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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

543rd MEETING

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WEDNESDAY,

JUNE 6, 2007

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The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Dr. William J. Shack, Chairman, presiding.

MEMBERS PRESENT:

- WILLIAM J. SHACK Chairman
- SAID ABDEL-KHALIK ACRS Member
- GEORGE E. APOSTOLAKIS ACRS Member
- J. SAM ARMIJO ACRS Member
- MARIO V. BONACA ACRS Member
- MICHAEL CORRADINI ACRS Member
- THOMAS S. KRESS ACRS Member
- OTTO L. MAYNARD ACRS Member
- DANA A. POWERS ACRS Member

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1 NRC STAFF PRESENT:

2 JOSE IBARRA

3 SUNIL WEERAKKODY

4 ERASMIA LOIS

5 RAY GALLUCCI

6 PHIL QUALLS

7 ZENA ABDULLAHI

8 GREG CRANSTON

9 MICHELLE HONCHARUK

10 TONY ULSES

11 RICHARD LEE

12 RANDY GANT

13 MICHELLE HART

14

15

16 ALSO PRESENT:

17 ALEX MARION

18 CHRIS PRAGMAN

19 RICK KINGSTON

20 SCOTT BOWMAN

21 JOSE CASILLAS

22 JENS ANDERSEN

23 JOSE MARCHE-LUEBA

24 JESS GEHIN

25 BERNARD CLEMENT

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

8:30 a.m.

CHAIRMAN SHACK: The meeting will now come to order. This is the first day of the 543rd meeting of the Advisory Committee on Reactor Safeguards. During today's meeting the Committee will consider the following: draft NUREG-1852 demonstrating the feasibility and reliability of operator manual actions in response to fire; maximum extended load and line limit analysis plus (MELLLA+) and supporting topical reports; an overview of the PHEBUS-FP experimental program and results of recent tests; a subcommittee report on the Vermont Yankee renewal application; a status report on the quality assessment of selected NRC research projects; and preparation of ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Sam Duraiswamy is the Designated Federal Official for the initial portion of the meeting. We have received no written comments or requests for time to make oral statements from members of the public regarding today's session. A transcript of portions of the meeting is being kept and it is requested that the speakers use one of the

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

4 And we're going to start this morning with
5 the draft 1852 on operator manual actions in response
6 to fire and George will be leading us through that.

7 DR. APOSTOLAKIS: Thank you Bill.
8 Sometime ago, the staff was developing a rule to
9 credit operator actions during a fire and as part of
10 that, there was a draft regulatory guide which the
11 Committee had the opportunity to see some time ago.
12 The rule was withdrawn about two years ago, but now
13 the draft regulatory guide has come to us as a NUREG
14 report and the intent is to support the staff's review
15 of possible exemption requests of the utilities, of
16 the licensees, that they may submit to the NRC. All
17 this is within the deterministic space of Appendix R.

18 The Committee had decided some time ago
19 not to review the draft guide, but wait until after
20 the public comments were received and resolved and
21 this is where we are today. You will hear about the
22 report itself but also the public comments and how the
23 staff disposed of them. So we start with Jose, I
24 think.

25 MR. IBERRA: Good morning. My name is

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1 Jose Iberra and I am the Branch Chief of the Human
2 Factors and Reliability Branch in the Office of
3 Nuclear Regulatory Research. We're here today to
4 brief you on the NUREG and request your endorsement so
5 we can public NUREG-1852 and the title of that is
6 "Demonstrating the Feasability and Reliability of
7 Operator Manual Actions in Response to Fire."

8 We have three presenters today. Dr. Sunil
9 Weerakkody, the Branch Chief from Fire Protection
10 Branch in the Office of Nuclear Reactor Regulation,
11 and Sunil will discuss the use of this regulatory
12 NUREG. Dr. Erasmia Lois from the Office of Research
13 will summarize the contents of the NUREG and tell us
14 the revisions that were made due to the public
15 comment. And then Ray Gallucci from the Office of NRR
16 will discuss the public comments and the staff's
17 response to that. Sunil.

