”
SC	Advisory Committee on Reactor Safeguards Subcommittee
SE	Safety Evaluation
TR	Topical Report
WCAP-18446-P/NP	WCAP-18446-P/WCAP-18446-NP, Revision 0, “Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs”

Enclosure 4

Westinghouse Closed Session Slide Package for the ACRS Subcommittee Meeting on WCAP-18446-P/NP

(Non-Proprietary)

March 2024

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

ACRS Fuels, Materials, and Structures Subcommittee Meeting

Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs, Westinghouse Topical Report WCAP-18446

Closed Session

Jeffrey Kobelak
Jim Laird
Yun Long
Westinghouse Electric Company
April 2024

Purpose of Meeting

- WCAP-18446-P/NP, "Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs" was submitted for NRC review by letter dated December 14, 2020
- A draft Safety Evaluation Report (SER) on the topical report has been made available to Westinghouse and the ACRS
- This meeting will provide an overview of the incremental burnup extension to the ACRS Fuels, Materials, and Structures Subcommittee

Overview

- Introduction
- Key Findings from NRC Review
- Discussion of Specific Functional Areas
  - Nuclear Design
  - Fuel Rod Design
  - Mechanical Design
  - Thermal-Hydraulic Design, Non-LOCA and Containment Analysis
  - LOCA Analysis
- Plant-Specific Implementation

Introduction

Key Findings from NRC Review

Discussion of Specific Functional Areas

- Nuclear Design
- Fuel Rod Design
- Mechanical Design
- T/H Design, Non-LOCA and Containment Analysis
- LOCA Analysis

Plant-Specific Implementation

Incremental Burnup Rationale and Benefits

- Utility Benefits
  - Improved fuel utilization
  - Improved backend cost
- Regulatory Benefits: Requires that various legacy issues are addressed and that utilities adopt latest regulatory guidance to implement
  - [ ]a,c
  - Incorporate PAD5 (explicitly accounts for thermal conductivity degradation (TCD)) into licensing basis
- Westinghouse Benefits
  - Provides a means to gather more high burnup data from rods in non-limiting locations

Constraints of Incremental Burnup Extension

- Limit on maximum rod average burnup of [ ]a,c
- Limited to rods in core peripheral assemblies
- Limited to rods which do not burst during a LOCA
- Limited to rods which [ ]a,c
- Expected limits on assembly and rod power vs burnup for incremental burnup rods and associated assemblies
  - Exact limits will be based on plant-specific implementation
    - Expect maximum rod relative power approximately [ ]a,c
    - Expect maximum assembly relative power approximately [ ]a,c

Constraints address fuel fragmentation, relocation, and dispersal (FFRD) for the fuel rods in the incremental burnup regime

Westinghouse

Overview of Incremental Burnup Topical Report

- Section 1: Overview and Methodology Roadmap
- Section 2: Fuel Assembly Mechanical Design
- Section 3: Core and Fuel Rod Performance
  - **Section 3.1: Fuel Rod Performance**
  - **Section 3.2: Nuclear Design Methods and Application**
  - Section 3.3: Thermal-Hydraulic Design
- **Section 4: Loss-of-Coolant Accident Analysis Methods**
- Section 5: Non-LOCA Safety Analysis Methods
  - Section 5.1: Transient Analysis
  - Section 5.2: Containment Integrity Analysis
- Section 6: Radiological Consequence Analysis
- Section 7: Summary and Implementation

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Introduction

Key Findings from NRC Review

Discussion of Specific Functional Areas

- Nuclear Design
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- LOCA Analysis

Plant-Specific Implementation

Key Findings from NRC Review

- Nuclear Design
  - Technical Specification Limit on Hot Channel Enthalpy Rise (FdH) at High Burnup
- Fuel Rod Design
  - Applicability of PAD5 to Higher Burnup Fuel Rods
- Loss-of-Coolant Accident Analysis
  - Addressing Potential for Fuel Dispersal
  - Criterion for Cladding Rupture
  - Research Findings Underpinning Draft 10 CFR 50.46c Rulemaking
  - Transient Fission Gas Release

Introduction

Key Findings from NRC Review

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Plant-Specific Implementation

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Incremental Burnup Application Impact for Fuel Management

- Allows for fuel only in peripheral locations to exceed the current 62 GWD/MTU pin burnup limit
  - [ ]a,c
  - Allows higher burned assemblies following two cycles of operation interior to the core to be used on the periphery
- Allows for a [ ]a,c feed assembly reduction per cycle when compared to an optimized design at current burnup limits
  - Higher enrichment of remaining feed assemblies offset reduced number of feeds
  - [ ]a,c

Application and Fuel Cost Benefit 3-Loop Core

a,c

Application and Fuel Cost Benefit 4-Loop Core

a,c

Impact of Incremental Burnup On Safety

- +/-8 Assemblies is within the current cycle-to-cycle variation
- Safety limit confirmation for each core reload to confirm assembly power assumed in LOCA analysis
- Peaking factors are slightly higher with lower number feeds but still retain acceptable margin to the TS limits

[ ]a,c

Westinghouse

ND Codes and Methods for Incremental Burnup Extension

- Nuclear Design principal codes and methods are based on NRC approved ALPHA-(PHOENIX/PARAGON)-ANC or APA codes
- Rod burnup extension up to [ ][a,c] does not require modification or updating of any previously NRC-approved topical reports assessing neutronics and nuclear design
- Methods implemented in the neutronic codes for fuel depletion remains unchanged and already contains the depletion capability to very high burnup for pellets exceeding 62 GWd/MTU in rods with an average burnup of 62 GWd/MTU

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Plant-Specific Implementation

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Fuel Rod Design - Introduction

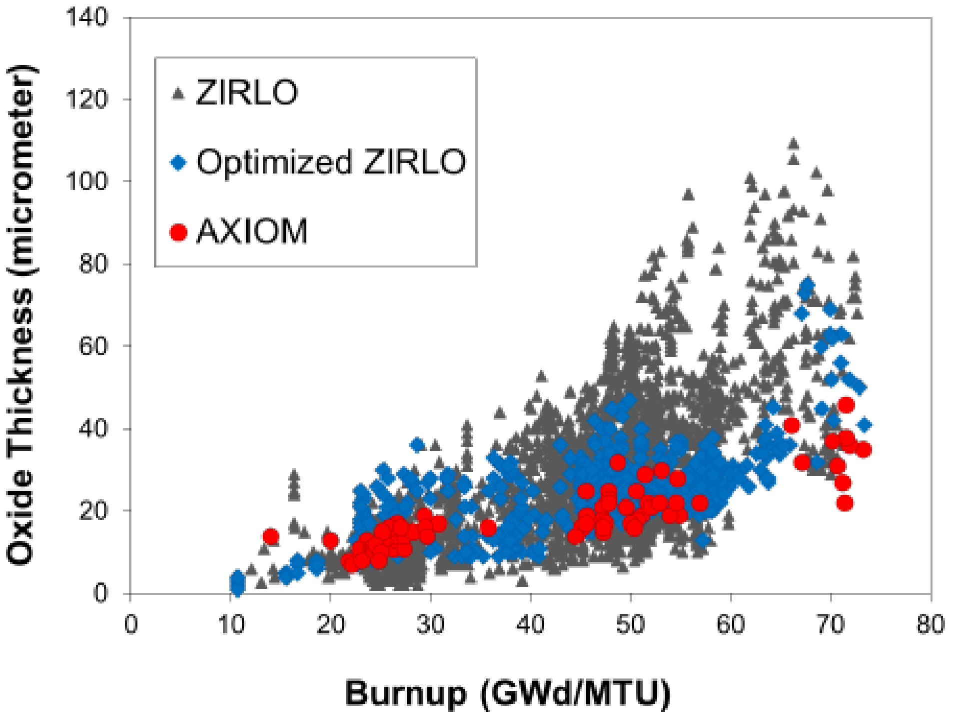
- Westinghouse fuel performance code PAD5 licensed in 2017 (WCAP-17642-P-A) was licensed for rod average burnup of 62 GWd/MTU, but was intended for high burnup application to **[ ]**^{a,c}
- Follow on topicals extended PAD5 application to **ADOPT**™ fuel and **AXIOM**® cladding
  - **ADOPT** fuel in WCAP-18482-P-A
  - **AXIOM** cladding in WCAP-18546-P-A
- Fuel performance models, database, and application methodology for design criteria were reassessed relative to extending the application to rod average burnups of **[ ]**^{a,c} from 62 GWd/MTU
  - No changes are needed

Westinghouse PAD5 FRD methods are applicable to rod average burnup of [ ]^{a,c}

Westinghouse

Fuel Rod Design - PAD5 Database

- Halden Project experiments provide measured fuel temperatures for UO_2 and Gd_2O_3-UO_2 fuel to high burnup [ ]^{a,c}
- Commercial irradiation programs provide measured fission gas release and rod growth data up to [ ]^{a,c} rod average burnup
- Joint International test programs provide data on high burnup [ ]^{a,c} fuel power ramp behavior



PAD5 has many high burnup and high duty data points

Westinghouse

Fuel Rod Design – PAD5 High Burnup Models

a,c

Technical bases for rod average burnup up to [[redacted]]a,c are provided in PAD5 topical

Introduction

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Plant-Specific Implementation

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Fuel Assembly Mechanical Design

- No change in current methods for evaluating Fuel Assembly (FA) performance under a given loading pattern for incremental burnup increase to a maximum of [ ]a,c rod average
- Methods are benchmarked to FA data with rods > [ ]a,c
- Codes providing inputs to FA analysis such as temperatures and fast neutron fluence are valid to > [ ]a,c rod average burnup
- [ ]a,c

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Plant-Specific Implementation

