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UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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604th MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THURSDAY

MAY 9, 2013

+ + + + +

ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear
Regulatory Commission, Two White Flint North, Room
T2B3, 11545 Rockville Pike, at 1:00 p.m., J. Sam
Armijo, Chairman, presiding.

COMMITTEE MEMBERS:

J. SAM ARMIJO, Chairman

JOHN W. STETKAR, Vice Chairman

HAROLD B. RAY, Member-at-Large

SANJOY BANERJEE, Member

DENNIS C. BLEY, Member*

CHARLES H. BROWN, JR. Member

MICHAEL L. CORRADINI, Member

DANA A. POWERS, Member

1 COMMITTEE MEMBERS: (cont.)

2 JOY REMPE, Member

3 MICHAEL T. RYAN, Member

4 STEPHEN P. SCHULTZ, Member

5 WILLIAM J. SHACK, Member

6 GORDON R. SKILLMAN, Member

7
8 NRC STAFF PRESENT:

9 MARK L. BANKS, Designated Federal Official

10 DONALD CARLSON

11 EDWIN HACKETT

12 STEVE JONES

13 MICHAEL MAYFIELD

14 TIM MCGINTY

15 MARK RUSSO

16
17 ALSO PRESENT:

18 DAVID ALBERSTEIN, Idaho National Laboratory

19 JIM KINSEY, Idaho National Laboratory

20 TOM O'CONNOR, Department of Energy

21 FINIS SOUTHWORTH, AREVA

22
23
24
25 *Present via telephone

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

(1:00 p.m.)

CHAIR ARMIJO: Good afternoon. The meeting will now come to order. This is the first day of the 104th Meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following, first, Next Generation Nuclear Plant key licensing issues; second, Generic Issue 189, Susceptibility of Ice Condenser and Mart III containers through early failure from hydrogen combustion during a severe accident; and, third, preparation of ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Mark Banks is the Designated Federal Official for the initial portion of the meeting.

We have received no written comments or requests to make oral statements from the members of the public regarding today's session. There will be a phone bridge line. To preclude interruption of the meeting, the phone will be placed in a listen in mode during the presentations and Committee discussion.

A transcript of portions of the meeting is being kept and it is requested that the speakers use

1 one of the microphones, identify themselves and speak
2 with sufficient clarity and volume so that they can be
3 readily heard.

4 The first briefing will be on NGNP. Dr.
5 Bley is in New Mexico on the bridge line. And I will
6 be chairing the briefing here. So I would now like to
7 turn the briefing over to Mr. Tom O'Connor, the
8 Department of Energy.

9 MEMBER REMPE: Mr. Chairman, I need to
10 interrupt you.

11 CHAIR ARMIJO: Yes. Go ahead, Joy.

12 MEMBER REMPE: I do have some
13 organizational conflicts of interest concerning this
14 topic.

15 CHAIR ARMIJO: Okay. Thank you very much.
16 With that, Tom.

17 MR. O'CONNOR: Good afternoon. By way of
18 introduction, I'm the Director of the Office of
19 Advanced Reactor Technologies. Since 2005, I've been
20 responsible for the Department's Generation IV Reactor
21 Research and Development Programs. So that addresses
22 all of the four concepts, SFRs, LFRs and of course the
23 NGNP program.

24 The NGNP program has its orientations in
25 the Energy Policy Act of 2005 and not only did it

1 specify what the project organization and management
2 structure should look like, but it also specified the
3 Department of Energy and the Nuclear Regulatory
4 Commission should work aggressively towards
5 identifying and laying out licensing framework and
6 strategy for this.

7 The report depicted on the slide reflects
8 the first fruits of that interaction, the 2008 Report
9 to Congress, which identified the licensing strategy.
10 And the licensing strategy is relative to an
11 admonishment by Congress to develop this which is to
12 ensure that we can develop a design based on a firmly
13 established licensing framework as well be able to
14 make the kinds of economic decisions with a solid
15 design that would determine whether or not the
16 reactors had the commercial viability necessary.

17 I think over the past eight years we have
18 worked quite well together with the Nuclear Regulatory
19 Commission not only in developing this strategy, but
20 also in developing a number of research and
21 development activities and collaborated on a number of
22 experiments.

23 In terms of the key pieces of the strategy
24 report, it identified many of the same topics that
25 were identified in earlier licensing efforts related

1 to high-temperature gas-cooled reactors. Those
2 associated with the earlier MHTGR and NPR data as well
3 as the work that was done in conjunction with the
4 Exelon's efforts to license a pebble bed reactor here
5 in the United States.

6 Following the licensing strategy report,
7 it was delivered to Congress in the 2008 time period.
8 We had a number of efforts ongoing with the NRC with
9 the development of a number of White Papers and
10 subsequent assessment reports that also identified the
11 four major key areas. And last year we got to a point
12 where we really needed to drive home resolution of the
13 four major positions that had been in essence dogging
14 the high temperature gas reactor space beginning with
15 the days of the MHTGR and NPR.

16 Right now, we continue to devote our
17 research and development efforts on some of the
18 resolution of some of the longstanding issues
19 principally associated with the fuels work and the
20 graphite. And I think that we're making a tremendous
21 amount of progress and inroads on that.

22 I think in terms of the work that was done
23 with the NRC we've also come to a good understanding
24 of what our issues are and what the path forward on it
25 needs to be. I would say though that at this point we

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1 still have some uncertainty associated with the
2 determination of design basis accidents that appears
3 to go beyond what the previous Commission policy on
4 the identification of those scenarios would be.
5 Hopefully, we can with your help get to a closer
6 resolution of that, a resolution that will help us
7 establish the licensing framework that will allow us
8 to move forward with the design efforts and ultimately
9 the commercialization of this technology.

10 That's the end of my opening remarks. I'd
11 be happy to entertain any questions that you might
12 have.

13 CHAIR ARMIJO: Your issue is with the
14 process for determining these DBAs or is it more than
15 that?

16 MR. O'CONNOR: It's associated with when
17 we -- The path that's proposed identifies a number of
18 deterministic approaches that are influenced by the
19 probability risk advisement. But it's at the end of
20 that that it seems at least based on recent
21 discussions that there will be other yet to be
22 determined accidents that need to be taken into
23 consideration, things that are beyond what we would
24 have considered as a part of the normal design and
25 safety iteration process.

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1 And it's that uncertainty that precludes
2 us from really understand what is going to be expected
3 of the design.

4 MEMBER CORRADINI: Tom, is the uncertainty
5 based in the fact that the design is yet to be
6 completed or is the uncertainty based that you're not
7 sure what staff is going to ask of you given that the
8 design is complete enough? What I'm trying to say is
9 that they said you might have to consider X and you
10 say X really isn't in the PRA. So why is X even out
11 there as a possible deterministic bound.

12 Or is it they're saying from your
13 perspective that we want to see more of the design.
14 And until we see more of the design, we can't tell you
15 what X is.

16 MR. O'CONNOR: More of the former. We
17 have to recognize that, yes, there are some designs
18 out there. But they have not progressed to a point
19 where you would do the kind of rigorous PRA analysis
20 that would be necessary. Our concern is that once we
21 have done the design and done the PRA and made the
22 adjustments to ensure that we keep all of our
23 accidents within the acceptable limits that when
24 presented then we would receive additional "You need
25 to go and look at this or you need to go and look at

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1 that." And that's where our uncertainty is.

2 And I would like to ask if -- That's what
3 the subject of Jim's presentation is.

4 MEMBER CORRADINI: Okay. I just wanted to
5 make sure --

6 MEMBER REMPE: But if they came in with a
7 small or you came in with a small nodular PWR and IPWR
8 do you anticipate you'd have the same problem with the
9 staff from these interactions?

10 MR. O'CONNOR: Not having focused on the
11 light water community I'm not going to go there.

12 MEMBER CORRADINI: Smart move.

13 MR. O'CONNOR: The bottom line for me is
14 that I need to have a framework that's well laid out.
15 It's not a moving target. It allows me to run through
16 my design iterations and based on the analysis that
17 I'm doing to be able to finish and finalize my design.
18 And I don't want to find myself having to go back and
19 rework my design because of additional requirements.

20 MEMBER RAY: Tom, let me turn Joy's
21 question around. Do you think the present situation
22 is unique to the NGNP that will be discussed here
23 later or is it more indicative of any reactor of this
24 same type coming down the path that it would come down
25 being not a water reactor for example? In other

1 words, is it a process issue or is it specific to the
2 NGNP itself?

3 MR. O'CONNOR: I would be inclined to say
4 that it would be something that other advanced
5 reactors have to contend with.

6 MEMBER SHACK: But why are you surprised?
7 I mean the NGNP DOE licensing agreement says you're
8 going to use Option 2 which says you're going to have
9 deterministic engineering judgment supplemented by,
10 complimented by, PRAs. So it actually gives the
11 weight to the engineering judgment, the deterministic
12 analysis. I mean it sounds like you're coming in with
13 Option 3 or Option 3 on steroids.

14 MR. O'CONNOR: Well, first, I don't want
15 to bog down in Option 2 or Option 3. But I want to
16 point to exactly how you framed it and that is first
17 you take your design and look deterministically to
18 make your engineering judgments to do your first set
19 of examinations. And then based on those
20 determinations you will overlay PRA on top of it. And
21 that should be the end of it.

22 Shouldn't be coming back after that and
23 saying "Well, I don't like the answers that you got.
24 You need to go and pick this thing or pick that thing"
25 which drags you in order to respond to that incredible

1 event to have to reengineer and redesign your whole
2 plan.

3 MEMBER SHACK: So propose the
4 deterministic one right up front and you don't like
5 it.

6 MR. KINSEY: I think this will be more
7 clear from the other --

8 MEMBER RAY: But that at least would be
9 different.

10 CHAIR ARMIJO: Yes, that would be
11 different. You'd know what you're working with.

12 MEMBER RAY: But that's the point is if a
13 deterministic event that they didn't like that would
14 be different than the situation they're in now.

15 MR. O'CONNOR: The PRA in that case would
16 show that that's not a credible event and push
17 outside. If it is a credible event and does have the
18 kinds of probabilities that warrant addressing, then
19 that's within the realm of the design cycle.

20 MEMBER CORRADINI: If I may just take one
21 more minute since somebody used to be sitting in this
22 spot that I remember quizzing him when we were doing
23 a letter for the licensing strategy. And if I went
24 back to the transcripts, I think we ended up with kind
25 of like a two prime. It wasn't two and it wasn't

1 three, but it was more towards two than it was towards
2 three. So it was -- I hate to use the word mushy, but
3 it was a bit grayer than clearly two or three.

4 I remember Commissions Apostolakis asking
5 about this because he wanted to link this to a testing
6 of the technology nuclear framework. I just want to
7 make sure we've got the sense of it as we were coming
8 out of the framework discussion. That's all.

9 CHAIR ARMIJO: We will hear examples of
10 particular kinds of issues that you're concerned
11 about. Okay. All right. Thank you.

12 MR. O'CONNOR: To facilitate Jim's
13 presentation I'm going to step back and rely on some
14 of the other members of Jim's team to sit up here at
15 the front table.

16 CHAIR ARMIJO: Okay. Thank you.

17 MR. KINSEY: Good afternoon. My name is
18 Jim Kinsey. I'm the Licensing Regulatory Affairs
19 Director for the NGNP project and the work at the
20 Idaho National Laboratory. The other folks here at
21 the table again work on our team at INL, Mark
22 Holbrook, David Alberstein and Fred Silady.

23 I wanted to also confirm we were planning
24 to have one or two folks on the line as well. Is David
25 Hanson on the line?

1 MEMBER CORRADINI: I think they are on
2 mute.

3 MR. KINSEY: We were expecting both David
4 Petty and David Hanson from the team on the line.

5 CHAIR ARMIJO: Let's see if we can get
6 this unmuted so they can confirm.

7 MR. KINSEY: We can move along. The basic
8 structure, we've got about ten slides or so here. I
9 think we can go through those pretty quickly. The
10 basic structure is an overview slide here at the
11 beginning, a couple of overview slides near the end
12 and the middle four or five slides are all around this
13 topic that Mr. O'Connor mentioned that has to do with
14 design basis accidents.

15 I think we had some dialogue on this topic
16 in the last subcommittee meeting. So the purpose
17 today was just to do remind folks of that those
18 particular processes are and just again summarize what
19 our questions or areas of uncertainty are.

20 CHAIR ARMIJO: Jim, if you want to check
21 if your people are on the phone.

22 MR. KINSEY: Sure. Is David Petty on the
23 line?

24 MR. PETTY: I'm here.

25 MR. KINSEY: Okay. And how about David

1 Hanson?

2 MR. HANSON: I'm here as well.

3 MR. KINSEY: Okay. And just so you know
4 if a question comes up where we need your help, I
5 think the system will may be on mute. So it may take
6 a moment to get you back online.

7 MR. HANSON: I've been on a mute button my
8 entire life.

9 MR. KINSEY: Okay.

10 CHAIR ARMIJO: Okay. Go ahead.

11 MR. KINSEY: So just a very brief overview
12 of the safety and design approach for the NGNP and the
13 modular HTGR arrangement. It's our intention and our
14 design goal to meet all of the NRC's offsite dose
15 requirements and the EPA protective action guidelines
16 at the exclusionary boundary which we define for
17 purposes of the project to be in the range of about
18 400 meters from the reactor center line.

19 The reactor designs and our licensing
20 strategy intended to be responsive to the advance
21 reactor policy statement which is associated with
22 coming up with designs that are highly reliable, less
23 complex, lower plant response time, simplified
24 features and maintaining considerable defense in
25 depth.

1 We've had dialogue in the past about
2 functional containment arrangement. It consists of
3 multiple concentric barriers. It's nominally five
4 barriers I just see listed there. Three of the five
5 are associated with the particle fuel configuration.
6 And then those are also supported by the helium
7 pressure boundary and reactor building.

8 And the key focus here or the emphasis is
9 on retaining the radionuclides at their source in the
10 particle fuel. Three key pieces of that intention
11 are the passive heat removal process, a process we
12 have through our reactor cavity cooling system,
13 control of heat generation and that occurs through the
14 negative reactivity temperature coefficient and
15 redundant sets of shutdown systems, and the control of
16 chemical attack or oxidation of the graphite. And we
17 control that by the use of a nonreactive coolant and
18 then configuring the plan in such a way that it's very
19 difficult for moisture or air to ingress and be in a
20 sustained ingress arrangement or situation.

21 So again the next five slides or so, Dr.
22 Corradini, kind of get back to trying to answer or
23 clarify your questions and some of the other members
24 questions around whether this is a process issue or an
25 HTGR or NGNP specific kind of a topic. I'll try and

1 step through those. Feel free to answer questions
2 along the way.

3 So in our overall event selection process
4 we start out by gathering up all of the applicable
5 regulatory criteria. We pull those into a group that
6 we refer to as the top level regulatory criteria.
7 Those tend to be off-site dose-based and they all are
8 deterministically developed. So those again come from
9 the NRC's regulations which are coming from a
10 deterministic background.

11 Then as we begin the design in the early
12 parts of the licensing process but primarily the
13 design, we select a series of events deterministically
14 based on a number of inputs. And one of those primary
15 inputs is past experience or past effort that's
16 occurred within the HTGR community. So make those
17 initial selections. And then as the design progresses
18 as envisioned in the licensing strategy we then
19 embellish or enhance that vision of those
20 deterministic events by including risk insights. And
21 again as the design develops, the community develop
22 the PRA and take a second look at the events that
23 we've selected and typically add to or modify it as
24 the process progresses.

25 That results in a series of event types.

1 We'll look at those on an F-C curve in a moment. But
2 there are essentially our anticipated events, design
3 basis events, but beyond design basis events and then
4 our design basis accidents.

5 We feel that that process is pretty
6 comprehensive and provides a soup-to-nuts approach
7 that looks at all event sequences and takes them
8 essentially out to completion except in some cases
9 where we group some of those sequences to facilitate
10 getting to the results.

11 MEMBER SKILLMAN: Jim, would you back up
12 one slide please?

13 MR. KINSEY: Sure.

14 MEMBER SKILLMAN: The last sentence of
15 your third bullet, Chapter 15 events derive from DBEs
16 with only safety related SSCs. That sounds like a
17 clever exclusion comment. What are you really
18 communicating?

19 MR. KINSEY: It's not intended to sound
20 like a clever exclusion. It's actually a highly
21 conservative deterministic portion of our process. If
22 we could go -- I'll get to some examples of how that
23 works in a couple of slides. If we could come to the
24 question, then. I think if you see it in a picture I
25 think it will be more clear.

1 MEMBER SKILLMAN: But what I'm really
2 wondering is if you can credit other equipment or if
3 you were limited to only that equipment.

4 MR. KINSEY: I'm sorry. With design basis
5 accidents, we limit the plants response to only the
6 safety related accidents. I'm sorry. I misunderstood
7 your question.

8 MEMBER SKILLMAN: Thank you.

9 MR. KINSEY: Next slide. I think we've
10 covered the frequency-consequence curve concept a
11 number of times in the past. We've had a lot of good
12 dialogue with the staff over this concept in our past
13 interactions.

14 A couple of things I wanted to point out
15 without getting into all of the detail is we've come
16 to agreement with the staff on the vertical events
17 sequence frequency portion of the scale that the
18 cutoffs we've established for each of the three event
19 types, the anticipated events, the DBEs and the BDBEs,
20 overlaid are in the right place. We've also come to
21 agreement with the staff that we've adequately and
22 correctly reflected the regulatory requirements that
23 apply to each of those regions. And you'll see those
24 on the curve that's going down the right side there.
25 And those are primarily from Part 20, from 50.34 and

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1 from the quantitative health objectives.

2 So at this point we understand that the
3 staff believes or agrees that this depiction of both
4 the requirements and our event types is reasonably and
5 accurately reflected.

6 CHAIR ARMIJO: Jim, you don't put the
7 design basis accidents on this chart.

8 MR. KINSEY: That's coming.

9 CHAIR ARMIJO: That's coming. Okay.

10 MR. KINSEY: Next slide. What we're going
11 to do in the next two slides is describe how design
12 basis accidents are derived. And then the next slide
13 after this one will be a picture from the MHTRG era.
14 And we'll talk through some examples there to make
15 sure that this process is correct.

16 So again, Mr. Skillman, getting back to
17 your question, when we develop the series of licensing
18 basis events that exist, all of the ones that end up
19 in that middle band on the curve which are the design
20 basis events are then reevaluated considering or
21 assuming that only the safety related structures,
22 systems and components are available and respond. And
23 we'll see what the effect of that is on the next
24 chart.

25 Again, those are selected out of that

1 design basis event region. And when we make that
2 deterministic decision to have only safety related
3 material responding or SSEs responding it tends to
4 drive as you could expect it the frequency of those
5 events down into the lower regions, either the BDBE
6 region or below. And you'll see that in the next
7 example.

8 When we evaluate the consequences of DBAs
9 we do that with a conservative upper bound analysis,
10 a 95 percent analysis, which is consistent with the
11 existing fleet as best I know. And we also wanted to
12 make the point that our DBAs are not derived from the
13 next region down which is the BDBE region. We apply
14 again consistent with regulatory practice that all
15 quantitative health objections, the QHOs, to that
16 region. That's how we go about defining what the DBAs
17 are.

18 If you move onto the next chart --

19 VICE CHAIR STETKAR: The second bullet
20 there, I've always had problems. Maybe you can help
21 me again. Why would the frequency of some DBAs become
22 smaller as a result of assumed failures for things
23 that I've taken credit for to get the frequency of
24 those sequences in the DBE, design basis event,
25 category? It would seem that the frequencies of some

1 beyond design basis event sequences would increase to
2 the DBE frequency range if I had failures of the
3 nonsafety related stuff that I did not have failure of
4 when they were in the BDBE range if that makes any
5 sense. In other words, if you go to the next.

6 MR. KINSEY: If I go to the next one, I'll
7 maybe talk through that a little bit.

8 VICE CHAIR STETKAR: Okay. I want to
9 understand why things are going down.

10 MR. KINSEY: I'll take a first stab at
11 that and I may ask for some help from our experts.

12 VICE CHAIR STETKAR: There we go. You
13 need to stay by a microphone and use the mouse.

14 MR. KINSEY: Okay.

15 VICE CHAIR STETKAR: Because otherwise
16 you're not on the record.

17 MR. ALBERSTEIN: Your mouse manager is
18 here.

19 MR. KINSEY: Okay. Let me just make some
20 key points.

21 MR. ALBERSTEIN: The mouse is wireless.
22 That's the range of the mouse.

23 MR. KINSEY: Thank you. The first thing
24 and this is related to some questions from past
25 sessions. The first thing I wanted to point out is

1 for all of our event sequences and I'll use the DBA 10
2 as an example, we look at an uncertainty band around
3 both the consequence and the horizontal axis on the
4 frequency of the requests. So we evaluate that
5 uncertainly for each event.

6 The next point that I'll make is and this
7 by the way if for an MHTRG plant facility that
8 consisted of four reactor models. The next thing that
9 we do within this process is we identify the series of
10 design basis events. And you can see those sort of
11 clustered around here with a couple of others in this
12 region.

13 We identify those design basis events.
14 We've done the uncertainty analysis around them
15 previously. And now we make the assumption that for
16 each of those events only the safety related
17 components would respond.

18 So, Dr. Stetkar, as I understand it and to
19 get to your question, when you reduce the number of
20 components that would respond to a particular event,
21 that response sequence would then be less likely to
22 occur than if everything responded.

23 VICE CHAIR STETKAR: If you're assuming
24 that everything that you respond is guaranteed to be
25 successful. But if I have two things that can fail

1 versus three things that could fail, failure of three
2 things is generally less likely than failure of two
3 things.

4 So if I take away that third thing and say
5 it's guaranteed to fail, the likelihood that two
6 things can fail is higher than the likelihood of three
7 things. If I take away that third thing the frequency
8 of that sequence ought to increase, not decrease,
9 unless I'm assuming that the two things that were --

10 MEMBER BLEY: No.

11 VICE CHAIR STETKAR: Hold on a second,
12 Dennis. Unless I assume that the frequency of the two
13 things that are left is either improves or I'm
14 assuming that they're guaranteed to be success.

15 Sorry. I just wanted to finish that.

16 MR. SILADY: My name is Fred Silady. And
17 we had a slide that unfortunately is not in the
18 backups here today that we presented in the January
19 subcommittee meeting. And that slide showed a mini
20 abbreviated tree. And it would have a DBE example in
21 which the entire plant is responding. And it would
22 have three things for heat removal as an example, the
23 heat transport system, the shutdown and cooling system
24 and then the last passive reactor cavity cooling
25 system.

1 And just for talking purposes, let's say
2 that that particular DBE with the entire plant
3 responding is smack in the middle of the DBE region.
4 So it had the entire plant responding. And it was
5 probably 90 percent chance that one of those first two
6 systems, each of them, are available in that
7 particular sequence.

8 Now the deterministic step is to be
9 consistent with Chapter 15 to be able to fit into the
10 regulatory mold here that we're not going to have that
11 heat transport system or that shutdown cooling system,
12 those first two systems and everything in the chain
13 out to the ultimate heat sink be in the sequence. So
14 we're out of frequency space. This is just a
15 deterministic assumption.

16 But if we were to ask where in the tree
17 would that sequence have been, you could go look for
18 it somewhere. It's much less likely that it's a
19 sequence. So that DBA if you were to try to plot it
20 on an F-C chart is going to be two orders of magnitude
21 lower, 90 percent and 90 percent, because all of these
22 three things were independent and so on.

23 Does that help?

24 MEMBER BLEY: No. This is Dennis. Let's
25 go back to the --

1 VICE CHAIR STETKAR: Dennis, hold on.
2 You're really mushy. So if you can help the audio.

3 MEMBER BLEY: Is this any better?

4 VICE CHAIR STETKAR: Yes, that's much
5 better. But I don't like where you're going.

6 CHAIR ARMIJO: Keep going, Dennis.

7 MEMBER BLEY: I forgot where I was. It
8 sounds like you'd go look for that sequence. That
9 sequence includes those other two systems.

10 VICE CHAIR STETKAR: Yes, you still have
11 three things there.

12 MEMBER BLEY: Yes. And when you're only
13 accounting for the safety systems, those other systems
14 don't exist. Protectively, they're guaranteed fail.

15 VICE CHAIR STETKAR: No, no. I'm not
16 looking for the sequence that says I guarantee them
17 fail and I lock them out. I'm looking for the
18 sequence that they failed either randomly or
19 dependently. That's what drives the frequency down.

20 MEMBER BLEY: Yes, that would. Assuming
21 they could get you out of trouble. So you're not just
22 relying on the safety system. Probably it's easier
23 for him to talk to.

24 VICE CHAIR STETKAR: In one sense, I can
25 kind of understand what they're trying to say, but it

1 doesn't make any sense in the way you think about
2 risk. They're trying to say the likelihood that those
3 non-safety systems are absolutely guaranteed failed is
4 really small.

