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2 NUCLEAR REGULATORY COMMISSION

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4 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

5 (ACRS)

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7 METALLURGY AND REACTOR FUELS SUBCOMMITTEE

8 + + + + +

9 TUESDAY

10 SEPTEMBER 17, 2019

11 + + + + +

12 ROCKVILLE, MARYLAND

13 + + + + +

14 The Subcommittee met at the Nuclear
15 Regulatory Commission, Two White Flint North, Room
16 T2D10, 11545 Rockville Pike, at 1:00 p.m., Ronald G.
17 Ballinger, Chair, presiding.

18
19 COMMITTEE MEMBERS:

20 RONALD G. BALLINGER, Chair

21 MICHAEL L. CORRADINI, Member

22 VESNA B. DIMITRIJEVIC, Member

23 WALTER L. KIRCHNER, Member

24 DAVID PETTI, Member*

25 HAROLD B. RAY, Member

1 JOY L. REMPE, Member

2 PETER RICCARDELLA, Member*

3 MATTHEW W. SUNSERI, Member*

4

5 DESIGNATED FEDERAL OFFICIAL:

6 KENT HOWARD

7

8 *Present via telephone

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P R O C E E D I N G S

1:00 p.m.

CHAIR BALLINGER: Good afternoon. The meeting will now come to order. I'm Ron Ballinger, Chairman of the Metallurgy and Reactor Fuels Subcommittee. This afternoon, the subcommittee will hear presentations on the Draft Interim Staff Guidance ATF-ISG-01 that will facilitate the staff's understanding of the in-reactor phenomena important to the safety for the chromium-coated zirconium alloy fuel cladding concept being pursued by several fuel as part of the U.S. DOE accident tolerant fuel program.

ACRS members are Harold Ray, Mike Corradini, Joy Rempe, Walt Kirchner, and Vesna Dimitrijevic. And I believe that Dave Petti and Pete Riccardella are on the line.

MEMBER RICCARDELLA: This is Pete. I'm here, Ron.

CHAIR BALLINGER: Good enough. Dave?

MEMBER PETTI: I'm here.

CHAIR BALLINGER: Oh, so Pete got his sandwich. Kent Howard of the ACRS staff is the designated federal official for this meeting. This afternoon, we will hear presentations from the Office of Nuclear Reactor Regulation and the Nuclear Energy

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1 Institute. And I think there's an EPRI presenter too,
2 part of it, regarding the draft ISG.

3 The ACRS was established by statute and
4 it's governed by the Federal Advisory Committee Act,
5 FACA. The NRC implements FACA in accordance with its
6 regulations found in Title 10 CFR Part 7. The
7 committee can only speak through its published letter
8 reports.

9 We hold meetings to gather information and
10 preform preparatory work that will support our
11 deliberations at a full committee meeting. The rules
12 of participation in all ACRS meetings, including
13 today's, were announced in the Federal Register on
14 June 13th, 2019.

15 The ACRS section of the U.S. NRC public
16 website provides our charter bylaws, agendas, letter
17 reports, and full transcripts of all full and
18 subcommittee meetings, including slides presented.
19 The meeting notice and agenda for this meeting were
20 posted there. Portions of this meeting can be closed,
21 which I don't think so, as needed to protect
22 proprietary information pursuant to 5 U.S.C.
23 552(b)(4).

24 As stated in the Federal Register notice
25 and in the public meeting notice posted to the

1 website, members of the public who desire to provide
2 written or oral input to the subcommittee may do so
3 and should contact the designated federal official,
4 that would be Kent Howard, five days prior to the
5 meeting as practical. We have also set aside ten
6 minutes for comments from members of the public
7 attending or listening at our meetings.

8 We have not received comments or requests
9 for time to make oral statements from members of the
10 public regarding today's meeting. A transcript of the
11 meeting is being kept and will be made available on
12 the ACRS section of the U.S. NRC public website.

13 We request that participants at this
14 meeting please use the microphones located throughout
15 the meeting room when addressing the subcommittee.
16 And make sure the green light is on by using the
17 little push thing down at the bottom.

18 Participants should first identify
19 themselves and speak with enough volume and clarity so
20 that they can be readily heard. A telephone bridge
21 line has been established for the public to listen to
22 the meeting. To minimize disturbance of the public
23 line, the public line will kept in a listen-only mode.
24 To avoid disturbance, I request that the attendees put
25 their electronic devices or cell phones in the noise-

1 free mode.

2 We'll now proceed with the meeting and
3 call on Jane Marshall to begin the presentations.
4 It's up to you.

5 MS. MARSHALL: Thank you. Good afternoon,
6 Dr. Ballinger, members of the subcommittee. Thank you
7 for your time this afternoon for staff to share with
8 you our progress on the draft version of interim staff
9 guidance that we're developing to assist staff in
10 reviewing chromium-coated cladding ATF applications.

11 The guidance is based on a phenomena
12 identification and ranking for PIRT exercise on
13 chromium-coated cladding which the staff commissioned
14 through Pacific Northwest National Lab in April of
15 this year.

16 This draft guidance is a key step in our
17 implementation of the NRC's AFT Project Plan which we
18 presented to you in February of last year. The
19 guidance is intended to provide direction to both
20 industry and NRC reviewers such that applicants
21 develop a high-quality submittal and the staff can
22 focus on the areas of highest safety significance in
23 reviews.

24 We recently held a public meeting to
25 discuss an earlier draft version of this guidance and

1 to seek some initial stakeholder feedback on that
2 document. And we've worked to address the comments
3 that we received in that draft, and those are
4 incorporated in the draft that you have for review.

5 We look forward to a productive discussion
6 here with you today. And following this meeting,
7 we'll again refine our guidance prior to issuing it in
8 the Federal Register for an official public comment
9 period. The staff have targeted completion of the
10 guidance by the end of this calendar year in
11 anticipation of the first chromium-coated Topical
12 Report submittals in early calendar year 2020.

13 At this point, I'd like to turn it over to
14 Jason Drake who will kick off the staff's
15 presentation. Jason?

16 MR. DRAKE: Thank you, Jane. Good
17 afternoon, Dr. Ballinger, and members of the
18 subcommittee. My name is Jason --

19 CHAIR BALLINGER: Excuse me. I need to
20 correct an error. Matt Sunseri is also on the line.

21 MR. DRAKE: Okay.

22 CHAIR BALLINGER: Go ahead.

23 MR. DRAKE: No worries. My name is Jason
24 Drake. I'm the project manager for accident tolerant
25 fuel in the Office of Nuclear Reactor Regulation.

1 Again, today we'll going over the -- presenting the
2 updates and development of the draft interim staff
3 guidance for chromium-coated cladding. With me today
4 presenting are Josh Whitman and Ashley Smith from the
5 Division of Safety Systems.

6 Slide here is key message that we'll be
7 covering throughout the presentation. First bullet
8 noted here, coating a zirconium alloy cladding can
9 impact fuel properties and specify acceptable fuel
10 design limits. More specifically, the PIRT will
11 address this in more detail. And Josh will be getting
12 into it about Slide 7.

13 Second bullet here notes that coated
14 cladding represents a modest departure from currently
15 operating fuel. That is to say vendors can rely on
16 current operating experience in the underlying
17 substrate property database to inform their analyses.

18 And the last bullet to note here is that
19 topical report submittals are expected in 2020. These
20 are vendor identified submittal dates starting in 2020
21 to support their batch loading targets by 2023.

22 We still have to develop the ATF Project
23 Plan that's noted here in this slide to outline
24 preparation strategy for ensuring the staff readiness
25 to perform timely licensing reviews. The ISG will

1 serve as the concept-specific licensing roadmap for
2 NRC staff reviews with applications involving fuel
3 products with chromium-coated zirconium alloy
4 cladding.

5 If you take a look at this illustration
6 here, it's in there distinct areas, blue, purple, and
7 orange arrows respectively. Blue is identified here
8 as ATF Concept Development. More specifically, that's
9 industry and issues which are DOE supported and
10 that'll help them inform their development of their
11 technical bases.

12 The purple areas here reference as the
13 PIRT and the refinement of regulatory infrastructure.
14 These are specific to NRC actions, noting that the ATF
15 Project Plan itself is comprehensive. But it's
16 anticipated that because of the modest departure from
17 current designs that the ISG will be sufficient to
18 support licensing actions. And then the Topical
19 Report and planned specific licensing actions, those
20 are just to identify the industry developed and NRC
21 reviewed actions.

22 CHAIR BALLINGER: Can you -- what does
23 refinement of regulatory infrastructure mean?

24 MR. DRAKE: Well, essentially -- what does
25 it mean? Well, we think right now, it's -- do you

1 want to speak to the ISG entirely or what?

2 MR. WHITMAN: So this is from the ATF
3 Project Plan. And I think it may have more parts for
4 some of the other technologies. But for this, I think
5 it's speaking primarily to this ISG.

6 MR. DRAKE: Right. It's supposed to --
7 yeah, it's supposed to be more comprehensive in the
8 totality of the project plan itself and not specific
9 for the ISG. We're just making a notation here that
10 we don't anticipate any infrastructure changes and the
11 ISG will be sufficient. Next slide.

12 So we noted before industry is pursuing
13 batch reloads of coated cladding in 2023 with three
14 major vendors developing concepts, again, DOE
15 supported. It's a very aggressive schedule with the
16 staff, a strategical position to support the
17 deployment.

18 The coating itself is extremely thin up to
19 approximately 20 microns in thickness. And the
20 application processes identified so far, physical
21 vapor deposition and cold-spray. And what that means
22 in the ISG is that, yes, you had to be scoped
23 appropriately in order to accommodate each one of the
24 vendor coating application concepts.

25 The amount of benefit sought in initial

1 licensing varies. That is to say what crediting is
2 sought by each vendor and initial licensing. And
3 that's again concept specific. And we know that LTAs
4 have -- the test assemblies have been deployed and
5 we're fully anticipating that the data acquired will
6 be incorporated into the TR submittal.

7 CHAIR BALLINGER: That was my question.

8 MEMBER REMPE: So I'm sorry, but I was
9 running late from another meeting. And I forgot the
10 beginning of the opening statements to acknowledge
11 that in accordance with our bylaws, I have reviewed
12 this topic in another forum by another agency --

13 MR. DRAKE: Okay.

14 MEMBER REMPE: -- or some aspects of this
15 topic. Thank you.

16 MR. DRAKE: Next slide. This is a vendor
17 example of coated cladding, some of their testing
18 results. And if we start at the right picture, this
19 illustrates the thickness of the coating compared
20 against substrate cladding. You can see -- well, it's
21 hard to depict from the picture.

22 But essentially, this is meant to
23 illustrate that no oxidation in the outer coated
24 diameter was presented when exposed to the high
25 temperature steam environment. If you look at the

1 left during the first testing, there was a noticed
2 reduction and deformation in the small burst area.

3 We're about to build a foundation for the
4 ISG. This is supposed to be a -- it's a visual
5 comprehensive of all the interactions and the efforts
6 that have been taken to this point in the ISG. You'll
7 see up front that the Project Plan was issued in 2018
8 at a comprehensive stakeholder engagement and some
9 industry developed reports that were taken account
10 into the guidance development.

11 This is a highly coordinated effort
12 between NRC and stakeholders where the aggressive
13 scheduling to support initially timelines into that
14 2023 target. Noting down below the recent exchange in
15 July 2019 for initial ISG draft and then the August
16 6th public meeting.

17 Stakeholder comments were incorporated
18 into the draft revisions, and then obviously anything
19 the subcommittee brings up today as far as feedback is
20 concerned will be considered into the final product
21 development.

22 MEMBER REMPE: So in your program plan,
23 you mention an industry white paper on chromium-coated
24 cladding that's an important part of this information.
25 Is that the October 2018 analysis? Or what is that in

1 this list of items? It's on page -- if you look at
2 the PDF, it's 13 out of 58. You --

3 MR. DRAKE: What we're doing in the ISG?

4 MEMBER REMPE: -- talked about what you're
5 doing, and it mentioned this --

6 MR. DRAKE: In the draft itself? Okay.

7 MEMBER REMPE: -- industry white paper.

8 MR. DRAKE: Josh, do you know exactly?

9 MR. WHITMAN: So there's an EPRI -- the
10 EPRI coated cladding gap analysis was included in the
11 development of the initial document that was sent to
12 all the participants, then eventually incorporated
13 into the final report as well as the NEI reactor
14 screening review. I'm not sure which one
15 specifically. I don't have the document up and I
16 don't have internet. So I can't get to it.

17 MEMBER REMPE: It's pretty vague, and I
18 just was curious --

19 MR. WHITMAN: Okay.

20 MEMBER REMPE: -- which of these it was.
21 But you're saying probably --

22 MR. WHITMAN: Yeah.

23 MEMBER REMPE: -- it's one of those two
24 but you're not quite sure?

25 MR. WHITMAN: Yeah. Without looking at

1 it, I'm not positive. Those documents as well as a
2 general literature review were incorporated into a
3 report that was sent to the PIRT participants to sort
4 of get them up to speed on what the PIRT was covering.

5 MR. DRAKE: Does that answer your
6 question?

7 CHAIR BALLINGER: Do we have that?

8 MR. WHITMAN: The --

9 CHAIR BALLINGER: That document?

10 MR. WHITMAN: Yes.

11 CHAIR BALLINGER: Because we have the gap
12 analysis report. That, I have. I wasn't sure about
13 the one you just referred to.

14 MR. WHITMAN: The PIRT?

15 CHAIR BALLINGER: We have the PIRT. But
16 you said you supplied --

17 MR. WHITMAN: So that initial report was
18 amended by the PIRT panel.

19 CHAIR BALLINGER: Okay.

20 MR. WHITMAN: It became the final. So
21 there's nothing in there that wasn't in the final
22 document.

23 MR. DRAKE: Okay. This is a good place to
24 turn it over then. So Josh -- I'll turn it over to
25 Josh Whitman. He'll go through that next slide.