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T/H Design, Non-LOCA and Containment Analysis

a,c

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Plant-Specific Implementation

LOCA Analysis: Overview

- Primary LOCA-related concern with incremental burnup is FFRD
- Introduction of incremental burnup extension [

  ]a,c
  - New and updated models implemented into the associated thermal-hydraulic system code (WCOBRA/TRAC-TF2) to analyze higher burnup fuel rods

Nuclear Physics Data

- Updated nuclear physics data to higher burnup
  - U-235 fission fraction shown as an example

[ ]a,c

[ ]a,c

Cladding Rupture Criterion: Evolution during Licensing

a,c

Cladding Rupture Criterion: Final Result

a,c

- Cladding rupture model based on NUREG-0630 framework
- Robust database
  - [ ]a,c

[ ]a,c

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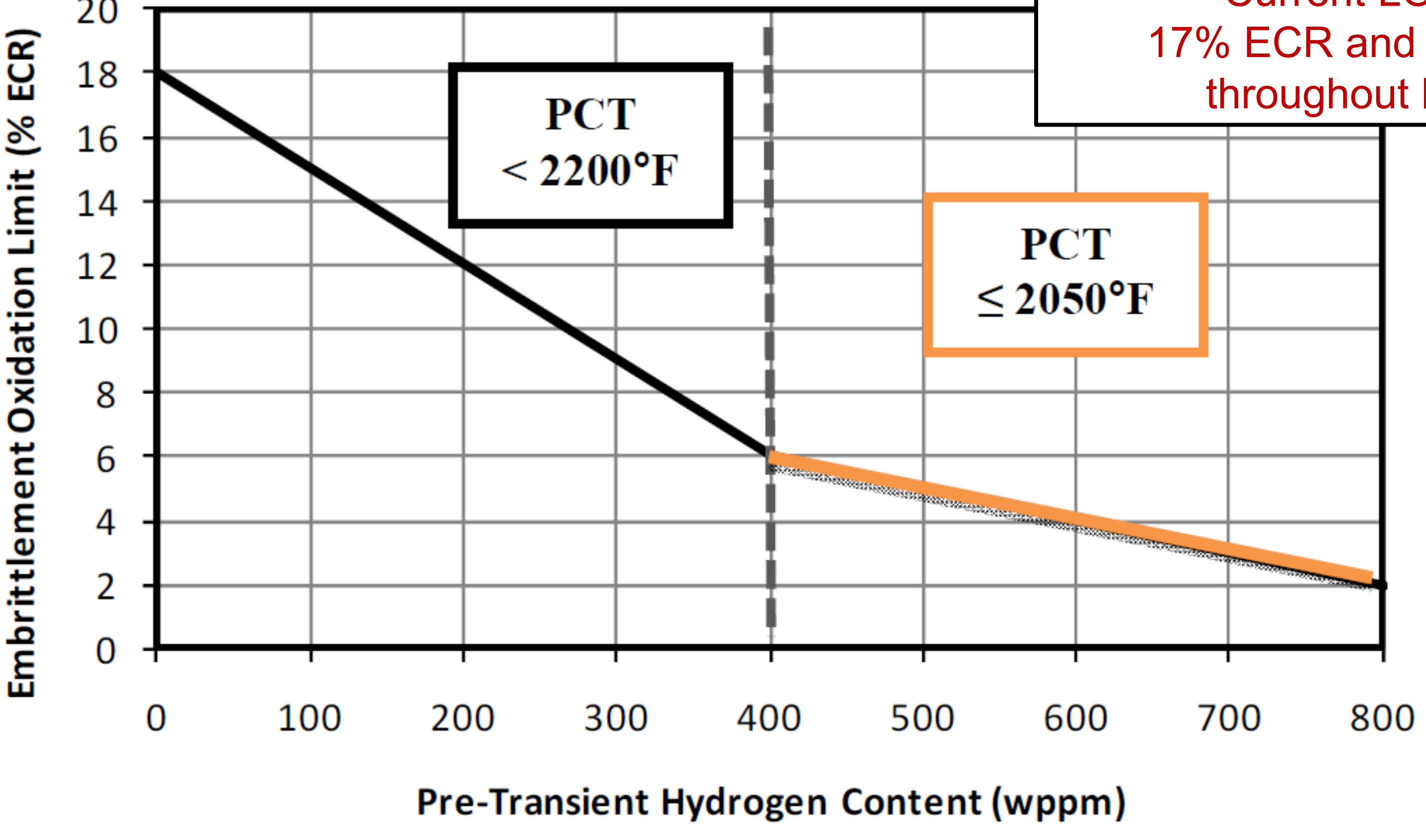
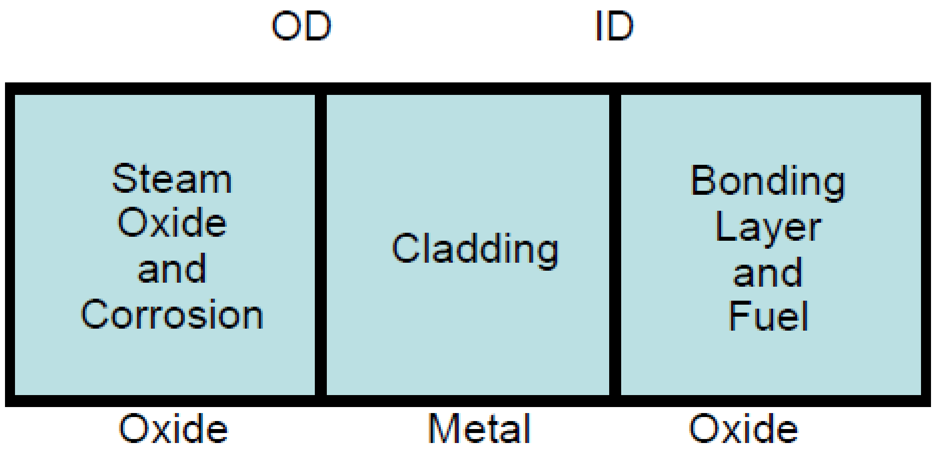
Research Underpinning Draft 10 CFR 50.46c Rulemaking

Current LOCA rule:
17% ECR and 2200°F PCT
throughout life of fuel



Oxygen enters cladding from oxide-bond-fuel layer



[NUREG/CR-6979]

[

]a,c

Transient Fission Gas Release
Prototypic LOCA Transient Fission Gas Release Testing

a,c

Transient Fission Gas Release
Fuel Temperatures for Incremental Burnup Fuel Rod

a,c

Fuel pellets for incremental burnup rods [ ]a,c

Transient Fission Gas Release
Fueled Rod Segment Heating Tests

a,c

Transient Fission Gas Release Conclusions

a,c

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Introduction

Key Findings from NRC Review

Discussion of Specific Functional Areas

- Nuclear Design
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- Mechanical Design
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- LOCA Analysis

Plant-Specific Implementation

Implementation

- Two parts to implementation

- 1: Generic topical report (today's topic)
  - Address burnup-related limitations and conditions on existing topical reports
  - Describe any required method updates or demonstrate that no updates are required for the various functional areas
  - Justify applicability of existing designs and methods for high burnup

- 2: Site-specific effort
  - Execute analyses, evaluations, and requirements of generic topical report
  - Plant-specific LAR submittal

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Site-Specific Implementation

- [ ]a,c
  - LOCA: Demonstrate no rupture in high burnup rods
- **FSLOCA** EM implementation (if not already completed)
  - Addresses TCD using fully NRC-approved methods
- "Not LOCA" PAD5 implementation (if not already completed)
  - Transient Analysis (Includes mechanistic DNB propagation evaluation method)
  - Fuel Rod Design

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Site-Specific Implementation (continued)

- Assess impact on existing analyses
  - Confirm mechanical design criteria are met
  - Confirm fuel rod design criteria are met
  - Confirm reload limits continue to be met
  - Assess vessel fluence calculations
  - Assess spent fuel pool and dry cask heat removal analyses

- LAR submittal for NRC review

Questions

Acronyms / Codes / Labels

Acronym	Definition
3D	3-Dimensional
ACRS	Advisory Committee on Reactor Safeguards
ADOPT	Advanced Doped Fuel
BOC	Beginning of Cycle
Bu	Burnup
CFR	Code of Federal Regulations
DNB	Departure from Nucleate Boiling
DNBR	Departure from Nucleate Boiling Ratio
ECCS	Emergency Core Cooling System
EM	Evaluation Model

Acronyms / Codes / Labels

Acronym	Definition
EOC	End of Cycle
FA	Fuel Assembly
FGR	Fission Gas Release
FRD	Fuel Rod Design
FSLOCA	FULL SPECTRUM LOCA
IBLOCA	Intermediate Break LOCA
ID	Inner Diameter
LAR	License Amendment Request
LBLOCA	Large Break LOCA
LOCA	Loss-of-Coolant Accident

Acronyms / Codes / Labels

Acronym	Definition
NRC	Nuclear Regulatory Commission
OD	Outer Diameter
OFA	Optimized Fuel Assembly
PAD	Performance Analysis and Design
PCT	Peak Cladding Temperature
RG	Regulatory Guide
SBLOCA	Small Break LOCA
SER	Safety Evaluation Report
T/H	Thermal-Hydraulic
TCD	Thermal Conductivity Degradation

Acronyms / Codes / Labels

Acronym	Definition
TS	Technical Specification
tFGR	transient Fission Gas Release
WCAP	Westinghouse Commercial Atomic Power

Management Perspective

- The technical issues raised by the non-concurrers are valid issues, and the non-concurrence resolution did not dispute any of them.

