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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
(ACRS)

+ + + + +

NEW REACTORS SUBCOMMITTEE

+ + + + +

TUESDAY

SEPTEMBER 15, 2026

+ + + + +

The Subcommittee met at Two White Flint
North, 11545 Rockville Pike, Rockville, Maryland, and
via videoconference, at 8:30 a.m. EDT, Robert P.
Martin, Chair, presiding.

COMMITTEE MEMBERS:

ROBERT P. MARTIN, Subcommittee Chair

GREGORY H. HALNON, ACRS Chairman

CRAIG D. HARRINGTON

ANNIE M. KAMMERER

SCOTT P. PALMTAG

DAVID A. PETTI

THOMAS E. ROBERTS

1 ACRS CONSULTANTS:

2 RON BALLINGER

3 VICKI BIER

4

5 DESIGNATED FEDERAL OFFICIAL:

6 CHRISTOPHER BROWN

7

8 ALSO PRESENT:

9 JUAN ARELLANO

10 MEG AUDRAIN

11 PAOLO BALESTRA

12 SAMUEL BAYLIS

13 SANTOSH BHATT

14 GORDON BLALOCK

15 RAY BRYANT

16 LARRY BURKHART

17 ZACHARY BURNS

18 BRIAN FROESE

19 TOM LIGON

20 DREW NIGH

21 ADAM OLER

22 JERROD POTGIETER

23 TRACY RADEL

24 ROBERT ROCHE-RIVERA

25 PRAVIN SAWANT

1 TIM SCHINNER
2 CLAIR SONG
3 TERRI SPICHER
4 MATT THOMAS
5 MARTIN VAN STADEN
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AGENDA

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Adjourn	

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

8:13 a.m.

CHAIR MARTIN: Good morning. The meeting will come to order. There is a live mic. Not anymore? All right. This is a hybrid meeting of the New Reactors Subcommittee of the Advisory Committee on Reactor Safeguards. I am Bob Martin, today's Chairman of the Subcommittee meeting. ACRS members in attendance are Greg Halnon, Greg Harrington, Scott Palmtag, Thomas Roberts, and myself. Virtually attending are Annie Kammerer and Dave Petti. I did not see Matt just yet, but Matt Sunseri was expected to be online. We do have our consultant, Ron Ballinger, online, and our consultant, Vicki Bier, online. If I missed anybody, Matt or Walt, please speak up. Chris Brown of the ACRS staff is our Designated Federal Officer for today's meeting. No member conflicts of interest were identified for today's meeting, and we have a quorum for today's meeting.

During today's meeting, the Subcommittee will receive a briefing from X-energy and the staff on the Long Mott CPA. Topics to be covered include: inherent reactivity control, transition from safe state to safe shutdown state, heat removal systems,

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1 and RCCS performance. Core structural integrity and
2 geometry maintenance and seismic and flooding design
3 aspects.

4 The ACRS is reviewing the Long Mott
5 Generating Station, LMGS CPA, to evaluate unique,
6 novel, and noteworthy -- and you'll hear us say or use
7 the acronym UNN -- UNN safety aspects of the X-energy
8 Xe-100 design, specifically focused on safety
9 functions and cross-cutting issues. This review is
10 aligned with Executive Order 14300, which mandates
11 that the ACRS reviews focus on UNN issues.

12 The ACRS was established by statute and is
13 governed by the Federal Advisory Committee Act, or
14 FACA. The NRC implements FACA in accordance with its
15 regulations. Additionally, in accordance with
16 Sections 29 and 182b of the Atomic Energy Act, the
17 Advisory Committee on Reactor Safeguards shall advise
18 the Commission with regard to the hazards of proposed
19 or existing reactive facilities and the adequacy of
20 proposed safety standards. In addition, ACRS is
21 implementing Executive Order 14300, ordering the
22 reform of the Nuclear Regulatory Commission, dated May
23 23rd, 2025. Section 4(b) of the Executive Order
24 states, in part, Functions of the Advisory Committee
25 on Reactor Safeguards shall be reduced to the minimum

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1 necessary to fulfill ACRS's statutory obligations, and
2 that review by ACRS shall focus on issues that are
3 unique, novel, and noteworthy.

4 The review and reporting on new reactor
5 facilities and proposed safety standards are the
6 minimum statutory functions of the ACRS under Sections
7 29 and 182b of the Atomic Energy Act. The Commission
8 may refer additional duties to the ACRS in accordance
9 with the Act.

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

15 All relevant information related to the
16 ACRS activity, such as letters, rules for meeting
17 participation, and transcripts, are located on the NRC
18 public website.

19 The ACRS, consistent with the Agency's
20 value of public transparency and regulation of nuclear
21 facilities, provides opportunities for public input
22 and comment during the proceedings. We have received
23 no written statements or requests to make an oral
24 statement from the public. We have also set aside
25 time at the end of the meeting for public comments.

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1 Portions of this meeting may be closed to
2 protect sensitive information as required by FACA and
3 Government in the Sunshine Act. Attendance during the
4 closed portion of the meeting will be limited to NRC
5 staff and its consultants, X-energy, and those
6 individuals or organizations who have entered into an
7 appropriate confidentiality agreement. We will
8 confirm that only eligible individuals are in the
9 closed portion of the meeting.

10 The ACRS will gather information, analyze
11 relevant issues and facts, and formulate proposed
12 conclusions or recommendations as appropriate for
13 deliberation by the full Committee.

14 A transcript of the meeting is being kept
15 and will be posted on our website. When addressing
16 the Subcommittee, the participants should first
17 identify themselves, turn on the camera if virtual,
18 and speak with sufficient clarity and volume so that
19 they may be readily be heard. If you are not
20 speaking, please mute your computer on Teams or by
21 pressing star six if you're on the phone.

22 Please do not use the Teams chat feature
23 to conduct sidebar discussions related to the
24 presentations. Rather limit the use of the meeting
25 chat function to report IT problems.

1 If you have any feedback For the ACRS
2 about today's meeting, we encourage you to fill out
3 the public reading feedback form on the NRC website.
4 I will make one note. We did receive the slides for
5 today's meeting a little late yesterday. The
6 applicant and staff slides are in the process of being
7 made public. So, it's government, there's a process
8 for everything. Of course, you may see there's slides
9 as part of the MS Team's meeting presentation now. As
10 soon as the slides are made public in ADAMS, we will
11 drop a link to the slides in the Teams chat. And the
12 links will be posted on the NRC public meeting
13 notification system.

14 We will now proceed with the meeting, and
15 I call, probably not Adrian. Jessica, who's speaking
16 first -- who's speaking first?

17 MR. ARELLANO: It's us.

18 CHAIR MARTIN: Juan? Okay. All right.
19 We'll turn to Juan, and we'll just begin with the
20 presentation by X-energy and LME.

21 MR. ARELLANO: Hey, good morning,
22 everyone. Juan Arellano, licensing engineer for X-
23 energy. Today, I'll kick us off with focus area
24 number 2, RSF 1.1 control reactivity. Before I move
25 on, I am up here with Adam Oler, who I'll allow to

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1 introduce himself.

2 DR. OLER: Hey, I'm Dr. Adam Oler with X-
3 energy, the reactor dynamics group manager.

4 MR. ARELLANO: Awesome. With that, let's
5 get started. I wanted to start us off before kicking
6 off into the mechanisms themselves, kind of two
7 definitions or terms because I believe the last time
8 we presented on them they were a bit confusing. So
9 they're safe stable end state, and then shut down.

10 Safe stable end state as defined in PSAR
11 Section 3115, the main success criteria associated
12 with safe, stable end state is the reactor is in
13 thermal equilibrium with heat removal. That means
14 that a safe and stable end state can be the reactor at
15 full power, reduced power, or shut down. Shut down is
16 just one of the safe and stable end states.

17 There are other success criteria in PSAR
18 Section 3115 defined there, but some of those being
19 fuel temperature is constant or decreasing, reflector
20 temperature is constant or decreasing, helium pressure
21 within limits, things like that. Now moving on to the
22 other term, shut down, which is defined in PSAR
23 Section 3.11. That's a mode in of itself where at
24 least 16 rods are inserted, and of course, at least
25 one fuel pebble is present in the core.

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1 Moving on into that, inherent reactivity
2 feedback is a means to get to a safe and stable end
3 state, so it's a mechanism there. For the Xe-100,
4 there's a very strong negative temperature coefficient
5 across the full operating range. It provides an
6 immediate, always available response. It arrests any
7 transient without operator action, without rod motion
8 -- one of the greatest features, at least in my
9 opinion, of HTGRs -- and it limits power to a stable
10 low level. In the next couple of slides, we'll show
11 an experiment of that being performed as well as an
12 analysis of our own reactor being performed. And
13 moving on to --

14 MEMBER HALNON: Juan, before you go on --
15 this negative moderator temperature coefficient, this
16 is Greg Halnon. If you were designing an LWR, I would
17 send love your way with a large negative moderator
18 temperature coefficient. But explain to me how that
19 doesn't conflict with the some of the goals of a gas
20 reactor where it, you know, you keep it hot.

21 MR. ARELLANO: I guess, I mean, did I say
22 moderator temperature coefficient or --

23 MEMBER HALNON: I'm sorry.

24 MR. ARELLANO: -- or moderator coefficient
25 or --

1 MEMBER HALNON: Temperature -- the
2 temperature.

3 MR. ARELLANO: Oh, temperature.

4 MEMBER HALNON: In general, negative
5 temperature coefficient. I'm sorry. See, I'm light
6 water.

7 MR. ARELLANO: Do you mind restating your
8 question?

9 MEMBER HALNON: Well, so you have a large
10 negative temperature. That's great.

11 MR. ARELLANO: That's correct.

12 MEMBER HALNON: It's great if you're
13 heating up. What about cool downs? I mean, it's a
14 double-edged sword, right?

15 MR. ARELLANO: That's correct. Right.
16 And I guess we'll show that in the next two slides and
17 kind of the balance of that and then what it does.

18 MEMBER HALNON: Okay.

19 MR. ARELLANO: Yeah.

20 MEMBER HALNON: Keep in mind, you know,
21 you're sort of helping us contrast your reactor to
22 what the contemporary knowledge of light water
23 reactors --

24 MR. ARELLANO: Right -- right.

25 MEMBER HALNON: And so just making

1 statements that it's great to have a large strong
2 negative temperature coefficient tends, at least in my
3 mind, spinning, trying to figure out, okay, how does
4 that relate to the goals of a gas reactor and how you
5 operate it.

6 MR. ARELLANO: That's fair. From a
7 traditional perspective, that is --

8 MEMBER HALNON: Okay. Yeah. Well, just
9 keep that in mind.

10 MR. ARELLANO: Yep. Yep.

11 MEMBER HALNON: And I may interject more
12 questions just based on that. It may sound dumb to
13 some of the gas reactor people, but that's just the
14 way I have to operate and --

15 MR. ARELLANO: Yeah. No, absolutely.

16 MEMBER HALNON: Thank you.

17 MEMBER ROBERTS: This is Tom. Let me
18 follow up on Greg's question. The term strong
19 negative temperature coefficient -- can you define
20 strong? What is it that's strong, say, compared to in
21 a light water reactor?

22 MR. ARELLANO: I see Martin's hand up.
23 I'll hand it over to him.

24 MR. VAN STADEN: Sorry, guys. I do want
25 to just interject. Martin van Staden, I'm the chief

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1 technology officer of X-energy. I just wanted to
2 answer the question maybe in a slightly different way.

3 Where it differs from a light water
4 reactor are two other aspects that are really key to
5 understanding gas-cooled reactors. The negative
6 temperature coefficient is very strong, but it's also
7 combined with a very low power density and a very
8 large thermal inertia and also a moderator that
9 doesn't change phase if you heat it up very quickly.

10 So, when you look at those three aspects
11 and balance them together, the negative temperature
12 coefficient, what we mean by strong, is that it will
13 always control the nuclear reaction and reduce the
14 power as the temperature heats up and the premise of
15 that is to protect the fuel. When you have that
16 strong negative temperature coefficient, that can
17 react fast enough to shut the core down or to lower
18 the power to protect the fuel because the power
19 density is low enough.

20 If you had a high power density, it might
21 not have worked. So, you could design a gas-cooled
22 reactor that has a high enough power density that will
23 damage the fuel, and the negative temperature
24 coefficient will not shut it down in time. So, it's
25 a really purposely designed feature, the negative

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1 temperature coefficient, by balancing it with the
2 power density and the thermal inertia of the core.
3 That's where the fundamental difference is from a
4 light water reactor, which has a power density of over
5 a 100 megawatts per cubic meter as opposed to about
6 4.85 megawatts per cubic meter. That's where the big
7 difference comes in.

8 MEMBER PALMTAG: Thank you. That helps
9 quite a bit.

10 MEMBER ROBERTS: Yeah, thank you. That's
11 a good definition of a strong. That's the first time
12 I've heard of that clearly. The box on the right has
13 a number of 3,000 some PCM for a 100 degree change in
14 temperature. That would imply a 30 PCM per degree
15 temperature coefficient, which seems rather high. Is
16 that number super conservative since you're doing cool
17 downs, it might just be you're conservative by a
18 factor of three to five. But I was wondering, do you
19 really have a temperature coefficient of 30 PCM per
20 degree or is it --

21 DR. OLER: I think there might be some
22 confusion in how the table's presented. The 100
23 degree temperature change is not connected to that
24 table. That table is the shutdown margin at 100 C.
25 So, that's assuming isothermal. I see the connection

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1 between the 100 C on the left and the 100 C on the
2 right. That's the shutdown margin with the assumption
3 that the entire reactor has cooled down. So, this is
4 meant to be an extreme limiting case.

5 MEMBER ROBERTS: Okay, thank you. That's
6 interesting.

7 DR. OLER: And then each one of those are
8 separate effects. And so decay of xenon's one effect.
9 Cooling down is one effect. Loss of one rod from each
10 bank is another effect. And you compile all those up,
11 make a conservative assumption of your total shutdown
12 margin, and then calculate what our rods worth are,
13 and then that's where that number comes from at the
14 end.

15 MEMBER ROBERTS: Right. Yeah, that number
16 seems reasonable for a 700 C cool down, which is about
17 what that would be. Okay, thank you.

18 MEMBER PALMTAG: Yeah, this is Scott
19 Palmtag. I just want to make a comment. Some of the
20 terminology on this slide, and I've seen it in other
21 slides too, is it seems to be rather loose. You know,
22 on the left-hand side, you have the reactor shutdown.
23 You use the term reactor shutdown, and then, you know,
24 two slides later it's stable low power. And then, for
25 example, in another slide you have, you know, power or

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1 very small power, but that would be still be not, you
2 know, critical.

3 Just might want to caution you on your
4 slides and documents. Be real careful when you say
5 the shutdown. I mean, do you really mean shutdown or
6 do you mean a stable low power? But I've seen that a
7 lot. It's confusing, and just be careful when you
8 start using these terms.

9 MR. ARELLANO: Juan Arellano license
10 engineer. I appreciate that comment. That's
11 something I noted from last time that you made, and I
12 tried reframing. I guess it's just still stuck in my
13 head, shutdown. But you're absolutely right. Yeah.
14 On that left slide when we mean shutdown, we mean more
15 so safe and stable end state. Shutdown would be
16 whenever you move the control rods in.

17 Again, Adam, appreciate you going over the
18 table. Moving on to the right to shut down itself,
19 RSF 1.1.2, that's your movable poisons RSF, and that's
20 when your nine reactivity control system and your nine
21 reactivity shutdown system rods are inserted. And as
22 shown on the table there, you can reach and sustain
23 subcriticality from any condition. This is your
24 limiting condition here in your cold shutdown margin.
25 That's an error in the table's title. But all to say,

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1 the main point is inherent feedback is an immediate
2 protective response while movable poisons provide an
3 assured and maintained subcriticality. And a point I
4 forgot to make here is in the PSAR, we only credit
5 shutting down on inherent reactivity feedback one
6 time, if at all, in the events. And then we have to
7 get the rods in to maintain subcriticality in the long
8 term.

9 MEMBER HALNON: There's also a diversity
10 question, right?

11 MR. ARELLANO: That's correct.

12 MEMBER HALNON: And I believe your safety
13 case leverages basically PDC 11 as really the
14 diversity in all this. If there was the need to
15 basically go to a cold shutdown condition, you know,
16 and, I'm not going to hazard a guess as to what that
17 scenario is leading up to that need. You don't really
18 have a diverse shutdown alternative, or am I
19 incorrect? And this to get basically to a cold
20 situation. This, of course, it's been a historic
21 debate, came up in the advanced light water reactor
22 time period. But I think it still remains a debate.
23 And, of course, before the advanced light water
24 reactor debate of the nineties, cold shutdown was shut
25 down, and Greg, correct me, it still is as far as the

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1 operating plants. Yeah.

2 MR. ARELLANO: I believe we are performing
3 analysis. I'll hand it over to Adam.

4 DR. OLER: The way that I typically
5 present the reactivity feedback shutdown is it's kind
6 of like a tank. It's going to shut the reactor down,
7 and you're correct, it will not maintain indefinite
8 shutdown on reactivity feedback alone. But there is
9 a difference between us being at a safe, stable end
10 state and being completely shut down.

11 The reactivity feedback shuts down the
12 reactor and keeps it off for the order of days, not
13 hours. And then it returns to a very low power. To
14 have sort of anything else go wrong, we would also
15 need failures of like RCCS and other things. The RCCS
16 is maintaining proper cooling. We're in a safe,
17 stable end state. I think that was kind of your
18 intention with rephrasing safe, stable end state
19 versus shut down. It's very, very low power, and it
20 can maintain it indefinitely, assuming that our RCCS
21 is maintaining cooling margins. And I think that's
22 it. All right.

23 MEMBER HALNON: This is Greg. I know it's
24 early in the design, but is operator action required
25 to maintain subcriticality?

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1 DR. OLER: After multiple days, if we did
2 not drop control rods, it would go back to low power
3 critical, very low power critical.

4 MEMBER HALNON: So, operators are
5 required.

6 DR. OLER: Yeah.

7 MEMBER HALNON: It's not going to be
8 something that's going on.

9 DR. OLER: But critical for a high
10 temperature gas reactor does not mean unsafe. We can
11 maintain that power indefinitely.

12 MEMBER HALNON: Yeah. And we're going to
13 struggle with that.

14 DR. OLER: Understood.

15 MEMBER HALNON: Just because again, what
16 I mentioned earlier is this --

17 DR. OLER: Completely understand.

18 MEMBER HALNON: -- versus not. And so our
19 questions may continue to poke at that and just be
20 patient with us as --

21 DR. OLER: No, not a problem

22 MEMBER HALNON: -- as we soak on it.

23 DR. OLER: They're great questions.
24 Martin Van Staden's got his hand up again, so we'll
25 let him address this as well.

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1 MR. VAN STADEN: Sorry, guys. I just also
2 wanted to add that, you know, there's no operational
3 state where we actually want to cool the reactor down
4 other than at midlife when we do a core refurbishment
5 on the graphite. And then we defuel the core, and
6 that in itself will reduce the reactivity and shut the
7 reactor down, even if you don't maintain shutdown, you
8 know, using rods. So, in a certain sense, that is
9 diverse as well.

10 But I think the importance here is the big
11 reason for cold shutdown in LWRs is because you need
12 to open the core up and remove the fuel and do fuel
13 shuffling, and you have water there to cool the
14 reactor. And if you can't shut down cold, you're
15 going to have a dangerous condition in the core when
16 you open it up. And that is fundamentally different
17 for an HTGR.

18 When you're doing maintenance on the rest
19 of the system, you actually want to maintain the
20 temperatures because of the large thermal inertia, it
21 takes you much longer to heat the core up again. So
22 there's no reason from an operational perspective or
23 a safety perspective that you would want to shut the
24 core down cold during maintenance. We don't foresee
25 any maintenance that would require the reactor vessel

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1 to be opened up. And therefore, it's part of our
2 operating philosophy is to keep the reactor hot and
3 during most of the maintenance conditions except when
4 we do the core refurbishment. I just wanted to put
5 that in perspective.

6 Secondly, when we go recritical after
7 about 100 hours. But the recriticality is actually
8 brought on not by the core primary cooling down but
9 because of the xenon decay. So, if you plot the xenon
10 decay curve over the cooling of the core and the
11 reactivity, you actually see it's when your xenon has
12 decayed. We go critical to the power of about 250
13 kilowatts. So, that's extremely low, as Adam said.
14 That 250 kilowatt, if you look at the plot, will
15 actually slowly get smaller and smaller over time.

16 Then the last thing I wanted to say is I'm
17 not sure we need operator action. Our RPS will
18 automatically trigger the rods to be inserted, and
19 that's not an operator action per se.

20 MEMBER HALNON: Okay. This is Greg.
21 Thanks, Martin. The only thing I take pause with what
22 you said, and I think I heard it right, you said that
23 the reason we go subcritical in LWR was solely because
24 we wanted to refuel. But as an ex-operator, I'm not
25 sure that's completely accurate from the standpoint of

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1 actual operations. It may be from a design
2 perspective.

3 MR. VAN STADEN: Mm-hmm.

4 MEMBER HALNON: But I have to think about
5 that. But --

6 MR. VAN STADEN: Okay.

7 MEMBER HALNON: It's a very comfortable
8 spot sitting in a control room with a subcritical
9 reactor as opposed to having one that's critical.
10 It's a major change of mode from mode 2 to mode 3.
11 So, I have to think about it, but I understand what
12 you're trying to say. Thanks.

13 MEMBER PETTI: This is Dave. I also
14 think, though, what is hard to think about here is
15 because it's online refueled, that's a big difference
16 than, you know -- if we were talking about a prismatic
17 here, we'd be talking about it in a slightly different
18 sense because you would end up refueling it, you know,
19 every 18 months. It's a unique aspect of an online
20 refueled system, I think, here, and the gas technology
21 come back together.

22 CHAIR MARTIN: This is Bob Martin. To
23 your point, Dave and Martin, you know, I heard Martin
24 say that, you know, maybe it's a stretch, but that the
25 capability to defuel could be its own kind of diverse

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1 shutdown. I wanted to explore that just a little bit.
2 Now how long would it take to basically defuel enough
3 to assure subcriticality?

4 MR. VAN STADEN: We can defuel at around
5 2,000 pebbles an hour, plus minus or actually slightly
6 faster. If we're not doing burn up measurement, it
7 can be faster. It's the burn up measurement that
8 limits us. So, I'm not sure if Theo Dowling, or one
9 of his team can give me that value. I think we've
10 done some calcs that show that once we've defueled
11 about 10,000 to 15,000 pebbles of the 220,000, you go
12 subcritical. So, you know, if you look at that, it'll
13 be about five days, which is faster than what it will
14 take to get to the recriticality if you really need
15 to.

16 CHAIR MARTIN: Hmm. Interesting
17 considerations. Thank you, Martin. Any further
18 questions by members, consultants? Okay. Good.

19 MR. ARELLANO: Juan Arellano here. Next
20 slide, please. Moving on to the next two slides, I'm
21 going to be talking about some inherent reactivity
22 feedback demonstrations. On this slide here, this is
23 an actual experiment performed, a real inherent
24 reactivity feedback demonstration performed at the
25 blanking out what HTTR mean, high temperature test

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1 reactor in Japan. It's right there. They tested the
2 inherent safety features in that reactor. They
3 started off at nine megawatts core thermal power, and
4 then they tripped the circulators without inserting
5 the control rods. And as you can see on figure 7
6 there on the right of the slide, the reactor shuts
7 down relatively quickly. And then it's not until
8 about eight hours that it goes re-critical, and it's
9 very low power.

10 MEMBER PETTI: Juan, just a question, a
11 comment here, right? That analysis not -- is not your
12 analysis. That's JAEA's analysis, I assume?

13 MR. ARELLANO: That's correct.

14 MEMBER PETTI: Okay. I like this slide,
15 but I really wish you could see the expanded stuff
16 when it all happens at the beginning and at the end.
17 The scale is not that great.

18 MR. ARELLANO: And you may like our next
19 slide a bit more.

20 CHAIR MARTIN: The first one.

21 MR. ARELLANO: For the first part at
22 least. But with caveat, we are extending this
23 analysis out this fall. But this is a preliminary
24 analysis of our Xe-100 shutting down on inherent
25 reactivity feedback alone. So again, no forced

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1 cooling and no rods being inserted. And you can see
2 here it also shuts down relatively quickly on inherent
3 reactivity feedback alone. Then at about 108 hours,
4 we go recritical, and it begins oscillating. But if
5 you were to extend the graph out, you would see it
6 would level out, become steady, which, again, we are
7 extending that analysis this fall to show that.

8 MEMBER HALNON: Juan, this is Greg. When
9 you say extending your analysis, that'll be reflected
10 in the OL when you come in for that?

11 MR. ARELLANO: That's correct.

12 MEMBER HALNON: Just trying to get your
13 key words and phrases.

14 MEMBER PALMTAG: This is Scott Palmtag
15 again. I apologize going back, but it took me a
16 second to realize this. Martin, you said 2,000
17 pellets per hour including the burn up measurements?

18 MR. VAN STADEN: Yeah, if we're doing burn
19 up measurements, it's around 2,000 an hour. Our
20 standard is about a 1,050 per day. Sorry.

21 MEMBER PALMTAG: That's like a couple
22 seconds per pebble?

23 MR. VAN STADEN: No, no, sorry. I
24 misspoke there. It's about 2,000 per day. And then
25 times --

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1 MEMBER PALMTAG: 2000 per day. Okay.

2 MR. VAN STADEN: -- yeah. Times 10,000
3 pebbles. Sorry.

4 MEMBER PALMTAG: All right. Thank you.
5 That makes a lot more sense.

6 MEMBER ROBERTS: Yeah, this is Tom.
7 Trying to understand the two plots especially the
8 reactivity axis. The one on the left has negative 12
9 dollars of reactivity. The one on the right is
10 negative 0.4 dollars. Why is there that much
11 overshoot? I assume it's the expanded scale that
12 requires the axis going into the 12 dollars, but that
13 implies a lot of heat up, you know. And, again,
14 thinking about the temperature coefficient of, you
15 know, maybe three to five PCM per degree, that seems
16 like a couple thousand degree heat up if I got the
17 math right. So, how is it there's that much feedback
18 say at, you know, ten hours in the left-hand plot?
19 It's negative 10 dollars and that's what? 7,000 PCM?

20 MR. ARELLANO: Yeah. I don't have the
21 specific numbers in front of me right now, but the
22 reactivity shut down comes from going up in the
23 direction of the reactivity curves. It's not an order
24 of heat up of thousands. It's this is a challenging
25 event but the reactor heats up and maintains

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1 temperatures below the failure limits for TRISO fuel.

2 If we had temperature plots along with
3 this, we'd be able to show that. I'll probably take
4 an action item to look it up and get you back those
5 exact numbers. But the reason we trust these
6 simulations and we use these simulations for Xe-100 is
7 a lot tied into the last slide. We've done heavy
8 validation, verification of all of our softwares. And
9 so we can glean things from HTTR, which is a prismatic
10 gas-cooled reactor. We look at HDRPM. We look at
11 other experiments that are just for flow, just for
12 heat transfer neutronics-only experiments. We put all
13 those together combined make sure we have good
14 acceptance criteria with those, and then we run these
15 simulations of Xe-100, which obviously hasn't been
16 built yet. But that gives us confidence that we can
17 accurately predict these. Apologies for not having
18 the exact numbers on hand for you, but we don't expect
19 this particular transient to challenge the fuel for
20 the Xe-100 reactor.

21 MEMBER ROBERTS: Okay, thanks. Yeah,
22 maybe worth a lot to check the scale on the left-hand
23 plot because it seems like you should mind the two
24 maybe off by a factor of 10 or so. Thank you.

25 DR. OLER: We'll double-check. Thank you.

1 Did I have one more slide? Next slide. No.

2 MEMBER PETTI: Tom, I think you may have
3 had the colors backwards. Reactivity was red.

4 MEMBER ROBERTS: Right. Yeah, yeah, Dave,
5 that was my interpretation too. The --

6 MEMBER PETTI: Oh, okay.

7 MEMBER ROBERTS: -- reactivity goes down
8 to about -10 dollars at maybe 10 hours, and that's why
9 I read the plot, and that just seems really high.

10 MEMBER PETTI: Oh, you're here. Okay --
11 okay. I thought you were looking at the oscillation
12 piece. Okay.

13 MR. ARELLANO: If there are no other
14 questions, that's all we've had on RSF 1.1.

15 MEMBER PALMTAG: This is Scott Palmtag
16 again. Just kind of to summarize your position,
17 though. For the two different kinds -- two diverse
18 sets of reactor shutdown, you're crediting the RCS and
19 RSS. That's your two diverse systems?

20 MR. ARELLANO: So, the two diverse systems
21 would be the RCSS, which is control rods, the separate
22 one of the reactivity feedback.

23 MEMBER PALMTAG: And we keep coming back
24 to the reactivity feedback as a shutdown, but then if
25 you look at it, it seems like it takes you to a low

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1 power, not a shutdown.

2 MR. ARELLANO: That's correct.

3 MEMBER PALMTAG: I'm still struggling to
4 under --

5 MR. ARELLANO: Martin's got his hand up.

6 MR. VAN STADEN: So guys, back in 2015,
7 2016, we started developing with the NRC and the
8 industry, the general design criteria for advanced
9 reactors. One of those aspects that we had many, many
10 discussions on was whether or not to credit the
11 negative temperature coefficient as a primary shutdown
12 mechanism. That was the one aspect. And the second
13 one was we actually redefined the term cold shutdown
14 to safe shutdown.

15 The requirement to safely shut down is
16 absolutely met by the negative temperature coefficient
17 because our safe shutdown is when we've protected our
18 fuel. And what we can show in these events is that we
19 do not exceed the maximum fuel temperatures. And
20 that's why we can take full credit for that negative
21 temperature coefficient. In a gas-cooled reactor,
22 it's not about that little bit of reactivity you get
23 because going up to 250 kilowatts of power is way
24 below the capability of the reactor cavity cooling
25 system. I think Adam mentioned that we, we balance --

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1 we're in a stable condition because with our RCCS, we
2 can remove around 700, 800 kilowatts of heat from the
3 core.

4 (Audio interference) go critical to around
5 250 kilowatts. Yeah, it's a pity we don't have the
6 temperature curve here, but you will see we're way
7 over the peak temperature at the point where we do go
8 recritical. So there's a tremendous amount of heat
9 removal margin in the system as well as additional
10 thermal inertia to ensure that we don't damage the
11 fuel. So, the focus should be on safe shutdown and
12 the fact that we don't damage the fuel and always are
13 protecting the fuel. I hope that helps.

14 MEMBER PALMTAG: Yeah, I still -- I do
15 understand there's a long history here, but it seems
16 like you always want to, you know, someone else on the
17 Committee said a couple of years ago, there always
18 needs to be an off switch, right? You need to be able
19 to shut the reactor down.

20 MR. VAN STADEN: We have that.

21 MEMBER PALMTAG: I don't want to --

22 MR. VAN STADEN: With the control rods and
23 the shutdown.

24 MEMBER PALMTAG: Right. Two diverse sets
25 of shutdowns.

1 MR. VAN STADEN: Correct.

2 MEMBER PALMTAG: And I understand you
3 never want to cool the reactor down. I understand
4 that from an operational point, but I can also think
5 of situations where something happens, something bad
6 happens. You have a leak, you have a pump or
7 something where you would want to shut this down.
8 Operationally, I agree. You never want to -- you
9 always want to stay hot, and you can do your
10 maintenance on the hot conditions, but I'm more
11 worried about you get in a situation where something
12 happens and you do want to shut it down. So all
13 right. Thank you for your comments.

14 DR. OLER: I would add to his point the
15 way that the control rods are operated, there's RCS
16 and RSS. There's a lot of RCS acronyms running
17 around, and I know it's confusing. There's control
18 rods and there's shutdown rods, two separate banks.
19 At hot shutdown, when we take back that margin that we
20 showed for the cold shutdown, we can properly shut
21 down the reactor with just the RCS. And so there's a
22 balance. At really elevated temperatures, we don't
23 need as much shutdown margin from our control rod
24 systems. And so at colder temperatures, we're not
25 challenged for the fuel, and we would obviously insert

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1 all 18 rods at the same time to maintain that shutdown
2 margin. But at elevated temperatures, we don't need
3 the full bank of rods to do that. And so it just, it
4 doesn't quite answer your question, but it adds to the
5 safety that we provided in operating this reactor.
6 But without control rods at all, it would maintain
7 criticality.

8 MEMBER PALMTAG: Yeah. Thank you for
9 that.

10 DR. OLER: I don't want to dispute that
11 point.

12 MEMBER PALMTAG: No, I, I --

13 DR. OLER: We all agree on that one, but
14 there's additional things that we've thought of in the
15 design to make sure that we're operating this safely.

16 MEMBER PALMTAG: Right. And I understand
17 this is also the CP stage, and, you know, a lot of
18 these things you haven't analyzed yet. But when it
19 comes to EOL, you know, we're going to have to look at
20 all these transients sections.

21 DR. OLER: I appreciate that, and we're
22 working on that.

23 MEMBER PALMTAG: I just want -- you
24 mentioned there's 18 total rods, but you can be shut
25 down with 16 rods inserted.

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1 DR. OLER: No. So, at hot shutdown,
2 they're in banks of nine. We can shut down with just
3 nine rods at hot shutdown.

4 MEMBER PALMTAG: Nine rods at shutdown?
5 Like just at --

6 DR. OLER: At operating temperature, not
7 at 100 C.

8 MEMBER PALMTAG: Yeah. I'm thinking of
9 the stuck rod criteria. So, it sounds like you can
10 meet the stuck rod criteria.

11 DR. OLER: Yeah. We've done that for both
12 RCS and RSS. So, we assume two stuck rods and then
13 maintain shutdown margin at 100 C, so very depressed
14 temperatures.

15 MEMBER PALMTAG: Okay. So you're actually
16 doing a high worth rod not being inserted in --

17 DR. OLER: Highest rod for each bank.

18 MEMBER PALMTAG: -- RCS.

19 DR. OLER: Yeah.

20 MEMBER PALMTAG: Okay. That's good.

21 DR. OLER: Yeah. So it's more
22 conservative, and we did that because we're operating
23 them in two different banks. So we wanted to assume
24 two different banks; one rod in each bank could fail,
25 and so the total shutdown margin calculated on that

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1 slide at 100 C is not 18 rods, it's 16.

2 MEMBER PALMTAG: Okay. Thank you. That's
3 clear.

4 DR. OLER: Thank you.

5 CHAIR MARTIN: This is Bob. You know, one
6 of the difficult parts of evaluating your argument is
7 that we get to see a lot of things. We see other
8 people, you know, maybe not pebble per se, but other,
9 you know, hot or high temperature reactors, and they
10 don't make the argument that you make. Right? I
11 guess, in my mind, I keep on thinking about the, you
12 know, potential to defuel as a pathway out.

13 So, then that begs the question is how do
14 you deal with the decay heat removal of almost the
15 full core outside the core? I haven't thought about
16 it. I don't know if it's in you know how that it
17 might be described in the CP. But say in this
18 hypothetical scenario where you end up having to
19 defuel. Now, granted, you might only be defueling
20 15,000 pebbles, but there would be a heat load
21 associated with that. And how would that get handled?

22 MR. ARELLANO: Adam, I don't know the
23 answer to that. If not, we can take that back because
24 we don't have somebody on the fuels team.

25 MEMBER PALMTAG: There's Martin.

1 MR. ARELLANO: Martin.

2 MR. VAN STADEN: So just a quick comment
3 on that. So our spent fuel storage system is designed
4 to handle a cask that has got a full contingent of
5 decay heat or pebbles that need to remove decay heat.
6 So we have a very conservative analysis on that. So
7 we would move that fuel to the spent fuel area as if
8 it was spent fuel if you had to defuel it. And that's
9 what we do during the midlife refurbishment as well.

10 CHAIR MARTIN: The midlife refurbishment,
11 that's a complete defuel?

12 MR. VAN STADEN: Complete defuel.

13 CHAIR MARTIN: So, then otherwise you
14 would need to be able to handle basically a fuel, a
15 full -- okay.

16 MR. VAN STADEN: Full core.

17 CHAIR MARTIN: All right.

18 MR. VAN STADEN: Correct.

19 CHAIR MARTIN: Okay. All right. Is that
20 in the CP? I should know, right? I should have read
21 everything.

22 MR. VAN STADEN: I think it is.

23 CHAIR MARTIN: I don't think I would have
24 focused too much on that.

25 MR. VAN STADEN: I think it's in there.

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1 CHAIR MARTIN: Okay. I'll take a look, a
2 little bit closer look at that -- but. Okay. All
3 right. Are there further questions on this topic?

4 MEMBER ROBERTS: Yeah. Tom, maybe just a
5 comment getting to both what Scott and Bob, what you
6 both just said. I think they made a key point. Juan
7 did the very first slide about safe, stable end state
8 versus safe shutdown. And Martin used the term safe
9 shutdown, and I think part of the maybe difficulty
10 we're having is understanding the word shutdown in the
11 definition of safe shutdown.

12 I think you're argument, and you can tell
13 me, Juan or Martin, if I've got this right, is that
14 you're not claiming safe shutdown for your inherent
15 feedback. You're claiming safe, stable end state as
16 your end state for that. And so you're meeting your
17 interpretation of -- your instance of PDC 26 by having
18 two means of reaching a safe, stable end state, not
19 necessarily two means to maintain safe shutdown. Is
20 that the right view?

21 DR. OLER: That is correct. And I noticed
22 we keep stumbling on our words but still to Scott's
23 point, I still understand the comment and I have noted
24 it to take it back, but that is correct. That is a
25 good reframing of the narrative, that there are two

1 independent means, I guess if you will, to reach a
2 safe and stable end state.

3 MEMBER PALMTAG: This is Scott again. But
4 okay, that makes it more confusing for me because
5 you've also said the safe, stable end state could be
6 100 percent power.

7 MR. ARELLANO: Right. Yeah.

8 MEMBER PALMTAG: I don't know how --

9 MR. ARELLANO: A specific safe and stable
10 end state, and I'm not sure if these three types are
11 defined --

12 MEMBER PALMTAG: So what's shutdown?
13 Yeah. Just want to be sure.

14 MR. NIGH: Drew Nigh, senior manager in
15 risk and performance safety analysis. Within the PRA
16 model, some of the event sequences, actually the most
17 frequent ones, land with recovering the plant, running
18 at full power steady-state operation. And so it's a
19 safe stable end state. We model that with the PRA but
20 100 percent power, normal heat removal through the
21 steam generator. That's one example of an end state
22 that ends in full power.

23 CHAIR MARTIN: Okay. I'm still not sure
24 what that is, but I'll have to read some more and
25 think about it a little bit. I don't think we're

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1 going to answer it here.

2 MR. NIGH: Okay. And I guess if you look
3 at a PRA event tree, that the very top event where
4 everything's successful, that usually ends in full
5 power, just like one, you know, if you want to --

6 MEMBER PETTI: This is Dave. Scott, I
7 think the PRA stuff can confuse you because you are
8 focused on events that challenge the reactivity
9 system. Whereas some of the events they're talking
10 about, the recovery from the event, you're still at
11 power, and it's not something that necessarily
12 challenges the reactivity system. It might challenge
13 heat removal or something.

14 CHAIR MARTIN: I think I understand that,
15 Dave. You're still going to be at some low power, but
16 then the definitions aren't really clear because in
17 the safe stable end state, you know, we've also heard
18 it's 100 percent power. So I just think it needs to
19 be clarified a little bit.

20 MEMBER PETTI: It can be in the PRA sense
21 because there are some events if you follow the event
22 trees where they end up getting the plant at a 100
23 percent power and have corrected, you know, because
24 all the redundancy in the plant it's able to keep
25 operating.

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1 MEMBER ROBERTS: Yeah, this is Tom again.
2 So the second piece of this is the PDC 26. At least
3 per Reg Guide 1.232 has four conditions of, you know,
4 diversity for reaching a safe, stable end state. And
5 one of them is shutting down the reactor to, you know,
6 service it. And in that case, it seems like you
7 really are counting on the defueling capability that
8 you have a unique capability with a pebble bed reactor
9 to be able to defuel online. And so if you had a
10 complete failure of your rod systems, you could reach
11 the objective of shutting the plant down.

12 So, it's just really the question of, as
13 I recall, the PSAR doesn't claim that as a means of
14 shutdown, but it seems like it's important. Maybe
15 it's semantics, maybe it's not, but I just wanted to
16 at least keep that on the table that that may be a
17 reason why, you know, your design meets all the
18 intents of the four clauses, but it's not clear from
19 the documentation that you're claiming that
20 capability. So, I'm not quite sure what that means in
21 terms of, you know, if you did claim it. What would
22 that do? Would that make the defuel capability more
23 robust or give it, you know, text back control or that
24 kind of thing? I don't know. It's something to --

25 CHAIR MARTIN: Yeah, no, that's my

1 thinking too, Tom, that it might be the get out of
2 jail free card. And then the question is the timing?
3 Is that, you know, of course, and not having looked at
4 any analysis to fully appreciate five or maybe even
5 seven days, is that sufficient? But maybe it's
6 something that could be deferred to the OL, but it
7 does kind of give you all a pathway to, you know, at
8 least be consistent with the other arguments for other
9 designs that clearly address the four conditions of
10 that PDC 26.

11 All right. Thanks. Any further questions
12 or comments really on this topic, right? We've seen
13 all three slides, right? Okay. Seeing none, you can
14 probably move on to the next topic.