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1 MR. WHITMAN: Okay. So thanks, Jason. So
2 the question leads right into this next slide. So in
3 April of this year, we convened the PIRT through a
4 contract with PNNL which consisted of participants on
5 the table on the right.

6 As you can see, we have individuals with
7 a range of expertise included on the panel, including
8 members from universities, national labs, multiple
9 industries. The panel was conducted publically to
10 enhance transparency to stakeholders. And the final
11 report of about 120 pages is available on ADAMS with
12 the ML number on the slide. So next slide.

13 So after reviewing the final report, we
14 created interim staff guidance based on the PIRT
15 findings. This guidance will supplement Chapters 4
16 and 15 of the standard review plan.

17 So first, I'll begin with some broad
18 statements on what the ISG does and does not do. The
19 ISG does provide guidance to the staff during reviews
20 of coated cladding Topical Reports and license
21 amendments and what areas are important to focus on
22 during their review.

23 It also provides fuel vendors and
24 licensees information on what the NRC staff expects
25 from industry submittals. But the ISG does not

1 introduce any new requirements, rules, or regulations,
2 nor does it prescribe or require any specific testing
3 or analyses. Next slide.

4 So to broadly cover the scope of the ISG,
5 the ISG covers concepts being pursued by the three
6 fuel vendors as part of DOE's ATF program. Two
7 vendors are pursuing thin layers of chromium applied
8 to the outside of the existing full cladding. But the
9 third vendor is pursuing a proprietary coating.

10 The PIRT touched on this where possible,
11 although the public nature of the PIRT and the
12 proprietary nature of that coating has limited the
13 applicability of the PIRT somewhat. However, the ISG
14 does provide general guidance applicable to any
15 coating in addition to specific items on chromium
16 coatings.

17 So for these coatings, the ISG provides
18 the outline of what is expected to be addressed in the
19 Topical Report submitted to the NRC. In the ISG, the
20 narrative provides some guidance on what level of
21 effort is needed which may be dependent on many
22 factors but is especially dependent on whether the
23 benefits of the coatings are being credited in the
24 safety analysis.

25 And then the ISG is organized to

1 supplement the SRP. So Chapter 4 makes up the bulk of
2 the ISG and covers fuel properties and SAFDLs which
3 I'll be covering. And then Ash will cover Chapter 15
4 which makes up the remainder of the document.

5 So Appendix B of the ISG covers fuel
6 properties that should be addressed in licensing
7 submittals. These parameters impact figures of merit
8 for Chapter 15 analyses since they're used in
9 thermomechanical fuels codes as well as in
10 thermohydraulic systems codes.

11 On this slide and others, I've labeled
12 some items with asterisks that I'll touch on because
13 they may have a larger impact on the analyses.
14 Although I do want to clarify that the absence of an
15 asterisk doesn't mean that there's no potential
16 impact.

17 So going through the list, I think
18 emissivity is an interesting property because it's one
19 where the coating may negatively impact that the
20 accident progression while other properties are more
21 likely to either have a neutral or positive impact.
22 So in short, the chromium coatings will stay shiny
23 after developing a very thin layer of oxide which can
24 reduce heat transfer through thermal radiation during
25 accidents -- heat transfer to steam.

1 Oxidation rate and hydrogen pick up as
2 well as high temperature steam oxidation are some of
3 the properties that vendors are hoping to improve with
4 the new coating technologies. And we've also see
5 preliminary information like the adjacent slide that
6 shows that the coatings may also improve ballooning
7 and burst behavior.

8 CHAIR BALLINGER: I was thinking about
9 that. And it's really the effect of a smaller
10 transform beta layer. I mean, during a LOCA, the
11 chromium, and during operation prevents oxidation and
12 prevents transport of oxygen through the -- into the
13 cladding. So that's the effect on ballooning
14 behavior. The chromium coating itself has no effect
15 on ballooning behavior. Is that correct?

16 MR. WHITMAN: Well, so we haven't actually
17 received any submittals from the vendors on these. So
18 there's only so much we can talk about. That when it
19 comes in, we'll see what they've credited and their
20 explanations.

21 MEMBER CORRADINI: But I guess he was
22 asking -- well, what I thought he was asking is, do
23 you know the mechanism --

24 CHAIR BALLINGER: Yes.

25 MEMBER CORRADINI: -- for the observation?

1 Is there a mechanism agreed upon as to -- that
2 explains the qualitative observation?

3 MR. WHITMAN: Not that I'm aware of.
4 Like, as I said, we haven't received submittals. And
5 I would kind of expect them to go into details when we
6 finally get topical reports in.

7 CHAIR BALLINGER: Because there's two very
8 different explanations, if you will.

9 MR. WHITMAN: Understood.

10 CHAIR BALLINGER: The chromium coating
11 itself just prevents oxidation. It's not mechanically
12 -- there's not a mechanical effect.

13 MR. WHITMAN: Right.

14 CHAIR BALLINGER: But it prevents oxygen
15 transport into the cladding.

16 MEMBER REMPE: So your ISG discusses the
17 eutectic temperature of the chromium-coated cladding
18 at 1,332 C. So you covered it there. I'm surprised
19 this list doesn't have any other little bullet that
20 says, low temperature eutectics that could impact
21 performance. Because I don't know what's the
22 mysterious one that's proprietary and does it have
23 such a eutectic temperature so that you could address
24 everybody.

25 MR. WHITMAN: So I have other slides that

1 talk more about the eutectic temperature specifically.
2 This is sort of a list of properties that are needed
3 primarily for the thermomechanical codes that'll need
4 to be updated by the fuel vendors but also for the
5 thermohydraulic codes. And right now, those codes
6 don't involve looking at a eutectic because it's --

7 MEMBER REMPE: Doesn't happen with
8 Zircaloy. So again, to be generic, I'd put another
9 bullet in there, low temperature reactions not
10 anticipated, or something like that, that could happen
11 at --

12 MEMBER CORRADINI: But it's over --

13 MEMBER REMPE: -- lower temperatures.

14 MEMBER CORRADINI: -- 2,200 Fahrenheit.
15 So why is it low? It's -- 1,333 is --

16 MEMBER REMPE: Well, it's a lower
17 temperature than melting is where I'm saying.

18 MR. WHITMAN: So that's included later in
19 the SAFDLs which --

20 MEMBER REMPE: Okay.

21 MR. WHITMAN: -- talk about the melting
22 temperature.

23 MEMBER REMPE: Okay.

24 MR. WHITMAN: So I think it's addressed
25 there.

1 MEMBER REMPE: Okay.

2 MR. WHITMAN: But we can certainly take
3 that into account when we go and revise this before
4 putting out for public comment.

5 MEMBER REMPE: Well, you got it in the
6 ISG. I just was looking at the bullets and thinking.
7 Okay.

8 MR. WHITMAN: All right. Where was I?
9 Oh, okay. So another thing I wanted to point out on
10 this slide is that the PIRT identified that
11 manufacturing may have a first-order effect on some of
12 these parameters. And the NRC staff does not
13 anticipate needing to regulate the details of any
14 manufacturing process for the coatings. But at this
15 preliminary stage, we can't rule out the possibility
16 that some key parameters may need to be included in
17 the approval of the cladding.

18 So this next slide identifies some key
19 places where stakeholder input has been considered in
20 the properties appendix while drafting the ISG
21 already. During the PIRT, emissivity was not
22 identified as a key property that would have a
23 significant impact on the Chapter 15 analyses. But a
24 stakeholder pointed out that the external emissivity
25 is both important and also likely different for the

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1 coated cladding concepts.

2 The PIRT suggested that cracked coating
3 should be tested to assess the oxidation rate of the
4 exposed substrate. And a stakeholder pointed out that
5 intentionally scratching the coatings may be a
6 necessary alternative if cracking the coating isn't a
7 feasible option.

8 CHAIR BALLINGER: I'm a little slow. Can
9 you back up one slide? Okay. Why is not cladding
10 coating thickness on that list? Because I've got some
11 familiarity with cold spray and other kinds of
12 coatings, and there's always a statistical
13 distribution on thickness. And that's got to make a
14 difference.

15 MR. WHITMAN: So I think that -- so this
16 is a list of sort of properties to be included in the
17 thermomechanical codes. And so the thickness goes
18 into how these properties are calculated. And the ISG
19 also goes into different ways of sort of evaluating
20 these.

21 So for example, thermoconductivity could
22 be evaluated as conductivity through the clad and then
23 another part that's conductivity through the coating.
24 Or it could be done as a bulk, what's the sort of
25 average conductivity through both.

1 CHAIR BALLINGER: But you're expecting
2 that a submittal would deal with the uncertainties in
3 that cladding --

4 MR. WHITMAN: Absolutely, absolutely.

5 CHAIR BALLINGER: -- and coating
6 thickness?

7 MR. WHITMAN: Okay. So the only other
8 thing I wanted to mention on this slide is that there
9 was also some language that was tweaked to avoid
10 implying any specific testing requirements. Next
11 slide.

12 So Appendix C of the draft ISG lists
13 SAFDLs and other concerns and breaks them up into a
14 few categories. The first category is SAFDLs related
15 to assembly performance. And while these should be
16 addressed in submittals, the coatings aren't expected
17 to have a significant effect, positive or negative, on
18 many of these.

19 Fretting wear is the one item I start on
20 this list. This is a phenomena where historically the
21 concern has been where on the fuel cladding from the
22 spacer grids. But in this case, that effect may be
23 reversed and instead there may be damage -- there's
24 possibility that there could be damage to the spacer
25 grids from the hardness of the coating. Next slide.

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1 CHAIR BALLINGER: Back again. Fuel
2 assembly, lateral deflection, fretting wear, hydraulic
3 lift loads and the like, those all sort of speak to
4 any kind of testing that might have to be done to
5 address delamination or those kinds of things due to
6 bending or something like that. Member Corradini
7 whispered in my ear, but he's conflicted. And I also
8 talked with another one of the members who I know.
9 And was there an issue on the PIRT committee related
10 to how to test for delamination bending versus c-ring
11 testing or that kind of thing?

12 MR. WHITMAN: I'm not sure that there's a
13 -- so again, we don't try and lay out any specific
14 testing in the ISG that we're requiring.

15 CHAIR BALLINGER: But you have to show
16 that you don't get delamination or --

17 MR. WHITMAN: Right.

18 CHAIR BALLINGER: -- the coating stays on
19 in other words.

20 MR. WHITMAN: Right. And that's addressed
21 in, again, a later slide.

22 CHAIR BALLINGER: Okay.

23 MR. WHITMAN: But the ISG doesn't say,
24 you need to do bending testing, or anything like that.
25 It's up to the reviewer to assess whether the safety

1 case has been made by the submittal. And that's done
2 intentionally because we don't want to put the vendors
3 in a box and make them do a certain testing when
4 perhaps some other form could be just as good.

5 MEMBER PETTI: But you have to demonstrate
6 the integrity of the coating?

7 MR. WHITMAN: I would certainly expect
8 that, especially if any of the benefits of the coating
9 are being taken that the integrity of the coating
10 would certainly be a major part of the review.

11 MEMBER REMPE: So if I read your ISG page
12 2 of 8, finally, if an applicant wishes to take credit
13 for coating behavior up to a certain burnup or during
14 certain accident conditions, it's necessary for the
15 adherence of that coating to the substrate to have
16 been justified for the full operating domain. That
17 sure implies testing to me up to a certain burnup,
18 doesn't it?

19 MR. WHITMAN: Well, it would certainly
20 imply testing, but not any specific --

21 MEMBER REMPE: It seems like you've got to
22 have radiation in there some way or other in that to
23 get that burnup, right?

24 MR. WHITMAN: I would expect it, yes.

25 MEMBER REMPE: Okay.

1 CHAIR BALLINGER: By the way, for folks on
2 the phone, you need to identify yourself if you make
3 a comment so the recorder can know who it is.

4 MR. WHITMAN: So the next section of the
5 appendix covers SAFDLs related to rod performance
6 during normal operation in AOOs. And so to quickly go
7 through the starred items on the list, there's a
8 concern from the PIRT that excessive cladding strain
9 may lead to coatings cracking. And if this is found
10 to be the case, the existing SAFDLs may need to be
11 amended to protect against this behavior.

12 Fatigue lifetime was also identified in
13 the PIRT as a potential area for degraded performance
14 of the coated claddings due to findings from study
15 that was reviewed. And so that's something that
16 should be addressed.

17 Oxidation and hydrating may have improved
18 performance versus the uncoated cladding. But
19 regardless, the existing oxidation and hydrating
20 models almost certainly don't apply. And so therefore
21 the oxidation hydrating SAFDLs should be addressed in
22 the submittal.

23 And then finally, the PIRT identified that
24 these coatings may affect the bubble nucleation
25 behavior of the cladding. And so it's important that

1 boiling crises be addressed. Next slide.

2 And so we also considered some stakeholder
3 comments on this section of the draft ISG. There was
4 some conflicting discussions about boiling crises in
5 the PIRT and that made their way into the ISG. And so
6 those have been clarified in the draft you guys have
7 seen.

8 And then additionally some general
9 questions were made to clarify the testing
10 expectations. And we don't believe that this is
11 something that we really can or should be trying to do
12 with this document. The level of testing required to
13 make a safety finding is going to depend on a large
14 number of variables, most of which are unknown to the
15 staff at this point or at the very least vary from one
16 vendor to the next.