Management Perspective

- The evaluation and disposition of this non-concurrence relied on two things:
  - How the technical issues are currently being handled by the NRC; and
  - How the technical issues relate to the topical report in question.

Current Actions on FFRD

- FFRD at burnups below 62 GWd/MTU are currently not considered to be an immediate safety issue.
  - Section B of the non-concurrence summarizes the reasons for this position.
- The agency continues to seek resolution of the key questions.
  - FFRD PIRT
  - IE rulemaking
  - Etc.

Nexus to WCAP-18446-P/NP

- Westinghouse effectively established a separate basis for acceptability of WCAP-18446-P/NP.
  - WCAP-18446-P/NP was shown to be acceptable within its range of applicability.
  - WCAP-18466-P/NP does not affect the current basis for acceptability of methodologies used to analyze rod average burnups up to 62 GWd/MTU.

Non-Concurrence Resolution

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- The technical/safety issues raised by the non-concurrers are being handled within other appropriate activities by the agency.
- The specific issues regarding rod burnups below 62 GWd/MTU are not within the scope of WCAP-18446-P/NP, so the limitation proposed by the non-concurrers was deemed to not be appropriate as part of a regulatory decision on the acceptability of WCAP-18446-P/NP.

Abbreviations

FFRD	Fuel Fragmentation, Relocation, and Dispersal
GWd/MTU	Gigawatt-days per Metric Ton of Uranium
IE	Increased Enrichment
NRC	U. S. Nuclear Regulatory Commission
PIRT	Phenomena Identification and Ranking Table
WCAP-18446-P/NP	WCAP-18446-P/WCAP-18446-NP, Revision 0, “Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs”

NONCONCURRENCE ON NRC SAFETY EVALUATION ON WCAP-18446-P/NP

PRESENTATION TO ADVISORY COMMITTEE ON REACTOR SAFEGUARDS FUEL, MATERIALS, AND STRUCTURES SUBCOMMITTEE

OPEN SESSION
APRIL 2, 2024

JOHN LEHNING, SR. NUCLEAR ENGINEER
KEVIN HELLER, NUCLEAR ENGINEER

SUMMARY OF NONCONCURRENCE

- Two technical staff who reviewed WCAP-18446-P/NP are unable to concur upon the NRC's draft safety evaluation conclusions regarding fuel dispersal
- Original safety evaluation drafted by the staff included a limitation and condition requiring licensees implementing WCAP-18446-P/NP to
  - Assess the potential for fuel dispersal from rods with less than 62 GWd/MTU rod-average burnup
  - Justify that the estimated quantity of dispersed fuel does not result in non-compliance with the acceptance criteria in 10 CFR 50.46
- Agency management removed proposed limitation and condition
- Absent the proposed limitation and condition, the nonconcurring staff found insufficient basis to conclude that
  - Plants implementing the methodology would comply with existing regulatory requirements
  - Public health and safety would be adequately protected

PRESENTATION OUTLINE

- **NONCONCURRING STAFF**
- BACKGROUND
- DISCUSSION
- ALTERNATIVES TO NONCONCURRENCE
- CONCLUSION

NONCONCURRING STAFF

J. Lehning

- 24 years of NRC service
- > 20 years in Division of Safety Systems
- M.S.E. & B.S.E., Nuclear Engineering & Radiological Sciences
- University of Michigan

K. Heller

- > 13 years of NRC service
- All in Division of Safety Systems
- M.S.E & Ph. D., Nuclear Engineering
- B.S., Electrical Engineering
- Pennsylvania State University

- This presentation describes the independent professional judgments of two long-serving employees in the Division of Safety Systems of NRR.
- Presentation is not intended to speak on behalf of the NRC staff

PRESENTATION OUTLINE

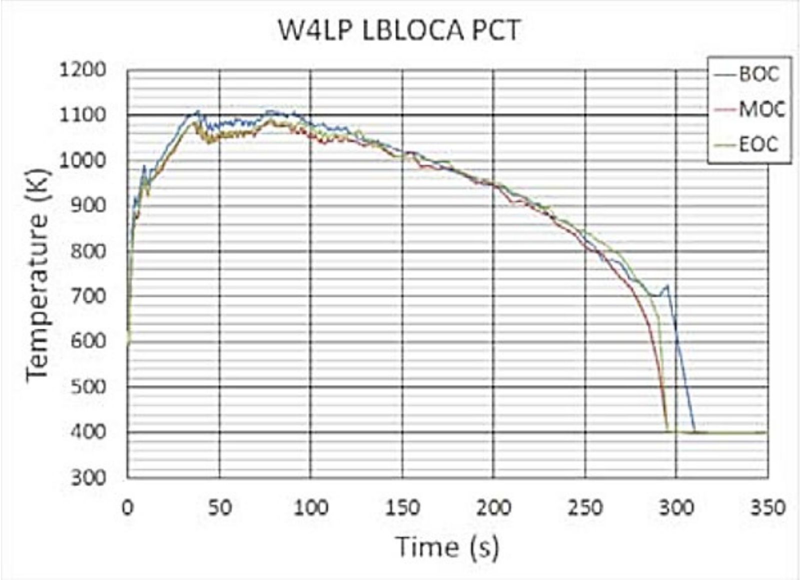
- NONCONCURRING STAFF
- **BACKGROUND**
- DISCUSSION
- ALTERNATIVES TO NONCONCURRENCE
- CONCLUSION

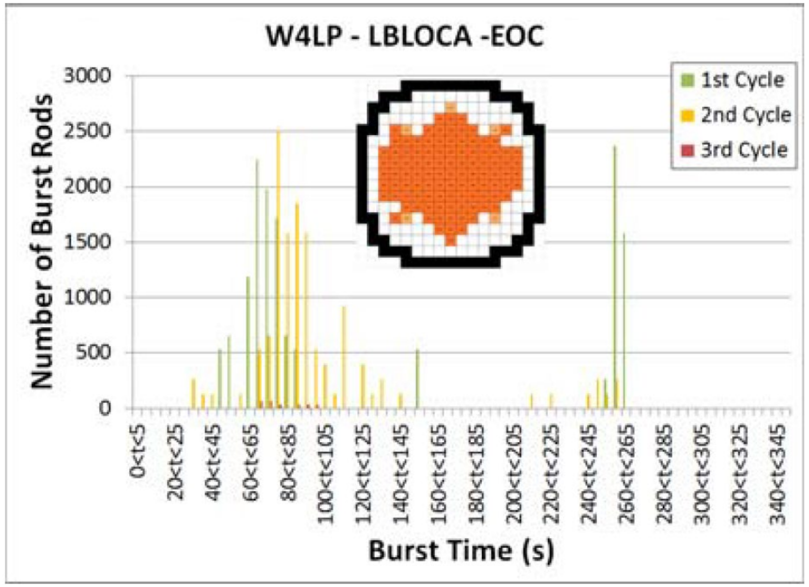
IS THERE A VALID SAFETY QUESTION ASSOCIATED WITH FUEL DISPERSAL?

- The modified safety evaluation includes an assertion that the NRC has a current position that *"fuel dispersal is not a significant safety issue for burnups below 62 GWd/MTU"*
  - No experimental or analytical basis is cited that is capable of supporting such a definitive conclusion
- Meanwhile, recent experimental evidence and analytical calculations suggest that substantial quantities of fuel could be dispersed from the cores of operating reactors during a loss-of-coolant accident:
  - RIL 2021-13 summarizes recent experimental data and describes how fuel fragmentation and dispersal might be modeled
  - NRC staff analyses presented at TOPFUEL and NURETH
  - Additional proprietary information to be discussed in closed session

RAYNAUD & PORTER TOPFUEL PAPER (2014)

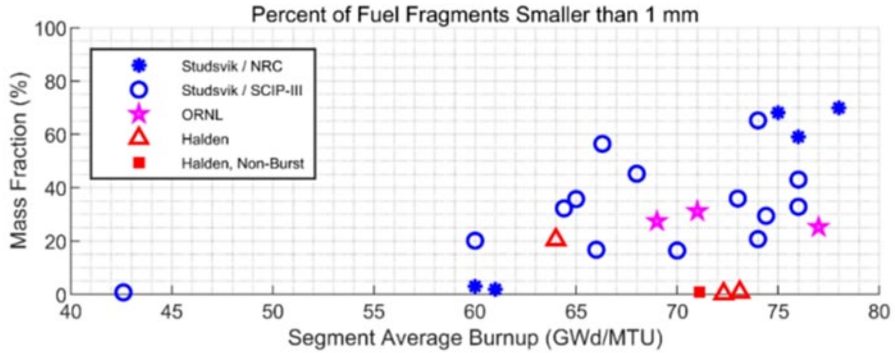
- Analysis using FRAPCON/FRAPTRAN and TRACE
- Dispersal of fuel assumed between 55 and 70 GWd/MTU local pellet burnup
  - Three different sensitivities on threshold
- Results at end-of-cycle very sensitive to burnup threshold for dispersal for Westinghouse 4-Loop reactor design
  - Core-average discharge burnup of 54.5 GWd/MTU
  - From ~~105 to 622~~ 35 – 207 kg of dispersed fuel predicted at EOC
- Other reactor designs considered showed no fuel dispersal
  - Combustion Engineering, General Electric BWR/4
  - Very low peak cladding temperatures (<975 K), apparently below rupture temperature for fuel rods susceptible to fragmentation