15 MR. NIGH: That's going to be a different
16 team up here, so.

17 CHAIR MARTIN: Okay.

18 MR. NIGH: Quickly change out.

19 MS. SPICHER: Just one second. Larry
20 forgot my name tag. We used to work -- I used to work
21 at NRC with him and Calvert Cliffs. Get back at me
22 for those --

23 MEMBER PETTI: That's live, so don't bring
24 it up.

25 MS. SPICHER: I will bring some of the

1 condenser fouling with crabs. We'll share. I'll
2 start off. I'm Terri Spicher, X-energy. Nice to see
3 everybody again. Thank you, ACRS, for coming.
4 Special thanks to the NRC staff. They did a great job
5 helping us get through this process.

6 We're excited to present to you very
7 important systems. We're going to start off first in
8 this presentation where Tim -- I'll let everybody
9 introduce themselves in a second, but we're going to
10 have our lead of our RCCS system explain how our RCCS
11 system works, the piping, the different components,
12 all that kind of good stuff. And then we have our
13 safety analysts, Paolo and Brian, they'll talk to you
14 and they're going to explain some of the safety
15 analysis we've done for this system. So first, I'd
16 like everybody introduce themselves, please.

17 MR. FROESE: Yep. Good morning, everyone.
18 Brian Froese, Senior Manager of Safety Analysis, X-
19 energy.

20 MR. SCHINNER: Tim Schinner, Mechanical
21 Engineering Lead for the RCCS.

22 MR. BALESTRA: Paolo Balestra, Safety
23 Analysis, System Analysis Manager, X-energy.

24 MS. SPICHER: Thank you. First slide,
25 please. So, the first slide, like I mentioned, Tim's

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1 going to go through with you a couple slides where
2 he's going to go through and explain the RCCS
3 performance, the piping, the systems, how we're making
4 it, and all that type of stuff. Okay, Tim?

5 MR. SCHINNER: All right. Tim Schinner.
6 We couldn't show the figure on this slide, so I'll
7 just kind of talk through it. So, for RCCS we have
8 two subsystems. The first is the Standpipe Functional
9 Area, acronym is SFA. It's the safety-related
10 subsystem of RCCS, and it's designed to ASME Section
11 III, Div 5. This subsystem is independent across each
12 reactor module.

13 Then we have our Process Functional Area
14 PFA. There's a typo there -- this is our NSRST
15 subsystem, designed to be III-1 and ASME Section VIII,
16 Div 1. This is the active subsystem that's shared
17 across all of the SFAs. We have two trains of air-
18 cooled heat exchangers. Each train is 3 by 25
19 percent, so we have a total of 150 percent capacity.
20 And that's based on our off-normal case. So off-
21 normal, our design load is four megawatts, so we have
22 a total of six megawatt capacity, so we have plenty of
23 design margin in those air coolers. And then we have
24 3 by 50 percent pumps, also sized at same capacity, so
25 it's 150 percent of our off-normal design load.

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1 Then on each of our supplied cooling water
2 to the SFA and on the heated water return from the
3 SFA, we have isolation valves. Those isolation valves
4 do not perform a required safety function, as if those
5 did not close during any event, we would not drain
6 water out of the SFA that would compromise our
7 required safety functions. We do have scenarios where
8 we would isolate those, and that would be during
9 maintenance or if there's a leak detected in the SFA,
10 but failure of closing those isolation valves would
11 not compromise our safety function. Dave, did I see
12 your hand up?

13 MEMBER PETTI: Yeah. Yeah. This is Dave.
14 I have a question because I'm a little confused. In
15 terms of the system, the PFA and the SFA are
16 connected, right?

17 MR. SCHINNER: Yes.

18 MEMBER PETTI: So, I'm struggling with how
19 you're designing them to different parts of the code
20 and whether there's any discontinuity here. You call
21 out B31.1 in the PFA, but inside the SFA, you know,
22 Section 3, Div 5 is for vessels, but there's pipes in
23 there. Are you designing them to a pipe standard or
24 a vessel standard inside the SFA?

25 MR. SCHINNER: To a pipe standard, you can

1 design piping in ASME Section 3, Div 5.

2 MEMBER PETTI: Oh, okay. Okay, that
3 helps. Is there any discontinuity in terms of the
4 design of the piping in the PFA versus the SFA that
5 could cause a different stress level or --

6 MR. SCHINNER: Yeah, so the code break is
7 made at our reactor building penetration, and the main
8 difference between the two codes is the load cases
9 that we're designing it to. And the SFA is designed
10 to a higher load case, and our main one is our seismic
11 case and making sure everything is structurally
12 supported to survive that event, where the PFA doesn't
13 need to be designed to that extreme of a load case.
14 And it mainly -- it doesn't really affect our pipe
15 wall thickness as much but maybe just our support
16 philosophy of the piping itself.

17 MEMBER PETTI: Okay. And this is, I don't
18 know, I wish Walt was the one that had raised this
19 issue, and he's not with us, but I don't know that
20 there are cases where one continuous system is
21 designed to different standards -- and if they are,
22 does it really matter when it needs to matter?
23 That's, I guess, the question. Okay. Thanks.

24 MEMBER HARRINGTON: This is Craig. So
25 you're taking the code break as a piping penetration,

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1 not at the isolation valves. Is that -- or are they
2 somewhat coincident?

3 MR. SCHINNER: They are very close in
4 location. I don't think we finalized the exact point.
5 I believe it's at a pipe flange at that penetration is
6 where we call the code break because we didn't want to
7 put the valve that close to the building itself. So
8 it's a flange right on the outside of the reactor
9 building is that code break.

10 MEMBER HARRINGTON: And I guess the
11 potential for siphoning if you had a pipe break or
12 something is prevented because of the what's the right
13 word anyway, on the --

14 MR. SCHINNER: Yep.

15 MEMBER HARRINGTON: -- the gooseneck vents
16 or whatever -

17 MR. SCHINNER: That's right.

18 MEMBER HARRINGTON: -- is at the top of
19 the boil-off side of the system.

20 MR. SCHINNER: Yep. So the boil-off tanks
21 have a vent, but then also our riser headers are
22 vented. So where the return water piping, it will
23 increase in elevation to penetrate through the reactor
24 building. And so it'll only come in to that header
25 location. And all the water below that is what we

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1 credit for the 72-hour required boil-off volume. So
2 we assume the kind of the worst case of we have a pipe
3 break. We will siphon off a little bit of water, but
4 we don't credit that water in our safety case.

5 MEMBER HARRINGTON: And then you have
6 basically for each reactor module, there's two sets of
7 standpipes. So you could -- the siphoning situation
8 we just talked about would that, that would affect the
9 connection between the supply. But then if you had a
10 break inside that on the safety related side, it would
11 only affect half of the cooling system.

12 MR. SCHINNER: That's correct. Yep.

13 CHAIR MARTIN: Okay. Thanks. This is
14 Bob. We have either discussed or acknowledged in a
15 previous meeting that the role of the RCCS is probably
16 more to protect the concrete. I think it came up in
17 the context of y'all considered a design without air
18 or water cooled RCCS, and then came to the conclusion
19 that the concrete probably would have a problem with
20 that.

21 Second to say that concrete, the reactor
22 vessel, but maybe the fuel was kind of a distant third
23 in all of this. Is there and maybe this is the
24 preface to the question and maybe one disadvantage of
25 only requiring internal events PRA at this point is

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1 not considering my favorite thing from being
2 reflecting my age is a single failure -- or single
3 failure kind of type criteria, which to me is a
4 surrogate for external events back in the day.

5 Is there a scenario where you could, say,
6 lose some azimuthal sector of the RCCS that maybe you
7 haven't analyzed because you've been focused on
8 internal events. But understanding thermal radiation
9 that could be a significant impact, maybe not as much
10 on actually on the concrete because, of course, you
11 basically have a shield in front of it. But the
12 concern would move to the reactor vessel that you
13 could create a hotspot by not having that thermal
14 radiation removal capability. Have you looked at
15 that? Again, I guess the first question really was
16 what's the vulnerability? Maybe you've already
17 designed that away.

18 MR. FROESE: Bob, this is Brian. Make
19 sure I understand your question. So you're asking if
20 we could lose an azimuthal section piece of the pizza
21 pie of RCCS?

22 MEMBER HARRINGTON: Exactly. Yeah.

23 MR. SCHINNER: So for our PSAR, the
24 standpipes are interconnected between the two
25 different trains, so we've only postulated a break of

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1 a single RCCS standpipe for the PSAR, which would
2 continue to allow cooling essentially around the
3 periphery. We are in the process, though, of doing
4 more analysis to look at losses of different sections
5 in the azimuthal pieces of it, though.

6 MEMBER HARRINGTON: Okay. So to be fair,
7 I guess, basically you're saying an OL type
8 investigation.

9 MR. SCHINNER: Okay.

10 MEMBER HARRINGTON: This is Craig again.
11 If you lose a single standpipe, that would effectively
12 drain the tank for that frame of the RCCS system,
13 right?

14 MR. SCHINNER: Yes, that's correct.

15 MEMBER HARRINGTON: Okay. So you go back
16 to just relying on one. Okay.

17 MR. SCHINNER: We'll get to this in the
18 next slide, but with the caveat that the pipes are U-
19 shaped at the bottom, and there's not a common header
20 at the bottom in this PSAR design. So you would still
21 have a considerable amount of water inventory inside
22 of the standpipes even if you did drain down the
23 tanks.

24 MS. SPICHER: I think it's a perfect lead-
25 in to our next slide, please.

1 MR. SCHINNER: Again, I wish we could show
2 the figure here because it kind of goes along with the
3 text. But as we were discussing earlier, we look at
4 that siphoning effect when we are evaluating our 72-
5 hour boil-off, so we're only crediting the water below
6 the riser header and to the RPV head as our 72-hour
7 inventory.

8 Those isolation valves don't need to close
9 if a break is detected to perform the required safety
10 function. And our safety analysis shows well over
11 seven days margin without refill, and I think we'll
12 get into that in some of the later slides here. But
13 in addition to the seven days, we have four different
14 refill methods to provide cooling after the 72 hours,
15 and this is through NI process water, our condensate
16 system, NI fire protection, and a backup/offsite water
17 source. We have multiple methods of how to get that
18 water in the boil-off tanks. We have a emergency fill
19 connection through our process functional area piping.
20 And then if that's compromised, we can refill through
21 the vents of the boil-off tanks to provide that
22 inventory. So four different redundant methods and
23 two redundant ways to get the water in.

24 MEMBER HALNON: This is Greg. I guess
25 this is the time to lament over the proprietary versus

1 non-proprietary and trying to understand it's not just
2 for us, it's for the public as well. And it seems
3 that if, in fact, the diagram that you cut out is
4 proprietary, I'll give you that. But certainly there
5 could be some representative simple down diagrams that
6 can help us understand this slide a little than just
7 a big blank space. So, maybe when you -- this is
8 nearing the end of our meetings, and I know these
9 slides are done fine.

10 As you go forward into the OL stage, I
11 would consider if you're developing proprietary
12 information that you don't want to show to, in the
13 public for business reasons or whatever reasons you
14 have, at least try to make the slide representative of
15 what you're trying to say so we can understand even
16 one line diagram type of thing. Because I read this
17 before you went through it, and there was -- I could
18 get nothing out of it. I got nothing out of what you
19 just said, and I'll take nothing away from that. So
20 that's enough said. Almost every meeting we've talked
21 about proprietary issues versus non, and I don't think
22 we need to mention it again.

23 MR. SCHINNER: Thanks, Walt.

24 MEMBER HALNON: Yes. You're welcome.

25 MR. SCHINNER: Channeling our member who's

1 missing.

2 MS. SPICHER: Next slide, please. Tim?

3 MR. SCHINNER: Yep. So this slide is
4 addressing the instability question that came up from
5 the ACRS members. So the instabilities that were
6 brought up, we are looking at, and they're mainly the
7 steam separation within the riser header, potential
8 geysering, parallel channel instability. These are
9 all kind of the phenomena that happen in the water as
10 it begins to reach saturation temperature. We are
11 looking at these in a lot more detail, and we will
12 address these as the design progresses, mostly
13 designing them out of it or ensuring that these
14 instabilities do not challenge our required safety
15 functions. Most of these are through kind of
16 structural evaluations. The geysering could have a
17 lot of pressure waves, pressure surges that we want to
18 make sure we fully capture, that our system is
19 designed to handle that, or design it out so that
20 wouldn't affect the design.

21 MEMBER HALNON: This is Greg. Tim, can
22 you give an example of maybe some of the design
23 changes you may be thinking of? Is it core flow
24 diverters and those types of things?

25 MR. SCHINNER: No, it's mainly involved

1 the around the piping configuration. So right now the
2 riser header of the SFA has its own vents and the
3 return line to PFA. If we routed those back to the
4 boil-off tanks, it would kind of become one natural
5 circulation loop where the heated water will rise to
6 the tank, which has more of an opportunity to separate
7 the vapor from the water and vent through those tanks.
8 That could greatly reduce the risk of geysering.

9 MEMBER HALNON: Okay. It was more of a
10 question to test whether or not you've thought through
11 it, and sounds like you have a success path --

12 MR. SCHINNER: Yes.

13 MEMBER HALNON: -- for each one of those
14 phenomenon.

15 MR. SCHINNER: That's right.

16 MEMBER HALNON: Thanks.

17 MR. SCHINNER: Mm-hmm.

18 MEMBER HARRINGTON: And this is Craig.
19 Real quick, the nominal rough size of the standpipes
20 is?

21 MR. SCHINNER: They're 14 inches.

22 MEMBER HARRINGTON: 14. Okay.

23 MR. SCHINNER: Yes.

24 MEMBER HARRINGTON: Some of the statements
25 you've made they seem speculative, although obviously

1 intending to err on the side of conservatism, because
2 you've not done tests, right? Not specific tests for
3 yourselves. But there are tests. We've mentioned
4 before the work done in Argonne. Are these phenomena
5 that had been observed in those tests. You know, I'm
6 just looking maybe at the first one, the steam
7 separation comment there. Where do you draw on these
8 hypothetical type concerns?

9 MR. SCHINNER: Yes.

10 MEMBER HARRINGTON: Or real, depending on
11 where you're drawing your information on, which is
12 basically the question.

13 MR. SCHINNER: Yes. The primary data is
14 from where the tests are from Argonne National Labs
15 and SDF facility. And they noticed the geyser
16 phenomena in their upper plenum tube back to the tank,
17 so that's the main thing we're drawing from. But also
18 we're doing additional work with like RELAP5 to kind
19 of look at these instabilities and quantify them.

20 MEMBER HARRINGTON: Oh, like RELAP5 has
21 the capability to model --

22 MR. SCHINNER: Model instabilities.

23 MEMBER HARRINGTON: -- instabilities.

24 MR. SCHINNER: Yes.

25 MEMBER HARRINGTON: Whatever that may be.

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1 MR. SCHINNER: Yes.

2 MEMBER HARRINGTON: I know there's some
3 work that was done at Texas A&M, Yassin Hassan, if you
4 pulled in their test data, test results.

5 MR. BALESTRA: It's Paolo Balestra. Thank
6 you. And this case is a part of our validation basis
7 for Gothic.

8 MEMBER HARRINGTON: Okay.

9 MR. BALESTRA: That's our software.

10 MEMBER HARRINGTON: In addition. Yeah.

11 MR. BALESTRA: Like, RELAP is from the
12 work from Argonne that they are doing internally.

13 MEMBER HARRINGTON: Right.

14 MR. BALESTRA: So, and we are
15 collaborating obviously.

16 MEMBER HARRINGTON: Right. It'd be, you
17 know, having obviously multiple tasks and --

18 MR. BALESTRA: Yes.

19 MEMBER HARRINGTON: You know, either it
20 provides another level of validation that the
21 phenomena, you know, is not necessarily designed.
22 Obviously, they're different scales, right? They're
23 much different scales, right? And if you see the
24 phenomena at multiple scales, obviously, it draws more
25 of your attention.

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1 MR. BALESTRA: Yes.

2 MEMBER HARRINGTON: At least.

3 MS. SPICHER: Before we go off the slide,
4 maybe Tim can walk us through the right-hand diagram.
5 It might help a little bit with more of block diagrams
6 to the pictures and especially identify what's in the
7 purple boxes and why they're important.

8 MR. SCHINNER: Will do. Yes. So walking
9 through the figure on the right, this is kind of a
10 simplified functional block diagram of the system.
11 I'm going to start on the inner portion of this
12 diagram. At the top, we have our gooseneck vents.
13 This is what keeps the system close to the atmospheric
14 pressure.

15 Then, we have our boil-off tanks right
16 below that. This is what receives the cooling water
17 from the PFA. And then water is driven down our
18 downcomer header up through the standpipe assembly
19 into the riser header. So that's our U-bend
20 standpipe. We have 50 of those standpipes in our
21 design, 25 per train, and they are interweaved, so
22 every other pipe is a different train. So like we
23 said earlier, if we lost a train, we'd only lose every
24 other pipe and still have pretty balanced heat
25 transfer still.

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1 Out of the riser header, that's where we
2 send the heated water return back to our process
3 functional area. Now, I'll kind of go through the
4 blue blocks here. So when the heated water comes out,
5 we send that through the heat exchanger, the air-
6 cooled heat exchangers, and then they're routed to our
7 pumps and are sent back to the boil-off tanks. That's
8 the active portion of the system.

9 Then the purple boxes show interfaces with
10 the system. NI process water is our main makeup
11 system, so that's what supplies our demineralated
12 water to make up any evaporation losses, any minimal
13 leak losses. But then we also have our backup field
14 manifold, and this receives three different water
15 sources, condensate system, NI fire protection, and
16 backup. And we arrange these in a way that we want to
17 use the highest quality water first. So that's the NI
18 process water in the condensate system. Both have
19 very high water quality specs. And then if those are
20 not available, we would use NI fire protection, which
21 is lower quality. And then lastly, backup/offsite
22 water source. This could include a cooling water
23 basin that is local to the site or just trucking in
24 water sources to be used. And then, of course, we
25 show the RPV interface with the standpipe assembly,

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1 and that's just a thermal interface.

2 MS. SPICHER: And I'd like to add, the
3 orange boxes are our passive system, and that's what
4 we need for our DBAs. And the blue lines are the
5 active system, which is the NSRST component.

6 MEMBER PETTI: This is Dave. I just had
7 a question. Maybe it's for Brian, just to be clear.
8 I thought I had heard in a previous meeting that the
9 analyses, all the calculations of the transients,
10 assumed an air-cooled RCCS because that was what was
11 considered very early, and then you guys moved to this
12 later. Is that true?

13 MR. FROESE: Hey, Dave. This is Brian.
14 Yes, that is correct. The thermal hydraulic analyses
15 that focused on fuel temperature were modeled based on
16 an air-cooled RCCS. However, we complemented that
17 with an analysis that looked at the heat transfer
18 capability to the RCCS and varied that to demonstrate
19 that fuel temperatures were very largely insensitive
20 to RCCS performance, and therefore the source term was
21 also largely insensitive to RCCS performance.

22 On top of that, from just a physics air-
23 cooled versus water-cooled standpoint, we generally
24 were going to argue that water-cooled RCCS should
25 outperform air-cooled RCCS. So we were comfortable

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1 with those results being in our construction permit
2 application.

3 MEMBER PETTI: Yeah, no, I agree. It
4 wouldn't affect -- it's more of a concern about the
5 vessel than it is, I think, about the fuel. So let me
6 go back to this other question that Bob asked because
7 I'm having trouble. I understand what his question
8 was about as a useful concern, but then I was
9 concerned about your comment back. As I look at this,
10 these are two trains that are interwoven. So how do
11 you get to a situation where, you know, let's say one
12 quarter of the circumferences somehow, you know, it
13 requires both trains to be partially damaged?

14 MR. FROESE: Yes. This is Brian again.
15 There's currently no credible internal event or design
16 basis hazard level event that would lead to a failure
17 of this section of RCCS.

18 MEMBER PETTI: Okay.

19 MR. FROESE: Just happened to be something
20 that we're looking at a bit more recently from a cliff
21 edge standpoint.

22 MEMBER PETTI: Okay. No, thanks. It's
23 early out here on the West. I was trying to figure
24 that out. Glad you confirmed it. Thank you.

25 CHAIR MARTIN: It is certainly one of the

1 difficult things that I have is, you know, knowing
2 that down the line there are external events that are
3 certainly more severe than what you have to
4 contemplate at this stage because you focus on
5 internal events. But it does, you know, you can kind
6 of anticipate based on having a suitable amount of
7 experience that you may have to make a pivot in the
8 design to accommodate -- I could imagine a crush of
9 some sort, you know, of a sector, which then, as of
10 course you've noted, the integral nature of the
11 standpipes, the use of them both. But, again, you
12 know, maybe it's not an internal event, but you make
13 decisions today or years ago, really, and then you
14 live through it with a CPA knowing kind of full well
15 that when you do your external event analysis, there
16 will be something else. Again, my bias towards
17 considering worse single failure earlier on as a
18 surrogate, I think, could save a little pain later,
19 but that's not the rules that we have.

20 MEMBER HARRINGTON: This is Craig. Just
21 to think through this, the capacity of the RCCS is
22 really driven by the concrete, I think. So you've got
23 twice as much capacity nominally, at least. You lose
24 half of that. You're still cooling the concrete and
25 as Brian just said, the fuel is relatively insensitive

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1 to whatever RCCS is doing. So, did I have that about
2 right?

3 MR. SCHINNER: I'd say yes, and the main
4 factor in keeping the concrete cool is having just
5 that thermal view coverage --

6 MEMBER HARRINGTON: Right.

7 MR. SCHINNER: -- between the two. So I'm
8 not sure if we looked at half the trains out and
9 assessing the concrete, but I would say we've seen
10 during accidents that keeping the concrete cool is
11 mostly just having that thermal view coverage between
12 them. And then -- oh, I was just going to say and you
13 know, to put this into perspective, right, RCCS is our
14 safety related means of heat removal. So during
15 design basis accidents it's still intact. So this is
16 just very low frequency beyond design basis events
17 that we're analyzing for a failure of a single RCCS
18 standpipe.

19 MEMBER HARRINGTON: Okay. Thanks.

20 MEMBER PALMTAG: What's the distance
21 between the reactor vessel and the RCCS wall?

22 MR. SCHINNER: One meter.

23 MEMBER PALMTAG: That's really close. So,
24 you know, referring to a few factors, of course, we
25 think of the concrete. You think about what's behind

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1 the RCCS, but there's concrete on the floor as well.
2 Do your analyses include the evaluation of the floor
3 concrete, and, you know, so what temperatures might it
4 get to?

5 MR. FROESE: We have done analyses looking
6 at concrete temperatures. It's a more challenging
7 problem, right? Because it's three-dimensional and
8 we've done some initial analyses with CFD, and we're
9 looking at optimizing the insulation that could be
10 required in those different areas around.

11 MEMBER PALMTAG: Okay. So insulation is
12 the solution in this and that insulation would be a
13 metal insulation of some sort, or maybe you've thought
14 about that far.

15 MR. FROESE: I don't have the answer to
16 that.

17 MEMBER PALMTAG: Yes.

18 MR. FROESE: Yes. Oh, Martin's had his
19 hand up for a little bit. Martin, did you want to a
20 -- sorry, I didn't see you over there. Did you want
21 to add anything else?

22 MR. VAN STADEN: Yes. I just wanted to
23 add. So, I mean, I don't think we've updated those
24 analyses, but I've done a tremendous amount of
25 analyses with CFD on RCCSs not just on our design, but

1 also on previous designs, the 400 megawatt PBMR
2 design. And the same principles, 100 percent same
3 principles apply and even at most -- we would be able
4 to maintain our temperatures even with half of the
5 RCCS pipes not operating. I've done those in PBMR, we
6 even ran a case where we had three systems in
7 parallel, and we took out two of the three systems,
8 and we still made our ASME requirements on the vessel
9 and the concrete. So, I think when we run those,
10 we'll see very similar results.

11 The other comment I just wanted to make
12 about external events, I think Brian really touched on
13 it and said that, you know, our site-related part of
14 the RCCS is not vulnerable. It's within the reactor
15 building, which can withstand aircraft impact and
16 therefore all external missiles. So it would be a
17 very quite a beyond design basis event that would take
18 out any one of those pipes. So I think there's a lot
19 of conservatism in that assumption.

20 CHAIR MARTIN: Any further questions on
21 this slide? Okay. Karen, then go ahead.

22 MS. SPICHER: Next slide, please. Now
23 we're going to go into some of our analysis. Paolo's
24 going to go through some of our safety analysis that
25 we've done. Paolo?

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1 MR. BALESTRA: Yep. Paolo Balestra. So
2 there were several questions asking about reactor
3 pressure vessel temperature, vessel fuel temperature,
4 and so on. These are simple representations of how
5 our passive cooling system works. I'm pretty sure
6 that most of you have seen this picture in different
7 forms, like online in publications, and this is just
8 like a simplified representation.

9 These are the main cooling mechanism that
10 we use during a passive cooling event. And, on the
11 right, you can see that this is like an electrothermal
12 analogy, and you have different paths for the heat to
13 escape the fuel. The main difference between a PLOFC
14 and the DLOFC is that the convection within the pebble
15 bed is gone basically during the PLOFC. It's
16 practically gone. There's still like atmospheric
17 pressure helium, but you know, it's way reduced by the
18 break that you have in the HPB. So what does that
19 mean? It means that the resistance that we have in
20 the DLOFC is higher with respect to a PLOFC. So
21 basically, our water heat flux is higher during a
22 PLOFC, the heat flux through the vessel, right? So
23 that means that the fuel temperature obviously is
24 going to go down and you can see in the results that
25 we have in the CPA that PLOFC are way milder than

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1 DLOFC in terms of fuel temperature. But more heat
2 flux might mean like higher RPV temperature because,
3 you know, like the heat flux basically increase the
4 delta T that you are going to have between the RCCS
5 and the RPV, right? Because of the resistance.

6 This is just like a simplified way to say.
7 You can switch to the next slide. That basically, you
8 know, we are designing within these two limitations,
9 right? So we have a temperature of the fuel during
10 the DLOFC. That is our, you know, limiting scenario
11 for the fuel and an RPV temperature during a PLOFC
12 that is like our limiting scenario for the RPV
13 temperature. Obviously, we have to design the reactor
14 to operate for 60 years, right? And material
15 properties will change. So, we're considering all of
16 that in our models. And we are designing to specs
17 including also uncertainties, and you can see some of
18 the limits that we're using there.

19 Obviously, you know, we are well aware
20 that these two limits can compete because if you put
21 like insulation between the RPV and the pebble bed,
22 you know, obviously, you're going to make the
23 situation better for the RPV, but the fuel temperature
24 will go up. But in general, if you improve the heat
25 exchange within the cavity, right, so you lower the

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1 RPV temperature. So we have a way to improve that.
2 And Scott, you have a question -- can I finish just
3 the last point?

4 MEMBER PALMTAG: Finish your thought.
5 Yes, yes.

6 MR. BALESTRA: Yes. Obviously the safety
7 analysis that we have done focus on the fuel
8 temperature, right? So because we use the fuel
9 temperature for the dose calculations for the -- and
10 that was the main focus for the CPA. We use end of
11 life graphite conductivities and we also add
12 conservatism also artificially reducing that graphite
13 conductivity to take into account the uncertainties.
14 That inevitably produces milder temperatures on the
15 RPV, but that's to maximize the fuel temperature.
16 Dedicated studies will be done to maximize the
17 temperature of the RPV. Obviously, we cannot maximize
18 both in the same calculation. So that's the theory.

19 MEMBER PALMTAG: Dave?

20 MEMBER PETTI: Yeah, no, that was my
21 question. I understood the logic. It was more on the
22 RPV temperature. It says including uncertainties. It
23 seemed to me you'd want to do a case where you recover
24 all the radiation damage, you anneal out it during the
25 DLOFC or the PLOFC and you move a heck of a lot of

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1 heat towards the RPV. The fuel temperatures will come
2 down, but the vessel temperatures would go up. Have
3 you looked at that?

4 MR. BALESTRA: We have the design team
5 that is looking the team that take care of the ASME
6 compliance and that look -- dedicate -- they
7 specifically look at that during the safety analysis
8 that we do for the dose calculations. We have a
9 reactor pressure vessel temperature. Obviously, it's
10 not -- the calculations are not like the one that you
11 saw in the PSAR. You know, they're not like dedicated
12 to the RPV temperature calculations. So there's not
13 like all the uncertainties that we need for maximizing
14 the dose, right? So, but yes, in parallel, design
15 team, you know, they perform calculations to check the
16 ASME limits. And so far, you know, we have
17 significant margin that makes us think that we can
18 move forward.

19 In the next slides, we going to show some
20 of the approach that we have in case, you know,
21 between now and OLA, you know, see the temperature
22 goes higher, we have options to reduce the temperature
23 of the RPV if needed.

24 MEMBER PALMTAG: Looking at your previous
25 slide where you have of course the graphic.

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1 Conduction and radiation, where you're generally going
2 to have low uncertainties. It's the convection that
3 can have large uncertainties. Your geometry will
4 matter. You know, Brian talks about the one D codes.

5 MR. BALESTRA: Yes.

6 MEMBER PALMTAG: That's not necessarily a
7 one D type phenomena. And whether there's convection
8 or not, -- it depends, or whether the convection
9 exists or doesn't exist is important depending on what
10 you're looking at or what is your figure of merit.
11 You know, if you had a lot of convection within the
12 reactor vessel, you could move more heat to that
13 reactor pressure vessel wall. And then if it was more
14 stagnant out in the cavity, then, you know, that would
15 be your meaning -- no convection.

16 MR. BALESTRA: Yeah.

17 MEMBER PALMTAG: That would be kind of
18 your limiting type scenario. Now, when you start
19 considering uncertainty, you really have to consider
20 that kind of limiting condition or go out there and do
21 a bunch of tests where you're not doing, which you're
22 not going to do, right? I mean, that would be, you
23 know, maybe a tremendous investment. The easy way out
24 is not to consider -- well, is to consider convection
25 in those limiting cases as I've kind of described for

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1 what this one situation where you're looking at the
2 reactor pressure vessel. Again, something else would
3 be like just the fuel or, I don't know, the concrete,
4 what have you. It would be different.

5 Have you at least acknowledged the
6 uniqueness of the uncertainties with convection and
7 looking at the broader scenarios involving the
8 different possibilities?

9 MR. BALESTRA: We are in the process of
10 doing the validation for our software, right? And one
11 specific case we are using is the HTTR mock-up, which
12 we have the convection into the cavity. So we're
13 trying to as part of our evaluation method, we're
14 evaluating the biases and the uncertainties that we
15 are going to get after we are finished with the
16 validation exercises. And in specific, that test is
17 going to tell us what's the uncertainties on the
18 prediction of the RPV temperature and based on, you
19 know, the performance and the heat flux that we have
20 during the transient.

21 MEMBER PALMTAG: Well, then, of course
22 Dave may roll his eyes, but this gets into the
23 question of scaling under Reg Guide 1.203. I don't
24 know how well you know the HTTR cavity that obviously
25 it's one folks area, would otherwise align with your

1 situation. But obviously very, very different designs
2 --

3 MR. BALESTRA: Yes. And I --

4 MEMBER PALMTAG: Have you done that kind
5 of scaling analysis and examined for distortion?

6 MR. BALESTRA: -- exactly in parallel with
7 the validation. So like, we are performing the
8 validation exercises. Actually, you know that.

9 MEMBER PALMTAG: Okay. Considered it all
10 under the validation.

11 MR. BALESTRA: Yeah.

12 MEMBER PALMTAG: But then have you just
13 simply looked at, you know, the limiting assumptions?
14 You can just say, lots of convection here, no
15 convection there, and do that work, and be able to
16 just say, Well, even if we have no knowledge, we know
17 at least what the limiting situation might be and that
18 we still survive it. That is your easy way out.

19 MR. BALESTRA: Yes.

20 MEMBER PALMTAG: Top card there.

21 MR. BALESTRA: Yes. That's a great
22 comment. I think and that's part of our you know
23 sensitivity studies that we do and cliff edge effect
24 studies.

25 MEMBER PALMTAG: So, they are TBD.

1 MR. BALESTRA: Because you are describing
2 situations which, you know, we are kind of cliff edge,
3 right? So completely stagnating the cavity in the
4 reactor pressure vessel, you know -- sorry, in the
5 reactor cavity, completely stagnating. That's kind of
6 a limiting scenario, right? Yes. We can see we will
7 do that between, you know, now and OLA.

8 MEMBER PALMTAG: Good.

9 MR. BALESTRA: Okay. So there were
10 several questions, and then we touched a little bit on
11 that before about train failures and so on. So just
12 wanted to bring up a couple of points and to build on
13 top of what Brian said. So every scenario in which we
14 have RCCS failures or type of failures are of the on
15 design basic action. So basically our DBAs, the RCCS
16 do performance function. And if one pipe break
17 doesn't compromise the RCCS function completely
18 because there's one feature that is very useful is the
19 staggering of the pipes. So, one train has a -- I did
20 not picture there, but just visualizing. So we have
21 a train A, train B, train A, train B, you know, all
22 around the reactor. So basically, if we lose a train,
23 we still have a 360 degree coverage, right? And
24 radiation technically diffuses. We need an entire
25 sector to go down. That's not possible with this

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1 configuration.

2 Technically speaking, we reduce the
3 performance, but we still have a coverage of the RPV.
4 We don't have specific hotspot there. Another outcome
5 of the validation that we are doing right now is that
6 the software that we decided to use, GOTHIC, is
7 capable of predicting the behavior of the RCCS really
8 well. And you can see the picture there is one of the
9 tests that we have in Argonne, that's NSDF, that's 57.
10 And we could predict the performance pretty well. Or
11 this for the primary benchmark, I would consider that
12 pretty well. And we are performing scaling analysis
13 on that too, to make sure that the facility is
14 representative, and the data are representative. But
15 the idea is that GOTHIC is capable of replicating the
16 performance of the RCCS, and we can use that to study
17 these scenarios in which we have like one of the train
18 fails, and then we might go in off normal operation.
19 Next slide, please.

20 MEMBER PALMTAG: So, slide here is really
21 reflecting my question earlier, right? About the
22 geyser and basically instabilities --

23 MR. BALESTRA: Yes.

24 MEMBER PALMTAG: -- that were otherwise
25 seen and you're showing that these are your analyses.

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1 MR. BALESTRA: Yes, of the previous slide.
2 Yes.

3 MEMBER PALMTAG: Okay. As opposed to say
4 analyses that they published whatever.

5 MR. BALESTRA: No. The G is for GOTHIC.

6 MEMBER PALMTAG: Yes. Okay.

7 MR. BALESTRA: That's just experiments.
8 To summarize, even if we lose the one train, as Brian
9 mentioned before, we don't affect the fuel
10 temperature. So that gives us confidence that our
11 estimations, those estimations are consistent.

12 For the RPV temperature, obviously, you
13 know, if we lose one train, the performance will go
14 down and the RCCS temperature will go up, you know.
15 But there are several options and several design
16 requirement that we can impose, you know, in case
17 we deem this not acceptable. For example, we can
18 treat the surface of the RCCS or we can reduce the
19 pressure. Because reducing the pressure extend the
20 life of the RPV a lot, and we have several means to
21 reduce the pressure in case we need to. And because
22 these are the on design basic action. As we said
23 before, if we see a hot spot in the cavity, you know,
24 we always have the option to insulate the concrete,
25 when the question of when the temperature of the

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1 concrete in goes too high.

2 MEMBER HALNON: Paolo, this is Greg.

3 MR. BALESTRA: Yes.

4 MEMBER HALNON: Are you doing additional
5 work to understand the both localized and total impact
6 on the concrete for temperature gradients and high
7 temperature, long-term high temperature operation? It
8 seems like we haven't talked about it much about that.
9 But you know, obviously we're dealing with impact of
10 concrete at lower temperatures in the industry today,
11 but these are pretty high temperatures for over a
12 period of time. Plus there's probably some tremendous
13 temperature gradients across there. So, is there any
14 more work going to be done to understand that?

15 MR. BALESTRA: I can just give an -- maybe
16 just, I mean we are doing CFD analysis on the cavity
17 to as design involved, you know, we're doing CFD
18 analysis to understand if there are hot spots and you
19 know, like --

20 MEMBER HALNON: Okay.

21 MR. BALESTRA: Correct about --

22 MEMBER HALNON: Because insulating
23 concrete is a double-edged sword too. I mean, again,
24 if you insulate pieces with concrete, then you're
25 leaving other pieces uninsulated, or if you're going

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1 to globally insulate it. So, there's a lot of
2 questions there, but you're saying CFD is going to
3 take care of it, Brian?

4 MR. BALESTRA: Yeah.

5 MR. FROESE: We're in the process of
6 analyzing and optimizing the insulation. Yes.

7 MEMBER HALNON: Okay. So there will be
8 some insulation on the concrete.

9 MR. FROESE: The main areas that we're
10 looking at for insulation is for the floor and the
11 ceiling, like we said earlier. We don't block in
12 those areas, but we're using the ACI 349 temperature
13 limits, so 64 degrees C for normal operation. So
14 we're designing to meet that temperature.

15 MEMBER HALNON: Okay.

16 MR. FROESE: Then 175 for the accidents.
17 I think the code allows for some hotter spots around
18 penetrations, and we may insulate there where we may
19 not have RCCS blocking that.

20 MEMBER HALNON: You're systematically
21 going through it with the ACI codes then?

22 MR. FROESE: Yeah. So, we're just meeting
23 the code limits.

24 MEMBER HALNON: Thanks.

25 MR. FROESE: Yes.

1 MEMBER PALMTAG: This is Scott Palmtag.
2 You seem to be focused on the concrete and haven't
3 really discussed the RPV temperatures that much. Is
4 the concrete much more limiting than the RPV, or are
5 you also looking at the RPV limits?

6 MR. FROESE: We're looking at both.

7 MEMBER PALMTAG: In general, is the
8 temperature of the concrete more limiting or?

9 MR. FROESE: Generally, I would say --

10 MR. BALESTRA: Can we define more limiting
11 in terms of like which one gets closer? I mean, we
12 are following the standard, so we are within the
13 margin. But we still have margin on both -

14 CHAIR MARTIN: Okay.

15 MR. BALESTRA: -- the analysis, so. But
16 I think the difference is that, you know, with the
17 concrete we still can isolate, right? We can put
18 insulations, and we have the RCC as a core. For the
19 RPV, you have to start to work on other, you know,
20 these other treatments here that impose requirements
21 and that are more complicated to work with. The
22 concrete, you know, that is more manageable. You
23 know, RPV we have to design within -- it's more
24 complicated, I would say, you know, to handle the RPV
25 temperature with respect to the concrete one. But we

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1 have margin on both.

2 CHAIR MARTIN: Okay. Because everything
3 you do that's going to affect the temperature of the
4 concrete, right, it's going to translate to the RPV
5 too. Walt kind of had drew a little cartoon last
6 time, well, our last meeting. I thought you were
7 actually going to go there, but that shows the
8 temperature profile as you leave the core out to the
9 core, to the pressure vessel, and then the concrete.
10 But okay, I just want to make sure, you know, just
11 make sure you're focused on the RPV too, so thank you.

12 MR. BALESTRA: Yes. Definitely.

13 MS. SPICHER: I think, Scott, that Paolo
14 is a couple slides back. We've talked a lot about
15 that. Yeah. Like, next one, Paolo. We know it's
16 like we're constantly going back and forth with in the
17 design phase, what's limiting the fuel, concrete, RPV,
18 and we're focusing on the two design basis accidents
19 here. That one of them has the RPV and one of them
20 has the fuel.

21 CHAIR MARTIN: Okay.

22 MS. SPICHER: So that was the point with
23 that slide.

24 CHAIR MARTIN: Okay. Any last thoughts
25 from the Committee consultants regarding the control

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1 of heat removal? See they're ready to move on. Do
2 you have to change staff? Okay. I'm thinking they
3 could do that now.

4 CHAIR MARTIN: All right. Terri, are we
5 ready?

6 MS. SPICHER: Yes, we're ready.

7 CHAIR MARTIN: Okay, go ahead.

8 MS. SPICHER: Thanks. We're now going to
9 go through RSF 1.4 just to let everybody know that we
10 didn't want to repeat the staff's slides. We know the
11 staff also had slides in the next session where they
12 talk about more the material qualification plan and
13 that type of thing. So, what we're going to do today
14 is go through some of the questions that we were
15 informed about that we'll try to answer, and they're
16 more like, again, we have a little bit more analysis
17 and that type of information. Just a little bit on
18 the material qual -- but the staff then again will go
19 through more of that in detail. I'll let my two
20 fellow leads introduce themselves.

21 MR. BURNS: My name is Zach Burns. I'm
22 the engineering manager for Reactor Vessel Internal
23 Design.

24 MR. LIGON: And my name is Tom Ligon, the
25 senior manager for Structural Analysis.

1 MS. SPICHER: So we have some on, some
2 fellow SMEs online as well. Jessica, could you ping
3 Jerrod? Just let him know, ping him that we're
4 starting graphite. Thanks. Okay.

5 So, we're going to start off with
6 discussing some of the areas that the questions that
7 you had asked, and so we're going to start off with
8 Tom. Go ahead, Tom.

9 MR. LIGON: All right. Thank you. Good
10 morning. So there were some questions related to how
11 we're combining loads with respect to our analysis of
12 the core. Specifically, we focused a lot on the
13 graphite. Starting out looking at just normal
14 operation. We're looking to ensure that all of our
15 relevant loads are considered. So what are those
16 relevant loads? Specifically temperature, so kind of
17 what are the normal operating temperatures of the
18 graphite? During operation, it is irradiated. That
19 irradiation causes the graphite to deform, so we
20 basically progressed the model through time as we
21 irradiate it, as the deformation changes through time.

22 We also consider, it's not actually on the
23 slide here, but things like gravity and deadweight.
24 You know, we sometimes do sub-modeling where you would
25 take credit for components above maybe the components

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1 you're looking at, so you'd include that deadweight
2 you typically put on as a pressure. And then there
3 are also pressures from the differential helium
4 pressure on either side of our various graphite
5 components. And then we also have pressure that is
6 simulating the loads from the pebble bed itself, where
7 we're distributing that load as you go up and down in
8 depth, kind of like a hydrostatic load.