17 So we also want to make sure that they're
18 not being overly prescriptive -- we're not being
19 overly prescriptive or preventing vendors from
20 addressing data needs in an innovative manner. So we
21 tried to leave things open ended while providing
22 guidance in the narrative that will help the reviewer
23 determine what level of testing is necessary to make
24 a safety finding. Next slide.

25 So the next section of the SAFDL appendix

1 covers SAFDLs related to rod performance during
2 accidents. There are more stars here for hopefully
3 obvious reasons. With accident tolerant fuel, you'd
4 expect more changes to their accident performance.

5 Cladding overheating should be impacted --
6 could be impacted by changes to the boiling crisis
7 behavior mentioned previously. And the balloon and
8 burst behavior seems to be affected based on
9 preliminary data that we've seen.

10 For cladding embrittlement, the PIRT also
11 pointed to the possibility of embrittlement due to
12 some unknown zirc-chrome interdiffusion. And then
13 clad melting is included because the PIRT raise the
14 possibility of a chrome-zirc eutectic that may form
15 that would need to be considered. And I'll talk about
16 that a little bit more on the next slide.

17 MEMBER REMPE: But --

18 MEMBER PETTI: So I can ask? This is Dave
19 Petti. In terms of cladding embrittlement, did the
20 PIRT identify radiation embrittlement of the chrome
21 itself as a potential problem?

22 MR. WHITMAN: Yeah. So I'm sort of
23 summarizing a relatively large subsection there. But
24 I think the -- basically, regardless of where the
25 embrittlement comes from, the embrittlement needs to

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1 be addressed and tested.

2 MEMBER KIRCHNER: Did the PIRT come to a
3 conclusion about the -- let's see. These are mainly
4 going to be PWR rods, right? So DNB and CHF. Did
5 they feel that the CHF correlations had to be
6 revisited?

7 MR. WHITMAN: Yeah, I don't think so. I
8 think the PIRT identified them as an area that needs
9 to be addressed. And there's a lot of different ways
10 that they could do it. I think comparative testing is
11 an area where a lot of these properties may be
12 addressed. And so showing that a coated and uncoated
13 rod behaviors similarly is probably sufficient.

14 MEMBER CORRADINI: So from an
15 informational standpoint, that's what's been done is
16 samples with and without the coating with different
17 corrosions have been tested. And they're -- on a
18 relative basis, they look about the same.

19 MEMBER KIRCHNER: About the same. Thank
20 you.

21 MEMBER CORRADINI: But not what I think
22 you want which is prototypical testing. Not yet.

23 MEMBER KIRCHNER: I assume they did just
24 the cladding.

25 MEMBER REMPE: So I guess that I'm going

1 back to my earlier question because I guess this is
2 where you said, we'll generalize melting. But with
3 the high temperature oxidation, you went up to 1,200
4 C. What if they have some sort of eutectic that is
5 above operating temperature but is not considered
6 accident conditions? I'm just wondering did you
7 really cover it all. Do you think so?

8 MR. WHITMAN: So I don't think that that
9 eutectic exists for what's being currently proposed by
10 the vendors.

11 MEMBER REMPE: You don't think, but I'm
12 looking at the generic one that we don't know what the
13 material is.

14 MR. WHITMAN: Yeah, so it's difficult with
15 this because of the proprietary nature of that
16 coating. The PIRT was definitely geared towards the
17 type of coating that proprietary coating is. I want
18 to be really careful about -- I know I sound cagey
19 talking about it. But that specific concern isn't
20 more of a concern for that than it is for the --

21 MEMBER REMPE: The others.

22 MR. WHITMAN: -- elemental chrome coated.

23 MEMBER REMPE: Joe comes in with new super
24 duper ATF that you've not seen that's got some sort of
25 coating. And I'm thinking of just how generic do you

1 want to be. And maybe it's not going to be an issue.

2 MR. WHITMAN: Yeah.

3 MEMBER REMPE: You hope it wouldn't, but

4 --

5 MR. WHITMAN: Yeah, it's difficult because
6 we had to draw a box somewhere on what's covered and
7 what isn't covered. And this, we sort of chose to
8 draw it around what's currently being proposed. And
9 certainly, there could be future coatings that have
10 some -- can take some benefit from the -- or this
11 applies somewhat but not in other areas. But we had
12 to draw a box because we need to be able to get this
13 document out.

14 MEMBER REMPE: Was the PNNL heard the
15 first time that this low temperature eutectic was
16 identified? Or was it identified by DOE already and
17 they were aware of a vender already and they were
18 aware this would happen?

19 MR. WHITMAN: I believe it was previously
20 identified. I'm not sure to what level who identified
21 it and what level it's addressed.

22 CHAIR BALLINGER: The zirconium-chromium
23 phase diagram is well known.

24 MR. WHITMAN: Exactly, yeah.

25 CHAIR BALLINGER: Where you might have an

1 issue would be a zirconium-niobium-chromium phase
2 diagram where if you have two and a half, three
3 percent or so niobium, now that's enough to have an
4 effect. And I didn't see -- I saw M5 and things. But
5 I didn't see a discussion of whether there might be
6 some unknown phase that forms that's still melting for
7 that system. Although I'm probably sure that our
8 friends in Russia probably know.

9 MR. WHITMAN: That's --

10 CHAIR BALLINGER: Well, no, they use --
11 we're not talking about bad stuff here. They've been
12 using zirconium-niobium cladding forever.

13 MR. WHITMAN: That's something we can look
14 into for the next draft of the ISG. I don't believe
15 that was covered by the PIRT. So the next slide.

16 So we'll get into the eutectic a little
17 bit more on this slide as well. But the final section
18 of Appendix C covers new degradation mechanisms and
19 other topics raised by the PIRT. These new
20 degradation mechanisms need to be addressed in the
21 submittals to the NRC. And for each mechanism, this
22 could mean either showing that they won't occur,
23 showing that existing SAFDLs protect against them, or
24 proposing new SAFDLs or adjusting existing SAFDLs to
25 ensure that these degradation mechanisms aren't

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1 encountered.

2 I'll also note that some of these are more
3 important if credit is taken for improved performance.
4 For example, the chromes are eutectic in form, but it
5 has a melting point greater than 2,200 degrees
6 Fahrenheit. So if a vendor wants to take credit for
7 the improved performance at higher temperatures and
8 try and raise the permissible LOCA PCT, this would be
9 something that we would expect would need to be
10 addressed in greater detail.

11 Finally, I'll point out that some of these
12 are also called out in the draft ISG as being a larger
13 concern for certain application methods. Just to give
14 an example, subsurface damage is likely to be highly
15 process dependent.

16 And so if you guys don't have any more
17 questions, I'll turn the presentation over to Ashley
18 Smith who will walk through the portion of ISG that
19 covers Chapter 15.

20 MEMBER KIRCHNER: But your PIRT did not --
21 I don't see any asterisks on this slide, so --

22 MR. WHITMAN: Yeah, these are all
23 asterisks.

24 MEMBER KIRCHNER: They are all asterisks?
25 Okay.

1 MR. WHITMAN: Yes, sorry. These are the
2 new mechanisms that need to be considered, so --

3 MEMBER KIRCHNER: But I think the
4 definition of the asterisk prior to this was
5 significant. Are any of these significant? Or do you
6 think they just all have to be addressed?

7 MR. WHITMAN: Well, I think they all need
8 to be addressed at certain levels. I mean, if a
9 vendor can show through an extreme test that the
10 coating never delaminates, that could be sufficient to
11 satisfy that.

12 MEMBER KIRCHNER: And to me, that one in
13 particular would stand out. That's why --

14 MR. WHITMAN: Yeah.

15 MEMBER KIRCHNER: -- I was fishing in my
16 questions. Thank you.

17 MEMBER PETTI: Can I just ask a broader
18 question? You seem very focused here on the operation
19 and the potential accident and the credit a vendor
20 might take. But does the purview -- NRC safety
21 purview consider things like during refueling as
22 you're moving assemblies around? If any of these
23 things delaminate because of the movement, that's
24 something I would think the utility would want to know
25 about. And so is the testing that comprehensive that

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1 it's going to look at those sorts of events as well?

2 MR. WHITMAN: Again, we haven't specified
3 any specific testing that would be done. I think that
4 a fuel handling accident is something that needs to be
5 considered during licensing analysis as a part of a
6 license amendment. And so that's something that could
7 come up there. And I would expect that if the coating
8 doesn't delaminate during normal operation, AOOs, or
9 accidents, that it would also hold on during core
10 reshuffles.

11 MEMBER REMPE: So in your program plan,
12 you emphasize the importance of earlier NRC
13 involvement. When you did this PIRT, I mean, I know
14 it says new. But that's with respect to -- different
15 from the Zircaloy-based cladding. Did you guys
16 identify anything new that had not been already
17 addressed by industry or DOE?

18 MR. WHITMAN: So I think it's difficult to
19 know what was addressed before the PIRT because we
20 don't have a submittal. Certainly, a lot of this is
21 stuff that I'm sure -- and I'll say hopefully all of
22 this is stuff that the vendors were already looking
23 at. I don't know if they'd come to us and say, oh, we
24 hadn't thought of that.

25 MEMBER REMPE: Yeah, okay. I mean, I

1 thought -- I was hoping that they -- you looked at
2 their papers and you could say none of their papers
3 talked about this mechanism when we started that PIRT
4 but it came up afterwards. But you don't have that?

5 MR. WHITMAN: Well, it's difficult because
6 a fair bit of this is proprietary as well. There is
7 some public information that's been released of things
8 like Top Fuel that were considered in the document
9 that was sent out before the PIRT. And so that sort
10 of formed the basis for a lot of this discussion. And
11 I know Korousch was on the PIRT panel. And at MIT,
12 they had actually procured some samples of cold spray
13 coated cladding and run them through some tests
14 themselves and then formed the PIRT. But does that
15 answer your question?

16 MEMBER REMPE: Yeah.

17 MR. WHITMAN: Okay.

18 MS. SMITH: The discussion up to this
19 point has covered SRP Chapter 4. I'm going to cover
20 how the ISG supplements the SRP Chapter 15 analyses
21 and accidents.

22 As described previously, coating cladding
23 may impact the cladding's material properties and
24 mechanical and thermal behavior. These changes should
25 be incorporated where necessary in the Chapter 15

1 demonstration.

2 The reviewer should also ensure the impact
3 of coating cladding on each of the Chapter 15 AOOs and
4 postulated accidents should be addressed. And as Josh
5 described, the addition of a coated cladding may
6 necessitate changes to existing SAFDLs or require new
7 SAFDLs. And these impacts will need to be
8 incorporated into the Chapter 15 demonstration. Next
9 slide.

10 For now, LOCA transients coated cladding
11 is not expected to significantly impact or require
12 changes to the LCOs -- initial conditions such as
13 LCOs, fuel rod parameters, core power distribution, or
14 fuel rod peaking factors. There's also no change to
15 the radiological source term or the safety system
16 components and their ability to mitigate them. Based
17 on what we've seen through the PIRT and other
18 interactions, it is expected that many FSAR AORs will
19 remain valid. Next slide.

20 During a postulated LOCA, the design
21 features of the coated cladding are expected to have
22 an impact on the fuel rod's performance. Vendors may
23 or may not take credit for this. Multiple phenomena
24 may be affected such as those listed here. And I
25 wanted to highlight emissivity since it may have a

1 negative impact as Josh has already described.

2 We don't know with certainty what credits
3 the applicants are going to use in the first topical
4 reports coming in. But we do know the behavior of the
5 transients will be similar to those so that existing
6 models and methods are expected to remain valid.

7 With that, Jason is going to cover the
8 path forward.

9 MR. DRAKE: Thank you, Ash. So the path
10 forward. So thank you for letting us present the
11 details of the draft interim staff guidance here
12 today. It's intended that the NRC staff review
13 applications involving fuel products, zirconium
14 coating or zirconium alloy cladding.

15 Staff will use the information contained
16 within the ISG to ensure that all known degradation
17 failure mechanisms for chromium coating or zirconium
18 alloy fuel cladding are considered such that their
19 impact on acceptance criteria contained in the SRP
20 Chapters 4 and 15 can be assessed.

21 The stakeholder feedback, as we discussed,
22 was incorporated. And how it was incorporated was
23 covered in the presentation, including inclusion of
24 the exchanges in the 8-6 public meeting.

25 A version of ISG is planned to be

1 published in the Federal Register by the end of the
2 month to elicit public comment. We anticipate having
3 another public meeting at the beginning of December to
4 resolve any comments. And then final guidance is
5 targeted by the end of the year.

6 One question that staff has with respect
7 to processing TRs and LERs on the expedited time table
8 is what level of ACRS expectations is for inclusion of
9 reviews so we can make sure that we have a full scope
10 on what your involvement might be when the submittals
11 start coming in.

12 CHAIR BALLINGER: I guess speaking as one
13 member, I would expect that we'd be able to see the
14 TRs, right? The topical reports?

15 MR. DRAKE: That's what I wanted to
16 clarify as far as comprehensively or --

17 MEMBER CORRADINI: Can I ask the question
18 a little differently?

19 MR. DRAKE: Sure.

20 MEMBER CORRADINI: They'll come in as
21 licensing amendments or just refueling -- as part of
22 the --

23 CHAIR BALLINGER: That's what I was
24 wondering.

25 MEMBER CORRADINI: That's what I think Ron

1 is --

2 MR. DRAKE: Topical reports are planned
3 initially for the concepts for the new technology.

4 MEMBER REMPE: Can I ask? Right now,
5 you've been focusing on what's needed for a safety
6 case to get the fuel in the reactor as a core reload.
7 It's not the economic benefits that might be
8 associated. I mean, they're probably -- do these
9 topical reports or License Amendment Requests also say
10 what kind of credit they'd like for substantiating an
11 economic case for using this fuel which may be more
12 expensive? I mean, you've not started to look at that
13 at all, right?