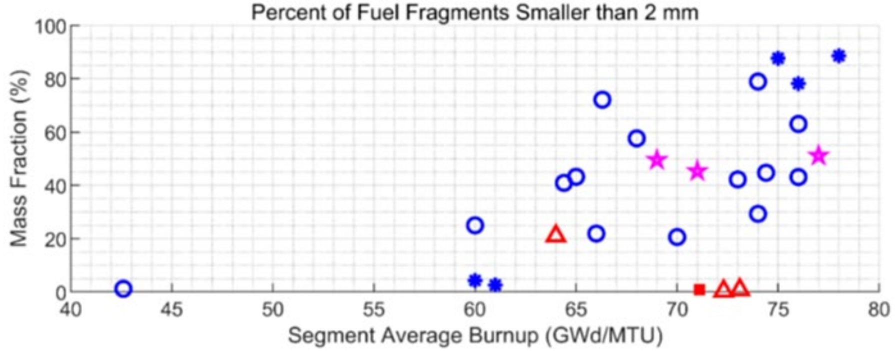




RESEARCH INFORMATION LETTER 2021-13

- Fuel fragmentation, relocation, and dispersal phenomena are correlated to burnup
  - Fuel dispersal is correlated with fuel fragment size and burst opening size
- Available data indicates that fuel dispersal is limited to fuel with
  - Pellet average burnup > 55 GWd/MTU
  - Cladding strain > 3%
- Modeling approaches in Appendix A can be used to predict the mass of dispersed fuel



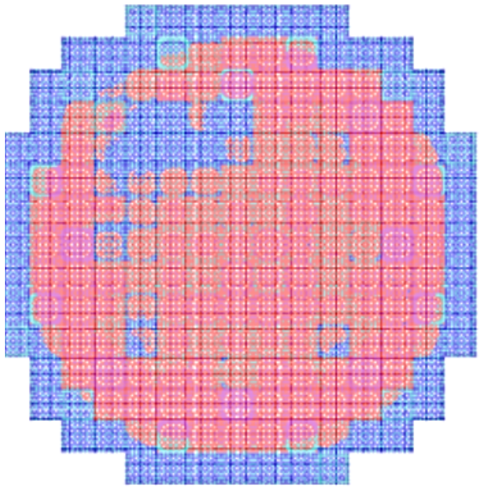


	Difference between dispersal predicted by the model and all mobile fuel observed in the experiment	
SCIP test	Mass (g)	Prediction/Measured
OL1L04-LOCA-2	125	250%
N05-LOCA	-19	76%
VUR1-LOCA-1	15	109%
WZR0067-LOCA	-16	83%
VUL2-LOCA1	-7	94%
VUL2-LOCA3	8	105%
VUL2-LOCA4	5	102%

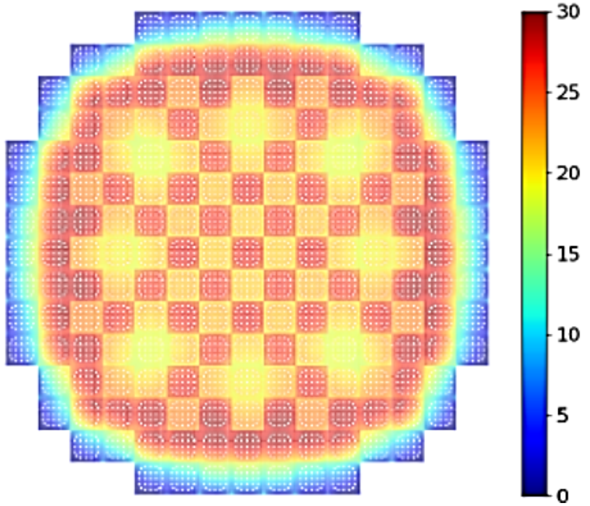
BIELEN, CORSON, STAUDENMEIER NURETH PAPER (2023)

- Analysis using SCALE/Polaris, PARCS/PATHS, TRACE, FAST
- EOL assembly burnups > 71 GWd/MTU
- Mass of fuel was estimated using various models derived from Appendix A of RIL 2021-13
- The paper calculated a percentage fuel dispersal between 0.6% and 3.5%…
- Considering that a large, Westinghouse 4-Loop reactor core, the total weight of UO_2 fuel may be ~100 tons…
  - the dispersed weight of fuel would be between ~0.5 and 4 tons

Parameter	Base Case	Chopped Cosine Power Shape	Top Peak Power Shape	Top Peak Power Shape (1 ECCS train)
Burst rods (%)				
IFBA	64	68	76	78
Non-IFBA	40	32	69	80
Total	58	58	74	78
Fuel dispersal (%)				
All fragment sizes	2.3	2.8	3.5	3.4
Fragments < 1 mm	1.1	1.9	2.1	2.1
Fragments < 1 mm above burst	0.6	1.3	1.1	1.1



Red/magenta = burst
Blue/cyan = non-burst



LHGR (kW/m)

KEY CONTENTION

- Absent further effort, it is not generally possible to conclude with the *"high level of probability"* required in 10 CFR 50.46(a)(1)(i) that compliance has been achieved with relevant regulatory requirements, including
  - coolable core geometry requirement in 10 CFR 50.46(b)(4)
  - long-term core cooling requirement in 10 CFR 50.46(b)(5)
  - equipment performance
- The nonconcurrence therefore advocates for the assessment and resolution of a well-founded safety question regarding fuel dispersal
  - The nonconcurrence is ***not*** asserting that
    - operating reactors are definitively out of compliance with regulatory requirements
    - corrective actions per 10 CFR 50.109 are necessarily justified
  - Rather, existing NRC processes should be exercised to address these safety questions
  - The NRC should further assure licensees' regulatory compliance prior to approving additional increases in fuel burnup that could exacerbate the existing safety question

WHERE DO WE FIND THE TECHNICAL BASIS DEMONSTRATING THAT PLANT OPERATION IS SAFE?

- The safety of each operating plant is demonstrated by, among other things, the licensing-basis safety analysis that is typically included in Chapter 15 of the Final Safety Analysis Report
  - Analysis of the loss-of-coolant accident (LOCA) event is typically in Section 15.6.5
- Safety analyses are typically performed using evaluation models approved by the NRC staff for their intended application
  - E.g., Westinghouse's Full-Spectrum LOCA evaluation model

DO EXISTING LOCA ANALYSES OR EVALUATION MODELS ADDRESS FUEL DISPERSAL AND ITS IMPACTS?

- The agency's response to the nonconcurrence states that

> *The proposed analysis methodology and associated NRC staff evaluation only addresses fuel dispersal in the requested burnup range. Demonstration of compliance with 10 CFR 50.46 requires analysis of all the fuel assemblies in the core, regardless of burnup. Therefore, fuel assemblies with a burnup less than 62 GWd/MTU will continue to require analysis to demonstrate compliance with applicable rules and regulations. Licensees may utilize current approved methodologies to evaluate fuel assemblies for burnups up to 62 GWd/MTU.*

- However, all existing LOCA evaluation models and analyses used for demonstrating compliance with the acceptance criteria in 10 CFR 50.46(b) completely neglect the modeling of fuel dispersal and its consequences
  - Can models that do not include the relevant phenomena be considered capable of providing confidence that regulatory compliance exists with respect to fuel dispersal?

NO DETERMINATION OF COMPLIANCE WITH REGULATIONS

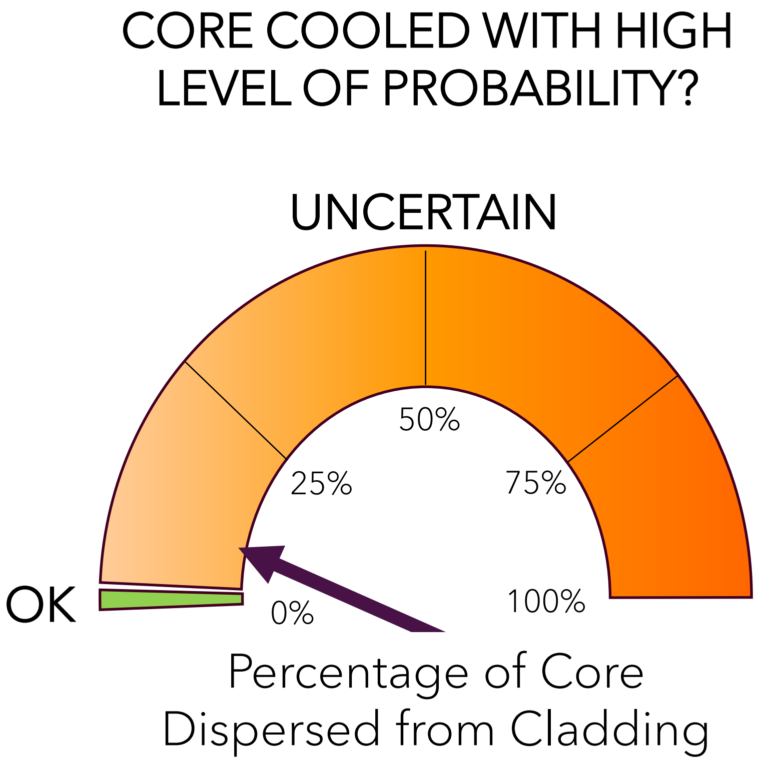
- The modified draft safety evaluation does not find it necessary to address regulatory compliance for operating reactors:

  > *… the NRC staff's approval of WCAP-18446-P/WCAP-18446-NP, Revision 0 does not imply any consideration about the acceptability of fuel dispersal for fuel cladding below 62 GWd/MTU peak rod average burnup…*

- The nonconcurrence believes a compliance demonstration is necessary, and presses the point in a slightly different direction:
  - Absent additional effort, it is not generally possible to conclude that licensees affected by fuel dispersal are reasonably assured of maintaining a coolable core geometry and complying with other related regulatory requirements
- The nonconcurrence does not, however, go so far as to assert that licensees are definitively out of compliance with applicable regulations
  - Rather, the nonconcurrence advocates that well-founded safety question concerning fuel dispersal should be resolved prior to approval of further fuel burnup increases that could exacerbate existing safety question

WHICH FACTORS HAVE HINDERED A REGULATORY COMPLIANCE DETERMINATION WITH RESPECT TO FUEL DISPERSAL?