5 MEMBER BLEY: That's true.

6 VICE CHAIR STETKAR: And that's true. And
7 in that sense the likelihood of that particular
8 sequence with those things guaranteed to be failed is
9 small, the probability that they're guaranteed to be
10 failed. That's I think the way they're trying to
11 think about it.

12 MEMBER BLEY: I think that's right. But
13 in the traditional sense.

14 VICE CHAIR STETKAR: But in the
15 traditional sense, it doesn't make any sense to --

16 MR. SILADY: Explain to me -- sorry for
17 interrupting. But explain to me if I have a plant
18 with those three systems. You're describing to me a
19 plant that only has safety related things and that
20 plant never exists.

21 VICE CHAIR STETKAR: But, see, you're
22 claiming. You have to be careful about the
23 differences between a systematic, quantitative risk
24 assessment and qualitative claims about what you're
25 going to call design basis events. You are creating

1 the construct that only safety related systems you can
2 take credit for. You're creating that construct. The
3 risk assessment --

4 MR. SILADY: Then Chapter 15. I'd love to
5 --

6 VICE CHAIR STETKAR: And that is also a
7 construct. Yes, that is a construct. But you're
8 creating that construct by presuming that only safety
9 related systems can participate. The risk assessment
10 which originally partitioned all of these sequences in
11 this eight order of magnitude or nine orders of
12 magnitude frequency space didn't make that
13 presumption.

14 MR. SILADY: No.

15 VICE CHAIR STETKAR: Making the
16 presumption that only safety related systems are
17 available can only increase what possibly remain the
18 same the frequency of sequences from the risk
19 assessment because you're removing things that could
20 have made things better.

21 MR. SILADY: I think this is as a result
22 of just looking at it as if you had a plant that only
23 had safety related systems.

24 MEMBER BLEY: Yes.

25 MR. SILADY: And we're not looking at it

1 as if we're going to build a plant. I'm looking for
2 the realistic risk. What's my actual frequency and
3 consequences coming from the sequence I'm going to put
4 in Chapter 15.

5 VICE CHAIR STETKAR: But you're selecting
6 your presumed scope of that from a specific frequency
7 range that has a population of a fixed set of
8 sequences. You're not looking in the beyond the
9 design basis event frequency range.

10 Suppose I had 11 systems in the plant, ten
11 of them I'm calling non safety related and I've only
12 got one that's safety related. And I do a risk
13 assessment and I take credit in that type of work. I
14 quantify all 11 of those systems. And as a result of
15 that I have a sequence with a frequency of 10^{-7} beyond
16 design basis. It's even below your less than 5 times
17 10^{-7} range.

18 MR. SILADY: Right.

19 VICE CHAIR STETKAR: If I only take credit
20 for the safety related system, is the frequency of
21 that sequence going to be higher or lower than 10^{-7} ?

22 MR. SILADY: That's not the process that
23 we're proposing here, but yes.

24 VICE CHAIR STETKAR: That's not the
25 process.

1 MR. SILADY: But I understand where that
2 would go.

3 VICE CHAIR STETKAR: It's going to be much
4 higher.

5 MR. SILADY: Yes. Sure.

6 MEMBER BLEY: Can I weigh in again? I'd
7 like to weigh in again. The discussion now clarifies
8 the two things that's going on. I think the problem
9 John and I have had is that the language of only
10 taking advantage of the safety system, the traditional
11 approach, which assumes those other systems are not
12 there. Once they've actually called these PDAs now
13 the frequencies are up and down, but they are PDAs.
14 And they're going to have to analyze the details that
15 PDA requires.

16 MR. SILADY: Absolutely.

17 VICE CHAIR STETKAR: And that's correct.

18 MEMBER BLEY: So I think it's more a
19 matter of semantics for it.

20 MEMBER CORRADINI: I think it is
21 semantics. I don't think it's substance.

22 VICE CHAIR STETKAR: I don't think it is
23 substantive. But I think they have to be very, very
24 careful about how you present this saying that when we
25 define these as design basis events -- Your words say

1 when we define them design basis events and take
2 credit only for the safety systems, their frequency
3 may decrease. And that second part of that sentence
4 is creating this source of confusion.

5 MR. SILADY: Okay. I'll think about that
6 little more, but I understand.

7 MR. KINSEY: So I guess carrying on with
8 the example you can see that for the design basis
9 events that are again clustered in that design basis
10 event frequency region when we make this assumption
11 and move them into design basis accident space, we can
12 see that they move a couple over here with limited or
13 zero consequence. Others move well down into
14 frequency space down actually below 5 times 10⁻⁷
15 cutoff.

16 And I'll point out this note in the margin
17 here that there are additional DBAs that aren't
18 reflected on the chart that go even below 10⁻⁸ from
19 that DBA, or excuse me, DBE set that was evaluated for
20 MHTGR.

21 MR. KINSEY: Any other questions about it?

22 MEMBER BLEY: Yes. Could I jump back in?

23 MR. KINSEY: Sure.

24 MEMBER BLEY: I've enjoyed this
25 conversation. We do have the problem of what people

1 might interpret from the word. The positive side of
2 this is that we're really shining a light on the
3 conservatism that exists from the DBAs and that's true
4 currently as well. So that's an interesting thing.

5 MR. KINSEY: I'd like to go onto the next
6 slide.

7 MEMBER SHACK: Let me just make one
8 comment. Again, the whole discussion assumes that you
9 know the frequencies and uncertainties of all these
10 sequences. So again that's a given in this approach.
11 And suppose I say I don't really believe your
12 frequency or your uncertainty for those beyond design
13 basis events and I want to make that into a DBA.

14 MR. KINSEY: I guess I understand that
15 question and that's one of the items when you're
16 asking some questions of Mr. O'Connor. That's one
17 which I guess requires additional design detail to get
18 into that dialogue.

19 MEMBER CORRADINI: Can I just follow on
20 with that because I thought Bill was going to go
21 somewhere else. But what I was going to ask is if it
22 was prismatic or pebble, does that design detail move
23 these dots around a lot, a little or yet to be
24 determined?

25 MEMBER SHACK: Well, even after I know all

1 the design detail, I still have to believe the
2 frequencies and uncertainties. And there may be
3 mechanistic processes that are going on here that I
4 haven't -- I'm not sure even for a light water reactor
5 how confident I am.

6 MR. KINSEY: But to answer your question,
7 the purpose here was to illustrate the process and
8 this is one example for the MHTGR.

9 MEMBER SHACK: Okay.

10 MR. KINSEY: Certainly for individual
11 designs, there are going to be different dots in
12 different places. This was to describe the construct.

13 VICE CHAIR STETKAR: But, Jim, if we're
14 going to talk about that notion since Bill brought it
15 up and if you want to postpone this, we can do that.
16 But that concern about selecting another scenario and
17 saying you need to treat this as a design basis event,
18 you could do that either because that scenario is not
19 in PRA. It's a new scenario, somebody dreams up the
20 Godzilla scenario. Or you could do it because it's a
21 scenario that's in the PRA but you just don't believe
22 the numbers.

23 MR. KINSEY: Right.

24 VICE CHAIR STETKAR: I mean both of those
25 are constructs.

1 MEMBER SHACK: The Godzilla one I would
2 just put into the PRA.

3 VICE CHAIR STETKAR: Okay. And that's an
4 important distinction because as the people conjure
5 new scenarios in principle there's nothing preventing
6 you from adding those scenarios to the PRA if they're
7 not already in there and quantifying them on this
8 scale consistently and evaluating where they're at.
9 Maybe you did miss something.

10 MEMBER SHACK: Sure.

11 VICE CHAIR STETKAR: And it's legitimate
12 to add it to the PRA. So that's one of these issues
13 about additional scenarios.

14 MEMBER SHACK: I don't look at that as an
15 issue. That's just a --

16 VICE CHAIR STETKAR: I don't either, but
17 we've had some discussion about it. And the
18 preliminary discussions seem to focus a bit in that
19 direction rather than in your direction. That's why
20 I wanted to bring it up here.

21 MEMBER RAY: John, can I ask a question
22 here? Excuse me, John. In what you and Bill are
23 talking back and forth about I guess I'm thinking and
24 trying to answer the question in my mind about isn't
25 what you're saying always going to be true. Or is it

1 something that exists because there isn't enough
2 detail now and would go away if I had more detail? So
3 be resolved sort of both.

4 VICE CHAIR STETKAR: But I'm presuming --
5 Let's presume you have a perfect knowledge of the
6 design. Let's just presume that from the beginning.
7 Someone can postulate the Godzilla scenario and say
8 "You didn't account for this in your PRA."

9 MEMBER RAY: That's right.

10 VICE CHAIR STETKAR: So that issue at that
11 level.

12 MEMBER RAY: I'm trying to say, "Yes,
13 that's true. I agree with you." But what I think is
14 more at issue here is at what point do I have enough
15 information to satisfy the questions that I can't
16 answer without that information. And it's necessary
17 in order for me to have -- I don't want to say issue
18 a design certification. But it's necessary for me to
19 have done a complete job of looking at the licensing
20 basis.

21 VICE CHAIR STETKAR: Okay. Licensing
22 events. But still let's take the Godzilla scenario.
23 I didn't quantify it in the PRA. I don't know exactly
24 what that is. Maybe I'm not sure what phenomena are
25 going on.

1 I can still quantify that in the context
2 of a PRA. I have uncertainties. I have scenarios.
3 I can evaluate the frequency, uncertainty and
4 consequences because I have that tool available. The
5 uncertainties might be large. But sometimes large
6 uncertainties don't make a difference. That may be
7 true. But if they do then I ought to --

8 Now, Bill, your construct of something
9 that's already in the PRA and I don't have confidence
10 about the frequencies or the uncertainties ought to be
11 addressed also within the PRA. Now the people
12 alleging the fact that I haven't quantified the
13 frequency on the uncertainty just can't say we don't
14 know anything and therefore you have to assume this is
15 a design basis accident because that is irresponsible.

16 They must provide an argument that said
17 "We believe based on the following state of knowledge
18 about the design or the phenomena or understanding
19 that the range of uncertainty is between X and Y."
20 And if they can't do that, they ought not to be just
21 dreaming new things.

22 MEMBER RAY: I think the things that's --

23 VICE CHAIR STETKAR: Once you do that, you
24 can put it in the --

25 MEMBER RAY: The question is --

1 VICE CHAIR STETKAR: This may be a
2 discussion for later but ---

3 MEMBER RAY: But the issue at hand anyway
4 is are there things that I might not be able to do as
5 you described very well because I don't know enough.
6 In other words, there are things that I can't
7 recognize without knowing more.

8 MEMBER SHACK: He can always quantify
9 uncertainty.

10 VICE CHAIR STETKAR: I can.

11 MEMBER SHACK: Some of us believe that we
12 can.

13 MEMBER RAY: Like I said, we ought to go
14 on.

15 VICE CHAIR STETKAR: But the reason I
16 wanted to bring this up in the context of -- You gave
17 me an opening, Bill. Because I understood the initial
18 discussion, it was focusing more on the scenarios that
19 -- my Godzilla scenario -- have not been quantified
20 that someone divines. And I wanted to understand a
21 little bit from your perspective. Is that correct?
22 Or is it more focused -- Is your angst more focused on
23 sort of Bill's issue?

24 MEMBER BLEY: I would still like to get in
25 on this.

1 VICE CHAIR STETKAR: Yes.

2 MEMBER BLEY: This argument, this is
3 something we've been talking about on the committee.
4 And it simplifies the picture. So I'm kind of full of
5 scenarios. Of course, if there is a new scenario, it
6 can be added.

7 Bill's point and Harold's is a different
8 way to look at the point as far as I'm concerned.
9 Once you've done the best you can, there still might
10 not be enough time for them in what's been done to
11 accept it as is and that's when the structural side of
12 this argument comes in. And we have something added
13 to defense in depth to protect against our uncertainty
14 of this process

15 We're never going to get away from that.
16 And I think that side of this thing is always going to
17 be here when you can't make the case that should
18 really cover it. Conventionally, you might need some
19 kind of defense in depth perspective against it.

20 MEMBER RAY: And does that go away,
21 Dennis, at some point when I get more and more detail?
22 Or is it just a reality that always exists?

23 MEMBER BLEY: If I ever think I have
24 really covered it, yeah. There will be issues where
25 people can point out that the experiments we have done

1 have some flaws. There are other things that we
2 haven't fully considered. In principle, eventually
3 you get rid of that. In fact, I'm not sure you really
4 do. And if you look back at Bill's technology neutral
5 framework, they always kept aside for the structurist
6 point of view to protect against those uncertainties.

7 MEMBER RAY: Okay.

8 MR. KINSEY: So I'd like to get back to a
9 couple of questions you asked just to be sure that our
10 angst with the direction it appears we're going come
11 from. If you use the Godzilla or some other newly
12 defined event sequences as an example, our concern is
13 that as we understand the draft guidance from the
14 staff that they would propose that events like that
15 could be identified in the future and would be just
16 directly added to our list of required DBAs.

17 Our preference and what we think the right
18 thing to do is if we find that our event
19 identification process wasn't complete and there is in
20 fact a new different event sequence that we need to
21 consider, we certainly would do that. But we think we
22 should put it into the process and turn the crank and
23 see what comes out and then deal with the result as
24 necessary.

25 I think an example of that without getting

1 into a lot of detail is from the MHTGR review. I
2 believe the staff did identify an additional event
3 that they felt should be evaluated in that whole suite
4 of event sequences.

5 It was evaluated by General Atomics at the
6 time and you see down towards the middle center of
7 this chart there's an Appendix G-2 event there. That
8 was the outcome of the result of that evaluation.

9 So the key for us is in this feedback.
10 We're certainly always open to evaluating additional
11 in that sequence if there is something that appears to
12 having missed something. We just are very
13 uncomfortable with just adding that event to the DBAs.
14 That's the issue.

15 VICE CHAIR STETKAR: Just arbitrarily
16 designate that event as another DBA.

17 MR. KINSEY: As Mr. O'Connor said, that
18 gives you sort of a bottomless pit of event sequence
19 frequency and you don't really ever know what's going
20 to be required until it's required.

21 MEMBER CORRADINI: So can I connect that
22 comment to John's description? The way I hear I would
23 interpret what you said is that if something is
24 offered to you you would say we have to evaluate where
25 it sits within this construct. And if it sits too far

1 down in your opinion or too far over in some way or
2 it's physically impossible because of the either
3 experimentation or a combination of experimentation
4 and analysis, it just shouldn't be there. That's kind
5 of what I heard you say.

6 VICE CHAIR STETKAR: Yes. But at least
7 you know, you have the knowledge, of where if it's in
8 the framework of everything else.

9 MR. KINSEY: The focus on the construct of
10 the framework.

11 MEMBER CORRADINI: But have I said it
12 approximately?

13 MR. KINSEY: Yes, exactly.

14 CHAIR ARMIJO: While I think this would be
15 an interesting discussion, I think we really have to
16 keep moving along. We've got roughly about another
17 hour and ten minutes to cover a lot of material.

18 MR. KINSEY: But I know we are past the en
19 of our time. I think we should just wrap up because
20 I think we've gone across the points.

21 CHAIR ARMIJO: Make the points you wanted
22 to make.

23 MR. KINSEY: I just wanted to go back.
24 Mark, if you could go back to the F-C curve. The
25 first one. I'm sorry.

1 So there are two key points and these are
2 reflected on the -- If you want to look at the hard
3 copy of slide 14 at the same time. It's the summary
4 of -- It's called "Summary of Findings." There are
5 two primary areas of significant uncertainty and I
6 guess a little bit of confusion.

7 The staff has proposed that additional
8 design basis accidents would likely or could
9 potentially need to come from two places. One would
10 be picking an event that's currently in the BDBE range
11 and calling a design basis accident. And then instead
12 of applying the QHOs as its rule set, upgrading it and
13 essentially causing the applicant to evaluate it
14 against Part 50.34. So that's one issue or concern.

15 And then the second is the one that we
16 just talked about and that's coming up with a new
17 deterministically selected sequence and just adding it
18 to the list of DBAs without putting it through the
19 process. So those are the two things that we really
20 appreciate some additional clarification on as these
21 documents are developed.

22 MEMBER CORRADINI: It would effect the
23 other slides we haven't gotten to in terms of source
24 term, etc., etc.

25 MR. KINSEY: It may effect everything.

1 MEMBER CORRADINI: That's what I thought.
2 Thanks.

3 MR. KINSEY: And again that summary slide
4 14 points out those sub-bullets there at the bottom
5 which are the two things that I just mentioned.

6 And the other thing I guess we threw in as
7 an example is on the very last slide on this general
8 topic from the draft safety evaluation of the MHTGR.
9 The staff seems to have come to the conclusion that
10 everyone had done a pretty thorough review of all the
11 event sequence types and they couldn't really think of
12 any others at that point.

13 That's not to say that some couldn't come
14 out in the future. But it doesn't to us that they
15 should if there are any new ones identify that they
16 should directly go on to the DBA list which would go
17 the process as it was done back in that day with that
18 example. I'm not sure. That's all I have.

19 CHAIR ARMIJO: Any other questions?
20 Comments? Dennis, anything else?

21 (No response.)

22 Okay. Let's move on then.

23 MR. KINSEY: Thank you.

24 CHAIR ARMIJO: And Staff?

25 DR. CARLSON: Okay. Mike Mayfield is on

1 the agenda to give some opening remarks.

2 CHAIR ARMIJO: Go ahead.

3 MR. MAYFIELD: Okay. I just wanted to say
4 a couple of things. First of all, I really enjoyed
5 previous discussion. It took me back about 25 years
6 because we've been having discussions for at least
7 that long. I wanted to characterize what Don's going
8 to present this afternoon in terms of what it is and
9 what it isn't.

10 Let me start out by saying what it isn't.
11 It is not a licensing review of a high temperature gas
12 coolant reactor. We have been having dialogue about
13 policy issues for a good long while, at least 25
14 years. Tom O'Connor and I talked about what do we do
15 with these things absent a specific design coming
16 forward absent more specific technology. What can we
17 do?

18 So we agreed about a year and a half, two
19 years, ago that we would do what we could to move
20 forward with some key policy issues and Tom identified
21 those four areas. And Don is going to talk about them
22 in more detail this afternoon.

23 Going into this, I don't think Tom or I,
24 either one, thought we would come to absolute
25 agreement on without question this is how you address

1 these policy issues. But could we move the dialogue
2 forward from the great religious arguments we were
3 having? We kind of wanted to get beyond the point
4 where the staff is referred to as Godzilla. But
5 hopefully we've gotten there. But perhaps not.

6 I do think that we can make further
7 progress on these absent a complete design. Tom was
8 expressing some concern about having invested in a
9 complete design, the Staff doing that with some
10 additional events to be considered.

11 We do see this and we've seen it with the
12 preapplication discussions on the large light water
13 reactors. And we absolutely are seeing it on the
14 preapplication discussions with the small modular
15 reactors where a design is reasonably complete. But
16 through discussions with the staff the designers are
17 going back dealing with some additional
18 considerations, dealing with some additional issues.
19 And they're not having to completely redo the entire
20 design.

21 I think that preapplication discussion on
22 these as we move forward can avoid the doomsday
23 scenario where a designer or vendor has spent a lot of
24 time and money developing a complete design and then
25 we stand down on its head. So I think the

1 preapplication discussions are designed to avoid that.

2 And that's where we would look to get once
3 we have a specific design, specific technology, beyond
4 just a generic, high temperature gas reactors.
5 Something more specific I think we can and would
6 expect to make further progress, potentially getting
7 this to the point of where we can dress up some of
8 these things and make policy proposals to the
9 Commissioners and let them react to them.

10 Absent more specifics, we felt like this
11 was about as far as we could go. With that bit of
12 introduction, Mr. Chairman, I would like to turn back
13 to Dr. Carlson to present the staff's assessment.

14 CHAIR ARMIJO: Don, go ahead.

15 DR. CARLSON: Okay. My tent says I'm NRR
16 but I'm really NRO. And so my name is Don Carlson.
17 And I am the lead PM for NGNP. I came before the
18 subcommittee and I was assisted by some excellent
19 presentations from Jim Shea, Arlon Costa, Dr. Tom
20 Boyle and Jonathan DeGange. But given the little bit
21 of time I'm going to handle the full presentation
22 myself today. But they may want to come to the
23 microphone to elaborate certain comments or questions
24 you may have.

25 I would also like to acknowledge there

1 have been a number of people involved in this activity
2 over the last few years. Sud Basu from the Office of
3 Research has been involved from the very beginning and
4 has been a major contributor through activities.

5 We also have Mark Caruso in the room who
6 has provided some excellent risk insights and Michelle
7 Hart. Joe Williams did some very good leadership of
8 the preapplication activities a year ago or two years
9 ago. And so a lot of that is due to the contributions
10 of those other participants. But Jim, Arlon, Tom and
11 Jonathan really did a lot of work to bring it down to
12 the wire the last year or so.

13 I would also like to acknowledge that we
14 have a lot of help in our fuel qualification from Dr.
15 Mike Konya who is a true expert. I believe he's
16 listening in today and I want to express our
17 appreciation. He really is a recognized expert on
18 TRISO fuel and he was a great help.

19 A little bit of the project history and
20 status. As you know, the project was created by the
21 Energy Policy Act of 2005. DOE was charged to
22 demonstrate high temperature reactor and they chose a
23 modular high-temperature gas-cooled reactor (HTGR) for
24 co-generating electricity and process heat in the NRC
25 licensing authority over the prototype plant.

1 We've had a number of majority
2 preapplication activities to date. I'd like to note
3 that back in 2007 we had a good start with DOE and NRC
4 conducting a joint Phenomena Identification and
5 Ranking Tables (PIRT) process. It had five PIRTs.
6 And Dr. Corradini was on one of the PIRT panels for
7 accident analysis.

8 CHAIR ARMIJO: And don't forget Dr.
9 Powers.

10 DR. CARLSON: And Dr. Powers was on the
11 panel for fission product and dose.

12 MEMBER CORRADINI: He's in his normal
13 location.

14 DR. CARLSON: I don't see him here today.
15 Those were very good PIRT exercises. And
16 I think they helped shape a lot of things that have
17 been going on since. And I would also like to
18 acknowledge that Dr. Powers and Dr. Petty participated
19 in an NRC research PIRT in 2003 on TRISO fuel. That
20 likewise was an excellent product and has helped us
21 gain insights which we based our review on ever since.

22 So the next item that was very significant
23 was our Joint Licensing Strategy Report to Congress.
24 And we talked about the Option 2. And again the
25 Option 2 framework was there were a spectrum of

1 options. Option 1 was traditional, deterministic and
2 Option 4 was risk-based and options two and three were
3 between the two extremes.

4 And the draft DOE-NRC working group
5 settled on Option 2 which is risk informed,
6 performance-based approach using deterministic
7 engineering judgments and complimented by PRA
8 insights.

9 Since 2010, we've been focused on our
10 assessment review of some DOE White Paper submittals
11 to better define the option approach.

12 Then a year and a half ago, DOE's decision
13 in a letter of Congress based on some NIAC
14 recommendations -- and we have some NIAC members here
15 -- DOE decided they would not proceed with NGNP design
16 activities. But they would continue to focus on their
17 R&D efforts and interactions with the NRC to develop
18 a licensing framework. And they continued their
19 efforts to establish a public-private partnership with
20 NGNP Industry Alliance.

21 We've had a number of interactions and
22 over the last year or so those consisted of -- We
23 issued our preliminary assessment reports, Rev 0 of
24 the White Papers. So one of them addresses fuel
25 qualification and mechanistic source terms. The

1 second one addressed the RIPB topics, defense-in-
2 depth, licensing basis event selection and systems
3 inspections and components classification.

4 At the same time we issued a letter to DOE
5 that we agreed to continue focusing the effort on
6 resolving these frame work issues under the key issue
7 headings of licensing basis, source terms, functional
8 containment performance and emergency preparedness.
9 And those are the issues that have been highlighted in
10 various forms in the Licensing Strategy Report to
11 Congress of 2008 and in our preapplication activities
12 for MHTGR going back 25 years. These kinds of issues
13 have been highlighted for a long time.

14 Then on July 6 last year DOE clarified its
15 approach to these key issues. We had a number of
16 public meetings and conference calls through November
17 of last year. And we did get two additional technical
18 documents that provide clarification that we reviewed.

19 Then in January this year, there was a DOE
20 information briefing of the subcommittee on NGNP
21 activities.

22 And then last month we briefed the
23 subcommittee a longer version of the presentation I'm
24 giving today.

25 So what we have are three staff products

1 that we're going to try to issue. They're now in
2 draft form. The first one is we issued a summary
3 report that basically responds to the specific request
4 for feedback that we got in that July 6th letter from
5 DOE on these four major issues.

