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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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ACCIDENT ANALYSIS SUBCOMMITTEE

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OPEN SESSION

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TUESDAY

SEPTEMBER 16, 2025

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The Subcommittee met via hybrid Video-Teleconference, at 8:30 a.m. EDT, Robert Martin, Chair, presiding.

MEMBERS PRESENT:

ROBERT P. MARTIN, Chair

VESNA B. DIMITRIJEVIC*

GREGORY H. HALNON*

CRAIG D. HARRINGTON

WALTER L. KIRCHNER*

SCOTT P. PALMTAG

DAVID A. PETTI*

THOMAS E. ROBERTS

MATTHEW W. SUNSERI*

ACRS CONSULTANT:

RONALD BALLINGER

DESIGNATED FEDERAL OFFICIAL:

WEIDONG WANG

ALSO PRESENT:

KEVIN BARBER, WEC

JEREMY DEAN, NRR*

AARON EVERHARD, WEC

JERROD EWING, WEC

BRIAN ISING, WEC

JEFFREY KOBELAK, WEC*

JOHN LEHNING, NRR

SCOTT KREPEL, NRR

JACK VANDE POLDER, NRR

BRANDON WISE, NRR

*Present via telephone

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

8:30 a.m.

CHAIR MARTIN: The meeting will now come to order. This is the meeting of the Accident Analysis Subcommittee on the Advisory Committee on Reactor Safeguards. I am Robert Martin, I'm Chairman of today's Subcommittee meeting. ACRS Members in attendance and present are Craig Harrington, Scott Palmtag, Thomas Roberts and myself. ACRS Members in attendance via virtual via Teams, I'm going to check here and see, make sure everyone is here, are Vesna Dimitrijevic, Matt Sunseri, I don't see Vicki Bier, Greg Halnon and Walt Kirchner and Dave Petti. We have one of our consultants participating in person, it is Ron Ballinger. If I have missed anyone, which I don't think I have, either ACRS Members or Consultants, please speak up?

Weidong Wang, the ACRS staff, is the designated federal officer for this meeting. No member or conflicts of identified for today's meeting. We have a quorum.

During today's meeting the Subcommittee will receive a briefing on topical report and staff's Draft Safety evaluation for Westinghouse Topical Report WCAP-18850, Adaptation of the Full Spectrum of

LOCA, Loss Coolant Accident, Evaluation Methodology to Perform Analysis Cladding Rupture for High Burnup Fuel.

The Westinghouse full spectrum LOCA evaluation model was licensed for the purpose of allowing licensees to demonstrate compliance with the emergency core cooling system acceptance criteria described in Title 10 of the Code of Regulations Part 50.46. The original full spectrum LOCA EM, evaluation model, was developed to analyze and demonstrate compliance, safety regulations for fuel burnups up to a certain limit.

With the Industry moving towards higher burnup fuel, which offers economic and operational benefits, a new methodology was required to address the unique behaviors of this advance fuel cycle. The primary objective of WCAP-18850 is to extend the applicability of Westinghouse's existing FSLOCA, particularly for the risk of cladding rupture and fuel fragmentation, relocation and disbursement.

ACRS was established by statute and is governed by the Federal Advisory Committee Act, or FACA. The NRC implements FACA in accordance with its regulations. Additionally, the importance of Sections 29 in 1(a), 2(b) of the Atomic Energy Act.

The ACRS advises the Commission with regard to the hazards of proposed or existing reactor susceptibilities and adequacy of the proposed safety standards. In addition, the ACRS is implementing Executive Order 14300 ordering to reform the Nuclear Regulatory Commission dated May 23rd, 2025. Section 4(b) of the EO states, in part, the functions of the ACRS shall be reduced to the minimum necessary to fulfill ACRS's statutory obligations and that review by ACRS shall focus on issues that are unique, novel and noteworthy.

The review and reporting on new reactor facilities and proposed safety standards are the minimum required functions of the ACRS under Section 29 and 2(b) of the Atomic Energy Act. The Commission may refer additional duties to the ACRS in accordance with the Act.

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

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

The ACRS, consistent with the Agency's value of public transparency and regulation of nuclear facilities provides opportunity for public input and comment during our proceedings. We have received no written statements or requests to make an oral statement from the public.

We have also set aside at the time of this meeting for public comments. Portions of this meeting may be closed to protect sensitive information as required by FACA, and the Government and Sunshine Act.

Attendance during the closed portion of this meeting will be limited to the NRC staff and its consultants, Westinghouse, and those individuals or organizations that have entered into an appropriate confidentiality agreement. We will confirm that only eligible individuals are in the closed portion of the meeting.

The ACRS will gather information, analyze relevant issues and facts and formulate proposed conclusions and declarations as appropriate for deliberation by the full committee. A transcript of the meeting is being kept and will be posted on our website.

When addressing the Subcommittee, the participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard. If you are not speaking, please mute your computer on Teams, by pressing *6 if you're on the phone. Please do not use the Teams chat feature to conduct sidebar discussions related to the presentations, rather limit use to limiting chat function to report IT functions.

For everyone in the room, please put all your electronic devices in silent mode. And mute your laptop microphone and speakers. In addition, please keep sidebar discussions in the room to a minimum since the ceiling microphone, particularly the one behind me, are live.

For presenters, your table microphones are unidirectional, and you'll need to speak into the front of the microphone to be heard. Notice how close I am at the moment.

Finally, if you have any feedback for the ACRS about today's meeting, we encourage you to fill out the public meeting feedback form on the NRC's website. All right, we will now proceed with the meeting. And to begin with, following the agenda, public's agenda, I'm going to turn to Scott Krepel for staff leadership opening remarks.

MR. KREPEL: Well thank you very much. I'm Scott Krepel speaking through a sign language interpreter, as I typically do, and I am the branch chief for the thermal methods and fuel analysis branch. And my staff is going to be presenting today their review of the WCAP-18850. And we will be giving a little bit of background about this topical report.

About one year ago my staff presented to you all on another topical reported related to incremental burnup. And so, that was to improve an increase in the burnup limits that the LOCA methods had been analyzed. So this topical report will go beyond that level. And it will support the fuel that the full high burnup for the Industry. And this will feed into the ALS that you will hear about in the future presentations.

But I want to emphasize that this method is not intended to address the FFRD explicitly. And so that will not be a topic of this discussion here today. But we will find out more when we get to the ALS presentation. So thank you.

CHAIR MARTIN: Okay. Thank you, Scott. And just to go on record here, a couple acronyms. ALS, Alternative Licenses Strategy. FFRD, Fuel

Fragmentation Relocation and Dispersal.

With that introduction we will now turn to Westinghouse. I believe Jerrod Ewing you are on deck here.

MR. EWING: I am indeed. Thank you, Mr. Chairman. Thank you, Members, for the opportunity to come in and discussion of our adaption of our Full Spectrum LOCA method to high burnup fuel as part of that EPRI alternative licensing strategy that Scott talked about.

This is obviously a very important initiative for the Industry as we like to add more megawatts on the grid. And I'm very excited to be able to present this to you all.

I want to thank Scott's staff for their review. It's been a good look at our method over the past year. And appreciate that.

And then also want to thank our partners in EPRI as part of this. And our customers as well. Can't forget them. So both those that are here in the room and those that are on the phone. Thank you.

CHAIR MARTIN: Do you want to introduce your speaker here --

MR. EWING: Sure.

CHAIR MARTIN: -- Jeffrey?

MR. EWING: Yes. So we have Mr. Kobelak will be presenting today. He is remote. I'll turn it over to him.

MR. KOBELAK: Okay, thank you, Jerrod, and thank you, Chairman Martin. I guess I did want to do a quick sound check. Are you able to hear me clearly in the room?

CHAIR MARTIN: We are. Go ahead.

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

So as Jerrod said, thank you for allowing us an opportunity on your agenda for the current Subcommittee meeting to present on WCAP-18850. This is a very important part of Westinghouse strategy moving forward with, I'd say really three different initiatives which kind of all mean the same thing. We typically refer to this as either ATF, meaning Accident Tolerant Fuel, HEF, meaning High Energy Fuel, or LEU+, all kind of referring to operating fuel products from a higher initial enrichment into a higher burnup regime.

So as part of my presentation today for the open session there are really four areas that I would like to cover in detail. The first one I wanted to talk a little bit about how this particular topical report interacts with our high energy fuel strategy, how it ties into the EPRI ALS for fuel dispersal. And really also the fourth coming 10 CFR 50.46(a) aspects of the increased enrichment rulemaking.

From there I'll move into an overview and purpose of WCAP-18850. The third topic I'd like to touch on is the focus areas within the topical report. And in the open session I will keep this relatively high level, but that will be a primary focus of the closed session presentations, which will happen later. And then finally, just a high level overview of the limitation and conditions associated with the topical report.

And I did want to point out there are a lot of acronyms used throughout this presentation. I did try to spell them out. For those who have a printed copy, there are tables at the end with all of the acronyms defined. And I will pause at the end of every slide for any questions.

Okay. So I wanted to start out with an overview of the integrated timeline for high energy fuel, or LEU+ deployment. And what you can see on this slide are bars indicating the relative timing of some of the key activities associated with the high energy fuel program.

So that first bar which shows the prime fuel futures, ADOPT fuel pellets and AXIOM cladding, those are all now products which have been reviewed and approved by the NRC available for region deliveries, and in some cases already being delivered as part of regions to utility customers.

The second bar there is the one that was referenced by Scott in his opening remarks. The incremental burnup topical report where we extended a number of our codes and methods up to an incremental increase in burnup which is in-between the limit of 62 gigawatt days per MTU and the limit that we're seeking for WCAP-18850.

The review on that has already been completed. And that is also an approved topical report by the NRC.

Where we're at today is working primarily on the next couple of lines here. So the next three, or four really, are all things that are running in parallel. So that third bar down is all of the different codes and methods that are needed to be developed for higher enrichment and higher burnup. And that is the grouping of topical reports that includes WCAP-18850, as indicated on this slide.

The fourth one is our chromium coated

cladding. So that's part of our encore ATF products. And the first topical report to license chromium coated cladding was already submitted to the NRC and it's currently under review by the NRC.

And then the third, the third piece there is the LEU+ manufacturing. So that's the facility that will produce the higher enriched fuel. That is also ongoing right now.