- Large uncertainties and significant unknowns exist with respect to physical phenomena governing fuel dispersal and its downstream impacts
- NRC does not have a well-defined, technically defensible agency position concerning what threshold quantity of fuel dispersal would constitute an uncoolable core geometry or result in other unacceptable safety outcomes



UNCERTAINTIES IN FUEL DISPERSAL AND DOWNSTREAM PHENOMENA

- The agency continues to sponsor research on fuel dispersal
  - This research may in the future yield sufficient insights to permit confident estimation of fuel fragmentation, relocation, and dispersal against defensible acceptance criteria
- Furthermore, the agency has used developmental analytical methods to provide the best available insights concerning with fuel dispersal and its impacts
- However, these developmental methods lack the pedigree of existing evaluation models used to satisfy requirements for peak cladding temperature and other 50.46(b) acceptance criteria
  - E.g., developmental approaches for modeling fuel dispersal and its impacts would not satisfy validation criteria or other guidance in RG 1.203, Evaluation Model Development and Assessment Process
  - Large uncertainties even on dispersed quantity (e.g., approximately a factor of 3 to 6 in published journal articles)… let alone downstream impacts

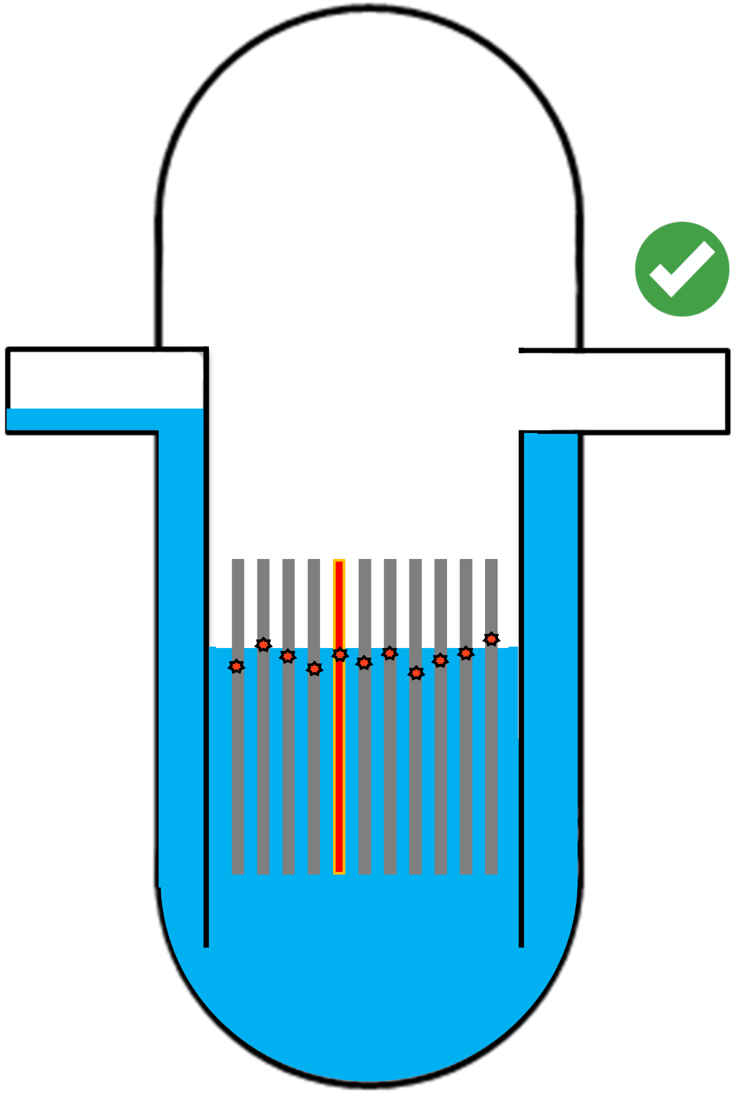
HOW MUCH FUEL DISPERSAL WOULD BE ACCEPTABLE?

- The nonconcurrence argues that the agency's actions regarding WCAP-18446-P/NP do not appear consistent with the existence of clear and documented acceptance criteria for fuel dispersal
  - The specific intent of the coolable core geometry requirement in 10 CFR 50.46(b)(4) with respect to dispersed fuel is not the central issue upon which this non-concurrence is founded
  - However, historical discussion is necessary to support a fulsome contextual understanding of existing regulatory requirements
- As we are considering the historical basis, we should keep in mind
  - While the Commission has delegated to the NRC staff authority to assess compliance with its regulations on routine matters, the NRC staff cannot change or reinterpret regulations
  - Revisions to regulations, including reinterpretation of existing requirements, must be done via rulemaking

COMMISSION'S OPINION ON 10 CFR 50.46 ACCEPTANCE CRITERIA

In its opinion on the matter of the rulemaking hearing on the acceptance criteria for emergency core cooling systems for light-water-cooled nuclear power reactors 10 CFR 50.46, the Commission stated relative to the acceptance criteria for peak cladding temperature and maximum local oxidation that

> *The purpose of these first two criteria is to ensure that the zircaloy cladding would remain sufficiently intact to retain the UO_2 fuel pellets in their separate fuel rods and therefore remain in an easily coolable array. Conservative calculations indicate that during the postulated LOCA, the cladding of many of the fuel rods would swell and burst locally with a longitudinal split. The split cladding would remain in one piece if it were not too heavily oxidized, and would still restrain the UO_2 pellets.*