6 And then we had updates. Rev 1 of the two
7 assessment reports that were developed previously
8 where we have additional staff participating in the
9 review process and we have a higher level of
10 management concurrence on those products, division
11 level at this time. Ultimately, after we get ACRS'
12 review and your comments in a letter, we will finalize
13 the products and publicly issue them to DOE as
14 attachments to a letter.

15 So at a very high level, our major
16 conclusions are there are no obvious show stoppers
17 here. They are proposed approaches to NGNP licensing
18 issues which are responsive to NRC Advanced Reactor
19 Policy Statement and then generally reasonable with a
20 number of caveats. And at a high level, the caveats
21 are the deterministic elements should be strengthened
22 and better aligned with Option 2 as opposed to Option
23 3 which it seems to look like.

24 Technical uncertainties, there are
25 technical uncertainties and we do believe that testing

1 in the NGNP prototype under 10 CFR 50.43(e) will be
2 necessary to supplement the technical understanding of
3 fuel and core performance. And that is actually quite
4 consistent with the Licensing Strategy Report to
5 Congress.

6 CHAIR ARMIJO: Don, I would like to
7 interrupt. This is an uncertainty that can only be
8 resolved by testing of a prototype. Is that what I
9 heard?

10 DR. CARLSON: Yes. The short answer is
11 yes. You could try to address it by additional
12 testing in the fuel program. But ultimately I don't
13 think additional testing of the fuel program would
14 reduce the scope of what you're talking about here.

15 CHAIR ARMIJO: How would you license that
16 prototype if you can't --

17 DR. CARLSON: Well, we have provisions and
18 the like in the regulation 10 CFR 50.43(e). So if
19 you're relying on prototype testing to establish your
20 safety or completeness of the defense of your safety
21 basis then this allows the staff to impose additional
22 requirements to protect the public and the workers
23 during the testing period.

24 CHAIR ARMIJO: Okay. Could you give just
25 one example of a particular type of test?

1 DR. CARLSON: An example will be in
2 several slides later.

3 CHAIR ARMIJO: Okay.

4 MEMBER REMPE: Could you also elaborate a
5 little bit more about the deterministic elements
6 should be strengthened to better align with Option 2?
7 Would you concur with what they indicated that the two
8 issues were? And are you going to have to specify
9 further and give us some specific examples?

10 DR. CARLSON: That's in a few slides.

11 MEMBER REMPE: Okay.

12 DR. CARLSON: Another conclusion that I
13 think was worth highlighting is that we didn't do a
14 lot of emergency preparedness approach, but we do feel
15 that future interactions this early are important and
16 they should be supported by specific information on
17 the NGNP design of the site and co-located user
18 facilities and that information should be provided by
19 the site.

20 There are a number of qualifiers in all
21 these conclusions. First of all, we considered
22 everything in terms of relevant prior staff positions.
23 And what we're saying here really is not inconsistent
24 to marginally very consistent with the relevant prior
25 staff positions, consideration of ACRS comments and

1 Commission policy direction.

2 And so I listed a few of the SECY papers
3 from NGNP 20 years ago, PBMR ten years ago, NUREG-1860
4 which is the technology nuclear framework, the
5 licensing strategy and a SECY paper that we wrote on
6 1860 a year and a half ago.

7 Staff feedback is advisory. So these are
8 not regulatory decisions. The decisions will be based
9 on a license application and related to the Commission
10 policy direction.

11 Of course, the NGNP RIPB approach overlaps
12 with the high level concepts being considered in other
13 context like you would 1860, the NUREG 2150 which is
14 the Apostolakis risk management report and the
15 Fukushima NTTF Recommendation 1. So any changes to
16 the framework presented from those activities per the
17 report first reflect on our staff positions for NGNP
18 and changed them.

19 Finally, there was discussion at the
20 subcommittee meeting and at the January information
21 briefing among the Committee members indicating that
22 this may be applied in the technology neutral sense.
23 We haven't looked at a technology neutral. DOE INF
24 has presented to us only as it would apply to the NGHP
25 modular HTGR design concepts and we have assessed it

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1 only that way.

2 So what is a modular HTGR design? I think
3 you've become familiar with that. It was really a
4 response to TMI. Until TMI, the HTGR community in
5 Germany and in the U.S. were going to build ever
6 larger HTGRs. I could show a slide like this that has
7 the German HTGRs on that where instead of Peach Bottom
8 we had ABR, Port St. Vrain. We had the THTR.

9 And instead of the large HTGR, it would be
10 the PMP 3000. I was in Germany during 1978 to 1983
11 and I witnessed up close the mind change and in fact
12 the first idea, the first paper, that gave us the
13 modular HTGR design concept in 1981 from Germany. And
14 in fact it was a very first collaboration in those
15 days between the German and the General Atomics and
16 Oak Ridge. And General Atomics followed suit with
17 their concept of the modular HTGR.

18 So what happened after TMI, two things
19 actually. About 1980 the Germans perfected the state
20 of the art of TRISO fuel. And they established what
21 people considered the gold standard of TRISO fuel.
22 Really high performing/high quality TRISO fuel.

23 And then TMI said "Let's see what we can
24 do to make this inherently safe." And so they
25 basically said, "We don't want to need coolant to keep

1 the fuel at safe temperatures." And so to do that
2 instead of the PCRV, the pre-stress concrete reactor
3 vessel, they went to a metallic vessel, put it in a
4 passively cool cooling system. Heat kept the geometry
5 nice and normal and slender. Reduced the power
6 density. So you don't need coolant to keep fuel
7 temperatures in the safe region.

8 I'm starting now with the licensing basis
9 event selection. The licensing basis event that you
10 traditionally consider for light water reactors don't
11 really make sense for this technology. So the task is
12 to identify events.

13 So we're going through the issues again
14 based as represented in the July 6th letter. Our
15 feedback on licensing basis, they want us to -- We
16 think that the frequency consequence curve and the
17 identification of top level regulatory criteria is
18 reasonable. That said future Commission policy may
19 consider alternate TLRC and F-C curves.

20 We think the proposed plant year method is
21 reasonable for using this for plants with multiple
22 reactors modules.

23 CHAIR ARMIJO: Why is that?

24 DR. CARLSON: I think I'll go to this
25 slide. This is a slide the DOE produced for us during

1 the last year in our interactions that has their blue
2 frequency consequence overlaid with the NUREG 1860
3 frequency consequence curve. What they did though was
4 they plotted the NUREG 1860 consequence curve as
5 though event sequences were considered on per plant
6 year as shown on the vertical axis there as opposed to
7 per reactive year in NUREG 1860.

8 And so the criteria in NUREG 1860 works
9 best per reactor year meaning that if you change the
10 number, if you increase the number, of reactor modules
11 at a plant, the acceptance criteria for those offsite
12 change.

13 And I would posit that the public really
14 doesn't care how many reactors you have at the site.
15 They care what's coming at them from the site. So we
16 think that's reasonable. We also think that it's of
17 course a very reasonable way of addressing events that
18 can cause releases from multiple modules.

19 CHAIR ARMIJO: You're talking simultaneous
20 release.

21 DR. CARLSON: Yes.

22 The selection approach for LBES is
23 generally reasonable, but over the risk based in some
24 respects as we've been discussing in search of better
25 language Option 2 was resulting a set of LBES from

1 their process may have to be supplemented. So we
2 think that it may be necessary to supplement their
3 DBE-derived DBAs again where DBAs are derived from
4 DBEs by assuming only safety related equipment
5 responses. So you may have to supplement those with
6 deterministically postulated DBAs and/or DBAs derived
7 from events that they would say are in the BDBE
8 region.

9 CHAIR ARMIJO: Don, what do you mean by
10 overly risk based? You don't believe that there risk
11 numbers are reliable enough?

12 DR. CARLSON: It's hard to say how
13 reliable their risk numbers are until we actually see
14 a PRA. But I do believe that because there's a lack
15 of experience with this. There's limited experience
16 with the technology and no experience, no modular HTGR
17 that have been designed or operated.

18 CHAIR ARMIJO: Well, maybe not, but ABR
19 did pretty well.

20 DR. CARLSON: But that was not a modular
21 HTGR. I'm very familiar with ABR. I've worked there
22 for five years.

23 CHAIR ARMIJO: I've been there.

24 DR. CARLSON: Yes.

25 CHAIR ARMIJO: Great little reactor.

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1 DR. CARLSON: Yes, but it was not a
2 modular HTGR. They did some proof principle type
3 tests there.

4 CHAIR ARMIJO: Yes.

5 DR. CARLSON: Those were very interesting.

6 MEMBER CORRADINI: Can I because I think
7 I know the answer? But I just want to make sure I've
8 got it from what you were saying. So the third bullet
9 and the reason you need to separate from the
10 postulated DBAs and the DBAs right from BDBEs is that
11 the design is not -- One of these three or all of
12 these three, the design is not complete. There's an
13 uncertainty in whatever the risk numbers they're doing
14 or there is incompleteness.

15 DR. CARLSON: It is all of them, but I
16 would take some latitude.

17 MEMBER CORRADINI: In completeness and
18 uncertainty.

19 DR. CARLSON: Uncertainty in the PRA
20 numbers. I mean it's hard to assess the reliability
21 of the uncertainty estimates being looked at.

22 MEMBER REMPE: So if someone came in with
23 the perfect PRA which would be evaluated at a higher
24 screen and believable data to support that PRA you
25 might not revoke from the traditional requirements.

1 DR. CARLSON: I don't know. Mark, do you
2 want to say anything more about the PRA and what we
3 think about relying on it under an Option 3 approach
4 as opposed to what we would do as an Option 2?

5 MR. RUSSO: Yes. We --

6 CHAIR ARMIJO: You are?

7 MR. RUSSO: I'm Mark Russo from NRO staff
8 from the Severe Accident PRA branch. Yes, I think
9 there's definitely cause to be concerned given the
10 level of information that we've got, what the degree
11 of uncertainty is going to be and talking these points
12 down on the frequency consequence curve.

13 As Dr. Stetkar has already commented, it's
14 not even clear what constitutes a point. Is it one
15 sequence or a bucket of sequences or whatever?

16 But given the issues with data, new
17 systems, there is certainly -- We would certainly
18 expect a fair amount of uncertainty, a great deal of
19 uncertainty.

20 MEMBER CORRADINI: Can I ask you, Mark?
21 Since the last slide, Slide 15, quotes the staff 25
22 years ago.

23 MR. RUSSO: The ACRS has this role as far
24 as I can tell.

25 MEMBER CORRADINI: So did something change

1 in the uncertainty range that at the time they judged
2 bounding events? Has something changed? Or is it
3 just that the design then is not the design now?

4 I'm still struggling with the source. Is
5 it design? Is it the PRA given the design? What are
6 the barriers to better uncertainty? Well, I looked
7 this up and indeed this was said. I looked at the
8 ACRS record.

9 MR. RUSSO: From my perspective I would
10 say, I mean the design -- Modeling the sequence
11 without the numbers and stuff I think is great
12 forward. You're going to know what the systems are
13 and I'm sure they deal with gas. I don't think
14 there's anything there that that's much different.

15 You know, I think the biggest areas are
16 data, failure data, because of systems we don't have
17 experience with, don't have service. Now I'm not sure
18 if you're aware of it but we didn't get a PRA. But we
19 got a White Paper right after the other White Papers.
20 It was called the PRA White Paper.

21 And it's referred to in the other White
22 Papers a lot. And we refer to it in our assessment,
23 although we read it. But we didn't review it like we
24 did the other ones. And mostly it's a plan that
25 describes how they're going to do the PRA.

1 And they do identify the different types
2 of data they're going to need for this model. And they
3 do make a qualitative assessment about which ones have
4 more uncertainty than others. Whether they're going
5 to be able to use water reactor data because the
6 components are the same. They're pumps and whatever.

7 That would have a lower amount of
8 uncertainty. Some of the areas where there's new
9 systems and gas systems which we don't have as much
10 experience with they'll try and use as much as they
11 can from the gas coolant reactors in England. But
12 they recognize the consumption.

13 So I think just like the ESBWR and all of
14 the new designs, the IPWRs, we've always been
15 concerned about the data or about these squib valve
16 data, what we can learn about the squib valves, brand
17 new design. So I think that's one of the main areas.

18 I think the other one would be that when
19 you look at these points that are plopped on this
20 curve a big part of this is the transport of
21 radionuclides. It's the mechanistic source term
22 that's buried in those points. And to me that's
23 probably going to be the most complicated part of
24 doing this PRA is that part of the sequence.

25 MEMBER CORRADINI: Okay.

1 MR. RUSSO: And so there will be
2 uncertainty in that, too. We haven't done that
3 before. I mean the technology is there I mean I think.
4 Sure, there will be uncertainty.

5 But I also think all the stuff is really
6 saying here is that they want to make sure that
7 there's allowance for addressing defense in depth
8 because of uncertainty in this design. And I don't
9 think there's an intent to do anything different than
10 what's been done 30 years ago where you came in with
11 a design.

12 The designer said, "I've gone through and
13 done my FMEA. I've identified the events and I have
14 some assessment of the frequencies." And at some
15 point you're going to create the envelope. And at
16 some point you're going to argue about should this one
17 be dropped off. Should vessel failure be dropped off
18 or not?

19 I commend this approach and it's bringing
20 in the use of reliability assessment, the PRA, to help
21 get a better handle on what these frequencies of
22 different events are. That would be helpful with
23 coming up with the envelope.

24 But given that there will be uncertainty
25 I think you're going to end up the same way with

1 starting with an envelope that includes all the PRA
2 design basis events which is fantastic. But you're
3 still going to be at this point where you're going to
4 struggle with do I need some that I just want to test
5 this design against. And there may be some
6 conservative binding kinds of events.

7 But those I agree with the designers. You
8 first identify those through the actual design and
9 technical allowances. You look at what do I know.
10 What is all the experimentation and analysis done tell
11 me about what I expect the frequency to be?

12 So it's got to be a rigorous technical
13 analysis. I don't think that the staff is saying that
14 they're just going to dream up something out of the
15 blue and say, "We don't care what the frequency is."

16 MEMBER CORRADINI: I'm going to stop you.

17 MR. RUSSO: Yes. Thank you.

18 MEMBER CORRADINI: That's alright. The
19 last part that you said I'm curious if Don is in
20 charge of this show.

21 MR. RUSSO: Yes.

22 MEMBER CORRADINI: Is the recycle of if
23 you come up with something that is deterministic that
24 doesn't fit into their mapping either because it's way
25 low or it isn't there going to inform and after

1 recycle there would have to be an analysis as John
2 suggested? I mean if I were on the designer's side of
3 this, I would say, "Wait a minute. This is not here
4 or it's way down there." And it's way down there
5 because of analysis that will show you versus thou
6 shalt take this one. End of story.

7 That's what I think. To recycle back into
8 the analysis I think is very important. Otherwise
9 you're going to come up with things that could be a
10 bit out of bounds.

11 MR. RUSSO: Yes, I think it has to be that
12 way. I don't think you can just ram something down
13 somebody's throat. They give you come west and this
14 is what we think. And if we say "Well, we know
15 there's one down there. So while you really think
16 it's down there."

17 "No, I disagree. Show me more." We do
18 this all the time.

19 MEMBER CORRADINI: Okay.

20 MR. RUSSO: And sometimes it's very, very
21 difficult because there's a lack of information and
22 it's going to end up being judgment and consensus and
23 all that. Thank you.

24 MEMBER SKILLMAN: Don, I want to go back
25 to that second bullet. I'm not comfortable with the

1 little -- Yes, with that sketch that you show. I mean
2 this technology is new. There isn't a lot of
3 operating experience for this type of machine. And
4 because that is the case it would seem to me that at
5 least until there's some run time to really understand
6 how a modular concept is successful, then the risk
7 really ought to be based on per reactor year.

8 Another variation is you don't know that
9 these four or six or ten in a plot are going to be
10 operated the same way. And so they can each have
11 their own operating history, their own personality,
12 their own DDT generation rate. So it seems like this
13 is a clever way to clump risk when in reality until
14 there's some experience it may be more prudent to
15 govern by reactor year versus plant year.

16 DR. CARLSON: I think this discussion is
17 really appropriate when you're looking at licensing
18 multi-modular plants. But the task before us is to
19 really license the prototype which is one module. So
20 I think when you focus on licensing a single module
21 there's discussion that comes into mind.

22 MEMBER SKILLMAN: I agree with that. But
23 when you say we're going to have four or six in an
24 array I think there's another discussion that needs to
25 occur.

1 DR. CARLSON: Yes, and there was a
2 discussion of site risk in past SECY papers. I think
3 SECY 05. I can't remember the number. The ACRS wrote
4 a letter on that. And the issue that was difficult at
5 that time remains difficult. But if you have a new
6 module reactor plant site and have an existing reactor
7 site, how do you portion this between those two?

8 We didn't go there in our discussions with
9 NGNP. We were busy looking at this from a module
10 plant that's at a green field site.

11 MEMBER SKILLMAN: For a single modular
12 plant.

13 DR. CARLSON: Yes, for a single modular
14 plant.

15 MEMBER SKILLMAN: Then I think the
16 argument is back on the table.

17 DR. CARLSON: But for licensing the
18 prototype it's kind of a moot point because it's a
19 single module.

20 MEMBER REMPE: Except that the site could
21 accommodate one module because that's why I think they
22 performed it that way at this time.

23 MEMBER SCHULTZ: That's fine. But are we
24 arguing about something that will be the licensing
25 approach for ten modules? Or we still don't have a

1 prototype?

2 MEMBER CORRADINI: I think there may be
3 some confusion. The way they do it here per plant
4 year.

5 MEMBER SCHULTZ: I might be wrong about
6 this.

7 MEMBER CORRADINI: Because they're doing
8 per plant year, they're actually taking the population
9 of all modules. It's actually more conservative than
10 doing it on a per reactor year basis.

11 VICE CHAIR STETKAR: Ten modules together
12 must meet the criteria.

13 MEMBER CORRADINI: Right. Ten modules
14 together. The assumption here is that I would have
15 ten failures simultaneously. So it's much more
16 conservative.

17 MEMBER REMPE: And they do have to come in
18 knowing that was something that we used to discuss and
19 kind of have an idea of how many you're going to put
20 on the site when you start off on the sites.

21 CHAIR ARMIJO: Everybody is in agreement.

22 DR. CARLSON: I thought I knew this F-C
23 crew, but I'd just like to note that there are many
24 different F-C curves that we could come up with. We
25 came up with one in some of our REIs. The ACRS wrote

1 a letter in 2007 on the NUREG 1860. And their comment
2 on this red F-C curve was that the 5 millirem
3 criterion from Appendix I ALERA was only restrictive
4 with essentially only things that really restrict
5 important. So we see the NGNP curve being more
6 consistent with the ACRS comment on that front.

7 Yes, we think the frequency cutoffs are
8 reasonable for the last bullet for HTGRs. We're not
9 sure they would be reasonable for other technologies.
10 But we think it's reasonable for HTGRs that provided
11 the PRA's full scope. And I think we understand what
12 we mean by full scope. And that's exactly what DOE
13 had proposed.

14 Furthermore, the processes for assessing
15 are generally reasonable for the LBEs, the meaning of
16 that sequence frequency. We look at uncertainties and
17 event sequence frequencies and consider the
18 consequences in relationship to the criteria. They
19 overlap the frequency ranges for each category.

20 The calculation methodology uses
21 consequences from full sequences, best-estimate
22 mechanistic source term which is the next topic with
23 realistic or conservative treatment of uncertainties.

24 The proposed use of realistic source terms
25 for compliance in the case of anticipated events and

1 beyond design basis events needs further
2 consideration. The staff has issued SECY 05-0006 was
3 that the plants should be conservative for all
4 categories. However, DOE provided some rationale for
5 considering their proposal and for the consideration
6 probably within from the Commission.

7 Also they have a process for
8 categorization of treatment of safety related
9 equipment. We think that their approaches are
10 reasonable and commensurate with ensuring that they
11 perform their safety functions in the LBES.

12 The next big issue area was Mechanistic
13 Source Terms. First, the staff and the Commission and
14 the ACRS has been receptive to the concept of
15 mechanistic source terms for advanced reactors for
16 many years going back to the early 90s for MHTGR. And
17 that was reiterated for PBMR ten years ago.

18 So the definition of mechanistic source
19 terms you could think of it as being in light water
20 reactor space something like the full-blown MELCOR
21 analysis. Their definition of source term is like the
22 PRA Level 3 source term. That's their definition of
23 the source terms and they are very event specific.
24 And they're mechanistic to the extent that can be
25 justified.

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1 They also take account for the features of
2 the reactor design, etc. All the barriers. This is
3 very consistent with the past positions both of the
4 staff and the ACRS and the Commission.

5 The DOE/INL has identified key fission
6 product transport phenomena for NGNP and they have
7 reasonable plans for evaluating and characterizing in
8 their NGNP fuel program which I'll discuss a little
9 bit more later.

10 We believe that the AGR program activities
11 are important in this area. And they should be
12 include additional planned activities that we
13 identified through our assessment interactions to
14 better address the effects of moisture ingress, air
15 ingress and effective dust on radionuclide transport.

16 MEMBER RAY: Before you go on, I apologize
17 for -- I'm doing the best I can to keep up. But it's
18 not easy. I'm trying to compare what was presented in
19 the subcommittee with what you're presenting now. And
20 for example in the license basis event selection of
21 the presentation on April 9th, there were seven issues
22 broken down for discussion if you recall.

23 DR. CARLSON: I didn't have time to go
24 through it at that level.

25 MEMBER RAY: In four of those cases in

1 four of those issues which it wasn't much longer than
2 what you said, but in any event the words "future
3 Commission direction may be appropriate for this topic
4 appearing in four of those seven cases." I was trying
5 to hear while I was looking at this. Is that still
6 true? Is that what you said the same thing you just
7 said that you didn't have time to say it?

8 DR. CARLSON: I would say it's still true.
9 I think we need to be careful about what we really go
10 to the Commission with. But we say potential needs
11 for Commission direction on some of these issues.

12 MEMBER RAY: All right. But I'm just
13 trying to make the committee aware that what the
14 subcommittee heard was repetition over and over again
15 of future Commission direction may be appropriate for
16 this topic. And I just wanted to have you say, yes,
17 that is still true.

18 DR. CARLSON: Yes, that is still true.

19 MEMBER RAY: Okay. Because if I just look
20 at what you're saying here I don't get that message at
21 all.

22 DR. CARLSON: I didn't put those
23 statements in here, but I will try to wrap up with
24 some statements on where we think the Commission
25 direction might be.

1 MEMBER RAY: Okay. Thank you.

2 DR. CARLSON: So I think most of us have
3 seen this diagram. It's been around for probably 40
4 years. It's image courtesy of DOE. The DOE data from
5 Bob Hanson. And I think it's been around for about 40
6 years. But it does show all of the barriers that
7 we're considering, the fuel kernel, the coatings on
8 the particles, about six billion coated particles in
9 the reactor core.

10 And then the transport of the
11 radionuclides through the coatings to the fuel compact
12 matrix into the graphite block into the circulating
13 helium pressure boundary into the circulating helium
14 and then deposition at various places in helium
15 pressure boundary in the form of plate out and dust
16 and then in accidents you get various mechanisms for
17 mobilizing and releasing those fission products that
18 are deposited around the system.

19 An interesting aspect of the source terms
20 are very low because you don't have major core damage.
21 You don't have fuel damage. And the source terms are
22 low. So the accumulation of long term fission
23 products like cesium-137 and strontium is significant.
24 So releases after 40 years of operation are being
25 substantially higher than after four years of

1 operation. This shows all of the boundaries including
2 the reactor building.

3 MEMBER CORRADINI: I guess what you just
4 said I'm processing. Can you repeat about why things
5 are going to build up here that they wouldn't in light
6 water reactor? I missed that. I'm sorry.

7 DR. CARLSON: I think they build up in
8 light water reactor.

9 MEMBER CORRADINI: All right. But I
10 thought somehow you were making a contrast.

11 DR. CARLSON: They are significant. I
12 think they're kind of in the noise of the source term
13 of the light water reactor compared to what you're
14 getting from fuel damage in the light water reactor.

15 MEMBER REMPE: So this is basically a
16 licensing condition if we were an LWR coming forward
17 in some of the design certifications we've seen. You
18 would do it for a period of time probably.

19 DR. CARLSON: The prototype testing?

20 MEMBER REMPE: Yes. And when you say
21 prototype, that could be the first plant that's full
22 scale.

23 DR. CARLSON: It wouldn't be identical to
24 the standard, but it could look a lot like it. But it
25 would need additional features to allow

1 instrumentation removal and instrumentation and things
2 like that.