9 As I mentioned, those loads are all
10 combined simultaneously. We look at them, how they
11 change throughout the lifetime. Then in addition to
12 that, there's also potentially times we have various
13 LBEs where the temperatures may vary during
14 transients. We would look at those transients
15 similarly at different times of life. The neutron
16 irradiation doesn't just affect the geometry of the
17 various GCCs. They're also going to affect things
18 like the conductivity. How those temperatures may
19 redistribute through the core may differ depending on
20 where you are in that time of life. We're looking
21 both at the various LBEs and the different transients
22 that could occur in the core that are predicted, but
23 then also we're ensuring that we're looking at that
24 happening at different times of life because how the
25 core behaves is going to differ depending on when that

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1 occurs.

2 I'll discuss seismic in the next slide.
3 I also wanted to mention that there are some loads
4 that were brought up that are not currently being
5 evaluated. We are evaluating what our oxidation
6 potential is in the core. Currently, we're expecting
7 that to be below the one percent limit, where that
8 limit's given to us from the ASME Boiler and Pressure
9 Vessel Code, Section 3 to 5 where if you're below one
10 percent, you do not need to consider how oxidation may
11 affect your material properties. So at this time,
12 that is not something that's being considered. If at
13 a later time we find that oxidation is above that
14 limit in some regions of the core, we would then bring
15 that in. In terms of flood within the pressure
16 boundary, we do not consider that to be a credible
17 loading. Any questions?

18 CHAIR MARTIN: This is Bob. You know, our
19 last team with Brian and Paolo, of course, when you're
20 dealing with thermal hydraulics, there's, of course,
21 a rich database and experience of testing, what have
22 you, that goes along with that. Now, when you're
23 dealing with, you know, the materials, I mean,
24 graphite in particular, of course, there is the same
25 experience, it just maybe doesn't get the same kind of

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1 attention in proceedings like this or by a community
2 that is as visible as thermal hydraulics.

3 I would say that you would also, along
4 with say, the analysis and the assumptions that you're
5 presenting here with the analysis, you should also be
6 able to go back and say, Well, you know, we've looked
7 at you know, graphite and the loads in for say, rain
8 or THTF or, you know, HTTR or any of the other prior
9 high temperature gas reactors. At least derive a
10 range of experience. If we're talking about
11 tolerances for control rod movements or something like
12 that or gaps or anything like that, there is an
13 experience base. And have you mined that database?
14 At least understand that, or say your designers
15 understand, that they're at least within an experience
16 base, not just making sure all the numbers add up in
17 the analysis space.

18 MR. BURNS: Yeah. Thanks for that
19 question, and it's something that is at the core of
20 how we've done our design work. Every engineer 1 and
21 2 that comes in starts with an operational experience
22 search, and that spans both U.S. experience, U.K.
23 experience, and a lot of the experience in Asia as
24 well. We've had pretty extensive conversations with
25 folks specifically with the AGR fleet that has more

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1 correlation specifically with our control rod entry
2 testing.

3 MEMBER PALMTAG: Yes.

4 MR. BURNS: You'll see that on the next
5 slide.

6 MEMBER PALMTAG: I see that's kind of the
7 number one thing.

8 MR. BURNS: Yeah. The Lewis method, which
9 I'll talk about shortly.

10 MEMBER PALMTAG: Okay.

11 MR. BURNS: At the core of what we're
12 doing.

13 MEMBER PALMTAG: Okay. All right. Thanks
14 for that answer.

15 CHAIR MARTIN: Ron has his hand up.

16 MR. BURNS: Oh, Ron? I'm sorry. I missed
17 that.

18 MR. BALLINGER: Just a general question.
19 Have you decided on the actual source of your
20 graphite?

21 MR. BURNS: Yes. We're using SGL's NBG 18
22 and Toyo Tanso's IG 110 graphites for the BLM reactor.

23 MR. BALLINGER: So that's the spec, but
24 what about the source?

25 MR. BURNS: Like the coke and pitch raw

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1 materials?

2 MR. BALLINGER: Yes.

3 MR. BURNS: Yes. So those have been
4 decided. They're largely proprietary with --

5 MR. BALLINGER: I get it. Okay.

6 MR. BURNS: But they have been decided and
7 documented.

8 MR. BALLINGER: So, that'll become -- I
9 can ask that question later. Yeah, that'll become
10 important in the OL for sure.

11 CHAIR MARTIN: Yes. Okay. Thanks, Ron.
12 Proceed.

13 MR. LIGON: Okay. Thank you. So moving
14 on. Similar story with seismic. Seismic's a little
15 bit more complicated where you need to consider both
16 various times of life and also there's no getting away
17 from considering the whole core altogether. It's all
18 going to interact. It's highly nonlinear. We model
19 it with LS-DYNA, and that model is also considering
20 the deformed shape from these different times of life
21 as that can affect things like the amount of
22 frictional area between your GCCs and details such as
23 those.

24 That model then feeds a lot of downstream
25 analyses. Those include the displacements as an

1 output of that. Basically, you have your seismic
2 event, we have clearances between most of our graphite
3 components, so they can move relative to each other.
4 And so there will be a new configuration of the core
5 after the seismic event. So then we would take that
6 configuration and look and evaluate whether or not the
7 rods can insert, evaluate what, if any, impact on heat
8 removal.

9 Then we'd also be looking to extract loads
10 to do more detailed stress analysis of those
11 components and then also extract loads to look for
12 interfacing loads for things like the core barrel or
13 any other interfacing components with the graphite.
14 And then on the next slide, we'll start talking about
15 the --

16 MEMBER BIER: Excuse me.

17 MR. LIGON: Yes.

18 MEMBER BIER: Before we go on, this is
19 Vicki Bier. On the slide about the seismic analysis,
20 I'm trying to understand: Is this hypothetical
21 seismic analysis about ability to insert the rods
22 after a seismic event, or are you talking about what
23 you will actually do if a seismic event occurs in
24 during operation?

25 MR. LIGON: I'll take those in turn. This

1 would be a postulated seismic event where, you know,
2 you would be looking to design for something that
3 could happen and that would be both a seismic event
4 where we would expect to be able to tolerate that
5 event and readily restart the reactor, and then with
6 basically minimal damage to any of the components.
7 There would be a separate evaluation on a higher,
8 stronger seismic event where we would want to purely
9 confirm that we would be able to continue to insert
10 the rods and safely maintain shutdown of the reactor.

11 MEMBER BIER: Okay. Thank you for the
12 explanation. I guess I have a follow-up question,
13 which is I would imagine that the shifting of core
14 elements could be pretty difficult to predict, kind of
15 inherently random or whatever with different
16 earthquake characteristics. Are you proposing to do
17 like a few hypothetical earthquakes or a comprehensive
18 Monte Carlo simulation of lots of possible
19 earthquakes? How do you plan to address that?

20 MR. LIGON: So multiple axes to that. And
21 it -- I could even go into there is more potential
22 options for that where, like I mentioned, there's
23 different states of life. The direction that the
24 ground motion could happen in could vary, and the
25 analysis would consider all those permutations and

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1 configurations. And even there's potentially material
2 properties that you would want to adjust, vary,
3 understand how those impact, how everything behaves
4 and what end state you end up at. So we are talking
5 about many, many, many analyses to evaluate all of
6 these different configurations and how they may impact
7 our ability to shut down the core, whether it will
8 damage the core, these types of questions.

9 MEMBER BIER: Thank you. That's
10 reassuring.

11 MEMBER HARRINGTON: This is Craig. Just to
12 follow up, is that many deterministic analyses or some
13 kind of a Monte Carlo approach or?

14 MR. LIGON: I think there may be a -- so
15 the details of this have not been entirely ironed out
16 in terms of what steps are going to get us to the
17 subset that is going to be the final basis. We're
18 still evaluating that, but it would be the analyses
19 themselves would eventually be deterministic, where
20 you're running a specific scenario. How you evaluate
21 what those deterministic cases are could be
22 probabilistic.

23 MEMBER HARRINGTON: Okay. Thank you.

24 CHAIR MARTIN: What exactly is XECORE?
25 That's your code.

1 MR. LIGON: Yeah. So XECORE is kind of
2 two things. One, it is, we sometimes call, a wrapper
3 around LS-DYNA, where it is acting to automate the
4 process where you basically can more rapidly build the
5 model, change these variables to rapidly iterate and
6 get these answers. It also does a lot of automated
7 post-processing so that we can then get the results
8 out and be able to evaluate them.

9 CHAIR MARTIN: It's not necessarily
10 providing actual analysis, per se.

11 MR. LIGON: It is not the solver. The
12 solver is LS-DYNA.

13 CHAIR MARTIN: Okay.

14 MR. LIGON: But then you may also -- we
15 sometimes refer to XECORE as just the methodology. So
16 this is like getting into the details of some of the
17 assumptions that are being used in that analysis.

18 CHAIR MARTIN: Right. I don't believe
19 we've seen a topic report that talks about this.

20 MR. LIGON: Not in details.

21 CHAIR MARTIN: I mean, again, it wouldn't.
22 You would expect it more in OL, but that is a plan to
23 have a topic report on this evaluation methodology.

24 MR. LIGON: I think we have considered it.
25 Have we? There's one not currently in progress. I'll

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1 put it that way. Being prepared. But we will take
2 that as advisement.

3 CHAIR MARTIN: Right. I think we'd be
4 curious. Obviously, it seems to fall in the unique,
5 novel, noteworthy when you're dealing with a design
6 like this.

7 MR. LIGON: Yes. I will say similar to
8 what Zach said, we are following precedent on how
9 other gas cooler reactors have designed their graphite
10 cores and done seismic analysis, but understand.

11 CHAIR MARTIN: Yes. Okay. Oh, Annie.

12 MEMBER KAMMERER: Yes. Just a few follow-
13 up questions on that. So, again, you know, following
14 up on Vicki's question. This is a time-based
15 deterministic single run tool, LS-DYNA, so how many
16 time histories do you intend to run for it? Because
17 you talked about a number of scenarios and cases,
18 which is great, but for each of those, how many time
19 histories do you anticipate running?

20 MR. LIGON: I don't have a hard number for
21 you, but multiple 10s, let's say, for --

22 MEMBER KAMMERER: Okay.

23 MR. LIGON: And like you could look at our
24 core is kind of symmetric, generally symmetric, about
25 the cross vessel hot gas duct. So we would look to

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1 kind of vary the relative directions horizontally at
2 a minimum to understand how that might affect the
3 response.

4 MEMBER KAMMERER: And then a follow up.

5 MR. LIGON: In addition to things like
6 frequencies, magnitudes.

7 MEMBER KAMMERER: Yes. And then as a
8 follow-up, how are you coupling the dynamics of the
9 pebble bed with the dynamics of the seismic loading?

10 MR. LIGON: I would say that is a work in
11 progress and something we're going to look at in
12 testing. We have some initial thoughts of looking.
13 So like I said, with the earlier -- we've been
14 applying the pebble loads as pressures, and we have
15 some thoughts on how we could vary that pressure as
16 the pebble bed is also accelerated from the ground
17 motion or from the motion at the base plate and
18 evaluating if that is a success path or not.

19 MEMBER KAMMERER: Is there any potential
20 for some top of bed, like sloshing phenomena or
21 anything like that within the design?

22 MR. LIGON: I think there is potential,
23 and we're going to evaluate as part of testing.

24 MEMBER KAMMERER: Okay. And so just to
25 follow up on the earlier comment, I think there is

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1 enough that's new here that I would encourage a
2 topical report on this topic. Thank you.

3 MR. LIGON: Okay. Thank you.

4 CHAIR MARTIN: And does planned testing
5 involve like a shaker table?

6 MR. LIGON: That's correct.

7 CHAIR MARTIN: Okay.

8 MR. LIGON: Yeah. And it would be at
9 scale. There's not a shaker table that would be able
10 to hold the entire core at full scale. So yes --

11 CHAIR MARTIN: Sure.

12 MR. LIGON: -- it would be at scale.
13 We're evaluating whether, you know, whether we reduce
14 the height at all, maybe shorten the bed a little bit
15 for practical reasons. But yes, that's what we're
16 intending to do.

17 CHAIR MARTIN: There are some big ones out
18 there.

19 MR. LIGON: There are some big ones out
20 there.

21 CHAIR MARTIN: They're not cheap. All
22 right. Thank you.

23 MEMBER PETTI: This is Dave. I just had
24 a question. Have you guys actually started to do some
25 analysis at all?

1 MR. LIGON: Yes. We have done some
2 analysis looking at more quasi-static loads. We don't
3 have a final answer on what the motion at the core
4 base plate is that we should be using. So we first
5 started with doing quasi-static, looking at just,
6 okay, if we kind of dynamically load everything to the
7 side, what kind of behavior are we seeing? Are our
8 models at that kind of level of motion looking
9 reasonable, et cetera?

10 The next step was we were looking at just
11 kind of pure sinusoidal input and how the core starts
12 to behave under those loads. And then the next step
13 would be look at an actual ISRS.

14 MEMBER PETTI: But in terms of the required
15 safety functions, is one more difficult to achieve
16 than the other?

17 MR. LIGON: I would say the -- I mean, so
18 part of this is evaluating the relative interactions
19 between the various GCCs and then how those clearances
20 build up to allow movement, and can we get the rods
21 in. And so one of the primary things to look at is
22 are we creating a situation where we're challenged
23 there? And so that's been some of the initial focus.

24 MEMBER PETTI: Yes. My guess would've
25 been the getting the rods in. The heat removal, I

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1 mean, I would think even if it's the geometry is a
2 little misaligned, all those visits are still going to
3 work. Maybe slightly degraded, but --

4 MR. LIGON: Agreed. We have a slide on
5 that, but that's the that's our takeaway as well.

6 MEMBER PETTI: Okay. Well, that was my
7 sense. I don't know about the stresses. That's, you
8 know, kind of TBD down the line. Thank you.

9 MR. LIGON: Thank you. Okay. So on that
10 topic, talking a little bit about the passive heat
11 removal potential after an event, so our models are
12 considering the gaps in between the graphite
13 components. The primary gaps of interest are between
14 what we call the inner side reflector. So this is
15 kind of the inner row of graphite components, and then
16 there's an interface between them and the outer side
17 reflector components.

18 Similarly, there's a gap between the outer
19 side reflector and then the core barrel. So the
20 primary heat mechanism that's being credited through
21 those interfaces is radiation. And to Dave's point,
22 we do not expect much of an impact to that kind of
23 heat flux through those based on small changes in the
24 geometry. The other gaps of interest are parallel to
25 the direction of heat transfer. So these would be,

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1 you know, between neighboring side reflectors or
2 neighboring so inner and outer side reflectors.

3 They're a little bit dependent on the
4 cross-sectional area, but our expectation is -- so
5 generally, the gaps are very tiny, and if things move
6 around, gaps open up. You know, there's a potential
7 that what is generally a conduction through that gas
8 space could even become convection. We expect the
9 heat transfer to increase. So at least from a
10 removing heat from the fuel, we would expect the heat
11 transfer to go up, and then we would evaluate if
12 that's going to challenge any other components, such
13 as the RPV as we were discussing previously.

14 Questions? Okay, control rod. Thank you.
15 Yes. All right, so control rod insertion. So just
16 for everyone's awareness, we didn't get a kind of de-
17 featured figure in here. The control rod is not a
18 single rod. It is made up of five individual
19 articulating pieces that can rotate and move relative
20 to each other. They do need to insert through a stack
21 of basically 20 graphite reflectors.

22 Within those reflectors, we have what we
23 call control rod sleeves. So these are, imagine, you
24 know, hollow cylindrical pieces that fit in that help
25 to better align those channels for our rod suits to

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1 fit in. As I mentioned, there's a number of
2 clearances between all these components. The largest
3 clearances are between the control rod itself and the
4 sleeve. But then we have the reason that this needs
5 to be evaluated is we have clearances between what we
6 call the dowels. These are kind of locating dowels
7 between the various tiers of side reflectors. There
8 is then just a clearance between the sleeve itself and
9 the reflector that it's housed within. Then there's
10 the clearance between the core barrel and the
11 graphite.

12 For those who don't live this every day,
13 one of the things to understand is that the metal will
14 expand faster than the graphite, and so generally that
15 clearance increases at higher temperatures. So you
16 kind of grow a little bit of space in the core. The
17 point here that I'm leading up to is, and we've kind
18 of discussed this already, there is an innumerable
19 number of configurations that the core could take.
20 And so to a question of, Hey, what's the maximum
21 tolerance of a misaligned geometry could you tolerate?
22 That's a really difficult question to answer.

23 And so if we go on to the next slide, go
24 ahead.

25 MEMBER PALMTAG: Okay, real quick.

1 MR. LIGON: Yeah.

2 MEMBER PALMTAG: Of course, this was kind
3 of my question that at least Zach kind of anticipated
4 in his answer. But I want to make sure you two are
5 talking, right?

6 MR. LIGON: Yeah.

7 MEMBER PALMTAG: You said it. Were you
8 listening? I mean, being able to go to the reactor
9 operating experience base, and at least you're not
10 trying to claim tolerances that are better than --

11 MR. LIGON: No.

12 MEMBER PALMTAG: -- than the past.

13 MR. LIGON: No, we are not.

14 MEMBER PALMTAG: Okay.

15 MR. LIGON: Correct me if I'm wrong, Zach.
16 Okay.

17 MEMBER HARRINGTON: And this is Craig.
18 Just to clarify, the sleeves are they a continuous
19 sleeve full height of the --

20 MR. LIGON: No, that's a good question.

21 MEMBER HARRINGTON: -- each block?

22 MR. LIGON: So each block, it -- well, so
23 the side reflectors, some of them are half height and
24 the sleeve passes through two. So there are multiple
25 sleeves that make up a stack. Those sleeves do have

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1 counter bores. They fit within each other. And then
2 those clearances are designed -- the design intent is
3 that if there is some relative movement between the
4 tiers, that movement is picked up by components like
5 the dowels, and you're not loading up that interface
6 between the sleeves. So the sleeves can move a little
7 bit relative to each other in that counter bore, but
8 they're not like loading up on each other and causing
9 local stresses there, is the intent.

10 MEMBER HARRINGTON: Now, there's obviously
11 tapers and things --

12 MR. LIGON: Correct.

13 MEMBER HARRINGTON: -- at each --

14 MR. LIGON: Yes.

15 MEMBER HARRINGTON: -- joint so that you
16 don't have additional impediments to --

17 MR. LIGON: That's correct.

18 MEMBER HARRINGTON: And so it's a metal
19 sleeve.

20 MR. LIGON: No, it's a graphite sleeve.

21 MEMBER HARRINGTON: It's a graphite
22 sleeve.

23 MR. LIGON: Well, so there's the sleeves
24 going through the graphite core assembly are also
25 graphite.

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1 MEMBER HARRINGTON: Okay, you said
2 something about metal expanding differently. Is that
3 --

4 MR. LIGON: Oh, that was in reference to
5 the core barrel. So the core barrel surrounding the
6 GCA will expand away, so that only gives you a little
7 bit more space. That's correct.

8 MEMBER HARRINGTON: Okay. All right.
9 Appreciate the clarifications.

10 MR. LIGON: Yep.

11 MEMBER PETTI: The guide tube's aren't
12 they carbon composite? That's what I read.

13 MR. BURNS: I'd need to double-check the
14 PSAR. I believe in our PSAR, all guide sleeves within
15 the graphite core are graphite. There's some question
16 as to what material would be used above the core
17 barrel top plate. But everything within the core is
18 graphite.

19 MEMBER PETTI: Oh, okay. Maybe that's
20 what I'm thinking about. Okay.

21 MEMBER PALMTAG: This is Scott Palmtag.
22 We've talked about the graphite or the control rods
23 going through the graphite sleeves, but the other
24 piece of this is the chains, right? There's a cog and
25 then a chain on the other side, and if those chains

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1 get held up by anything, it's going to prevent the
2 control rods from inserting. So, what do you do on
3 the chain side to make sure that's not tangled up, is
4 that another tube that goes through that, or is it
5 coiled up somehow, or what's the chain look like?

6 MR. BURNS: Yeah, I can take that one. So
7 the chain is held entirely within the rod's pressure
8 vessel. Everything is above the top of the reactor
9 pressure vessel head. Any insertion of the chain will
10 stop before it reaches the graphite core, and that's
11 maintained in a separate chamber in the -

12 MEMBER PALMTAG: I guess my question
13 wasn't clear. So, you pull the control rods up,
14 right? And then if you're going to have extra chain
15 off the other side, what does that chain look like so
16 it doesn't get tangled up?

17 MR. BURNS: I see. That currently is
18 maintained in a separate tube in the pressure boundary
19 that holds both the guides and the --

20 MEMBER PALMTAG: Okay. So you have one
21 tube that the control rods are going to come through,
22 and then you have a completely other tube that's just
23 where the extra chain. They move up and down.

24 MR. BURNS: Some of the details of that
25 need to be worked out for OLA, but there's an intent

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1 to keep those separate in separate spaces in that
2 channel.

3 MEMBER PALMTAG: But it will be just a
4 hanging down in a tube, not coiled up somehow.

5 MR. BURNS: Correct. It won't be coiled
6 up.

7 CHAIR MARTIN: Okay. Because if anything
8 happens it's almost more important if that chain gets
9 held up, that's going to prevent the insertion of
10 control rods. Okay. Thank you.

11 CHAIR MARTIN: This is Bob. To your
12 comment there about the location of the chain, I
13 gather the motivation for kind of keeping it out is so
14 that you don't expose it to any significant heat flux
15 that's coming off the core. I see you've done this
16 analysis to make sure that whatever material you're
17 using for the chain is not otherwise reaching, you
18 know, any threshold of failure.

19 MR. BURNS: Yeah. We have. We've
20 documented temperature limits for the chain, the
21 control rod material, and all the rod mechanism
22 components.

23 CHAIR MARTIN: Okay.

24 MR. BURNS: And those are all tracked in
25 ARM.

1 CHAIR MARTIN: Okay.

2 MR. LIGON: Okay. Next slide. Okay. So
3 this gets a little bit more into the details of the
4 insertion methodology for evaluating whether we can
5 get the rods through our graphite core in a disturbed
6 state. The high level -- so, we have our system level
7 modeling using LS-DYNA, which would predict the
8 deformed and displaced GCA. Then we have a separate
9 model, custom model, that is built that treats
10 everything kinematically.

11 So you have completely rigid components,
12 and you look to see if those components can fit
13 through the geometry that they're being presented with
14 while allowing the articulation between the five
15 segments of the control rods. If we find that there
16 is a geometry through which that rod cannot pass, that
17 would be the no-go, just kinematically. So there's no
18 accounting for friction. There's no accounting for if
19 it could bend to get through.

20 This methodology is very similar to what
21 was done for the AGRs using what they call their Lewis
22 software. And they were able to demonstrate also
23 through testing that the using this method of just can
24 this kinematically fit is generally conservative or
25 was always conservative relative to the reality where

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1 edges could maybe bend a little bit; the rod may be
2 able to bend. There's some, you know, all the
3 materials are flexible to some extent that they could
4 demonstrate that this was a conservative methodology.
5 But we are planning to -- obviously, they have their
6 components through which they did that testing, and we
7 are going to reproduce this with our components to
8 demonstrate the same conservative. Questions?

9 CHAIR MARTIN: I'm just looking at the
10 time, and we had a scheduled break here in a little
11 bit. I know I probably pushed the limit. It's been
12 two hours. I think it's an okay spot as we pivot on
13 the subject matter away from the control rods. Would
14 you say that's fair? That maybe we could have a 15-
15 minute break at this point? Okay. No protest -- no
16 protest. Must go. Okay. All right. Let's do that.
17 It is 10:40. Let's return at 10:55. So, we are
18 recessed till 10:55.

19 (Whereupon, the above-entitled matter went
20 off the record at 10:40 a.m. and resumed at 10:55
21 a.m.)

22 CHAIR MARTIN: Go ahead, Terri.

23 MS. SPICHER: Terri Spicher, back with X-
24 energy. I'm going to go through one more slide on
25 regarding the graphite core assembly. Just going to

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1 talk a little bit through the --

2 MEMBER PALMTAG: Terri, sorry to interrupt
3 you for a second, but I'm going back to that one quick
4 question on the control rods. I realize you have a
5 new cast up here. Is it safe to say that the control
6 rods are very similar to the AGR, or is there another
7 reactor closer?

8 MS. SPICHER: Yes. Jerrod, are you on
9 line? Jerrod's our SME. Jerrod?

10 MR. POTGIETER: I am on, yes, I'm online.

11 MS. SPICHER: Oh, great.

12 MR. POTGIETER: Not familiar with the
13 control rods themselves, sorry.

14 MS. SPICHER: Can you repeat the question,
15 please?

16 MEMBER PALMTAG: Yeah. The control rod
17 design is it very similar to the AGR reactor?

18 MR. POTGIETER: I'm sorry. I'm not able
19 to comment on that. The control rods or reactivity
20 control system engineer is not on this meeting right
21 now.

22 MEMBER PALMTAG: Okay. That's fine.

23 MR. POTGIETER: Sam Baylis, can you maybe
24 answer that?

25 MR. BAYLIS: Similar in principle but I'm

1 not aware of the details.

2 MEMBER PALMTAG: Okay, that's fine.
3 Thanks.

4 MEMBER PETTI: Scott, this is Dave. I
5 don't know which aspect, but they trace -- they don't
6 go to AGR. They trace to THTR, most likely the, the
7 German pebble bed, the chains and all of that. Now,
8 they may have actually also been used in Fort St.
9 Vrain. Where's Martin, there's Martin. He'll know.

10 MR. VAN STADEN: Yeah. I'm not sure about
11 AGR, but AVR and THTR used similar approaches,
12 especially THTR. So we worked with the German guys
13 that actually designed the control rods for THTR in
14 the early stages of our development.

15 MEMBER PALMTAG: Okay. Thank you. This
16 is just one I asked and then --

17 MR. VAN STADEN: And we will -

18 MEMBER PALMTAG: -- before you have

19 MR. VAN STADEN: -- we will be doing
20 complete set of testing on those rods and on the
21 mechanism and the chain and sprocket part to make sure
22 that we don't have any fouling or, you know, jamming
23 of those mechanisms at our helium test facility in
24 Frederick.

25 MEMBER PALMTAG: All right. Thank you.

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1 MEMBER HARRINGTON: This is Craig. Scott,
2 are you meaning mechanically similar or?

3 MEMBER PALMTAG: Mechanically, right.

4 MEMBER HARRINGTON: Okay.

5 MEMBER PALMTAG: The chain and the
6 segmented rods and the cams and the --

7 MEMBER HARRINGTON: Yeah -- yeah

8 MEMBER PALMTAG: -- arms.

9 MEMBER HARRINGTON: Okay, thanks.

10 MS. SPICHER: Okay, great. All right. So
11 I'm just going to go through one more slide on
12 graphite and then I'm going to hand it over to Ray,
13 who is licensing engineer, who I work with, who's
14 going to go through the seismic.

15 We had a couple questions about how are we
16 handling into the future with inspections and
17 reliability of our graphite. We are going to comply
18 with the ASME RIM program, which is the Reliability
19 and Integrity Management program. We've added more
20 discussion in our PSAR to describe exactly what that
21 is, but it follows ASME Section 11, Div 5.

22 This diagram on the right is just to show
23 you an overview of the RIM program right out of the
24 code how we go through the different processes. And
25 you know, probably the core of the program or the

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1 baseline of the program is how we're going to do some
2 baseline monitoring and how we also going to do the
3 non-destructive evaluation requirements and identify
4 them in the design phase. And we are already in the
5 process of doing that. Jerrod, who's on the line, we
6 have a report already drafted, a preliminary report
7 that we've gone through for this process, and so we're
8 following through with it. At this point, at the CPA,
9 we did commit to it. So that's basically all I wanted
10 to say about the RIM program, unless anybody had any
11 specific questions.

12 MEMBER PETTI: Yeah. This is Dave. I had
13 just a question since this reactor won't really be
14 opened up until halfway through its life, how do you
15 actually inspect? Are you basically -- what can you
16 do from the outside between time 0 when you go
17 critical to 30 years?

18 MS. SPICHER: Do you want to talk about
19 that, Jerrod? What we're thinking about and what
20 we've talked about.

21 MR. POTGIETER: Sure thing. So we have
22 identified a range of monitoring and non-destructive
23 examination techniques that are available to us and
24 that have been used in other high temperature gas
25 reactors around the world. So, you are correct that

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1 it's typically pretty difficult to open up the reactor
2 vessel, and then even if you do, it's difficult to see
3 what is inside. We have reports of examinations from
4 Fort St. Vrain and from the AGRs where they're only
5 typically able to visually inspect all parts of the
6 core to detect cracks. Often in those areas when they
7 do detect cracks, they're not negatively impacting
8 their ability to perform their safety functions.

9 X-energy will be following the AC section
10 11, the two reliability integrity management program,
11 and we'll be utilizing a variety of monitoring and
12 non-structural examination techniques. So, we haven't
13 finalized this list. We are still developing this
14 program. But there are a variety of techniques you
15 can use, such as periodic controlled insertion testing
16 to make sure that the structural reliability of your
17 insertion channels has been maintained. You can
18 monitor the content of the helium gas to ensure that
19 you haven't had any excessive chronic oxidation above
20 the levels that you've assessed. You can insert
21 dosimetry measurement samples to confirm that the dose
22 that you have used in your analysis is in line with
23 what you predicted.

24 There's a variety of other inspection
25 techniques that do require a bit more access, such as

1 putting feelers into the various accessible channels,
2 such as was done by the AGR. Each one of these
3 methods will give us a different type of information,
4 a different indication as to if we've exceeded our
5 expected environmental conditions or if there have
6 been disparate failures of components that are
7 required to perform our safety functions, and together
8 they will be able to give us a --

9 MR. BALLINGER: Yes, you're right.

10 MR. POTGIETER: -- broader understanding
11 of the status of the system in general.

12 MEMBER PETTI: I appreciate those. I was,
13 you know, when you look at AGR, not everything because
14 you're not refueling and you're not planning to open
15 it up. So, there are some differences, I guess. So
16 thanks. But the other idea gave me some idea of what
17 you're thinking about.

18 CHAIR MARTIN: Okay. Ron, go ahead with
19 your question.

20 MR. BALLINGER: Yeah. And just for the
21 record, I'll keep harping on it, but this is the first
22 case where Division 5 and the RIM program and the like
23 for Section 11 will be used. So it's easy to say
24 we're going to do it at the construction permit stage,
25 but boy, when it comes to the operating -- the OL

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1 stage, this is one area where I'm sure you can expect
2 some very detailed discussion.

3 MR. POTGIETER: Thank you. I appreciate
4 that, and I do agree with you. It has been a
5 challenge so far, and we have put a lot of time and
6 resources and very specialized people onto this. It
7 has been a huge effort over the last year. So you are
8 correct that there is a lot to do as this has never
9 been implemented and there are a lot of questions to
10 be answered.

11 CHAIR MARTIN: This is Bob. Of course,
12 we've been exposed on the ACRS to the MoCA challenge
13 with the LWRs and the progress that has been made, or
14 should I say credits has been made, with monitoring
15 and inspection. And of course, and how the track
16 record in the LWR industry has otherwise allowed
17 considerable improvements in the expectations of risk,
18 or particularly the frequency of failures because of
19 these active programs. You know, besides, of course,
20 this reactor being unique on its own, it would seem to
21 me that the uncertainties associated with the failure
22 probabilities or failure frequencies of equipment that
23 cannot or indirectly be monitored and cannot be
24 inspected would otherwise be higher. Now, how would
25 you otherwise quantify that? I don't know. But have

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1 y'all considered that? And that may not be a question
2 for you all, but maybe Drew or somebody like that more
3 exposed to that, and I don't know. Invite Drew to
4 come up. It's more of a PRA question. He's hiding at
5 the back.

6 MR. NIGH: Yeah. Are we asking about
7 probably model graphite failure rates in PRA?

8 CHAIR MARTIN: Well, just collectively,
9 you know, regarding the -- but yes, we're focused on
10 graphite control assembly. But this question about
11 you don't open up the system, right, for years. And
12 you don't really have the benefit of the inspection
13 and monitoring in the same way, say, other industries
14 have been able to benefit from them. It might
15 translate, I don't know, I'm not the expert, might
16 translate into a greater uncertainty in failure rates.

17 I mean, it's really hard to separate the
18 failure frequency rates that we do assume in PRA from
19 programs that have always existed related to
20 inspection and monitoring. When you can't open up a
21 system or you don't open up a system for years, it
22 seems to me, it's a new component of uncertainty to
23 the failure frequency.

24 MR. NIGH: Yeah, Bob, this is Drew Nigh,
25 senior manager of risk and performance safety

1 analysis, X-energy. From PRA standpoint, we haven't
2 yet identified licensing-based events that
3 structurally failure graphic core assembly. That
4 said, we have additional actions we're taking to
5 reevaluate the possibility in our ongoing PRA and
6 design evolutions. For example, we're doing failure
7 modes and effects analyses. When we determine failure
8 modes, we will translate those to how the failure
9 modes would affect our performance of PRA safety
10 functions. For instance, shifting graphite blocks
11 preventing insertion of a control rod failure -- your
12 ability to insert the control rods.

13 CHAIR MARTIN: Yeah, we're about to talk
14 about, of course, the hot gas well.

15 MR. NIGH: Yeah. What you're alluding to
16 is generally seen as one of the weaknesses of how we
17 apply PRA to advanced reactors when so many of the
18 safety functions are performed by passive components
19 that don't lend themselves well to probabilistic
20 modeling.

21 CHAIR MARTIN: Okay. So you're trying to
22 focus on really failure focus and what could happen.
23 I don't know if that ever elevates something from a
24 beyond design basis to a design basis, or design base
25 to an AOO. There are certainly rules of thumb with

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1 uncertainties and if the uncertainties span into
2 multiple domains, you have to look at them both from
3 an AOL standpoint and a DBA, for instance.

4 MR. NIGH: The way I'd say it is that
5 we're trying to apply nuclear codes and standards and
6 plant programs and traditional engineering practices
7 as much as possible to make events -- extreme events
8 -- that fail passive components officially unlikely
9 that they're in the residual risk region, which is
10 what we see now with light water reactors and in how
11 they model, for example, structures in their PRAs.

12 CHAIR MARTIN: Right. Yeah. I'm not sure
13 that's the right answer that I'm looking for, but I
14 appreciate your comment there. I don't know. You
15 have any thoughts on that, Craig? You've spent more
16 time in that world of the benefits of monitoring and
17 inspection and reliability of components and systems.
18 You see what I'm trying to get at there where -- sorry
19 to put you on the spot.

20 MEMBER HARRINGTON: Yeah, I mean, I think
21 it heavily rests on that degradation analysis, what
22 can go wrong analysis, and what can you do about it to
23 monitor it? Where that's challenging and the whole
24 thing is just a challenging problem.

25 CHAIR MARTIN: Right.

1 MEMBER HARRINGTON: And the extent to
2 which you can anticipate the kinds of things that can
3 go wrong, which we didn't always do well with light
4 water reactors. Things happened that we didn't
5 necessarily expect so. We've got to be a learning
6 organization too as you gain experience.

7 CHAIR MARTIN: Yeah. Like I said, my
8 concern is whether an event that you have determined
9 to be a design basis event say after 20 years that you
10 haven't opened it up that because of more indirect
11 monitoring and in inspection that it ends up really
12 being, well, something happens in a lifetime. It
13 happens, right? And, we learned a lot with the
14 programs that, of course, EPRI led with LWRs, really
15 in how much benefit there is. There really a couple
16 orders of benefit. But, the baseline for that, I
17 mean, I would think still had some element of regular
18 inspection of some sort. You know, the original
19 failure frequencies that were attributed to piping and
20 what have you must have had some benefit of
21 experience. And we're not just assembled, put in
22 operation, and you walk away from it, and wait till
23 something breaks.

24 MR. NIGH: Drew Nigh, risk-informed safety
25 analysis senior manager. One thought on that is NEI

1 904 does drive us to consider uncertainties and lack
2 of operating experience and how we assign requirements
3 to systems and components that might perform redundant
4 functions. So, just to give you one example, if we
5 decided that graphite thermal conductivity over the
6 lifetime was not modeled with sufficient certainty or
7 in a bounding way, that would lead to higher fuel heat
8 up and conduction cool down events. Or we could, as
9 a result, make the helium pressure boundary pressure
10 protection function NSRST to compensate for that
11 uncertainty, and so we'd set a reliability target and
12 implement plant programs on components we can expect
13 and inspect during operation as a way to compensate
14 for that. It's just a theoretical example.

15 CHAIR MARTIN: I like that. You know, as
16 I think about the role of the NSRST, there's a lot of
17 flexibility in dealing with uncertainty. So, okay.

18 MR. NIGH: That's how the process is
19 supposed to work.

20 CHAIR MARTIN: Yeah, yeah. Okay, I like
21 that answer. Thanks.

22 MEMBER PETTI: So this is Dave. To me,
23 the question I'm not worried about the heat removal.
24 The concern I have is the AGL reactor experience with
25 the cracking of graphite. I think it needs to be put

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1 in the proper perspective, and I'm sure X-energy
2 probably agrees. If you were to crack the graphite,
3 let's say, the inner reflector because that's the
4 heaviest dose area and it's because of obviously some
5 sort of tensile stress probably caused the crack.

6 What's the impact? It's a big deal in the
7 AGRs, and I understand in those reactors why they
8 were. But here, what would a crack mean besides that
9 it could propagate? I mean, you're not worried about
10 bypass flow effects. I think you got plenty of margin
11 on fuel temperature in normal operation. What would
12 be the safety concern if you start to see cracks?

13 MS. SPICHER: Do you want to take that,
14 Jerrod?

15 MR. POTGIETER: Sure. Jerrod Potgieter
16 here at Graphite Core Systems, ASME. We have taken a
17 lot of our design basis, I suppose, from this specific
18 operating case from the AGRs where they did find
19 cracks that they did not expect and landed up using a
20 significant amount of modeling seismic testing to
21 eventually redo their safety case to show that they
22 can deal with a significant amount of cracks in
23 different areas and configurations and still maintain
24 the ability to perform their safety functions.

25 That experience did carry over into the

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1 generation of ASME Section III, Division 5 where we
2 are required to demonstrate as part of the code that
3 we have a damage tolerant design and that we can
4 continue to be able to perform our safety functions
5 with the failure of individual core components. We
6 have a damage tolerance assessment methodology that we
7 are implementing in line with the RIM program. It
8 feeds our design, but it also feeds our RIM program to
9 some extent where we do assess what happens if we get
10 cracks in areas where we do not expect it due to
11 things like disparate flaws and manufacturing errors
12 that we could not detect and then show that we can
13 still perform our specific safety functions.

14 As we discussed, cracks don't have a
15 significant impact on our ability to remove heat. So
16 while we have done assessments on this, you would need
17 many cracks in pretty much all of the blocks to
18 eventually add significant thermal resistance.
19 Whereas for our control rod channels major cracks or
20 fracture of components could lead to a situation where
21 we cannot get a certain rod in. We do first of all
22 have a high amount of margin to that. Because we have
23 the, you know -- we set our shutdown margin
24 requirements with failure of one to two rods. Part of
25 the reason we do that is to account for the fact that

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1 if we had a disparate flaw in a component in a channel
2 somewhere and we did have a break in a way we could
3 not expect, which prevented a control rod or an
4 absorber rod from being inserted, we could still shut
5 the reactor down, and we use this in many of our
6 design choices.

7 We design our components with redundant
8 load pathways. So, if we have a connecting feature or
9 you know, an alignment feature such as the dowels or
10 the inner side reflectors, if we have a failure in one
11 of those areas, we always maintain positive alignment.
12 And then lastly, we have designed our components in
13 certain ways, specifically the sleeves, where we have
14 separate components from the sleeves to the rest of
15 the reflectors. The reflectors around them have
16 significantly higher doses and temperature gradients
17 and have much higher loadings on them, much higher
18 stresses, and they interface with the pebbles.
19 Whereas the sleeves have been mechanically decoupled,
20 so we can rely on them to maintain adequate gas flow
21 to cool the control rods down. But they have very low
22 stresses during normal operations; roughly the order
23 of magnitude less than what you see in the inner side
24 reflectors purely due to radiation.

25 We ensure that the components that we want

1 to remain intact during seismic events or other events
2 that structurally challenge the components are not the
3 ones that are being consistently placed in high levels
4 of stress during normal operation. With all of this,
5 we will be doing our damage tolerance assessments,
6 which we didn't place in our LTR but did mention it in
7 our LTR to assess what happens if we have cracks in
8 areas we don't expect in multiple different places,
9 and we'll be doing certain analysis with these cracks
10 or fractures implemented to show that we can still
11 perform our safety functions.

12 MEMBER PETTI: Thank you. I didn't -- if
13 you guys covered this, I lost my internet for like 15
14 minutes earlier today, so thank you.

15 MS. SPICHER: One last comment, I'd like
16 to go back. I think it was Bob who made a comment
17 about the RIM program is new for the super reactor.
18 I would like to say that the NRC and us during the
19 audit had an all-day meeting on this. We talked about
20 it. The NRC, we talked -- the NRC was very good with
21 us with working through this issue with the RIM
22 program, and I believe later on today they're going to
23 talk a little bit more about it. But this was -- like
24 you said, Bob -- this was a topic we talked a lot
25 about -- about how we're going to implement this and,

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1 you know, the rules for it, knowing that the whole
2 process is new. Thanks to the NRC, we had a lot of
3 good conversations about this to figure this one out.