And then of course complementing many of these activities is the ongoing testing. Whether it's being done by Westinghouse or through cooperative agreements with National Labs on various high burnup and other ATF fuel samples that have been provided by Westinghouse. So the primary purpose in this scheme of WCAP-18850 is to demonstrate cladding rupture will not occur in high burnup fuel thereby precluding any concerns about the consequences of fuel dispersal.

CHAIR MARTIN: Okay. Jeff, this is Bob Martin. Just as a point of clarification, and maybe just, and really just for the record.

You currently have, Westinghouse currently has, I believe the TR is WCAP-16996, correct? That is your Full Strength LOCA that was approved a number of years ago. This is in addition, because that goes up to certain burnup limit, and then from that burnup limit on you have this new topical report. And it is a separate analysis that hangs on each of the original, is that correct?

MR. KOBELAK: Yes, that is correct. Maybe just one small clarification is that we are working on extended that WCAP-16996 approved methodology to higher enrichment and higher burnup to demonstrate compliance with the ECCS criteria. So that's a submittal that we're expecting to make at the end of this year.

And then as you indicated, WCAP-18850 is an additional separate method and separate analysis that's done in addition to the ECCS analysis specific to demonstrating no cladding rupture, to preclude fuel dispersal. So taking fuel up the higher burnup for LOCA requires both of those components. The analysis for the ECCS criteria and the application of 18850, as envisioned by Westinghouse.

CHAIR MARTIN: Okay. So that begs the question, again, obviously you're kind of thinking about it in that step, is why not just one analysis method that covers all these questions?

How do you think you need the two separate, or could you not incorporate into a single methodology both the questions related to ECCS 10 CFR

50.46 compliance and the high burnup into, let's say a single analysis evaluation model?

MR. KOBELAK: Yes, I'd say there is a couple reasons for that. The first one is that the fuel of interest for fuel dispersal is not necessarily the same fuel that's going to be limited when assessing the ECCS acceptance criteria. So the population of fuel rods that we're interested in relative to fuel dispersal is a different population of fuel rods than what we're interested in when we're trying to capture a limiting result anywhere in the core to demonstrate compliance with the 50.46 criteria.

So I would say that's probably the predominant reason. But there are at least one, or maybe a handful of parameters, that are treated differently for conservative reasons in demonstrating compliance with the ECCS criteria versus cladding rupture. So I'd say because of those two factors primarily it was easier, and maybe even required, to develop two separate methods rather than trying to do it all within a single analysis.

CHAIR MARTIN: Yes, I appreciate that. And I guess some of that information we might get into in closed session --

MR. KOBELAK: Yes.

CHAIR MARTIN: -- right?

MR. KOBELAK: Yes, I apologize. I kind of went a little bit higher level with that second response because it is the open session.

CHAIR MARTIN: Sure. I understand that. I see that we have a question from our full Committee Chair Walt. Go ahead.

MR. KIRCHNER: Yes, good morning. This is Walt Kirchner. I'm looking at this slide. It's a rather interesting choice of words. It's a view graph. Are you designing fuel for dispersal?

MR. KOBELAK: Walt, could I maybe ask you to clarify, when you say designing fuel for dispersal what you mean by that?

MR. KIRCHNER: Well you just stated that WCAP-18850, you were going to use to demonstrate no rupture for cladding bursts. So, what fuel dispersal are you talking about?

MR. KOBELAK: So, yes. So the intent of WCAP-18850 is to demonstrate that there would be no cladding rupture in the higher burnup fuel rods with the intent of then demonstrating that there is no fuel dispersal. And if there is no fuel dispersal, than there is not a need to analyze the downstream consequences.

So at least in the near-term leveraging this WCAP-18850, in conjunction with EPRI ALS, or potentially the 50.46(a) rulemaking as part of the increased enrichment rulemaking, our intent would be to demonstrate no cladding rupture and no dispersal in the near-term without having change aspects of the fuel design to particularly address fuel dispersal.

MR. KIRCHNER: So --

MR. KOBELAK: Did that answer your question?

MR. KIRCHNER: I just wanted you to go on record and say you're not designing for fuel dispersal. You're developing a methodology to demonstrate that you do not have fuel dispersal?

MR. KOBELAK: Yes, that is correct.

MR. KIRCHNER: All right, thank you.

CHAIR MARTIN: Kevin, you don't have to raise your hand.

MR. BARBER: Yes --

CHAIR MARTIN: You're in the room.

MR. BARBER: Yes, I just wanted Jeff to know that he may be giving me a second here since he's remote.

CHAIR MARTIN: Okay, go ahead.

MR. BARBER: I just wanted to note that we were here as part of the increased enrichment rulemaking ACRS Committee in December and January. We presented in conjunction with NEI and the other vendors and utilities in the Industry.

And just to be crystal clear, it's still Westinghouse's intention, because we see by precluding dispersal, precluding burnup of high, precluding rupture of high burnup rod we are able to avoid a lot of the uncertainties that are associated with coming up with a high probability statement related to fuel dispersal. I think that our intention is to avoid quantification of uncertainties.

And we have talked about it with the staff at a lot of the FFRD workshops we've had over the summer, and we have later this week, to kind of spawn from those ACRS meetings earlier this year. And again, so from our point of view, especially with the status with 50.46(a) rulemaking and the potential demarcation of beyond design basis analysis and design basis analysis.

Everything we're presented today is within the context of the design basis analysis. So we're looking at this in a high probability lens. And because there is so much uncertainty from our point of view related to coolability aspects after the fuel is dispersed, given the nature of the data that's existing in the Industry.

As Jeff mentioned, you know, we're working closely, obviously with the National Labs and skip program and invitees, et cetera. We're still trying to keep that same, on that same track where we were nine months ago. And so, just to be crystal clear, for Walt's question, we, at this time, have no intention of coming up with any fuel dispersal high probability calculations.

MR. PALMTAG: So this is Scott Palmtag. I just want to follow-up a little bit on the strategy here. So this is all for AXIOM fuel? Chromium coated fuel.

MR. BARBER: Yes, and, Scott, we have actually, Jeff is going to give a, maybe, Jeff, if you can jump to the next slide?

MR. KOBELAK: Yes, I was going to say, I'll cover that in just a moment, if we can hold the question. I'm going to get to the applicability of the method.

MR. ROBERTS: This is Tom Roberts. I want to follow-up on what Kevin and Jeff are saying in response to one question.

If I understand right, there is two branches, at least two branches, they're looking at. One is ALS, which says there would not be a calculation of anything beyond what you could show no plant rupture for. So that would be 1(a) 50 topical report where we can find the method you used.

The second approach would be, if you used 50.46(a) but it requires some sort of calculation for the larger break, beyond transition break. I think what you said at that future work, that you're not covering that today. And you would cover that either in future topical or some other way. But that would not be a no rupture, I would think, in your current thought. That it would not be demonstrated in these methods with the, you know, the beyond transition break, size break that you could show no rupture, is that right?

MR. BARBER: Yes. Yes, that's right. Go ahead, Jeff.

MR. KOBELAK: Yes. So I guess I could jump to this slide because I was just about to come to this one. I think I tend to agree that, yes, what you said is consistent with our planned approach. So I put this slide in here just to kind of differentiate the potential approaches exactly as you would outline.

So one possibility of using this WCAP-18850 is under EPRI ALS. So for EPRI ALS we would define a transition break size, which is essentially aligned with the largest connecting line to the main loop RCCS piping.

And for all LOCAs that are at break sizes equal to or smaller than the connected line pipping, we would demonstrate no cladding rupture using this method. So that's the top left blue box on this slide.

And then for breaks that are larger than that transition break size, we would aim to credit the EPRI ALS method that's currently under review by the staff to demonstrate that a large break LOCA with fuel dispersal was not a credible event. So no explicit analysis is needed. So that's the ALS option that you mentioned.

Under the increased enrichment rulemaking, 10 CFR 50.46(a) framework, I think that that's a little bit more uncertain until we see what the final state of that rule is. But for the small breaks that are under the transition break size the approach would essentially be identical. We would aim to demonstrate no cladding rupture.

And for breaks that are larger than that transition break size where we would be able to use design basis analysis methods, I think one option could be to potentially leverage the margin that comes out of that more best estimate or nominal analysis and potentially demonstrate that rupture doesn't occur. If that's not the case I do think that it would likely reduce the extent of potential dispersal and then we could look at other means to address coolability.

From my perspective, that's something that would be done on a longer timeline given, as Kevin mentioned a lot of the uncertainties that we're still trying to resolve around important phenomena for coolability with dispersed fuel.

MR. ROBERTS: Okay, thanks, Jeff.

MR. KOBELAK: Did that --

MR. ROBERTS: Yes, thank you.

MR. KOBELAK: No problem. Did that cover your question?

MR. ROBERTS: Yes. Have you done some sort of a quick look analysis that it's plausible to show no rupture for the large break? Or is that --

MR. KOBELAK: Yes, Kevin --

(Simultaneous speaking.)

MR. KOBELAK: Kevin, Kevin actually has done some work on that. We have a paper that will be presented at top fuel. I don't know, Kevin, if you want to take a moment just to provide a high level summary?

MR. BARBER: Yes. So, I mean, I think that was another hot topic during the December and January ACRS meeting on the rulemaking what exactly it to mean to be beyond design basis in a LOCA methodology. So that's something that we've looked at in, for both Ps and BWRs, which is interesting because obviously FSLOCA is with a state of the art as far as best estimate plus uncertainty methodology, and that's only applicable to PWRs. But we also have methodologies that are Appendix A based that the staff is actually looking at right now for some updates for boilers.

And so, you know, it was a very different starting place. Whether you have an appendix A methodology or something like that, that's LOCA.

So at the time being, that's in the paper that Jeff mentioned is going to be presented at Top Hill next month, will primarily focus on adaptations to the FSLOCA method. And looking at all the uncertainty contributors that we have in the, as approved topical report and trying to look at different ways of defining what we would consider to be best estimate true nominal or something that's reflective of beyond design basis analysis requirement.

And in that paper we looked at different Westinghouse PWR designs. Obviously from our experience base we understand that some different plants denied attributes leading to more limiting LOCA events or a higher P, calculated PCTs and local oxidation, et cetera.