18 DR. WEERAKKODY: Why don't I go ahead and
19 start what I have to say. My objective is to share
20 with you as Jose said the role that this NUREG will
21 play in ensuring the safety of our plants. Go to the
22 second slide.

23 For the benefit of the members here,
24 especially after hearing the number of issues you go
25 through in one day, let me quickly go through the

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1 context of this NUREG. In the fire protection
2 regulations, we have labeled the typical use called
3 III.G.2. It's pretty much when we say an area is a
4 III.G.2 area, we refer to an area where redundant
5 safety equipment or cables are located.

6 In maintaining fire safety, the regulation
7 has provided three provisions for III.G.2 areas. You
8 are required to have a three hour fire barrier or a
9 one hour barrier with detection and suppression or an
10 24 foot separation with detection and suppression.
11 There is no provision for III.G.2 areas for operator
12 manual actions.

13 When this issue came to life that some
14 licensing are used unapproved manual actions, there
15 were a number of deliberations with the Office of
16 General Counsel, CRGR, the Commission and as Dr.
17 Apostolakis summarized here, you know, the industry
18 said to us if based on the staff position the
19 implementation could result in the Agency receiving
20 about 1,000 exemption requests. At that point, we
21 went to the Commission and said let's amend the rule
22 and the provision to enable the user of operator
23 manual actions given that the licensees had detection
24 and suppression and needs criteria which we typically
25 call as feasibility and reliability criteria.

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1 The Commission received the proposed rule.
2 They approved the proposed rule with a 5-0 vote and
3 basically those in the staff, we do and at the time
4 when they issued the SRM, they did agree with the
5 staff on the detection and suppression and also
6 specifically mentioned in the SRM some of the
7 controversial issues, things like time margin and
8 agree that the time margin should be addressed. And
9 this is the time as Dr. Apostolakis said, we were due
10 to do a NUREG.

11 The rule when it was proposed, we got a
12 lot of public comments. Other industry stakeholders
13 said if the rule stays as is, we are still going to
14 get thousands of exemptions. Our stakeholders like
15 the public, they basically said we are watering down
16 fire safety. So we weren't making anybody happy. We
17 withdrew the rule.

18 When we withdrew the rule, by process, we
19 go and tell the Commission here is why we are going to
20 withdraw the rule. It's not meeting the intended
21 purpose. The Commission endorsed again with the 5-0
22 vote that the rule should be withdrawn, but more
23 importantly, in the SRM, they basically said we need
24 to deal up some guidance to deal with the 1,000
25 exemptions that we would get and that meant an

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1 extension to SRP-951. That's the standard review plan
2 for the fire protection. If you go to that, there is
3 a post reference coming from there to the reg. guide
4 to this NUREG.

5 So the place of this NUREG, the reason we
6 want this NUREG, is if we then receive the 1,000
7 exemptions we want the staff here in the NRR to
8 perform consistent reviews. That is the intent and
9 that is the only intent. But we recognize that a
10 structure or streamline, the knowledge, was out there
11 in fragmented fashion. So we like this NUREG.

12 As I said, the intended role of this draft
13 NUREG is if a licensee chooses to rely on an OMA as
14 opposed to the passive features required by the
15 regulation and seeks NRR approval of the exemptions
16 from the rule or an amendment for the post-79s for the
17 license, the NRR staff will use this NUREG to enter
18 consistent reviews of those requests, i.e., the NUREG
19 is an extension to our SRP. Let's go to the next
20 slide.

21 Before you hear from Erasmia and Ray which
22 will be a number of details that some of it would be
23 tough to understand, I want to put forth the context
24 of the public comment. When we sought comments on the
25 NUREG, we were asking comments on the content of the

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1 NUREG, not the regulatory context of the NUREG.
2 Nevertheless we got a large number of comments on the
3 regulatory context of the NUREG. In our way -- we had
4 addressed those ways not one but a couple of times
5 with CRGR, with the Commission and the Commission
6 endorsed our positions with 5-0 vote each and every
7 time. However, just so we put all the information in
8 front you, the memo from our Director captured all
9 comments whether they were pertaining to the NUREG or
10 they were pertaining to the regulatory context.