3 MEMBER REMPE: For temporary effect.

4 DR. CARLSON: Yes.

5 MEMBER CORRADINI: Let's just make sure
6 that I'm clear about this because one I want to be
7 clear about. So it would not necessarily be normal
8 operation. You would have to take it through some
9 paces to show that what you thought was happening with
10 definable transients actually do occur here. So you
11 would have to take it through some unusual paces.

12 You would probably have to go through
13 power ascension. You would probably have to extra
14 instrumentation. So if I were an owner operator
15 wanting to get revenue out of this, I'm not going to
16 get revenue out of this for a while because -- not
17 that we care of this here -- I wouldn't get revenue
18 out of this because I would have to take it through
19 its paces.

20 DR. CARLSON: I think that's a correct
21 statement.

22 MEMBER CORRADINI: Okay.

23 MEMBER REMPE: But for how long? I guess
24 I'm still puzzled about this. This is something
25 that's been discussed a lot. And what is it you're

1 envisioning?

2 MEMBER CORRADINI: Well, we're arguing
3 with each other out loud.

4 MEMBER REMPE: Yes.

5 DR. CARLSON: Speaking from the staff's
6 side, there was a lot of discussion on our part of
7 wouldn't be nice if we had a little bit more design
8 information and could engage in a strategic discussion
9 of how you would do this prototype so that you get the
10 information you need in a few years as opposed to two
11 decades.

12 MEMBER REMPE: So you're thinking of
13 making them do testing for a couple of years.

14 DR. CARLSON: Oh, I think so. Yes.

15 MEMBER REMPE: And you're thinking of
16 transients, not just normal operation. Could they get
17 power out of it for a couple of years?

18 DR. CARLSON: I listed some things of
19 likely impossible. I would consider the first three
20 that I listed here as likely, almost common sense.

21 MEMBER REMPE: Yes. And that could be
22 done while they're producing power and making money.

23 DR. CARLSON: The fourth one would be
24 where you're trying to simulate some accidents. You
25 could possibly do that. That would be more

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1 challenging. Yes, you could shave off some
2 significant uncertainties perhaps if you did that
3 right.

4 MEMBER CORRADINI: So let me just take
5 this a little step further. Is it fair to say that --
6 now if it's not fair you stop me -- any nonlarge light
7 water reactor, even a small modular light water
8 reactor, may have to go through certain of these paces
9 to create the necessary certainty for staff to unwrap,
10 unbundle, relax what you might have to put on this as
11 restrictions for the first one? Is that a fair
12 statement?

13 DR. CARLSON: Yes.

14 MR. MAYFIELD: Let's be a little cautious
15 with that one.

16 MEMBER CORRADINI: That's why I said you
17 could stop me.

18 MR. MAYFIELD: Where we have well-
19 understood technology, then we would look at pre-
20 operational testing just like we do with the large
21 lights. If you've got some aspect of it that you
22 needed to invoke the prototype licensing provision,
23 then we would expect testing to validate whatever that
24 shortcoming is that's being addressed through the
25 prototype provision.

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1 The notion with high temperature gas and
2 it's speculation at this stage because we don't have
3 a specific application to address is you might have to
4 go through more testing for a longer period of time
5 than if you had a more proven technology. But until
6 you have a specific design and specific issues you're
7 trying to address through the prototype provisions, it
8 really gets dangerous to speculate is it days, weeks,
9 months, years, decades. I really don't want us to go
10 there absent more specifics that would need to be
11 addressed through the prototype provision.

12 MEMBER REMPE: Okay. So then I guess if
13 I were somebody trying to do this, I would say "Well,
14 how much money, how big does it have to be? Can I do
15 something that's half scale and do this and give you
16 an update if it's cheaper?"

17 DR. CARLSON: Actually, the regulation
18 says 10 CFR 50.43(e). It's got to be full scale
19 prototype. So, of course, you can always try to get
20 an exemption or exception and do something to scale.
21 But I would think full scale is essential here.

22 MR. MAYFIELD: A prototype provision or
23 regulation is contemplating the full scale reactor.
24 You can address some of the things you might need to
25 or might want to address through a prototype. But you

1 can address that through other testing. We're not
2 saying you have to do all the testing with the
3 prototype. But there very well may be the
4 expectations.

5 (Simultaneously speaking.)

6 MEMBER REMPE: -- the regulation. And it
7 wasn't clear that you had to have a prototype for
8 everything.

9 DR. CARLSON: The expectation is you're
10 going to have a full scale prototype -- prove out
11 pieces that you can't reasonably prove out. Don't
12 have data or can't do that. Separate phases or that's
13 the notion.

14 CHAIR ARMIJO: Mike. Likely impossible of
15 this set of testing requirements which you would say
16 right now would be required.

17 DR. CARLSON: I'm saying the first three
18 are --

19 CHAIR ARMIJO: Okay. And the rest you
20 might address them or you might not. But the top
21 three are required.

22 MEMBER SCHULTZ: And five would more
23 likely be done with a separate effects approach rather
24 than the prototype.

25 DR. CARLSON: Yes.

1 CHAIR ARMIJO: Five we do with fuel stuff
2 all the time.

3 DR. CARLSON: A whole gamut of separate
4 effects. The point is that you do enough separate
5 effects so that the designer is confident that the
6 testing of the prototype isn't going to have a lot of
7 bad surprises.

8 CHAIR ARMIJO: Okay.

9 MEMBER RAY: This is mere semantics
10 probably. But do you differentiate between prototype
11 and demonstration plan. A full-scale prototype many
12 people call a demonstration plan.

13 DR. CARLSON: You could license a
14 demonstration plan without the prototype technical
15 provisions. What we're saying in the licensing
16 strategy report to Congress specifically said
17 prototype technical provisions.

18 MEMBER RAY: Do you understand that
19 because I'm still -- it's vague.

20 CHAIR ARMIJO: I don't think we have time
21 for semantics.

22 MEMBER RAY: Evidently you're trying to
23 communicate something with the word prototype and I'm
24 just trying to understand what it is as opposed to --

25 DR. CARLSON: I could put up the

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1 regulation.

2 MEMBER RAY: No, no. You're just using
3 the word out of the regulation is what you're telling
4 me.

5 DR. CARLSON: Yes.

6 MEMBER RAY: And if somebody were to call
7 that a demonstration plan, would that be in conflict
8 with the regulation?

9 DR. CARLSON: No. You can call it what
10 you want.

11 MEMBER RAY: Okay. It's important.

12 MR. MAYFIELD: That's an important
13 distinction. This is Mark Mayfield again. If you
14 seek to invoke the prototype regulation 50.43(e),
15 that's going to bring about some very specific things
16 that the staff will look for to be addressed through
17 the testing and operation of that prototype plan so
18 that the license conditions that would be invoked in
19 granting that license can be removed.

20 MEMBER RAY: All right.

21 MR. MAYFIELD: Okay. So the demonstration
22 notion is a nice philosophical concept. It's not
23 embedded in regulation. Prototype is a very specific
24 piece of the regulation that contemplates you may not
25 have adequate data to satisfy all of the regulatory

1 criteria in advance. So you can do that three
2 testings where those license conditions, other
3 constraints, only operations to ensure public health
4 and safety while you were validating the things that
5 you didn't have adequate data to support.

6 MEMBER RAY: But in my experience a
7 prototype plant might also not satisfy all the license
8 conditions that would be applicable to a demonstration
9 plant or the first of a series of commercial plants.

10 MR. MAYFIELD: A demonstration plant is
11 going to satisfy all the regulations. It's going to
12 satisfy all the regulations and you're going to
13 operate it to prove that life is good. The prototype
14 is going to have some specific conditions imposed on
15 it at licensing that a demonstration plant might not.

16 MEMBER RAY: Okay. Got it.

17 DR. CARLSON: Okay. Moving on as we noted
18 with the subcommittee previously we think that peer
19 review of the PRA is very important in that
20 particularly mechanistic source terms or the PRA
21 component is going to be subject to peer review and
22 staff review.

23 The further consideration of bonding
24 events with air ingress and moisture, I'll get more
25 into that in a couple of slides. And as I said before

1 source terms for compliance, can you consider
2 compliance based on realistic as opposed to
3 conservative? That's an issue for further
4 consideration.

5 Okay. So functional containment. It's
6 intimately related to the source terms.

7 MEMBER RAY: Could I? One last thing. I
8 just was again looking at the subcommittee
9 presentation and I think I want to underscore this.
10 A graded EP may be different for NGNP prototype plant
11 versus subsequent standard plants. I mean that's what
12 I was trying to make clear.

13 MR. MAYFIELD: There are a lot of things
14 about a prototype that might be different. You would
15 prove out through the prototype testing so that you
16 would relax those constraints on Unit 2.

17 MEMBER RAY: Sure.

18 MEMBER CORRADINI: Okay. So you were
19 going down a path I wanted to make that I'm not
20 misinterpreting which is that the prototype gives one
21 the advantage as I understand your description that
22 you would start I'll use the word earlier but start in
23 some manner that you're more restricted. But as you
24 prove it out or move uncertainty, that whatever a
25 demonstration plant is would have more I'll call it

1 long-term and I'll use the word reasonable
2 restrictions for safety regulation.

3 MR. MAYFIELD: Yes. Let me try this a
4 little differently.

5 MEMBER CORRADINI: You'll do a better job
6 than I.

7 MR. MAYFIELD: The notion of licensing a
8 prototype there would be some aspects of the design of
9 the supporting data that are not as robust as the
10 applicant or the staff might like to see to just grant
11 a license. We would impose in principal. The concept
12 is we would impose like through license conditions,
13 perhaps power limits, perhaps different ascension
14 testing, different trip setpoints, to assure the safe
15 operation of that design while you are operating it,
16 both normal operation and some of the simulated
17 transient to gather data to demonstrate the safety
18 operation of that plant.

19 As you gather adequate data, the licensee
20 will come back, seek to have that particular license
21 condition removed so that at the end of the day they
22 would have all of those license conditions removed.
23 And now you would have operation that's consistent
24 with the regulatory structure where we now have
25 adequate operation and testing data to support.

1 MEMBER CORRADINI: Thank you.

2 CHAIR ARMIJO: So it's evolved into a
3 demonstration plan at that point.

4 MR. MAYFIELD: Yes.

5 MEMBER CORRADINI: Thank you. Does that
6 help?

7 MR. MAYFIELD: Yes, that' helps a lot.

8 DR. CARLSON: That was a finite testing
9 period. So the definition of functional containment
10 is very consistent with what we considered 20 years
11 ago. And in SECY-03-0047 and you could read the
12 definition. It's reasonable. We are supposed to come
13 back to the Commission some day with functional
14 containment form of standards. DOE discussed those
15 with us. What they're proposing is essentially
16 identical to what the staff proposed in SECY-05-0006
17 with the important addition at the end specific to
18 modular HTGRs with limiting air ingress after helium
19 depressurization accidents. And I'll get into that a
20 little bit more in a couple of slides.

21 They also wanted feedback on the AGR fuel
22 program activities. And we find that the scope of
23 their AGR program activities is generally reasonable
24 and complete in the context of prototype testing.
25 That doesn't mean if you do it you don't have to be

1 testing the prototype of course.

2 Early AGR irradiation and safety testing
3 results seem to be quite favorable. So this is a
4 major accomplishment on the part of DOE and they may
5 even be establishing new standards for TRISO fuel.

6 Now completion of the plant AGR activities
7 is key for modular AGR safety case. The AGR fuel
8 program should continue to give attention to such
9 areas as we say in one of our assessment reports"
10 specification of fuel service conditions for normal
11 operations and activities based on specific design
12 information; evaluation and treatment of AGR fuel test
13 irradiation temperature uncertainties. We saw an
14 interesting report about that this last year. They
15 seemed to be doing a good evaluation of that, but the
16 uncertainties are significant. And potential needs
17 for additional fuel and fission product transport data
18 for bounding events, I'll get into that a little bit
19 more.

20 As we've said, the prototype testing is a
21 little more detail for the transport fuel irradiated
22 in the prototype we would want to do testing on that
23 to fully address the coating interactions with
24 plutonium fission products. HGHP produces in fission
25 more plutonium than what you get in water cooled test

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1 reactors like the ATR.

2 MEMBER CORRADINI: I remember this from
3 the SECY. But if my reactor physics is wrong you'll
4 correct me. But the time scale for what you just said
5 is years. It's not months.

6 DR. CARLSON: We're talking about the
7 irradiations.

8 MEMBER CORRADINI: Yes. Okay.

9 DR. CARLSON: The irradiation tests and
10 such.

11 MEMBER CORRADINI: So licensed fine. I
12 got it.

13 DR. CARLSON: So the ATR and AGR are
14 irradiation systems. And the ATR don't give you the
15 fission product in the choice which is a total
16 indication that it would be prototypic and those
17 fission products can affect the TRISO fuel product
18 coatings. And that came out in the TRISO PIRT.

19 The temperature effects of these kinds of
20 fission product interactions, the coatings aren't
21 fully addressed by accelerated irradiation. So real
22 time irradiations are important. And the irradiations
23 in the ATR are really emphasizing the high ends of
24 irradiation parameters. High temperature, high burn-
25 up, high fluence.

1 We think that more prototypic combinations
2 of irradiation parameters may or may not give you
3 difficult performance. It remains to be seen. And
4 then again testing and surveillance to confirm core
5 operating conditions, hot spots, etc.

6 CHAIR ARMIJO: Then to address this issue
7 of the plutonium fission products, what do you have
8 do? Do you have to test?

9 DR. CARLSON: Well, you have to irradiate
10 it in an HTGR and preferably the prototype. So the
11 conditions are fully prototypical.

12 CHAIR ARMIJO: So that would be fuel
13 that's removed after a certain amount of irradiation
14 and you verify in hot cells or some other way.

15 DR. CARLSON: Through safety, in-depth
16 testing you do PRA like we're doing in the AGR program
17 on the test agreement.

18 MEMBER CORRADINI: But you would need
19 time. You would have to cook it longer before you
20 look at it.

21 DR. CARLSON: Yes, it would have to go in
22 your discharge unit.

23 MEMBER CORRADINI: Okay.

24 CHAIR ARMIJO: But you don't have to have
25 irradiations in another HTGR somewhere else in the

1 world and then use that as a prerequisite before you
2 would license this.

3 DR. CARLSON: I think that if you did it
4 might reduce ever so slightly the scope the of testing
5 the prototype. But we can talk about that.

6 CHAIR ARMIJO: Okay. I just --

7 DR. CARLSON: What is interesting that the
8 German program they did test irradiations in the ABR
9 and the Chinese and the Japanese have done test
10 irradiations in the HTGRs.

11 So the staff agrees that the core melt
12 accident for event selection for plant siting and
13 functional containment assessments. We believe that
14 the core melt accident that is at issue of light water
15 reactor for the footnote in the regulations may not be
16 applicable to modular HTGRs. And this is consistent
17 with what the staff said 25 years ago for the MHTGR.

18 MEMBER RAY: I've taken a note every time
19 somebody referred to 30 years ago, 25 years ago, 20
20 years ago. Quite a few times. And I guess I'm just
21 beginning to wonder. Maybe that's part of what's
22 going on here. We're looking at the way things used
23 to be done and we're in a different era now. I just
24 offer that.

25 I know that we repeat it over and over

1 again. This is the way we did things in the past.
2 And I'm not sure that that is in fact what we're
3 facing today as a society. But go on. You said it
4 again. So I just wanted to make my point.

5 DR. CARLSON: I think in reviewing what
6 the staff did years ago I think they did a really
7 great job.

8 MEMBER RAY: Without doubt. That's not
9 what I'm talking about. I'm talking about what you've
10 not yet talked about and that is Commission decisions
11 and policy that may be still from 30 years ago. But
12 the problems that we face today may be in need of
13 something different. You'll come to that.

14 DR. CARLSON: This is where I address Dr.
15 Corradini's question of what has changed. You were
16 reading what the ACRS and the staff were 25 years ago.

17 MEMBER RAY: You're right.

18 DR. CARLSON: Yes. What chimney effect
19 interferes there? We took this to the Commission and
20 the Commission came back to us with an SRM that said
21 and I'm prepared to read it here that "The Commission
22 believes that for the MHTGR the staff should also
23 address the following type of event sequence." And
24 this was after they looked at all the bounding event
25 sequence that the staff proposed on the MHTGR and we

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1 saw some of those plotted today in the slides
2 presented by DOE INL. And said, "We want you to also
3 consider the following types of events, the loss of
4 primary pressure boundary integrity whereby air
5 ingress did occur from the chimney effect resulting in
6 graphite fire and the subsequent loss of integrity of
7 the fuel particle coatings."

8 So the Commission said, "You looked at
9 some bounding events. But we want you to look at more
10 and we want you to focus on air oxidation of
11 graphite."

12 Now there is one thing I would change
13 about NUREG-1338 and I said so last month. And that
14 is there's a section of NUREG-1338 from 1989 that is
15 called graphite fires. And they said that Chernobyl
16 was a graphite fire of a significant type and
17 Windscale was a graphite fire.

18 Now we have, and I think this has been
19 presented to ACRS in recent years, presentations by
20 our graphite expert in the Office of Research. I
21 think Dave Petty also presented something in recent
22 years. They looked at Windscale a few years ago. I
23 think it was in 2006. They had photos. Graphite is
24 there for the most part. So what burned at Windscale
25 was the metal fuel. And it took some graphite with

1 it. Likewise with Chernobyl. Most of the graphite is
2 still there.

3 So, yes, I think what we wrote about
4 graphite fire in NUREG-1338 we would change that
5 today. It in fact is hard to make graphite burn.
6 Some people compare graphite to coal and that's not a
7 good comparison at all.

8 MEMBER CORRADINI: Don, you're a perfect
9 straight man. Wouldn't -- If I had any of the
10 Commissioners from 20 years ago say, "You guys were
11 just technically wrong. You shouldn't have said this
12 because there was no technical? Or is there a
13 possibility this is just a frequency variable?"

14 DR. CARLSON: I think what the Commission
15 wrote down in the SRM is basically reasonable.

16 MEMBER CORRADINI: So there is a
17 possibility of having a high point vent where I would
18 just cook the core.

19 DR. CARLSON: I'll go into that a little
20 bit now.

21 MEMBER CORRADINI: Okay.

22 DR. CARLSON: And I did last month if you
23 recall. The SRM is fundamentally sound I think. It
24 does reflect a desire to understanding the safety
25 terrain.

1 Okay. What are the bounding events? I
2 think it's important for the staff and it's our job to
3 understand the safety terrain to answer the question
4 "What would it take to get a big release from these
5 reactors?" And then to say, "Okay. What is it that
6 keeps us from getting there?" Those are what I call
7 safety terrain studies.

8 And it's really not PRA per se. It's just
9 you take the basic design concept and just assume a
10 bunch of things to see where it takes you. See where
11 the safety terrain is. And then we go back and say
12 this is how we don't get there.

13 We discussed this and this is not in the
14 White Papers. But the language that we agreed on
15 during our discussions over the past year was the
16 applicant should submit for NRC consideration risk
17 informed selection of siting events, building on the
18 types of bounding events that the staff imposed on
19 them for NUREG-1338.

20 And then furthermore to address the SRM
21 from SECY-93-092 to be sure there are no cliff edge
22 effects which would be high dose consequences. And
23 understand what the safety capability. We should be
24 further informed by bounding effects that take
25 insights from exploratory studies.

1 MEMBER CORRADINI: So can I just probe
2 this? So what you're really saying when you say
3 safety terrain out here I hear consequence studies.
4 That is I'm not going to think about the probability
5 of this occurring. I'm going to say first off to get
6 it as physically possible. Once I conclude this
7 physically possible I'm going to string a set of
8 events together and say what's the consequence.

9 DR. CARLSON: Yes.

10 MEMBER CORRADINI: But what I want to ask
11 is wouldn't have you have to come back. And point
12 back to Mr. Stetkar, you have to come back and ask
13 it's there. But it's way out there.

14 DR. CARLSON: Yes.

15 MEMBER CORRADINI: Therefore it really is
16 not reasonable.

17 DR. CARLSON: Exactly. We're going to use
18 judgment. We're not going to go to things that are
19 way beyond reason.

20 MEMBER CORRADINI: Okay.

21 DR. CARLSON: So exploratory events should
22 be physically possible and they go way down into below
23 frequency range. Exactly some exploratory studies
24 like that have been done. If Dr. Powers were here, I
25 think he remembers a presentation I gave 12 years ago

1 in the other ACRS room as part of a quasi-PIRT study
2 that we did in 2001. And I put up a view graph of a
3 study terrain study what I now call it that Syd Ball
4 did for us Oak Ridge back in the late '80, early '90
5 for the MHTGR.

6 And they said, "What would happen if you
7 had a rod withdrawing and you didn't scram and you ran
8 the helium circulators? Just kept running them."

9 You would defeat the negative feedback
10 from Doppler essentially. You would get local even in
11 the fuel up to the 2000 degree range. Now there are
12 probably arguments that would say "Wow, that's not
13 credible. But it's part of the safety terrain."

14 There were also studies that have been
15 done that would say "Well, what if you have a large
16 break and you give them pressure boundary and you run
17 the shutdown blower system of the helium circulators?"
18 Basically, you're sucking air in. You're exacerbating
19 the air ingress rapid oxidation of that. It could get
20 you in trouble. Okay.

21 There have been other safety terrain
22 studies that have been published. And I think it
23 would be nice someday if the staff could do that with
24 independent analysis. And furthermore, the siting
25 events we evaluate and this way we're giving you a

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1 basis for assessing the retention requirements of a
2 functional containment system.

3 Now I'll move on with Emergency
4 Preparedness. The background is that they did submit
5 a white paper on emergency preparedness on emergency
6 planning zone size determination and scales emergency
7 response. We did not do a full review of the white
8 paper submittal because of priority considerations,
9 particularly Fukushima at the time. It was just not
10 practical to allocate staff resources to that review.

11 DOE/INL did participate in NRC public
12 meetings on EP framework for small modular reactors on
13 IPWRs. It's stated NGNP goal as we've noted is to
14 justify an EPZ at the 400-meter exclusion area
15 boundary. And that's part of the process of the
16 application. We did see that is important.

17 A year and a half ago the staff issued
18 SECY-11-0152 and it described a general approach for
19 scaling EPZs. It's also important to note that the
20 regulation allows EPZ size for gas-cooled reactors to
21 be considered on a case-by-case basis. And the 5-mile
22 instead of a 10-mile EPZ.

23 So the approach in the white paper is at
24 a high level consistent with the SECY paper 11-0152.
25 We would be open to considering future proposals by

1 industry, but we're not going to come up with further
2 policy in this area absent such proposals.

3 And we'd considered such topics as
4 proposed in the white paper, PRA informed approach
5 that includes accident dose assessment versus
6 distance, determining the point at which the probability
7 of exceeding the PAG is acceptably low.

8 MEMBER RAY: Would you repeat the point
9 about we're not going to do this absent such
10 proposals? I'm trying to find it.

11 DR. CARLSON: Yes, it's not on the slide.

12 MEMBER RAY: I know. I'm trying to read
13 and listen to you at the same time. It's a little
14 tough.

15 DR. CARLSON: I'm sorry.

16 MEMBER RAY: That's alright. I did have
17 in mind and I was trying to figure out if this is what
18 you were saying. It was again one of these future
19 Commission policy directed statements. It sounded
20 like that's what you were saying. It was in the early
21 session of the meeting saying that maybe appropriate
22 determines the criteria for HTGR containment.

23 DR. CARLSON: Once we have the specific
24 proposals, then I think we would probably go to the
25 Commission.

1 MEMBER RAY: What does the specific
2 proposal mean? It means an application I take it or a
3 pre-application at least.

4 DR. CARLSON: A pre-application.

5 MEMBER RAY: But something more than what
6 you have now.

7 DR. CARLSON: And I think that an
8 important feedback is that it's not the designer that
9 gives us that. It's the site applicant with detailed
10 information about the design, the co-located facility
11 and the process.

12 MEMBER RAY: That's what I recall from our
13 discussion at the subcommittee meeting. I think this
14 is what I make the chicken or egg metaphor, which came
15 first. It's hard to get an applicant if you don't
16 know the answer to the question. But you can't answer
17 the question until you have an offer is what it sounds
18 like.

19 DR. CARLSON: Yes.

20 MEMBER CORRADINI: Sounds like a Catch-22.

21 MEMBER RAY: He calls it a Catch-22. I
22 call it a chicken and egg. Dennis, if he could speak
23 to it, would call it a conundrum I think.

24 DR. CARLSON: I thought we had an
25 excellent discussion with that last month.

1 MEMBER RAY: Yes.

2 MEMBER CORRADINI: Yes, we did.

3 MEMBER RAY: But I was trying to find the
4 point if it was still there which amounts to what I
5 just said. And do you have anything to offer in terms
6 of how to resolve that conundrum? In other words, if
7 you say I can't get an applicant without first
8 answering the question. But I can't answer the
9 question without having an applicant. Is there any
10 way to solve that dilemma?