So we used, we looked at a handful of plants to look at this. And as you kind of start ratcheting back these different uncertainty contributors we do see a potential path for avoiding cladding rupture in that beyond design basis accident, with the criteria that would be expected for the treatment uncertainties in that scenario.

There are some of the more limiting plant design that are kind of very close to that threshold of cladding rupture. And I think that's something that as a couple will become public for comment, I think the current schedule that the Agency had communicated to Industry and to the public that they will be able to see in February in 2026 to provide public comment.

At that point we're hoping to get a little more clarity on exactly what we may or may not be able to credit in that beyond design basis circumstance. But we do see, indeed, a large majority of the PWRs expecting to not predict cladding rupture for the large break conditions.

MR. ROBERTS: Okay, thank you.

MR. BARBER: Just one other note, for the Members knowledge. So one of the things would be taken back from recent meetings here is that we were trying to provide more information in the open session. There are going to be slides that are quite similar to Jeff's presented in the closed session, so if there is, we'll have another kind of opportunity to ask maybe more direct questions related to proprietary information in a few hours.

MR. PALMTAG: This is Scott again. So going back to the accident question. So is this all for the accident fuel? And I guess where I'm really going is, are the older fuel designs going to go to the higher burnup or are you only allowing the AXIOM fuel to go to the higher burnup?

MR. KOBELAK: So let me, let me, yes, let me just jump to that real quick and then I'll come back. So here is where we're aiming as far as the applicability of what can operate within this higher initial enrichment, higher burnup regime.

So for cladding we are focused on the AXIOM cladding. At least for near-term applications. We also would expect that the chromium coated cladding could operate in this regime. That that's listed as future because it's not yet approved by the NRC it's currently under review. But we would certainly expect that cladding to be appropriate as well.

At present we are not looking to support some of the older alloys, like Zirc-4, ZIRLO. For the extended cycle lengths, and the higher fuel duty, the corrosion and hydrogen becomes less desirable to operate into high burnup than some of the more modern alloys.

For fuel we are including both our standard UO2 and ADOPT fuel pellets. No real change to burnable absorbers. We would allow unpoisoned rods if by gad and discrete burnable absorbers within this regime.

As far as the specific enrichment and burnup, we'll talk about that more in the closed session. But needless to say, higher than five weight percent and greater than 68 gigawatt days per MTU.

And then as far as plant classes, I know it goes a little beyond the question, but this method was designed for two-loop, three-loop and four-loop Westinghouse plants as well as C-design plants.

MR. PALMTAG: Okay. And just to, I think you said, just to clarify, the existing fuel that the Zirc-4 cladding will not be allowed to go to high burnup fuel?

MR. KOBELAK: That's correct. Zirc-4 would not. ZIRLO would not. At least as current envisioned, or is supported, by these methods.

MR. PALMTAG: Okay.

MR. BALLINGER: This is Ron Ballinger. As a practical matter, nobody is using Zirc-4 anymore anyway, right? And that includes ZIRLO. So are there any plants that you would, that are using this material?

MR. KOBELAK: There are a handful --

(Simultaneous speaking.)

MR. BALLINGER: -- by the time it gets approved?

MR. KOBELAK: There are actually a still a handful of plants that use ZIRLO cladding material. I think that there is relatively near-term plans for those plants that transition off of them. But there is still some plants that use that material.

MR. BARBER: Yes, maybe to expand a little bit on Jeff's response. I mean, the majority of the Westinghouse is, utilizes optimizes ZIRLO cladding.

And when we licensed AXIOM, and AXIOM presented to the Committee, we showed some comparisons and how optimized ZIRLO and AXIOM cladding performed at these high burnup, high duty scenarios. And one of the, one of the goals at AXIOM was to enable a higher burnup operation to the reasons that Jeff had noted. The corrosion and the hydrogen pick up.

I think the well-established fuel performance aspect, fuel cladding performance aspects that have been discussed with Westinghouse and the Committee and the staff. And certainly others within the Industry. So that's why we were very specific in our, in the slide that Jeff just had up there, and the applicability of what materials and what plant classes would potentially be applied in this method.

CHAIR MARTIN: Jeff, this is Bob Martin.

MR. KOBELAK: Okay, so -- oh, sorry.

CHAIR MARTIN: And I'm also kind of looking at the clock here and looking at your slides. I think looking at what, the slides in between where you're at now and the applicability slide, you're probably, I know the contact we have certainly sat in on several meetings discussing ALS. In fact, you identified three topical proportioned to EPRI. We will be looking at those on some level. That one.

We had a conversation, I think at our last full committee meeting just two weeks ago where I reported in my impressions of those. So we understand this slide.

The next slide, I think we talked something about the background here. Objectives already.

The next slide. I think we've already kind of addressed, okay, we know the 50.46 limits, right? Somewhat familiar with the code. Maybe there is some nuance here that you might want to mention, just knowing that there is a difference here between this topical report and your previous that you might want to throw in. Right? You're relying more on WCOBRA/TRAC with this methodology more than, say with ECCS.

MR. KOBELAK: Yes, Bob. Maybe, so in the interest of time, if I keep my comments very brief, yes, I would say that it's important to know that WCOBRA/TRAC-TF2 is associated with the FSLOCA EM. It's a very different code than some of the prior codes that you and others may be familiar with. It was updated specifically focusing on the core and fuel rod models for high burnup and higher initial enrichment.

And then it utilizes fuel performance data from PAD5 for the fuel rod initialization. And PAD5 is similarly being updated to support higher enrichment and high burnup.

CHAIR MARTIN: And just, can you all agree, I think we saved a little bit of time.

MR. KOBELAK: Okay. You want me to resume from Slide 12 then?

CHAIR MARTIN: Yes. If you've already talked about it just kind of skip on through.

MR. KOBELAK: Okay.

CHAIR MARTIN: We can start with 16 if you like, but --

MR. KOBELAK: Okay. Yes, not too much more to say on this one. I think we've already talked in the introductory remarks and earlier on about incremental burnup, so I'll move on past this one then just noting that that was approved by the NRC last year.

I think we've also kind of covered this slide at length. The purpose of this method. So I will jump then to 16.

So this is just a very high level flavor of the focus areas within the topical report. A large portion of it is focused on ensuring that we have appropriate fuel rod and core models to analyze higher enrichment and higher burnup fuel.

Details will be provided in the closed session, but just to mention here, the areas that we looked at on the fuel rod are the pellet clad and gap conductance model, cladding deformation and cladding rupture. How the fuel rod is initialized.

And then a number of things that are kind of newly important to the higher burnup fuel rod. So susceptibility to find fragmentation where we see a lot of this phenomena starting to occur. The potential for fission gas release within the fuel rod during the LOCA transition itself, in addition to the preexisting fission gas in the fuel rods.

Looking at pre-birth fuel relocation. So the ability of fuel to fragment and relocate within the rod prior to rupture occurring. And then ensuring that the fuel pellet thermal conductivity is appropriate modeled up the higher burnup.

And on the core-wide front, the main focus was on the kinetics and the decay heat. And the idea there is of course to assess those models to make sure that the energy addition being modeled during the LOCA transient is reasonably to conservatively captured.

CHAIR MARTIN: And maybe I'll just fill in a gap for you. These of course weren't just pulled out of the air, right? There was an NRC PIRT done 20 some odd years ago. And I believe you also did maybe your own PIRT type exercise to kind of at least confirm some of the conclusions from the NRC's PIRTs, as well as maybe new insights you gained from the past 20 years of maybe in-house testing and just Industry experience, correct?

MR. KOBELAK: Yes, that's correct. We leveraged both the Industry PIRT, and as you indicated we did create our own internal PIRT focused on a high burnup fuel rod response during a LOCA so those were factored into determining this list. And I think the NRC is planning to speak a bit more about that in their presentation as well.

CHAIR MARTIN: Thanks.

MR. KOBELAK: Okay. Here, again, just very high level as far as methodology in the areas of focus within this topical report. So a lot of the discussion centered around the treatment of regions and ensuring that we have appropriate coverage of the entire break spectrum. So when I say regions I'm talking about basically portions of that break spectrum which have common phenomena.

So as you go through the entire spectrum, different phenomena become important at different break sizes. And we wanted to make sure that all of those were appropriately captured.

Reviewing the methodology uncertainties to ensure that they remain appropriate or updating them for higher burnup and higher enrichment fuel rods. And of course, as was mentioned earlier, factoring in information available since the original FSLOCA EM was approved. And then some discussion regarding the treatment of offsite power availability, while there's a few other miscellaneous considerations.

And then finally, I have just a handful of slides on the limitations and conditions. And again, I think the NRC staff will cover this in much greater detail in their presentation. But there were two different types of limitations and conditions on the topical report. A subset that were inherited from the base Full Spectrum LOCA EM.

So any limitations and conditions from the FSLOCA EM, which remained applicable, were generally imposed on this topical report as well. There were a number of limitations and conditions that weren't applicable since we were focused just on the prediction of cladding rupture rather than the ECCS criteria as a whole. So things like long-term core cooling, those were not included.

And then there is a number that were superseded. So for example, the burnup limit in the FC LOCA EM was superseded by a new limit imposed on this topical report.

In summary there is 11 limitations and conditions on this topical report. I just wanted to touch on them at a very high level. The first limitation and condition covers the different PWR designs, which are included within the applicability of the topical report.

The second one covers some limitations and conditions relative to the decay heat modeling to make sure it remains appropriate and conservative. Limitation and condition 3 covers the maximum allowed fuel rod average burnup. Limitation and Condition 4 covers the fuel performance data that is allowed to be used for initialization of the fuel rods.

Limitation and Condition Number 5 is specific to a particular uncertainty analysis parameter. And Limitation and Condition Number 6 covers requirements related to the seed and the uncertainty analysis inputs. As well as what needs to be done if we get an unacceptable analysis result and reporting of the analysis ranges to the NRC.

Limitation and Condition 7 is a requirement relative to the offsite power availability analyzed. Limitation and Condition 8 just pulls forward three of the limitations and conditions from the base FSLOCA EM.

Limitation and Condition 9 covers the applicable cladding materials and fuel designs that I mentioned on an earlier slide. Limitation and Condition 10 covers the allowable burnable absorbers that I also presented earlier. And then Limitation and Condition 11 covers the maximum initial fuel rod enrichment.