14 MR. WHITMAN: I think some of that is
15 covered by the ISG. I mean, certainly, it's up to the
16 vendors as to what -- I mean, oftentimes, it'll be a
17 more difficult case to make that here's higher
18 performance. You would expect more testing to be
19 performed, let's say, to take credit for higher
20 performance than simply saying, this is as good as the
21 status quo for some of these properties. But the list
22 of properties is still going to be the same.

23 But the vendors have sort of -- they
24 haven't submitted their topical reports to us. And so
25 we have an idea from our early engagement with them

1 what sort of benefits they're going to be claiming and
2 whether they're going to be coming back later to get
3 certain benefits versus just --

4 (Simultaneous speaking.)

5 MEMBER REMPE: See, you said later. And
6 that's what I'm saying. Getting it in the reactor is
7 one thing. But then to say, okay, I have it in the
8 reactor. Now I'd like to do less testing on other
9 components because I have more margin. That's another
10 bar that you've got to meet, right?

11 MR. WHITMAN: Right. And I think that
12 they're not going -- I think that from what we've
13 heard from the vendors, they're not going to be very
14 aggressive with that, with the first round of
15 submittals. But again, I'm sure they're still
16 discussing this in their meetings too about --

17 MEMBER KIRCHNER: Well, it's seems to me
18 --

19 MR. WHITMAN: -- what they want.

20 MEMBER KIRCHNER: -- that since the path
21 that you've taken do not require any changes on the
22 regulatory side. So you still have Appendix K and I
23 don't remember chapter and verse of 50 for ECCS and so
24 on. So the apparent benefit then obviously would be
25 burnup.

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1 And although you do not specify testing
2 requirements, somehow that would come back and require
3 either through these lead test assemblies or through
4 other mechanisms some empirical evidence. I would
5 submit that would allow them to capture some gain in
6 the economic realm.

7 MR. WHITMAN: Yeah, I agree with that.

8 MR. DRAKE: Yeah, I agree. I think you'll
9 hear from -- potentially from the industry
10 presentation of the business case that's presented
11 before them as far as their crediting, et cetera. We
12 heard a little bit of that last week on the burnup and
13 increasing enrichment presentation by industry as far
14 as them evaluating the benefits or the credits there
15 and that they'd be taken. But as far as the ISG is
16 concerned, that's really just our guidance on how
17 we're going to be processing the topical reports when
18 they come in.

19 CHAIR BALLINGER: So the topical reports
20 are due in 2020 thereabouts?

21 MR. DRAKE: Yes.

22 CHAIR BALLINGER: And a reload would be,
23 you say, 2023?

24 MR. DRAKE: Correct.

25 CHAIR BALLINGER: Will that require a

1 License Amendment Request?

2 MR. DRAKE: Yes.

3 CHAIR BALLINGER: So there'll be a License
4 Amendment Request sometime between 2020 and 2023
5 obviously?

6 MR. DRAKE: Yes. Each one of the reviews
7 has come in with a requested accelerated schedule for
8 our review in order to accommodate that.

9 MR. WHITMAN: And again, that's our
10 expectation. We haven't received these submittals
11 yet. So --

12 MR. DRAKE: Right.

13 MR. WHITMAN: -- if they wanted -- if a
14 vendor were to choose a different licensing path,
15 that's a possibility.

16 CHAIR BALLINGER: So I would expect that
17 ACRS intersection would be at the topical report
18 stage, unless other members have some other -- we're
19 just trying to understand.

20 MEMBER CORRADINI: We're just trying to
21 understand. What is -- you indicated there's another
22 path. What other path would there be?

23 MR. WHITMAN: Well, I mean, theoretically,
24 a plant could come in with basically a topical report
25 attached to their license amendment and say, this is

1 our license amendment. I mean, that I don't think is
2 generally a path that they like to take and that we'd
3 like to entertain. But we don't have these
4 submittals, so we're kind of talking what we expect.

5 MEMBER REMPE: Hypothetically speaking,
6 you could have a topical report that's not really with
7 the economic case. It's just is this safe enough.
8 And so there might be some interaction with ACRS on
9 that. And then when they start coming in saying, I
10 want some economic credit, then that's another issue
11 where it seems like it might behoove a look at it.

12 CHAIR BALLINGER: Why would they say
13 anything to us about economic credit?

14 MEMBER REMPE: Because suddenly the
15 significance of things with respect to risk, they're
16 safety issues. If you want to -- I mean, yeah, I
17 don't care what price they pay for the fuel. But if
18 you're starting to say that certain things don't have
19 to be tested as frequently because -- and it won't
20 adversely affect plant safety. I do think I need to
21 -- or somebody needs to think about the safety case,
22 right?

23 CHAIR BALLINGER: But that's the safety
24 case, not the economic case.

25 MEMBER REMPE: Well, it's poor wording on

1 my part. What I'm trying to say is you're going to
2 change the safety case of the plant because of this
3 fuel, but it is associated with their economic. Then
4 I think there does need to be some safety review.
5 Okay? Did I make it clearer now with what I'm getting
6 to?

7 CHAIR BALLINGER: So noted.

8 MEMBER REMPE: Thank you.

9 MR. DRAKE: Well, that concludes our
10 presentation.

11 CHAIR BALLINGER: Okay. Are there any
12 other questions or comments by members before we
13 change out? We're way ahead of schedule. I probably
14 just jinxed myself.

15 MEMBER KIRCHNER: Then let me ask a
16 question since we're ahead. Just a clarification.
17 The Slide No. 5, 1,800 psi, is that internal pressure?

18 MR. WHITMAN: Yes.

19 MEMBER KIRCHNER: Okay. Thank you.

20 MR. WHITMAN: These are just example
21 slides that --

22 MEMBER KIRCHNER: No, I know. I just want
23 to clarify it wasn't external pressure. It's the
24 internal pressure.

25 MR. WHITMAN: These are -- this entire

1 presentation is only words without those pictures.
2 Tried to make it a little bit more colorful.

3 CHAIR BALLINGER: Okay. Then -- and let's
4 see. Matt, Pete, or Dave, any additional questions
5 for the staff?

6 MEMBER PETTI: No.

7 MEMBER SUNSERI: This is Matt. I don't
8 have any.

9 MEMBER RICCARDELLA: This is Pete. I have
10 none.

11 CHAIR BALLINGER: Okay. So we should
12 probably just push ahead. And I don't know where the
13 -- you're ready to go. Thank you. This is going to
14 be interesting.

15 (Pause.)

16 CHAIR BALLINGER: You're on.

17 MR. ASHKEBOUSSI: I'm Nima Ashkeboussi
18 with the Nuclear Energy Institute. I want to thank
19 the committee for the invitation today to speak about
20 industry's views on accident tolerant fuel and the
21 draft ISG.

22 We appreciate the interactions that we've
23 had to the staff as they've developed it and the
24 engagements that we've had to date. Before I begin,
25 I just want to clarify for the record the agenda. It

1 lists Al Csontos as an NEI member. But just want to
2 correct that as Al is with EPRI.

3 MEMBER CORRADINI: So he's undercover?

4 (Laughter.)

5 MR. ASHKEBOUSSI: We're both doing our
6 numbers. So industry is excited to develop, license,
7 and deploy accident tolerant fuel. And we're working
8 on an accelerated schedule with our efforts to achieve
9 this. We see accident tolerant fuel as a product not
10 that only enhances safety but the one that improves
11 plant economics as well.

12 So for the benefit of the committee, we
13 just wanted to highlight how we're structured. In
14 2016, NEI established the accident tolerant fuel
15 working group. The purpose of this working group is
16 to coordinate industry's efforts in addressing generic
17 issues associated with ATF.

18 This group includes executives from
19 utility vendors, fuel -- excuse me -- fuel vendors,
20 utilities, and engineering supply companies. So we
21 also collaborate with the Electric Power Research
22 Institute, and they lead research efforts in support
23 of ATF.

24 We have two task forces. Our external
25 affairs task force focuses on communication and

1 congressional outreach of accident tolerant fuel. And
2 then we have another task force that manages licensing
3 and safety benefits issues associated with ATF. So
4 they looked at what exactly are the safety benefits
5 with these ATF concepts and how do we go about
6 licensing them.

7 So also wanted to highlight some key
8 milestones and where we see ATF moving over the next
9 several years. So we're very proud as an industry to
10 have deployed ATF concepts last year at Plant Hatch.
11 Several have been deployed earlier this year. We have
12 Clinton and ANO deploying concepts this fall. So
13 these concepts represent not just new fuel pellet
14 types but also cladding.

15 MEMBER CORRADINI: So the colors mean
16 something?

17 MR. ASHKEBOUSSI: The colors -- right,
18 each color refers to a different concept.

19 MEMBER CORRADINI: So just for the sake --
20 since there's no legend, let me make sure I
21 understand. Orange is iron clad FeCrAl and light blue
22 is a coating?

23 MR. ASHKEBOUSSI: Yes, that's correct.

24 MEMBER KIRCHNER: And green is pellets?

25 MR. ASHKEBOUSSI: Green is pellets along

1 with purple is pellets as well.

2 MEMBER CORRADINI: What is -- oh, okay.

3 MR. ASHKEBOUSSI: So blue, orange, and
4 brown are claddings. Green and purple are pellets.

5 MEMBER CORRADINI: A legend would've
6 helped. Just a thought. Thank you.

7 MR. ASHKEBOUSSI: So as mentioned in the
8 previous presentation, all vendors now have LTAs and
9 reactors. And we expect the first LTAs to come out
10 this coming spring 2020. And we are planning on batch
11 reloads in 2023 with a full core of ATF in 2026.

12 So before I turn it over to my colleague,
13 Ben Holtzman, I just want to say that we agree with
14 what NRC said in the last presentation that these near
15 term concepts are modest departures from the current
16 fuel that is licensed in reactors. But we do have a
17 differing viewpoint when the staff says that the ISG
18 does not add new requirements. And we'll go into that
19 as part of our presentation.

20 MEMBER REMPE: So could I ask you to
21 clarify your statement about all vendors have LTAs.
22 There used to be a differential between near term and
23 longer term concepts. And so is there a caveat you
24 want to say that all vendors' near term concepts have
25 LTA? Or do we now have all the advanced ones also as

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1 LTAs with the fuel as well as in the cladding that's
2 intended?

3 MR. ASHKEBOUSSI: So the three vendors,
4 Framatome, Westinghouse, and GE, all have near term
5 concepts --

6 MEMBER REMPE: As LTAs?

7 MR. ASHKEBOUSSI: -- as LTAs. There are
8 longer term concepts by other companies that have not
9 been deployed.

10 MEMBER REMPE: That's what I was thinking.
11 Thank you.

12 MEMBER CORRADINI: I'm still going on the
13 color chart. So something has been put inside a
14 reactor with U3Si2 fuel?

15 MR. ASHKEBOUSSI: Yes.

16 MEMBER CORRADINI: So that's not short
17 term in my view. That's in Byron?

18 MR. ASHKEBOUSSI: That is correct.

19 MEMBER CORRADINI: And the cladding is
20 what? I'm trying to understand. The cladding is
21 chromium-coated cladding?

22 MR. HOLTZMAN: Yes. The Byron -- this is
23 Ben Holtzman from NEI. So the Byron LTAs which were
24 Westinghouse technology, so there's different -- the
25 rods specifically are a combination of those three.

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1 They're not a -- it's not a single rod with each of
2 them in there.

3 MEMBER CORRADINI: It's an assembly with
4 a --

5 MR. HOLTZMAN: With different rods. Some
6 of the rods have U3Si2 fuel, uranium silicide.

7 MEMBER CORRADINI: So it's mixed?

8 MR. HOLTZMAN: Correct.

9 MEMBER CORRADINI: Okay.

10 CHAIR BALLINGER: And Westinghouse silicon
11 carbide cladding is in an LTA?

12 MR. HOLTZMAN: No. The silicon carbide
13 cladding which in this chart is the --

14 (Simultaneous speaking.)

15 CHAIR BALLINGER: Oh, that's -- okay,
16 okay.

17 MR. HOLTZMAN: -- brown. Those are
18 further out to the right.

19 MEMBER REMPE: Is it planned to have fuel
20 with that cladding? Because I know we did one LTA or
21 LTR or something. It was just unrodded cladding. But
22 you're planning to put fuel with this cladding in --

23 MR. HOLTZMAN: '22.

24 MEMBER REMPE: -- 2022?

25 MR. HOLTZMAN: My understanding is that

1 they have not yet determined whether or not the
2 silicon carbide LTAs will be fueled or unfueled.

3 MEMBER CORRADINI: So let me make sure
4 I've got this right. I was with you all the way until
5 I saw the purple. So Westinghouse manufactured the
6 U3Si2 fuel?

7 MR. HOLTZMAN: Yes, I believe it was
8 manufactured at INL. But I'd have to confirm with --

9 MEMBER CORRADINI: Okay.

10 MR. HOLTZMAN: -- Westinghouse.

11 MEMBER CORRADINI: Okay. So INL did it?

12 MR. HOLTZMAN: On behalf of Westinghouse,
13 yes.

14 MEMBER CORRADINI: Okay. Thank you.

15 MR. HOLTZMAN: Okay. So as Nima
16 mentioned, I'm Ben Holtzman from NEI. So we wanted to
17 -- we're going to transition a little bit and talk
18 more specifically about kind of our thoughts regarding
19 the ISG. So obviously the durable guidance leads to
20 regulatory stability and predictability. And in order
21 to achieve this durable guidance, we want the ISG to
22 be clear in terms of its requirements.