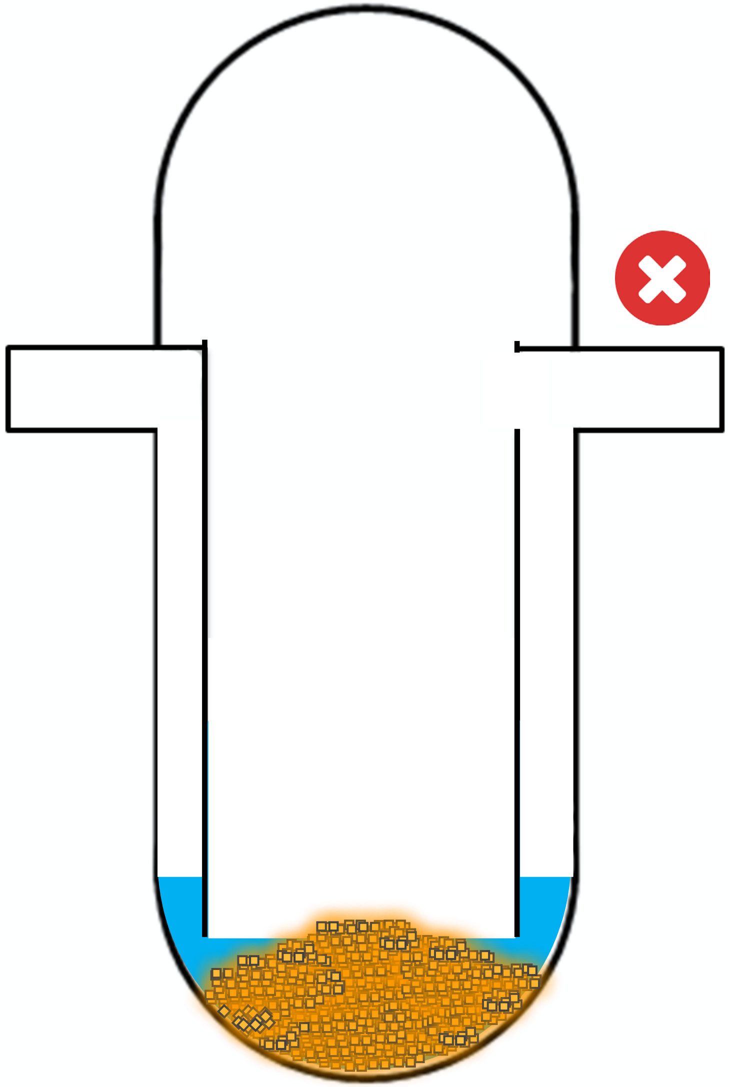


COMMISSION'S OPINION ON 10 CFR 50.46 CORE COOLABILITY

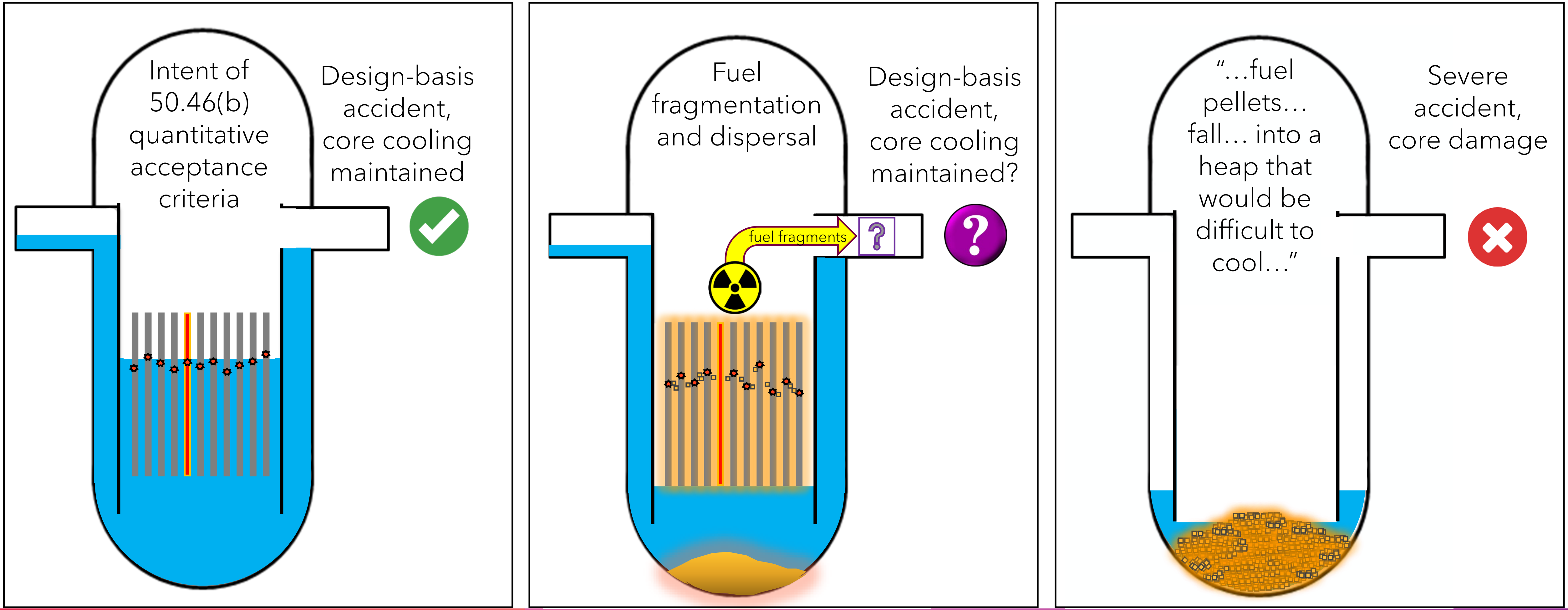
Concerning the requirement in (b)(4) for a coolable core geometry, the Commission further stated that

> *If there were no emergency core cooling after a LOCA, the core would probably eventually fuse together into a large mass with insufficient external surface area to allow the fission product heat generated within it to be transferred away. Intermediate steps in arriving at such a state might be the oxidation and melting of the zircaloy cladding, allowing the uranium dioxide fuel pellets to fall together into a heap that would be difficult to cool….*

> *Considering all of the required features of the evaluation models, we are inclined to agree that, for any situation that we have been able to anticipate, this criterion should be superfluous. However, in view of the fundamental and historical importance of maintaining core coolability, we retain this criterion as a basic objective….*



IS SIGNIFICANT DISPERSAL OF FUEL CONSISTENT WITH THE INTENT OF 10 CFR 50.46?



DOES REGULATORY COMPLIANCE MATTER?

- Absolutely – as stated in a 2004 Director's Decision in response to a Union of Concerned Scientists petition concerning the Davis-Besse Nuclear Power Station:

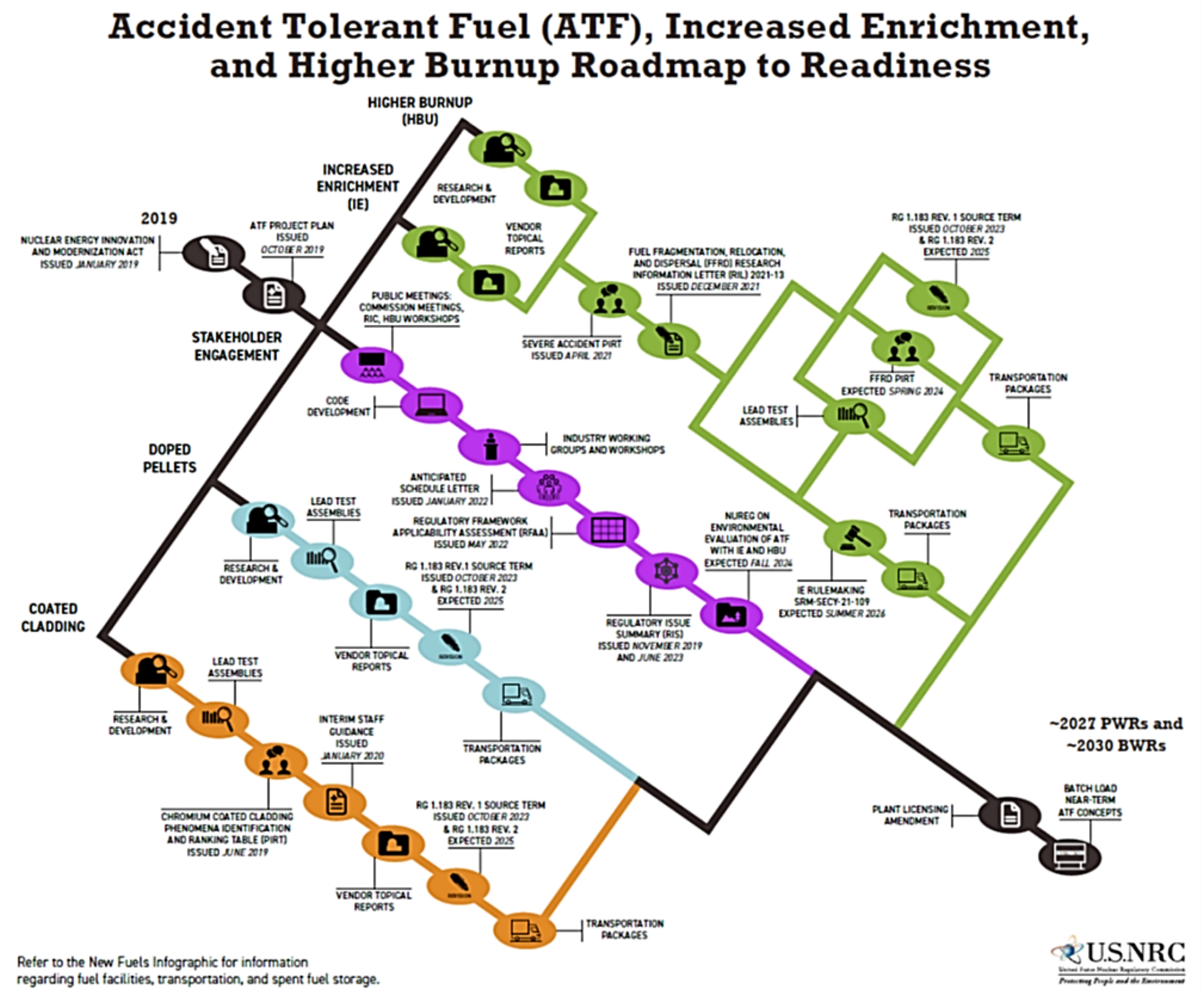
> *Reasonable assurance of adequate protection of public health and safety is, as a general matter, defined by the Commission's health and safety regulations themselves.*

- An inability to demonstrate regulatory compliance is not logically equivalent to inadequate protection of public health and safety
- However, an inability to demonstrate compliance implies a safety question that should be addressed in a timely manner consistent with the regulator's public safety mission

WHY ARE WE BEFORE YOU NOW? MISSED OPPORTUNITIES TO RESOLVE FUEL DISPERSAL SAFETY QUESTION

- Generic Issue Program (2011-2016)
  - Issue was submitted and passed acceptance review as generic issue
  - Issue screened out due to potential inclusion in 10 CFR 50.46c proposed rule
    - However, fuel dispersal was not included in 50.46c proposed rule
  - Subsequently, rather than continuing pursuit of fuel dispersal as a generic issue, the issue was closed out in 2016 with a 2-page memorandum
- SECY Paper for Increased Enrichment Rulemaking (2022)
  - Staff recommended a SECY paper to document explicitly the agency's interpretation of the core coolability requirement in 10 CFR 50.46
    - NRC staff anticipated the need to decide licensing requests such as WCAP-18446-P/NP prior to rulemaking completion
  - Agency-selected approach for the increased enrichment rulemaking did not include the recommended paper

WHAT IS THE TIMELINE FOR RESOLVING FUEL DISPERSAL AT OPERATING PLANTS?



- An intricate timeline with defined dates exists for the licensing of advanced fuel designs (including high burnup)
  - Batch loading of near-term advanced fuel designs for pressurized-water reactors is planned for 2027
- Is an analogous process timeline in place for determining whether operating plants are in compliance with regulatory requirements for fuel dispersal?
  - No, despite the existence of agency processes specifically intended for addressing emergent safety questions

PRESENTATION OUTLINE

- NONCONCURRING STAFF
- BACKGROUND
- **DISCUSSION**
- ALTERNATIVES TO NONCONCURRENCE
- CONCLUSION

OBJECTIVE OF NONCONCURRENCE

- The foregoing background discussion has discussed at least a few policy matters
  - Determining agency policy extends well beyond the responsibility of working-level technical staff
  - The nonconcurrence is not intended as advocacy for any particular policy
- Rather, technical staff is responsible for and does advocate for
  - Faithfully implementing the Commission's existing regulations
  - Ensuring a valid technical basis exists for agency decisions
- Nonconcurrence at its core simply reflects disagreement with a specific agency decision on the WCAP-18446-P/NP safety evaluation that, in the context of other related actions the agency is taking / not taking:
  - Does not ensure compliance with existing agency regulations
  - Does not provide a valid technical basis to demonstrate protection of public health and safety

BASIS FOR NOT FINDING WCAP-18446-P/NP TREATMENT OF FUEL DISPERSAL ACCEPTABLE

- Licensees cannot be assured of complying with 10 CFR 50.46(b)(4) and other regulatory requirements at the present time
  - Irrespective of whether the WCAP-18446-P/NP methodology would predict additional dispersal of fuel in incremental burnup range
  - Regulations are not concerned with whether excessive fuel dispersal is from fuel rods within current burnup limits or fuel rods in incremental burnup range
  - Plants implementing the methodology cannot be assured of complying with regulatory requirements
- Because existing margins to regulatory requirements may be degraded or negative for plants implementing WCAP-18446-P/NP, sufficient defense-in-depth margin may not be available to accommodate significant, irreducible uncertainties associated with fuel behavior at increased burnup.