4 CHAIR MARTIN: Thanks for adding that,
5 Terri. Yeah, I mean, we've certainly have heard
6 others talk about the role of the RIM program.

7 MS. SPICHER: Yeah.

8 CHAIR MARTIN: Yours is a little bit more
9 unique than others. They're all unique, but yours is
10 unique in its own way it drives different questions.

11 MS. SPICHER: Okay, next slide, and I
12 think it's going to be Ray's turn for a little bit.
13 We're going to go into the cross-section. Oh, okay,
14 we're not doing that, is it? Okay. Okay, we're going
15 to go into the cross-section. I'm sorry. I'm still
16 on -- okay.

17 We got some questions about the cross
18 vessel and the hot gas stuck. And I would like to
19 introduce Gordon. You want to introduce yourself?
20 He's our expert in this area.

21 MR. BLALOCK: I don't know about expert.
22 Gordon Blalock, design lead for the helium cross-
23 connect.

24 MS. SPICHER: And Venkata, you are on the
25 line. Is that a yes? We'll see if he jumps on if we

1 have any questions. Okay, go ahead Gordon.

2 MR. BLALOCK: Okay. Cross vessel end
3 connections helium leakage from the cross vessel is
4 prevented by a ,seal weld interface between the
5 reactor pressure vessel as well as the steam generator
6 pressure vessel. The seal welds will be appropriately
7 sized to account for various loading conditions. This
8 image's design was taken from our PSAR slides.

9 MEMBER HARRINGTON: So this is Craig.
10 Presumably, it's like a COL there below the bolted
11 connection.

12 MR. BLALOCK: Correct. Down in that V,
13 lower V section.

14 MEMBER HARRINGTON: Yeah. Okay. I guess
15 you're going to have to install bolts and take out
16 bolts and --

17 MR. BLALOCK: Sure. Yeah.

18 MEMBER HARRINGTON: -- work through
19 implementing that seal then. Okay.

20 MR. BLALOCK: Yeah. We're evaluating that
21 and also considering other alternatives.

22 MEMBER HARRINGTON: Okay. Thank you.

23 MR. BLALOCK: Moving on to the hot gas
24 duct design features. The set of components will
25 operate with an internal delta T on the order of 500

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1 degrees from the hot helium shown there in red moving
2 to the right and the cooler helium, roughly at 260,
3 moving back in the annulus area. We're design
4 leveraging technology matured by the German AVR and
5 the Chinese HTR. This is to minimize differential
6 pressure loads across the hot liner wall and to allow
7 free axial extension of the hot liner to reduce
8 thermal stresses in that liner; basically unrestricted
9 and free to expand axially.

10 The hot liner does not provide any
11 structural function. It will be assessed as a
12 metallic core support structure at elevated
13 temperature per that Division 5, subsection H, HG,
14 subpart B. The outer hot gas duct structural liner
15 operates at a lower temperature, roughly the same as
16 the cooler helium 260. We are using a high
17 temperature alloy just to provide significant margin
18 to that component. Yes.

19 CHAIR MARTIN: Ron, I see your hand up.

20 MR. BALLINGER: Yeah, with regard to the
21 800 H, there's another flavor of 800, I think it's
22 called AT or something like that, which is designed to
23 better deal with creep. And I'm just curious, you
24 know, you're doing it in Division 5 here; you're going
25 to have to do a creep analysis on this thing,

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1 especially during off normal conditions. Is that a
2 consideration, or you're just sticking with 800 H?

3 MR. BLALOCK: No. I am not familiar with
4 HT. I will definitely take that back to our material
5 team.

6 MR. BALLINGER: Well, I think it's called
7 AT. I've got to look it up. But it's a slightly
8 higher carbon version of 800. It goes 800, 800 H, and
9 800 and whatever this AT thing is. And it's designed
10 for better creep resistance, and the load limits
11 between the two types are different. They're also
12 pretty darn low at these temperatures.

13 But the question I had was also related to
14 the uncertainty associated with the overall analysis
15 that you're going to have to do with this, because I
16 don't think the allowables are very high for this
17 material at these temperatures.

18 MR. VAN STADEN: Ron, just to confirm, I
19 Googled it. It is 800 AT.

20 MR. BALLINGER: AT, okay. I don't know
21 these acronyms.

22 MR. BLALOCK: What was that again, please?

23 MR. VAN STADEN: AT.

24 MR. BLALOCK: AT?

25 MEMBER PETTI: Martin had his hand up,

1 yeah.

2 MR. VAN STADEN: Yeah. Thanks, Ron. I
3 just wanted to point out it's really important to note
4 that this liner is actually just part of the
5 insulation material. It doesn't take any stress, so
6 the creep shouldn't really affect it because you need
7 a continuous strain to really drive the creep and
8 there's no, I would almost say, no measurable strain
9 that you're placing on this liner other than friction.

10 MR. BALLINGER: I was concerned with off
11 normal conditions, accident type conditions and stuff
12 where you might actually get a load differential
13 pressure across that.

14 MR. VAN STADEN: Yeah. I don't see where
15 you can do that because the differential pressure is
16 taken up by the outer part of that. How can I say
17 that? The structural housing -- what's -

18 MR. BALLINGER: Yeah.

19 MR. VAN STADEN: The gray part. That is
20 the pressure boundary section between the two, and the
21 maximum ΔP over that even is less than 200 kPa.
22 So, your maximum load is not during normal operation.

23 MR. BALLINGER: Yeah -- yeah. I mean,
24 this is sort of looks like NGNP, am I correct Dave?

25 MR. VAN STADEN: Very similar.

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1 MEMBER PETTI: Oh, yeah. This idea has
2 been around a long time, and obviously the Chinese
3 have implemented it, you know? We know you can do
4 this.

5 MR. VAN STADEN: And the Germans did a lot
6 of testing on this.

7 MR. BALLINGER: Yeah.

8 MR. VAN STADEN: To evaluate this at full
9 temperature and pressure. Actually, AVR ran at 950
10 degrees C with this for more than 10 years of its
11 operating life, where we're at 750.

12 MR. BALLINGER: But you're qualifying it
13 800 H at a higher temperature -- code temperature,
14 right?

15 MR. VAN STADEN: Yeah, but I mean, it's
16 not -- I think maybe we're shooting ourselves in the
17 foot by doing that because --

18 MR. BALLINGER: Yeah, I think maybe you
19 are.

20 MR. VAN STADEN: -- this is not a pressure
21 component.

22 MR. BALLINGER: Yeah. I think you are.

23 MR. VAN STADEN: So, it shouldn't really
24 be subject to those same requirements. But it's very
25 important to note there's no pressure causing a strain

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1 on this material. That's actually an insulation
2 liner.

3 MR. BALLINGER: Yeah. Thank you.

4 MS. SPICHER: There was a question also
5 about how we are going to monitor and inspect this
6 component. We just wanted to let you know that we're
7 going to have what we call a RAM program, which is a
8 reliability, availability, and maintainability
9 program. And this program is described in chapter 8
10 of our PSAR.

11 It's basically a RIM light program.
12 That's the easiest way to explain it. We're going to
13 go through all the steps of RIM for the NSRST
14 components. We've committed to that in the PSAR, and
15 again it's just basically a RIM program that we're
16 going to use, and we're going to go through like we go
17 through with all the other safety-related passive
18 components, the process, and identify where the
19 degradation is and how we're going to inspect it and
20 monitor it. And that's basically what this slide is,
21 just to let you know that that's in our chapter 8, and
22 it is described in there.

23 MR. BALLINGER: But it's still consistent
24 with the code, right?

25 MS. SPICHER: It's not to the code.

1 That's why we're calling it RIM light. It's not --
2 this is NSRST component, so it's not totally going to
3 have to comply with the code.

4 MEMBER HARRINGTON: This is Craig. The
5 focus is not so much the safety side of things that it
6 is just economics and operational kinds of
7 efficiencies or maintainability, because I can't
8 really see where there's direct safety implication.
9 It's more just to make sure the plant is economical
10 and maintainable, right?

11 MS. SPICHER: That as well as defense-in-
12 depth. I mean, because it is NSRST component, so we
13 do need that out as well. We do have PSS that are
14 part of that we have to comply with on the NSRST
15 function, safety function, so we do still have that as
16 well.

17 MEMBER HARRINGTON: Okay.

18 MS. SPICHER: It's not NST.

19 MEMBER HARRINGTON: Yeah.

20 MS. SPICHER: Next slide, please. And
21 this, sorry, this is just a slide about a question was
22 asked about our operational envelope of our cross
23 vessel and hot gas dock. This is the information
24 that's in our PSAR about what our design temperatures
25 are and our operating conditions. We're designing

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1 this component to Section 3, Div 5. This component is
2 NSRST. However, we are designing it to the safety-
3 related level. It will need to comply with the three
4 service limits, the A, B, C, and D loading conditions.
5 And again, it's to ensure component structural
6 integrity mainly. Next slide, please. Oh, there's a
7 question.

8 MR. BALLINGER: Oh, wait a minute. I
9 guess the question keeps popping up, why do you have
10 to qualify these materials at a higher temperature
11 than the code? I mean, it's not just the temperature.

12 [REDACTED]

13 MS. SPICHER: Do you remember that? Can
14 you answer that?

15 MR. BLALOCK: I think right now mainly has
16 to do with potential transient conditions.

17 MR. BALLINGER: Okay, so several services

18 --

19 MR. BLALOCK: And stratifications.

20 MR. BALLINGER: Okay. Okay. So, this hot
21 duct temperature or some other temperature could, in
22 principle or in theory, I suppose, get higher, right?

23 MR. BLALOCK: It could. We're evaluating
24 that now.

25 MEMBER PETTI: But it's also fair, this is

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1 Dave, it's also fair, you're using 800 H other places,
2 right?

3 MR. BALLINGER: Yep.

4 MEMBER PETTI: And that may be why they
5 have to do the testing.

6 MR. BALLINGER: Now, I don't know that
7 they're --

8 MEMBER PETTI: Concerned with island of
9 stress.

10 MR. BALLINGER: Yeah, I don't know that
11 they're at those temperatures. But anyway, yeah,
12 you're right.

13 MEMBER PETTI: Inlet to the steam
14 generator? Pretty close I bet.

15 MR. BLALOCK: No, the higher condition is
16 the outlet of the reactor.

17 MR. BALLINGER: Yeah. So, that's the
18 cross-duct temperature, right?

19 MR. BLALOCK: Excuse me?

20 MR. BALLINGER: That's at the cross-duct,
21 right?

22 MR. BLALOCK: Yes, yes. The entrance to
23 the hot gas duct.

24 MR. BALLINGER: Yep, yep.

25 MR. BLALOCK: And we may or may not have

1 to incorporate knockdown factors for wells.

2 MR. BALLINGER: Okay. Thank you.

3 MS. SPICHER: Go ahead, Jessica.

4 MR. BRYANT: This is Ray Bryant, licensing
5 engineer with X-energy. I'll be discussing the
6 evolution of our seismic design categorization
7 approach with support from my structural technical
8 fellow, Brent Tegler. So high-level background, our
9 seismic categorization approach has evolved since Rev
10 0 of the CPA with the original categorization scheme
11 being three categories: Category I, Category II, and
12 Category III.

13 There were some revisions as we were going
14 through the audit process and design process that we
15 wanted to make to this categorization scheme to make
16 it a better fit for the design that we're trying to
17 execute here. The first one being that the original
18 scheme was tethered to the safety classifications from
19 NEI 18-04. Safety-related components had to go into
20 Category I. In order to be in Category II, you had to
21 be NSRST. There's a potential for those to be in
22 Category III, but there is no way for NST components
23 to be in any higher seismic category.

24 What we decided to revise was to group
25 SSEs more in terms of what kind of functions do we

1 expect out of them and we want out of them during a
2 seismic event, rather than just tethering them to the
3 seismic classifications. And that resulted in these
4 four seismic categories that you see here: Category
5 I, II-A, II-B and Category III.

6 Category I is applicable to SSEs that
7 perform an RSF during a safe shutdown event. Category
8 II-A is for SSEs that have a risk significant or
9 safety significant function related to DID. That is,
10 they affect one of the risk metrics that we track in
11 NEI 18-04 or one of the DID risk metrics, or they have
12 some kind of enhanced geometry requirement during a
13 seismic event. So we've rather used the term seismic
14 2 over 1 that an SSE cannot fail in such a way that it
15 affects a safety-related SSE during a safe shutdown
16 earthquake. And that can mean a lot of different
17 things, right? Because things can fail in a lot of
18 different ways.

19 And so what we've divided into is Category
20 II-A is more for SSEs that are dynamically coupled
21 with some of these safety-related SSEs. So an example
22 would be you have the reactor, which is tied into the
23 hot gas duct, and the SGST may have stricter
24 requirements from an analysis standpoint during a
25 seismic event to properly qualify, compared to a

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1 structure that goes around a safety-related SSE that
2 doesn't really interact with it dynamically or is not
3 dynamically coupled to its characteristics. An
4 example of a structure like that would be the inner
5 unit access tunnel, where you have the Ross driving
6 through with a canister of fuel, but it doesn't really
7 dynamically couple to the characteristics of that
8 canister during a seismic event. Something like that
9 in the future could be down categorized into Category
10 II-B.

11 In the graded approach that we've taken,
12 we've decided that wherever there is an RSF being
13 credited to an SSE, it's going to be placed in
14 Category I to begin with. And then in blended
15 systems, where you have a combination of safety-
16 related and non-safety-related systems, those non-
17 safety-related systems will all be placed in the
18 Category II-A, which is the higher one for the time
19 being, until at some point we can determine that
20 they're effectively seismically decoupled from that
21 system. An example of that would be, let's say, you
22 had a safety-related electrical cabinet that was
23 sending a signal. The conduit lines that were
24 attached to it, let's say they were solid, would be
25 category II-A because they have an influence on the

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1 geometry and would be important for the dynamic
2 characteristics. In the future, perhaps, they may be
3 seismically isolated through a flex connection, in
4 which case they can be down-categorized to II-B
5 because at that point, you're just trying to prevent
6 them from falling onto some other component.

7 As our table shows here and then the next
8 table shows that, you know, we decided to go with a
9 higher category at the preliminary stage until we can
10 demonstrate that a lower category for these blended
11 systems is appropriate. We can also just show the
12 next slide with the -- so, yeah, sorry, the previous
13 slide had the structural table. Oh, I have a question
14 from -- is it Annie?

15 MEMBER KAMMERER: Yeah. Hi, this is Annie
16 Kammerer. I have a quick question for you. Thank you
17 for that example. That was actually really useful as
18 a way to clarify it. So when do you anticipate
19 providing information on the final set of
20 categorization, and how do you anticipate that being
21 communicated to the NRC?

22 MR. BRYANT: Right. So we're still, I
23 think, going through the final phases of building
24 design through the end of the year. The specific of
25 details of that, maybe, Brett, I don't know if you can

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1 speak to on maybe when we would have more finalized
2 categories from a design time.

3 MR. THOMAS: Hey, this is Matt Thomas,
4 licensing manager. I think, to answer Annie's
5 question, that final set of categorizations will be
6 provided at the OLA once we have, as Ray was alluding
7 to, the final design complete.

8 MEMBER HARRINGTON: This is Greg. Oh, go
9 ahead. Go ahead, Annie. Finish up.

10 MEMBER KAMMERER: Yeah, we're pushing.
11 We're pushing a lot up off to the OLA. I understand
12 that it's not here at the CP stage, but would that be
13 provided at the early part of discussions with staff,
14 you know, as you move to pre-application or for that
15 portion of it rather than like sort of pushing it
16 towards the end? Because this is obviously going to
17 be have a lot of technical detail associated.

18 MR. THOMAS: This is Matt Thomas again,
19 licensing manager at X-energy. I think it really
20 depends on where the design is at during those pre-
21 application engagements. If it has evolved to that
22 point, then most definitely that can be a point of
23 discussion during pre-app. Otherwise, the information
24 will ultimately be presented in the final SR that's
25 submitted. But I think the approach that we've taken

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1 now at the preliminary stage again is a conservative
2 approach, given that there's analyses, future
3 analyses, future design to be conducted that will
4 support decategorizing SSCs where necessary or where
5 appropriate. But until we have that information,
6 until we have the final design and conduct the final
7 analysis, the categories that you see right now in the
8 PSAR are conservative.

9 MEMBER KAMMERER: Yeah, I concur with
10 that. On the next -- well, I should have let you
11 maybe get to the next slide before asking. So, in
12 terms of the number of potential changes that you
13 intend to justify, is it a handful? Is it a larger
14 number? Do you have a sense of the number of SSCs
15 that you may be wanting to change to a lower category?

16 MR. BRYANT: So I would anticipate a small
17 amount of changes because for this Category II A and
18 II B the biggest change is going to be in the way that
19 we analyze the structures, the level of rigor. And
20 so, in the methodologies used where for this NSRST
21 Category II A, we're mostly going to be using ASE 43
22 analysis methods to hit those performance targets.

23 For Category II B for structures where
24 it's appropriate, like I said, where the goal is more
25 collapse prevention and you're dynamically decoupled

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1 from SSCs within, we can switch to more of an ASE 7
2 commercial approach with a heightened ground motion to
3 ensure we have the same probability of failure, if
4 that makes sense.

5 MEMBER KAMMERER: Yeah. I guess what
6 triggered the question was the example that you gave
7 where it was actually a change to a more flexible
8 attachment. I wasn't sure how many design elements
9 like that might still be up for or you're still
10 evaluating.

11 MR. BRYANT: Right. And -- so -

12 MEMBER KAMMERER: Versus it just being a
13 structural analysis question.

14 MR. BRYANT: Right. And I think part of
15 this also comes down to. So like, within Category II
16 A, you can have a variety of acceptance criteria. So
17 let's just say we -- like the going back to the
18 conduit line example. It's basically it's maintaining
19 a boundary with that component of a certain type. If
20 it's a solid connection, you know, there might be a
21 certain rigidity that needs to be maintained. But
22 then, as the design evolves and we switch to a flex
23 connection, maybe that control gets released, right?
24 So, it's really more what we track and evaluate for
25 than necessarily the design having to change

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1 completely. Okay.

2 Yeah, the previous table had our
3 preliminary categorization for the buildings, and then
4 we added a table to, again, go over some of these
5 blended systems where it's a combination of safety-
6 related and non-safety-related SSCs. And at the
7 preliminary stage, the safety-related SSCs within
8 those systems are designated as Category I to perform
9 their RSF. And then all the other SSCs are Category
10 II A by default until demonstrated that they're
11 sufficiently decoupled from that system to where they
12 can just be in a sort 2 over 1 collapse prevention or
13 interaction prevention role.

14 CHAIR MARTIN: All right. That was your
15 last slide or -- oh, we've got one more topic here.

16 MR. BRYANT: And so again, Ray Bryant with
17 X-energy. I'm going to be discussing the design basis
18 flood hazard. So, per NE 18-04, we have a DBHL flood
19 hazard identified or -- sorry, determined for the
20 site. This flood hazard was determined
21 deterministically from an analysis of surrounding
22 bodies of water, various flooding situations, river,
23 dam rupture, hurricane as well was considered.

24 For the DBHL, you're assuring that your
25 safety-related SSCs can perform their RSFs, and for

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1 the flood, in some cases, the NSRSS SSCs may perform
2 their functions just given the nature of the hazard
3 specifically flood. I'll just go to the next one.
4 When addressing the design basis flood hazard, there's
5 pretty much two main considerations. First, there's
6 the structural consideration of the buildings,
7 ensuring that it's considered in a load and that they
8 can resist the hydrostatic loads on them to prevent
9 collapse. And then there's the actual behavior of the
10 SSCs performing RSFs during a DBHL flood.

11 We can pretty much take on that problem
12 through three different approaches. First, we can
13 make sure the function is available by raising the SSC
14 above the postulated DBHL flood height. We can ensure
15 that they're available by making sure the location is
16 watertight through like a code, such as like ASC 24,
17 which details how to seal off certain areas of
18 buildings and put in procedures to make sure that
19 water does not intrude or qualify the necessary SSC
20 function when it's submerged. And in our case, with
21 our design, we were able to elevate pretty much all of
22 our safety-related SSCs above the flood height, so
23 they don't need to be qualified for submerged
24 behavior. And while water tightening openings could
25 be considered in the future for our safety case, we

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1 feel like at this point we've at least demonstrated
2 that by elevating everything the functions will be
3 available. That is with the exception of the fuel.

4 The fuel at multiple locations in several
5 buildings, including the IUAT, SFISF, and canister
6 processing facility, will be submerged. But in
7 Section 3.9 of the PSAR, we have the XCOR analysis
8 which details why that doesn't create an unsafe
9 condition. So it's basically qualified for submerged
10 behavior.

11 MEMBER KAMMERER: So I'm taking from this
12 that you have no operator actions to prevent ingress?

13 MR. BRYANT: Not detailed at this time,
14 no.

15 MEMBER KAMMERER: Okay, but there may be
16 some --

17 MR. BRYANT: Yeah, to provide additional
18 layers of defense, right? Because if you look at the
19 SFISF, IUAT, the reactor building as a whole, right,
20 they're not really designed for prolonged personnel
21 access anyway, which makes them easy to put
22 administrative controls to not access them or if we
23 anticipate some kind of flooding event from a
24 hurricane, to prepare for that adequately through
25 operator controls and seal off those openings to add

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1 an additional layer of defense for water intrusion.
2 But like I said, as the design has been submitted now,
3 we've ensured that all the safety-related SSCs within
4 RSF are elevated above the flood height sufficiently
5 to perform their function with the exception of the
6 fuel, which has been analyzed for that condition.

7 MEMBER KAMMERER: Thank you.

8 CHAIR MARTIN: Any more questions for X-
9 energy? I think this concludes your morning and open
10 presentation, correct? Right. So, we're only an hour
11 behind. It's far -- I would suggest that we get
12 started with the staff. What do you think? Just go
13 ahead and take a lunch to 12:50? All right. So
14 that's what we'll do then. We will break at this time
15 for lunch, and since it's 11:47, we will return or
16 reconvene at 12:50. Gives everyone an extra three
17 minutes to go over to Dave's Chicken and take care of
18 business.

19 MR. BALLINGER: Bob, when we reconvene
20 that will still be an open session initially?

21 CHAIR MARTIN: It will be, yes. We still
22 have to go through the staff presentations.

23 MR. BALLINGER: Yes. Thank you.

24 (Whereupon, the above-entitled matter went
25 off the record at 11:47 a.m. and resumed at 12:51

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1 p.m.)

2 CHAIR MARTIN: All right, we're back. It
3 is 12:51, and we have swapped out X-energy with the
4 staff.

5 MS. RADEL: Could you try again?

6 CHAIR MARTIN: Sorry. There's always
7 someone. Who's going to start us off? Okay, go
8 ahead, Tracy.

9 MS. RADEL: Tracy Radel, senior nuclear
10 engineer within Office of Advanced Reactors. I'm
11 going to kick us off here. Next slide. We're going
12 to cover the same topics that LME just covered. Next
13 slide. Starting with the inherent reactivity control
14 and transition from safe state to shutdown state.
15 Next slide.

16 So, this is just a slide to kind of
17 demonstrate the reactivity behavior and reactivity
18 feedback that's going on here. And so, we have, you
19 know, an event occur where we lose heat removal,
20 whether that's a partial loss or a full loss of heat
21 removal. Your temperatures are going to increase.
22 Reactivity feedback is going to decrease the power,
23 which is going to decrease the temperature. And then,
24 as the temperatures decrease, you're going to have
25 that reactivity feedback increase in power. And so,

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1 that's why we see that oscillation behavior that LME
2 showed on their slides from their actual analysis.

3 The key part to understand here is that,
4 you know, where it settles out is really going to be
5 when your heat generation is balanced with your heat
6 removal. And so, it's really important that all those
7 different heat removal cases and situations
8 represented in the accident analysis get evaluated
9 and, you know, in order to ensure that the bounding
10 cases are represented in the application. So, next
11 slide.

12 MEMBER HALNON: So Tracy, this is Greg.
13 The question I was having earlier, because it was a
14 double-edged sword, is there any transients that move
15 that temperature decrease first so that there's
16 actually an overpower problem?

17 MS. RADEL: So, I think, you know, the
18 thermal inertia is a big thing within this system
19 that's going to prevent kind of a rapid insertion due
20 to temperature change, but it is part of why, you
21 know, we talked a lot about this in audit, and there
22 are commitments to analyze all those situations.

23 MEMBER HALNON: Okay. So even with those
24 overcooling elements?

25 MS. RADEL: Yes.

1 MEMBER HALNON: Okay, thanks.

2 MEMBER HARRINGTON: And this is Craig.
3 And so, the bounding scenario is tied to fuel, I
4 assume, as opposed to the other -- the vessel or the
5 concrete or anything else?

6 MS. RADEL: I think all of the pieces --
7 the key pieces for ensuring safety, which would
8 include the fuel from a radionuclide release
9 temperature standpoint, the vessel from a vessel
10 integrity standpoint, as well as the concrete from a
11 structural standpoint, would all need to be shown to
12 be acceptable in all cases. And so, you know, LME in
13 the CP stage has analyzed bounding from a loss of heat
14 removal standpoint where you -- you know, complete
15 loss of any active cooling and RCCS -- passive RCCS
16 being limiting. And in their preliminary analysis,
17 they show that to be bounding. But, you know, we will
18 look at all those cases and expect to see all those
19 cases at the OL to confirm that.

20 MEMBER HARRINGTON: Okay. So, it could be
21 multiple bounding?

22 MS. RADEL: Right. What's bounding for
23 fuel may not be bounding for vessel and --

24 MEMBER HARRINGTON: Okay.

25 MEMBER PALMTAG: Yeah, this is Scott. We

1 never really talked about the big differences between
2 the graphite reactors and the LWRs, but one thing,
3 Dave brings this up, but -- Dave brought it up
4 earlier, too, is there's just a lot of thermal
5 inertia. This thing is not going to -- LWR
6 temperatures can change relatively rapidly in a
7 graphite cooled reactor. You know, you add reactivity
8 feedback or something, things are going to heat up
9 really slowly and cool down really slowly. I think
10 that's it's just going to kind of --

11 MEMBER HALNON: Scott, what's a typical
12 over -- I mean, we could see temperatures drop really
13 quickly.

14 MEMBER PALMTAG: Yeah, we saw this on the
15 transient -- we haven't seen the detailed transients,
16 but there's hours. You know, these temperatures kind
17 of go up and down.

18 MEMBER HALNON: Okay.

19 MEMBER PALMTAG: But we'd have to look at
20 the individual transients, but it's just a much slower
21 reaction than you're used to in an LWR.

22 MEMBER HARRINGTON: And my question had
23 more to do with the bullet. It just is -- like
24 there's one bounding condition and thinking maybe
25 there could be multiple bounding instances. So, that

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1 was really --

2 MEMBER PETTI: This is Dave.

3 MEMBER HARRINGTON: -- the question.

4 MEMBER PETTI: I think, yeah, I mean,
5 you're right, Craig. That's why I keep pushing. Some
6 assumptions make the fuel better or worse but also
7 impact the vessel or the concrete. So, you've got to
8 look at that space, you know, quite a bit. I would
9 also say, though, that power density plays a big role,
10 too. You can get the temperatures up if you could --
11 if you were in a graphite reactor at LWR power
12 densities, it's going to move, you know. Fort St.
13 Vrain was a much higher power density machine than
14 what we're talking about here. Temperatures would get
15 to 3,000 degrees in Fort St. Vrain, worst case events,
16 so.

17 MS. RADEL: Next slide. I think we've
18 covered a little bit of this already, but as they
19 showed in their analysis, they're seeing this damped
20 reactivity oscillation, power oscillation, which will,
21 you know, reach an equilibrium. And so, they have to
22 run that full set of cases to demonstrate that for the
23 OL. And that's a key part of being able to credit the
24 inherent reactivity feedback as a shutdown mechanism
25 or as a reactivity -- negative reactivity insertion

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1 mechanism there.

2 And as Craig pointed out, you know, that
3 last bullet is really referring to bounding for the
4 fuel. You know, the -- confirming whether that is
5 also bounding for the vessel is something we will do
6 at the OL stage, so. Next slide.

7 MEMBER PETTI: Tracy, this is Dave. Just
8 a question when you're saying a full range. So, this
9 could also be scenarios in which it's not RCCS but the
10 shutdown cooling system operating. There's much
11 greater capacity, I would think, potentially in the
12 shutdown system. And so, where the reactor ends up,
13 you're thinking all the different systems, right, to
14 remove heat?

15 MS. RADEL: Right. Because with the -- if
16 there is, you know, partial active cooling available
17 or you're cooling through Triple S, you are going to
18 settle out at a higher power, you know --

19 MEMBER PETTI: Right.

20 MS. RADEL: -- when you get to
21 equilibrium, you know, because of the higher
22 reactivity at colder temperatures. So, you need to
23 look at that full range to ensure that the actual
24 consequence that you're, you know, providing is
25 bounding, so.

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1 MEMBER PETTI: Thanks.

2 MS. RADEL: Next slide.

3 CHAIR MARTIN: Tracy, just to clarify that
4 last bullet, so boundary scenario in this case is the
5 peak temperature?

6 MS. RADEL: For this bullet, yeah.

7 CHAIR MARTIN: Yeah. Okay.

8 MS. RADEL: We're really speaking to fuel
9 temperatures there. You know, their PSAR analysis was
10 done with the air-cooled RCCS, and so, you know,
11 water-cooled designs leads to lower temperatures. And
12 all those analyses were not available at the CP stage,
13 but we had done confirmatory analysis in, you know,
14 MELCOR and looked at those temperatures, and so we got
15 enough confidence that those analyses will come out
16 okay at the OL, but we'll need to see that full range.

17 CHAIR MARTIN: Are there any scenarios
18 that concern you that would have a higher steady state
19 power because of the higher cooling load?

20 MS. RADEL: I do believe, you know, based
21 on what we saw in the discussions in audit, that
22 that's not going to be the bounding from a
23 radionuclide release perspective, you know, bounding
24 case overall, but the use of this inherent reactivity
25 feedback, if you don't have any rods go in, you know,

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1 I do think you have to cover that full scope to
2 confirm.

3 CHAIR MARTIN: Sure. Yeah, it seems like
4 steady stated 1 megawatt or steady stated 250
5 kilowatts would both have the same basic consequence.
6 Okay, thanks.

7 MS. RADEL: Yep. So, from the control rod
8 perspective, they are safety related for long-term
9 subcriticality. There's two sets of rods. They each
10 have nine rods, and in the analysis they assume that
11 one rod out of the nine does not go in. The
12 reactivity control system that's used for normal
13 reactivity and power control during operation. And
14 then the reserve shutdown system is there to, also,
15 insert if a trip signal -- or trip level is reached,
16 and they will both insert both from the investment
17 protection system, as well as the reactor protection
18 system. So, there's some diversity there with the
19 actuation systems.

20 CHAIR MARTIN: But aren't they still
21 vulnerable to the common cause failure? The design's
22 basically the same. Are they using the same trip
23 signals or same part --

24 MS. RADEL: They have two different, you
25 know, control systems that can initiate the trip.

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1 They're -- you know, the same set of sensors is
2 providing information to both of those systems, but it
3 is a two out of four logic. So, they do have the four
4 different sensors on each of the trip inputs. So, we
5 see, you know, some redundancy there and diversity in
6 portions of it. But you're correct, the rod designs
7 are essentially the same. And so, we did have a lot
8 of discussion in audit on that kind of common cause
9 failure potential from the rod design.

10 They are performing integrated tests of
11 the graphite stack up and the rod -- insert, you know
12 rods and that is discussed in -- I'll have to find the
13 PSAR section I believe on the RCCS. And so, you know,
14 we did get that confidence that they have both
15 analysis and testing that they're going to be doing to
16 demonstrate that those will go in. And then, they do
17 have scenarios where the rods don't go in, and they've
18 evaluated that from an, you know, inherent reactivity
19 feedback perspective.

20 CHAIR MARTIN: But they're not. I mean,
21 you meant -- you used the word diversity, but they're
22 not really claiming credit in that -- with the
23 diversity in the --

24 MS. RADEL: Not in the rod design.

25 CHAIR MARTIN: Yeah.

1 MS. RADEL: Yep. And I know there were
2 some questions earlier on the, kind of, two
3 independent means. I did want to point to, you know,
4 in the July engagement, we had kind of mapped over the
5 different pieces of PDC 26 and 11 into their PDC 26
6 and 11 and kind of showed where those show up in
7 there, and they are meeting those fully. I think one
8 of the key aspects is that, you know, it's not that
9 both of those need to maintain the long-term shutdown.
10 You know, when we look at those PDCs that, you know,
11 you can have that strong reactivity feedback and
12 ensuring you don't exceed SRTLs, you know, from both,
13 right? But that maintaining long-term shutdown piece
14 maps just to the control rod PDC for them, so.

15 CHAIR MARTIN: Right. You know, and of
16 course, one argument they make is of course -- you
17 know, I expect this from operations continue for 20
18 years or whatever before they otherwise shut down to
19 do their mid-life inspections. Practically speaking,
20 I mean, if you look at, you know, the history of LWRs
21 particularly, brought on a new technology, you know,
22 60 years ago. And there were a lot of problems that
23 they did shut down right away. You know, if anything,
24 they most likely are going to shut down very early in
25 their operation because something goes wrong. But

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1 that aside, I mean, there are -- you know, we talk
2 about AOOs as being events that happen within the
3 lifetime, basically 40 years of a plant, you know?

4 Some set of those you might expect in the
5 first half of its life, so the need to go all the way
6 down, you know, well before a planned outage like that
7 certainly seems to be there. I mean, to what extent
8 did you, you know, consider these events, again, AOOs
9 in particular, that might otherwise require some
10 opening up and, you know, tweaking of -- because I
11 remember how tough it is to even get inside. So, you
12 know, while maybe a lot of those events are not
13 serious safety concerns, but, you know, if you've had
14 to open things up if there's, say, misalignments or
15 what have you that otherwise, you know, could
16 contribute to this situation, you might want to have
17 another way, another diverse way, at least.

18 MS. RADEL: Yeah, and if you go to the
19 next slide, so, in talking about those events where
20 you do have a failure to trip, you know, they do have
21 these events captured within their analysis, and, you
22 know, all of their DBAs were run with, I'm assuming
23 rod insertion there in the short term. And so, they
24 got some preliminary analysis in the CP on that and
25 then, we talked about this, you know, capability to

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1 remove the fuel as kind of a additional non-safety
2 related way that you could, you know, reduce
3 reactivity if you were to determine that the rods
4 didn't insert.

5 And so, I know there was some discussion
6 on this earlier, and I would point to Sections 3.9 and
7 3.10 in the PSAR and the SE. Those have the
8 criticality, as well as the thermal analysis for the
9 spent fuel storage. And so, they discuss, you know,
10 maximum temperatures that'll be reached in the SF/ISF.
11 So, we did look at that and evaluate that as another
12 way, you know, that could be used if they did have to
13 shut down and cool down, even though they don't intend
14 to, right?

15 CHAIR MARTIN: Sure. Well, and as was
16 acknowledged, they really haven't presented that as a
17 diverse shutdown mechanism.

18 MS. RADEL: Correct. Yeah.

19 CHAIR MARTIN: At least you're saying that
20 this was something you discussed and maybe if you
21 pursued it in the OL, it could very well indeed be the
22 claim argument and eventually evidence to otherwise
23 support, you know, a traditional compliance with PDC
24 26.

25 MS. RADEL: I think, you know, our

1 position is that they're complying with the PDCs
2 through their two independent means now. Having that
3 additional mechanism does give, kind of, additional
4 assurance beyond meeting the requirements, right? We
5 don't want it to be that there's nothing kind of
6 beyond that. So, you know, it's a piece of it, but we
7 don't necessarily expect them to change their position
8 on PDC 26 and 11 going into the OL.

9 CHAIR MARTIN: You know, we talk about
10 independence. Sometimes we -- I think, want to look
11 at each PDC as being independent themselves. And when
12 they have PDC 11, the solution to that is one thing,
13 and then PDC 26, the solution is also that same thing.
14 It's not the -- PDCs themselves should almost be
15 independent. But again, there's no requirement for
16 that.

17 (Simultaneous speaking.)

18 MS. RADEL: And that -- well, I think I
19 just want to be clear. They also do have it -- so,
20 their PDC 26 is their rods, and their PDC 11 is their
21 reactivity insertion. In the Reg Guide and the GDCs
22 that, you know, PDC 26 is both -- you know, like two
23 sets of rods essentially. So, they've kind of
24 remapped it and again, I would point to those slides
25 where we kind of did the mapping with all those colors

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1 to show kind of where those pieces ended up. But we
2 still, you know, saw those as being met, so.

3 CHAIR MARTIN: Okay. Dave, go ahead. I'm
4 sorry to delay you.

5 MEMBER PETTI: No, you were talking about,
6 you know, how difficult it is to get into the reactor
7 once it's going. I should just give you guys a data
8 point. The pebble bed in China has been operating now
9 for a while. They've had some issues with the steam
10 isolation valve, so that's something that we should
11 all keep our eyes on. And if you know that the fuel
12 free pebbles broke up, they weren't manufactured
13 properly, apparently. But the reactor never scrammed,
14 you know. It was still running, sometimes rods in to
15 keep power down while they were doing stuff. But I
16 was amazed at how much they could do, you know, and
17 deal with issues and still stay at power, the machine.
18 It's interesting. So, just a point.

19 CHAIR MARTIN: So Dave, would there be a
20 unique challenge given, I mean, obviously the Chinese
21 reactor, it's a lower temperature -- or not lower
22 temperature, but lower power.

23 MEMBER PETTI: No.

24 CHAIR MARTIN: Lower power

25 MEMBER PETTI: No, higher power.

1 CHAIR MARTIN: Is it higher power than
2 this one?

3 MEMBER PETTI: Oh, yeah, yeah.

4 CHAIR MARTIN: Okay, never mind.

5 MEMBER PETTI: Yeah.

6 CHAIR MARTIN: So, experience does
7 contribute to the story here.

8 MEMBER PETTI: Yeah.

9 MEMBER HARRINGTON: So, this is Craig.
10 The first bullet here, coming from a PWR background is
11 just really weird. Rods don't go in, so you cut off
12 your heat removal.

13 MS. RADEL: Yeah, and this was --

14 MEMBER HARRINGTON: Very strange.

15 MS. RADEL: This was one of the pieces we
16 really like right at the start of the review we're
17 needing to dig into more here, is this kind of balance
18 that you have to have between heat removal and your
19 inherent reactivity feedback, which is, you know,
20 control of heat generation. So, you end up with these
21 two pieces that seem like they're kind of on different
22 sides and kind of have different actions that you
23 would take based on these two pieces. But, you know,
24 in the focused audits that we had with LME, they were
25 able to kind of walk us through, you know, having

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1 looked at this range of cases and still showing that
2 it's safe. And so, you know, that full analysis will
3 be provided at the OL, but preliminary analysis, we
4 saw enough within audit and kind of understanding with
5 the thermal inertia and different pieces that saw how,
6 you know, that can demonstrate it.

7 But yes, there is this function to trip
8 the circulators if you determine that the rods did not
9 insert, keep that temperature high so that when you do
10 settle out in that heat generation, heat removal
11 balance that you know you're at a really low power
12 level. I think that was helpful to understand. One
13 thing with that is at the OL, we'll be looking at how
14 you trip set points for that whether you can return
15 the circulators. So, you will then have to know
16 whether or not you've gotten rods in order to kind of
17 return the circulator function or have demonstrated
18 that that is also safe, even if rods didn't insert.

19 So, there's some pieces to demonstrate
20 there, and I think that's, you know, one of the key
21 things on crediting inherent reactivity feedback that
22 there's a lot more analysis that needs to be done to
23 show that it's not a simple, straightforward thing of,
24 you know, inherent reactivity feedback. It can always
25 be demonstrated to be a shutdown mechanism. But, you

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1 know, they've -- they're doing the analysis to fully
2 demonstrate that by the OL.

3 MEMBER PALMTAG: And Tracy, this is Scott.
4 I just had a more general question. I'm not really
5 sure where this fits, so I'll ask it now.
6 Traditionally I'm a computational guy, and people
7 never trust the computational models, and now we're
8 talking about this first of a kind -- it's not quite
9 first of a kind, but a first of a kind reactor, and
10 everything is kind of hinged on these models that look
11 fairly simplistic, at least at the CP stage. We're
12 making a lot of decisions, you know, that if
13 temperature goes up, we're going to come back down to
14 the steady state. We can understand the steady state.

15 Is there enough uncertainty built into the
16 models? How well do we know that where it comes -- I
17 mean, that's tricky because you have to balance all
18 the different reactivity components. You have
19 conduction, all kinds of things going on. How
20 confident are they that they're going to be able to
21 come down to a certain level, or is there still a lot
22 of uncertainty in there?

23 MS. RADEL: Yeah, that's a great question,
24 and having spent almost a year trying to establish
25 uncertainty bands on reactivity coefficients at one

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1 point in my career, it is challenging even just the
2 uncertainty on the reactivity coefficients because the
3 majority of critical experiments and benchmark
4 experiments are done without changing temperature.
5 And so, you know, do you have enough cases to define
6 that uncertainty on even your coefficients? And then
7 you have to include uncertainty on the thermal
8 parameters and, you know, other pieces that factor
9 into those analyses.

10 We talked quite a bit about it in audit
11 space and, you know, looked at their validation plans
12 and whether, you know, they seem to have enough
13 experiments in there to get to the right uncertainty
14 treatment and, you know, looked and had reasonable
15 confidence that they had the cases there to be able to
16 do that. But, you know, that full uncertainty
17 treatment won't come until the OL, so.