So that was all the remarks I had for the open session. Happy to take any other questions.

CHAIR MARTIN: A little gun shy to ask some questions because of course it might touch on proprietary content. It's not so unusual for it to be a little quite during an open session when we know there is a closed session later.

I will turn to my colleagues here in the room or online. Are there any questions to Westinghouse before we transition to the staff? Not seeing any I will thank you all very much.

And we'll make that transition over to the staff's presentation. Give us a few minutes online.

MR. KOBELAK: Okay, thank you very much.

CHAIR MARTIN: Thank you.

Are you ready?

MR. LEHNING: Yes, we are ready. It's my pleasure, and our pleasure, to be here in front of you all this morning. My name is John Lehning from the Nuclear Methods and Fuel Analysis Branch in the Office of Nuclear Reactor Regulation, as are my colleagues too who are here, and one who is virtual. One of us who participated in the review, Patrick right now has left the Agency but was a principle contributor. And we present somewhat on his behalf.

We will tag team this presentation. We'll introduce ourselves as we transition speakers. I'm just going to help out, do the introductions right now. So to my left, Brandon, do you want to introduce yourself really quickly?

MR. WISE: I'm Brandon Wise in the Nuclear Methods and Fuel Analysis Branch in the Division of Safety Systems.

MR. LEHNING: And Jack?

MR. VANDE POLDER: I am Jack Vande Polder in the Division of Safety Systems, Nuclear Methods and

Fuel Analysis Branch.

MR. LEHNING: And remotely our lead review, Jeremy is going to take it from here and do the first five slides I think. So go ahead, Jeremy.

MR. DEAN: Great, thank you, John. My name is Jeremy Dean, I'm the lead reviewer for this topical report. As said, I'm in the same branch as my colleagues and report to Scott Krepel.

So we're going to cover, here in the open session, just at a high level, what the staff's review of this topical report. So next slide, John.

Here is just a quick presentation outline. This is more important in the closed session to show where we spent most of our time reviewing. And then the, trying to be brief, we'll try to skip through these pretty fast.

Next slide. So Westinghouse submitted a topical report, WCAP-18850, to extend Full Spectrum LOCA to incorporate effects of high enrichment and high burnup. During this one new phenomena is of primary interest for this. For fuel fragmentation, relocation dispersal.

And one means of addressing that is to prevent rods that are susceptible to this phenomena and just prevent their rupture from occurring. And from the NRC staff's point of view, right, this is the highest standard you can apply to this in regards to health and safety of the public.

So WCAP-18850 provides a method of applying FSLOCA, the original framework, to determine with high probability that cladding rupture is not going to occur during a loss coolant accident.

Next slide, John. So a little bit of background on the original Full Spectrum LOCA. Just a best estimate, realistic loss of coolant accident and evaluation model that accounts for uncertainties. It covers the entire break spectrum, up to a full double ended guillotine break. It was approved in 2017, and applicable to Westinghouse three and four-loops.

And as a sub note, they're working on expanded their trivariate analysis for 50.46 acceptance criteria to other pressurized reactor water designs. And to be clear, the FSLOCA methodology does not address fuel dispersal, there is so many complexities with dispersal of fuel into the coolant. Whether it meets regulations, the uncertainties of coolability and where that fuel goes. So those, there are some models included for fragmentation relocation in the initial model, but 18850 will not address that piece.

Next slide, John.

CHAIR MARTIN: You didn't include dispersal, that's the key, right?

MR. DEAN: Yes.

CHAIR MARTIN: Okay.

MR. DEAN: Absolutely.

CHAIR MARTIN: If anything, the fragmentation relocation is really the, kind of creating more local power at the rupture site, which gives you --

MR. DEAN: Yes. So again, we'll get into that in the closed section. But right, once the pellet starts to become very, very small and fragmented along it's green boundaries, it can relocate axially in the fuel rod. In particular, if it starts to balloon it can start to pack into the region. And models need to be included for that.

MR. LEHNING: If you can hear me? This is John Lehning speaking. I'll just add, we will touch on a little bit of the distinction. And, you know, obviously the full spectrum when it was approved, the amount of knowledge we had was not quite up to what we know now, and so we'll touch just briefly on some of the distinctions there.

MR. DEAN: Yes. Next slide, John, unless there is any more questions on that one?

Really quickly on the review timeline. 18850 was submitted in February 2024. We did our acceptance review in the spring. We spent the summer reviewing and preparing for an audit in the fall with numerous questions going into that. We were able to resolve a lot of those and issued RAIs in November of last year.

Westinghouse, just so you know, they responded in two separate responses to answer all of our questions. Then we took the latter part of the spring into mid-summer to come up with our draft safety evaluation. And now we're here ready to present to you folks on the Subcommittee meeting.

Next slide. So I'm going to turn it over to Jack here and let him talk about the regulatory background and what's applicable there.

MR. VANDE POLDER: Hello, everyone. So here are the key regulatory requirements and guidance for LOCA. Of note, our 10 CFR 50.46 and general design criteria 35. 10 CFR 50.46 is the main reason which guided Westinghouse into their approach. And then GDC 35 had the LOOP requirements, Loss of Offsite Power, for Westinghouse in their review.

Next slide please. So Westinghouse WCAP-18850, the methodology must be capable of predicting an occurrence of cladding rupture. The methodology is based on the previously approved Full Spectrum LOCA methodology. Westinghouse evaluated the PIRT phenomena for increased burnup. And there were two key model updates that were needed. Fuel rod modeling and kinetics and decay heat modeling.

Next slide please. For further detail --

CHAIR MARTIN: One point of clarification. So when you say two main areas, okay, fuel, but under that title there are several --

MR. VANDE POLDER: Yes.

CHAIR MARTIN: -- updates.

MR. VANDE POLDER: Yes, there are several updates.

CHAIR MARTIN: Okay. As opposed to, I guess kinetics decay heat. There are obviously two distinct phenomena due to the same site closure models, okay.

MR. VANDE POLDER: Yes. So to the PIRT, Westinghouse evaluated the FSLOCA PIRT and the Industry high burnup PIRT. They didn't identify, there were no new phenomena identified that needed to be evaluated.

They did find some, there were three categories of areas. There were things that would be conservative or would have no effect if left as the, such as void generation or the water volume. There were several things that need to be change, such as the after mentioned fuel rod models and decay heat.

And then there are items that we precluded by their methodology, such as time and location of bursts. The NRC staff found that the PIRT evaluation by Westinghouse was comprehensive and adequate.

Next slide. So the fuel rod models, it's more complex than just one model as there are several things, such as cladding rupture, cladding deformation. All the models that go into the fuel rod modeling would be impacted or potentially impacted so Westinghouse had to evaluate those. So the details for these are a little too proprietary though so they will be discussed in the closed section.

And I will be handed it off to my colleague Brandon.

MR. WISE: Thank you. I am Brandon Wise and I'm going to discuss the kinetics in the heat model, as well as the cladding rupture methodology.

Westinghouse updated the WCOBRA/TRAC-TF2 kinetics and the heat models to be applicable to the higher burnup and higher enrichment readings. The updates are performed used PARAGON2, which was approved in June 2021. That topical report has an enrichment and power applicability that bound WCAP-18850.

These same updates were applied in WCAP-18446, which is the incremental burnup extension. And WCAP-18773, which is the high enrichment for PWR topical report. In both those topical reports the staff found that the methodology could prove the new kinetics and decay heat model was acceptable.

The staff found that the model is acceptable and that the heat sources that are being modeled are appropriately characterized for the purposes of cladding rupture calculations. For the cladding rupture methodology I'm going to discuss some of the important topics proposed in WCAP-18850.

First, the FSLOCA EM is the base methodology with some modifications discussed in WCAP-18850. The purpose of the methodology is to preclude cladding rupture of fuel rods susceptible to cladding fragmentation. The cladding rupture analysis is performed parallel to a typical FSLOCA EM analysis demonstrating compliance with 10 CFR 50.46 Bravo 133.

The cladding rupture -- sorry. CAP-18850 provides a new analysis region. That's region 1(b), which lies between the small and large break representing the intermediate break spectrum. And closes a methodology for analyzing that region, which is a mix between Region 1 and 2, being mostly related to Region 1. Which is small break LOCA. WCAP-18850 also proposes a few changes to Region 1 and 2 uncertainty analysis for cladding rupture calculations.

CHAIR MARTIN: Point of clarification on cladding rupture. Historically LOCA evaluation models have leveraged the latest NUREG-0630, right? Looking over at John, he's nodding his head so I did remember something from a long time ago.

And it's a very, it's a relatively simply type of cladding cooling rupture model. Has Westinghouse departed from that? Is that a proprietary type thing?

And in general, are fuel vendors moving away from that old lot?

MR. LEHNING: We will cover somewhat in the closed session in more detail.

CHAIR MARTIN: Okay.

MR. LEHNING: I don't want to speak out of turn here. I will say that I think just in general, in the broad sense, that vendors in general tend to use that, I think as you know, maybe their own versions or their own sort of data sets. It may sometimes be cladding specific or other times they may demonstrating the certain claddings fall within other data that they have, but basically I would say that the overall methods and approaches are highly consistent with what was developed for that NUREG-0630.

CHAIR MARTIN: Okay. Maybe some of the parametrization is a little different based on, say fuel specific testing?

I will say that if our Committee, I think it was a couple years ago, so prior to a couple members, did visit Westinghouse and we did get to look through their testing program where they were specifically looking at FFRD phenomena and trying to improve their fuel designs.

And I can see how that, that work could feed into a new model. Or at least maybe, maybe a parametrization, re-parametrization, of an old model.

MR. LEHNING: And I'm sure Westinghouse has a slide or two on that, and the staff does too, in our closed presentation.

CHAIR MARTIN: Okay.

MR. LEHNING: So we will talk more on --

CHAIR MARTIN: All right, thanks.

MR. WISE: Next slide please. So based on the changes discussed on the previous slide the NRC staff made the following findings. We found that the adaptation of the FSLOCA EM is a base methodology appropriate to prevent cladding rupture calculations.

Including in that there were several model updates that were found to be acceptable for the applicable burnup and enrichment range. We also found that the methodology was supported by significant data and has been acceptable for predicting the occurrence of cladding rupture and rods susceptible to cladding fragmentation.