SAFETY ISSUES ASSOCIATED WITH PAST BURNUP INCREASES: FUEL FRAGMENTATION / DISPERSAL

- In the 1990s, licensed burnup limits for many types of fuel were increased to approximately 62 GWd/MTU
- The potential for fuel fragmentation and dispersal was not known at the time and not explicitly addressed in the staff's approval of these fuel burnup increases
- Concerns with fragmentation, relocation, and dispersal of fuel are still being recognized and reckoned with now, decades later
- Fuel dispersal in particular is at present not analyzed or addressed within the licensing basis of any plant
  - The licensing basis safety analysis for a plant is the objective rationale presented to the outside world for the safety of the plant
  - Licensing basis analyses should address real phenomena that are significant to the calculation

SAFETY ISSUES ASSOCIATED WITH PAST BURNUP INCREASES: THERMAL CONDUCTIVITY DEGRADATION

- As fuel burnup increases, cracking creates gaps that impede heat transport within a fuel pellet, increasing stored heat
  - Consequently, loss-of-coolant accident results can become more limiting mid-cycle
- Issue was discussed in three information notices between 2009 and 2012
- Licensees have since implemented interim patches to their existing fuel thermal-mechanical analysis methods
- Fuel vendors have since received approval for updated fuel thermal-mechanical methods
  - However, 15 years later, not all licensees have yet adopted approved updated methods
  - WCAP-18446-P/NP safety evaluation, Limitation and Condition 7 is a testament to this fact (staff-imposed condition that implementing licensees must use PAD5 for all safety analyses)

ON THE NEED TO MAINTAIN DEFENSE IN DEPTH MARGIN

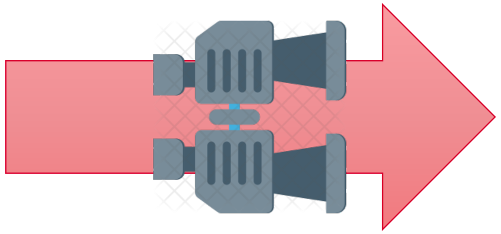
- The NRC strives for reasonable assurance of safety, not absolute assurance
  - While agency makes best possible decisions based on available evidence, its judgments are not infallible and new information or issues can emerge:
    - Fuel fragmentation, relocation, and dispersal
    - Thermal conductivity degradation
- Maintaining adequate defense-in-depth margin permits time for safety issue resolution:

Issue Resolution Stage	Fuel Dispersal	Thermal Conductivity Degradation
Issue initiation	1990s	1990s
Latency / issue recognition	2011	~2009
Assessment of significance	In progress (?)	~2009-2012
Interim measures	N/A	~2011-present
Approved solution	N/A	In progress

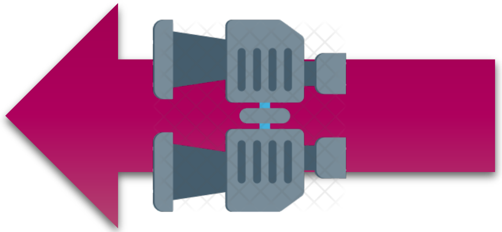
- If existing safety questions are left unresolved prior as fuel performance is pushed further, can we remain confident in the continued existence of adequate safety margins?

HOW CAN NRC ADDRESS EMERGENT SAFETY QUESTIONS?

Voluntary, forward-looking licensing basis changes



Mandatory backfit per 10 CFR 50.109



HOW CAN NRC ADDRESS EMERGENT SAFETY QUESTIONS? (1)

VOLUNTARY FORWARD-LOOKING CHANGE

- When an applicant agrees to implement a safety improvement, frequently as a condition for obtaining approval for a related, requested licensing action
- Only effective for licensees that voluntarily implement WCAP-18446-P/NP
- Burden of proof to demonstrate regulatory compliance is on licensees
- Use of voluntary, forward-looking change would be appropriate because a positive determination of compliance with relevant regulatory requirements is the basis for protection of public health and safety
  - Absent addressing fuel dispersal within current burnup limits, there is no basis for confidence that existing regulatory requirements are satisfied

HOW CAN NRC ADDRESS EMERGENT SAFETY QUESTIONS? (2)

MANDATORY BACKFIT PER 10 CFR 50.109

- When the NRC uses its statutory authority to require a licensee to implement corrective actions to its facility in accordance with 10 CFR 50.109
- Could be performed generically in a manner that encompasses all operating plants, irrespective of implementation of WCAP-18446-P/NP or other licensing actions
- Burden of proof is on staff to demonstrate:
  - Not only regulatory compliance
  - But also adequate cost-benefit justification
- Performance of a backfit evaluation for all operating plants would be appropriate because
  - Assuring a coolable core geometry is fundamental to reactor safety
  - A valid rationale for agency action / inaction supports principles of good regulation

PRESENTATION OUTLINE

- NONCONCURRING STAFF
- BACKGROUND
- DISCUSSION
- **ALTERNATIVES TO NONCONCURRENCE**
- CONCLUSION

ALTERNATIVE 1: ISSUE SAFETY EVALUATION WITH A LIMITATION AND CONDITION

- Original draft safety evaluation had included a limitation and condition requiring licensees implementing WCAP-18446-P/NP to assess fuel dispersal and assure compliance with 10 CFR 50.46(b)(4):

> *"Licensees implementing WCAP-18446-P/WCAP-18446-NP, Revision 0, shall assess the potential for fuel dispersal from fuel rods with less than 62 GWd/MTU rod-average burnup and justify that the estimated quantity of dispersed fuel does not result in non-compliance with the acceptance criteria in 10 CFR 50.46."*

- Discussion clarifying how it could be addressed was also included:

> *"…the NRC staff has phrased Limitation and Condition 11 in a performance-based fashion that would allow licensees implementing WCAP-18446-P/WCAP-18446-NP to consider information and regulatory positions developed under the rulemaking process in the resolution of the limitation and condition."*

ALTERNATIVE 1:ISSUE SAFETY EVALUATION WITH A LIMITATION AND CONDITION (2)

- Limitation was not intended to mandate that licensees implementing WCAP-18446-P/NP must demonstrate zero fuel dispersal (or any other particular dispersal limit)
  - Proposed limitation was rather intended as a flexible, performance-based requirement to
    - Assess fuel dispersal – which has up through the present, not been evaluated with technically defensible methods within any operating plant's licensing basis
    - Justify that compliance exists with applicable regulatory requirements
  - NRC staff has considerable latitude to impose such limitations and conditions where necessary to reach a finding of regulatory compliance
- NRC management removal of the proposed limitation and condition prompted the nonconcurrence of the two technical staff reviewers

ALTERNATIVE 2:PERFORM A BACKFIT EVALUATION FOR ALL OPERATING REACTORS

- Issue the WCAP-18446-P/NP safety evaluation with a commitment that the NRC would initiate a timely backfit evaluation to assess for all affected licensees whether imposition of corrective actions to address impacts of fuel dispersal within existing burnup limits is justified.
- Would establish a clear, public commitment to perform a timely, comprehensive assessment of:
  - Whether licensees are in compliance with existing regulatory requirements
  - Any corrective actions necessary to assure adequate protection of public health and safety and regulatory compliance against 10 CFR 50.109
- Completion of such an evaluation would encompass all evaluations and any corrective actions necessary to address fuel dispersal for plants that could potentially adopt WCAP-18446-P/NP (i.e., the focus of this nonconcurrence)

ALTERNATIVE 2:PERFORM A BACKFIT EVALUATION FOR ALL OPERATING REACTORS (2)

- A public commitment in the safety evaluation for WCAP-18446-P/NP to complete a comprehensive backfit evaluation would provide:
  - Adequate assurance the safety evaluation could be issued at the present time, because
    - A reasonable expectation would exist that the backfit results would be available prior to the agency's passing judgment on requests to adopt WCAP-18446-P/NP
- Non-concurring staff would find a public commitment to performing a backfit analysis an acceptable alternative to nonconcurrence
- NRC management did not agree with this alternative

ALTERNATIVE 3:DELAY SAFETY EVALUATION UNTIL REGULATORY COMPLIANCE IS DETERMINED

- Delay issuance of the WCAP-18446-P/NP safety evaluation and regulatory determination concerning its acceptability until validated analytical capabilities can be established to
    - Quantify how much fuel may be dispersed under LOCA conditions
    - Assess downstream impacts
- As elaborated earlier, defining acceptance criteria and performing calculations for fuel dispersal and downstream impacts remains a significant challenge
- Ongoing research, some of which is connected to the increased enrichment rulemaking, may result in validation and modeling enhancements that could better resolve fuel dispersal and its impacts

ALTERNATIVE 3:DELAY SAFETY EVALUATION UNTIL REGULATORY COMPLIANCE IS DETERMINED (2)

- Non-concurring staff would find this approach acceptable
  - Allow time to develop an adequate technical basis for evaluating fuel dispersal
  - Technical basis would determine with reasonable assurance whether licensees implementing the methodology would be in compliance with 10 CFR 50.46(b)(4) and other requirements