11 Finally and last, we are here, NRR is
12 here, to seek your support, your endorsement, to this
13 NUREG in a final form because we truly believe that
14 this NUREG together with all the other elements out
15 there is going to make a real difference to the safety
16 of our operating plants which may be operating for 40,
17 50 or 60 more years. The reason I emphasize that
18 point is we have some plants out there who want to
19 rely on OMAs or operator manual actions as opposed to
20 the engineered factor features and this Agency is dead
21 against that. So for some plants where they have a
22 few operator manual actions, they would work. But if
23 you have 100 operator manual actions and you don't
24 know whether they are feasible or reliable, the
25 pressure is on and we want to get to that end. Thank

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1 you very much.

2 DR. APOSTOLAKIS: Now you mentioned the
3 three requirements that are in III.G.2. Three hour
4 barrier, one hour barrier with detection and
5 suppression capability and 20 foot separation again
6 with detection and suppression. The licensees can use
7 the operator manual actions in lieu of any one of
8 these? In other words, in the absence of the three
9 hour barrier somewhere, they can say we were doing
10 something else plus we rely on manual action.

11 MR. WEERAKKODY: Yes.

12 DR. APOSTOLAKIS: Any of the three?

13 MR. WEERAKKODY: Any of the three, that's
14 correct.

15 DR. APOSTOLAKIS: Because my impression
16 was that it was primarily in the second one, one hour
17 fire barrier, but it's --

18 MR. WEERAKKODY: It could be just another
19 option. The other things we're emphasizing is if you
20 are replacing your passive feature which is in III.G.2
21 you need staff to even approve it and we are telling
22 when you send that in, I'm telling my staff, here are
23 the elements that the amendment or the exemption
24 should address. So, for example, if a plant area
25 doesn't have detection and suppression, then in

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1 addition to meeting the criteria that are listed here,
2 they still can ask for approval but we would look for
3 some additional information to justify why it is still
4 good even without --

5 DR. APOSTOLAKIS: Now, the other
6 impression I have is that you don't -- I mean, you
7 don't intend to approve manual actions alone. I mean,
8 they have to be accompanied by something else, too,
9 like detection and suppression capability or something
10 else. Can someone come in there and say, look, "We
11 don't have a one-hour fire barrier, we don't have
12 detection and suppression, but boy, we have trained
13 our people and they can do this in 30 seconds". Is
14 that something that you would look into or is it dead
15 on arrival?

16 MR. WEERAKKODY: It's not dead on arrival.
17 What we would look for is, if you don't have
18 detection and suppression, we would look for a higher
19 level of safety in terms of you mentioned we have
20 crane operators. We would look for the combustible
21 loadings. We would look for, you know, what are the
22 emission frequencies, the other features they have
23 before we -- it's not dead on arrival.

24 DR. APOSTOLAKIS: Can you look at ignition
25 frequencies in a Appendix R?

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1 MR. WEERAKKODY: Qualitatively, you could.

2 DR. APOSTOLAKIS: Qualitative, that's an
3 interesting idea. The qualitative frequency is what,
4 yellow per year?

5 MR. WEERAKKODY: If you look at before
6 PRA, how we approved some of these exemptions, okay,
7 we would -- you know, really we would be looking at
8 the singular elements but the decisions were made in
9 a qualitative manner. Like a licensee would say, "I
10 have no combustibles in this area", or they might say,
11 "I have only one cabinet and some features," and say,
12 "it's 50 feet away from the two trains", that type
13 now.

14 But now, there is the PRA, obviously, it's
15 most likely going to be into the PRA area here. If
16 you have PRA.

17 DR. APOSTOLAKIS: You said frequency, you
18 made a mistake.

19 DR. MAYNARD: What is the situation right
20 now because most of these exemptions are not going to
21 be because people want to remove something they have,
22 it's because they can't meet one of these requirements
23 and they haven't met it for some time? So without
24 issuance of this, we're in the situation right now, so
25 what is the current situation of plants that aren't in

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1 compliance with these three?