23 So one aspect of this that we have given
24 the NRC some feedback on, as noted previously, there
25 was a public meeting on August 6th. So some of this

1 is similar to the feedback. But we wanted to give you
2 guys the same impact in terms of what our thoughts
3 were. And we have some updates with respect to our
4 thoughts regarding how the NRC has been incorporating
5 the comments that we provided, both in our letter and
6 during the public meeting itself.

7 So the ISG kind of puts all the
8 information into a single bin. Essentially, the idea
9 is that as industry have been looking through the ISG,
10 it's not clear necessarily what specifics are solely
11 for fuel licensing actions and what information is
12 more towards the realization of benefits.

13 So we've kind of tried to highlight on
14 this slide kind of where some of this information
15 falls into the different parts of the -- the buckets,
16 if you will. So we kind of view this as kind of
17 having a natural progression for licensing.

18 Obviously, industry needs to cover the
19 material required to license fuel. And some of the
20 vendors will be licensing additional benefits
21 associated with their topical submittals such as the
22 increased burnup and enrichment or other specific
23 benefits as the vendors have the data to support it.

24 MEMBER CORRADINI: So can I say it a
25 different way? You're saying there are certain things

1 that appeared in NRC's ISG that is clearly a benefit
2 and it doesn't need to be there or that it doesn't
3 need to be quantified. That's what I'm -- I'm not
4 understanding where you're going.

5 MR. HOLTZMAN: Sure. So in terms of
6 scope, we looked at this and said, we have a current
7 -- we'll call it a box, if you will. There's a
8 current amount of information that is required to
9 license current fuel technologies. And we said, okay,
10 if this is what we're doing for current fuel
11 technology, M5 optimizer, whatever technology we're
12 looking at. And now we wanted to go do a coated
13 cladding technology.

14 So coated cladding is the same base
15 substrate material with a 10-30 micrometer coating on
16 top of it as the previous presentation noted. So if
17 that's what we're looking at, I have my existing
18 requirements and maybe there's a couple specific
19 questions that are coming up solely for coated
20 cladding.

21 If that's what we're calling the base
22 requirements in terms of licensing the fuel, when we
23 read through the ISG, there are additional questions
24 associated with it. Most of those questions in terms
25 of what information they're looking at are things

1 where from our perspective NRC is trying to identify
2 what are the additional benefits that we're going
3 after and what information would a vendor need to
4 submit in order to realize some of those benefits. So
5 --

6 MEMBER CORRADINI: Before the benefits are
7 even being claimed?

8 MR. HOLTZMAN: Before -- yeah, so the ISG
9 is trying to lay out the framework of what information
10 industry would need to provide for those benefits.
11 But the challenge that we -- the concern that we have
12 is that the ISG is not as clear as it could be in
13 terms of what parts of this are solely part of that
14 base licensing activity and which of these are part of
15 realization of benefits.

16 And the reason why we have that concern is
17 since each of the vendors are going to be submitting
18 their own topicals and they'll likely be submitting
19 their own unique mix of what the benefits are that
20 they're looking at based on the data and the unique
21 properties of what they're proposing.

22 So if a vendor is submitting that mix and
23 they're saying, okay, I want Benefits A, B, C, and D
24 in addition to my current base submittal in terms of
25 information. If the NRC reviewer is looking at the

1 ISG and saying, the ISG is meant to give me the
2 information to inform my review. And while, yes,
3 there's information on A, B, C, and D but not E, F, G,
4 H, or I which are benefits that that specific vendor
5 in that application did not try to claim benefit for.

6 MEMBER CORRADINI: There's no need to
7 submit.

8 MR. HOLTZMAN: There's no need providing
9 or touching upon those different topics.

10 MEMBER REMPE: Could you give us some
11 examples? I mean, the burnup thing, well, that's
12 normal. I mean, you might not go to the full life.
13 But they can get in as long as they have data. The
14 way they've worded it, as long as you have data to
15 support the intended use. But give me some other
16 examples.

17 MR. HOLTZMAN: Sure. And so obviously the
18 way that the burnup one is written now, obviously as
19 you noted, increasing the burnup limit itself is not
20 specifically tied to a coated cladding topical. But
21 obviously you have a burnup limit that's in every
22 topical report and loaded in there.

23 Some of the additional ones that we kind
24 of -- that we noted, one of which is the eutectic
25 formation. And they're highlighting that as something

1 that's occurring above the DBA temperature limit. We
2 recognize that this is something that they're
3 highlighting as potentially in the future we might be
4 trying to increase that number or that at some point
5 that this may become applicable.

6 And I know we talked earlier before, such
7 as for a potential system that this may become
8 something of interest. And obviously if the
9 technology made it so that this did start falling into
10 the current design basis temperature regime and it
11 would then therefore be something considered, that's
12 a different story.

13 But at the moment, it's something that's
14 being called out as beyond the scope of current
15 licensing. We don't normally answer questions in a
16 topical report regarding beyond design basis
17 accidents.

18 MEMBER REMPE: Is that the only example,
19 or do you have others?

20 MR. HOLTZMAN: There are others, and we
21 have some of them noted in the letter. I don't know
22 if you remember a couple other ones off the top of
23 your head, but --

24 MEMBER REMPE: I don't think we got a copy
25 of the letter is why --

1 (Simultaneous speaking.)

2 MR. HOLTZMAN: Okay. We can share the
3 letter with our comments. It makes the way over.
4 It's in ADAMS currently, I know.

5 MEMBER REMPE: Okay. We'll try and get
6 our staffer to give it to us.

7 CHAIR BALLINGER: To reword it a little
8 bit, what you're saying is, is that if it's an actual
9 benefit to you, meaning that you're claiming a
10 relaxation or an increase in some temperature, that's
11 a benefit to you. That has got to be in your
12 submittal. But if it's a benefit, if you will, that
13 you're not claiming buys you anything but it is a
14 benefit, it doesn't need to be addressed?

15 MR. HOLTZMAN: Correct. And the concern
16 that we had was that if the guidance is not clear, we
17 may end up in a do-loop of RAIs coming out of a
18 reviewer who's asking questions about something that
19 has been called out in the ISG but is not part of the
20 review. It's not part of our topical report and is
21 not part of the scope of what we're trying to achieve
22 with that report.

23 MEMBER CORRADINI: So let me -- if I
24 might, let me turn to the staff. Was that their
25 intent that they would have to quantify things that

1 are potential but not actual? Maybe we're
2 misunderstanding.

3 MR. WHITMAN: Is this on? This is Josh
4 Whitman with the staff. I think we use the term
5 addressed to allow for some wiggle room here. So for
6 example, if we're talking about the eutectic, a
7 licensee could address -- or a vendor could address
8 this by saying the eutectic occurs above the
9 temperatures that we're requesting operation to. And
10 that may be sufficient to address the eutectic.

11 MEMBER CORRADINI: And then if I might
12 just push the point, if there are some of the other
13 ones, if the applicant -- it's not applicable to their
14 current request, not applicable is an acceptable
15 response?

16 MR. WHITMAN: I think so.

17 MEMBER CORRADINI: Now I'll turn back to
18 the applicant. Is that an acceptable answer? I'm not
19 looking to negotiate, but I'm just trying to
20 understand.

21 CHAIR BALLINGER: You're just saying put
22 it in writing is what you're saying?

23 MR. HOLTZMAN: If it's clear, that would
24 be the best. If with the clarification, hopefully
25 that clarification would be applied for -- that would

1 -- the verbal discussion that we just had would be
2 clear to any NRC reviewer when the topical reports
3 came in. So if --

4 MEMBER KIRCHNER: It would seem to me from
5 both sides, it's not unreasonable when you introduce
6 a new material into a well proven system to explore
7 what mechanical material or radiation performance
8 changes are incurred. I would think on the question
9 of eutectic, that's not an unreasonable thing for the
10 regulator to look at.

11 I think you could quickly dispense with it
12 by showing that the eutectic forms at temperatures way
13 above what you're going to license your fuel loads to
14 which is -- because they're not changing the 2,200 or
15 any of the other ECCS and Appendix K regulations.

16 So it would seem to me a quickly addressed
17 manner. But it's not an unreasonable thing in a guide
18 for the regulator or the staff to ask. See where I'm
19 --

20 MR. HOLTZMAN: Yeah, that --

21 MEMBER KIRCHNER: From a physical,
22 phenomenological standpoint. Not from any long-term
23 performance gains and other aspects.

24 CHAIR BALLINGER: But there are other
25 eutectics that exist now, nickel, chromium, iron,

1 nickel-based alloy, 718 grids, zirconium alloy
2 cladding and things like that. But those are way up
3 above there too.

4 MR. HOLTZMAN: Yeah. Can you hit the one
5 forward? So essentially kind of where this is looking
6 at is, and so on the next slide, this slide is kind of
7 highlighting a little bit of kind of the overall scope
8 that was being covered in some of these documents.
9 And so while, yes, there's a path that we can address
10 some of these things.

11 So if you started at the initial gap
12 analysis that EPRI developed and issued in October of
13 last year and then look at that compared to the PIRT
14 rev zero and then the revision of the PIRT rev one
15 which was after the PIRT meeting itself in April. And
16 then we're looking at the initial issuance of the ISG
17 which was the version that we looked at for the August
18 6th meeting.

19 What we were seeing is kind of this slow
20 increase in expansion essentially of what is all the
21 different types of materials or questions that we need
22 to be addressing. And the initial intent of when we
23 kind of talked about this a little bit in 2018 and
24 then when we started off this PIRT exercise was that
25 we were trying to draw a box to constrain the overall

1 review.

2 The intent was -- and this was the way NRC
3 explained it during our meetings last year was that
4 they were trying to develop essentially a set of
5 bounds to help ensure that when industry topical
6 reports came in, the reviewers had a set of guidelines
7 to look at that said, okay, these things are in scope
8 for us to look at; these things are out of scope for
9 us to look at.

10 And while I agree we have a path forward
11 in terms of how do we address things, for many things,
12 obviously again same base substrate. We can look at
13 this in terms of, well, did this do any harm? Is
14 there any difference in terms of how this is going to
15 perform? Not even whether or not, like, there's a
16 benefit and we want to try to realize that benefit.
17 But just can we demonstrate that this is equivalent to
18 our current materials that were currently licensed?

19 But the challenge that we were having is
20 that, well, if this box in terms of what we're being
21 asked to address just continues to expand, at some
22 point, is this no longer even helpful for the NRC
23 reviewer in terms of making them having an efficient
24 review of the industry topical report? And are we
25 just being asked to cover so many different topics

1 that this starts becoming unwieldy to some degree?

2 And obviously, we can do this. We can put
3 in additional information and go forward. But to some
4 degree, this coated cladding is honestly -- this
5 should be the most straightforward ATF implementation,
6 right? This is, again, same base substrate material.
7 So that's kind of more of where our thought process
8 were in terms of answering your question.

9 MEMBER KIRCHNER: Let me ask a rhetorical
10 question. Not knowing the proprietary nature of all
11 the things being considered, is everything, in terms
12 of the coating, 100 percent chromium? Or are people
13 looking at alloys? As you indicated, if you put a
14 little niobium in, it --

15 CHAIR BALLINGER: In the cladding.

16 MEMBER KIRCHNER: -- changes the game.

17 CHAIR BALLINGER: Zirc-niobium --

18 MEMBER KIRCHNER: Yeah, yeah.

19 CHAIR BALLINGER: -- cladding is being
20 used.

21 MEMBER KIRCHNER: Yeah.

22 MEMBER CORRADINI: I don't think they can
23 answer that question from my understanding.

24 MR. HOLTZMAN: We can't go into the
25 specific details of the vendors mix. But I'm sure

1 they'll be very clear in their topical reports what
2 exactly the technology is and they will get into it
3 there.

4 MEMBER DIMITRIJEVIC: I do have a question
5 which is completely because you're listing all these
6 maybe benefits, maybe not benefits. A lot of plans
7 have a risk-informed application currently approved by
8 NRC. This is definitely going to -- in this risk-
9 informed application require plan to maintain the PRA.
10 And whenever some change happen in the design or
11 changing obviously, a significant change which can
12 impact success and therefore can impact PRA. That can
13 impact risk-informed application currently approved
14 for this plan. Was this ever discussed as this?

15 MR. HOLTZMAN: Yeah. So we have been
16 looking at the potential impact on the PRA as well.
17 So generally when we look at in terms of types of
18 benefits, right? Essentially, the benefits fall under
19 at the highest level three different types of
20 categories.

21 There's benefits that industry would be
22 looking at trying to realize that are solely industry
23 scope. It's things that don't impact the licensing
24 basis, don't impact necessarily PRA or things like
25 that. Those are obviously things that industry --

1 they can go off and realize on their own.

2 You then have benefits that would fall
3 under -- that would be NRC review but would be a
4 generic application. And what I mean by that is they
5 would be covering multiple plants in terms of the
6 submittal. So increased burnup and enrichment, for
7 example, is one that would fall under that. And then
8 you have kind of one-offs that would be a specific
9 plant is looking at this. But it would also require
10 NRC interaction.

11 And the reason why I think that kind of
12 distinction is important is that when we were looking
13 at what are the potential impacts for the PRA, to some
14 degree, we were looking at this and saying, okay, for
15 2023, what are the types of benefits that we're
16 looking at and trying to realize. And the things that
17 were impacting the PRA, those are things that we're
18 looking at for a longer term implementation time
19 frame.

20 So Nima had on the previous slide,
21 indicated we're looking at 2026 in terms of full core
22 implementation. Pretty much anything that we are
23 looking for a PRA aspect, we would be realizing once
24 we have full cores.

25 So until then, we'd be looking at this and

1 saying, well, even if there's a potential benefit in
2 PRA space, we're not going to try to realize this
3 until we have the full core anyway in 2026. And so
4 we're not looking at this in terms of a near term PRA
5 impact associated with the 2023 submittals.