- NRC management did not agree with this alternative

ALTERNATIVE 4:ISSUE SAFETY EVALUATION AND PROPOSE FUEL DISPERSAL AS A GENERIC ISSUE

- At present, the generic issue process appears incapable of determining in a timely manner how much fuel may be dispersed under LOCA conditions and the downstream impacts
  - Section IV of Management Directive 6.4 indicates the three-stage process for resolving generic issues may take between 6.75 and 14.5 years
  - Whereas, licensees may begin requesting implementation of fuel burnup increases as soon as WCAP-18446-P/NP is approved
- While potentially viable in 2011 (when fuel dispersal was first raised as a generic issue), referral to the generic issue program no longer appears capable of providing adequate basis for issuance of the safety evaluation
- Non-concurring staff do not find this approach acceptable

ALTERNATIVE 5:ISSUE SAFETY EVALUATION WHILE CONTINUING FUEL DISPERSAL RESEARCH

- The management-endorsed, modified safety evaluation essentially follows Alternative 5 as described in the nonconcurrence
- The nonconcurring technical staff support further testing and analysis to resolve the fuel dispersal issue
- However, the management-proposed approach to approve burnup increases before research and analysis is completed to demonstrate compliance with NRC regulations does not appear sufficient to protect public health and safety because
  - Future research plans, and any speculation concerning possible insights therefrom, should not influence present regulatory decisions
  - Regulatory conclusions should be based upon currently available knowledge of fuel dispersal and the methodology's compliance with current regulatory requirements

ALTERNATIVE 5: ISSUE SAFETY EVALUATION WHILE CONTINUING FUEL DISPERSAL RESEARCH (2)

- The modified safety evaluation asserts that the NRC has a current position that "*fuel dispersal is not a significant safety issue for burnups below 62 GWd/MTU*"
- It is not clear to the nonconcurring staff how NRC management reached a conclusion that fuel dispersal is not a significant safety issue
  - No validated, licensing-basis safety analysis including the impacts of fuel dispersal has been performed for any operating reactors
  - No comprehensive compliance determination or backfit analysis has been performed for the fleet of operating reactors
- For the nonconcurring technical staff, the limited available evidence remains insufficient to justify a definitive conclusion regarding the safety significance of fuel dispersal
  - Fuel dispersal remains an open safety question that should be addressed before concluding WCAP-18446-P/NP demonstrates compliance with regulatory requirements

ALTERNATIVE 5: ISSUE SAFETY EVALUATION WHILE CONTINUING FUEL DISPERSAL RESEARCH (3)

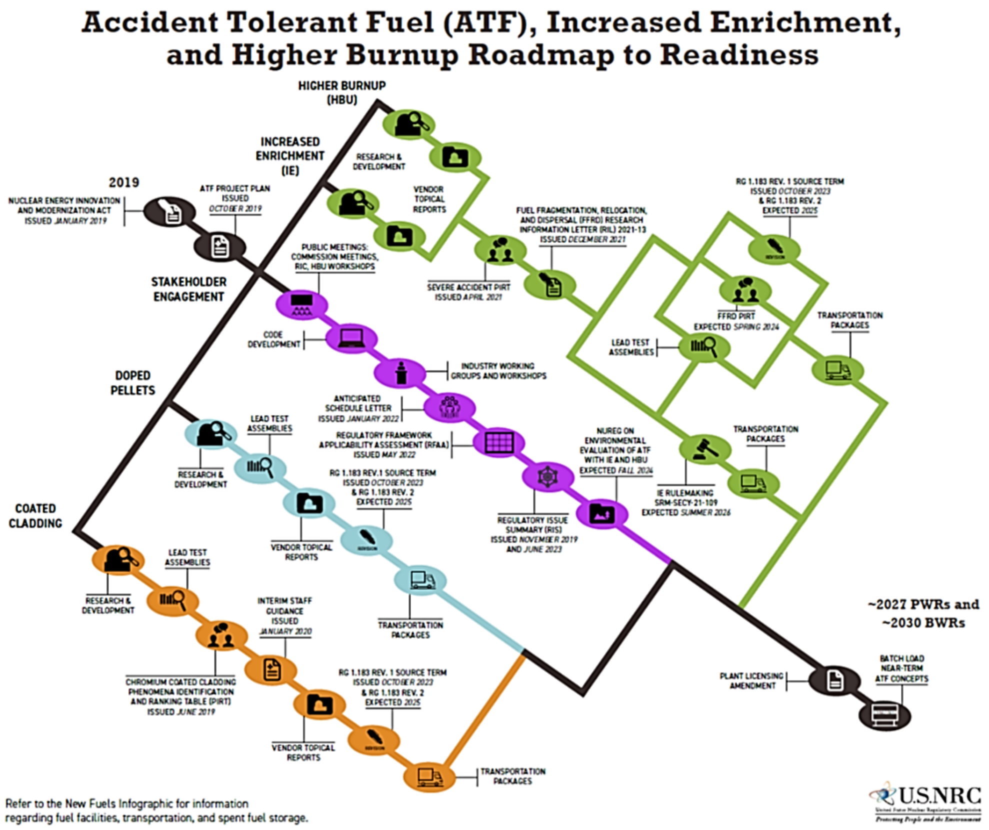
- The management-modified draft safety evaluation further notes that the NRC is sponsoring a PIRT on impacts of fuel dispersal
- The non-concurring staff note the agency's decision to perform such an exercise appears to acknowledge limited knowledge and significant open questions regarding fuel dispersal and its impacts
  - A PIRT is typically performed early in the process of analyzing a potential safety concern to identify and rank phenomena to focus upon in further experiments and analysis
- Is the acknowledged need for such basic research as a PIRT consonant with the definitive conclusion that "*fuel dispersal is not a significant safety issue for burnups below 62 GWd/MTU*"?

ALTERNATIVE 5:ISSUE SAFETY EVALUATION WHILE CONTINUING FUEL DISPERSAL RESEARCH (4)

- The modified safety evaluation notes that NRC will take appropriate regulatory action if future research challenges the NRC's position
- Non-concurring staff would agree appropriate regulatory action should be taken when a safety issue is identified after the NRC has made a regulatory decision, however:
  - The analytical effort involved with a backfit is far from trivial
  - The capability to justify imposing corrective actions per 10 CFR 50.109 is far from assured
  - The possible capability to impose corrective action via backfit is not an appropriate substitute for making an evidence-based, safety-focused, up-front decision

ALTERNATIVE 5:ISSUE SAFETY EVALUATION WHILE CONTINUING FUEL DISPERSAL RESEARCH (5)

- Considering the abstract nature of a PIRT, it appears unlikely, on its own, to be capable of confirming or refuting the safety significance of fuel dispersal for all operating reactors
- Definitive confirmation or refutation typically occurs via further downstream research or analysis for which the PIRT serves merely as a foundation
  - At present, such research and analyses sufficient to address fuel dispersal impacts at operating plants remain undefined and unscheduled
  - This indeterminacy is in contrast with the agency's roadmap for implementing increased fuel burnup, which has a detailed plan for achieving implementation by 2027



ALTERNATIVE 5: ISSUE SAFETY EVALUATION WHILE CONTINUING FUEL DISPERSAL RESEARCH (6)

- The modified safety evaluation indicates an expectation that the conclusions of future research will not conflict with the staff's findings regarding WCAP-18446-P/NP
- However, no objective basis for this expectation is apparent
  - If the agency's knowledge in an area were already reasonably assured, additional research or analysis in that area would be unnecessary to reach a regulatory conclusion
  - Yet the agency has deemed additional research necessary, and this research is currently at an early stage
- Ultimately, the modified safety evaluation makes no conclusion regarding whether operating reactors are currently in compliance with applicable regulations
- An approach that relies upon the results of future research cannot assure that licensees implementing WCAP-18446-P/NP would be in compliance with regulatory requirements regarding fuel dispersal in the present
- The nonconcurring staff do not find this approach acceptable

ALTERNATIVE 6: ISSUE SAFETY EVALUATION; PRESUME FUEL DISPERSAL ADDRESSED BY RULEMAKING

- The NRC staff is currently developing a proposed rule for the Commission's consideration concerning increased enrichment and has been directed to address fuel fragmentation, relocation, and dispersal therein
- The nonconcurring staff would support consideration of any dispersed fuel, irrespective of burnup, in the increased enrichment rulemaking
  - Considering the stated position in the modified safety evaluation that fuel dispersal within existing burnup limits is not a significant safety issue, its fate remains unclear
- Ultimately, neither the Commission's decisions concerning the content and acceptability of the proposed rule, nor its timeline, are knowable in the present
- The nonconcurring staff could not concur with issuing a safety evaluation that does not assess compliance with existing NRC regulations, under the presumption that a future rulemaking effort would allow substantial fuel dispersal

PRESENTATION OUTLINE

- NONCONCURRING STAFF
- BACKGROUND
- DISCUSSION
- ALTERNATIVES TO NONCONCURRENCE
- **CONCLUSION**

CONCLUSION

- Two individual staff have nonconcurred upon a management-modified draft safety evaluation associated with increased fuel burnups and fuel dispersal
  - The individual staff could not concur upon the safety evaluation's treatment of fuel dispersal
  - The safety evaluation is incapable of ensuring compliance with existing NRC regulations concerning core cooling and thereby assuring adequate protection of public health and safety
- Past agency decisions have not contributed to the effective resolution of the fuel dispersal safety question on a more generic basis
  - Decision not to fully assess fuel dispersal under Generic Issue program
  - Decision not to pursue a SECY paper to define intent of existing regulations
  - Decision not to pursue forward-looking regulatory action to address issue for licensees implementing WCAP-18446-P/NP
  - Decision not to undertake a generic backfit evaluation to address issue
- Fuel dispersal is an ongoing safety question that is not currently addressed in the safety analyses for operating reactors
  - The path forward for assessing and as necessary resolving the issue remains indeterminate
  - Even as well-defined plans further to increase fuel burnup continue to move forward

Meeting title
WCAP-18446-P Subcommittee
4/2/2024

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