11 DR. CARLSON: That's pre-application
12 review. It's when you have a serious pre-applicant
13 and you have enough design information, enough site
14 information, enough co-locator user.

15 MEMBER RAY: So you're saying I need
16 somebody who is prepared to become an applicant at the
17 very least.

18 DR. CARLSON: Yes.

19 MR. MAYFIELD: This is Mike Mayfield. I
20 think you're right. You'll need to go beyond the
21 philosophical with this and get to the bit more
22 specificity absent the full application. And there
23 are views on the staff that we need to see an
24 application. Not everyone including some of the
25 senior management subscribes to that.

1 But we need more than a philosophical
2 discussion. And you have to consider in this, and I
3 think Don mentioned this, you need to look at from the
4 emergency preparedness sampling the potential impact
5 of the nuclear plant on the surrounding facilities and
6 personnel. You also need to look at the impact of
7 those co-located facilities on the safety.

8 And that's why you need the next level of
9 specificity to what this really means.

10 MEMBER RAY: And we've spent a lot of time
11 trying to understand what you just said. But again
12 the language before was selection of siting source
13 term events. I understand totally about siting and
14 each site is a specific site. It has its own needs
15 and demands.

16 On the other hand, the question arises as
17 to whether or not there is any source term event that
18 are site-independent enough to be addressed before you
19 have an applicant or even a pre-applicant.

20 MR. MAYFIELD: In the 11-0152 paper that
21 Don mentions, there's a discussion about a graded EP
22 approach in concept. That's something that we're
23 still willing to consider. But we need more to it.

24 One of the notions in there is that if
25 you're at the protective action guidelines at the site

1 boundary given accident dose, then you still have to
2 do the all-hazards analysis like the other industrial
3 facility. But you might not have a specific emergency
4 preparedness based on a nuclear plant.

5 MEMBER RAY: Yes.

6 MR. MAYFIELD: That's all speculation
7 until you get more specific.

8 MEMBER RAY: Yeah. I understand that you
9 can't go beyond a certain point without an applicant.
10 The question is whether or not we're at the point
11 where policy direction which is what was referred to
12 repeatedly before is possible to any degree or whether
13 now I can't get policy direction without an applicant.

14 MR. MAYFIELD: What we have said to the
15 Commission in papers that have subsequent briefings is
16 that once we have specific proposals from the industry
17 and I emphasize industry as opposed to specific
18 applicant that if we get enough specificity in that
19 proposal then we would consider that and potentially
20 bring it to the Commission for a policy determination.

21 MEMBER RAY: All right. We're just not
22 there yet is what you're saying.

23 MR. MAYFIELD: We're not there yet. We
24 haven't seen those specific proposals from the small
25 PWR community, not from the gas community. But we're

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1 not trying to be obstructionists in this, but we can't
2 reasonably take specifications to the Commission and
3 ask for a policy determination. We haven't figured
4 out how to wrap that one up.

5 MEMBER RAY: And I don't want to try and
6 solve that now. I just want to understand where you
7 are.

8 DR. CARLSON: So the rest of these
9 considerations on co-location, they're more in the EP
10 white papers and some other submittals that we didn't
11 really review in detail from DOE. So we're in
12 agreement, but they need to consider all these things.
13 And that would be the consideration in this area.

14 With that, that's my last slide. I would
15 like to thank the Committee for their comments and
16 look forward to getting your letter so we can address
17 your comments and finalize these products.

18 CHAIR ARMIJO: Okay. Do I hear any
19 comments from the members? Dennis, are you still on
20 the line? I hope the bridge line is open.

21 Dennis is our bonafide chairman of the
22 subcommittee.

23 MEMBER BLEY: This is Dennis. No
24 comments, but thanks to the staff for this
25 presentation. They were very helpful.

1 CHAIR ARMIJO: Okay. Thank you.

2 Any other? Let's see. We have no one
3 else on the bridge line. Is there anyone on the
4 bridge line that would like to make comments?

5 (No response.)

6 Anyone in the room?

7 MEMBER SCHULTZ: Sam, there is one.

8 CHAIR ARMIJO: Give your name please.

9 MR. SOUTHWORTH: Good afternoon. Just one
10 comment. Finis Southworth. I'm Chief Technology
11 Officer at AREVA Inc. And I'm also an executive board
12 member of the NGNP Industry Alliance. And I just have
13 one comment and I'll try to be brief since you're a
14 little bit over time already.

15 The Alliance is an industry advocacy group
16 supported commercialization of high temperature gas
17 coolant reactor technology and its stated intent
18 presently of the Alliance is to develop and employ the
19 AREVA steam cycle HTTR design for both process steam
20 and electricity. It has been planned in the Alliance
21 for some years. And it is documented in a business
22 plan that once the first reactor module of a first-of-
23 a-kind plant is constructed, we would presume that
24 under the NRC license conditions we would plan to
25 utilize a two year inspection, maintenance and testing

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1 period to demonstrate the operability and the safety
2 of the commercial scale HTGR reactor.

3 During this period, the reactor would be
4 sufficiently instrumented to obtain necessary data and
5 to validate plant operational and safety
6 characteristics. Tests would be conducted in a
7 controlled manner with various particle levels to
8 demonstrate operability and confirm expected
9 performance.

10 The HTGR technology is not new as Don has
11 pointed out. The high temperature gas coolant have
12 been and two are still operating today around the
13 world successfully demonstrating the key
14 characteristics. Granted there are differences among
15 the seven test reactors.

16 We believe there is sufficient test and
17 experimentation facilities available in the U.S.
18 presently and worldwide to allow licensing with a
19 commercial scale reactor utilizing this technology.
20 The fuel, the reactor passive shutdown would be
21 sufficiently tested separately to provide a high level
22 of confidence to operate the first module with ample
23 safety margins to satisfy the requirements of 10 CFR
24 50.43(e) under Subpart 1 such that no additional
25 safety features would be necessary under 10 CFR

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1 50.43(e) Subpart 2.

2 We believe this approach is critical for
3 the timely licensing and commercial viability of the
4 FOAK, a demonstration of plant and its subsequent
5 commercialization of the technology. And that's my
6 comment. Thank you.

7 CHAIR ARMIJO: Okay. Thank you.

8 What I'd like to do now is take a recess
9 and reconvene at 3:25 p.m.

10 (Whereupon, the above-entitled matter went
11 off the record at 3:07 p.m., and resumed at 3:25 p.m.)

12 CHAIR ARMIJO: Okay. We'll start again
13 with addressing the issue completion of Generic Issue
14 of 189: "Susceptibility of Ice Condenser and Mark III
15 Containments to Early Failure from Hydrogen Combustion
16 During a Severe Accident." And Dick Skillman will
17 lead the Committee through the briefing.

18 MEMBER SKILLMAN: Mr. Chairman,
19 Colleagues, we are bringing this issue in front of the
20 ACRS as an information briefing. And the reason we're
21 doing it is I'm certain that the images are still
22 fresh in your mind of the Fukushima buildings
23 exploding with the hydrogen. And since that image is
24 so raw, the completion of this item is really intended
25 to address hydrogen in containment buildings. I

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1 thought it prudent to bring it in front of the whole
2 group.

3 So what are we talking about here? We're
4 talking about 14 plants of the currently licensed 104.
5 There are 10 PWRs: Sequoyah, McGuire, Catawba, D.C.
6 Cook and Watts Bar 1 & 2, and four Mark III
7 containments. We've talked a lot about Mark Is and
8 Mark IIs. But we really haven't talked a lot about
9 the Mark IIIs. The Mark IIIs are Perry, Clinton,
10 River Bend and Grand Gulf in some 14 plants.

11 And that this is really about is ensuring
12 that the hydrogen igniters have backup power supplies.
13 And the NRC required those plants to provide that
14 backup power. And the licensees proceeded to provide
15 that power. And we're here today to talk about
16 closure of this item based on those actions.

17 I would like to recognize Tim McGinty, new
18 Director in NRR. And then introduce Mr. Steve Jones.

19 Tim.

20 MR. MCGINTY: Thank you, Dick. Mr.
21 Chairman, Committee members. I'm a relatively new
22 director in the Division of Safety Systems in NRR. I
23 really can't add a better preamble than Dick already
24 covered on what we're about to discuss with you in
25 this information briefing.

1 We did plan a comprehensive briefing
2 because it's been quite some time before we brought
3 this issue before the ACRS. And with that, Steve
4 Jones is on my staff. And I would like to turn it
5 over the presentation to Mr. Jones.

6 MR. JONES: Thank you, Tim. Good
7 afternoon. Just to mention, I'm Steve Jones from NRR.
8 And I just want to go run through our cases for
9 closing out Generic Issue 189.

10 To start with an introduction, I intend to
11 discuss the basis for initiating the generic issue,
12 the regulatory requirements that currently exist with
13 respect to combustible gas control, technical
14 information related to the severe accident progression
15 that's of concern for this particular event and early
16 stakeholder interactions we had discussing this issue,
17 the regulatory analysis that was completed, the
18 implementation plans that the licensees developed for
19 this, our verification activities and finally the
20 nexus of this issue to what happened in Japan in 2011.
21 This issue really originated with efforts to risk
22 inform various safety regulations in Part 50 and this
23 relates specifically to 10 CFR 50.44, Combustible Gas
24 Control for Nuclear Power Plants.

25 In that risk informed effort, three major

1 changes were identified to 50.44, (1) to specify a
2 severe accident combustible gas source term
3 particularly for the new reactors; (2) remove
4 requirements to deal with hydrogen generation during
5 a design basis LOCA as that was considered a very low
6 risk threat to containment integrity; and (3) then
7 modify the combustible gas requirements for the ice
8 condensers in Mark IIIs because of an identified issue
9 regarding the -- Well, really it's the detonation of
10 hydrogen within these two reactor containment types
11 which dominated the failure modes that could affect
12 those two reactors or two containment designs.

13 In SECY-2000-198, the staff recommended
14 proceeding with the first two issues through
15 rulemaking and the third item through the generic
16 issue program. And the Commission agreed with that
17 approach.

18 This is really the way 50.44 stands today
19 after those two risk informed issues were implemented.
20 All containments need to have the capability to
21 provide a mixed atmosphere and monitor the
22 concentration of hydrogen in containment. For the
23 large dry and subatmospheric containments which cover
24 59 current operating licenses, there is no additional
25 requirements based on the large volume and high design

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1 pressure of those containment designs. That was based
2 on fragility analysis that determined a low
3 conditional probability of failure.

4 For the BWR Mark Is and IIs which cover 31
5 operating licenses, they continue to be required to
6 maintain an inert atmosphere within containment and
7 provide oxygen monitoring capability to ensure that
8 inert condition is maintained throughout an accident.

9 For the ice condensers in Mark IIIs, the
10 regulation maintained the existing requirements with
11 respect to combustible gas control. That is existing
12 AC powered igniters were considered acceptable. And
13 the existing equipment survivability analysis and
14 containment integrity analysis based on a 75 percent
15 metal-water reaction was considered acceptable.

16 For the new reactor types which is over on
17 the right at the top, we have a couple new pressure
18 suppression containment designs, the advanced boiling
19 water reactor and the ESBWR. Those are both inerted
20 containment types and they maintain the requirement
21 for oxygen monitors like the Mark Is and IIs. And
22 then also the rule added consideration of significant
23 beyond design basis accidents such as a station
24 blackout.

25 For the new large dry containment AP-1000,

1 APWR and EPR, they're not inerted. They have to do an
2 equipment survivability and containment integrity
3 analyses but instead of 75 percent based on 100
4 percent metal-water reaction in containment, have
5 hydrogen control measures that contain less than 10
6 percent hydrogen within containment following an
7 accident and again add significant beyond design basis
8 accidents into the consideration for that design.

9 The ice condensers in Mark IIIs have as
10 mentioned an AC powered ignition system. They're
11 really essentially something that would be used in
12 large diesel generator type to provide an ignition
13 source for start-up. It's just a relatively small
14 heat element inside a shielded cover. And they're
15 distributed throughout containment in two trains, each
16 backed by the emergency diesel generators on the site.

17 The containments have between
18 approximately 50 to 75 of these containments depending
19 on the specific containment distributed throughout.
20 And ice condensers, both the lower compartment and the
21 upper compartment have them. And in the BWR Mark
22 IIIs, both within the dry well and in the wet well
23 outside the dry well area, these igniters are
24 distributed.

25 In all cases, they are manually initiated

1 by the controlling staff based on emergency operating
2 procedure direction. They're not automatically
3 started or left in operating. The power consumption
4 is typically about a little less than 15 kW per train.
5 So it's not a high power consumption, but far more
6 than the batteries could support for any length of
7 time.

8 MEMBER SKILLMAN: Steve, would it be fair
9 to characterize as igniter as a glow plug versus a
10 spark plug?

11 MR. JONES: Yes.

12 MEMBER SKILLMAN: Thank you.

13 MR. JONES: Just a hot element. And
14 they're really designed to operate so that they
15 maintain the hydrogen concentration just at about the
16 flammability limit. So if any ignition occurs at that
17 site it would generally just propagate upward. You
18 wouldn't have a three dimensional propagation from
19 that.

20 MEMBER REMPE: Could you elaborate a
21 little bit more about the emergency procedure
22 direction about when they manually initiate it and
23 what indicators are used?

24 MR. JONES: Within a design basis
25 accident, there are hydrogen monitors. The direction

1 doesn't really rely on those though. It's based on
2 cooling provisions. If there's recognition and
3 control that core cooling has been lost, that's
4 typically --

5 MEMBER REMPE: So they put them before you
6 ever have any hydrogen generated.

7 MR. JONES: Right.

8 I'll briefly run through the tube
9 containment designs. On the left is ice condenser
10 containment design. There's a separation as I
11 mentioned a lower and upper compartment. That barrier
12 wall covers the steam generator pressurizer and the
13 loop piping and directs any release from the reactor
14 coolant system through doors on the side and up
15 through ice beds. You'll see there's that kind of
16 cross-hatched areas in that diagram. And up into the
17 upper compartment.

18 What's important to note I think is that
19 even the lower compartment reaches all the way out to
20 the outer edge of the containment and therefore
21 combustion there could overpressurize containment to
22 a point and cause leakage in the lower compartment as
23 well as the upper compartment.

24 Also this picture depicts what's the
25 configuration as far as the overall design for the

1 McGuire, Catawba, Sequoyah and Watts Bar plants. They
2 have a freestanding steel containment with a separate
3 concrete shield structure shield building around that.
4 And there is annular space available inside.

5 The D.C. Cook plant is a little bit more
6 like the diagram on the right as far as the outer
7 containment design in that it's a reinforced concrete
8 with a steel liner and only at the lower portions
9 where the penetrations are is there any secondary
10 structure that can contain any leakage.

11 The Mark III boiling water reactor diagram
12 is on the right. The important thing to note there
13 with respect to this issue is that the dry well is
14 really almost a square, the square structure in the
15 center, around the reactor. And that does not go out
16 to the outer wall of the containment.

17 Any release from inside the steam
18 isolation valve would be directed in the dry well, go
19 over the rear wall and into the suppression pool at
20 the bottom here. So the releases would go this way
21 through the suppression and then up into the wet well
22 portion of the containment.

23 Again, there are two different designs for
24 the outer containment shell. This shows the Grand
25 Gulf and Clinton designs which are reinforced concrete

1 with a steel liner. The Perry and River Bend plants
2 have more like the other picture with the freestanding
3 steel containment and a concrete shield building.

4 Both these units are intermediate in size
5 in that they're about a quarter of the size of the
6 largest large dry containments. But they're double
7 the size of the Mark I and Mark II containment
8 designs. The design pressure is about a quarter the
9 typical design pressure of a large dry or a BWR Mark
10 I or II for this same power.

11 Just to go through briefly accident
12 progression, this issue predominantly applies to an
13 extended station blackout scenario because we're
14 looking at it if the diesel generators were available
15 we would presume there would be power available to the
16 igniters to control hydrogen. And that would maintain
17 containment integrity by controlling the combustible
18 gas concentration.

19 However, in an extended station blackout
20 scenario or other scenarios that have similar effects
21 on a plant like a large fire or possibly a beyond
22 design basis seismic event, you would not have any
23 power to any of the AC components.

24 MEMBER BANERJEE: How much power does the
25 igniters need?

1 MR. JONES: On a couple of slides back, it
2 mentioned about 15 kW per train is the design basis
3 loading that used in the FSAR for the diesel.

4 MEMBER BANERJEE: I mean for the igniters.
5 Do you need 15 kW?

6 MR. JONES: Yes, per train. That's doing
7 between 25 and 36.

8 MEMBER BANERJEE: That's a lot of
9 kilowatts.

10 MR. JONES: Right. It's far more than the
11 battery could reasonably handle. That's why that
12 really wasn't a consideration.

13 MEMBER BANERJEE: Is that true for all
14 igniters?

15 MR. JONES: There are passive
16 autocatalytic recombiners that perform a similar
17 function. And those are being used overseas and the
18 EPR has those. And the AP-1000 has a mix of igniters
19 and passive autocatalytic recombiners. And that was
20 considered as part of this issue, but they would take
21 some time to get going before they're operating at
22 peak capacity to recombine the hydrogen with oxygen.

23 MEMBER BANERJEE: Do they work well in
24 steam?

25 MR. JONES: Yes. If there is a high

1 enough steam concentration, I don't -- we're not
2 really worried about combustion or recombination. I
3 think it would --

4 MEMBER BANERJEE: My concern would be if
5 they get wet. Do they just dry off by themselves or
6 what happens?

7 MR. JONES: Are you talking about the
8 passive ones?

9 MEMBER BANERJEE: Yes.

10 MR. JONES: I really don't have that level
11 of detail to discuss that.

12 MEMBER BANERJEE: It's fine. I'm sure
13 somebody here knows the answer.

14 MEMBER POWERS: It's kind of like hydrogen
15 recombiners would start reacting with hydrogen.
16 Technically, a couple of designs and materials out
17 there. Technically, they're just metal sheets with
18 palladium and platinum particles on it or you can have
19 aluminum oxide, things like that.

20 The problem is no one worries about that
21 passive catalytic hydrogen recombiners is poisoning
22 our occlusion and it can poison with sulfur. It can
23 occlude them by reacting with organic vapors causing
24 carbon undersurface and things like that.

25 MEMBER BANERJEE: So they're not always.

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1 reliable.

2 MEMBER POWERS: I wouldn't say that. I
3 think they're very reliable because they don't take
4 any power.

5 MEMBER BANERJEE: But other than that.

6 MEMBER POWERS: Will they degrade over the
7 course of an accident? Well, maybe. I mean the
8 problem is really poison. Some plants use them and
9 they check for degradation every few outages.

10 MEMBER BANERJEE: Okay.

11 MEMBER POWERS: I mean I think eventually
12 -- They're expensive relative to a glove box.

13 MEMBER SKILLMAN: My answer to your
14 question is that they will work when they are moist.
15 And the platinum plating recombiners are not too
16 different than what you have in the exhaust of your
17 car. The same kind of recombiner technology and you
18 are actually passing vapor through the automobile
19 engine. And so the platinum or palladium reaction
20 will cause recombination.

21 So moist is decay. That is what we use in
22 the shipments for the submerged mineralization systems
23 resins from TMI. They work wet.

24 MR. JONES: Again, I just wanted to
25 discuss briefly the accident progression in the core.

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1 We were talking about an extended station blackout
2 scenario and you really basically have a large steam
3 level forming over the reactor and that would be
4 causing the fuel to begin drying out. As the
5 temperature of the zirconium cladding gets above 1,000
6 degree you'd get a relatively rapid rise in the
7 cladding oxidation damage. It produces -- It rips
8 oxygen out of the steam molecule and then it puts
9 hydrogen excess heat generated. And that heat can
10 exceed the decay heat of the reactor and also further
11 increases the rate that the vessel dries out.

12 So you can end up with a relatively fast
13 development of a large amount of hydrogen from the
14 core. This hydrogen could be released to containment
15 through the loop operation in the RCS or deliberate
16 reactor vessel venting. That may have a part earlier
17 in the valve as stuck open or actuated automatically.

18 Without the operating hydrogen igniters,
19 we expect hydrogen would accumulate inside containment
20 to the combustible level. The conditional containment
21 failure probability for the Mark III and ice condenser
22 types for that scenario is very high, greater than
23 0.1, our regulatory guideline for defense-in-depth
24 purposes.

25 However, the Mark III containment because

1 of the design with the dry well inside the wet well is
2 likely to retain suppression pool scrubbing of any
3 releases because it's a little bit harder to fail that
4 interior dry well structure especially for denotations
5 of the current wet well region.

6 Given that scenario, there is potential
7 for a large early release in the absence of igniter
8 function. However, it's a very low frequency event
9 sequence around I believe it was below 1 E^{-5} for most
10 of these plants or right in that vicinity for reactor
11 year. And there was substantial uncertainty in the
12 consequence determination because of the questions
13 about the end state of the containment and what type
14 of plate out or release would develop in this accident
15 sequence.

16 During the initial investigation by the
17 Office of Research, they did look at backup power for
18 the igniters and then also looking at backup power for
19 both the igniters and the recirculation fans to ensure
20 the containment environment was well mixed. And
21 lastly providing passive autocatalytic recombiners.

22 Research's recommendation was to provide
23 backup power to it based on the relatively low cost.
24 And that would be uncertainty in consequences.

25 MEMBER BANERJEE: This would be backup

1 power in --

2 MR. JONES: No, small generators that
3 would be either pre-staged or portable and connected
4 to a motor control center in the electrical
5 distribution system at some point in the auxiliary
6 building where it would be able to get directly to the
7 hydrogen igniters. You need to have the voltage
8 linked with the -- The voltage of the generation would
9 have to match the design voltage of the motor control
10 center.

11 In order to address this issue, the staff
12 scheduled several public meetings with stakeholders to
13 discuss the technical issues behind this and the
14 accident sequences, the purposed design criteria for
15 any backup power supply and also what procedures
16 specifically to use for implementation, whether it
17 should be emergency operating procedures which are
18 regulated or the severe accident management guidelines
19 which are not regulated and at a lower level of
20 detail.

21 At that time, there was not any
22 consideration of any other type of procedures. These
23 were really the two main groups.

24 The interface included several
25 organizations including the Nuclear Energy Institute,

1 the Union of Concerned Scientists, BWR Owners Group as
2 well as the individual owners of the effected units.
3 The discussion areas in these meetings got into the
4 design of the portable backup supply. I mean that is
5 whether it would be portable or pre-staged. A need
6 for detailed design criteria such as how long should
7 that generator function for without replenishment of
8 fuel. How do you enhance its survivability for
9 external events like earthquakes or floods in the
10 area? Also how to deal with the timing for activating
11 a hydrogen igniter. So at what stage in the accident
12 should the backup power be supplied? And that would
13 drive in part whether or not it was portable or pre-
14 staged.

15 Following these meetings or I guess with
16 consideration of a number of these meetings, the BWR
17 Owners Group suggested the use of the Division III
18 Emergency Diesel Generators powered igniters. Those
19 are the generators dedicated to powering the high
20 pressure course load in the Mark III design.

21 The staff's concern there is really
22 there's a relatively large fraction of station
23 blackout events that go to core damage where you're
24 not going to have a generator available anyway. I
25 mean if it was available you'd probably have the core

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1 spray pump and you would probably not have core
2 damage. That was one issue with that.

3 But PWR licensees were suggesting this --

4 MEMBER RAY: Why did they make that
5 recommendation? Did you ever figure that out given
6 what you said?

7 MR. JONES: I guess in one sense we're
8 just looking at loss of the two power supplies to the
9 hydrogen igniters. And it's true that this third
10 diesel generator doesn't power those. In that sense,
11 some licensees had relatively high estimates of its
12 survivability even with failure of the other two
13 diesel generators. I really don't see it.

14 MEMBER RAY: Okay.

15 MR. JONES: And then for the pressurized
16 water ice condenser licensees they had various diesel
17 generators available on site that they would wish to
18 credit for backup power sources. There was also a
19 course discussion on benefits relative to the costs of
20 recommending various options.

21 So the staff initiated a regulatory
22 analysis in the late 2004-2005 time frame to evaluate
23 the costs and benefits using more plant specific
24 information that was used by the Office of Research.
25 They used the SPAR models for core damage frequency

1 estimates and for estimating reliability of other
2 recovery actions.

3 This regulatory analysis both considered
4 voluntary measures and rulemaking to require backup
5 power supply. They looked at the passive
6 autocatalytic recombiners, backup power to the
7 igniters, backup power with the recirculation fans,
8 and also repowering the hydrogen analyzers to be able
9 to monitor containment hydrogen concentrations
10 throughout an accident.

11 And it also assumed different containment
12 failure probabilities for the different pressurized
13 water designs based on a Sandia study that evaluated
14 containment fragilities. Those had conditional
15 failure probabilities from 0.22 to 0.97 of the ice
16 condenser designs.