Additionally the staff compiled a definition of Revision 1(b) and its treatment of the FSLOCA EM to be comprehensively described and acceptable. Found that the proposed changes to Revision 1 and uncertainty analysis is acceptable.

The exact details of these two topics are closely provided here. And we discuss it in more detail in the closed session. But we can say that the proposed treatments are supported by sensitivity studies compared to calculations of engineering judgment that the staff found to be acceptable.

Now I'll turn the presentation back to Jeremy Dean, who will discuss limitations and conditions.

MR. DEAN: Thank you, Brandon. So for limitations and conditions the staff asked Westinghouse to address all the 15 limitations and conditions from their FSLOCA evaluation model.

We also, we did this for a couple of reasons. One, it helps the NRC staff, you know, if the applicant helps define the range of applicability for their analysis rather than having the staff do that for them, it's advantageous to them because we would likely be more restrictive. And so in some cases we did modify the suggested limitations and conditions.

So several were directly propagated. These were limitations and conditions 3, 12 and 13. Several were modified, 2, 4, 5, 6, 8, 11 and 15.

Next slide. The NRC's draft safety evaluation ultimately resulted in 11 limitations and conditions that the licensees must adopt. Again, these were originally proposed by Westinghouse in their submittal. And we modified several of these.

We covered three limitations and conditions during, in this open session, but the most, I would say interesting and more restrictive, 8, will be discussed during the closed session.

Next slide. And here are the ones that were directly transferred. And we can talk a little bit during the open session here, so.

Limitation and Condition 1 can only be applied to Westinghouse two-loop and combustion engineering plants after the base models have been approved for these applications. And the applicable differences and deviations are addressed. And what that really means is the FSLOCA EM needs to then include these new reactor types.

As Jeff alluded to in his portion, Limitation and Condition 9, they're only applying this to standard UO2 pellets and their ADOPT pellets. And it's only applicable to AXIOM cladding.

And then Limitation and Condition Number 10 is just a repeat of Jeff's. That's it's applicable to unpoisoned fuel, fuel with inoperable, fuel burnable absorbers, particularly gadolinia. And it doesn't preclude the other discrete burnable absorbers that Westinghouse may use.

Next slide.

CHAIR MARTIN: Just a quick question. Bob here.

MR. DEAN: Sure.

CHAIR MARTIN: You mentioned, previous slide, about limits, limitations and conditions related to range of applicability. And of course, maybe pushing that back to Westinghouse to incorporate that under PR. Some range of applicabilities relate to inputs that are easy to control. Were any of those ranges of applicabilities related to a calculated parameter, variable that might have to be tracked by, tracked through the calculation and require maybe a little bit more effort on their part to assure maybe a wording or something like that?

Sometimes that happens more than often than not it's the former. Where they're relatively easy. But sometimes you're dealing with, say some closure limit. And as a calculated result that is constrained by a range of applicability and it has to he checked.

MR. LEHNING: Jeremy, this is John.

MR. DEAN: Yes, go ahead.

MR. LEHNING: And I guess I, to answer that one. And Westinghouse, feel free to jump in and offer your perspective. I don't think that there are any like that that are, and I'm sort of reading your question as if maybe sometimes, I've seen where maybe if a certain model gets activated, maybe you have to go back and check through the files and output and see.

CHAIR MARTIN: Yes.

MR. LEHNING: I don't think there are any like that. I think all the ones that are associated with it, that come to my mind, are ones where either a parameter is set right at the beginning and it's just to wrap around, there is nothing to check or so forth. But, Westinghouse, if you have a different view please feel free to address that.

MR. KOBELAK: No, John. This is Jeff Kobelak from Westinghouse. I agree with your assessment relative to the parameters. And maybe the only other thing I would add are, there are one or two that are kind of more procedural in terms of reporting certain results to the NRC. Or at least reporting results under certain conditions. And we have placed those type of requirements into our analysis guidance to make sure that they are not lost or forgotten as we apply these methods.

CHAIR MARTIN: John, would those guidance documents be something you reviewed?

MR. LEHNING: I don't know that we reviewed any of the guidance documents of how

Westinghouse does their calculations as part of this review. It might have been during some of the initial review of the base methodology. We may have, we did a lot of audits and that might have been.

I know some of the statistical parts of this, we did talk through at a high level. I don't know that we reviewed their actual documents, but we did get pretty detailed into that part for sure.

CHAIR MARTIN: Okay, appreciate that.

MR. DEAN: Yes, I concur with that. Most, it's really bias in certain parameters that are applicable to this, you know, sort of single variate for fuel rod burst that would be different than you would do for the tried varied analysis for 50.46 acceptance criteria.

All right, so conclusions. So during our review we found that WCAP-18850 does provide an acceptable approach for determining the high probability that cladding rupture will not occur. We'll go into great detail in the closed session of how we were able to accomplish that. And of course, that's for fuel rods that are only susceptible to find fragmentation.

The staff conclusions are, of course, predicated on the methodology being used within its approved range of applicability. And we'll outline that a little bit more as well in the closed section. And specifically addressing all the limitations and conditions of Section 4 of the safety evaluation. I believe that's the last slide.

CHAIR MARTIN: It is.

MR. DEAN: So any more questions we can answer for you during this open session?

MR. ROBERTS: Yes, this is Tom Roberts. I was wondering if you could resolve the arithmetic for these license, LNC slides?

If you start with the first slide it says there are 15 that were assessed, then the next part of that slide says there were ten that were adopted or modified. That's ten of 15. And then it says on the next slide you adopted 11. Then the slide after that lists three that aren't on that first slide, which brings you up to, you know, I think it was 13. So what is it arithmetic here?

MR. LEHNING: This is John Lehning --

(Simultaneous speaking.)

MR. DEAN: Go ahead, John.

MR. LEHNING: So the three that are shown in the open presentation, those are part of the 11 that are on Topical Report WCAP-18850. There are eight more that we will cover that will be in the closed session.

Now the 15 that came from the original base methodology it looks like, yes, I think if you add those up, which I hadn't necessarily thought to do before, but there are three, four, five, six, seven, eight, nine, ten there. So none of those that are in the WCAP-18850 propagated from the base method. And apparently there is one that came in that essentially is a new one that is not sort of covered in this paradigm based on the way it's presented here. So hopefully that's resolve the numbers.

And obviously out of this --

MR. DEAN: Remember also --

MR. LEHNING: -- 15 that there were five that did not, were not applicable for whatever reason. And obviously the different objectives of these analyses, so some of them were perceived by Westinghouse and the staff found acceptable that they weren't necessary to do the calculation for this cladding rupture.

MR. ROBERTS: So there were 15, five were resolved as not applicable, and then one was added? That's how you get to 11?

MR. LEHNING: That seems to be correct.

I hesitate to, I mean, because like I said, we hadn't really done that math but that is what I believe to be true.

MR. DEAN: Hey, John --

(Simultaneous speaking.)

CHAIR MARTIN: -- details coming in the closed session, I guess we can rectify the numbers there.

MR. DEAN: -- just a little bit tricky that one limitation and condition pulls over three into one. So yes, at first glance it looks like maybe we didn't add it up right, but I assure you we did.

MR. ROBERTS: That is all right. Okay, thank you.

CHAIR MARTIN: Any further questions or topics of discussion from the Committee? Consultant stab at this? Anything on your mind, Ron?

MR. BALLINGER: No.

CHAIR MARTIN: Okay. I think at this point we need to go to public comments. Looking over here? Okay. So if there is any member of the public that has a burning question, this is your opportunity to speak up.

Please use, if you're on Teams, please raise your hand and we will give you a couple minutes here to provide your comment. Is there anyone out there? Gave it a good 15 seconds, huh? All right, not seeing any I believe we can close our open session.

And of course there is some logistics that we have to take care of going into the closed session to make sure everyone that is here is allowed to be here. And for those of you that can be here virtually, I believe there is going to be a, there is a different link so be aware of that.

And we're going to have a break. Right now it is 9:41. We're going to break until 10:00. It's what's on the schedule. So meeting is recessed until 10:00.

(Whereupon, the above-entitled matter went off the record at 9:41 a.m.)

NRC Staff's Review of Westinghouse Topical Report WCAP-18850-P, *"Adaptation of the FULL SPECTRUM™ LOCA (FSLOCA™) Evaluation Methodology to Perform Analysis of Cladding Rupture for High Burnup Fuel"*

Open Presentation to

Advisory Committee on Reactor Safeguards, Accident Analysis Subcommittee

September 16, 2025

J. Dean, U.S. NRC

B. Wise, U.S. NRC

J. Vande Polder, U.S. NRC

J. Lehning, U.S. NRC

U.S.NRC

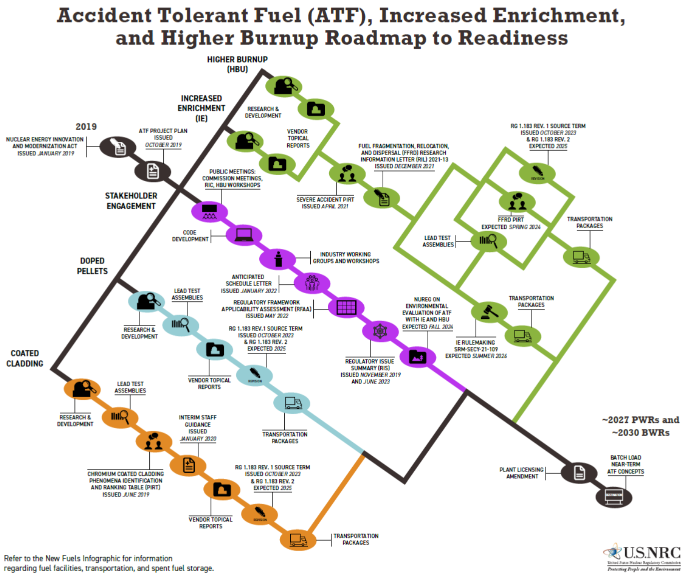
United States Nuclear Regulatory Commission