6 MEMBER DIMITRIJEVIC: Well, what I wanted
7 to point out, as I say, maybe benefit, maybe not.

8 MR. HOLTZMAN: Yeah.

9 MEMBER DIMITRIJEVIC: It's not necessarily
10 benefit, it existing this --

11 MR. HOLTZMAN: Sure.

12 MEMBER DIMITRIJEVIC: -- information
13 because it's going to impact human performance.
14 Because that's where you're buying more time to your
15 success for the damage to occur. So therefore, if
16 it's impacting human performance, then a lot of risk-
17 informed applications are based on proving the
18 agreement is not important. But that change relative
19 importance of the things.

20 So there is costs associated with updating
21 PRA. There is costs associated with maintaining your
22 risk-informed applications. And it may not be benefit
23 or not. You cannot say this is benefit. We're not
24 going to claim it. You will have to maintain PRA --

25 MR. HOLTZMAN: Yeah, we --

1 MEMBER DIMITRIJEVIC: -- if you have a
2 risk-informed application. And almost all plans in
3 the United States have at least risk-informed ISI. So
4 therefore, based on that, they have to maintain the
5 PRA. Once you change, you have to update the PRA.
6 That means you have to update Chapter 50 which provide
7 the success.

8 MS. GAVRILAS: This is Mirela Gavrilas of
9 the staff. Perhaps I can add a bit of clarity. There
10 is an entire cast in the accident tolerate fuel
11 project plan that deals with PRA for exactly the
12 reasons that you just mentioned. So we are fully
13 aware that for PRA to be applicable, it needs to be
14 for the plan as constructed.

15 So we have an entire chapter that deals
16 with that. And we're calling out that if there are
17 differences that -- and by the way, this dialogue has
18 been -- your concern, I know I've raised it about
19 three years ago. And we captured it in the plan. We
20 recognize that it exists. So if there is a deviation
21 in the PRA, they will need to address it if they want
22 their risk programs like ISI or 5069 or 505 to remain
23 applicable.

24 MR. CSONTOS: So EPRI has done a generic
25 analysis, generic four-loop Westinghouse PRA model

1 with the coatings, all right, and the other consoles.
2 It's all in our report. Okay? And what we found was
3 that for the coatings, we got an actual improvement.
4 Okay? It's a reduction in core damage frequency for
5 that generic four-loop by about five percent. Okay?

6 When you take the advanced longer term
7 concepts, you're talking about anywhere between 10 or
8 15 percent, okay, reduction of CDF. So what we're
9 talking about here is what needs to be done now. We
10 agree that there's a lot of things that have to be
11 addressed. Okay? The comment is that if you are
12 doing no harm or if you can show that you have a
13 reduced CDF, okay, generically, all right, can you go
14 in and do things now to license versus doing something
15 in 2026?

16 The other question that we have to ask
17 ourselves is when do we need to do these types of
18 analyses? Do you do it after first load -- first
19 batch load? Do you do a second or a third reload?
20 When do you do this? Okay? These are all things that
21 we can have and spend time on over the course between
22 now and 2026 to develop, create those individual,
23 possibly site specific PRA models to address those
24 types of things.

25 But at the current perspective that we're

1 looking at here is what needs to be done. What's the
2 minimum that needs to be done now to license products?
3 What's the technical requirements that are needed?
4 Okay. Versus what needs to be done later to get some
5 of these benefits.

6 So for example, if you don't want to take
7 credit to going up to a certain temperature and you
8 keep everything the same now. Do you need to go after
9 and get that data now? Or if you -- or for a vendor
10 or a utility says, we want to go to a higher
11 temperature for our DBA analysis. Then can we bring
12 in that data to you? Okay?

13 Because right now, we have limited
14 facilities. We have limited products. I heard
15 Framatome talking at one of our industry meetings
16 saying they can't make it fast enough. Okay? And so
17 we have limited capabilities to get all these test and
18 to get everything done. Okay?

19 And so we need to figure out we can't --
20 if we're going to take a bite out of this steak which
21 we've got to take small bites. We can't take it all
22 at one time. Okay? And so we need to figure out what
23 do we need to go after.

24 I think going after what's the limited
25 data sets for getting reloads in. That's kind of the

1 focus of what we're talking about. So what testing
2 needs to be done, things like that. The other pieces,
3 we don't disagree that they need to be done. It's
4 just the timing of when they need to be done.

5 MEMBER DIMITRIJEVIC: I got it. I just
6 was trying to warn. And I know that they're thinking
7 that's important. Actually, all this doesn't mean --
8 actually doesn't mean benefit because what contributes
9 to risk change, the risk is relative.

10 So for example, so many of these agendas
11 can become much more important than they were before.
12 And you cannot anymore do the, you know, maintenance
13 online. And it increases your operational cost which
14 is not benefit. So this was just my point. It has to
15 be very particularly addressed. It's absurd, but
16 that's how it goes.

17 MEMBER REMPE: Just a point of
18 clarification in your response, Al, when you go to
19 this benefit of core damage frequency. It's assuming
20 certain properties --

21 MR. CSONTOS: Properties.

22 MEMBER REMPE: -- that are not yet
23 validated with experimental --

24 MR. CSONTOS: Correct. These are --

25 MEMBER REMPE: -- data. So you're --

1 MR. CSONTOS: Oh, no, no, no. Those were
2 provided to us from the DOE program back --

3 (Simultaneous speaking.)

4 MEMBER REMPE: The DOE program --

5 MR. CSONTOS: -- to 2016-17 time frame.

6 MEMBER REMPE: Did DOE have the data to
7 validated the fuel performance to say the core damage
8 frequency has decreased?

9 MR. CSONTOS: No, no, no, no, no. That's
10 not -- I'm talking about the physical properties of
11 the coatings, the physical properties, the
12 temperature, the melt temperature of the different
13 concepts. We have that information.

14 MEMBER REMPE: Okay. You probably needed
15 some sort of MELCOR or map analysis --

16 MR. CSONTOS: Map analysis.

17 MEMBER REMPE: -- to do that. And they
18 don't consider a lot of things like other materials in
19 the core, in a BWR, the cladding channel boxes, et
20 cetera. So put a caveat that you --

21 (Simultaneous speaking.)

22 MEMBER REMPE: Yeah, okay. That's why I
23 just wanted to -- it's not so certain.

24 MR. CSONTOS: We need to update them in
25 the future once we get a better handle of things. But

1 we're talking about coding. The existing codes are
2 fairly -- they're good enough. And you go to the
3 silicon carbides and things like that --

4 MEMBER REMPE: I'm even talking --

5 MR. CSONTOS: -- I completely agree.

6 MEMBER REMPE: Again, you may change the
7 fuel, but you may not change the severe accident
8 response yet because they don't have that in the codes
9 yet is where I'm going. So put a caveat in there.
10 Okay?

11 MR. CSONTOS: Yeah.

12 CHAIR BALLINGER: For the record, 15
13 percent change in core damage frequency up or down,
14 what's the uncertainty on the number to start with?

15 MR. CSONTOS: Right.

16 CHAIR BALLINGER: So it's basically a
17 wash.

18 MR. CSONTOS: Right. And that's what
19 we're getting at here is that if you're going to be
20 going -- and the concept here is we're putting a thin
21 coating and already approved and already existing.
22 You have all the analysis done. Okay?

23 And so it's a matter of what data do you
24 need to get to go and do the licensing, okay, to show
25 to NRC that it's safe enough? Okay? And then we go

1 after those benefits. But really those benefits, some
2 may not want to go after those benefits. They'll just
3 take it.

4 CHAIR BALLINGER: One more slide.

5 MR. HOLTZMAN: Well, okay. And so the
6 last thing I wanted to say on this was just that there
7 is no safety imperative for why we're going to be
8 implementing accident tolerant fuel. The current fuel
9 is very safe. It is the determination of the benefits
10 in economic space.

11 Essentially, the marketplace between the
12 vendors and the utilities that'll be moving that'll
13 help us determine what benefits we're trying to
14 realize in our submittals and how we're going to
15 actually implement this for the cross industry.

16 So we talked about some of this on this
17 slide already. One thing that we wanted to highlight
18 as well is that obviously as we -- and NRC kind of
19 talked about this a little bit. So the ISG is
20 intended to provide guidance on chromium-coated
21 zirconium alloy cladding.

22 At some points, it's kind of -- it sounds
23 like this is more specific in terms of generic
24 coatings in general where in other places it's getting
25 into the specifics regarding chromium-coated

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1 applications itself.

2 And so I believe that NRC kind of took --
3 did take some of that feedback to heart from our last
4 meeting and made some denotations on that. So we
5 thank you for that in terms of the adjustments on the
6 previous revision.

7 I think that there's still a few instances
8 where we could potentially look at that for having
9 additional clarification regarding whether or not
10 something is being denoted specifically for the
11 chromium-coated application or for generic
12 applications itself.

13 Additionally, there was a -- in Appendix
14 Bravo, in terms of the oxidation rate, there's a bit
15 of information in terms of how the coatings would
16 impact the thermohydraulic characteristics. The
17 reason why we wanted to bring this up is that again
18 this is something that was not brought up during the
19 PIRT itself. So this is another example for us in
20 terms of how the -- the boxes, if you will, in terms
21 of scope have been increasing as we've been going
22 forward.

23 We don't anticipate that coatings would be
24 severely impacting the thermohydraulic characteristics
25 associated with it. But that's not to mean that we

1 disagree entirely with the ISG itself. We do note in
2 our comments and we called out a couple during the
3 August 6th meeting as well that there are several
4 instances of agreement between industry and NRC
5 regarding the ISG.

6 So while are discussing a lot of where we
7 have differences, I didn't want you to come away from
8 this with the impression that we disagreed entirely
9 with this document. Oh, is there a letter? Thank
10 you.

11 Okay. So some additional areas of scope
12 creep. So just like today's cladding, it's important
13 that the cladding material and finished fuel rod
14 conform to the specifications and it's free from
15 manufacturing imperfections that would negatively
16 impact fuel performance.

17 The fuel vendors currently produce a very
18 high quality, defect free fuel rods through the
19 current supply chain qualification process. Quality
20 control suppliers, manufacturing, product inspections
21 and certifications under the provisions of 10 CFR 50
22 Appendix Bravo.

23 The coating cladding fuel concepts as we
24 noted before are not conceptually different from the
25 current fuel products. And as such, the existing

1 manufacturing oversight framework is considered to be
2 adequate. This was something that we noted as well in
3 the public meeting. And NRC noted in their
4 presentation as well that they took that feedback and
5 they tried to make some revisions associated with
6 this.

7 However, as we've been reviewing the
8 current revision of the ISG, it's industry's opinion
9 that there's still some discrepancy regarding the
10 intent regarding the manufacturing requirements.
11 There is some language that still remains in the ISG
12 document. And therefore, some additional cleanup
13 would be required to remove this lingering language to
14 prevent the possibility of different interpretations
15 by different reviewers which again would harm the
16 overall regulatory predictability and certainty.

17 But we agree with the opinion expressed by
18 NRC earlier during their presentation which is that we
19 should not be creating new manufacturing oversight
20 through the ISG. That the current process of QA
21 oversight of manufacturing is adequate and it does
22 ensure that we have the product performance for both
23 coated cladding when we get there and for current fuel
24 technology.

25 MEMBER CORRADINI: But I was trying to

1 listen carefully. So how you framed it at the end is
2 not how it's framed in the ISG? I thought it was.

3 MR. HOLTZMAN: So the -- so again -- so
4 the initial revision of the ISG which was the version
5 that we had for the August 6th meeting --

6 MEMBER CORRADINI: Public.

7 MR. HOLTZMAN: -- public meeting was the
8 entirety -- the mention of manufacturing was calling
9 out saying that they were going to try -- that NRC
10 staff was going to be involving themselves in the
11 manufacturing process. We had the discussion during
12 the August 6th public meeting. NRC management said,
13 yes, we agree. We should be using the current fuel
14 manufacturing process. We would apply the existing
15 vendor QA process to coated cladding. And NRC staff
16 indicated that they would be going through and
17 revising the text to fix that discrepancy.

18 What we found as we've been reviewing this
19 version of the ISG, which is the version that was
20 provided to everyone on this committee, was that --

21 MEMBER CORRADINI: Thank you.

22 MR. HOLTZMAN: -- some instances had been
23 addressed but not all instances regarding the
24 manufacturing impact. And so our comment remains that
25 while we agree with what we are verbally stating and

1 what we are hearing, we just need -- we want to make
2 sure that the text is clear so that, again, we have
3 regulatory certainty going forward.

4 MEMBER CORRADINI: Okay. Thank you.

5 MR. HOLTZMAN: So additionally, one of the
6 things that we brought up in terms of the Chapter 15
7 impacts. So this was something that we brought up at
8 the August 6 meeting. The original text on this was
9 something that had indicated that the Chapter 15
10 impact would be significantly increasing the scope of
11 work.

12 Essentially, that we would be redoing all
13 of Chapter 15 safety analyses if any parameter that
14 was noted was going to be variable. And NRC actually
15 did a very good job in our opinion on fixing this and
16 revising the text to remove that so that it's clear
17 that now that this may cause an increase which
18 provides additional flexibility and ensures that it's
19 clear that something changing, if it doesn't change
20 outside the existing bounding values that are used as
21 part of the passing of information from the fuel
22 performance. The safety analysis aspects wouldn't
23 require all safety analysis to be redone immediately.