18 MEMBER PALMTAG: Yeah. I think another
19 piece I'm a little -- have some questions about is the
20 state of the core. A lot of this depends on, you
21 know, when you go up to the high temperatures if you
22 can go subcritical, it's going to be from the decay
23 heat. Fresh core is not going to have the large
24 amount of decay heat in there. You're going to have
25 the startup pebbles. You're going to have the low

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1 enriched fuel. You're going to have the high enriched
2 fuel. I see a lot of uncertainty in my mind. There's
3 a lot of uncertainty going in there, and -- but I see
4 these real simple calculations like, oh yeah, we're
5 going to come back down to the safe state. I just
6 want to make sure -- I mean, I understand that this CP
7 and all this has to come out in the operating license,
8 but there's going to have to be a lot of work and a
9 lot of validation to show that this actually works.

10 MS. RADEL: Yes. Yeah, and you're asking
11 the same questions that we asked in audit there, and
12 we did see initial calculations of the transition from
13 the non-field core to field core on, you know,
14 preliminary reactivity coefficients, you know,
15 throughout that getting to steady state core because
16 you have to make sure that that behavior is safe at
17 all points, you know, within that process of getting
18 to steady state, not just at steady state. And so, we
19 looked at the preliminary reactivity coefficients and
20 ensured that they were, you know, comparable or more
21 conservative or stronger and that gave us enough at
22 the CP stage here. But to your point, they're going
23 to need to have done that analysis throughout for the
24 OL as well.

25 MEMBER PALMTAG: Yeah. The other piece of

1 this is not the reactivity, but it's also the heat
2 conduction.

3 MS. RADEL: Yeah.

4 MEMBER PALMTAG: I mean, there's a lot of
5 heat conduction to the -- I mean, we saw a graph
6 earlier. You have the heat conduction, you have the
7 radiation, you have the convection, you know, through
8 the pebble bed, through the gaps. I mean, this is a
9 difficult question, and I -- there needs to be a lot
10 more validation to actually make sure they can
11 calculate -- these temperatures are correct, and you
12 can easily be off hundreds of degrees on these types
13 of calculations, if not more so.

14 MEMBER PETTI: Scott, let me -- I just
15 disagree a lot with what you said.

16 MEMBER PALMTAG: I thought you would.

17 MEMBER PETTI: That's because I've lived
18 it. I lived this for half my career.

19 MEMBER PALMTAG: But you never built a
20 reactor. You never had to measure data. I mean, all
21 this is theoretical.

22 MEMBER PETTI: No, no, no. Scott, let me
23 -- no, let me finish. There has -- there's data,
24 okay? ABR did reactivity events. You know, showed
25 this decrease in the temperature coefficient. HTTR

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1 did it in Japan. The Chinese have done it. So, there
2 are. There's an international benchmark done through
3 the IAEA, completely different codes. So, you --
4 those should give some confidence. I'm not arguing
5 about, you know, how you get the details and the
6 uncertainty but different codes. MELCOR, look at what
7 MELCOR did compared to what their calculations did.
8 There's a lot that has been done that can give
9 confidence that it's safe in a --

10 MEMBER PALMTAG: Yeah.

11 MEMBER PETTI: -- generic sense. Not --

12 MEMBER PALMTAG: No, Dave, I agree with
13 that. I agree with the physics thing. I guess my
14 more concern is where's this reactivity balance? I
15 mean, you can be off plus or minus hundreds of
16 degrees. I mean, 100 degrees. And likewise, the
17 conduction. I agree with the physics. I agree with
18 the safe. I'm just kind of -- we're throwing these
19 numbers out, and where that final point is is going to
20 matter. Are you at 10 watts? Are you at a megawatt?
21 I mean, or higher? If it's going to --

22 MEMBER PETTI: Yeah. And if you look at

23 --

24 MEMBER PALMTAG: These are the questions
25 I'm concerned about.

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1 MEMBER PETTI: If you look at the IAEA
2 benchmark, you'll find many codes miss --

3 MEMBER PALMTAG: Yeah.

4 MEMBER PETTI: -- exactly what you said
5 because they don't have the, you know, the modeling
6 right.

7 MEMBER PALMTAG: Yeah. No, I'm not
8 arguing with the physics.

9 MEMBER PETTI: But there's a lot done on
10 that.

11 MEMBER PALMTAG: I agree with you. It's
12 a advanced reactor --

13 MEMBER PETTI: Yeah.

14 MEMBER PALMTAG: Safer reactor. I like
15 all that. I'm just -- there's a lot of details to be
16 worked out.

17 MEMBER PETTI: I agree. The validation
18 mountain is steep. I do agree with you on that. But
19 the experimental work that's been done should count
20 for something when you stack it all up.

21 MS. RADEL: I think, just real quick, I
22 think too, on the margin, it matters what parameter
23 you're looking at. If it's not impacting consequence
24 significantly, if there is a different temperature,
25 and there's larger uncertainty there. And so, it's

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1 depending on which piece you're looking at, but -

2 MEMBER PETTI: Right. And what you're
3 saying is safety margin can offset how accurate you
4 need to be.

5 MEMBER PALMTAG: Right. Exactly.

6 MEMBER PETTI: So, yes. No. I completely
7 agree, so.

8 MEMBER PALMTAG: Really.

9 MR. SAWANT: I just wanted to add a couple
10 of things to this discussion. Now, what you raised as
11 a point, like the physics that is happening in
12 reactor, so many different phenomena with
13 uncertainties, and what's the final uncertainty in
14 fear of merit. So, one expectation is that, and
15 that's what they have committed in their topical
16 reports for their evaluation models, which are based
17 on GOTHIC, PHONIX, and VSAW in Neutronics code that
18 they are developing this model following Reg Guide
19 1.203, which is MDAP process, evaluation model
20 development and assessment process. Which, if it is
21 followed, you know, closely, it would account for gaps
22 in code predictability that shows up during their
23 validation work.

24 As a part of their applicability
25 evaluation, we expect them to address those gaps as a

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1 part of final methodology. The last step in that MDAP
2 process is uncertainty evaluation, which should
3 account -- where they are expected to account for
4 uncertainty in prediction of experimental data, both
5 separate effect data as well as integral effect data.
6 So, that commitment to follow that REG Guide is one of
7 the very important elements in our review. Feeling
8 comfortable at this stage that by the time we have OL
9 application, we will see complete picture if they
10 follow the process closely.

11 MEMBER PALMTAG: Yeah. That's a very good
12 point. Thank you. So, the next step on this, right,
13 you have your uncertainties, and it all comes back to
14 the functional containment and the fuel qualification.
15 Same questions. I won't go into the fuel
16 qualification, but there's the same types of questions
17 on the fuel qualification. In the end, you have to
18 show that your reactor doesn't hit these temperatures
19 from the fuel qualification. So, we can agree on the
20 physics and the which way things move and kind of
21 generally, but in the end you got to make sure your
22 temperatures are within your range. I just want to
23 point out, I think there's a lot of work to be done
24 between now and the OL, which is acceptable.

25 MS. RADEL: Okay. And next, we're going

1 to transition to heat removal and Santosh.

2 MR. BHATT: Hi, this is Santosh Bhatt.
3 I'm a senior nuclear engineer in OAR. SO, I just
4 wanted to give an overview of the heat removal
5 systems. We saw this slide earlier in the previous
6 meeting as well. I just wanted to give overview of
7 they start with 40 initiators, and then the PSAR goes
8 into -- they kind of combine into 16 transient types
9 which lead to there were 289 non-DBA LDEs that were
10 analyzed for different frequencies. And then, you
11 know, from those 289 LDEs, they selected certain AOO,
12 certain DBs, certain BDBs for detailed analysis that
13 was presented for consequence purposes. They were
14 grouped together, you know, based on what was more
15 representative. So, they kind of boiled down to 10,
16 12 events from each bucket there to do consequence
17 analysis.

18 And from there, DBEs kind of mapped into
19 DBAs, where only safety-related systems were credited.
20 There were some AOOs and BDBs, which the 5th and the
21 95th percentile for LME, you know, falls into that DBE
22 region, and that was mapped into a DBA as a more
23 deterministic analysis. So, this was just an overview
24 of how their whole 289 non-DB LBEs and different
25 initiators kind of fell into place. Next slide,

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1 please.

2 So, what we're looking at is what's the
3 heat removal for the LBEs versus what was used in the
4 consequence analysis. All the AO -- when you look at
5 that slide, you can see a lot of the events end up in
6 active cooling, whether it's through main feed water
7 pumps or triple S cooling. I believe the first bullet
8 there should say all AOOs end in active cooling
9 because there's two AOOs that end in active RCCS
10 cooling. I believe it was one of the AOOs or the
11 steam generator tube leak, and one was single module
12 loss of primary flow. But most of those end up in
13 main feed water pumps or triple S cooling it. And
14 then for DBEs and BDBEs, you know, a lot of those end
15 in main feed water cooling or the SSS triple S
16 cooling. And then for other events, active RCC was
17 assigned.

18 Now, for the consequence analysis,
19 anything that ended up in active RCCS cooling was
20 assigned P-LOF C or D-LOF C long-term consequence
21 resolve. And since the P-LOF C and D-LOF C long-term
22 analysis were using passive RCCS, they are assigned a
23 higher dose consequence. So this, we're looking at a
24 whole set of events where the end states and what
25 cooling was applied. There were a few events that,

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1 you know, ended up in no active cooling, so either
2 were assigned. They had passive RCCS cooling or if
3 there's degraded RCCS cooling, it was assigned a
4 seismic DBA dose at this point to be analyzed at the
5 OAR application stage. Next slide, please. Just
6 wanted to --

7 MEMBER ROBERTS: Santosh, could you go
8 back to the previous slide? When I read this slide,
9 and I listened to you carefully, I'm still not sure I
10 understand what higher dose consequence means in that
11 last sub-bullet. Because the implication is having
12 active cooling is bad. I'm just trying to understand.
13 I don't think that's the message. I think what you're
14 saying is, higher than they would otherwise have had.

15 MR. BHATT: Yeah.

16 MEMBER ROBERTS: Not higher than, you
17 know, to theirs without active cooling.

18 MR. BHATT: Yeah. So, higher than
19 abounding dose consequence by using passive RCCS. So,
20 the event ends in active RCCS, but when they ran the
21 consequence analysis. For example, if there's an
22 event, DBE that has a green, which is active RCCS that
23 for the consequence analysis was assigned a passive
24 RCCS cooling, so would lead to a higher dose
25 consequence that would be bounding.

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1 MEMBER ROBERTS: Right. So, the dose
2 categories are considerably high for any event that
3 had active cooling. Not that active cooling makes
4 things worse. Okay, thank you.

5 MR. BHATT: Yep. So, this one basically,
6 you know, their final cooling states, the first three
7 boxes in the first row there: feed water pumps, SSS
8 cooling and active RCCS. The descriptions for the
9 first box are taken from what the present into PCR,
10 you know, ends up in either feed water pump cooling it
11 or successful SSS cooling or the active RCCS cooling.
12 Now, the forced feed water cooling is not shared
13 within modules. It's a non-safety related component.
14 Triple S is NSRST. It is forced convective cooling.
15 It is shared where it has sequential cycling between
16 modules for about first three days, and after that, it
17 is capable of cooling all four units at the same time.
18 It is NSRST.

19 Then we have the active RCCS cooling,
20 which has active heat removal from RPV using pumps and
21 heat exchangers. It is shared but has decay heat
22 removal capacity for all four modules. This one is
23 NSRST. And then finally, there's passive RCCS
24 cooling, and that basically is a passive boil-off
25 mode, safety related at 72-hour coping time and is not

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1 shared. Each individual unit has it. And when you
2 look at, you know, the event progressions, you have
3 the NSC feed water pump schooling, and some events
4 have the failure of those leading to triple S cooling.
5 Whereas the triple S cooling is not available. You
6 end up in active RCCS cooling, and as we discussed in
7 the previous slide, events that end up in active RCCS
8 cooling for the consequence analysis were assigned
9 passive RCCS cooling, which is safety related.

10 SO, this kind of gives the picture of
11 combining with the previous slide where the events
12 start out, where they end up, progression of different
13 events, and how they are cooled, and also what
14 consequence analysis applied to those.

15 CHAIR MARTIN: This is Bob. As
16 clarification, so my understanding, the NSRST features
17 are not credited in the evaluation in the
18 determination of LBES.

19 MS. RADEL: The NSRST would not be
20 credited for the DBA analysis.

21 CHAIR MARTIN: Yeah.

22 MS. RADEL: So ,for any of the non-DBA
23 analysis, the NSRST and NST, you know --

24 CHAIR MARTIN: Sure.

25 MS. RADEL: -- are assumed to function

1 unless they've failed during the event.

2 CHAIR MARTIN: Right.

3 MR. BHATT: Okay.

4 CHAIR MARTIN: Not for the DBAs. So --

5 MR. BHATT: Just for the DBAs, it's only
6 safety related.

7 CHAIR MARTIN: Right.

8 MR. BHATT: That's all I have. Any
9 questions? Thank you.

10 MR. SAWANT: Okay. My name is Pravin
11 Sawant, Senior Nuclear Engineer Office of Advanced
12 Reactor. I will present our review of RCCS. RCCS is
13 obviously established that it's safety significant
14 system. It has two parts of SEO RCCS, which is safety
15 related, and it's called standpipe functional area.

16 I think there is some repetition now in
17 this presentation because we already saw LME presented
18 most of the design for us here. So, I will go through
19 these slides quickly, first three slides. So this
20 passive RCCS removes decay heat from reactor core and
21 cavity through conduction, radiation, convection to
22 the series of standpipes that surrounds the reactor
23 vessel. The standpipes are filled with water, which
24 boils off to remove the heat passively. It is
25 designed to transfer the sufficient heat during DBIs

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1 and DBAs so that fuel and release limits are not
2 exceeded, as well as to make sure that RPU temperature
3 stays below the design temperature.

4 While active RCCS is classified as NSRST
5 system called process functional area, PFA, it
6 operates with the SFA to remove the heat using pumps
7 and air-cooled heat exchangers. And design aligns
8 with PDC RFDC 34 and PD CDC 34, which are passive and
9 active residual heat removal PDCs. Next slide.

10 This slide just summarizes key design
11 features of the SIPP-related portions of the RCCS.
12 Again, like, there are two independent trains of SFA
13 for each module. Each train includes 25 standpipes,
14 with downcomer and riser sections. These are cross
15 diameter standpipes. On both ends of the standpipes,
16 there are headers, which are toroidal shape headers,
17 and again, in closed section, we will see the
18 schematic that will give better idea about the design.

19 For each train of the SFA, there are two
20 boil-off tanks. These tanks are located above the
21 downcomer headers and connected to the downcomer
22 header. And both the boil-off tanks as well as the
23 riser headers are vented to the atmosphere via
24 gooseneck vents that penetrates through the top of
25 this sealed structure. And all of these SFA

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1 components, they are located inside this shield
2 structure. And as presented by LME, the total
3 inventory in all these four tanks, both the riser
4 headers, as well as riser standpipes that are above
5 the elevation of RPV head, is designed for 72 hours of
6 passive cooling. There are four different sources of
7 external water for defense-in-depth beyond 72 hours of
8 cooling.

9 Again, SFA is a passive system. Loss of
10 active cooling would automatically trigger the natural
11 circulation and boil up of water inside standpipes, so
12 it doesn't require power or operator action to
13 activate.

14 MEMBER HALNON: So, this is Greg. You
15 looked at -- did you assess the weight of the pipes
16 and the down supports underneath and the intermediate
17 supports to make sure there's not a lot of wobbling
18 around? I don't know how long these pipes are. Are
19 they --

20 MR. SAWANT: Right now, the PSAR provides
21 commitments to design the supports to account for
22 those kind of loads, including, I think, loads due to
23 temperature gradient causing the things like bowing of
24 these standpipes. So, our structural side of the
25 review looked at like the adequacy of the proposed

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1 course that they would follow to design these
2 structures.

3 MEMBER HALNON: Okay. And there's no high
4 energy around them at all? I don't -

5 MR. SAWANT: There are, as we see in next
6 few slides, there are some thermal hydraulic phenomena
7 that we were concerned --

8 MEMBER HALNON: Okay.

9 MR. SAWANT: -- such as instabilities or
10 boiling that could induce additional mechanical
11 stresses. And we have again commitment in PSAR to
12 account for those stresses when they design these
13 supports. So --

14 MEMBER HALNON: Okay, good.

15 MR. SAWANT: We'll talk about that.

16 MEMBER HALNON: Thanks.

17 MR. SAWANT: Yes. So, 50 14-inch
18 standpipes. I think height is in meters. And then,
19 on top of that, these two big toroidal headers. It's
20 a large structure supported by RXST. That is a
21 reactor support structure.

22 MEMBER HALNON: Thank you. They're the
23 whole height of the whole structure. They're very
24 tall.

25 MR. SAWANT: Yes, above the RPV. Because

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1 the 72 hours of inventory is all resided above the RPV
2 head elevation. Yeah.

3 CHAIR MARTIN: This is Bob. As mentioned
4 by Tracy a moment ago, the RCCS role in the analyses
5 in the original CPA were air-cooled.

6 MR. SAWANT: Mm-hmm.

7 CHAIR MARTIN: Correct? Now we're talking
8 about water. So, this appears in Rev 1. So, what
9 transpired in this transformation from air to water?
10 And is air still, say, in some way credited in the CPA
11 now, or is it just a water-based RCCS?

12 MS. RADEL: This is Tracy. I just want to
13 clarify. The PSAR design was always water-cooled, so
14 it was the analysis that was performed using air-
15 cooled. And so, the design switch from air-cooled to
16 water-cooled occurred before the PSAR timeframe. But
17 the analysis, they've determined through some
18 sensitivities and, you know, looking at the analysis
19 that it would be bounding of the water-cooled.

20 CHAIR MARTIN: True.

21 MS. RADEL: And so, they didn't rerun the
22 analysis, but the PSAR Rev0 and Rev1 were always a
23 water-cooled design, so.

24 CHAIR MARTIN: So, I would agree that
25 assuming air would be a bounding condition. When you

1 consider, say the reactor vessel, you must have looked
2 at some analysis of water to see the margin gain with
3 water. I mean, it just seems a little bit of apples
4 and oranges, and you don't know until you know. I
5 mean, you ultimately want to understand the margins in
6 a pivot like this, or is it a pivot? I mean, it's a
7 claim up front, but then all analysis is done a
8 different way. I mean, that's kind of the bad taste,
9 right?

10 MS. RADEL: Yeah. So, this is Tracy. We
11 performed our confirmatory analysis using water-
12 cooled. So, from those results, we got enough
13 confidence in acceptability of that shift and --

14 CHAIR MARTIN: Looking at multiple figures
15 of merit in the --

16 MS. RADEL: Yeah. Looking at know, all
17 the outputs of MELCOR, you know, looking at the field
18 temperature, the vessel temperature, the distribution
19 of temperatures in the pebble bed, we felt confident
20 in that, so.

21 MR. SAWANT: And this is Pravin. And we
22 will talk about some of the physics and phenomena that
23 we thought were unique to water-cooled system and can
24 have impact on performance of water-cooled system so
25 --

1 CHAIR MARTIN: Okay.

2 MR. SAWANT: -- in next few slides. Okay.
3 So, yeah. This slide again talks about the key
4 features of the NSRST portion of the RCCS. As it was
5 mentioned earlier, this PAP system is shared between
6 all four modules includes three pumps, six air cool
7 heat exchangers. So overdesign, like a 150 percent,
8 of the capacity. And also includes supply and return
9 piping that connects the PFA to SFA portion of the
10 RCCS and some instrumentation, specifically the level
11 measurement in boiler tanks. One of the key design
12 feature of this PAP is elevation of the supply and
13 return piping. The highest elevation is above the
14 boiler tank level that prevents the siphoning and
15 protects the inventory in SFA if there is a leak or
16 break in NSRST portion of the RCCS.

17 And also, there are motor operator
18 isolation walls located on the supply and return
19 piping that allows operator to isolate the SFA portion
20 of the RCCS if there is a leak detected in that
21 portion. That essentially prevents or protects the
22 function of rest of the PAP system. And we'll talk
23 about these shared systems in a few slides later. All
24 the supply and return piping that is inside the SST is
25 designed as sector related. And the NSRST supply

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1 return marking is located outside of SST. Then active
2 RCCS is also designed to maintain our reactor cavity
3 temperatures below 65 degree Celsius during normal
4 operation.

5 CHAIR MARTIN: So, you're talking about
6 the evaluation of the LBEs as of course, y'all
7 corrected me a moment ago. The difference between the
8 LBE analyses and the DBAs, or the DBEs and DBAs, is
9 the role of the NSRT. So, what goes -- I mean, these
10 components that we mentioned here, SFA, et cetera, are
11 not involved with the DBA analysis. Now, what is the
12 criteria that is being used for the DBAs? Are we
13 using also a reactor cavity concrete temperature as an
14 acceptance criteria in those analyses, as well as
15 reactor vessel temperature in those DBAs? How are
16 they being used, and what criteria are being used
17 there?

18 MR. SAWANT: So, currently when we looked
19 at DBAs, the main figure of merit presented was fuel
20 and fuel temperatures, peak fuel temperatures, average
21 fuel temperatures, and the focus was on releases based
22 on those. But they were -- I believe, for some DBEs,
23 the RPV temperatures were provided, and then based on
24 that, we did our confirmation calculations for RPV
25 temperatures, but that was based on water-cooled RCS.

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1 So, our numbers were a lot lower than what we saw for
2 DBEs presented in the PSAR. But those were the main
3 criteria we looked at. We did not really look at any
4 cavity concrete temperatures or at the stage 4 CP as
5 it stays right now. The primary goal was to make sure
6 fuel temperatures and where they land the releases on
7 there.

8 CHAIR MARTIN: Mm-hmm. You know, having
9 done things deterministic all my life, I have a harder
10 time coming around to, you know, the two different
11 approaches. I mean, the complementary and themselves
12 a analytical defense-in-depth by looking at DBAs and
13 the DBEs. To look at -- I think one thing from my
14 experience with high temperature gas reactors is that
15 the typical minimum margin is not the fuel, right?
16 And we've already talked about it. It's more likely
17 the vessel, although it could be some other structural
18 aspect.

19 Of course, you look at that. Should we be
20 looking at these DBAs closer at really the limiting
21 safety related component? And fuel is always
22 important, and obviously it is ultimately is going to
23 drive the consequence analysis downstream. But they
24 incorporate, of course, really a lot of the
25 uncertainties, and I think, whatever acceptance

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1 criteria, we want to latch on to that, that's what
2 people want to know.

3 MS. RADEL: This is Tracy. At the CP
4 stage here, we were looking kind of more detailed at
5 how the modeling's done as well as the code
6 commitments and then confirming that doses were below.
7 And then, for the detailed analysis of the thermal
8 analysis of the concrete that wasn't available at this
9 stage but we talked through the design approach, the
10 codes, and then also validation of the codes. So we
11 talked through the aspect of the temperature and
12 analysis of the temperature at the bottom portion of
13 the reactor vessel, and how that may use different
14 codes than some of the other analyses, and their
15 approach to validating that and confirming that and
16 demonstrating it at OL.

17 So, we talked through the pieces and
18 what'll need to be there at the OL stage, and, you
19 know, they've committed to the appropriate codes to
20 ensure that they stay within limits, but seeing that
21 demonstrated will come at the OL stage.

22 CHAIR MARTIN: All right. I'll chew on
23 this a little bit more. Thanks.

24 MR. SAWANT: And just to add a little bit
25 to that discussion, SRDC for RCCS includes fuel

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1 radionuclear limits as well as RPV temperature limit.
2 So, it's part of their design criteria for RCCS,
3 specifically safety related SFA portion of the RCCS.
4 Next. Yeah. So, one of the focus area for our review
5 was environmental effects and dynamic effects under
6 PDC 4. We investigated this impact of thermal
7 fatigue, which is potentially coming from temperature
8 fluctuations associated with two-phase flow, as well
9 as in boiling instabilities. Also fouling effects
10 which can affect the long-term RCCS heat removal
11 performance, and also potential for stress corrosion
12 cracking.

13 For the thermal fatigue, PSAR provided
14 their approach for analyzing the impact of temperature
15 distribution on thermal stresses and their commitment
16 to follow the core guidance on analyzing these thermal
17 stresses. For fouling effects as well as stress
18 corrosion cracking, they are primarily relying on
19 their water chemistry control program to maintain the
20 water quality and minimize the fouling as well as keep
21 the chloride concentration low to minimize the
22 potential for stress corrosion cracking. Next slide.

23 Another focus area was related to the
24 sharing of the SSCs under PDC 5. What's the impact of
25 shared PFA that NSR STPA system between all modules,

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1 and what's the impact of that shared system on the
2 performance of SFA? That is a safety related portion
3 of the RCCS. As I mentioned earlier, this key design
4 feature that supply and return piping elevation
5 preserves the inventory in separate portion of RCCS if
6 there is a break in the piping. So, that one was
7 critical where it is in PDC file.

8 Then I also talked about motor-operated
9 isolation valves on the supply and return piping.
10 These valves are located in NSRST portion of the RCCS
11 and allows isolation of the SFA if there is a break in
12 SFA standpipes. Although I want to point out here is
13 that these isolation walls are not required to protect
14 the 72-hour boil of inventory in unaffected SFA of the
15 unaffected modules.

16 MEMBER HARRINGTON: This is Craig. I
17 think what you're saying is there's no automatic
18 isolation action. It's entirely manual, up to the
19 operator if they see a need or --

20 MR. SAWANT: They have NSRST measurement
21 of a boil-off tank level, and that level -- I think
22 there is some kind of alarm. And yes, that's not an
23 automatic action to close the isolation walls.
24 Although they have mentioned that there for OL, there
25 is still some design considerations to look into these

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1 signals and operator actions, but right now they are
2 classified as NSRST action.

3 Another design feature I mentioned earlier
4 was this overdesign for PFA RCCS, PFA portion of RCCS.
5 It's almost like it is designed to remove six megawatt
6 heat around three times more than needed for DBA heat
7 removal requirement. So, what that allows is that if
8 that there is, suppose one of the modules was going
9 through any transient with different heat load on
10 RCCS, it doesn't affect the continued cooling of
11 unaffected modules because of this high heat removal
12 capacity. So, these are like kind of design features
13 that minimize the impact of sharing of the systems.

14 MEMBER HARRINGTON: This is Craig again.
15 That last bullet, that's if a single module goes
16 transient and is not isolated, the -- let's see, PFA
17 continues to cool. PFA's passive part.

18 MR. SAWANT: So idea is that -- our
19 question was that, suppose single module sees any kind
20 of transient, like not anything specific. But then,
21 if that changes the load on RCCS associated with that
22 module, how that affects the performance of RCCS for
23 other modules, because under PDC file we want to look
24 at all impact of sharing of the SSCs. So what we
25 wanted to point out here is that because of that high

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1 heat removal capacity, the impact is lower because
2 it's really oversized, and any change in heat removal
3 requirement can be compensated by this overcapacity
4 RCCS.

5 MEMBER HARRINGTON: Yeah, I was getting in
6 my brain confused between the S and the P, but the
7 active cooling system is capable of handling the
8 normal operational load of three modules plus the
9 transient load of the impacted module.

10 MR. SAWANT: Exactly.

11 MEMBER HARRINGTON: Yeah. Okay. Thanks.
12 That's, what I was trying to get straight in my head.

13 MR. SAWANT: Next slide. We also looked
14 at several design issues related to the RCCS. And one
15 of the issue was the rate of steam separation for the
16 SFA portion of RCCS when it goes to the boiling
17 transition. Its effectiveness would depend upon how
18 effectively the steam separates from these riser
19 header and riser standpipes. The -- basically right
20 now, PSAR states that their assumption is that
21 gravity-based separation is adequate considering the
22 heat load on these SFA portions of the RCCS. However,
23 they are committing to investigate that through
24 further analysis at the OL stage.

25 Similar to like this issue, we asked about

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1 boiling instabilities geysering and parallel channel
2 instabilities, and how those instabilities would
3 affect the long-term performance of RCCS, as well as
4 their impact on the design due to mechanical and
5 thermal stresses. Again, like another topic we looked
6 at was level swell -- potential level swell, and loss
7 of inventory because of entrainment when there is a
8 transition to boiling. And another topic we looked at
9 is transition from single phase natural circulation to
10 two-phase boiling and, again like, its impact on RCCS
11 performance as well as on RCCS integrity.

12 For all these topics which we thought were
13 critical for eventually for design as well as modeling
14 of RCCS performance in long-term cooling, PSAR
15 provides a commitment to address these topics through
16 further analysis as well as potentially if needed
17 implementing design changes at the final design stage.
18 So coming back to this topic that we discussed at the
19 start of this presentation, how RCCS is modeled in
20 PSAR analysis. It's modeled as a boundary condition.
21 It is a heat flux temperature-dependent heat flux
22 boundary condition. They are from a stand-alone RCCS
23 model for air-cooled RCCS in GOTHIC code. It is
24 expected to provide conservative results compared to
25 the performance of water-cooled RCCS, primarily

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1 because of higher heat transfer coefficient in water-
2 cooled system, as well as PSAR notes that the heat
3 transfer area itself is higher for water-cooled system
4 as compared to air-cooled system.

5 So we understand that this would provide
6 conservative results for the cases where reduced heat
7 removal is bounding, which is mainly for fuel and
8 radioactive limits in core which was a primary focus
9 for the CP review and dose analysis. But as we see in
10 the next slide -- can you go to our next -- yeah. We
11 do have like several questions on the performance of
12 water-cooled RCCS in long phase because the
13 fundamental phenomena in water-cooled RCCS we
14 understand that they are well understood, which are
15 like conduction, convection, radiation, and boiling
16 heat transfer. However, when we look at this unique
17 geometry and like in this passive -- unique geometry
18 for the passive RCCS, it kind of introduces the
19 uncertainty on integral performance of RCCS as a
20 function of time in long-term cooling phase. And
21 considering all these design issues that I presented
22 in earlier slides and integral components of RCCS,
23 there is a need of additional testing and model
24 development. Next slide.

25 So PSAR provides a commitment to perform

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1 this additional testing as well as perform this model
2 development, following again like Reg Guide 1.203
3 process evaluation model development and assessment,
4 in-depth process. They are committing to use integral
5 effect test facility data from NSTF facility, which is
6 a facility at Argonne National Lab which was initially
7 it was air-cooled RCCS design which was converted to
8 water-cooled RCCS. Also, PSAR provides commitment to
9 perform top-down and bottom-up scaling and distortion
10 analysis to show the applicability of this data to Xe-
11 100 RCCS for full range of conditions.

12 Also, PSAR commits to perform additional
13 integral effect test or separative test if the scaling
14 and distortion analysis shows that there is gap in the
15 data. And we expect that this MDA process if it is
16 followed for the model development, the gaps in
17 validations will be captured in the final evaluation
18 model. So these commitments for the OL to perform
19 these validations and model development are critical
20 for the CP approval.

21 And -- sorry, the last point there is that
22 PSAR also provides commitments to perform pre-
23 operational and start-up testing to confirm that as-
24 built RCCS performs as expected for range of
25 conditions that are expected during different LBAs.

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1 That's also an important commitment that allows us to
2 approve this design for CP.

3 CHAIR MARTIN: This is Bob, but much of
4 that is still IOU, correct?

5 MR. SAWANT: Yes.

6 CHAIR MARTIN: Earlier, I had the question
7 specifically to NSTF and scaling and distortion. You
8 really haven't seen scaling analysis at this point.
9 They did remark that it is something that they're
10 working on. Have y'all made any effort to -- you do
11 a lot of work up front to anticipate what you're going
12 to get, such as the analyses -- thermal hydraulic
13 analyses that you've done. Any kind of insight on
14 scaling and potential distortion waiting?

15 MR. SAWANT: Yeah. We didn't receive any
16 insights on scaling and distortion analysis, but what
17 we expect is that -- based on my outside reading about
18 the NSTF facility, it was designed to represent some
19 other RCCS design not exactly this geometry. So I'm
20 expecting that scaling and distortion analysis to
21 clearly show the gaps in applicability. I'm expecting
22 that methodology eventually would account for those
23 gaps if there is applicability gaps.

24 There are some areas that we have listed
25 in our safety evaluation, like fundamental differences

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1 in geometries of NSTF and these RCCSs, and we expect
2 applicant to address those differences. And the good
3 thing about MDF process is that it allows you to once
4 they go through the bottom-up and top-down
5 applicability evaluation, they should be able to
6 clearly capture the gaps in applicability and account
7 for those in their analysis. And it looks like they
8 do have a large margin because we saw that cool RCCS
9 is showing that they can mitigate DBAs and so they
10 probably will be able to account for those gaps if
11 there is a distortion, significant distortion, but we
12 haven't seen any distortion.

13 CHAIR MARTIN: Right. Yeah, no, and
14 scaling analysis can be a double-edged sword. We
15 noted maybe -- Dave and I might disagree a little bit
16 on the role of scaling and the Reg Guide, but maybe
17 only a little bit. I mean, you can get yourself lost
18 in the calculation for sure, whereas I might expect if
19 you look -- looking just at thermal radiation and
20 conduction, you know, those two phenomena I'd say
21 earlier, I separated out convection. But with the
22 RCCS only a meter away from the reactor vessel, I
23 believe that in the argon testing, there's a larger
24 gap there.

25 This might actually be you're considering say,

1 the heat that might otherwise bake the concrete
2 beneath it. A more conservative representation, but
3 it often -- it creates a distortion that might say at
4 a high level that it's not applicable. But you take
5 a step back, you realize, oh, wait a second, it's
6 really the test that's more conservative than the
7 actual design and there's still value there from the
8 standpoint of just the pure thermal hydraulics.

9 But it is a bit of a trap unless you really are
10 kind of on top of things. You know pick apart each
11 phenomenon. I picked earlier on convection, and
12 generally I think that's just a very difficult one in
13 general to tackle separately, you know, without having
14 just the exact geometry scaled or otherwise. It's
15 oftentimes just easier to look at bounding conditions
16 and accept that even if that means slight design
17 tweaks.

18 MR. SAWANT: Yeah. It's always difficult
19 to build a facility with no distortion. There is
20 always going to be some compromise. It's like -- one
21 area is that because this facility was not built
22 specifically for this design, they probably did not
23 have control on what type of distortions they would
24 allow versus what they are already existing in the
25 facility. So again, like, what we relied upon is

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1 commitment in PSAR that says that if there are gaps
2 that indicates that they would need additional
3 testing, then PSAR does commit to perform testing
4 under appropriate test program, which was one of the
5 crucial commitment for us to feel comfortable.

6 CHAIR MARTIN: Sure, sure.

7 MEMBER PETTI: This is Dave. Bob as
8 Pravin said, I think, it was the AREVA design was the
9 only one around at the time that was water-cooled that
10 they scaled against. But how that looks compared to
11 what we see today I don't recall the details. But
12 they it was scaled, I know that, so.

13 CHAIR MARTIN: Right. Right. Are you
14 talking about the Antares? I mean, that's what --

15 MEMBER PETTI: Yes.

16 CHAIR MARTIN: At least AREVA called their
17 --

18 MEMBER PETTI: Right.

19 CHAIR MARTIN: -- HCTR at the time.

20 MEMBER PETTI: Right.

21 MR. SAWANT: And as I noted earlier, we do
22 list some of the differences in our safety evaluation
23 compared to NSTF facility design which we think are
24 critical. But again, since we haven't seen a formal
25 scaling and distortion analysis, and we will wait for

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1 the OL to see it and see what level of applicability
2 the data has.

3 CHAIR MARTIN: Yep.

4 MR. SAWANT: That's it on RCCS.

5 MS. RADEL: We're going to need to swap
6 prisoners here.

7 MR. BHATT: Okay.

8 MEMBER ROBERTS: I do have a question from
9 two weeks ago that slide 10 will give me a good chance
10 to ask if you can put up slide 10. The question from
11 two weeks ago was that the LMP process requires ALOs
12 at the fifth percentile if they're less than 10 to the
13 minus 2 to be considered for DBAs. So here you've got
14 all AOOs ending in active feedwater cooling or SSS
15 cooling. Were all of those above 10 to the minus 2 at
16 the fifth percentile?

17 MR. BHATT: There were some AOOs that the
18 95th percentile was mapped into a DBE. I don't recall
19 the exact number, but there was same thing for BDBs as
20 well where some DBEs, the fifth percentile mapped into
21 DBEs.

22 MS. RADEL: The opposite. Yeah.

23 MEMBER ROBERTS: Okay. For my question on
24 AOOs, I'm reading this slide again carefully. The
25 it's only the events that they were counting on RCSS

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1 that are mapped into the un-active cooling, is the way
2 I read this. So if you had active feedwater cooling
3 or SSS cooling, then you would not have to use that
4 assumption. Is that the right way to read this or no?

5 MS. RADEL: The slide here is really
6 speaking to the scope of non-DBA events and where they
7 map into the cooling. And then in the DBA analysis,
8 that's all performed with passive no matter what is
9 mapping into it. And so those would all have passive
10 RCCS cooling as their DBA event because you can't
11 credit any of the non-safety-related.

12 MEMBER ROBERTS: So any AOO whose fifth
13 percentile is below 10 to the minus 2 had to be
14 analyzed using passive only?

15 MS. RADEL: Yeah.

16 MEMBER ROBERTS: With AOO dose limits?

17 MS. RADEL: Yes, and shown to be below the
18 25 --

19 MEMBER ROBERTS: Oh, 25.

20 MS. RADEL: Yeah. So it's --

21 MEMBER ROBERTS: Okay. DBA dose limits.

22 MS. RADEL: Right. So you're comparing to
23 different limits for the different analyses. Within
24 the non-DBA analysis, you're comparing to the 'FC
25 target line, which is much lower at the ALO region.

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1 And you're showing that you meet that with that non-
2 DBA analysis. Then as you go into the DBA analysis,
3 my understanding is the real goal of that is to
4 confirm that you have enough in that safety-related
5 bin.

6 Your AOOs are obviously not going to be
7 controlling there from an analysis standpoint, and you
8 shouldn't identify any new safety-related items
9 through the AOOs, right? It's going to be likely in
10 those BDBEs that map in at the 95th percentile that
11 you're more likely to say, Oh, well, we don't quite
12 have enough safety-related here and so that's just
13 kind of that double check that you have enough there.

14 MEMBER ROBERTS: Yeah. I think that's how
15 that works here. So if you had an AOO that did not go
16 below 10 to minus two, then you would still do what's
17 on this page. And would you then assume that there
18 was a long-term passive cooling?

19 MS. RADEL: You wouldn't have to according
20 to LMP, and we talked about that a little bit last
21 time of why you don't map all AOOs in. LME actually
22 did decide to map all AOOs and not just the fifth
23 percentile one.

24 MEMBER ROBERTS: Okay. That makes -

25 MS. RADEL: So it -- it makes more --

1 MEMBER ROBERTS: I think that makes more
2 sense. Because it just doesn't make sense to me, I'm
3 still struggling with why an AOO that's less likely
4 has to have more stuff done with it.

5 MS. RADEL: Yes. I also struggle on that
6 one. But I think it's just their general kind of
7 approach of consider the frequency bands and their
8 scope of that DBA analysis is DBEs, and so just by the
9 nature of us considering the frequencies, you have to
10 --

11 MEMBER ROBERTS: Yeah. I think what LME
12 is doing makes more sense. It's something I don't
13 know if you're looking at in terms of lesson learned,
14 but I'm just, again, scratching my head why you do
15 more for something that's less likely.

16 MS. RADEL: Yes. It did come up in kind
17 of feedback, lesson learned, because there is that
18 chance that you have an AOO that has a frequency band
19 that doesn't extend into the DBE region and then a
20 correspond -- like the next failure brings you into
21 the BDBE region. And if you don't have a frequency
22 band extending into the DBE, you wouldn't have a DBA
23 covering that event sequence set. And so that's
24 something we look at.

25 MEMBER ROBERTS: That makes sense. That

1 event sequence, that's a very different scenario. So
2 it's just the straight -- my AOO is above 10 to minus
3 2 at a fifth percentile level, you know, I'm good to
4 go. If it's below, I've got to do more.

5 MS. RADEL: Right. It almost encourages,
6 yeah, the opposite of what you want there.

7 MEMBER ROBERTS: Yep -- yep. Okay.
8 Thanks.

9 MR. BHATT: This is Santosh. Just to add
10 to that LME is committed to doing this analysis with
11 like grouping of the event families. It will become
12 much more intuitive when you look at the groupings of
13 the certain events in each families. You see okay,
14 this is XYZ event with any additional failure, it
15 jumps into same family of the event in the next
16 category. So, when we see -- when we look at that I'm
17 hoping to see a much cleaner lines of event families
18 at the OL stage.

19 MEMBER ROBERTS: Yeah. It also maps real
20 well into the defense-in-depth model because that's
21 where you get from level two to level three of
22 defense-in-depth. Okay. Thank you.

23 MS. AUDRAIN: All right. Are we ready?
24 Okay. I'm Meg Audrain. I'm a materials engineer in
25 OAR. This section is actually the geometry

1 maintenance, but we thought this was the best area to
2 do a quick overview of the materials qualification
3 plan for metallics.

4 Their materials qualification plan is
5 described in Rev. 1 of the PSAR in Section 3.8 and
6 includes requirements for code supplementation for the
7 following areas: welds that do not have design rules
8 within ASME Section 3 to 5, extension of qualified
9 lifetime temperature and fatigue curves, multi-
10 material stress relaxation cracking. Also includes
11 environmental compatibility assessment information and
12 degradation mechanisms assessment. Limited scope of
13 the material qualification plan is also included in
14 their R&D program. Those are the items associated
15 with safety-related SSCs.

16 LME differentiates treatment of their
17 NSRST SSCs based on risk significance in the following
18 areas related to materials and mechanical which is the
19 R&D scope, the RIM versus the RAM program for in-
20 service monitoring inspection and the IST versus the
21 maintenance program for in-service testing. I will
22 note that the NRC position is that all safety
23 significant SSCs would appropriately be scoped into
24 the RIM and IST programs, and that would include NSRC
25 defense in-depth SSCs. However, because these are

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1 operational programs, the review and approval of those
2 programs are appropriately left to the operating
3 license. We have encouraged early engagement prior to
4 the operating license in those areas.