17 For the BWR Mark III, they used a standard
18 0.19 as the conditional containment failure
19 probability of an unscrubbed release. That is for
20 having both a dry well and wet well failure that would
21 allow a direct release from the core through the outer
22 wall containment without passing through the
23 suppression pool.

24 This regulatory analysis did not fully
25 evaluate external events or security related events.

1 And to whatever extent that the staff might apply
2 didn't consider directly enhanced defense-in-depth
3 provided by reduction in the conditional containment
4 failure probability.

5 The results of the regulatory analysis
6 indicated that passive autocatalytic recombiners are
7 substantially more expensive than the backup power
8 supply. And part of that is because of outage
9 duration requirements to install some of the igniters
10 inside containment. I mean recombiners inside
11 containment.

12 MEMBER CORRADINI: So if it weren't for
13 the installation is the ongoing basis the parts the
14 same cheap?

15 MR. JONES: I don't have that information.
16 I would say on an ongoing basis --

17 CHAIR ARMIJO: I would think people
18 wouldn't install something that don't have to be wired
19 up.

20 MEMBER CORRADINI: That's what I would
21 think.

22 MEMBER POWERS: I suspect it was cost, the
23 ongoing cost that you have with the parts. For
24 instance, Canadians pull a plate every outage and look
25 at it, go test it. If it fails the test then they

1 replace all the plates. Everything. And so you get
2 into a aging or what caused the plates to fail, vapor,
3 paint, oils, all kinds of things.

4 So you have to protect them during outage
5 from activities that you would take on. They take a
6 lot of maintenance relative to what was set up and I
7 don't think anybody pays any attention to them after
8 they get installed.

9 MR. JONES: They did test them
10 periodically. I don't think they're maintenance
11 intensive or anything.

12 The regulatory analysis also concluded
13 that mixing fans and hydrogen analyzers were
14 unnecessary. The mixing fans were basically because
15 if the igniters are available and operable any
16 combustion will help mix the containment environment.
17 And they are so widely distributed within containment
18 that there is no concern or not a substantial concern
19 with the large.

20 MEMBER POWERS: In the ice condensers
21 they're all up in the --

22 MR. JONES: There are some in the lower
23 loop areas as well.

24 MEMBER POWERS: But they're not in the big
25 regions.

1 MR. JONES: The ice bed region, no.

2 MEMBER POWERS: And so do you run into the
3 problem that you can get DDT up through the bed?

4 MEMBER BANERJEE: What up through the bed?

5 MEMBER POWERS: Deprivation to detonation
6 transition.

7 (Simultaneously speaking.)

8 MR. JONES: I don't have that.

9 MEMBER POWERS: It seems to me that if
10 people would look at that that it depends on who you
11 talk to. I guess it's just not a clear case of
12 whether you can or can't.

13 MR. JONES: I do expect that for at least
14 early in the accident a lot of the ice would still be
15 there from them.

16 MEMBER BANERJEE: Not if you ignite it and
17 there's a detonation run. Is it going to matter --

18 MEMBER POWERS: Say it again.

19 MEMBER BANERJEE: Does it have a lot of
20 narrow passages?

21 MEMBER POWERS: Well, it depends on
22 whether the ice is there. If there is no ice then
23 it's -- I mean there are a lot of baskets that will
24 induce turbulence and that will give you the potential
25 of going to getting deprivation to detonation

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1 transition.

2 MEMBER CORRADINI: You're talking about
3 ice-less baskets.

4 MEMBER POWERS: Yes. I mean the ice is
5 pretty much gone by the time you get to extensive core
6 damage.

7 MEMBER CORRADINI: Didn't Marshal --
8 didn't your buddy test the hell out of this already in
9 their big tunnel? Didn't they put obstructions in?
10 I thought they had with Joe Sheppard.

11 MEMBER POWERS: Yeah. I mean what they
12 were doing in the FLAME facility was looking at the
13 potential for getting the deprivation to detonation
14 transition.

15 MEMBER CORRADINI: But I thought there was
16 a database here where they put in the big tunnel
17 obstructions like baskets to see. That's in my
18 memory.

19 MEMBER POWERS: I don't remember any tests
20 with baskets. I remember lots of tests with
21 obstructions and how much bending you have.

22 MEMBER CORRADINI: I can send it up to
23 Sheppard to find out.

24 MEMBER POWERS: I mean all that tells you
25 is you can get DDT. The question is do you get DDT in

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1 these kinds of things without -- I mean how much
2 natural circulation do you get? And there is
3 presumably some natural circulation because it's hot
4 down low and cool above or cooler up above.

5 MEMBER CORRADINI: Right.

6 MEMBER BANERJEE: Once the deflagration
7 starts it generates turbulence. So you don't have
8 much flow. It's really whether you've got
9 obstructions on how much turbulence you generate
10 behind the obstruction.

11 MR. JONES: I think really the idea is to
12 get the igniters running early enough that I guess
13 they would capture or begin oxidizing any hydrogen
14 before it enters the bottom of the ice baskets. And
15 then if it's oxygen starved in that region it will go
16 through. And then once it gets to the --

17 MEMBER BANERJEE: Why don't they put some
18 igniters lower down?

19 MR. JONES: They are. They are in the
20 loop areas. They're just not in the ice beds
21 themselves.

22 MEMBER BANERJEE: Somebody must have done
23 a calculation.

24 MR. JONES: I guess if there was a concern
25 within the ice beds, then I think we'd be dealing with

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1 this issue as I guess a compliance issue right now
2 because that would really be a problem with compliance
3 50-44 itself.

4 Okay. For the PWRs, specifically the ice
5 condensers, the backup power from these or the backup
6 power provided substantial safety benefits at
7 justifiable cost. Most of that benefit was provided
8 by just the voluntary measures, having a third or in
9 some cases a fifth diesel generator onsite to power
10 the igniters that's independent of what's used to
11 normally power the core or to prevent core damage was
12 providing a substantial benefit. And rulemaking was
13 not just applied after consideration of these
14 voluntary measures.

15 For BWRs, the Mark III containment design
16 with that inner dry well, the cost of implementing any
17 option were not justified by the increased protection
18 because it's a low frequency initiating event plus a
19 relatively low conditional containment failure
20 probability. And the sensitivity analyses that were
21 performed didn't change those conclusions. And they
22 looked at things like changing the initial containment
23 failure probabilities in particular for the boiling
24 water reactors. Following the completion of the
25 regulatory analysis, the staff continued meeting with

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1 effected licensees predominantly about security
2 related issues in closed meetings.

3 Eventually, staff reached agreement with
4 the licensees about proposed backup capabilities that
5 provided some benefit for security related scenarios.
6 The Catawba and McGuire units credited their
7 establishment of a permanent new power supply direct
8 from their safe shutdown facility diesel generators to
9 at least one of the transit igniters. The Sequoyah and
10 Watts Bar plants were using an onsite portable
11 generator and connecting that with the plant
12 electrical distribution system and power igniters from
13 that.

14 D.C. Cook had previously installed two
15 relatively large diesel generators that are used
16 predominately for extended allowed outage times for
17 emergency diesel generator maintenance. And these
18 generators are permanently connected into the
19 electrical switch gear and configured such that they
20 could replace any one of the emergency diesel
21 generators at that site. And they installed in
22 addition to that additional operating switches to
23 start the igniters in the event of an accident.

24 The BWRs all provided portable diesel
25 generators for local power to the igniters. It's

1 providing it as I mentioned earlier to a local motor
2 control center near the containment penetration. And
3 implementation of these backup power supplies was
4 implemented at the level of detail to severe accident
5 guidelines.

6 MEMBER REMPE: All of these are voluntary
7 actions, right?

8 MR. JONES: Right.

9 MEMBER REMPE: And what oversight from the
10 NRC if it's a voluntary action as opposed to something
11 like a further rulemaking or whatever?

12 MR. JONES: It's a little more difficult.
13 There is a formal commitment process and we do track
14 that and audit it. And I don't get into how we verify
15 that this was implemented correctly.

16 MEMBER REMPE: And it will be continuing
17 on as the years go by to check and see if maintenance
18 is done on the equipment? People practice to see if
19 their procedures can be implemented in a timely
20 fashion, etc.?

21 MR. JONES: There is commitment audit
22 process that's ongoing. But it won't necessarily I
23 guess go to this specific item. However, I'll get to
24 other requirements that are coming into play related
25 to this issue.

1 MEMBER REMPE: Okay. Also the timing.
2 Are all these things going to be done? There's a dead
3 period that we could have hydrogen generation accruing
4 and then is that considered in all these procedures
5 and voluntary actions?

6 MR. JONES: Part of the verification
7 process was to look at the capability to get the power
8 supply in place within a three hour time period. That
9 should allow sufficient time to identify that you're
10 having trouble feeding the core.

11 MEMBER REMPE: For hydrogen generation.

12 MR. JONES: The core for substantial
13 hydrogen generation, yes.

14 The verification the staff implemented was
15 documented in Temporary Instruction 2515/174. And
16 that began implementation in 2008 and most of the
17 sites had completed that verification process by the
18 middle of 2008.

19 The major modifications at Catawba and
20 McGuire extended the generic issue process and the
21 last unit was not complete until early 2010. At the
22 same time, Watts Bar Unit 2 was beginning their
23 licensing process. And we requested a commitment. I
24 think there was some problem with their understanding
25 of what exactly we were looking for.

1 So in late 2010 we received the correct
2 commitment that would implement the same measures at
3 Watts Bar Unit 2 as have been committed for Unit 1.
4 And the inspections revealed no deviations from the
5 commitments.

6 Next in line, shortly thereafter after
7 receiving that Watts Bar commitment, we had the events
8 in Japan. I considered that accident progression
9 somewhat similar to what we're talking about with
10 Generic Issue 189 in that looking at externally
11 initiated sustained station blackout event and yet
12 core damage with significant hydrogen generation. And
13 of course there was also a significant release due to
14 the containment overpressure, although that was caused
15 by -- At least there is no definitive information
16 about any hydrogen combustion causing that containment
17 failure. It was more likely just in general
18 overpressure and possibly steam explosion.

19 Nevertheless we considered that in the
20 context, the staff, of developing the mitigating
21 strategies order. That's EA 12-049. And the
22 guidelines for implementation of that order now
23 include strategies to maintain containment integrity.
24 And for the ice condensers in Mark IIIs those
25 strategies include providing a power supply to the

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1 hydrogen igniters.

2 MEMBER SHACK: When I read 12.06, it says
3 even for PWRs you have to have a portable power
4 supply. So does that mean the previous fixes are now
5 going to be supplemented with an additional portable
6 supply?

7 MR. JONES: That's really going to -- As
8 a commitment the licensees are free to change the
9 previous commitments. Now for Catawba and Watts Bar,
10 I expect that their modifications are going to remain
11 in place. That was a permanent change. For D.C.
12 Cook, they had a permanent change as well.

13 For the ice condensers -- I'm sorry. For
14 the BWR Mark IIIs, I expect they're going to basically
15 supplant their existing equipment that dealt with this
16 commitment with equipment they're procuring
17 specifically for the mitigating strategies order which
18 typically is a larger portable generator and more of
19 them distributed throughout the site. Also for
20 Sequoyah and Watts Bar they fall in that latter
21 category where I expect they're going to replace their
22 commitment with the flex equipment that they're using
23 to meet this order.

24 Since that for the mitigating strategies
25 perspective, there's a lot of overlap and I guess

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1 interaction between the components. These generators
2 are typically used for multiple purposes, not just for
3 providing power to igniters. They also are used for
4 RCS inventory management for instance to power a
5 charging pump or something of that nature. So they're
6 again relatively larger portable generators.

7 The benefit here which is what you were
8 alluding to is it's a durable regulatory requirement
9 on this capability. The way the flex order is being
10 implemented provides a little bit better assurance of
11 external events not damaging capability to provide the
12 igniters. Those are the two points from this order.

13 In conclusion, we feel that effective
14 measures have been implemented to control combustible
15 gas during extended station blackout events. And
16 we've done some verification and inspections to
17 confirm the capabilities that we expect from the
18 commitments.

19 Going forward, I think the order will
20 enhance this capability. I expect that the
21 maintenance of that flex capability will somehow fit
22 into the inspection program and won't be lost or fall
23 into the background.

24 So accordingly we're recommending closure
25 of GI 189. We understand the ACRS has already issued

1 a letter to the Executive Director regarding this but
2 supporting staff's closure and we will be proceeding
3 with closing this out this month.

4 MEMBER POWERS: The events in Japan
5 pertinent to hydrogen combustion could occur in the
6 reactor building which is not protected either by
7 igniters or inerting. Is the agency thinking about
8 responding to that finding since the reactor coolants
9 include lots of equipment needed for design basis
10 accidents?

11 MR. JONES: I can't really speak directly
12 to that because I'm not working on that issue. But I
13 guess there is a couple of things. One of them is I
14 mean it interfaces with the containment vent order for
15 the Mark Is and IIs as far as if you're able to manage
16 the hydrogen generator in containment and get it fully
17 outside the reactor building.

18 For the other reactor types, I think
19 that's going to have to be addressed in the I believe
20 it's a Tier 3 item to look at that but that will be
21 over a longer period of time. I just don't work in
22 that area.

23 MEMBER POWERS: It's just when we think
24 about Mark Is and IIs we think that inerting gets rid
25 of the problem. And if it does unless you get leakage

1 of hydrogen in the reactor. You can be sure the
2 required hydrogen vents in the Mark Is because the
3 vents pass right past the equipment needed for
4 handling the accident.

5 So now you're banking on not getting any
6 leakage at any time in an accident. And you know you
7 have vulnerable seals and things like that throughout
8 the plant. And it would be unfortunate to have all
9 this protection and then lost it just because of a
10 little hydrogen, wouldn't you?

11 MR. JONES: I can't address it for the
12 broad spectrum of plants. These plants have a
13 relatively low design pressure to start with.

14 MEMBER POWERS: Well, design pressure for
15 the Mark I is actually pretty common.

16 MR. JONES: Right. I was referring to the
17 ice condensers in Mark III.

18 MEMBER POWERS: Yes, but the ice
19 condensers are really unfortunate designs.

20 MEMBER SKILLMAN: Other members like to
21 have comments for either Steve or Tim?

22 (No response.)

23 Are there any comments from the public?

24 (No response.)

25 MEMBER POWERS: I enjoyed the

1 presentation. Very informative.

2 MEMBER SCHULTZ: The presentation was a
3 nice documentation of the closure documents.

4 MEMBER SHACK: I admire the staff's
5 tenacity. I mean they finally got their order.

6 MEMBER POWERS: Even the main version of
7 1206 didn't have that in there. But the final one
8 did.

9 MEMBER SKILLMAN: Colleagues, Mark is
10 indicating there is nobody on the bridge line. Okay.
11 So if there are no further comments, Steve, thank you
12 very much. Tim, thank you. Mr. Chairman, back to
13 you.

14 CHAIR ARMIJO: Okay. Thanks, Dick. Well,
15 we're finished with the formal parts of the meeting.
16 Now we would like to -- I'd just assume start writing
17 that letter.

18 MEMBER SHACK: I'd assume not, but I guess
19 we have to.

20 CHAIR ARMIJO: Why don't we just close.
21 Off the record.

22 (Whereupon, at 4:17 p.m., the above-
23 entitled matter was concluded.)
24
25



U.S. DEPARTMENT OF
ENERGY

Nuclear Energy

**ADVISORY COMMITTEE ON REACTOR
SAFEGUARDS
604th MEETING**

NGNP Introduction

**Tom O'Connor
Advanced Reactor Technologies
Office of Nuclear Energy
U.S. Department of Energy**

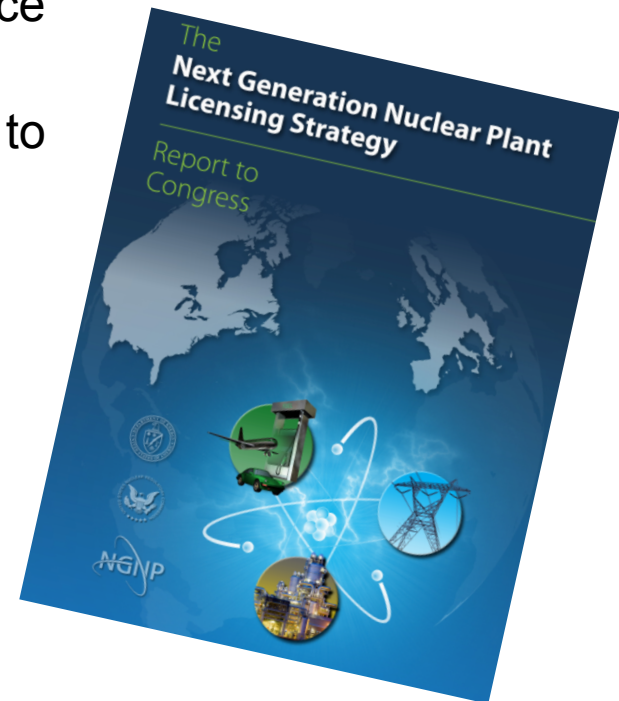
May 9, 2013



NRC-DOE Licensing Strategy – 2008 (Report to Congress)

■ **“It will be necessary to resolve the following NRC licensing technical, policy, and programmatic issues and obtain Commission decisions on these matters”**

- Acceptable basis for event-specific mechanistic source term calculation, including the siting source term
- Approach for using frequency and consequence to select licensing-basis events
- Allowable dose consequences for the licensing-basis event categories
- Requirements and criteria for functional performance of the NGNP containment as a radiological barrier





NRC Staff Positions Requested by DOE

■ NGNP transmitted a letter to NRC on July 6, 2012 reinforcing areas of priority for licensing framework development

- Consistent with focus areas summarized in NRC to DOE letter dated February 15, 2012

■ NRC staff positions were requested in four key areas:

- Licensing Basis Event Selection
- Establishing Mechanistic Source Terms
- Functional Containment Performance Requirements
- Development of Emergency Planning and Emergency Planning Zone Distances



Reducing Regulatory Uncertainty for Modular HTGR Deployment

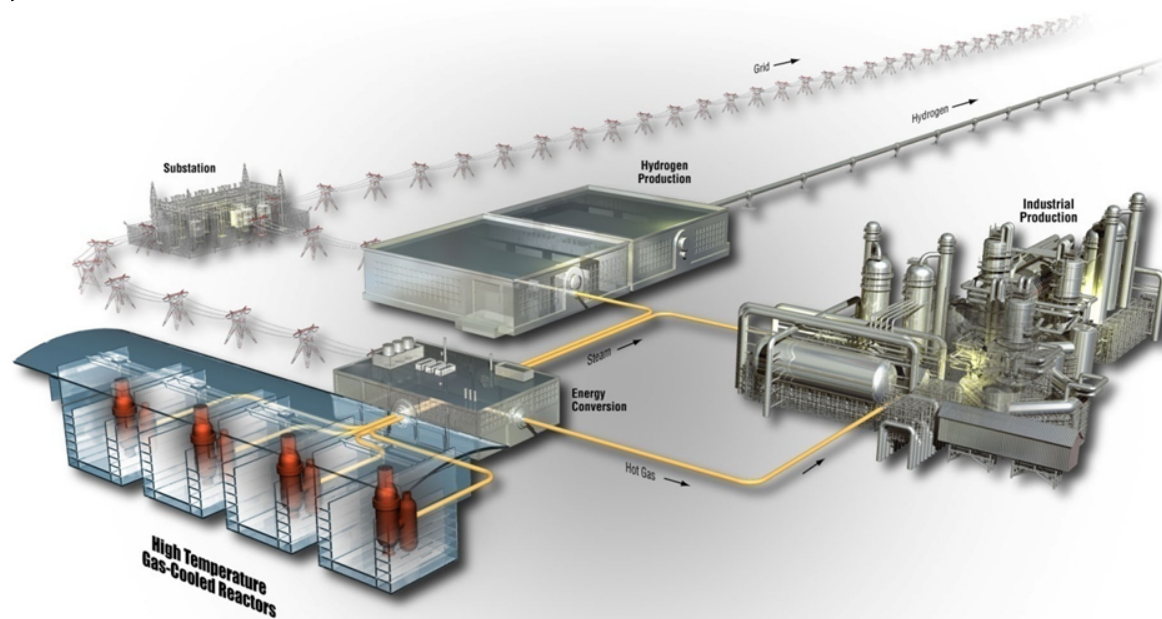
- **DOE is focused on the resolution of long-standing HTGR licensability issues, and eliminating the significant uncertainty that goes with them**
- **Status of key issue resolution generally well understood, with significant progress from DOE-NRC pre-licensing interactions**
- **However, significant uncertainty remains regarding the process for design basis accident (DBA) selection**
 - No apparent lower limit on event sequence frequency
 - Potentially hampers the ability of the designer and applicant to demonstrate that safety margins are increased, as directed by the Commission's Advanced Reactor Policy Statement
 - Creates significant uncertainty for NGNP stakeholders and other advanced reactor designs

NGNP Licensing Overview

ACRS 604th Full Committee Meeting

May 9, 2013

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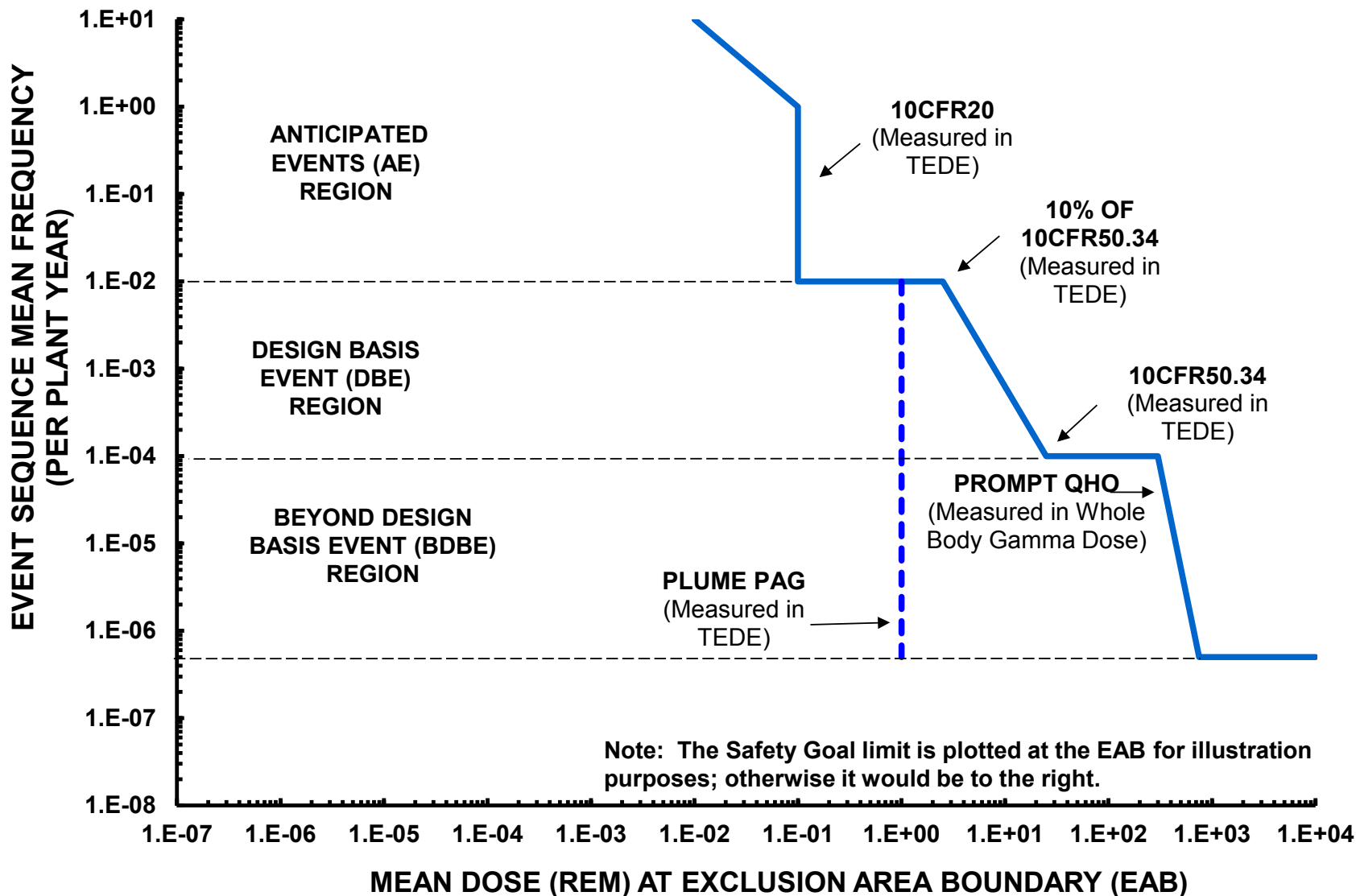
Safety Approach and Design Basis Summary