Protecting People and the Environment

Presentation Outline

Topic	# of Slides
Introduction / Background	4
Review History	1
Requirements and Guidance	1
Technical Evaluation (open portion)	7
• Modeling Basics	(1)
• Phenomenon Identification and Ranking	(1)
• Fuel Rod Modeling Updates	(1)
• Kinetics and Decay Heat Model Updates	(1)
• Cladding Rupture Methodology	(3)
Applicability, Limitations and Conditions	3
Conclusions	1
Acronyms	1
Presentation Total	**18**

Introduction

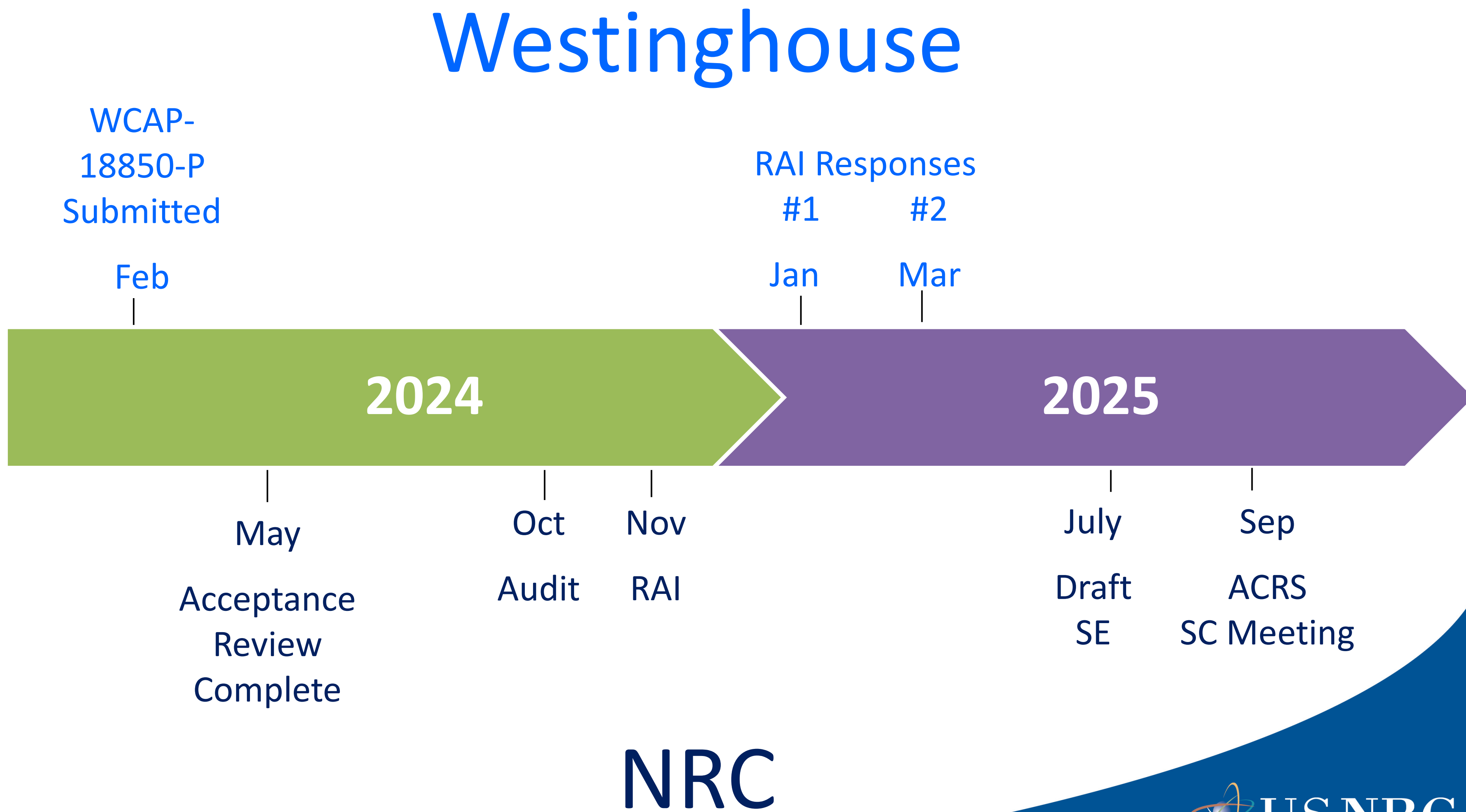


- Westinghouse proposed WCAP-18850-P to extend its approved FULL SPECTRUM LOCA methodology to higher fuel enrichment and burnup levels
- One means of addressing fuel dispersal is preventing rupture of fuel rods susceptible to fragmentation
- WCAP-18850-P provides a method for applying FSLOCA framework to determine with high probability that cladding rupture will not occur during a LOCA

FSLOCA Background WCAP-16996-A

- FSLOCA is a realistic LOCA evaluation model that accounts for uncertainty
- Methodology addresses scenarios across entire postulated spectrum of break sizes
- Current methodology applicable to Westinghouse 3- and 4-loop pressurized-water reactors was approved in 2017
  - Extensions currently being pursued for additional pressurized-water reactor designs
- Licensed FSLOCA methodology does not address fuel dispersal
  - Models are included for fragmentation and relocation

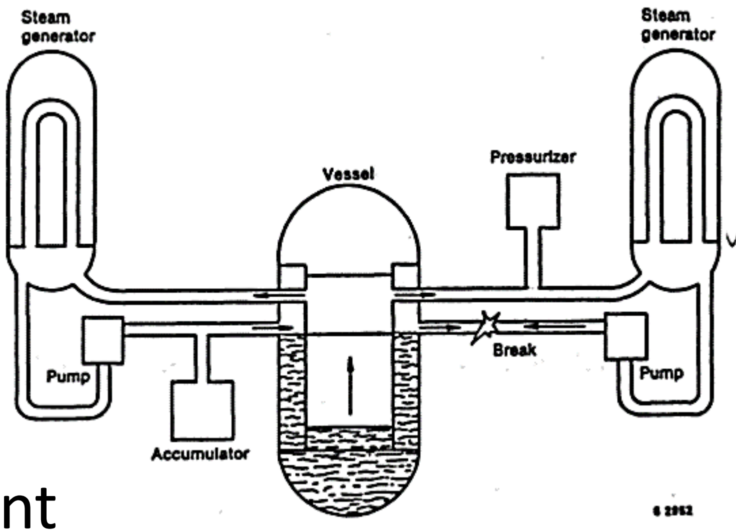
Review Timeline



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

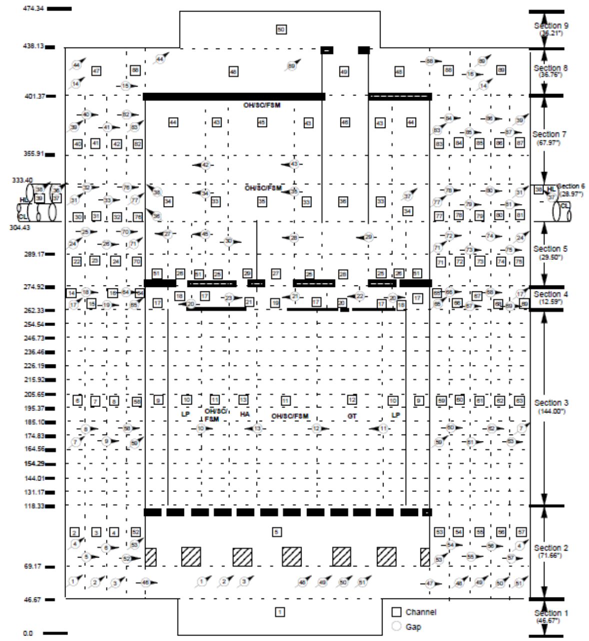
Key Regulatory Requirements and Guidance for LOCA

- 10 CFR 50.46
- General Design Criterion 35
- 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"



Loss-of-Coolant Accident Analysis Methods

- WCAP-18850-P methodology must be capable of predicting occurrence of cladding rupture during a LOCA
  - Modeling based on FULL SPECTRUM LOCA methodology (WCAP-16996-P-A)
  - WCOBRA/TRAC-TF2 code



- Westinghouse evaluated PIRT phenomena for impacts of increased burnup
- Key model updates in two main areas
  - Fuel rod modeling
  - Kinetics and decay heat modeling

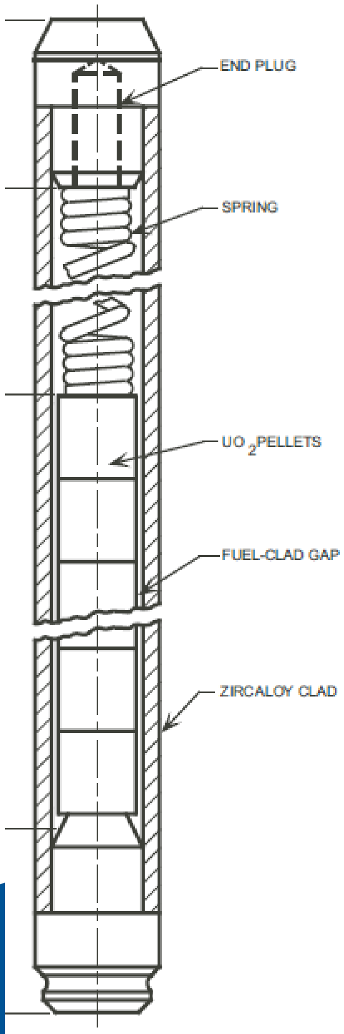
Phenomena Identification and Ranking

- WCAP-18850-P evaluated the FSLOCA PIRT and an industry high burnup PIRT.
  - No new phenomena identified
  - Updates to WCOBRA/TRAC-TF2 and other models where appropriate
    - Fuel Rod Models, Kinetics and Decay Heat, Burst Criteria
  - Burst size, location, etc. determined to be unimportant.

- The NRC staff found that the PIRT evaluation is comprehensive and adequately identifies where model updates are needed to account for FFRD and high burnup and enrichment.