5 A quick overview of the graphite core
6 assembly. It's a safety-related system. It has an
7 associated topical report which supports material
8 qualification in the design. They'll be using ASME
9 Section 3 to 5, and two different grades of graphite
10 will be qualified and used in their GCA. Staff
11 implemented 25 conditions on the topical report
12 related to justification for any code departures,
13 demonstration that properties and methodologies are
14 supported, and demonstration of their IGNIS analysis
15 tool. The GCA is seismic Category I and will meet
16 Appendix S requirements. And as discussed earlier,
17 their rod insertion evaluation is still in
18 development. It is an Appendix B QA program, and as
19 it's safety-related, it will be in the RIM program.

20 I will note here that the 2019 edition of
21 RIM, which is what is endorsed in Reg Guide 1.246,
22 does not include rules for graphite materials.
23 However, there was a code case developed and recently
24 published, and staff is incorporating that in our
25 draft guide which will endorse the 2025 edition of

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1 RIM.

2 MS. SONG: Hello, my name is Clair Song.
3 I'm mechanical engineer at OAR. I'm going to present
4 the core metallic structure, the active pressure
5 vessel data vessel support structure, and a reactor
6 support structure. The staff's review for these
7 systems are focused on the key design aspects, the
8 code compliance, the material qualification plan, and
9 also the programmatic treatment to gain confidence
10 that the final design will ensure the structural
11 integrity and the core geometry maintenance, yes.

12 For the core metallic structure and the
13 reactor pressure vessel, LME committed to follow the
14 ASME Section III, Division 5. Here, we look at how
15 the load transfers, how the core is supported in
16 lateral and the vertical directions. The core
17 metallic structure provides the vertical support to
18 the core -- to the core barrel base pedestal from the
19 bottom and also the clear spans on the top. The core
20 barrel base pedestal is connected to the reactor
21 pressure vessel bottom.

22 One thing we discussed with LME during the
23 audit is the graphite lateral support. That feature
24 is still under design. I'm going to talk about that
25 later. And then the lateral loads, it transfer from

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1 the core metallic structure to reactor pressure vessel
2 through the bumpers at the top of the core barrel
3 shield sections that make even contact to the RPV
4 inner surface. So for the material qualification
5 plan, LME committed it to do the code supplementation
6 assessment and also the environmental compatibility
7 assessment. From that assessment, they identified
8 that the core barrel base pedestal could operate in
9 the elevated temperature. So, that identified the
10 code supplementation to extend the lifetime of the
11 base pedestal material.

12 They also identified the environmental
13 compatibility assessment. That's to look at the
14 impact of radiation to the mechanical property of the
15 material at the elevated temperature. Both systems
16 are categorized as seismic Category I. Each designed
17 to meet the seismic requirements in 10 CFR 50,
18 Appendix S. The program managerial treatment includes
19 the Appendix B quality assurance program. Also they
20 are included in the ring program. Next slide.

21 For the reactor vessel support structure
22 and the reactor support structures, they are both
23 classified as safety-related. The reactor vessel
24 support structure provides the vertical and the
25 lateral support to the reactor pressure vessel. It's

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1 designed to ASME Section III, Division 5. The reactor
2 support structure provides additional vertical and
3 lateral support for the RPV. It's designed to AISC N-
4 690. They are both categorized as seismic Category I
5 designed to meet seismic requirements of 10 CFR 50,
6 Appendix S. Again they are included in the Appendix
7 B quality assurance program.

8 For the reactor vessel support structure
9 that's included in the RIM program. And for the
10 reactor support structure that's included in the
11 maintenance programs. We also want to talk about the
12 review for the hot gas duct and core vessel systems.
13 These systems are classified as an NSRST, but they are
14 still designed to ASME Section III, Division 5. The
15 key design aspects for the hot gas duct, the metallic
16 part of the system, is made of the material alloy E
17 800H. There's an insulation layer between the hot gas
18 duct, the inner surface, and the outer surface. That
19 insulation layer is classified non-safety related.

20 I'm going to talk about the other
21 discussion we had with LME about the insulation layer
22 function. The maximum design temperature for the hot
23 gas duct is 760 degrees C. That's equal to the upper
24 limit of the temperature allowed by the code. We had
25 some discussion about that with LME. Because of that,

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1 they have identified a code supplementation need for
2 hot gas duct. So that includes extended the lifetime
3 of the E 800H and also extend the qualified
4 temperature to a higher temperature, also changing the
5 fatigue curves to the higher temperature.

6 LME also identified the environmental
7 compatibility assessment need including:
8 Carburization, decarburization, and stress relaxation
9 cracking. For the cross vessel, the material is SA-
10 508, so the design temperature is 285 degrees C. They
11 are both categorized as seismic Category II A and will
12 meet the seismic requirements of 10 CFR 50 Appendix S.
13 They are included in the design program.

14 CHAIR MARTIN: Okay. Ron, I see your hand
15 up.

16 MR. BALLINGER: Yes. I may have misheard
17 you, but the upper limit for 800H is well, you know
18 what, whatever the number was, 760 or there C. The
19 design temperature is 760 C. And is it the staff
20 discussion that resulted in them having to do a code
21 supplement to go higher than the design limit for the
22 800H? Or did the applicant conclude that the
23 uncertainty in the temperature goes above the current
24 design limit for 800 and therefore that they need to
25 do a code supplement to do this?

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1 MS. SONG: So, the design temperature,
2 that's for the normal operation and AOO and when you
3 look at the level B, C, D, the off-normal conditions,
4 the transient, the temperature, it's very likely to go
5 above 760.

6 MR. BALLINGER: Okay. All right. I
7 thought I heard something like that in the applicant
8 presentation, but I wanted to be sure that -- and I
9 think we've said that, yeah, it was level C or D or
10 something like that that resulted in higher
11 temperatures. Okay. Thank you.

12 MS. SONG: Next slide. For the core
13 barrel evaluation, we talked to LME about the graphite
14 lateral report. Especially, we were concerned about
15 those wedges in the annular gap between the graphite
16 blocks and the core barrel inner wall. So it's on our
17 discussion. The mechanism is still in development
18 that LME can commit to ensure that the wedge will be
19 maintained in place for all the operating conditions,
20 including the seismic event. Also their federal
21 design will consider the displacements of the graphite
22 due to the irradiation and also thermal effects and
23 other loadings. They committed to ensure the
24 sufficient lateral support to the graphite such that
25 the graphite will perform their safety functions.

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1 Another thing we talked about, I think LME
2 presented this morning, about the rod insertion
3 evaluation method. So they have developed a
4 preliminary rod insertion evaluation method. That
5 approach is going to be validated by tests and LS-DYNA
6 analysis to ensure control rod insertion for all the
7 operating conditions. I think ACRS had a question
8 about the load combination, currently -- also the
9 transient loads. Currently, we don't have information
10 about the transient loads, the off-normal operating
11 conditions, but LME committed to follow ASME Section
12 III, Division 5 for the node combination and also the
13 stress deformation analysis. We think we have
14 sufficient confidence that those concerns can be taken
15 care of. Also, they have, like, a material
16 qualification plan that includes the code
17 supplementation and the environmental compatibility
18 assessments. They are going to -- They have done some
19 assessments and when they have more information about
20 the off-normal conditions, they will take another look
21 at those assessments. We believe that's a systematic
22 approach to ensure that all the failure modes, the
23 service degradation of the material, will be
24 considered, but we are going to look at that at the
25 OOA stage.

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1 Another thing I would like to mention is
2 that the environmental compatibility assessment that
3 also includes the graphite and metal interaction.
4 Next. Also, for the cross vessel and hot gas duct
5 evaluation, we talked about the classification of the
6 insulation layer as non-safety related. LME stated
7 that that insulation layer is not relied to maintain
8 the cold helium temperature within the requirements.

9 That's why that can be classified as non-
10 safety related. So, we are good with that at CP
11 stage, but we are going to review this thermal
12 analysis when it's available to confirm that the
13 temperature of the cross vessel will be maintained in
14 the allowable range for the materials they select in
15 SA-508. Again, they are going to follow ASME Section
16 III, Division 5 for the load combination and a stress
17 deformation analysis. I think we talked about the
18 code supplementation to extend the qualified
19 temperature. For the seismic classification, they are
20 both categorized as IIA, but it's designed consistent
21 with the seismic design criteria for seismic class
22 Category I. That's all we have.

23 CHAIR MARTIN: We focused on a few new
24 structures, systems, components and much of the
25 conclusion, I guess, leading to reasonable assurance

1 at this stage has been commitments with regard to code
2 cases and maybe the development of data, material
3 data, or what have you. Does that mean beyond what
4 we've just talked about here in their presentation,
5 your presentation, is there kind of a one-to-one
6 mapping across all the safety-related -- I guess,
7 those that are related to, say, core structure or just
8 plant structure and codes? Is that all complete,
9 would you say, at this point? All the commitments in
10 place? Did you just -- or kind of focus on the ones
11 that are most safety significant, something in
12 between?

13 MS. RADEL: As far as code commitments and
14 what they're designing to materials and programmatic
15 treatments we saw the full range of commitments for
16 safety significance, so safety related and NSRST in
17 there. In addition, for those where we saw they were
18 kind of pushing the limits, we had additional
19 discussion on that and the R&D that may be needed to
20 address those aspects.

21 And then, from kind of an analysis
22 standpoint, for certain ones that are going to be
23 constructed much earlier and going to -- aren't ones
24 that you're necessarily going to be able to go in and
25 change later, we went a bit deeper on those in audit

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1 space and tried to look at where available the
2 preliminary analysis. It was kind of a range
3 depending on that safety significance, but from a
4 commitments on codes and standards, materials
5 programmatic special treatment, we made sure that that
6 was fully evaluated here at the CP and is present in
7 the PSAR and evaluated in the SE.

8 CHAIR MARTIN: So, and obviously, there's
9 a considerable amount of commitments, I mean activity,
10 analysis, testing that ultimately will go to
11 demonstrating that code commitment. Again, going back
12 to my questions with DBs versus DBAs and looking at
13 something beyond the fuel. One thought, in my use of
14 DBAs in the past has been we look at safety related
15 everything. Now, with light-water reactors in
16 particular, there's the margins for everything but the
17 fuel are usually more significant.

18 Then looking at some non-light-water
19 reactors, it's not necessarily the case. Now, I can
20 appreciate that in the design activities, and of
21 course I'm imagining a design center with, of course,
22 all their -- all the different disciplines and they
23 are looking for inputs to -- you know, maybe from the
24 safety analysis people, maybe on their own, that
25 represent, say, the transient accident conditions and

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1 to, of course, determine how thick a wall is, for
2 instance. It seems to me that with the use of DBAs
3 focusing really on the dose consequences and siting
4 you're not necessarily going to get a holistic
5 analysis that looks at the scope of safety measures,
6 the scope of the figures of merit related to all SSCs.
7 And, you know, the first argument against that is that
8 different events or different figures of merit may
9 have different limiting conditions.

10 The challenge, I think, for an external
11 reviewer is not so much that maybe we can't convince
12 ourselves that the information is there somewhere,
13 it's that it's not neatly there that we can easily see
14 it. If you had an analysis that -- you know, well
15 okay, in this analysis we look at the fuel, we look at
16 the vessel, we look at the structures in the core, we
17 look at concrete, and it can go uh-huh, uh-huh, uh-huh
18 on down the list. And when you kind of segregate some
19 of this work to all right, well, the designer used
20 these loads as the limit, and you can trace them to
21 some justifiable analysis, but they're not all there.

22 I mean, you get to see it because you have
23 a year to look at this or 18 months to look at this.
24 Then for us, it's just a little bit on trust that all
25 the pieces connect. So the challenge, like I said, it

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1 would be much more convenient to see more of the
2 safety analysis covering a broader set of figures.
3 We, of course, said this so much in our lessons
4 learned letter. But at the same time, we can
5 appreciate it. It's not necessarily required under
6 LMP in the sense that --

7 MS. RADEL: I think a key piece there to
8 what you're speaking to there, is in the capability
9 targets. And so those aren't all available here at
10 the CP stage, but at OL they will have defined
11 capability targets for each SSC that matches with the
12 LBE analysis and DBA analysis being included in the
13 LBEs.

14 We talked in audit space with the team
15 that's working on developing those capability targets
16 and how they're going about doing that, and how they
17 are looking at the full scope of LBEs in which that
18 SSC is relied on to operate within PRA and DBA, and
19 feeding that back to the design team, and having the
20 design team confirm that that system can perform in
21 all those conditions. If it's determined that it
22 can't perform in those conditions, they will fail that
23 SSC within the PRA analysis for that event and ensure
24 that it's within the limits.

25 I think that's the piece where, yes, we're

1 focused on dose consequence, but the capability and
2 reliability targets to ensure that those SSCs are
3 designed to perform in all those ways and meet the
4 limits and not exceed any limits at which they would
5 fail is done through those capability targets. We
6 talked on how they're set and right now they're more
7 a system level and they're kind of high level of
8 sufficient heat removal for these scenarios. But at
9 the OL stage, that will have been distilled down to
10 the component -- you know, what each component is
11 doing, right, to meet that and its role within that
12 safety analysis. It would be nice to have that all
13 right now, but that is something that they will
14 provide and we'll review at the OL.

15 CHAIR MARTIN: But, still, there is not an
16 expectation or not a requirement for one single
17 analysis to cover all these other things. And it's
18 always been a dilemma of how much talking the safety
19 analysis people, which are supposed to be independent
20 design verification with their tools and of course,
21 the design team through the design process. And with
22 LWRs, we were always very careful not to cross a line
23 in do an analysis and say, You must be this, because
24 we have all these assumptions in there and then the
25 design team goes back, Well, all your assumptions are

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1 too expensive and they're pushing back, but we usually
2 found a way. The contemporary view of safety and
3 design, we get a little bit more of this integration
4 -- team integration in the development process
5 particularly at these milestones, like a CP stage
6 where the stake is in the ground, and then we share
7 that information and then move forward with it.

8 MS. RADEL: I think on that, you know, I
9 think there's a lot of value in that close connection
10 between the design team and the safety analysis team
11 to ensure that the safety analysis is accurately
12 reflecting that design. The goal is to iterate and
13 get to something that works for both safety analysis
14 and design from a cost schedule, other consideration
15 perspective. That independence -- there is that
16 independence through the NQA-1, QAPD, QA to ensure
17 that each of those safety analyses are independently
18 reviewed and verified.

19 But working closely between design and
20 safety analysis, I think, gets to the most effective
21 design and safety analysis in my experience, but so
22 it's good because they're going to have the same
23 assumptions, they're going to have the same
24 understanding -- you know, deep understanding of the
25 system performance and be able to accurately reflect

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1 that in the safety analysis. I think that kind of
2 iteration and kind of close tie is valuable, and then
3 you also need the independence on the review side
4 within the safety analysis. For sure.

5 CHAIR MARTIN: Right.

6 MS. RADEL: For sure.

7 CHAIR MARTIN: Right. Well, I mean, it
8 just comes down to transparency in all of this
9 information because it's not easy to follow for us who
10 are these theory experts and it's certainly going to
11 be more difficult for say any public that's online.
12 All right, let's move on to the next topic.

13 MR. ROCHE-RIVER: Next slide. Yeah. Good
14 afternoon. My name is Robert Roche-Rivera. I'm a
15 senior structural engineer in the Office of Advanced
16 Reactors, and I'm going to present the staff's review
17 of the seismic and flooding design aspects.

18 This slide is presenting an overview of
19 the seismic categorization approach implemented by
20 LME. A lot of this was presented during their portion
21 of the presentation. We'll recap some of those
22 aspects here. Their seismic categorization is based
23 on a number of factors, including consideration of the
24 safety function of SSCs, considerations of whether an
25 SSC is dynamically coupled or forms part of the load

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1 path of a safety-related SSC, consideration of seismic
2 safety significance, and consideration of seismic
3 interaction potential.

4 At the preliminary design stage, all SSCs
5 with a required safety function, or in other words,
6 all safety-related SSCs, are assigned to seismic
7 Category I. All NSRST SSCs are assigned to seismic
8 Category IIA, and this includes SSCs that provide
9 essential support for safety-related SSCs as part of
10 their load path and also includes safety significant
11 SSCs that are assigned to seismic Category IIA at
12 different levels based on their safety significance
13 and based on their impact to NEI 18-04 risk metrics.
14 SSCs that do not meet the criteria for either seismic
15 Category I or seismic Category IIA but have a -- or
16 represent a seismic interaction source or some
17 potential to engage in seismic interaction with either
18 a seismic Category I or a seismic Category IIA SSC are
19 then placed into the seismic Category IIB seismic
20 categorization.

21 All other SSCs that do not meet any of
22 these other criteria associated with the previous
23 seismic categories then are placed into seismic
24 Category III. Next slide, please.

25 Here we have a brief summary of the design

1 criteria that is associated with each one of the
2 seismic categories. Seismic Category I SSCs are
3 designed to the most stringent criteria, and that
4 criteria includes the design to safe shutdown
5 earthquake design response spectra that is also
6 referred to as the seismic Category I design response
7 spectra. They are designed in accordance with the
8 provisions from ASCE 43-19, which is a nuclear
9 standard that is applicable to safety-related
10 structure system and components, and also to limit
11 state B, which essentially refers to designing these
12 structure system and components to respond essentially
13 in the elastic regime in response to a safe shutdown
14 earthquake.

15 Seismic Category IIA SSCs are designed to
16 a seismic Category IIA design response spectra, which
17 is a scaled design response spectra from the seismic
18 Category I design response spectra, and they are
19 designed in accordance with ASCE 43-19. We have some
20 additional details that we can share with you during
21 the closed portion of the meeting related to the
22 seismic design criteria.

23 For seismic Category IIB, these are
24 designed to a seismic Category IIB design response
25 spectra, which is an enhanced design response spectra

1 relative to the spectra that would be determined by
2 applying or implementing the provisions from the ASCE
3 716, which is an non-nuclear standard. It has
4 provisions to develop seismic hazard at different
5 sites. But then the seismic Category IIB SSCs,
6 although they implement the provisions of ASCE 716
7 this area, it's an area of an enhancement for these
8 SSCs because the design response spectra that they
9 implement in their design, is an enhanced version of
10 a design response spectra relative to the one that
11 would be provided by ASCE 716. Then also we have some
12 details about that in the closed portion of the
13 meeting.

14 Then the seismic Category III SSCs they
15 are designed in accordance with the standard
16 provisions from ASCE 716. The preliminary design
17 stage assigns these categories and the associated
18 seismic design criteria. With then final confirmation
19 at the operating license stage supported by a seismic
20 probabilistic risk assessment. Next slide, please.

21 Turning now to flooding, the external
22 flood design basis hazard level is bounded by the
23 probable maximum storm surge, which includes a still
24 water level -- or is defined by a still water level of
25 about 5 feet and the total water level including wave

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1 run-up of about 15 feet. The flood protection
2 strategies to protect against the hazard coming from
3 this flooding DBHL for safety-related SSCs includes
4 accounting for the DBHL loads that are induced in the
5 building structure. So these loads are explicitly
6 accounted for in the design of the building
7 structures: locating openings above the flood height
8 and/or making them substantially impermeable; and also
9 with respect to the systems that will be housed within
10 the buildings, then ensuring that the system and
11 components will be above the still water flood height;
12 and/or also a combination of strategies that would
13 seek to implement features that would provide
14 waterproof protection locally within the building
15 structures or designing the SSC to function under
16 submergence conditions. Next slide, please.

17 In the case of NSRST and NST SSCs, some of
18 these SSCs may fail during the flooding DBHL, which
19 then could include or result in the unavailability of
20 electrical power and monitoring equipment. LME's
21 approach to cope with this condition includes
22 developing emergency plans that are focused on
23 achieving a safe shutdown from the main control room
24 or from the RPS cabinets that are located in the fuel
25 handling annex building before the site inundation.

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1 And also this will be supported by the use of portable
2 monitoring equipment to track plant status and
3 radiological conditions during the flooding event,
4 with somewhat limited information available through
5 RPS cabinets while power is available to those
6 cabinets. The detailed emergency plans will be
7 provided at the operating license stage. The PSAR
8 also addresses how NSRST SSCs will be protected from
9 higher frequency, but less severe, flooding events,
10 and that will be based on their safety significance.

11 CHAIR MARTIN: Okay. I believe this is
12 your last slide. Annie?

13 MEMBER KAMMERER: Yeah. Hi. Can we go
14 back to the -- well, you don't have to go back to the
15 slides, but I guess my question relates to the seismic
16 aspects. I'm sorry I'm not there with you in person.
17 I'm a little under the weather. I understand that all
18 of this is developed based on approaches which have
19 made their way into code, which have a technical basis
20 and are intended to develop more risk-balanced plans,
21 which is all a noble goal.

22 I guess my question relates to the degree
23 in which there's experience in actually implementing
24 these overall approaches. My question is, have you
25 seen and evaluated and applied these approaches with

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1 other examples such that there's sort of a lesson
2 learned or a familiarity with the approaches or is
3 this all something that's fairly new to staff in the
4 implementation?

5 MR. ROCHE-RIVER: I would say that in some
6 precedent applications that even have been recently
7 reviewed by the staff, there is some implementation of
8 graded approaches to seismic. From that perspective,
9 even though there are differences in the specific
10 design and analysis requirements associated with, for
11 example, in this case, each of the seismic design
12 categories, the fact that this is following like a
13 graded approach, considering, again, safety
14 significance, safety functions to be performed. I, in
15 my opinion, see that as somewhat consistent with both
16 recent precedent, and I would even maybe even say with
17 past precedents. Because even -- for previous -- you
18 know, for example, large light water reactors design
19 there was always, for example, that consideration of
20 2 over 1 and then that seismic categorization of
21 seismic Category I for safety-related SSCs. But then
22 for non-seismic Category I SSCs, then some graded
23 application of seismic design requirements aimed at
24 preventing adverse damage to safety-related SSCs.

25 I think another aspect is that we do see

1 a risk-informed graded approach here, but then a lot
2 of what we see here and that we have presented is
3 essentially relying on standard practices that are
4 coming from well-known standards like ASCE 43-19 and
5 then also even the non-nuclear standard ASCE 7-16.

6 MS. RADEL: This is Tracy. I just want to
7 add to another piece of that. Taking a graded and
8 risk-informed approach is confirming at the OL, that
9 the graded approach on the different SSCs based on
10 their risk significance that you're still meeting that
11 FC target. They've committed to do an SPRA to confirm
12 and demonstrate that, because in kind of approaching
13 it with kind of less than full safety-related
14 treatment, it's complex in the fragility curves and
15 the application of those codes and standards in a
16 risk-informed way, and that confirmation is a key part
17 at the OL stage.

18 MEMBER KAMMERER: Yeah, it'll be
19 interesting to see how this all gets pulled together
20 at the OL stage.

21 CHAIR MARTIN: Any further questions from
22 the Committee or consultants?

23 MEMBER BIER: Yeah, this is --

24 MEMBER HARRINGTON: Go ahead, Vicki. Go
25 ahead, Vicki.

1 MEMBER BIER: This is Vicki Bier. I had
2 a question on the flooding aspect. Given that it says
3 the emergency plan will focus on achieving the safe
4 shutdown prior to inundation, do you envision that
5 that might be some kind of a limiting condition of
6 operation or a licensing commitment to monitor
7 meteorological forecasts and shut down in advance of
8 certain situations?

9 MS. RADEL: This is Tracy. Perhaps, they
10 would have to demonstrate in their emergency plans
11 that they do have all the things in place to implement
12 their emergency plans, and that may be stuff that ends
13 up being within their tech specs. But we don't have
14 clarity on that yet at this point.

15 MEMBER BIER: Sure. I wouldn't expect to
16 have the details yet, but I believe that was done
17 years ago for Indian Point. Under -- I think for
18 them, the concern was wind but same issue of a
19 commitment to shut down ahead of time, so. All right,
20 thank you.

21 MEMBER HARRINGTON: So this is Craig.
22 Again, to continue on the flooding topic, you have
23 listed still water level approximately 5 feet and 15
24 feet with wave run-ups. It's obviously relative to
25 something, I assume, some nominal plant elevation -

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1 MS. RADEL: Correct. It's -

2 MEMBER HARRINGTON: Yeah.

3 MS. RADEL: -- it's relative to the
4 finished floor height, that five feet.

5 MEMBER HARRINGTON: To the finished floor
6 height of?

7 MS. RADEL: Safety-related structures.

8 MEMBER HARRINGTON: Safety-related. Okay
9 -- okay. There may be rooms, things lower than that
10 that would not be considered safety-related or that
11 would have to respond to the other bullets of
12 substantially impenetrable or shouldn't allow
13 operations submerged and things like that.

14 CHAIR MARTIN: Or you don't need them.

15 MEMBER HARRINGTON: Or you don't need
16 them, yeah.

17 MS. RADEL: Correct. They would need to
18 demonstrate that either it's okay that they fail
19 within the flooding event or that they're protected.
20 The kind of flooding PRA or flooding bit of
21 probabilistic analysis is likely going to come into
22 play there for those NSRST SSCs and which ones of
23 those need to be protected at different flood heights
24 because the DBHL flood is a pretty low probability
25 when you attach a probability to it. But that kind of

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1 conservative deterministic approach is used at the CP
2 to not have to do the full probabilistic analysis.
3 We'd suspect and expect that they will do some
4 probabilistic evaluation to demonstrate for the
5 different flood heights that they have sufficient
6 protection for those NSRST SSCs to meet the limits.

7 MEMBER HARRINGTON: Okay. Thanks.

8 MEMBER HALNON: Yeah. This is Greg. I
9 believe the staff is working on a PFH flooding --
10 probabilistic flooding RIM guide at this point, too,
11 I think. At least that's where we were last year.
12 They were working on it.

13 CHAIR MARTIN: Okay. Any further
14 questions? Because this is the end of the open
15 session. So going once, going twice. All right. At
16 this point, we would like to open this up to any
17 public comment. if you have questions or a comment
18 that you would like to express here, raise your hand
19 if you're online. Certainly, if you're in the room,
20 which is a possibility, you can just do the same and
21 then I'll call on you. That is not someone raising
22 their hand. All right. I'm not seeing any curious
23 members of the public willing or desiring to express
24 a public comment.

25 I think at this time we can close the open

1 session, and we will have a closed session that
2 follows this. Of course, we'll have to vet everybody,
3 and that will be on a different link, obviously. We
4 will also, of course, take a break. So, what do we
5 think we need? 15, 20 minutes? 3:15? Okay.

6 MR. BURKHART: Yes, Chairman Martin. This
7 is Larry Burkhart. I would just reiterate that this
8 is on the full Committee agenda in October on October
9 7th.

10 CHAIR MARTIN: Okay. Thank you, Larry.

11 MR. BURKHART: First thing in the morning.

12 CHAIR MARTIN: Yeah. All right. Thank
13 you very much. Again, for those of us who are
14 participating in the closed session, we will shoot out
15 the link, and we will pick that up at 3:15.

16 (Whereupon, the above-entitled matter went
17 off the record at 3:00 p.m.)
18
19
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25



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ACRS Sub-committee Meeting for the Long Mott Generating
Station Construction Permit Application Review
September 15, 2026



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Agenda

September 15, 2026

- Focus Area #2: RSF 1.1: Control Reactivity
- Focus Area #3: RSF 1.2: Control Heat Removal
- Focus Area #5: RSF 1.4: Maintain Geometry
- PSAR Chapter 13 – Research and Development
- Other Miscellaneous Items

Focus Area #2

RSF 1.1

Control Reactivity

Safe, Stable End State and Shutdown

- Safe, Stable End State (Defined in PSAR Section 3.1.1.5)
 - Xe-100-specific success-criteria endpoint for the PRA safety functions
- Shutdown (Defined in PSAR Table 3.11-1)

- Inherent Reactivity Feedback (RSF 1.1.1)
 - Strong negative temperature coefficient across full operating range
 - Relatively small temperature increases (on the order of 100 °C) during operation lead to reactor shutdown due to the large negative reactivity
 - Provides an immediate, always available response
 - Limits power to a stable, low level

- Movable Poisons (RSF 1.1.2)
 - RCS + RSS inserted
 - Reach and **sustain** subcriticality from any condition

Component	Reactivity Worth (pcm)
RCS Reserve (Load Follow)	1556
Reduction in Core Temperatures (100 C)	3039
Zero Power Isotopic Decay	3785
Loss of 1 Rod (RCS+RSS)	1000
Total Shutdown Requirement	9381
RCS + RSS in	-13210
Total Margin	-3830

Equilibrium Core Hot and Cold Shutdown Margin

KEY MESSAGE: Inherent feedback is an immediate protective response; movable poisons provide assured and maintained subcriticality.

Inherent Reactivity Feedback Demonstrations

- OECD-LOFC HTTR Project*
 - Inherent safety features demonstrated in the High Temperature Engineering Test Reactor in Japan
 - At 9 MW core thermal power, circulators are tripped without scram
 - Without rods, the cooldown and Xe decay eventually result in recriticality, however, temperature feedback and passive heat removal from the core limit the power level to less than 1% nominal power

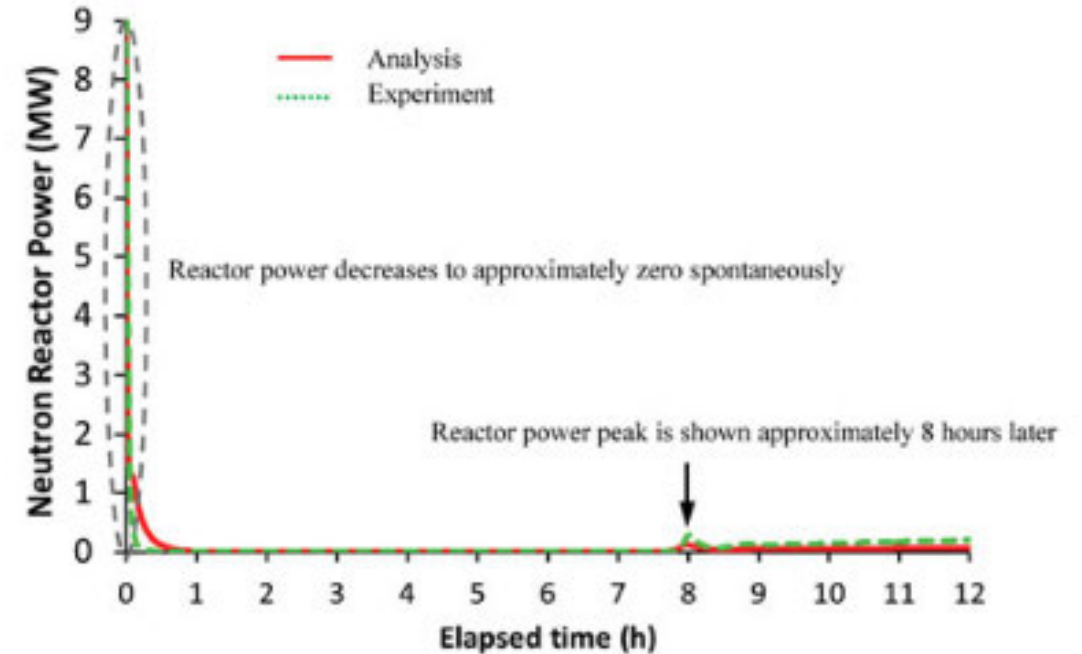


Figure 7. Analytical and experimental results of the reactor power transient in the LOFC test at 9 MW.

Source: Takamatsu et al., "Experiments and validation analyses of HTTR on loss of forced cooling under 30% reactor power," J. Nucl. Sci. Technol., Vol. 51, Nos. 11–12 (2014), pp. 1427–1443. Japan Atomic Energy Agency

* Project co-sponsored by the NRC

Inherent Reactivity Feedback Demonstrations

- Preliminary analysis shown of Xe-100
- Simulation is stopped after recriticality (~108 hours) but before power level turns over
- In the time period evaluated, the maximum fission power during the reactivity oscillations is approximately 0.15 %
- Eventually, the rate of heat loss from the reactor core matches the rate of decay heat generation, declining slowly with temperature

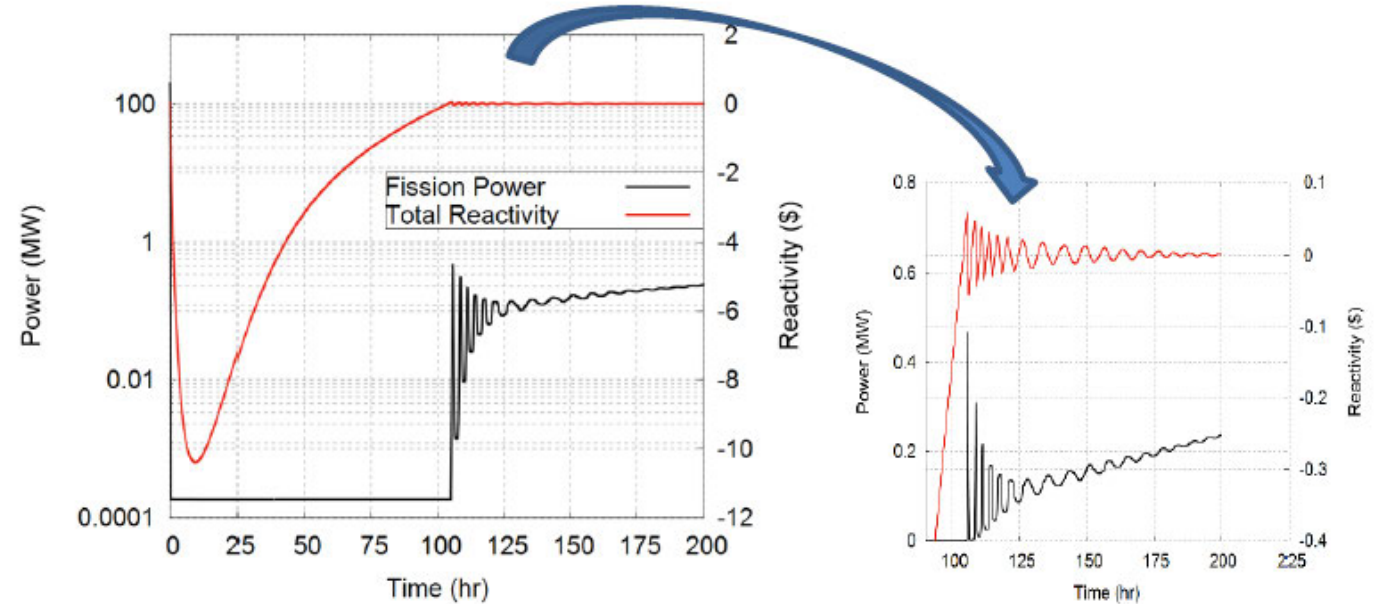


Figure 27: Fission Reactor power during DLOFC event

Focus Area #3

RSF 1.2

Control Heat Removal

RCCS System Overview

Standpipe Functional Area (SFA; SR; ASME III.5) [[

- Passive subsystem independent across reactor modules.

Process Functional Area (PRA; NSRST; B31.1; ASME VIII.1)

- Active subsystem shared across four reactor module SFAs.
- Two trains of 3 x 25% Air-Cooled Heat Exchangers (6 MW_{th} Capacity)
 - Substantial margin ensures thermal differences across reactor modules do not affect one another.
- 3 x 50% Pumps
- Motor operated isolation valves on each SFA cooling water supply & return pipe.
 - Isolates a single SFA for maintenance or when a leak is detected, ensuring active cooling is maintained in the other SFAs. Failure to isolate does not compromise any reactor module's SFA RSF.

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KEY MESSAGE: Sharing of the PFA across reactor modules does not adversely impact performance of individual SFAs. Sharing of PFA does not cause a common failure within PFA to compromise the PSF of any SFA.



RCCS Passive System Overview: SFA

- Required 72-hour boil-off volume considers the water below the supply & return piping elevations (a break in the piping does not compromise the RSF).
- Safety Analysis shows >>7 days margin without refill.
- In addition, there are four refill methods (NST) to replenish SFA inventory to support 30-day cooling thereafter.
 - NI Process Water
 - Condensate System
 - NI Fire Protection
 - Backup/Offsite Water Source

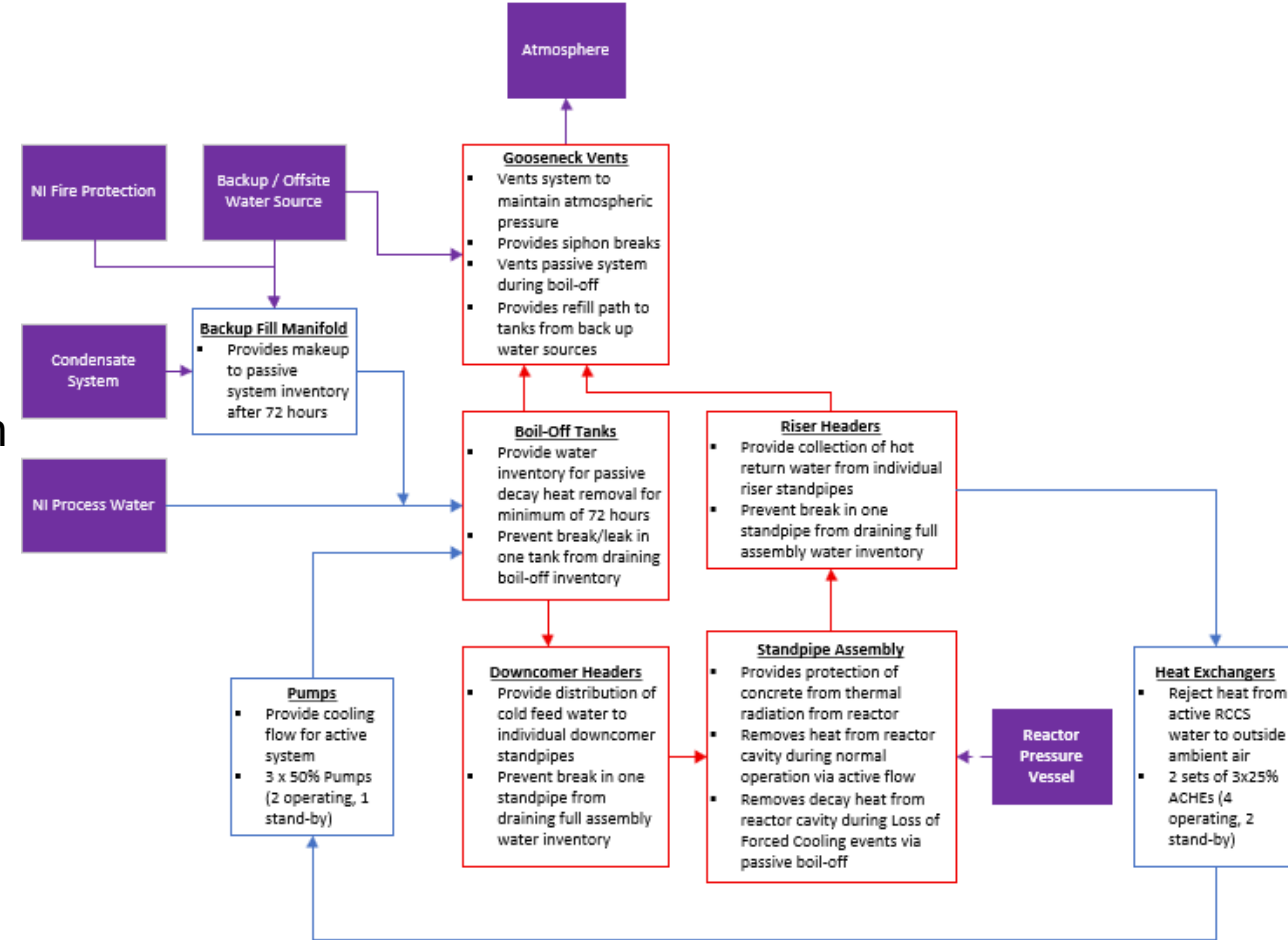
KEY MESSAGE: Substantial water volume margin is provided in the SFA to withstand the 72-hour DBA passive cooling.