24 So I wanted to leave this in and call that
25 out as NRC doing a good job of being responsive to the

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1 conversation and discussions that we had from the
2 meeting. So with that --

3 MEMBER REMPE: Talk about the last bullet.
4 What did you have in mind with increasing the burnup?

5 MR. HOLTZMAN: Yeah. So we had talk about
6 this a little earlier which is why I was skipping over
7 it. Initially, there was text that had indicated that
8 we had to be evaluating -- or that she we should be
9 looking at increased burnup and enrichment which was
10 again an example of NRC kind of looking ahead in terms
11 of increasing burnup and enrichment itself is not
12 something explicitly tied to coated cladding or chrome
13 coated cladding applications but is something that
14 industry has expressed and an intention to try to
15 pursue.

16 But the ISG itself shouldn't be noting
17 that there's a requirement to be providing additional
18 burnup data beyond 62 gigawatt-days per MTU for PWR
19 applications obviously in that if for whatever reason
20 a vendor chose not to go to increase burnup associated
21 with their fuel topicals which there shouldn't be a
22 requirement to provide data to do so.

23 MEMBER REMPE: So right now I think I read
24 earlier in the meeting what it says about burnup. You
25 better have data to demonstrate the performance which

1 includes in a radiation environment for this fuel up
2 to whatever you're going to have it in the core for.

3 MR. HOLTZMAN: Correct. And this --

4 MEMBER REMPE: And you seem happy enough
5 with that?

6 MR. HOLTZMAN: Correct. This was another
7 example of NRC changing the ISG based on the feedback
8 and comments that we had provided during the August
9 6th meeting and through our comments. So now we
10 believe that the language is clear that you need to
11 have data to support the main that you're applying
12 for.

13 MEMBER REMPE: But I have a curiosity
14 question. How is industry -- have you discussed with
15 them in your meetings about how they plan to get that
16 data? I mean, you have lead test assemblies. You
17 could try and take it out and do a cook and look. But
18 you've got to ship it to some hot cell somewhere and
19 get that. You don't have Halden anymore. Where are
20 you going to get that data?

21 MR. HOLTZMAN: Just to be clear, your
22 question specifically, have we had discussion with NRC
23 regarding --

24 MEMBER REMPE: No, with industry. Where
25 are they planning to get the data?

1 MR. HOLTZMAN: Sure. So essentially what
2 we've been starting to look at, and obviously this is
3 a little outside the scope --

4 MEMBER REMPE: Absolutely.

5 MR. HOLTZMAN: -- of the ISG.

6 MEMBER REMPE: It's a curiosity question.

7 MR. HOLTZMAN: Sure. So there's a couple
8 pathways available to industry in terms of how to get
9 that data. The current kind of near term path that
10 they're looking at is that industry is interested in
11 increasing the burnup levels to kind of mid-60
12 numbers. So again, in PWR-space, somewhere in the 66,
13 68 ballpark associated with 2023. And that would be
14 an application for both the ATF coated claddings and
15 for the current fuel concepts.

16 So what we would be doing is being able to
17 utilize more than just the LTAs or test samples of ATF
18 but also current high burnup field that exists. And
19 we would be look at this in terms of potentially doing
20 tests in Idaho or at other labs, either inside or
21 outside the United States such as --

22 (Simultaneous speaking.)

23 MEMBER REMPE: Oh, yeah. I'm more
24 interested in the cladding.

25 MR. HOLTZMAN: Sure.

1 MEMBER REMPE: And yeah, maybe you could
2 do something in a foreign reactor somewhere. But in
3 the U.S., you would not use the LTAs and try and ship
4 them to Idaho because that's going to be difficult
5 because --

6 MR. HOLTZMAN: Sure.

7 MEMBER REMPE: -- of political constraints.

8 MR. HOLTZMAN: Sure.

9 MEMBER REMPE: And so I'm just kind of
10 wondering where they're planning to so it. And I go
11 I guess I'm hearing probably the only place you'd have
12 would be to do it overseas?

13 MR. HOLTZMAN: Potentially. The other
14 aspect of this is that in terms of when we need to
15 start doing the additional actual, like, burnup
16 testing itself, some of the vendors have some data
17 already that goes above 62. And we're starting to
18 figure out our plan in terms of whether we could do
19 this with additional methodologies similar to the,
20 like, no burst criterion or something like that.

21 MEMBER REMPE: What about even with ATF-
22 coatings? Do you really even have ATF coated fuel
23 that's up to 62 megawatt-days for --

24 MR. HOLTZMAN: Not from the LTA programs
25 yet.

1 MEMBER REMPE: Right. So where are you
2 going to get even the data for 30? I mean, what's the
3 highest burnup you've gotten? What radiated cladding
4 do you have that's AFT cladding with the appropriate
5 fuel pellets? How high a burnup can you go to? If I
6 read that thing, it doesn't say, higher than 60
7 megawatt-days. How high can you go right now with
8 this fuel?

9 MR. HOLTZMAN: Correct. And again, we
10 agree with the way that the text is now written in
11 terms of you have to be able to justify the burnup
12 range associated with it, so --

13 MEMBER REMPE: And how far can they go
14 right now with that text?

15 MR. HOLTZMAN: Sure. So there's two
16 aspects of this essentially for the coated cladding
17 application. So the first again is that it's the same
18 base substrate material in terms of how the cladding
19 is performing in terms of burnup activities. The
20 second aspect is we do have some data associated from
21 the test samples that I know came out of ATR and --

22 (Simultaneous speaking.)

23 MEMBER REMPE: A higher burnup than the
24 ATR?

25 MR. CSONTOS: So I think the answer here

1 is that he can't give you a specific number because
2 that's between the vendor and NRC. Okay?

3 MEMBER REMPE: You say --

4 MR. CSONTOS: And the negotiation between
5 the vendors and NRC are how to get the data at the
6 time for the applications to submit to a certain
7 burnup range. What Ben was talking about in terms of
8 getting the data sets for NRC for their reviews will
9 be made available to them from the vendors because
10 they're doing testing now.

11 And wherever they're doing testing, there
12 are a lot of places. But they don't want to say where
13 they're doing testing yet, I'm sorry. Okay? And
14 they're collecting the data and they're going to be
15 providing it to NRC. It's between the vendors and NRC
16 in terms of the negotiated maximum range for the
17 highest burnup to the available possible data sets
18 that they have. So it's really between the vendors
19 and their testing program through the DOE program that
20 they have with DOE. And those test plans are with DOE
21 and within the vendor's domain.

22 And what they do is they go out and
23 collect that data, provide it to the NRC and their
24 topicals. And it's really between the vendors and NRC.

25 MEMBER REMPE: So maybe it's proprietary

1 and you can't give me a number. But is it less than
2 30? Is it less than 10? You just can't say anything?
3 Okay.

4 MR. CSONTOS: Between the vendors and NRC.

5 MEMBER REMPE: Okay. Thank you.

6 MEMBER CORRADINI: She tried.

7 MR. HOLTZMAN: Any other questions?

8 MEMBER KIRCHNER: What is the status of
9 the ISG in response to your August 14th letter? Have
10 you been in negotiations with the staff on
11 incorporating your suggestions, or --

12 MR. HOLTZMAN: We have not yet had
13 discussions with NRC staff regarding our --

14 MEMBER KIRCHNER: Or it's coming out?

15 MR. HOLTZMAN: Our --

16 MEMBER KIRCHNER: Or they're taking it
17 under advisement?

18 MR. HOLTZMAN: Our understanding is that
19 as NRC staff will be posting, I believe, this revision
20 of the ISG for public comment at the end of the month.
21 We'll be providing additional comments regarding how
22 our August 14th letter had been incorporated as well
23 as any additional comments at that time.

24 CHAIR BALLINGER: All set?

25 MR. HOLTZMAN: Yes, sir.

1 CHAIR BALLINGER: Okay. I think now we
2 have to do the go around the room first and then get
3 the line open for public comment. So while we're
4 getting the line open, are there any folks in the room
5 that would like to make a comment? If you would like
6 to make one, come up to the microphone and state your
7 name and make your comment. Seeing no rush.

8 It's open. Is there anybody on the public
9 line at all? Well, must be R2D2 out there. Okay. No
10 people on the public line. We can close that off
11 then. And now Matt, Pete, and Dave, do you have any
12 comments?

13 MEMBER PETTI: No comments. No comments
14 from Dave.

15 MEMBER RICCARDELLA: No comments from Pete.

16 CHAIR BALLINGER: Okay. Last but not --
17 whoops.

18 MEMBER SUNSERI: This is Matt. I
19 appreciate the staff and the industry's updates on
20 progress. That's all. Thank you.

21 CHAIR BALLINGER: Okay. Good. Okay. So
22 let's go around the room and get last comments from
23 members. Vesna?

24 MEMBER DIMITRIJEVIC: Thanks for the
25 presentation and discussion. I don't really have a

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1 comment. I have something to add for your comment
2 about ten percent uncertainty. The reduction in CDF
3 is definitely not benefit. Add the menu for tablet,
4 but tablet is already doing good. The reduction in CDF
5 is actually additional burden. So it could be just
6 one percent or 0.5 percent. The future uncertainty
7 could be burden for the license holder. That's my
8 point.

9 CHAIR BALLINGER: Walt?

10 MEMBER KIRCHNER: Thank you for the
11 presentations. No, I think I don't have further
12 comments at this point.

13 CHAIR BALLINGER: Joy?

14 MEMBER REMPE: I just wanted to say thanks
15 to the staff and industry for their presentations too.
16 But I have no additional comments.

17 MEMBER CORRADINI: No more comments.

18 CHAIR BALLINGER: Harold?

19 MEMBER RAY: And none from me. Thank you,
20 Ron.

21 CHAIR BALLINGER: Well, in that case,
22 thank you very much. Good presentations. And we are
23 adjourned.

24 (Whereupon, the above-entitled matter went
25 off the record at 2:40 p.m.)

ACRS Subcommittee Meeting: Draft Interim Staff Guidance for Chromium-Coated Cladding

Jason Drake, NRR
Josh Whitman, NRR
Ashley Smith, NRR

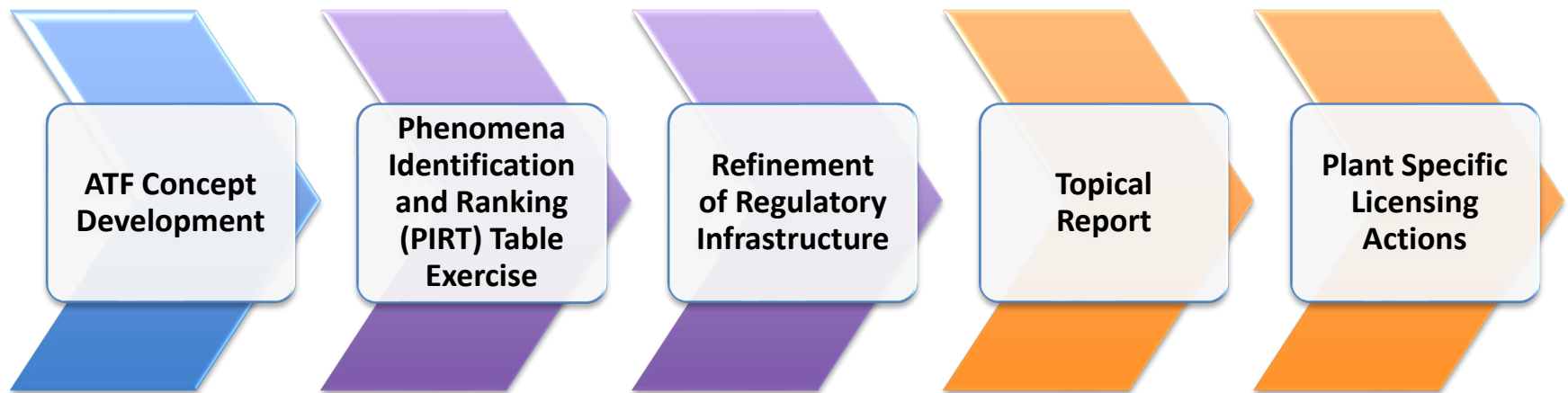
September 17, 2019

Key Messages

- Coating zirconium alloy cladding can impact fuel properties and specified acceptable fuel design limits (SAFDLs)
- Coated cladding represents a modest departure from currently operating fuel
- Topical report submittals are expected in 2020

ATF Project Plan outlines a new strategy for fuel licensing

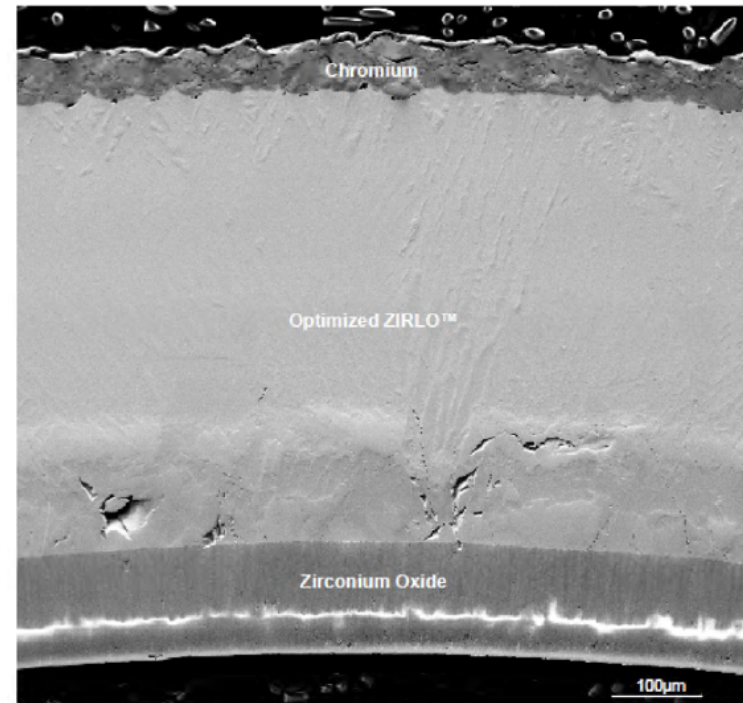
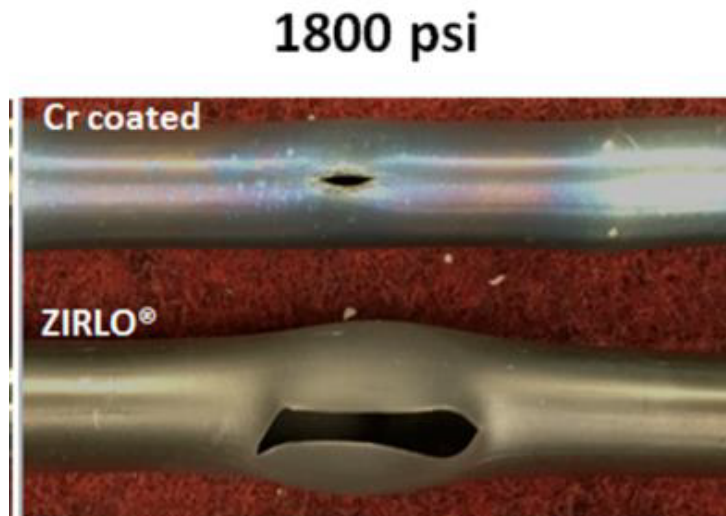
- Enables enhanced stakeholder engagement
- Provides framework for activities to proceed in parallel:
 - Completion of the technical basis
 - Regulatory infrastructure work
 - Licensing submittals