- Top objective is to meet the NRC offsite dose requirements and EPA Protective Action Guides (PAGs) at the Exclusion Area Boundary (EAB) for spectrum of events within and beyond the design basis
- Responsive to Advanced Reactor Policy
- Modular HTGR designs employ multiple concentric, independent barriers to meet radionuclide retention requirements – these barriers comprise the Functional Containment
 - Fuel Elements
 - Fuel kernels
 - Particle coatings (most important barrier)
 - Compact matrix and fuel element graphite
 - Helium Pressure Boundary
 - Reactor Building
- Emphasis is on radionuclide retention at the source within the TRISO fuel coatings
 - Passive core heat removal
 - Control of heat generation
 - Control of chemical attack

Licensing Basis Event (LBE) Selection

- Licensing Basis Events determine when Top Level Regulatory Criteria (TLRC) must be met
- Selected throughout design and licensing process with risk insights from comprehensive full scope PRA that addresses uncertainties
 - Start with deterministic events based on history of related design/licensing efforts; used for scoping studies and early design development
 - As design matures, PRA risk-informs the event selection
- Includes anticipated events (AEs), design basis events (DBEs), beyond design basis events (BDBEs), and design basis accidents (DBAs) (Ch 15 events derived from DBEs with only safety related structures, systems, and components [SSCs] available)
- Comprehensive: Addresses a full-spectrum of internal and external events on a per plant-year basis, including event sequences that could affect multiple reactor modules

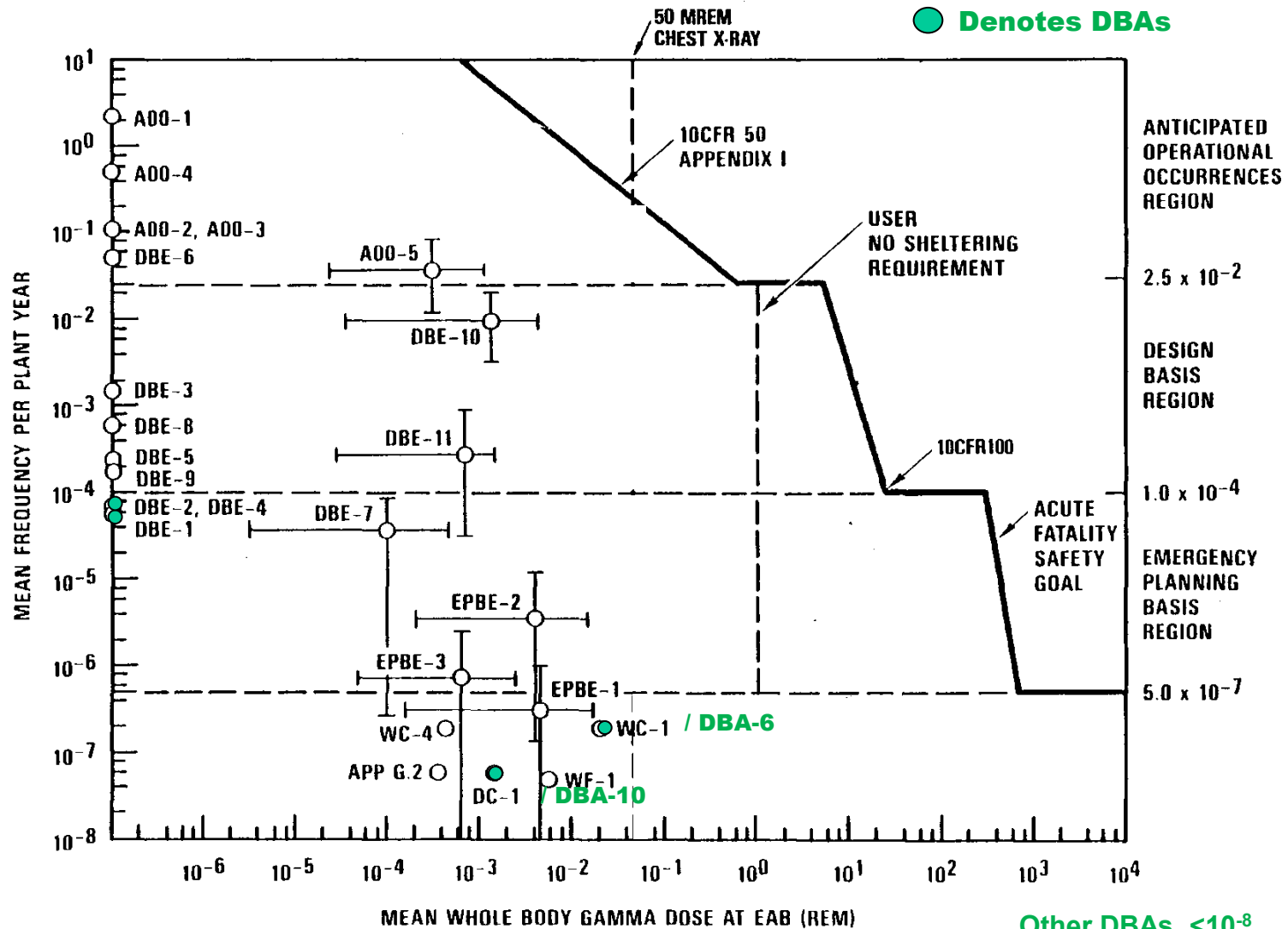
NGNP Frequency-Consequence Curve



Design Basis Accident Derivation and Dose Limits

- DBAs (analyzed in Chapter 15 of SARs) are deterministically derived from DBEs by assuming that only safety-related SSCs are available
- The event sequence frequency for some DBAs is expected to fall in or below the BDBE region as a result of the assumed failure of the non-safety related SSCs
- Consistent with regulatory practice, DBAs must meet the DBE dose limits based on conservative (upper 95%) analyses
- DBAs are not derived from BDBEs. Consistent with regulatory practice, BDBEs must meet the NRC Quantitative Health Objectives (QHOs) on a cumulative basis with an expected (mean) analysis

MHTGR DBEs, DBAs, and BDBEs (aka EPBEs) on F-C Plot (circa 1987)



Siting Source Term Summary

- The NGNP approach to SSTs is essentially the same as that proposed by DOE in the MHTGR PSID and accepted by the NRC staff in NUREG-1338
- The approach is consistent with discussions of containment function and mechanistic source terms in more recent NRC SECY documents and with approaches previously reviewed by the NRC staff for modular HTGRs
- The approach implements a modular HTGR-appropriate interpretation of the 10CFR50.34 (10CFR52.79) footnote regarding siting evaluation
- Limiting DBAs are evaluated to determine SSTs
- Further, to ensure that there are no cliff edge effects, physically plausible Bounding Event Sequences (with frequencies below the BDBE region), including those involving graphite oxidation, are deterministically chosen and considered

Functional Containment Performance Summary

- Radionuclide retention within fuel during normal operation with relatively low inventory released to helium pressure boundary (HPB)
- Limiting LBEs characterized by
 - an initial release from the HPB depending on leak/break/pressure relief size
 - a larger, delayed release from the fuel
- Functional Containment will meet 10CFR50.34 (10 CFR 52.79) at the EAB with margin, without consideration of radionuclide retention by the reactor building, for the wide spectrum of DBEs and DBAs
- Functional Containment will meet the NGNP design target EPA PAGs at the EAB with margin, with consideration of radionuclide retention by the reactor building, for the wide spectrum of DBEs, DBAs, and BDBEs

Fuel Qualification and Radionuclide Retention Summary

- Fuel Development and Qualification Program is providing data, under an NRC-accepted QA program, necessary to better understand fuel performance and fission product behavior for modular HTGRs
- Fuel program is laying the technical foundation needed to qualify UCO TRISO fuel made to fabrication process and product specifications within an envelope of operating and accident conditions that are expected to be bounding for modular HTGRs
- Results to date are consistent with current design assumptions about fuel performance and radionuclide retention. The program is obtaining additional data to support model development and validation
- Results to date support the safety design basis, including the functional containment and mechanistic source term approaches
- It is expected that operation of the first modular HTGR will confirm the design assumptions

Summary of DOE/INL View on Staff Findings

- The NRC staff has responded to most of the positions requested by DOE/INL in its July 6, 2012 letter (emergency planning position has been deferred)
- The Staff has found most elements of the NGNP licensing approach to be “reasonable” with some caveats
- DOE/INL has concerns regarding uncertainty created by the Staff’s positions on Design Basis Accidents:
 - Derivation of additional DBAs from Beyond Design Basis Events
 - Imposition of additional deterministic DBAs with no apparent lower limit on event sequence frequency

Previous NRC Staff/ACRS Positions on MHTGR Low Frequency Event Sequences

Excerpts from MHTGR draft safety evaluation; NUREG-1338 (1989):

- (p 15-7) – “The staff judges that these [bounding events proposed by the staff] results show that the MHTGR has the potential to cope with extremely rare and severe events without the release of a significant amount of fission products”
- Appendix C, (p 4) – ACRS statement: “Neither the designers, the NRC staff, nor members of the ACRS have been able to postulate accident scenarios of reasonable credibility, for which an additional physical barrier to the release of fission products is required in order to provide adequate protection to the public”

Staff Assessment of Next Generation Nuclear Plant (NGNP) Key Licensing Issues

**ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
604th Meeting
May 9, 2013**

Dr.-Ing. Donald E. Carlson

Donald.Carlson@nrc.gov, 301-415-0109

James Shea, Arlon Costa,
Dr. Thomas Boyle, Jonathan DeGange

**Office of New Reactors (NRO)
Division of Advanced Reactors and Rulemaking (DARR)**

NGNP Project Mission, Energy Policy Act of 2005

- Department of Energy (DOE) and Idaho National Laboratory (INL) will demonstrate by 2021 a prototype modular high temperature gas-cooled reactor (HTGR) for co-generating electricity and process heat
- NRC will have licensing and regulatory authority for the prototype plant

Major NGNP Pre-Application Activities to Date

- NGNP Phenomena Identification and Ranking Tables (PIRT), 2007
NUREG/CR-6944: Five PIRTs on accident and thermal fluidic analysis; high-temperature materials; nuclear graphite; process heat with hydrogen co-generation; and fission product transport and dose
- Joint DOE-NRC Licensing Strategy Report to Congress, 2008
Option 2 risk-informed and performance based approach: Use deterministic engineering judgment and analysis, complemented by PRA insights, to establish NGNP licensing basis
- NRC assessment of DOE/INL white paper submittals, 2010-present

DOE decision in letter to Congress, October 2011

- DOE will not proceed with NGNP detailed design activities at this time
- NGNP Project will continue to focus on high temperature reactor R&D, interactions with NRC to develop a licensing framework, and establishment of a public-private partnership

Recent NGNP Interactions

- February 2012 - NRC issued preliminary assessment reports to DOE
 - Assessment of Fuel Qualification and Mechanistic Source Terms (Rev. 0)
 - NGNP Fuel Qualification (FQ) White Paper
 - NGNP Mechanistic Source Terms (MST) White Paper
 - Assessment of Risk-Informed and Performance-Based (RIPB) Approach (Rev. 0)
 - NGNP Defense-in-Depth Approach (DID) White Paper
 - NGNP Licensing Basis Event Selection (LBE) White Paper
 - NGNP Safety Classification of Structures, Systems, and Components (SSC) White Paper
 - Use DOE reimbursable funds to further address framework issues in four key areas
 - (1) Licensing Basis Event Selection (2) Source Terms
 - (3) Functional Containment Performance (4) Emergency Preparedness
- July 6, 2012 - DOE/INL letter clarified approaches to four key issue areas
 - Public meetings and conference calls between NRC and DOE/INL thru November 2012
 - NRC staff review of additional technical documents submitted by DOE/INL
- January 17, 2013 - DOE/INL briefed ACRS Future Plant Designs Subcommittee on NGNP Activities
- April 9, 2013 - NRC Staff and DOE/INL met with ACRS Future Plant Designs Subcommittee on Assessment of NGNP Licensing Issues

Three Staff Products for NGNP

1. ISSUE SUMMARY REPORT

New staff report: “Summary Feedback on Four Key Licensing Issues”

- i. Licensing Basis Event Selection
- ii. Source Terms
- iii. Functional Containment Performance
- iv. Emergency Preparedness

2. FQ-MST ASSESSMENT REPORT (REV. 1)

Updated staff report: “Assessment of White Papers Submittals on Fuel Qualification (FQ) and Mechanistic Source Terms (MST).”

3. RIPB ASSESSMENT REPORT (REV. 1)

Updated staff report: “Assessment of White Paper Submittals on Defense-in-Depth (DID), Licensing Basis Event (LBE) Selection, and Safety Classification of Structures, Systems, and Components (SSC).”

➤ After ACRS review, staff will finalize products and publicly issue them to DOE

MAJOR CONCLUSIONS

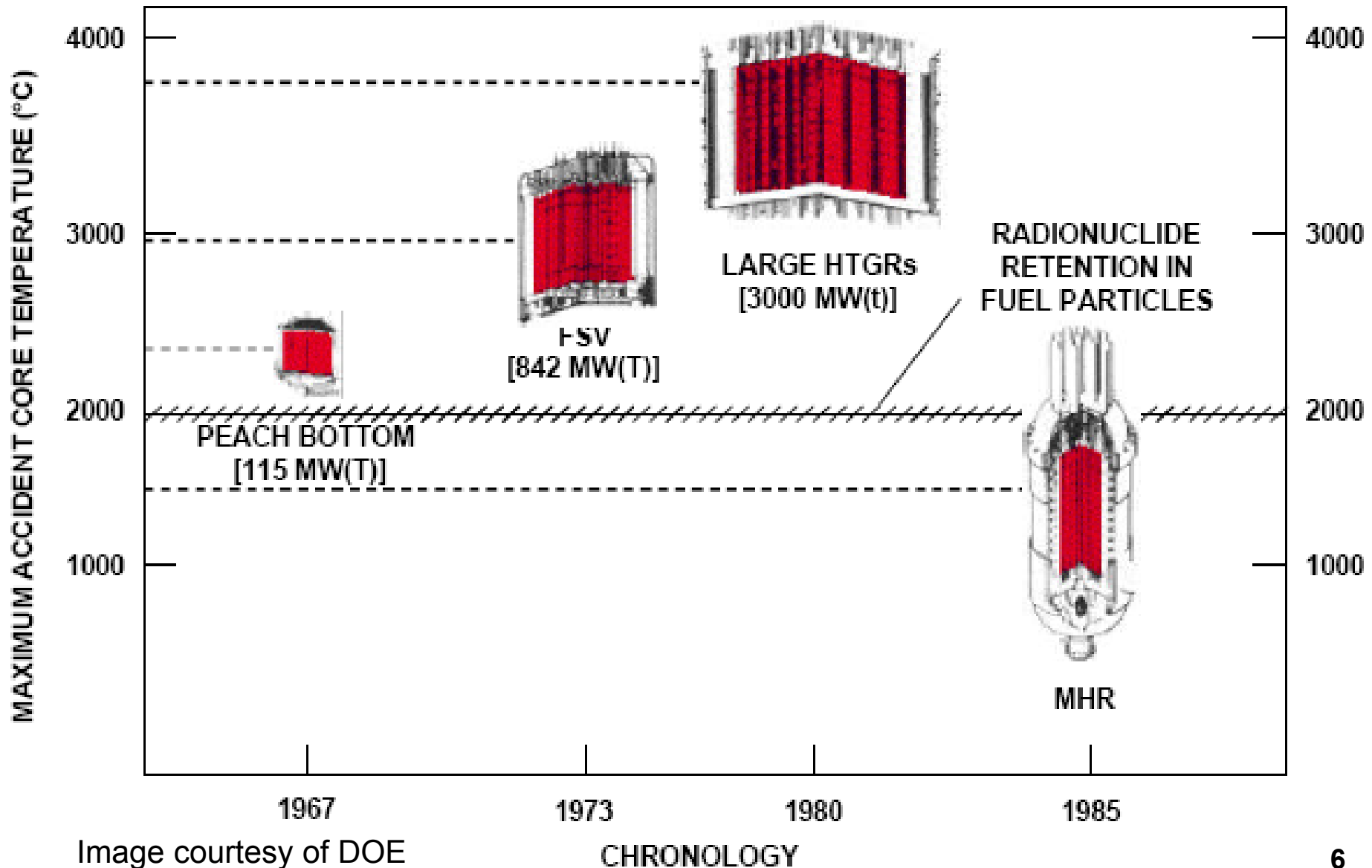
- No obvious show stoppers. DOE/INL's proposed approaches to NGNP licensing issues are responsive to NRC Advanced Reactor Policy Statement and generally reasonable, with caveats:
 - Deterministic elements should be strengthened to better align with Option 2
 - Technical uncertainties should be resolved in the NGNP prototype through testing under 10 CFR 50.43(e)(2) to verify core and fuel performance
 - Future interactions on site pre-applicant's proposals for Emergency Preparedness should be supported by specific information on NGNP design, site, and co-located user facilities

QUALIFIERS

- All issues are considered in view of relevant prior staff positions, ACRS comments, and Commission direction (e.g., SECY-93-092, NUREG-1338, SECY-03-0047, SECY-05-0006, NUREG-1860, NGNP Licensing Strategy, SECY-11-0152)
- Staff feedback is advisory. Regulatory decisions will be based on NGNP license application and related Commission policy determinations
- Proposed NGNP approach overlaps with high-level RIPB concepts considered for NUREG-1860, NUREG-2150, and NTTF Recommendation 1. New or revised frameworks resulting from these other efforts may affect staff positions for NGNP
- Proposed NGNP approach is assessed solely for modular HTGR design concept

HTGR Design Evolution (U.S. & Germany)

Post-TMI Shift to Modular HTGR Safety Concept



LICENSING BASIS EVENT SELECTION

NRC STAFF FEEDBACK ON LBE SELECTION (1/2)

- Proposed selection of TLRC and placement on F-C curve are reasonable. Future NRC policy may consider alternate TLRC and F-C curves
- Proposed “per-plant-year” method is reasonable for addressing risks from plants with multiple reactor modules
- Proposed LBE selection approach is generally reasonable but overly risk-based in some respects. To better align with Option 2, resulting set of LBEs may have to be supplemented:
 - Supplement DBE-derived DBAs with postulated DBAs and DBAs derived from BDBEs
 - Include AEs evaluated against HTGR specified acceptable fuel/core design limits (SAFDLs)
- Proposed DBE and BDBE frequency cutoffs of $1\text{E-}4$ and $5\text{E-}7$ per plant-year are reasonable for modular HTGRs if the supporting PRA is full-scope

Comparison of Alternate TLRC and F-C Curves: NGNP Proposal versus NUREG-1860

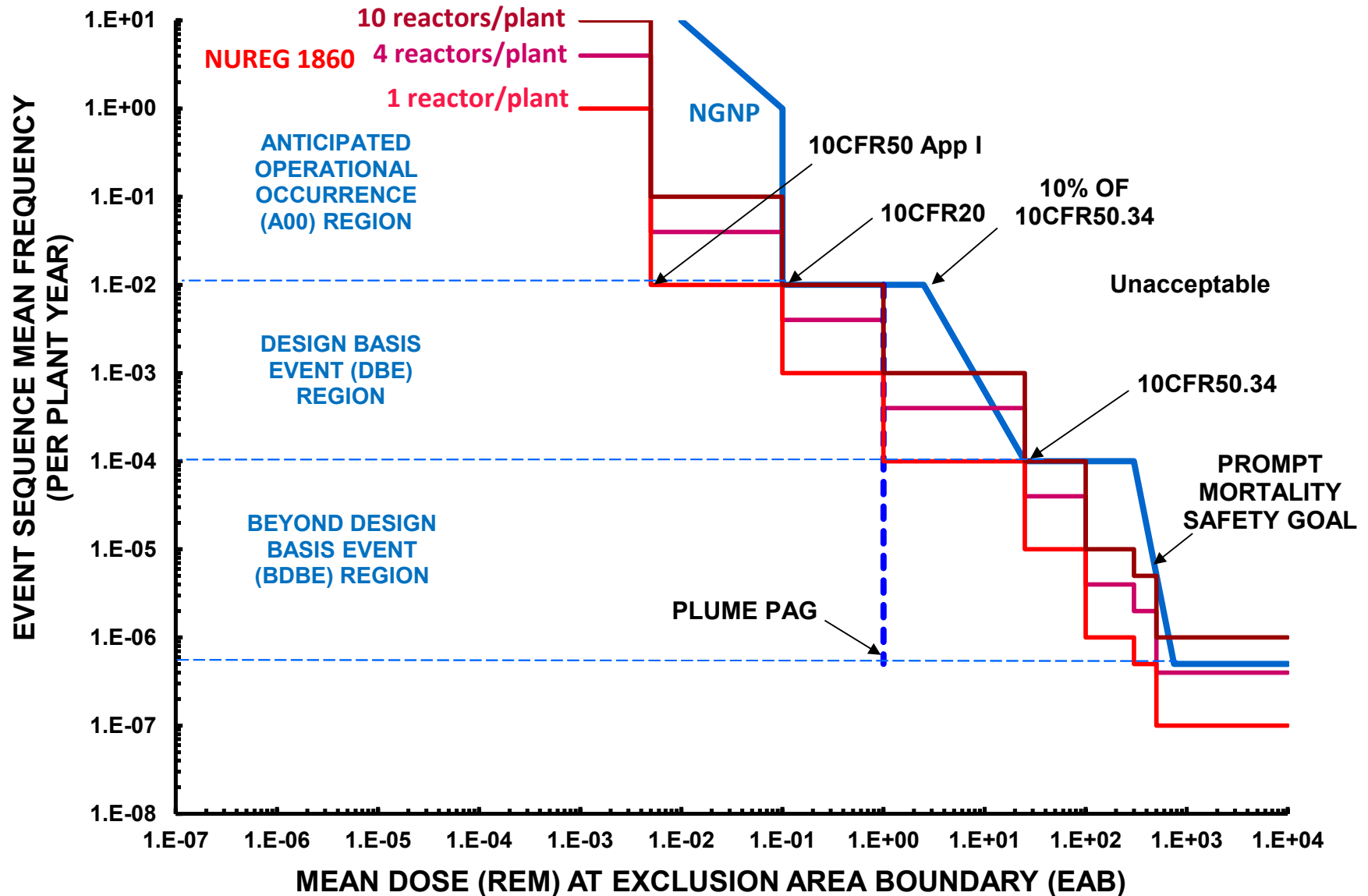


Image courtesy of DOE

NRC STAFF FEEDBACK ON LBE SELECTION (2/2)

- Proposed processes for assessing LBEs against TLRC are generally reasonable:
 - LBEs are categorized based on mean event sequence frequency
 - LBEs with upper (95%) and lower (5%) frequency uncertainty bounds that straddle event category regions are analyzed against dose criteria for each region
 - Calculation methodology evaluates dose consequences from full event sequences using best-estimate mechanistic source term models with realistic (mean) or conservative (95% confidence) treatment of uncertainties
- Proposed use of realistic source terms for AE and BDBE dose compliance needs further consideration and would involve new regulatory interpretations
- Proposed processes and categorizations for SSC safety classification are reasonable. Special treatments for SR and NSRST are commensurate with ensuring that SSCs can perform required safety functions in LBEs.