RCCS Passive System Overview: SFA

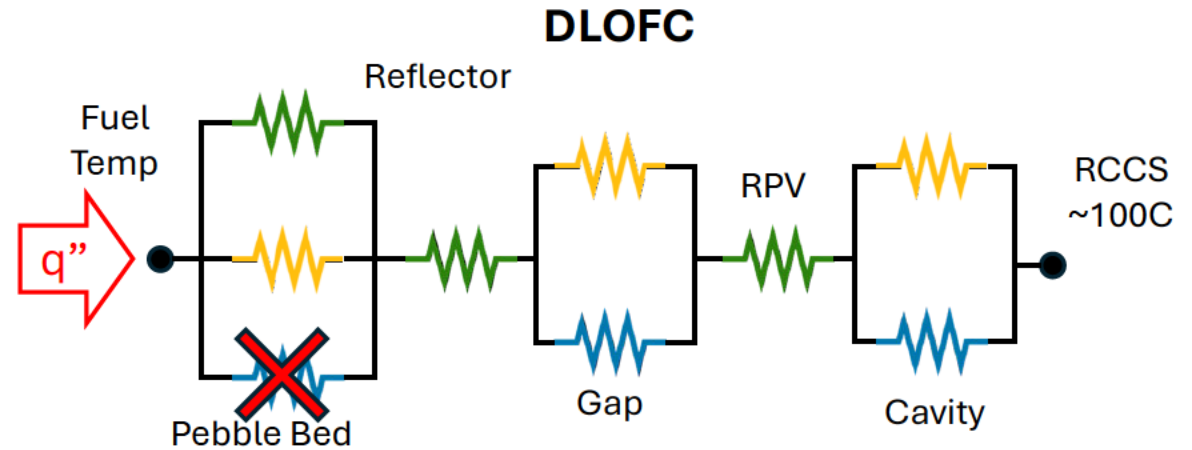
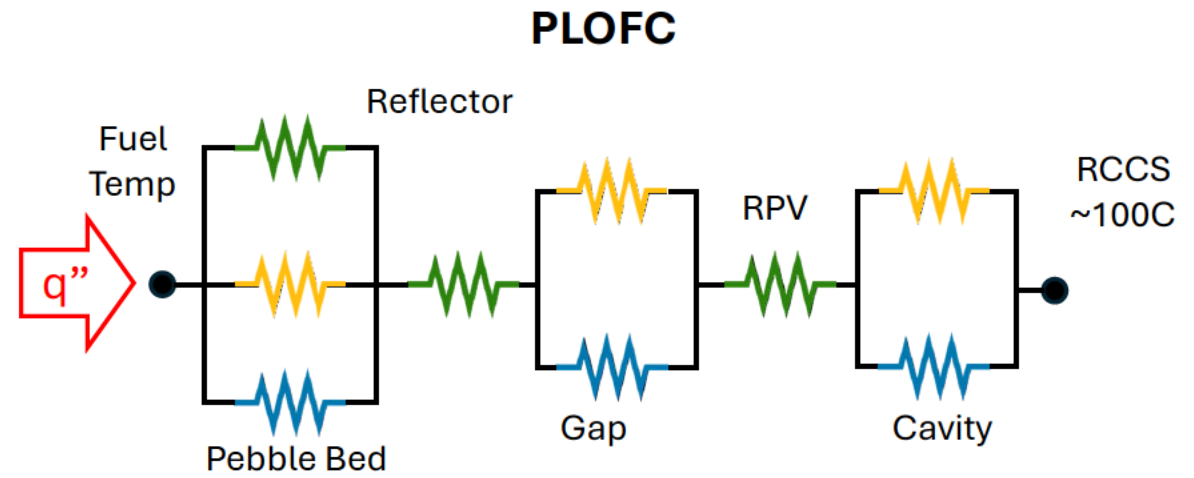
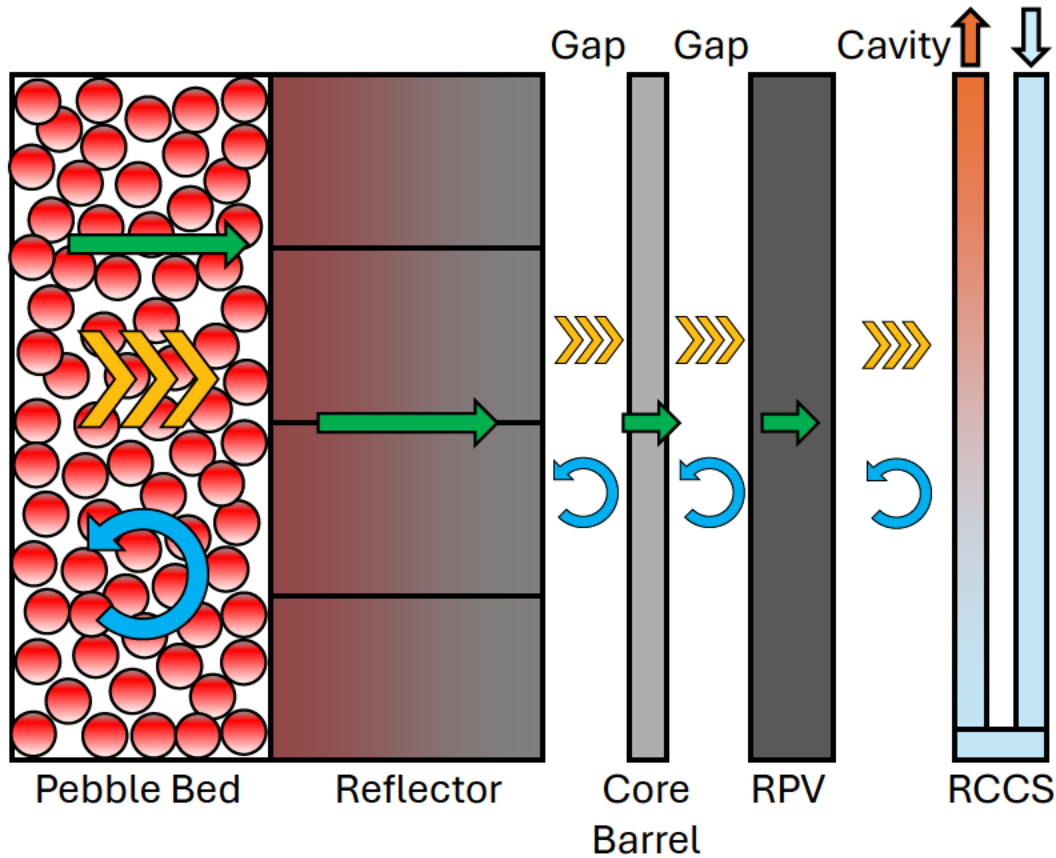
Instabilities

- Rate of vapor generation is assumed to be slower than the rate at which liquid and vapor can separate. Assumed effective steam separation within the riser header, with vapor venting through goosenecks and liquid remaining in the headers/standpipes.
- Potential geysering has been shown to generate high pressures that could lead to significant structural stresses, making it the primary concern.
- Potential parallel-channel instabilities are not inherently problematic on their own, but they may create conditions that promote geysering and degrade thermal performance.
- These phenomena are being evaluated through detailed analyses and design changes will ensure instabilities do not comprise the RSF of the system.



KEY MESSAGE: RCCS boiling-related instabilities are recognized, are being evaluated in detail, and design updates will ensure they are either designed out or shown not to challenge RSF or long-term system performance.

Limiting Scenarios

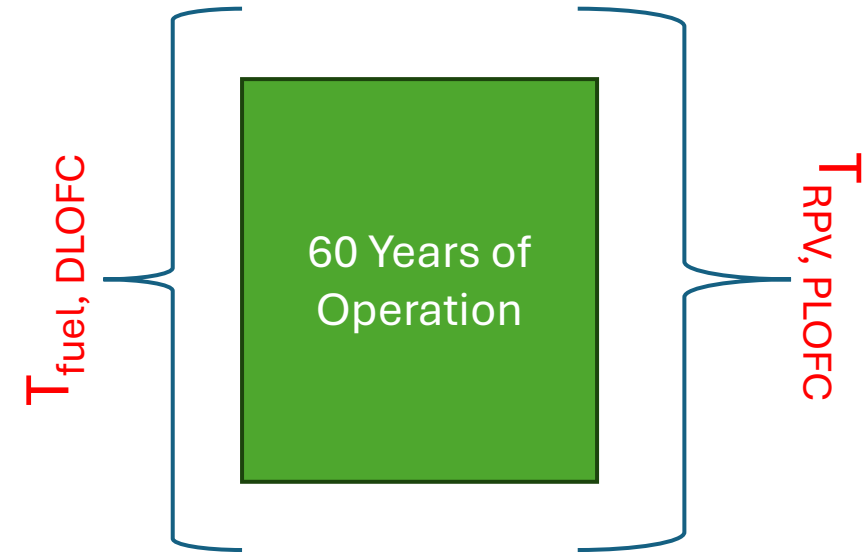


$q''_{\text{PLOFC}} > q''_{\text{DLOFC}}$ hence $T_{\text{fuel,PLOFC}} < T_{\text{fuel,DLOFC}}$ but $T_{\text{RPV,PLOFC}} > T_{\text{RPV,DLOFC}}$

KEY MESSAGE: DLOFCs are limiting for fuel temperature whereas PLOFCs are limiting for the RPV Temperature

Limiting Scenarios

- **RPV temperature**, including uncertainties, must satisfy the **ASME Section III, Division 5** limits throughout the reactor's operational life.
- **Fuel temperature**, including uncertainties, must remain below the fuel qualification limit of 1900°C across the entire operational life of the reactor.
- **These two limits can compete.** Insulating material between the RPV and the fuel lowers heat flux, reducing RPV temperature during a PLOFC but raising fuel temperature during a DLOFC. In contrast, lowering the reactor cavity's thermal resistance significantly reduces RPV temperature with little impact on peak fuel temperature.
- **The safety analysis model focuses primarily on fuel temperature for dose calculations.** It uses reflector graphite properties at end of life, further reduced to account for uncertainty and maximize fuel temperature. This conservatism inevitably yields lower RPV temperatures, but still provides useful insight into the available margins, which will be confirmed through dedicated design studies.



KEY MESSAGE: Peak fuel and RPV temperatures stay within their qualification limits for the full plant life; the conservative, fuel-focused safety model gives ample RPV margin that dedicated design studies will confirm.

RCCS Performances during BDBEs

- **RCCS Pipe-failure scenarios are classified as BDBEs**, reflecting the passive design and the reliability of its components.
- **A pipe break in either of the two trains drains only the affected tanks.** Water in the remaining pipes is retained, and pipe volume exceeds tank volume, so significant cooling capacity is preserved.
- **Staggering the pipes across the two trains** ensures every portion of the RCCS can still radiate heat to the intact train even after one train fails, which would not be possible without staggered piping.
- **RCCS performances can be effectively predicted using GOTHIC**, which is currently being validated against boil-off transients performed at NSTF.

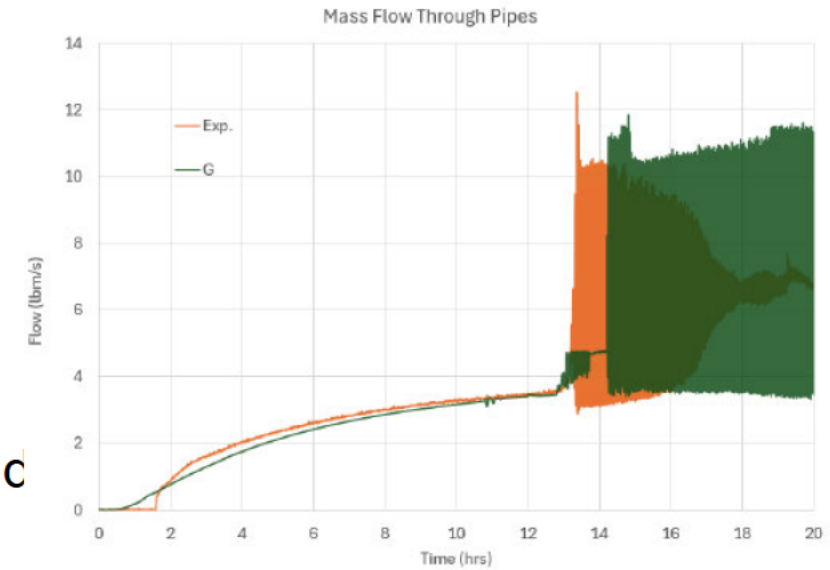


Figure 13 Test057 Mass Flow Rate

[[

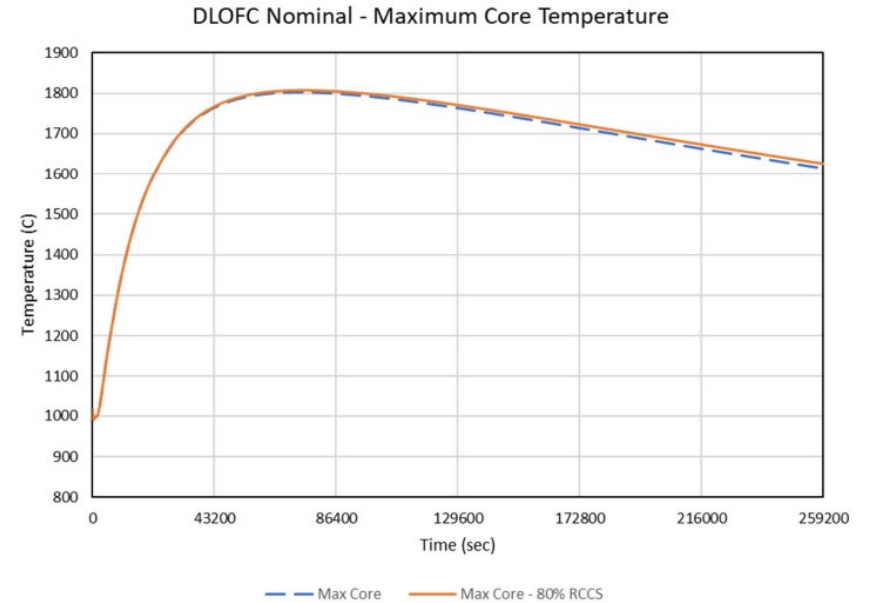
KEY MESSAGE: Even if one train fails during a BDBE, the RCCS does not lose all of its function; by design, it continues to remove heat from the RPV



]]^P

RCCS Performances during BDBEs

- **Losing one train does not significantly affect fuel temperature.** The concrete behind the RCCS has high thermal inertia, and the water remaining in the pipes ensures the failed train does not heat up quickly.
- **RPV temperature will rise compared to the two-train case, but mitigating strategies are available:**
 - **Surface treatment of RCCS and RPV emissivities** has not yet been considered, but it has the potential to lower RPV temperature; a requirement could be added if needed.
 - **Reducing HPB pressure during a PLOFC** is another option to lower stress on the RPV and extend its life if needed.
 - **Insulating the concrete.**



KEY MESSAGE: The RCCS stays effective on a single train, fuel temperature is largely unaffected, and the RPV temperature rise can be offset with available mitigations if required.



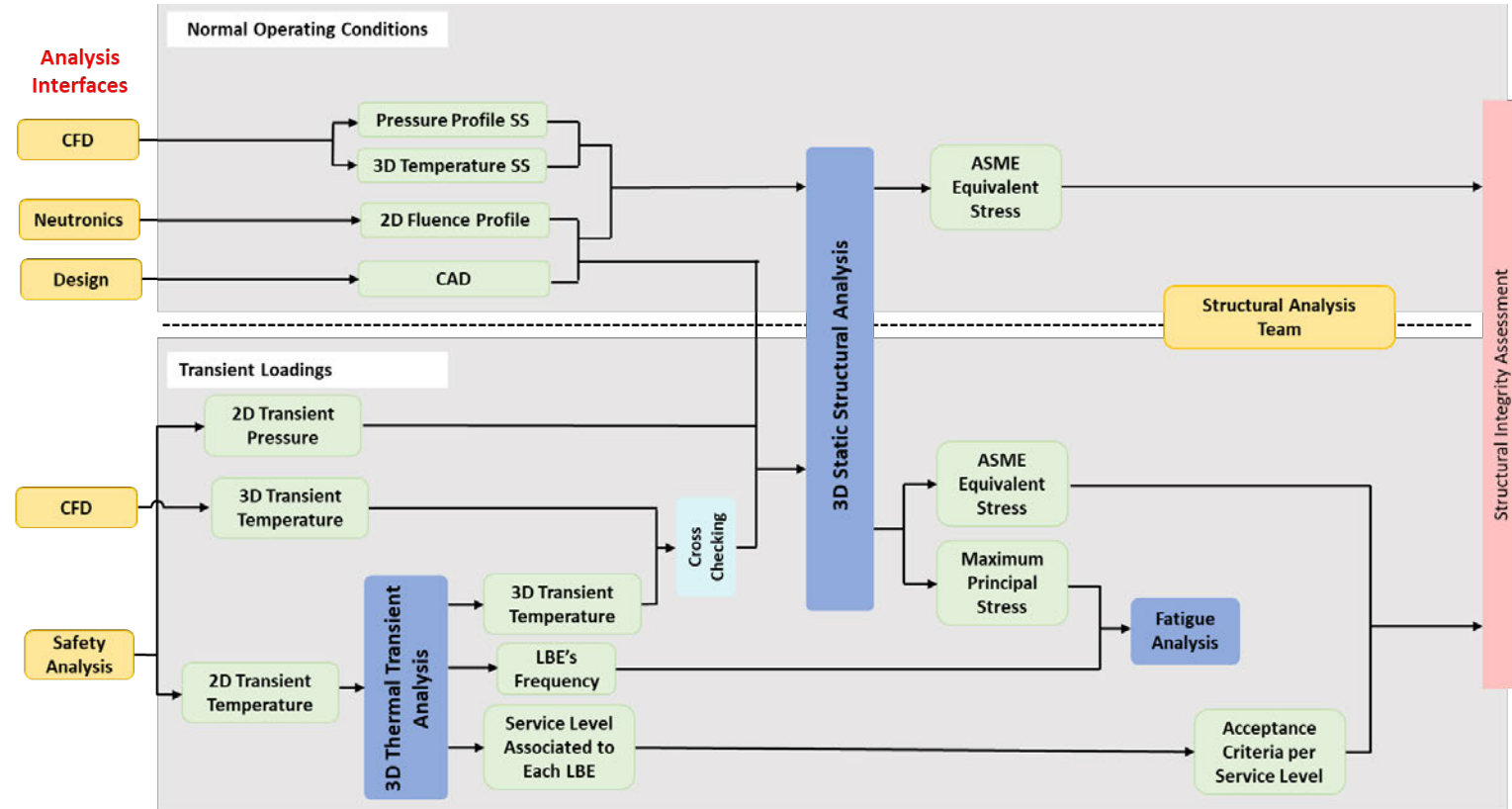
Focus Area #5

RSF 1.4

Maintain Geometry

Core Structural Integrity and Geometry Maintenance

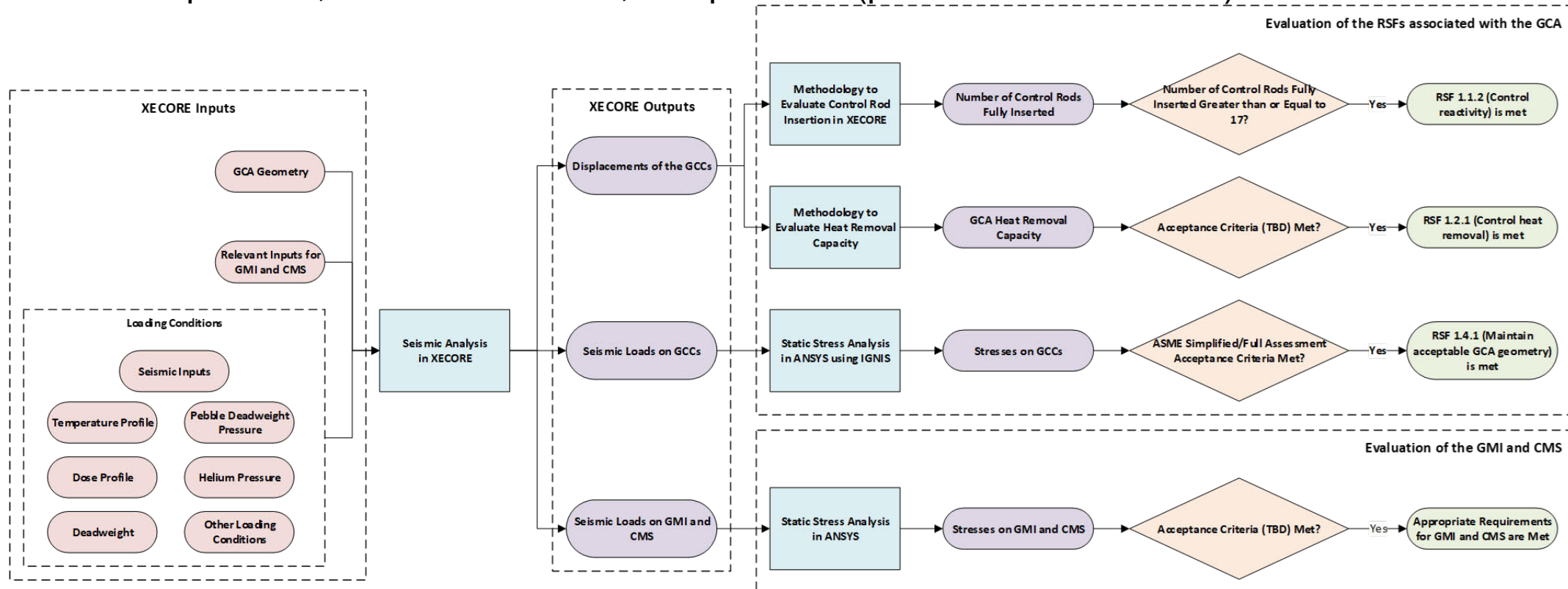
- Relevant normal operation loads are combined at various times of life.
 - Temperature (normal operation and transient)
 - Neutron irradiation
 - Pressure (pebble bed and differential helium)
- Seismic (next slide)
- Loads not currently considered:
 - Graphite oxidation being evaluated but not currently considered in analysis (anticipating <1%)
 - Reactor pressure boundary is not subject to flood conditions.



KEY MESSAGE: Core integrity assessed using relevant load combinations at various times of life during normal operation and transient LBEs.

Core Structural Integrity and Geometry Maintenance

- Seismic analysis performed starting at various times of life
 - Modeling using LS-Dyna considers initial GCA deformed shape and geometry from temperature, neutron irradiation, and pressure (pebble bed and helium)



KEY MESSAGE: Seismic events assessed at various times of life that includes the relevant pre-event load combinations and degradation.

Core Structural Integrity and Geometry Maintenance

- Passive Heat Removal
 - Models account for the reduction in radial heat conduction at the perpendicular “Inner Side Reflector (ISR) / Outer Side Reflector (OSR)” & “OSR / Core Barrel interface gaps.”
 - Primary heat transfer mechanism is radiation through gaps
 - Negligible reduction in radial heat transfer if those gaps increase by less than ISR width
 - Gaps parallel to the direction of heat transfer
 - Dependent on conduction path cross sectional area
 - If gaps open, conduction paths stay the same or increase if convection increases

KEY MESSAGE: Effect of GCA misalignment on passive heat removal within design clearances is either negligible or increases heat transfer



Core Structural Integrity and Geometry Maintenance

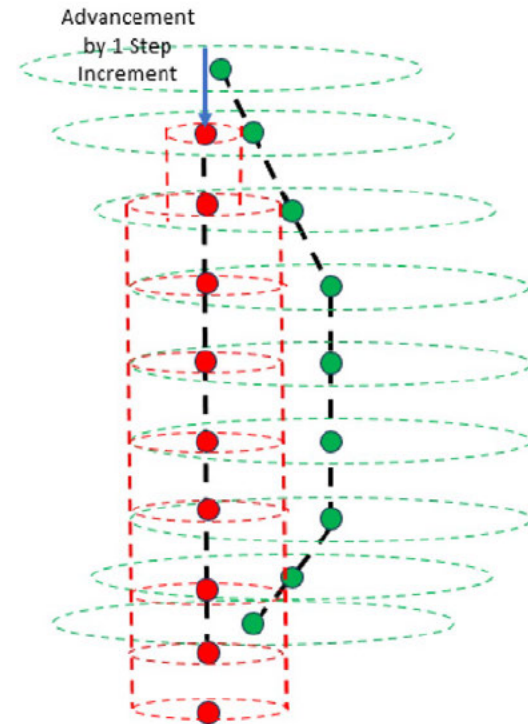
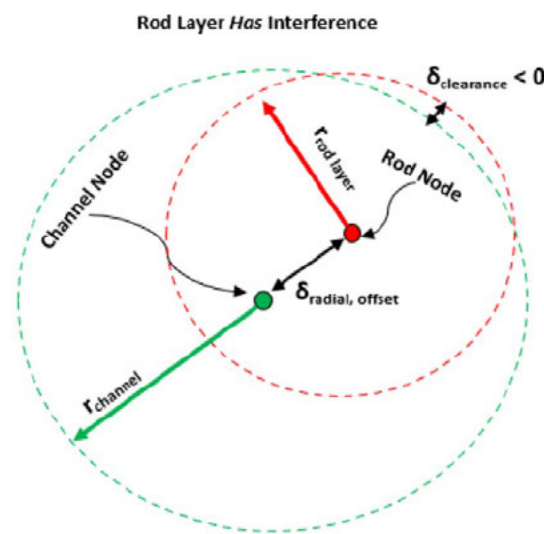
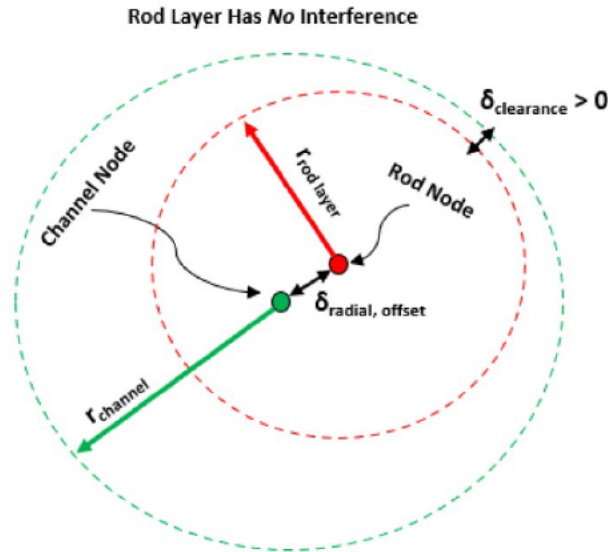
- Control Rod Insertion
 - Control rod is assembly of 5 individual articulating rods
 - Control rod channels machined through 20 graphite reflectors and include guiding control rod sleeves
 - Design clearances at multiple interfaces:
 - Control rod diametral clearance
 - Side Reflector dowel clearance
 - Diametral control rod sleeve clearance
 - Graphite to core barrel clearance
 - Innumerable number of potential configurations for control rods to insert through

KEY MESSAGE: There is not a deterministic misalignment tolerance for control rod insertion



Core Structural Integrity and Geometry Maintenance

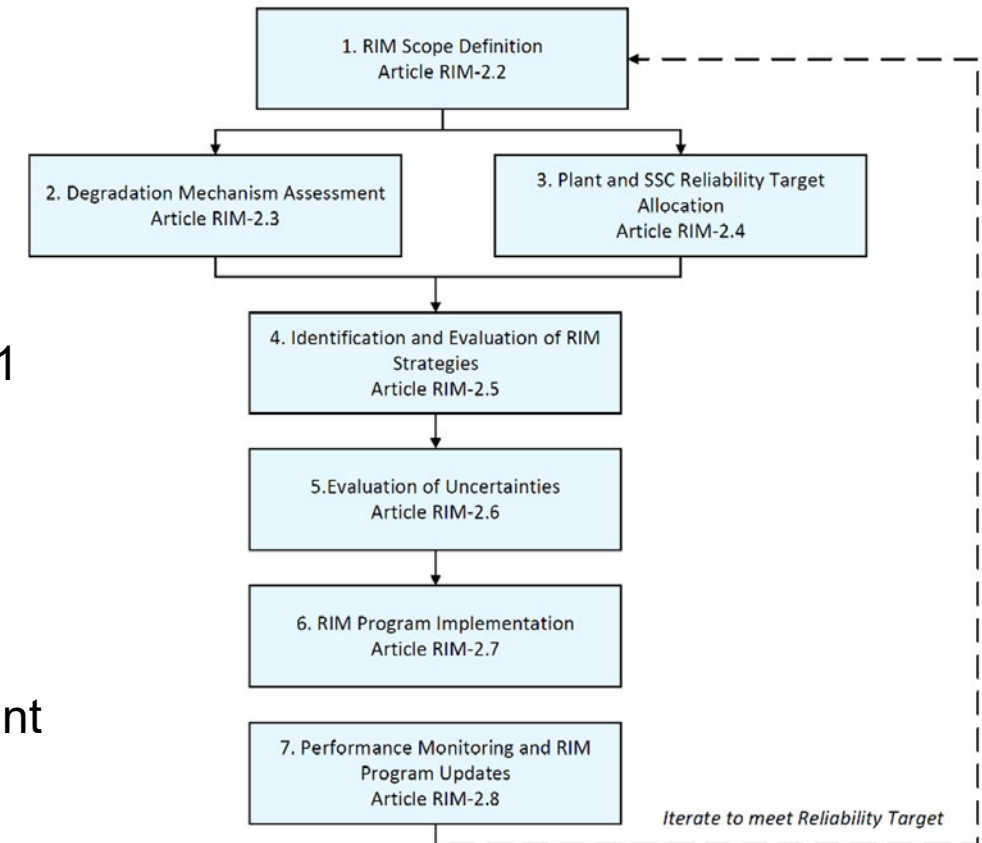
- Detailed analysis to evaluate control rod insertion
 - System level modeling (LS-Dyna) to predict deformed and displaced GCA geometry during normal operation and following a seismic event
 - Iterative rigid kinematic model evaluates ability to insert control rods through geometry at all states
 - Methodology based on proven AGR LEWIS software



KEY MESSAGE: Control rod insertion evaluated using proven methodology at all relevant times of life including post-seismic conditions.

GCA – Reliability and Integrity Management Program (RIM)

- Graphite block and supports failures are detectable and inspectable through the life of the plant
- LME has committed to ASME Section XI, Div 2 (RIM program)
- The RIM program is designed to ensure that passive SSCs meet their reliability targets over the plant's life cycle
- It is intended to address the unique challenges of advanced reactor designs where traditional ASME Section XI Division 1 inspection standards (developed mainly for light water reactors) may not be fully applicable
- The LME RIM Program Document states that the baseline monitoring and non-destructive examination (MANDE) requirements must be identified in the design phase so that baseline MANDE activities can be completed by the cognizant organization.

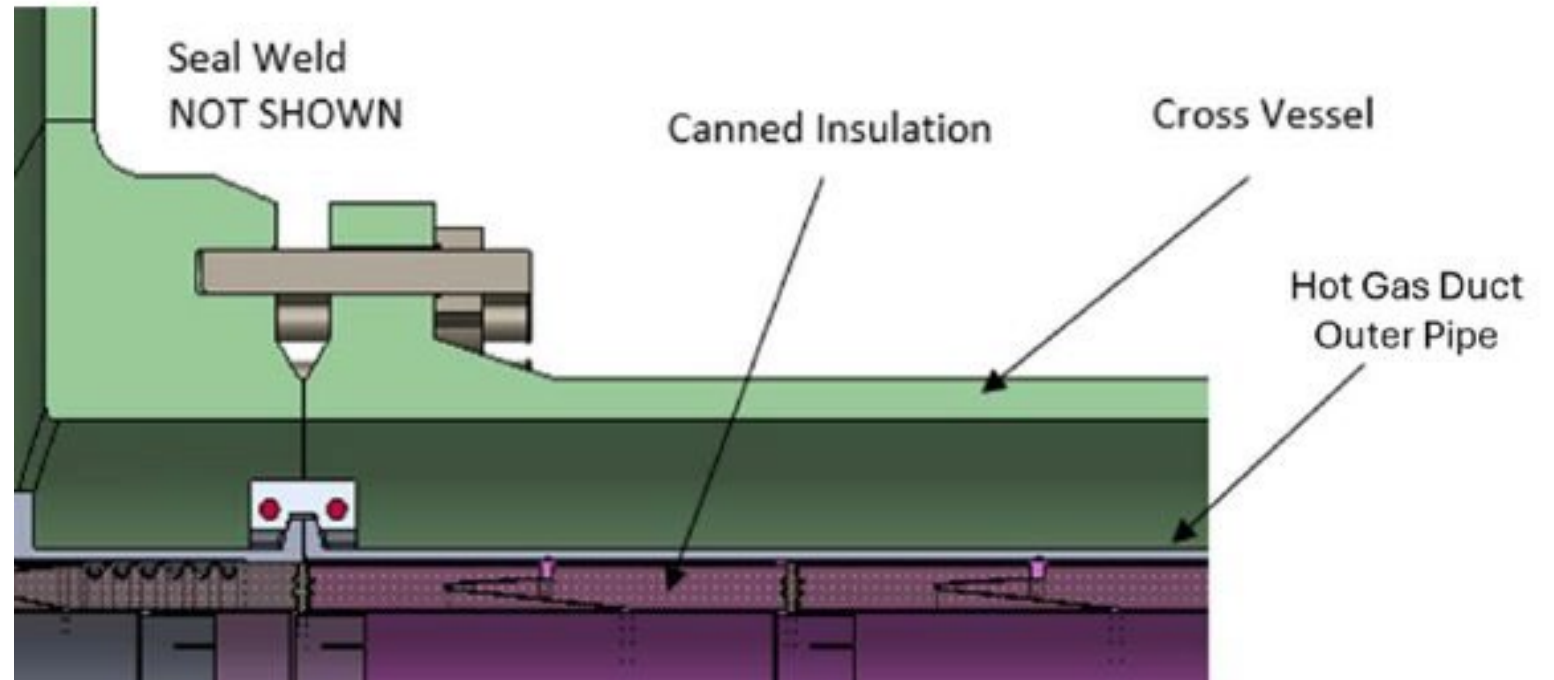


KEY MESSAGE: LME has incorporated all aspects of the RIM program in the design to detect and address safety-significant failures.



Cross Vessel End Connections

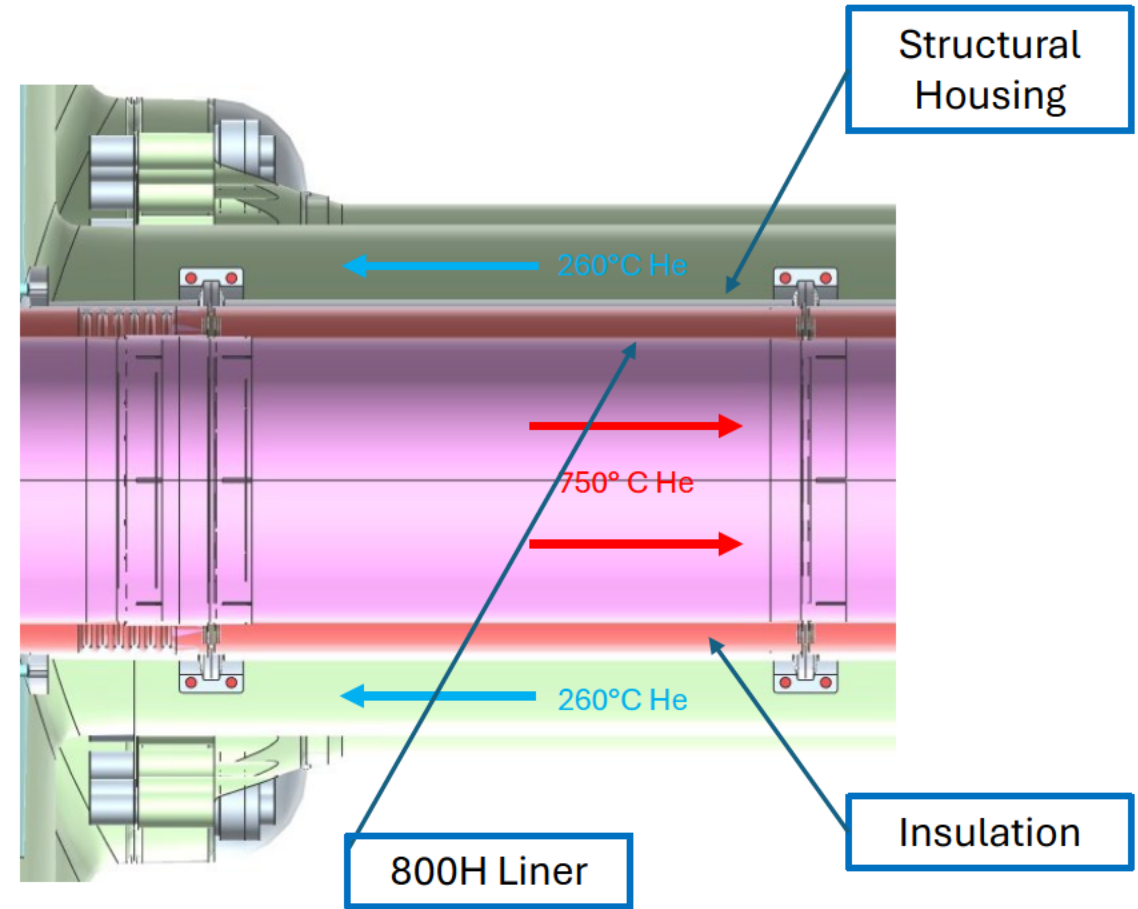
- Helium leakage from the CV is prevented by the Seal Welds at both the RPV and the SGPV interfaces
- The seal welds will be appropriately sized to account for the various loading conditions based on the design life of the component



KEY MESSAGE: The two flanged and bolted ends of the CV are sealed with welds.

Hot Gas Duct Design Features

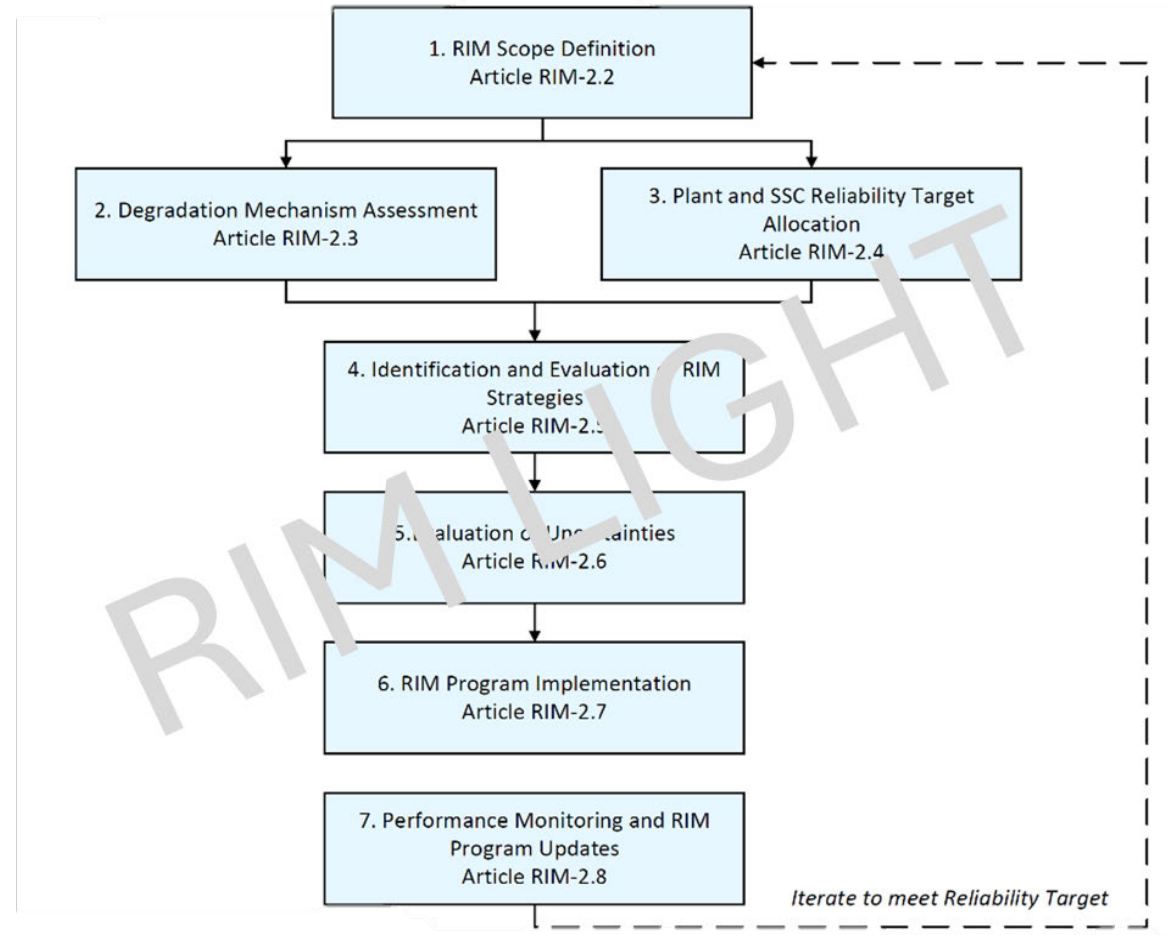
- This set of components will operate with an internal delta-T on the order of 500° C
- The Xe-100 HGD design leverages the technology matured by the German AVR design (also used by Chinese HTR-PM) to minimize the differential pressure load across the hot liner wall; and to allow for free axial extension of the hot liner to reduce thermal stress
- While the hot liner does not provide any structural function, it will be assessed by the acceptance criteria of ASME Section III, Division 5, Subsection HG, Subpart B, as supplemented by an ASME material code case
- The outer HGD structural shell operates at low temperature per ASME Division 5, but high temperature alloy is used for construction to provide significant temperature margins



KEY MESSAGE: The HGD robust design has conservatism incorporated to include following ASME Section III, Div 5

CV-HGD Reliability, Availability, and Maintainability (RAM)

- LME's RAM program includes the CV and HGD systems.
- At the design phase, inspection, maintenance, and monitoring for a 60-year design life is being addressed.
- The RAM program will be similar to the RIM program - referred to as "RIM Light"
- The RAM program involves design interaction, performance monitoring, inspections, tests, maintenance, and replacements as strategies to ensure the SSCs achieve the reliability targets defined through the LMP process



KEY MESSAGE: LME's RAM program will be a "lighter" version of ASME Section XI, Div 2

Cross Vessel / Hot Gas Duct Operational Envelope

- **Hot Gas Duct Design Conditions**

- Design temperature 760°C

- **Hot Gas Duct Normal Operating Condition**

- Hot Helium Temperature 750°C
 - Cold Helium Temperature 262°C
- Preliminary results of our first thermal mechanical analysis show overwhelmingly positive margins for the Hot Gas Duct.
- Design changes will be implemented as needed to address any negative stress margins.

- Designed to ASME Section III, Div 5
- which requires comprehensive evaluation of natural phenomena, including seismic events, through defined service limits for Level A, B, C, or D loading conditions.
- These categories include normal operations, anticipated operational occurrences, design basis events and design basis accidents
- ensuring component structural integrity

KEY MESSAGE: Cross Vessel and Hot Gas Duct structural and thermal analysis at CPA have met acceptance criteria.