Fuel Rod Model Updates

- WCAP-18850-P addresses fuel rod models that could be impacted by increased burnup:
  - Pellet-cladding gap conductance
  - Cladding deformation
  - Cladding rupture
  - Fuel rod initialization
  - Susceptibility to fine fragmentation
  - Transient fission gas release
  - Pre-burst fuel relocation
  - Fuel rod material properties
- Proprietary details discussed further in closed session



WCOBRA/TRAC-TF2
Kinetics and Decay Heat Model Updates

- Westinghouse updated the models to incorporate increased enrichment and higher burnup
  - Nuclear physics data provided by PARAGON2 (Approved June 2021)

- Similar model updates were previously approved in:
  - WCAP-18446-P-A (Approved June 2024)
  - WCAP-18773-P (Final SE Issued July 2025)

- The NRC Staff found the model updates to be acceptable because they were consistent with previous approvals. Unique characteristics associated with the expanded range of applicability and cladding rupture calculations were examined.

Cladding Rupture Methodology

- WCAP-18850-P…
  - Uses the FSLOCA EM as a base methodology and adapts it as appropriate
  - The purpose of the methodology is to preclude cladding rupture of rods susceptible to fine fragmentation.
    - The WCAP-18850-P cladding rupture analysis is performed parallel to the WCAP-16996-A FSLOCA base analysis that demonstrates compliance with 10 CFR 50.46(b)(1)-(b)(3).
  - Defines a new break spectrum region, Region IB
  - Proposes a methodology for analyzing cladding rupture in Region IB
    - A mix of Regions I and II, with some unique characteristics
  - Proposes changes to Region I and II uncertainty analyses

Cladding Rupture Methodology

- The NRC Staff…
  - Found the adaptation of the FSLOCA EM base methodology appropriate to perform cladding rupture calculations. Several models were updated to incorporate the increase range of applicability for burnup and enrichment
  - Found the methodology to be supported by significant data and is acceptable for predicting the occurrence of cladding rupture of rods susceptible to fine fragmentation.

Cladding Rupture Methodology

- The NRC Staff…
  - Found the definition of Region IB and its treatment in the FSLOCA EM to be comprehensively described and acceptable.
  - Found the proposed changes to Region I and II uncertainty analyses acceptable.
  - The proposed treatments are supported by sensitivity studies, comparison calculations, and engineering judgment.

Review of Limitations and Conditions from FSLOCA (WCAP-16996, R1)

- Westinghouse assessed the 15 limitations and conditions from WCAP-16996, R1, for applicability to the derivative WCAP-18850-P methodology
- Applicable limitations and conditions from WCAP-16996, R1, were propagated into WCAP-18850-P topical report
  - Direct propagation of FSLOCA L&Cs 3, 12, and 13
  - Others adopted in modified form (FSLOCA L&Cs 2, 4, 5, 6, 8, 11, 15)

Limitations and Conditions for WCAP-18850-P

- The NRC staff's draft safety evaluation contains 11 limitations and conditions that licensees adopting the methodology must address
  - These limitations were originally proposed by Westinghouse in WCAP-18850-P
  - NRC staff modified several of these limitations
- Three limitations and conditions will be covered in the open presentation
  - Remaining eight will be discussed during the closed presentation

Limitations and Conditions: Methodology Applicability

- Per Limitation and Condition 1, the methodology can only be applied to Westinghouse 2-Loop and Combustion Engineering plants after
  - The base model is approved for these applications
  - Applicable differences and deviations have been addressed
- Per Limitation and Condition 9, WCAP-18850-P is only applicable to fuel products with
  - Uranium dioxide or ADOPT fuel pellets
  - AXIOM cladding
- Per Limitation and Condition 10, WCAP-18850-P 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)

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United States Nuclear Regulatory Commission
Protecting People and the Environment

Conclusions

- The NRC staff found the WCAP-18850-P methodology provides an acceptable approach for determining, with high probability, that cladding rupture will not occur for fuel rods susceptible to fine fragmentation

- The NRC 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

Table of Abbreviations

10 CFR	Title 10 of the *Code of Federal Regulations*
ACRS	Advisory Committee on Reactor Safeguards
FULL SPECTRUM™ LOCA, FSLOCA™	WCAP-16996-P-A, Revision 1, 'Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (Full Spectrum LOCA Methodology)
L&C	Limitation and Condition
LOCA	Loss-of-Coolant Accident
NRC	U. S. Nuclear Regulatory Commission
PIRT	Phenomenon Identification and Ranking Table
RAI	Request for Additional Information
SC	Advisory Committee on Reactor Safeguards Subcommittee
SE	Safety Evaluation
WCAP-18850	WCAP-18850-P/NP, Revision 0, “Adaptation of the FULL SPECTRUM LOCA (FSLOCA) Evaluation Methodology to Perform Analysis of Cladding Rupture for High Burnup Fuel”

Enclosure 2

Westinghouse Open Session Slide Package for the ACRS Subcommittee Meeting on WCAP-18850-P/NP

(Non-Proprietary)

September 2025

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

Overview of WCAP-18850: Adaptation of the FULL SPECTRUM LOCA (FSLOCA) Evaluation Methodology to Perform Analysis of Cladding Rupture for High Burnup Fuel

Jeffrey Kobelak
Westinghouse Electric Company
September 2025

Overview

- Interaction of WCAP-18850 with Westinghouse high energy fuel (HEF) / accident tolerant fuel (ATF) / low enriched uranium+ (LEU+) program
  - Fuel dispersal during a postulated LOCA and Electric Power Research Institute (EPRI) alternative licensing strategy (ALS)
- Overview and purpose of WCAP-18850 (Westinghouse Cladding Rupture Methodology)
- Focus areas within topical report
- Topical report limitations and conditions (L&Cs)

Westinghouse Activities for HEF / ATF / LEU+

Introduction to WCAP-18850

Methodology Overview

Limitations and Conditions

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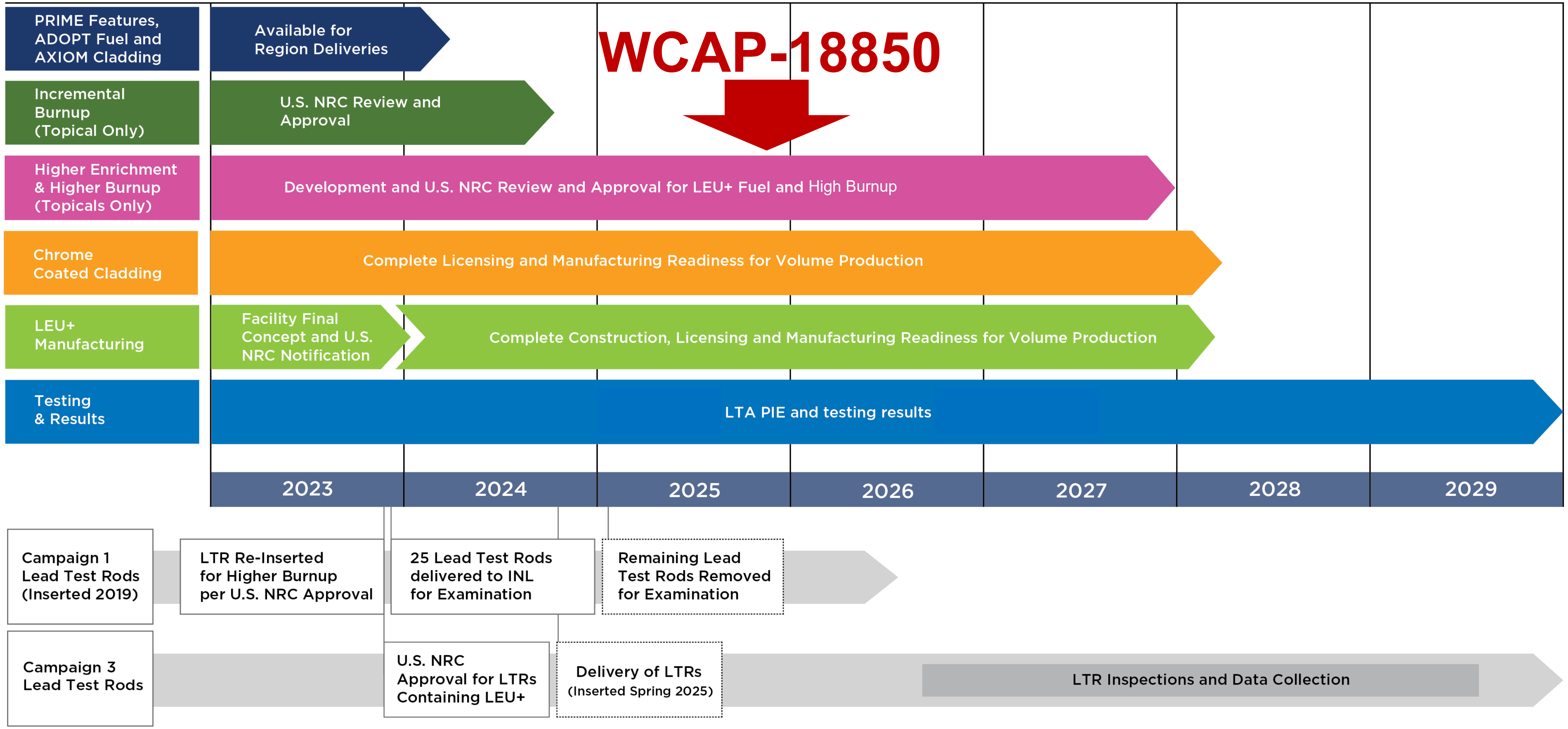
EnCore High Energy Fuel Program
Integrated Timeline for LEU+ Fuel Deployment



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WCAP-18850 will be leveraged to address fuel dispersal within codes and methods for LEU+

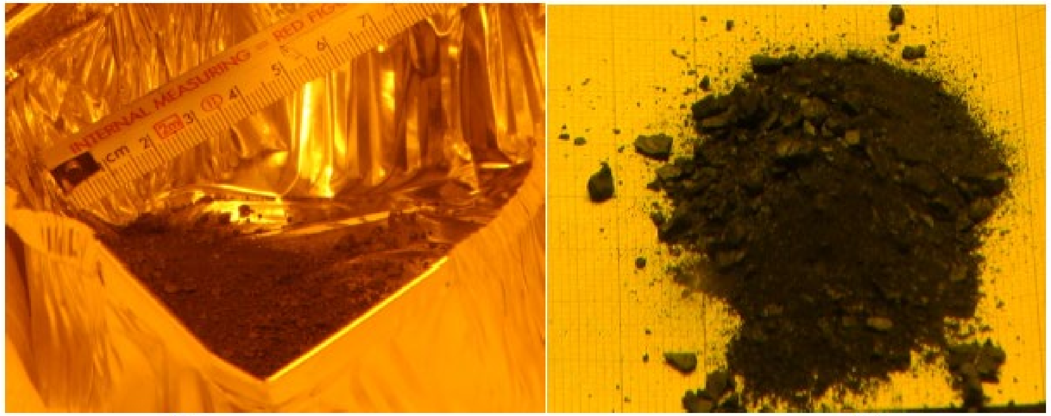
Fuel Fragmentation, Relocation, and Dispersal (FFRD)