MECHANISTIC SOURCE TERMS

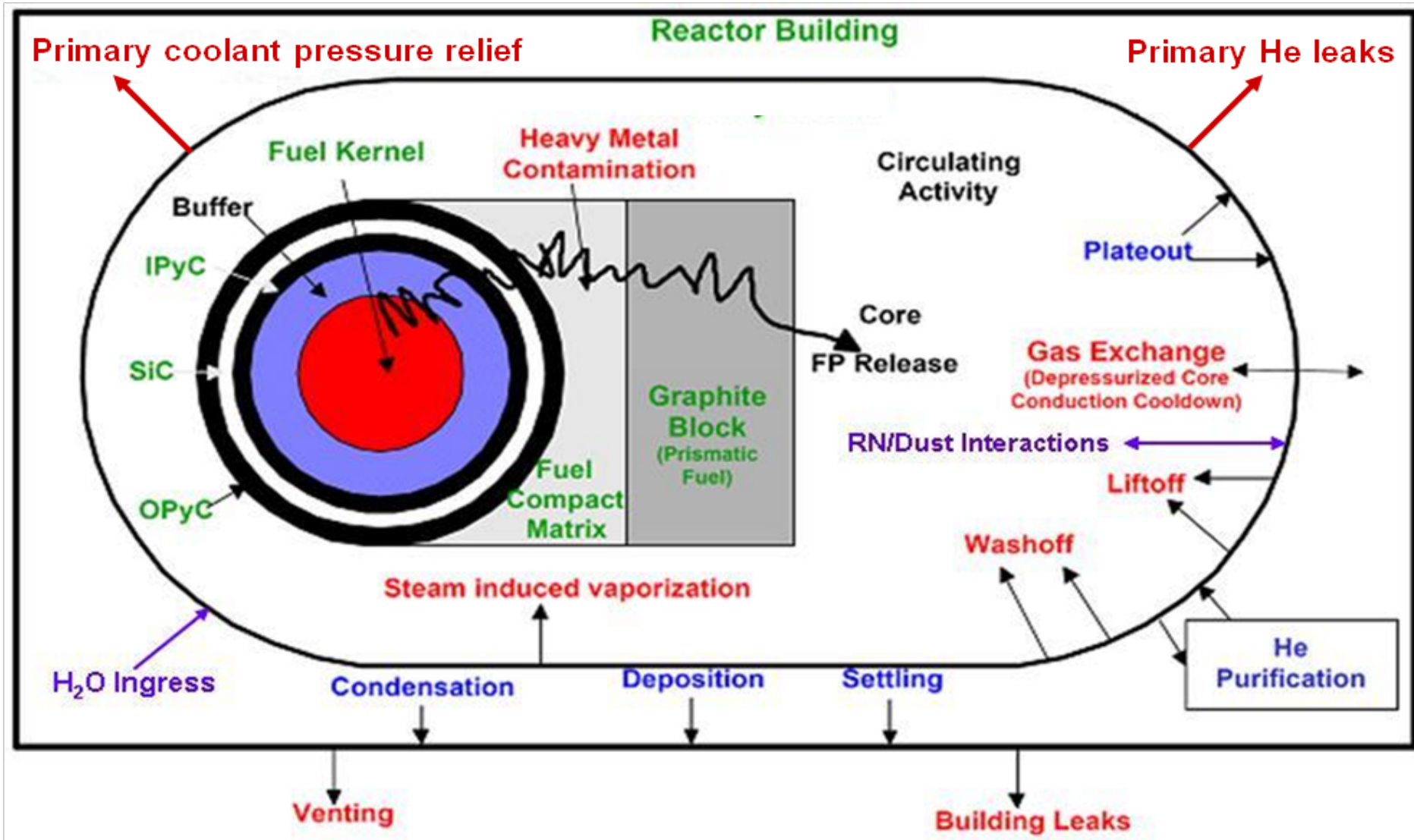
NRC STAFF FEEDBACK ON SOURCE TERMS (1/3)

- Proposed definition of NGNP mechanistic source terms is reasonable:
 - Defined as the quantities of radionuclides released to the environment in LBEs, including timing, physical and chemical forms, and thermal energy of the release
 - NGNP source terms are event-specific and determined mechanistically using models of radionuclide generation and transport that account for fuel and reactor design characteristics, passive features, and radionuclide release barriers

Definition is consistent with ACRS comments and Commission SRMs on staff recommendations in SECY-93-092 and SECY-03-047

- DOE/INL has identified the key fission product transport phenomena for NGNP and has established reasonable plans for evaluating and characterizing those phenomena and associated uncertainties
- Completion of related ongoing and planned AGR Fuel Program activities is viewed as very important, including planned additional activities to better address effects of moisture ingress, air ingress, and dust

Mechanistic Source Terms



NRC STAFF FEEDBACK ON SOURCE TERMS (2/3)

- Prototype Testing: Data from NGNP prototype tests under 10 CFR 50.43(e)(2) would be needed to verify and supplement the technical bases for NGNP accident and source terms analysis
- Likely/possible examples of NGNP prototype testing and surveillance:
 - PIE and accident heatup testing on used fuel discharged from the prototype
 - Mapping of in-core and outlet temperatures during normal operation using either off-the-shelf or novel sensor systems
 - Tests to establish/confirm detection thresholds for plausible core operating anomalies (e.g., core hot spots caused by local obstructions of helium flow)
 - Mapping of core and system temperatures during controlled pressurized or depressurized loss of forced cooling events
 - Tests to further refine/validate selected fission product transport models
- During the prototype testing period, conservative requirements and limits on core outlet temperatures, thermal power levels, trip set points, safety equipment, etc., may be necessary

NRC STAFF FEEDBACK ON SOURCE TERMS (3/3)

- The draft ASME/ANS PRA standard states that all PRA elements (including the mechanistic source terms element) must undergo peer review. Such peer review has particular importance for the implementation of risk-informed approaches to NGNP licensing.
- Further consideration of bounding events with air ingress and moisture ingress may be necessary to adequately challenge all available barriers in the assessment of event-specific mechanistic source terms
- In SECY-05-0006, staff recommends that source terms for compliance should be 95% confidence values based on best-estimate calculations

FUNCTIONAL CONTAINMENT PERFORMANCE

NRC STAFF FEEDBACK ON FUNCTIONAL CONTAINMENT (1/3)

Functional Containment Definition and Performance Standards

- Proposed definition of functional containment is reasonable:
“The collection of design features that, taken together, ensure that
 - *Radionuclides are retained within multiple barriers, with emphasis on retention at their source in the fuel*
 - *NRC regulatory requirements and plant design goals for limiting releases of radionuclides are met at the Exclusion Area Boundary”*
- Proposed NGNP approach presents a reasonable option for establishing modular HTGR functional containment performance standards (per SRM to SECY-03-0047)
 - Radionuclide containment function: reduce releases to the environs
 - Other “containment” of “reactor building” functions as discussed in SECY-05-0006
 - Protect risk-significant SSCs from internal and external events
 - Physically support risk-significant SSCs
 - Protect onsite workers from radiation
 - Remove heat to keep risk-significant SSCs within design and safety limits
 - Provide physical protection (i.e., security) for risk-significant SSCs
 - Reduce radionuclide releases to environs (including limiting core damage)
 - Limit air ingress after helium depressurization accidents

NRC STAFF FEEDBACK ON FUNCTIONAL CONTAINMENT (2/3)

AGR Fuel Program Activities

- Overall scope of AGR Fuel Program activities is generally reasonable in context of pre-prototype testing
 - Early AGR irradiation and safety testing results are favorable
 - Completion of planned AGR activities is key for modular HTGR safety case
- AGR Fuel Program should give continuing attention to such areas as:
 - Specification of fuel service conditions for NGNP normal operations and accidents
 - Evaluation and treatment of AGR fuel test irradiation temperature uncertainties
 - Potential needs for additional fuel and fission product transport data for bounding events

Additional data from NGNP prototype testing under 10 CFR 50.43(e)(2) would be needed to provide reasonable assurance of targeted retention in fuel

- Test data on TRISO fuel irradiated in NGNP prototype to more fully address
 - Coating interactions with plutonium fission products (Pd, Ag)
 - Time-at-temperature effects during real-time versus accelerated irradiations
 - Prototypic combinations of fuel irradiation parameters (temperature, burnup, fluence)
- Testing and surveillance to confirm core operating conditions and establish detection thresholds for potential core “hot spot” operating anomalies

NRC STAFF FEEDBACK ON FUNCTIONAL CONTAINMENT (3/3)

Event Selection for Plant Siting and Functional Containment Assessment

- Staff agrees that the substantial core melt accident assumed for LWRs may not be applicable to modular HTGRs
- Proposed approach to event selection for siting source terms is generally reasonable when supplemented with insights from future “safety terrain” studies
 - *Applicant should submit for NRC consideration a risk-informed selection of siting events, building on the types of bounding events considered by staff in NUREG-1338 for MHTGR*
 - *To assure there are no “cliff-edge effects” [credible events with high dose consequences] and to understand ultimate safety capability, bounding event selection should be further informed by exploratory studies of postulated extreme events, including bounding events with air oxidation of graphite per the SRM to SECY-93-092. Such exploratory events should be physically plausible, may have estimated frequencies below the BDBE region ($< 5E-7$), and will consider inherent behavior of the modular HTGR design*
- Selected siting events should be used as basis for retention requirements of reactor building in functional containment system

EMERGENCY PREPAREDNESS

BACKGROUND ON NGNP EMERGENCY PREPAREDNESS (EP)

- In October 2010, DOE/INL submitted a white paper on “Determining the Appropriate Emergency Planning Zone Size and Emergency Planning Attributes for an HTGR”
 - NRC staff did not formally review this white paper submittal
 - DOE/INL participated in NRC public meetings in 2011 on emergency preparedness framework issues for small modular reactors (SMRs)
 - Stated NGNP goal is to justify Emergency Planning Zone (EPZ) at 400-meter Exclusion Area Boundary
- In October 2011, NRC staff issued SECY-11-0152, “Development of an Emergency Planning and Preparedness Framework for Small Modular Reactors”
 - Described a general approach to scalable EPZs
- 10 CFR 50.47(c)(2) allows EPZ size for gas-cooled reactors to be considered on a case-by-case basis

NRC STAFF FEEDBACK ON EP APPROACH FOR NGNP

- Proposed EP approach is consistent with SECY-11-0152. Staff would be open to considering future proposals by industry or pre-applicants on such topics as:
 - PRA-informed approach that includes accident dose assessment versus distance
 - Risk-informed criteria for determining the point at which the probability of exceeding the PAG values is acceptably low
- Specific proposals from NGNP site pre-applicant should be supported by details of the NGNP design, site, and co-located process-heat user facilities
 - EP approach addressing PAGs must be developed by the NGNP site applicant
 - Graded EP may be different for NGNP prototype versus subsequent standard plants
- Proposals should address considerations specific to co-location and co-generation
 - Co-location considerations and guidance for current LWRs are largely applicable
 - Potential EP-basis events and EP strategies may be influenced by
 - Co-location and external events impacting the site
 - Co-generation issues associated with coupling between modular HTGR plant and user facility
 - Consider different regulatory nexus for reactor and user facilities
 - Expect staff considerations of new regulations, hazards assessments, accident evaluations, and security issues

THANK YOU



U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Completion of Generic Issue 189

**Susceptibility of Ice Condenser and Mark III
Containments to Early Failure from Hydrogen
Combustion during a Severe Accident**

Steve Jones

Division of Safety Systems

Office of Nuclear Reactor Regulation

Briefing for ACRS

May 9, 2013

Introduction

- Initiation of Generic Issue
- Regulatory Requirements
- Technical Information
- Early Stakeholder Interactions
- Regulatory Analysis
- Implementation Plans
- Verification Activities
- Nexus to Events in Japan
- Conclusion

Initiation of GI-189

- Risk-Informed Changes to 10 CFR 50.44, “Combustible Gas Control for Nuclear Power Reactors”
 - Specify a severe accident combustible gas source term
 - Remove requirements to monitor and control combustible gases associated with design-basis LOCA
 - Modify combustible gas requirements for Ice Condenser and Mark III containment designs
- In SECY 00-198 (Risk informing 10 CFR 50.44), Staff recommended proceeding with rulemaking on the first two items and processing the third item through the Generic Issue program

10 CFR 50.44 Requirements (2003)

All Containments:
Mixed Atmosphere
Hydrogen Monitors

New Pressure-Suppression
Containments
(ABWR and
ESBWR DCs):
Inerted
Oxygen Monitors
Adds significant
beyond design-
basis accidents

New Large Dry
Containments
(AP1000, APWR,
and EPR DCs):
Equipment
Survivability
Analysis w/100%
Metal-Water
<10% Hydrogen
(PARs and/or
Igniters)
Adds significant
beyond design-
basis accidents

PWR Large Dry
and
Sub-Atmospheric
(59 OLs):
No Additional
Requirements
Based on Large
Volume and High
Design Pressure

BWR Mark I & II
(31 OLs):
Inerted
Oxygen Monitors

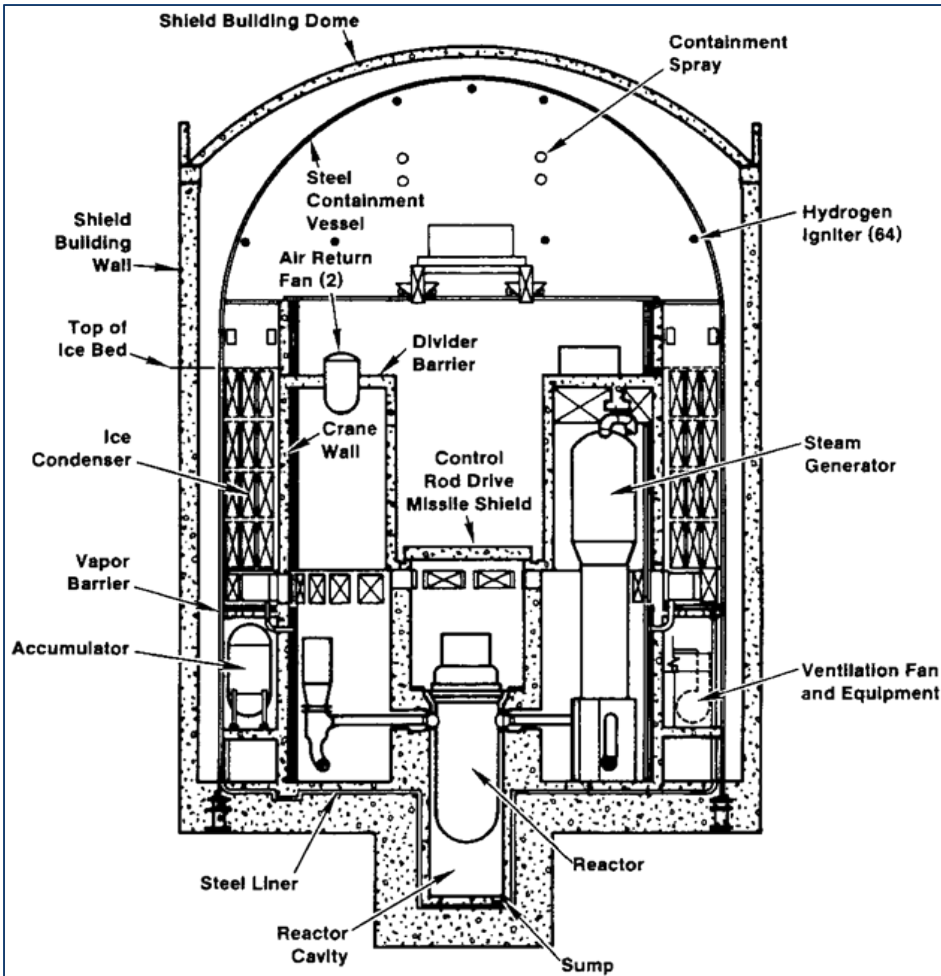
PWR Ice Condenser (9
OLs & 1 CP) and BWR
Mark III (4 OLs):
Combustible Gas
Control (Existing
AC-Powered Igniters)
Equipment Survivability
Analysis w/75%
Metal-Water (Existing
Analyses)

Ignition System Design

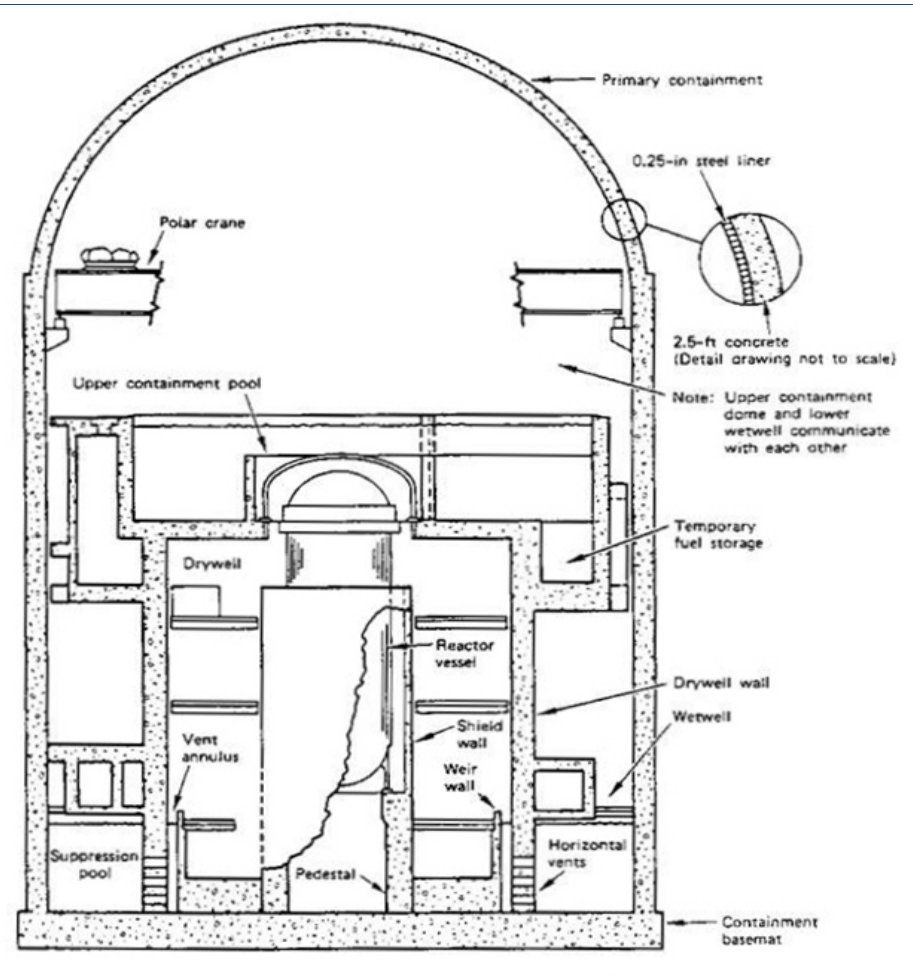
- Igniters distributed throughout containment in two trains
- Either train provides full coverage to initiate combustion of hydrogen at low concentrations to limit pressure rise
- Igniters are manually initiated based on emergency procedure direction
- Power consumption is typically less than 15 kW per train



Containment Designs



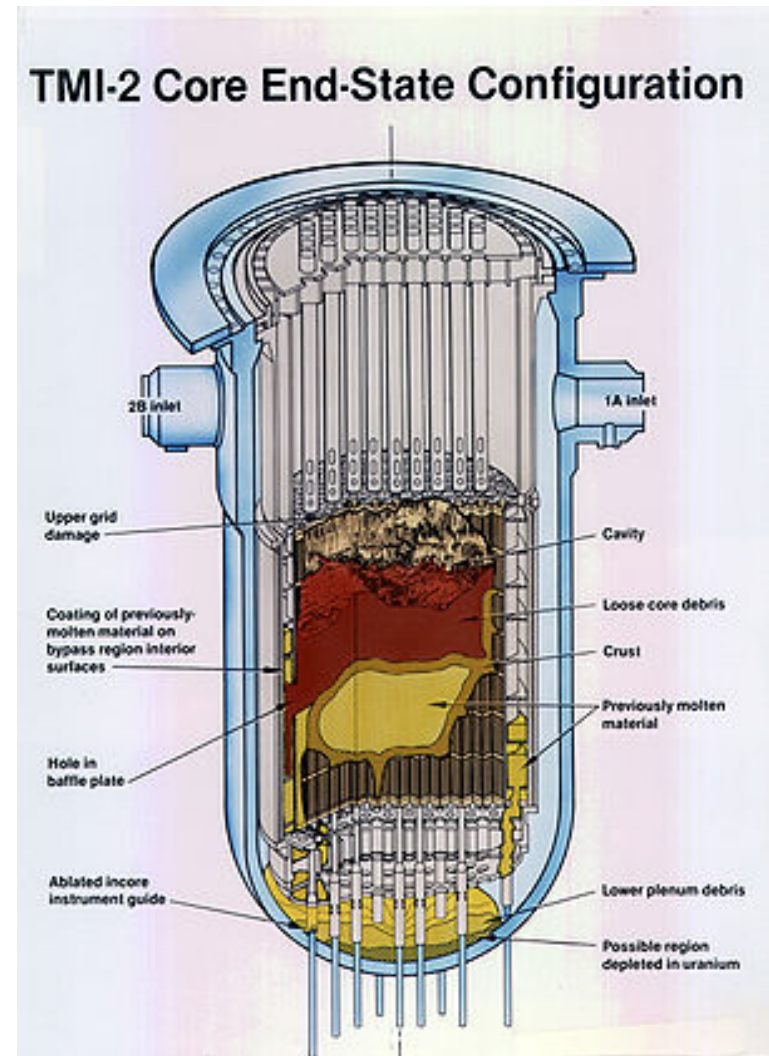
PWR Ice Condenser Containment (Free-standing Steel w/Shield Building – Representative of Catawba, McGuire, Sequoyah, & Watts Bar Units; Cook Units have Reinforced Concrete Containment w/Steel Liner)



BWR Mark III Containment (Reinforced Concrete w/Steel Liner– Representative of Grand Gulf and Clinton Units; Perry and River Bend have Free-standing Steel Containment w/Shield Building)

Technical Background

- Zirconium oxidation by steam at high core temperatures (>1000 C).
 - Cladding Oxidation Damage
 - Production of Hydrogen and Heat
- Heat generation rate from oxidation can exceed decay heat
 - Increased rate of residual coolant inventory loss
 - Increased rate of cladding oxidation
- This feedback mechanism can produce substantial amount of hydrogen in a short time
- Hydrogen released to containment
 - Relief valve operation
 - RCS leaks
 - Deliberate reactor vessel venting



Ice Condenser and Mark III Containment Performance

- Hydrogen could accumulate in containment without operating ignition system
- Conditional containment failure probability (as a result of hydrogen combustion) exceeds regulatory guideline (0.1) for ice condenser and Mark III containment designs
- Mark III containment likely to retain suppression pool scrubbing of releases following hydrogen combustion in wetwell

Initial Investigation of Issue

- Potential for large early release in absence of igniter function
- Very low frequency event sequence
- Substantial uncertainty in consequence determination
- Considered:
 - Back-up power for igniters
 - Back-up power for igniters and recirculation fans
 - Passive autocatalytic recombiners
- Recommended back-up power to igniters based on relatively low cost and consequence uncertainty

Interface with Stakeholders

- Staff scheduled several public meetings with stakeholders to:
 - Explain technical issue
 - Describe accident sequences
 - Propose design criteria for back-up power supply
 - Discuss implementation procedures (EOPs vs SAMGs)
- Interface with several organizations, including:
 - Nuclear Energy Institute
 - Union of Concerned Scientists
 - BWR Owners Group

Discussion Areas

- Design of backup power supply
 - portable verses pre-staged
 - need for design criteria
 - timing for activating hydrogen igniters
- Alternatives to rulemaking
 - BWROG suggested use of Division III EDG to repower igniters
 - PWR licensees suggested use of various on-site DGs as backup power sources
- Benefits and costs

Regulatory Analysis

- Evaluated costs and benefits using plant-specific SBO core damage frequencies and populations
- Considered:
 - voluntary measures and rulemaking
 - PARs, igniter back-up power, and auxiliary equipment
 - containment conditional failure probability (CCFP)
 - Assumed plant-specific CCFPs ranging from 0.22 to 0.97 for ice condenser containments
 - Used CCFP of 0.19 for an unscrubbed release (i.e., wetwell and drywell failure) for the BWR Mark III containments
- Did not fully evaluate:
 - External event and security-related initiators
 - Benefit from enhanced defense-in-depth

Regulatory Analysis Results

- Provision of backup power to igniters adequate
 - PARs substantially more expensive than backup power
 - Mixing fans and hydrogen analyzers unnecessary
- For PWRs, backup power provided a substantial safety benefit at a justifiable cost
 - Most of the benefit provided by proposed voluntary measures
 - Rulemaking not justified after consideration of voluntary measures
- For BWRs, costs of implementing any option were not justified by the increased protection
- Sensitivity analyses did not change conclusions

Licensee Commitments

- Staff continued meeting with affected licensees about security-related issues
- Licensees proposed backup capabilities that provided benefit for security scenarios
 - Catawba and McGuire established permanent power supplies from Safe Shutdown Facility DGs
 - Sequoyah and Watts Bar developed procedures to power igniters from large, portable DGs
 - D.C. Cook enhanced capability to power igniters from large, permanently connected yard DGs
 - BWRs provided portable DGs for local power
- Implementation procedures at the level of SAMGs

Verification Activities

- Verification procedure established in TI 2515/174, “Hydrogen Igniter Backup Power Verification”
- Commitment implementation and verification inspection completed at most sites by early 2008
- Major modifications at Catawba and McGuire completed at last unit in 2010
- Commitment for backup power at Watts Bar Unit 2 received in 2010
- No identified deviations from commitments

Nexus to Events in Japan

- Accident progression similar to GI-189 event
 - External event initiated station blackout
 - Core damage with significant hydrogen generation
 - Significant release due to containment overpressure
- Mitigating strategies order includes strategies to maintain containment integrity
 - Hydrogen igniter power for PWR ice condenser and BWR Mark III containments
 - Addresses external event equipment survivability
- Imposes durable regulatory requirement

Conclusion

- Effective measures to control combustible gas during an extended station blackout have been deployed
- Verification inspections have confirmed capabilities
- Agency response to events in Japan will enhance this capability
- Accordingly, GI-189 can be closed