Seismic Design Approach

- PSAR Section 3.7, “Civil and Structural Analysis” was enhanced with additional information to describe the method of seismic analysis and design for structures, systems, and components
- The seismic categorization methodology removes the direct tie to safety classifications
- A higher seismic categorization is assumed based on an SSC's seismic function until a lower category can be justified
- Seismic Categories:
 - Category I
 - Category IIA
 - Category IIB
 - Category III

Table 3.7-1: Classification of LMGS Civil Structures / Buildings

System Name	Safety Classification			Seismic Category			
	SR	NSRST	NST	Cat. I	Cat. IIA	Cat. IIB	Cat. III
Reactor Building (RB)							
Reactor Support Structure (RXST)	X			X			
Shield Structure (SST)		X			X		
Steam Generator Support Structure (SGST)		X			X		
Fuel Handling Annex Building (FHAB)		X			X		
Spent Fuel Intermediate Storage Facility (SFISF)		X			X		
Inter-Unit Access Tunnel (IUAT)		X			X		
Canister Processing Facility (CPF)		X			X		
Main Electrical Building (MEB)			X				X
Helium Service Facility (HSF)			X				X
Nuclear Island Auxiliary Structure (NIAS)		X			X		
Controls & Electrical Building (CEB)		X			X		
Radwaste Building (RWB)			X				X
Access & Security Building (ASB)			X				X
Conventional Island (CI) Structures			X				X

KEY MESSAGE: Seismic design approach for CPA used a higher seismic categorization that will be evaluated as the design progresses.

Seismic Design Approach

- The provisional/graded seismic classification ensures necessary SSCs maintain geometry at the CPA stage
- [[
-]]
-]]
- This function necessitates maintaining deflections and vibration characteristics within limits that allow the system to meet its performance goals during a seismic event.

KEY MESSAGE: Seismic design approach for CPA used a higher seismic categorization that will be evaluated as the design progresses.

System Section	Seismic Category		System Seismic Function	
	SR	NSRST	SR	NSRST
Fuel	Cat I	N/A	RSF	N/A
Core Metallic Structure (Core Barrel)	Cat I	Cat IIA	RSF	-[[]]
Graphite Core Assembly	Cat I	N/A	RSF	N/A
Defuel Chute	Cat I	N/A	RSF	N/A
Reactor Pressure Vessel	Cat I	Cat IIA	RSF	-[[]]
Reactor Pressure Vessel Support	Cat I	N/A	RSF	N/A
Defuel Chute Pressure Vessel	Cat I	Cat IIA	RSF	-[[]]
Reactivity Control and Shutdown System	Cat I	Cat IIA	RSF	-[[]]
Reactor Cavity Cooling System	Cat I	Cat IIA	RSF	-[[]]

Other Miscellaneous Items

Response to the Design Basis External Flooding Hazard

- The design basis external flood hazard is used to identify a design basis hazard level(s) (DBHLs), which then becomes a design requirement(s)
- By definition, in both NEI 18-04 and NEI 21-07:
 - DBHLs provide the level of severity or intensity of a hazard for which the Safety-related (SR) SSCs are designed to withstand with no adverse impact on their capability to perform their RSFs
 - Likewise, SR SSCs are credited in the fulfillment of required safety functions (RSFs) and are capable to perform their RSFs in response to any DBHL
 - Therefore, by definition, Non-Safety-Related with Special Treatment (NSRST) SSCs that perform NSRST PSFs are not required to perform their NSRST PSFs in response to any DBHL
 - Depending on the hazard, some NSRST SSCs are expected to remain functional
- Similarly, but distinct from the above, NEI 21-07, Section 6.1.3 states that both NSRST and Non-Safety-Related with No Special Treatment (NST) SSCs must have design requirements to support special safety functions to prevent adverse impacts on the ability to SR SSCs to perform RSFs
 - For example, during the design basis external hazard, the NSRST Shield Structure cannot fail in such a way as to impacts the Reactor Cavity Cooling System (RCCS) from performing its RSF of Control Heat Removal.

Response to the Design Basis External Flooding Hazard

- Design considerations for an external flood can be split into two categories:
 1. Structural design of credited flood barriers (structures and their openings)
 2. SSC behavior and survivability under submerged conditions:
 - 1.Ensure SSC functions are available by raising SSC above DBHL flood height
 - 2.Ensure SSC functions are available by ensuring SSC location is watertight
 - 3.Qualify necessary SSC functions when submerged
- Design Approach:
 - DBHL still flood level is approximately ~5.5 ft with ~15ft of wave runup
 1. Structures are designed to withstand flood loads as described in PSAR Section 3.7
 2. All SR SSCs except for fuel are located above the DBHL flood height, ensuring their functionality under the postulated DBHL conditions
 3. Fresh and spent fuel has been qualified to remain in a safe state when submerged as detailed in PSAR Section 3.9
 4. The feasibility of waterproofing cavities housing SR SSCs as an additional layer of defense will be evaluated will be evaluated during the OLA development
 5. Operating procedures to shutdown the plant in anticipation of the design basis external flood to include capabilities to meet Defense-in-Depth Layers 4 and 5 will be assessed

KEY MESSAGE: The DBHL flood has been adequately considered in the LMGS plant design by ensuring SR SSCs are protected by at least one and possibly more layers of protective measures

NRC Review of Long Mott Generating Station Construction Permit Application

**ACRS Subcommittee Meeting
September 15, 2026**

Office of Advanced Reactors (OAR)

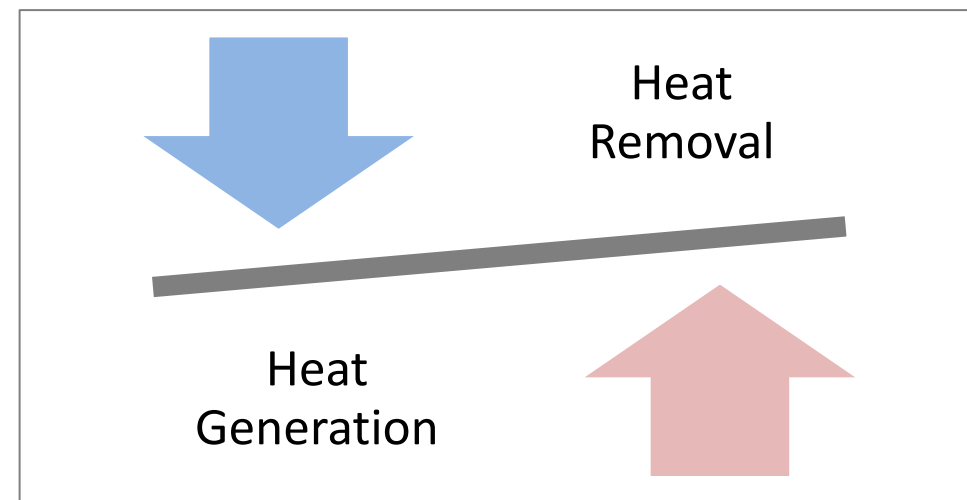
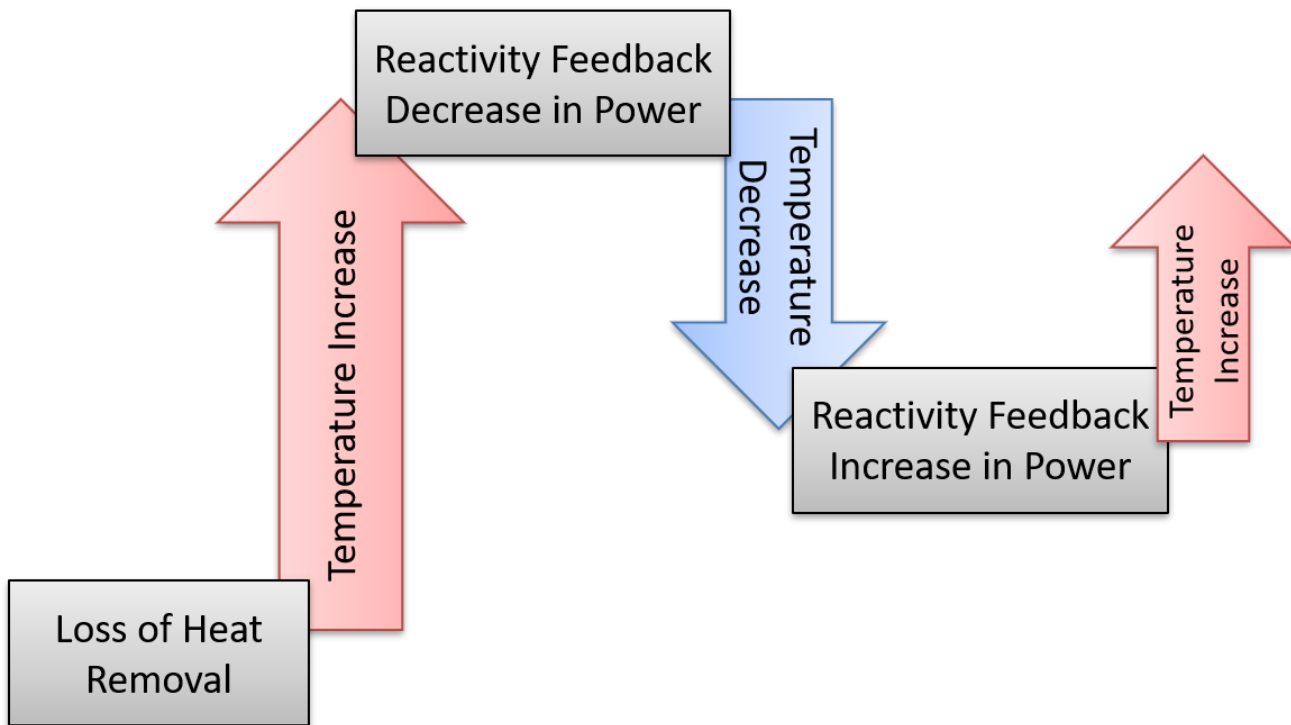
Topic Areas

- Inherent reactivity control and transition from safe state to shutdown state
- Heat removal systems and RCCS performance
- Core structural integrity and geometry maintenance
- Seismic and flooding design aspects

Inherent Reactivity Control and Transition from Safe State to Shutdown State

Tracy Radel, Sr. Nuclear Engineer, OAR/DARE/AREB1

Inherent Reactivity Feedback Balance



Inherent Reactivity Feedback Analysis

- LME is in the process of evaluating long-term reactivity and power level without rod insertion
- Analysis shows damped reactivity oscillations with equilibrium power level dependent on what heat removal mechanisms are available
- Evaluating full range of heat removal scenarios within the scope of LBEs for OL to demonstrate that scenarios evaluated for FSAR bound all possible heat removal scenarios
- Preliminary analysis shows that bounding scenario is with low heat removal, as analyzed in the PSAR

Transition from Safe State to Shutdown State

- Control rods safety-related for maintaining long-term subcriticality
- Reactivity control and shutdown system (RCSS) has two separate rod banks
 - Reactivity control system (RCS)
 - Reserve shutdown system (RSS)
- Each rod bank consists of nine absorber rods with dedicated CRDMs
- RCS is used for reactivity control during normal operations
- RSS does not perform any at-power control function
- Both RCS and RSS, insert on trip signals from the investment protection system and the reactor protection system (RPS) to reach a shutdown state

Failure to Trip

- RPS includes a function to trip the helium circulators if neutron flux detectors indicate that the reactor trip failed
 - There are 19 LBEs where one or more modules fail to trip
 - One is a DBE, rest are BDBEs
 - Four require DBAs, currently mapped to seismic DBA
- Capability to remove fuel through the fuel handling system to reduce reactivity if rods do not insert

Heat Removal Systems

Santosh Bhatt, Sr. Nuclear Engineer, OAR/DARE/AREB3

LBEs Included in PSAR

16 Transient Types (40 Initiating Event Types)

- Reactor trip (RT)
- Turbine trip (TT)
- Main steam line break (MSLB)
- Main feedwater line break (MFLB)
- Control rod group withdrawal (CRW)
- Small depressurization (SD)
- Medium depressurization (MD)
- Large depressurization (LD)
- Loss of primary flow (LPF)
- Loss of steam generator feedwater (LFW)
- Steam generator tube leak (SGTL)
- Steam generator tube rupture (SGTR)
- Loss of reactor building cooling water (RBC)
- Loss of instrument air (LOIA)
- Loss of condenser heat sink (LHS)
- Loss of offsite power (MLOOP)

289 non-DBA LBEs

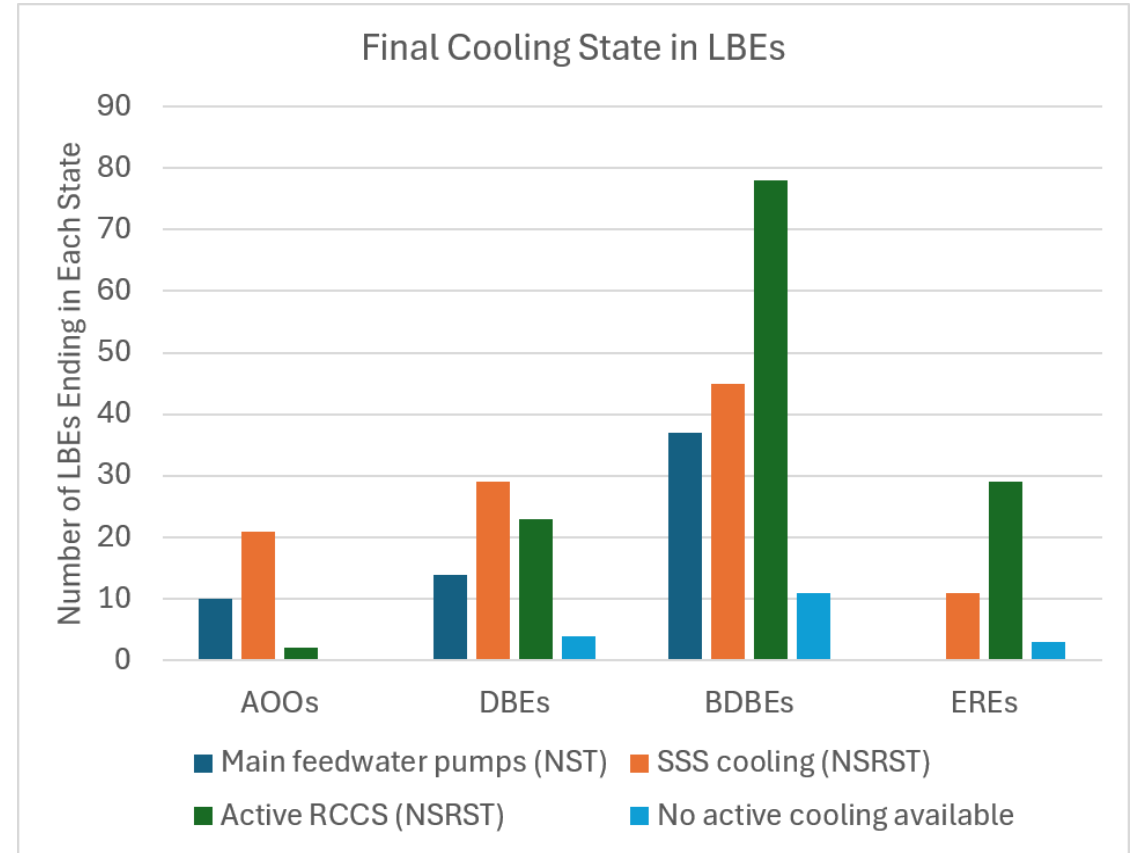
- 38 AOOs
 - 17 risk-significant
- 66 DBEs
 - 7 risk-significant
- 185 BDBEs
 - 21 risk-significant

10 DBAs

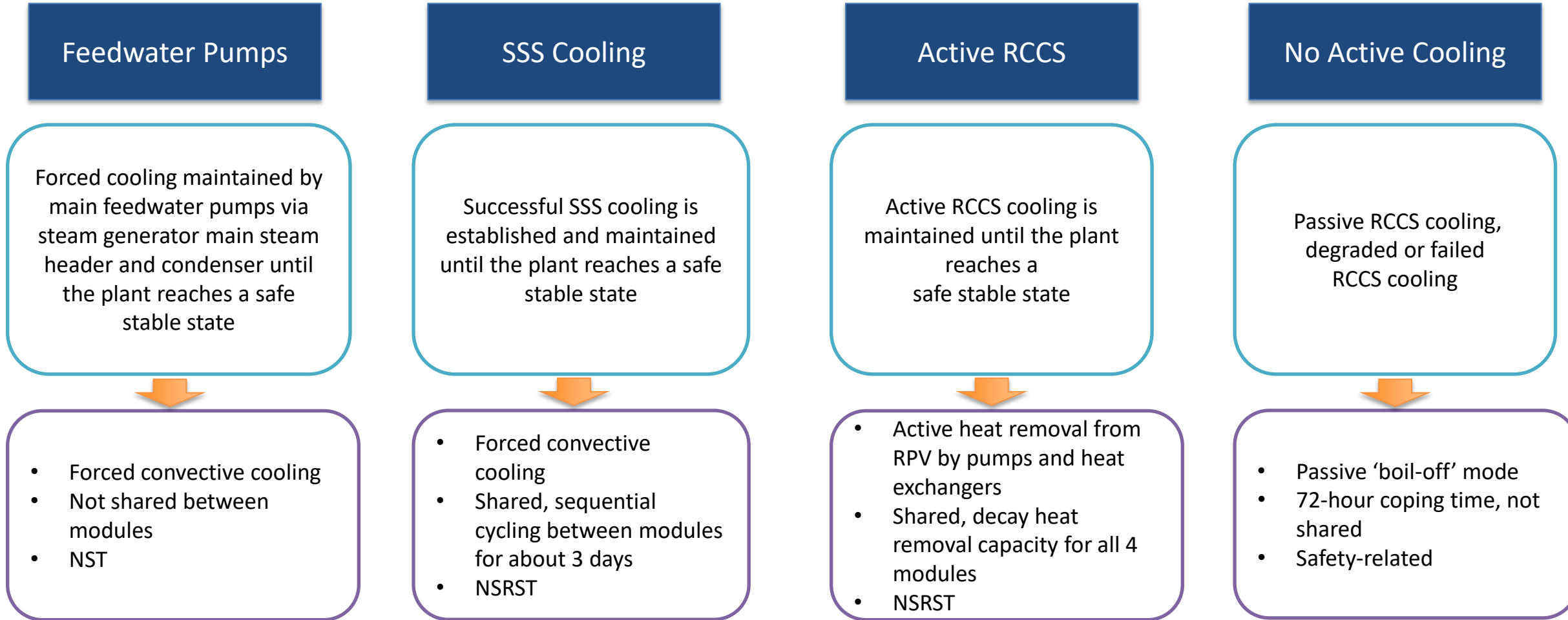
- Single module control rod withdrawal (SCRW)
- Multimodule loss of primary flow (MTLPF)
- Small depressurization (SD)
- Medium depressurization (MD)
- Multimodule loss of feedwater (MTLFW)
- Multimodule feedwater line break (MFLB)
- Multimodule steam line break (MSLB)
- Steam generator tube leak (SGTL)
- Steam generator tube rupture (SGTR)
- Seismic

Heat Removal in LBEs versus Consequence Analysis

- All AOOs end in active feedwater cooling or SSS cooling
- Small number of DBEs, BDBEs and extremely rare events (EREs) end in no active cooling available
- Pressurized loss of forced cooling (PLOFC) and depressurized loss of forced cooling (DLOFC) results were added to any event that ended in a long-term RCCS cooling
- PLOFC and DLOFC were run using passive RCCS (SR)
 - Result is higher dose consequences for LBEs with active cooling available



Final Cooling States in LBEs



RCCS Performance

Pravin Sawant, Sr. Nuclear Engineer, OAR/DARE/AREB5

Safety Significance

- Passive SR standpipe functional area (SFA) subsystem removes decay heat from core and reactor cavity through conduction, radiation, and convection to a series of standpipes surrounding the vessel
 - Standpipes are filled with water which boils off to passively remove heat
 - SFA is designed to transfer sufficient heat during DBEs and DBAs
 - to ensure fuel and radionuclide release limits are not exceeded
 - to limit the RPV temperature to maintain core geometry
- Active NSRST process functional area (PFA) subsystem operates with SFA to remove cavity heat during normal operation and certain LBEs using pumps and heat exchangers
- Design aligns with PDC-RFDC 34 and PDC-CDC 34 (passive/active residual heat removal)

Design Features – Safety-Related SFA

- Two independent trains per reactor module; each train has 25 standpipes with downcomer and riser sections (14-inch OD) connecting headers
- Two boil-off tanks above downcomer headers; riser headers and tanks vent to atmosphere via gooseneck vents
- All SFA components within shield structure (SST) except vents that penetrate the roof of SST
- Total inventory in tanks, riser headers, and riser standpipes above RPV head is sized for ~72 hours passive cooling with defense-in-depth makeup options
- Loss of active cooling triggers natural circulation and boil-off
- Operation requires no power or operator action in passive mode

Design Features—NSRST PFA

- Shared across four modules: three pumps, six air-cooled heat exchangers (~150% capacity), supply/return piping, and instrumentation
- Supply and return piping elevation above boil-off tank level prevents siphoning and preserves SFA inventory during PFA-side leaks/breaks
- NSRST motor-operated isolation valves (manual override) on each module's interface with the SFA allows isolation of affected SFA train in the event of a detected leak or break in SFA subsystem preventing loss of PFA inventory
- All SR supply and return piping is inside SST, NSRST supply and return piping is outside SST
- Active cooling maintains reactor cavity concrete temperatures $< \sim 65^{\circ}\text{C}$ during normal operation

Environmental Effects and Dynamic Effects (PDC 4)

- Focus areas for review of PDC 4
 - Thermal fatigue from temperature fluctuations associated with potential two-phase flow and boiling instabilities
 - Plans to develop temperature fields for bounding transient and to evaluate thermal stresses using analysis consistent with ASME Section III, Div 5
 - Fouling effects on RCCS heat-removal performance
 - Chemistry control program maintains acceptable water quality and limits fouling
 - Potential for stress corrosion cracking
 - Water chemistry program maintains low chloride level lowering SCC risk

Sharing of SSCs (PDC 5)

- RCCS design features minimize impact of shared PFA
 - Supply and return piping elevation
 - Preserves 72-hour SFA boil-off inventory of each module if there is break in PFA piping
 - Motor-operated isolation valves on the supply and return piping
 - Allows isolation of affected SFA if there is break in the SFA standpipes
 - Isolation valves and associated operator action classified as NSRST
 - Not required to protect 72-hour SFA boil-off inventory in unaffected modules
 - If a single module goes through transient
 - PFA continues to cool unaffected modules without impairment due to large heat removal capacity

RCCS Design Issues (PDC-RFDC 34)

- Focus areas for review of long-term cooling performance of RCCS
 - Separation of steam in the riser standpipes and headers
 - Boiling instabilities such as geysering and parallel channel instabilities can induce mechanical and thermal stresses and affect performance
 - Level swell in riser pipes and headers may result in entrainment and loss of RCCS inventory
 - Transition from single phase natural circulation to boiling and two-phase flow impact RCCS performance and structural integrity (e.g., temperature gradient and standpipe bowing)
- PSAR commits to address these aspects through further analysis and by implementing design changes, if necessary, in final design

RCCS PSAR Analysis

- PSAR analysis used a boundary condition to model RCCS heat removal in GOTHIC and Flownex
 - Derived from air-cooled RCCS design
 - Expected to provide conservative results as compared to water-cooled RCCS design
 - Higher heat transfer coefficient (convective and boiling heat transfer in water cooled RCCS)
 - Larger heat transfer area

RCCS Evaluation Model

- PSAR provides commitment to develop evaluation model for water-based RCCS using RG 1.203 process (EMDAP)
 - Fundamental phenomena and processes at the subsystem and component level for water-based RCCS are generally well understood (e.g., radiation, conduction, convection, and boiling heat transfer)
 - Unique geometry and configuration of passive RCCS introduces uncertainty regarding integral system performance over time, particularly during the long-term cooling phase
 - Several critical aspects of water-based RCCS performance are expected to be addressed with additional testing and model development

Additional Testing and Model Development

- PSAR identifies development activities required to produce a water-cooled RCCS evaluation model consistent with RG 1.203
 - Experimental validation using NQA-1 NSTF data
 - Top-down and bottom-up scaling and distortion analyses to show the applicability of NSTF data to the Xe-100 RCCS across full range of conditions expected during long-term passive cooling
 - If needed, PSAR commits to perform additional integral-effects or separate-effects testing under an appropriate test program
 - EMDAP process is expected to identify and account for gaps in applicability of experimental data and evaluation model
- PSAR provides commitments to perform pre-operational and startup testing to confirm RCCS performance under conditions as close as practical to those expected during LBEs

Core Structural Integrity and Geometry Maintenance

Clair Song, Mechanical Engineer, OAR/DARE/AREB3

Meg Audrain, Materials Engineer, OAR/DARE/AREB1

Materials Review Overview

- Materials qualification plan described in PSAR section 3.8. Includes requirements for:
 - Code supplementation
 - Welds that do not have design rules within III-5
 - Extension of qualified lifetime beyond 300,000 hr
 - Extension of qualified temperature and fatigue curves
 - Bolting material
 - Stress relaxation cracking
 - Environmental compatibility assessment
 - Degradation mechanisms assessment
 - A limited scope of the materials qualification plan is included in PSAR Ch. 13 as an R&D item
- LME differentiates treatment of NSRST SSCs based on risk-significance in the following areas:
 - R&D scope
 - RIM vs RAM for in-service monitoring and inspection
 - IST vs maintenance program for in-service testing

Graphite Core Assembly

Graphite Core Assembly

Classification: safety-related

Key Design Aspects	• ASME Section III Div 5, two grades of graphite • “Graphite Core Assembly Material Qualification and Design Methodology” supports material qualification and design
R&D scope	• Staff implemented 25 Conditions on TR: • Justification for Code departures • Demonstration that properties and methodologies are supported • Demonstration of IGNIS analysis tool
Dynamic Effects	• Seismic Category I; design meets 10 CFR 50 Appendix S • Rod insertion evaluation method in development; will consider GCC displacement due to thermal effect, irradiation, and external loadings (e.g., seismic); to be verified by testing and LS-DYNA analyses
Programmatic Treatment	• Appendix B QA • RIM; preliminary MANDE includes visual inspection, temperature, radiation, and chemistry monitoring

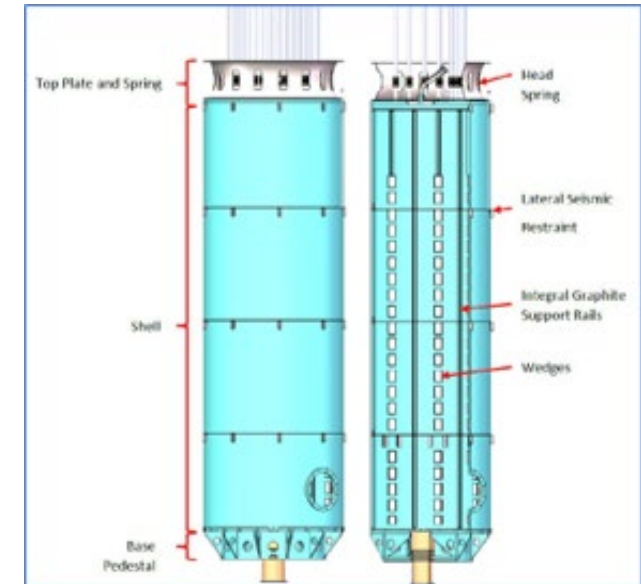
PROP, ECI

Core Metallic Structure and Reactor Pressure Vessel

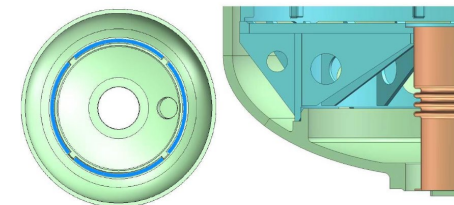
Core Metallic Structure (CMS) Reactor Pressure Vessel (RPV)

Classification: safety-related

Key Design Aspects	• ASME Section III Div 5 • CMS provides vertical support to core through CB base pedestal connected to RPV bottom and closure spring at the top lid • CMS provides lateral support to core through graphite lateral supports (under design) and transfers load to RPV through bumpers at top of CB shell sections that make even contact to RPV inner surface
R&D scope	• Anticipated future use of ASME Div 5 HGB for CB base pedestal (2.25 Cr-1Mo); Code supplementation needed to extend lifetime of base pedestal material • Environmental compatibility assessment required
Dynamic Effects	• Seismic Category I; design meets 10 CFR 50 Appendix S
Programmatic Treatment	• Appendix B QA • RIM; preliminary MANDE includes visual inspection, temp, radiation, and chemistry monitoring



CMS Components



RPV CB Support Ledge

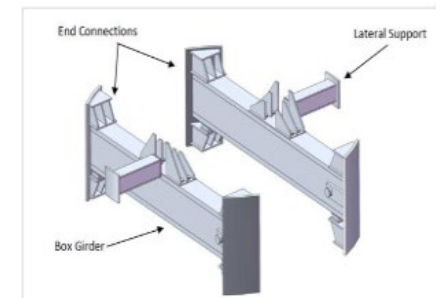
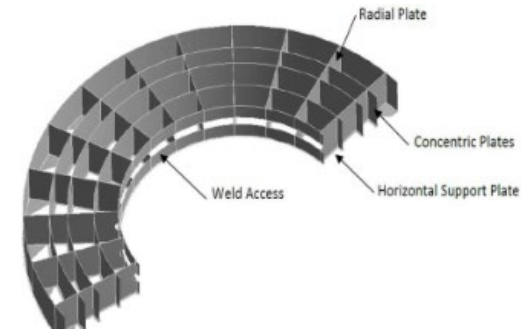
Reactor Vessel Support Structure and Reactor Support Structure

Reactor Vessel Support Structure (RVSS)

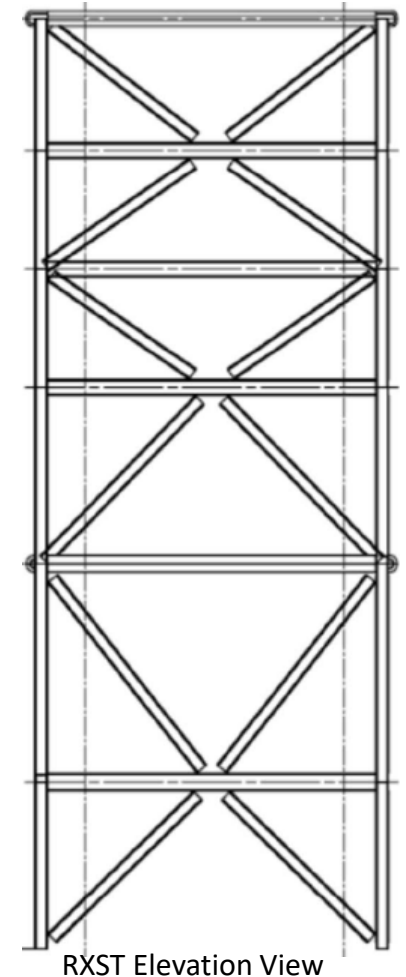
Reactor Support Structure (RXST)

Classification: safety-related

Key Design Aspects	- RVSS provides vertical and lateral supports to RPV and core - Designed to ASME Section III Div 5 - RXST provides additional vertical and lateral support for RPV - Designed to AISC N-690 (nuclear standard for SR steel structures)
Dynamic Effects	Seismic Category I; design meets 10 CFR 50 Appendix S
Programmatic Treatment	- Appendix B QA - RIM for RVSS; preliminary MANDE includes visual inspection, temperature, radiation, and chemistry monitoring - Preliminary maintenance programs requirements for the RXST include visual inspection, temperature, radiation, and seismic monitoring



RVSS Top Ring and Lower Supports



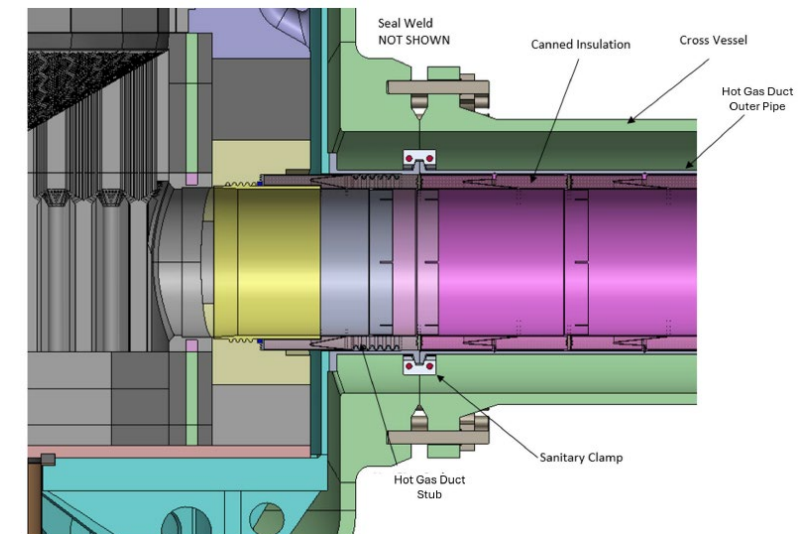
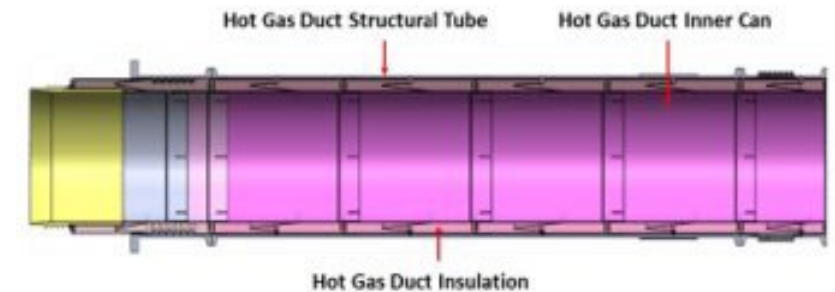
RXST Elevation View

Hot Gas Duct and Cross Vessel

Hot Gas Duct (HGD) and Cross Vessel (CV)

Classification: NSRST

Key Design Aspects	- HGD: ASME Div 5 HGA/HGB; Material 800H and NST insulation; Design temperature 760 °C - CV: ASME Div 5 HBA; Material AS-508; Design temperature 285 °C
Materials Qualification scope	- HGD included in Materials Qualification Program - Code supplementation needed *Extend lifetime of 800H to [[]] ^{PROP} - Extend qualified temp for 800H to [[]] ^{PROP} - Extension of fatigue curves for 800H to [[]] ^{PROP} - Environmental compatibility assessment *(de)carburization - Stress relaxation cracking
Dynamic Effects	Seismic Category IIA; design meets 10 CFR 50 Appendix S
Programmatic Treatment	RAM; preliminary MANDE includes temperature, radiation, and chemistry monitoring; does not permit access for remote ISI



* In R&D program for FUCH

Core Barrel Evaluation

- Graphite lateral supports under design
 - Mechanism in design to ensure wedges in the annular gap between graphite blocks and CB inner wall maintained in place for all operating conditions, including seismic event
 - Committed to ensure safety function of GCA by analysis and testing
 - Displacements of GCCs due to irradiation and thermal effect will be accounted for in final design
- Preliminary rod insertion evaluation method developed and to be validated by tests and LS-DYNA analyses to ensure control rod insertion for all operating conditions
- ASME Section III, Div. 5 will be followed for load combination and stress/deformation analysis
- Off-normal conditions
 - Transient load not available yet, but LME committed to code supplementation and environmental compatibility assessments to ensure all degradation mechanisms and failure modes will be properly addressed by design and inservice inspection
 - Environmental compatibility assessment includes graphite-metal interaction

Cross Vessel and Hot Gas Duct Evaluation

- Insulation layer classified as NST
 - LME stated insulation layer not relied on to maintain cold helium temperature within required range
 - Staff will review thermal analysis during OL application stage to confirm that temperature of CV be maintained in the allowable range for SA-508 material
- ASME III.5 will be followed for load combination and stress/deformation analysis
- Off-normal conditions
 - Transient load not available yet
 - Design temperature (760 °C) for HGD equal to max temperature allowed by code; LME plans code supplementation activities to extend qualified temperature to [[]] ^{PROP}
- Seismic Classification
 - Seismic Category IIA
 - Designed consistent with the seismic design criteria for SC-I

Seismic and Flooding Design Aspects

Robert Roche-Rivera, Sr. Structural Engineer, OAR/DARE/AREB5

Seismic Categorization & Design Criteria

- SSCs categorized as SC-I, SC-IIA, SC-IIB, or SC-III based on safety function, dynamic coupling/load path considerations, seismic safety significance, and seismic interaction considerations
 - SSCs providing essential support for SR SSCs, as part of the load path are classified NSRST and assigned SC-IIA
 - Seismic safety significance assigned SC-IIA and protected at various levels within SC-IIA based on impact to NEI 18-04 risk metrics
- Preliminary Design Stage
 - All SSCs with an RSF (all SR SSCs) assigned SC-I
 - All NSRST SSCs assigned SC-IIA
 - SSCs not part of SC-I or SC-II systems with seismic interaction potential assigned SC-IIB
 - All other SSCs assigned SC-III

Seismic Categorization & Design Criteria (Cont'd)

- SC-I SSCs: designed to the SSE (i.e., SC-I DRS) and ASCE 43-19, Limit State D
- SC-IIA SSCs: designed to SC-IIA DRS (scaled from SC-I DRS) and ASCE 43-19

- [[

]]^{PROP}

- SC-IIB SSCs: designed to SC-IIB DRS and ASCE 7-16

- [[

]]^{PROP}

- SC-III SSCs: designed to ASCE 7-16 DRS and associated standard provisions
- SPRA will be used to confirm or adjust seismic categorization/criteria at OL application

Flooding Design

- The external flood DBHL is bounded by the probable maximum storm surge
 - Still water level ~ 5 ft
 - Total water level including wave run-up ~ 15 ft
- Flood protection strategies for SR SSCs
 - Flooding DBHL loads are accounted for in the design of buildings
 - Building openings are either located above the flood height or designed to be substantially impermeable
 - Systems and components within the buildings
 - Located above flood height
 - Designed to be substantially impermeable
 - Designed to function under submergence conditions

Flooding Design (Cont'd)

- NSRST and NST SSCs may fail during the flooding DBHL and require strategies and procedures to cope with their unavailability (e.g., electrical power and monitoring equipment expected to fail)
 - Emergency plan, focused on achieving safe shutdown condition from the MCR or from RPS cabinets in the FHAB prior to site inundation
 - Portable monitoring equipment used to monitor the status and radiological condition of the plant during flooding event
 - Limited information available through RPS cabinets while power available
 - LME will provide detailed emergency plans at the OL stage
- NSRST SSCs will be protected from higher frequency, less severe flooding based on safety significance

Acronyms

- AOO Anticipated Operational Occurrence
- BDBE Beyond Design Basis Event
- CB Core Barrel
- CMS Core Metallic Structures
- CP Construction Permit
- DBA Design Basis Accident
- DBE Design Basis Event
- DBHL Design Basis Hazard Level
- DLOFC Depressurized Loss of Forced Cooling
- ERE Extremely Rare Event
- FHAB Fuel Handling Annex Building
- FSAR Final Safety Analysis Report
- FUCH Defuel Chute
- GCA Graphite Core Assembly
- GCC Graphite Core Component
- IGNIS Irradiated Graphite Numerical Iterative Solver
- ISI Inservice Inspection
- IST Inservice Testing
- LBE Licensing Basis Event
- LME Long Mott Energy
- LME Long Mott Energy
- MANDE Monitoring and Non-Destructive Examination
- MCR Main Control Room
- NRC Nuclear Regulatory Commission
- NSRST Non-safety related with special treatment
- NST Non-safety related with no special treatment
- OL Operating License
- PDC Principal Design Criteria
- PDC-CDC Principal Design Criteria - Complementary Design Criteria
- PDC-RFDC Principal Design Criteria - Required Functional Design Criteria
- PFA Process Functional Area
- PLOFC Pressurized Loss of Forced Cooling
- PSAR Preliminary Safety Analysis Report
- QA Quality Assurance
- R&D Research and Development
- RAM Reliability, Availability, and Maintainability Program
- RCCS Reactor Cavity Cooling System
- RCS Reactivity Control System
- RCSS Reactivity Control & Shutdown System
- RIM Reliability and Integrity Management
- RPS Reactor Protection System
- RSS Reserve Shutdown System
- RVSS Reactor Vessel Support System
- RXST Reactor Vessel Support Structure
- SCC Stress Corrosion Cracking
- SE Safety Evaluation
- SFA Standpipe Functional Area
- SPRA Seismic Probabilistic Risk Assessment
- SR Safety-Related
- SSC Structures, Systems, and Components
- SSS Startup Shutdown System
- SST Shield Structure
- TR Topical Report

Backup Slides

Evolution of Seismic and Flooding Design Aspects

Seismic

- Initial categorization included SC-I (SR), SC-II (NSRST II/I interaction), and SC-III (subset of NSRST and NST)
- During review, staff identified challenges for some NSRST and NST SSCs that warranted additional considerations
- LME revised its approach to include a new subcategory (SC-IIA) for SSCs that are part of the load path for SR SSCs and NSRST SSCs that need to perform their function during and after a seismic event

Flooding

- The staff's review identified potential challenges to ensuring availability of SSCs given the flooding DBHL at the LMGS site
- LME updated its approach to include relocation of systems and components above the still water level where possible, waterproofing strategies, designing SSCs to function under DBHL flooding conditions, and developing emergency plans to cope with unavailability of certain systems and components