Industry pursuing batch reloads of coated cladding in 2023

- Three major vendors developing concepts
 - Supported by DOE
- Up to ~20 micron thickness
- Application processes:
 - Physical vapor deposition
 - Cold-spray
- Amount of ‘benefit’ sought in initial licensing varies
- LTAs deployed

Vendor example of coated cladding



After Steam Oxidation for 20 minutes @1200°C

Westinghouse

Building a foundation for the ISG

- September 2018: NRC's Accident Tolerant Fuel (ATF) Project Plan issued (ML18261A414)
- October 2018: Electric Power Research Institute (EPRI) Coated Cladding Gap Analysis
- November 2018: Nuclear Energy Institute (NEI) ATF In-Reactor Screening Review
- January 2019: Initial NRC report on degradation and failure mechanisms of Cr-coated cladding issued
- April 2019: Expert panel convened to conduct phenomena identification and ranking table (PIRT)
- June 2019: Final NRC PIRT report on degradation and failure mechanisms of Cr-coated cladding issued (ML19172A154)
- July 18, 2019: Initial public ISG draft issued
- August 06, 2019: Public meeting to solicit stakeholder feedback on ISG

PIRT panel convened in April 2019

- Conducted under contract with PNNL
- Experts from academia, national labs, and coating/nuclear industries
- Panel was conducted as a public meeting
- Report publicly available: ML19172A154

Participant	Affiliation
Neal Pierce	Hohman Plating & Mfg. LLC
Douglas Wolfe	Penn State
Jeff Venarsky	PNNL
Koroush Shirvan	MIT
Michael Corradini	Univ. of Wisconsin-Madison
Gregg Swindlehurst	GS Nuclear Consulting, LLC
Charles Berger	Hitemco
David Senior	PNNL

ISG will inform staff reviews using PIRT findings

- ISG does:
 - provide guidance to staff, informed by the PIRT, on important areas for review
 - provide information to vendors and licensees on what is expected
- ISG does not:
 - introduce new requirements
 - create new rules or regulations
 - require specific testing or analyses

ISG covers coated cladding concepts currently proposed by vendors

- Focused on Cr-coated cladding
 - Covers additional coatings as well
- Provides outline of what should be addressed in a licensing topical report safety evaluation
 - Narrative helps inform what level of effort is needed
 - Level of effort may differ significantly depending on whether benefits will be credited

ISG includes fuel properties that should be addressed in submittal

- thermal conductivity
- thermal expansion
- emissivity*
- enthalpy and specific heat
- elastic modulus
- yield stress
- thermal and irradiation creep rate
- axial irradiation growth
- oxidation rate*
- hydrogen pickup*
- high temperature ballooning behavior*
- high temperature (800-1200°C) steam oxidation rate*

* = potentially significant impact

Stakeholder comments about material properties have been considered

- Emissivity
 - Identified as less important by the PIRT
 - Stakeholder identified reduced external emissivity as area where current cladding properties are non-conservative
 - ISG has been modified to account for this
- Oxidation rate
 - Replaced cracked coating suggestion with intentionally damaged
 - Noted possible use of non-fueled data
- Tweaked language for other properties to avoid implying specific testing requirements

SAFDLs related to assembly performance may be impacted minimally

- Rod bow
- Irradiation growth
- Hydraulic lift loads
- Fuel assembly lateral deflection
- Fretting wear*

* = potentially significant impact

SAFDLs related to rod performance during normal operation and AOOs

- Cladding stress*
- Cladding strain*
- Cladding fatigue*
- Cladding oxidation, hydriding, and crud*
- Fuel rod internal pressure
- Internal hydriding
- Cladding collapse
- Overheating of fuel pellets
- Pellet-to-cladding interaction
- Boiling crises*

* = potentially significant impact

Stakeholder comments about SAFDLs have been considered

- Discussion on boiling crises updated based on feedback
 - Contradictory statements in different appendices were clarified
- General request was made to clarify testing expectations
 - Not directly addressed. Difficult to do generally without being overly prescriptive

SAFDLs related to rod performance during accident conditions

- Overheating of cladding*
- Excessive fuel enthalpy
- Bursting*
- Mechanical fracturing
- Cladding embrittlement*
- Violent expulsion of fuel
- Generalized cladding melting*
- Fuel rod ballooning*
- Structural deformation

* = potentially significant impact

New degradation mechanisms and other considerations

- Coating cracking
- Coating delamination
- Cr-Zr interdiffusion
- Radiation effects on Cr
- Subsurface damage
- Residual stress
- Galvanic corrosion
- Defects
- Eutectic formation

SRP Chapter 15 - Transient and Accident Analysis

- Changes to material properties and thermal mechanical behavior should be incorporated
- Impact on each anticipated operational occurrence (AOO) and postulated accident should be addressed
- Impacts of changes to existing SAFDLs should be addressed

Non-LOCA Transients

- Coated cladding is not expected to significantly impact or require changes to the following:
 - Initial conditions
 - Limiting conditions of operations (LCOs)
 - Fuel rod parameters (e.g., stored energy)
 - Core power distribution or fuel rod peaking factors
 - Radiological source term
 - Ability of safety-related SSCs to perform mitigating actions
- Many UFSAR non-LOCA analyses of record are expected to remain valid

Loss-of-Coolant Accidents

- Coated cladding is expected to impact fuel rod performance during the transient
 - Vendors may or may not take credit
- Phenomena which may be affected:
 - Heat of oxidation
 - Rate of embrittlement due to oxygen ingress
 - Hydrogen-enhanced beta-layer embrittlement
 - Plastic strains
 - Emissivity (may have negative impact)
- With minor modification (depending on credit), existing approved LOCA models and methods are expected to remain applicable

Path Forward

- ISG provides guidance to staff reviewing applications with coated cladding
- Impacts of Cr-coating on SRP Ch. 4 and 15 reviews are included in the ISG
- Initial stakeholder feedback has been incorporated
- Updated draft will be published in *Federal Register* for public comment by end of the month

ISG on Chromium Coated Cladding ATF

ACRS Meeting

September 17th, 2019

Nima Ashkeboussi, NEI
Al Csontos, EPRI
Ben Holtzman, NEI



Government Affairs
and Communications
Advisory Committees

Nuclear Strategic
Issues Advisory
Committee

EPRI ATF Research Collaboration

Mission: Foster Research
Cooperation and
Collaboration



Accident Tolerant Fuel Working Group (ATFWG)

Mission: Guide Industry Policy and Actions on ATF

- Exelon Generation Company, LLC
- Tennessee Valley Authority
- Duke Energy Corporation
- Southern Nuclear Operating Company
- Dominion Generation
- Arizona Public Service Company
- Xcel Energy
- GE Hitachi Nuclear Energy
- Framatome
- Westinghouse Electric Company
- Lightbridge Corporation
- General Atomics
- X Energy
- NAC International
- Jensen Hughes
- Excel Services
- Electric Power Research Institute
- Nuclear Energy Institute

National Labs

Universities

International

Regulators

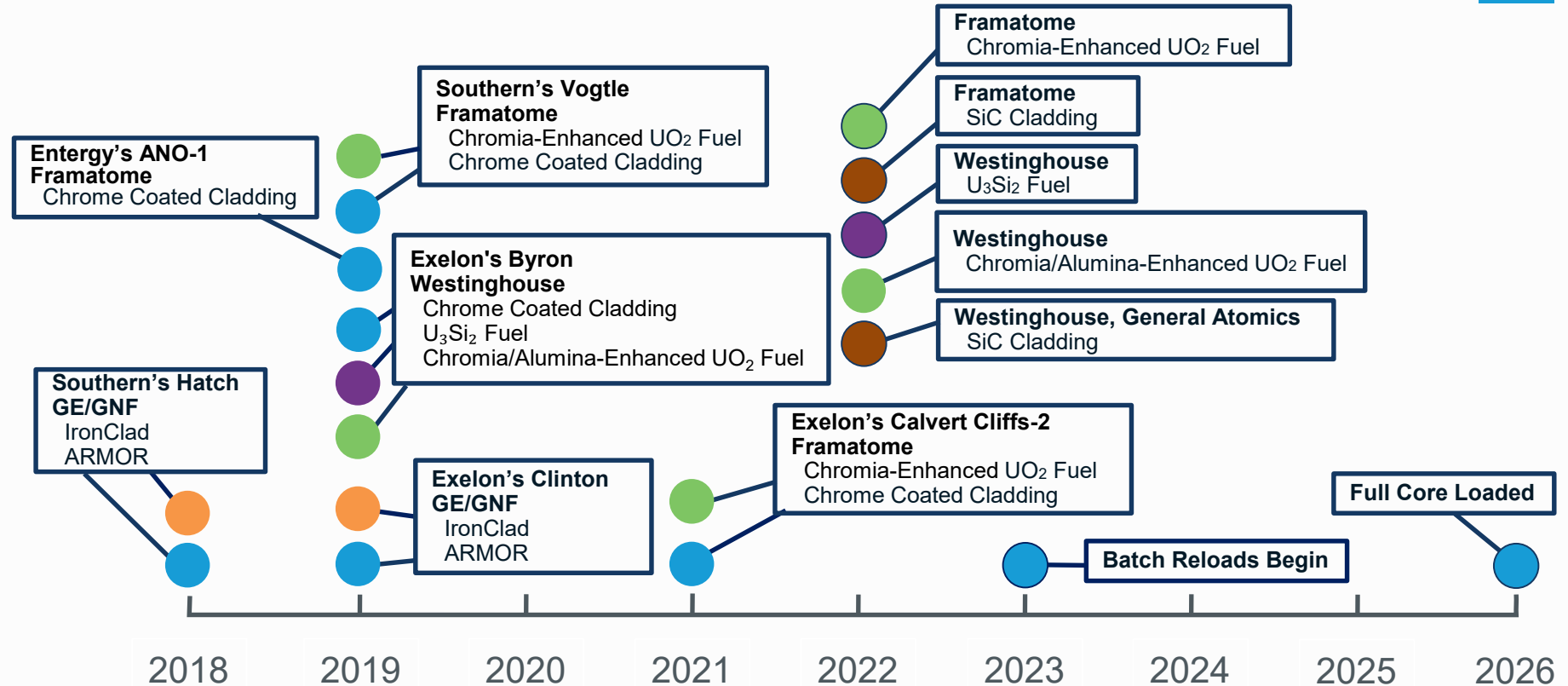
Fuel Vendors

Utilities

ATF External Affairs Task Force
Funding and Communications

ATF Fuel Licensing and Safety Benefits Task Force
Fuel Qualification to Deployment, and Realization of Regulatory Benefits & Enrichment

Key ATF Fuel Milestones



Coated Cladding Implementation Strategy

- Regulatory Predictability and Certainty
- Licensing coated cladding is separate from efforts to realize benefits.
 - Several of the high-ranked mechanisms from the PIRT that are included in the ISG are believed to relate to *improved* performance due to the coating.

Near-Term Regulatory Strategy

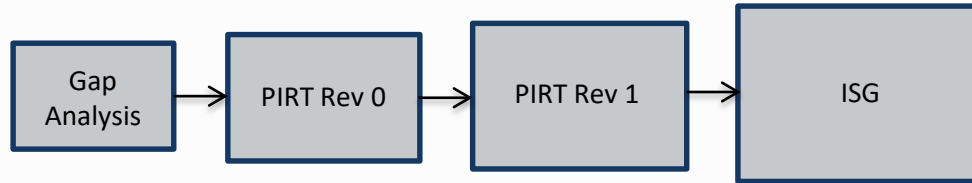
- Fuel Licensing
- Burnup and Enrichment*
- Ancillary Benefits*

Long-Term Regulatory Strategy

- Ancillary Benefits*

Industry Feedback on the ISG

- Chromium Coating Applications vs Generic Coatings
- Scope Expansion



- Will the Expansion of Scope help NRC Reviewers?

Potential Areas of Scope Creep

- Manufacturing
 - Industry believes that standard 10CFR50 Appendix B quality control programs at fuel manufacturers are adequate to assure product performance for coated cladding
- Chapter 15 Impact
- Regulatory Changes for Increasing Burnup Limits

Questions?

Questions