55 GWd/MTU Rod
Average Burnup
Large Fuel Fragments

(a) (b)

Figure 4-42 Images of fuel particles collected from test rod (a) 196 and (b) 198 revealing large fragments

72 GWd/MTU Rod
Average Burnup
Fine Fragmentation



(a) (b)

Figure 4-41 Images of fuel particles collected from test rod (a) 192 and (b) 193 revealing a very small, sand-like fragmentation size

Figures 4-41 and 4-42
of NUREG-2121

Addressing fuel dispersal for design basis accidents such as LOCA is one key element of code and method updates

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Fuel Dispersal
EPRI ALS versus Draft Increased Enrichment Rulemaking

SBLOCA

ALS

Demonstrate No Cladding Rupture

IBLOCA

Credit Leak-before-Break (No Dispersal Analysis)

LBLOCA

Westinghouse has aligned with industry to support the EPRI ALS for Fuel Dispersal

- Accounts for the extremely low likelihood of occurrence for a postulated large-break LOCA (LBLOCA)
- WEC performed analyses following the WCAP-18850 methodology demonstrating no burst for small-break LOCA (SBLOCA) & intermediate-break LOCA (IBLOCA) scenarios

WCAP-18850 can be leveraged to demonstrate no rupture under 10 CFR 50.46a framework

- Directly applicable for breaks below the transition break size (TBS)
- Break above the TBS would be analyzed in a beyond design basis manner starting from the WCAP-18850 methodology

SBLOCA

50.46a

Demonstrate No Cladding Rupture

IBLOCA

Best-Estimate or Nominal Analysis

LBLOCA

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Commonality between EPRI ALS and Draft IE Rulemaking in approach for breaks below the TBS for PWRs

Current Status of EPRI ALS

Westinghouse Submittal

WCAP-18850: Methodology for Cladding Rupture Calculations

- Submitted February 2024
- Accepted May 2024
- Audited October 2024
- RAI Responses March 2025
- Draft SER July 2025
- **ACRS Subcommittee September 2025**
- Potential ACRS November 2025

EPRI Submittals

3002028674: LOCA Cladding Rupture Calculations

- RAI Responses Complete (except uncertainty analysis reruns)
- Draft SER Expected February 2026

3002028673: Alternative Licensing Strategy for Fuel Dispersal

- Submitted April 2024
- Accepted June 2024
- Audits Completed June 2025
- RAI Responses in progress
- Draft SER Expected February 2026

3002023895: xLPR Estimation of PWR LOCA Frequencies

- RAI Responses Complete
- Draft SER Expected December 2025

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Westinghouse Activities for HEF / ATF / LEU+

Introduction to WCAP-18850

Methodology Overview

Limitations and Conditions

Objective

- Provide an overview of the Westinghouse methodology to perform cladding rupture calculations for high burnup fuel
  - Initial driver was to support the EPRI ALS for fuel dispersal
  - Topical report is generically applicable to perform rupture calculations

- Builds on prior Westinghouse methods that are NRC approved
  - **FULL SPECTRUM**™ LOCA (**FSLOCA**™) Methodology (WCAP-16996-A, Revision 1)
  - Incremental Burnup Extension (WCAP-18446-A)

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Background: FULL SPECTRUM LOCA EM

- The FSLOCA evaluation model (EM) is NRC-approved to demonstrate compliance with the 10 CFR 50.46 ECCS acceptance criteria
  – Peak cladding temperature (PCT) less than 2,200°F
  – Maximum local oxidation (MLO) less than 17%
  – Core-wide oxidation (CWO) less than 1%
- WCOBRA/TRAC-TF2 (TF2) is the thermal-hydraulic system code associated with the FSLOCA EM
- Fuel performance data utilized for fuel rod initialization in TF2 is from PAD5

FSLOCA EM Approved by NRC in 2017

Background: Incremental Burnup

- Incremental burnup topical report leveraged the FSLOCA EM framework to perform cladding rupture calculations for higher burnup, lower power fuel rods
  - Demonstrate no cladding rupture with high probability
- WCOBRA/TRAC-TF2 code was reviewed and updated as part of incremental burnup
  - Revised models appropriate to higher burnup fuel
  - New models necessary to analyze higher burnup fuel

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Incremental Burnup Approved by NRC in 2024

Introduction to Cladding Rupture Methodology (WCAP-18850)

- Code and method used to perform the cladding rupture calculations adapted from the FSLOCA EM and Incremental Burnup program
  - WCOBRA/TRAC-TF2 code was modified to analyze higher burnup fuel with higher initial enrichment
  - Considers all higher burnup fuel rods in the core
    - Not just peripheral rods as in incremental burnup
  - Analysis is focused on cladding rupture
  - Lessons learned from licensing of incremental burnup were accounted for in the development of the cladding rupture methodology

Applicability of Cladding Rupture Methodology

- **Cladding**: **AXIOM®** Cladding (current), coated cladding (future)
- **Fuel**: Standard UO_2, **ADOPT™** fuel pellets
- **Burnable Absorbers**: Un-poisoned, IFBA, Gadolinia, Discrete BAs
- **Initial Enrichment**: Greater than 5 w/o enrichment
- **Fuel Rod Average Burnup**: Greater than 68 GWd/MTU
- **Plant Classes**: 2-loop, 3-loop, 4-loop W-NSSS plants, CE-NSSS plants

Westinghouse Activities for HEF / ATF / LEU+

Introduction to WCAP-18850

Methodology Overview

Limitations and Conditions

Topical Report Focus Areas
Fuel Rod and Core Models

- Pellet-Cladding Gap Conductance
- Cladding Deformation
- Cladding Rupture
- Fuel Rod Initialization
- Susceptibility to Fine Fragmentation
- Transient Fission Gas Release
- Pre-Burst Fuel Relocation
- Fuel Pellet Thermal Conductivity

Models were assessed and/or updated primarily to ensure that all fuel rod phenomena associated with higher burnup levels were appropriately captured to support high probability, licensing basis calculations

- Kinetics and Decay Heat

Models were assessed and/or updated to ensure energy addition from kinetics and decay heat models is reasonably-to-conservatively modeled

Topical Report Focus Areas
Methodology

- Treatment of regions
  - Coverage of entire break spectrum
- Methodology uncertainties
  - Assessed relative to higher burnup, higher enrichment, and information available since the approval of the FSLOCA EM
- Offsite power availability
- Miscellaneous considerations

Additional Details will be Provided in the Closed Session Presentation

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Westinghouse Activities for HEF / ATF / LEU+

Introduction to WCAP-18850

Methodology Overview

Limitations and Conditions

Type of Limitations and Conditions

- Two different types of limitations and conditions
  - L&Cs inherited from the FSLOCA EM
    - L&Cs which remain applicable are generally inherited into this topical report
    - Some are not applicable (e.g., long-term cooling)
    - Some are superseded (e.g., prior burnup limitations)
  - New L&Cs imposed on this topical report

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Limitations and Conditions

- **L&C #1**: Applicability to different PWR designs
- **L&C #2**: Conditions related to decay heat modeling and uncertainty
- **L&C #3**: Maximum fuel rod average burnup
- **L&C #4**: Fuel performance data should be from a code that is approved for the intended analysis conditions, and explicitly accounts for thermal conductivity degradation (TCD)
- **L&C #5**: Condition related to an analysis uncertainty parameter
- **L&C #6**: Conditions related to the seed and uncertainty analysis inputs; also requirements for unacceptable analysis results and reporting of analysis ranges

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Limitations and Conditions

- **L&C #7**: Requirement to perform the Region II (LBLOCA) analysis with offsite power available (OPA) and loss-of-offsite power (LOOP)
- **L&C #8**: L&Cs number 3, 12, and 13 from the FSLOCA EM (WCAP-16996-P-A, Revision 1) remain applicable to WCAP-18850
- **L&C #9**: Applicability to cladding materials and fuel designs
- **L&C #10**: Applicability to various burnable absorbers
- **L&C #11**: Maximum initial fuel rod enrichment

Questions

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Acronyms / Codes / Labels

Acronym	Definition
ACRS	Advisory Committee on Reactor Safeguards
ALS	Alternate Licensing Strategy (for FFRD)
ATF	Accident Tolerant Fuel
CE	Combustion Engineering
CFR	Code of Federal Regulations
CWO	Core-Wide Oxidation
ECCS	Emergency Core Cooling System
EM	Evaluation Model
EPRI	Electric Power Research Institute
FFRD	Fuel Fragmentation, Relocation, and Dispersal

Acronyms / Codes / Labels

Acronym	Definition
FSLOCA	FULL SPECTRUM LOCA
HEF	High Energy Fuel
IBLOCA	Intermediate-Break LOCA
IE	Increased Enrichment
IFBA	Integral Fuel Burnable Absorber
L&C	Limitation and Condition
LBLOCA	Large-Break LOCA
LEU+	Low Enriched Uranium+ (between 5 and 10 w/o)
LOCA	Loss-of-Coolant Accident
LOOP	Loss-of-Offsite Power

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Acronyms / Codes / Labels

Acronym	Definition
LTA	Lead Test Assembly
LTR	Lead Test Rod
MLO	Maximum Local Oxidation
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
OPA	Offsite Power Available
PAD	Performance Analysis and Design
PCT	Peak Cladding Temperature
PIE	Post-Irradiation Examination
PWR	Pressurized Water Reactor

Acronyms / Codes / Labels

Acronym	Definition
RAI	Request for Additional Information
SBLOCA	Small-Break LOCA
SER	Safety Evaluation Report
TBS	Transition Break Size
TCD	Thermal Conductivity Degradation
TF2	WCOBRA/TRAC-TF2; thermal-hydraulic code licensed as part of the FSLOCA EM
W	Westinghouse