2 MR. WEERAKKODY: There's 42 plants who
3 have -- who are addressing this issue through the 805
4 transition using five PRAs.

5 DR. APOSTOLAKIS: I'm sorry, say that
6 again, 40?

7 MR. WEERAKKODY: There are 42 reactor
8 units who are addressing all of operator manual
9 actions, everything out there, the barrier issues
10 through the risk informed process, 42, 805.

11 DR. APOSTOLAKIS: 805?

12 MR. WEERAKKODY: Yes. Out of the
13 remaining 62 plants, this is the non-805, there's a
14 number of plants who don't have -- now, I don't have
15 the exact numbers, who don't have that many operating
16 manual actions and they're okay. You know, if you go
17 to the later vintage boiling water reactor where the
18 -- you know, even the old vintage boilers where you
19 have a lot of space and they can easily do this, but
20 then there's a set of plans, you know --

21 DR. APOSTOLAKIS: How many are out there?
22 I mean, what are we talking?

23 MR. WEERAKKODY: I don't want to give you
24 numbers that I can't defend, but there's a number of
25 plants and, you know --

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1 DR. APOSTOLAKIS: But it's a small number?
2 Is it half or is it -- I mean, you don't have to be
3 specific. I mean, is it a big deal for the industry
4 or is it a few licensees that worry about this?

5 MR. WEERAKKODY: Okay, this is personal
6 speculation but I'll answer your question.

7 DR. APOSTOLAKIS: All right.

8 MR. WEERAKKODY: When I, based on my
9 personal experience and what I have observed, all the
10 PWRs which are compacted design don't have a lot of
11 separation and if they are using a number of operator
12 manual actions, then right now, you asked for right
13 now the situation, the Commission said they have three
14 years to fix the problem which ends in March 2009.

15 I have gotten so far as opposed to the
16 1,000 at this point, like two exemptions in house. We
17 have -- like there was one case where you know, I
18 vaguely recall, there was a 3(D)(2) area that was a
19 top of a roof, okay. So we look at what can happen
20 and we approve that. So the thing is though, not
21 every 3(D)(2) area is the top of a roof, okay.

22 DR. MAYNARD: Well, I'm trying to
23 understand for those who are like using the PRA and
24 some other -- is everybody -- no matter how they're
25 showing compliance right now or how they're doing it,

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1 is everybody going to have to come back in with
2 exemptions then?

3 MR. WEERAKKODY: Some will have to come in
4 with exemptions, yes. It's a choice of the licensee.

5 DR. APOSTOLAKIS: Not under NFPP 805.

6 MR. WEERAKKODY: Not under 805. Under 805
7 they send out this one big submittal.

8 DR. APOSTOLAKIS: Yeah, it's very
9 difficult.

10 MR. WEERAKKODY: The other plants, we
11 expect some plants to see some situations. Let's say,
12 you know, Plant X has only three operator manual
13 actions and they want to address that and they might
14 send, you know, single exemptions or three and ask us
15 the --

16 DR. MAYNARD: And just one last question.
17 You said that the Commission gave the industry three
18 years to fix it. What form did that come out in?

19 MR. WEERAKKODY: It came out in a Federal
20 Register notice. When we -- when the Commission
21 approved the finding that we draw the rule, in that
22 FRN, they told plants that they are required to put
23 comp actions right away and then fix the problem by
24 March 2009. If you want me to provide you that FRN.

25 DR. MAYNARD: No, thank you.

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1 DR. APOSTOLAKIS: So shall we go on?
2 Erasmia?

3 MS. LOIS: Sure. So, I would like to note
4 here that the NUREG 1852 has been developed with
5 strong collaboration, actually, it's a project of both
6 offices, Research and NRR. NRR has been given all of
7 the qualitative criteria, the determination criteria,
8 research with the development of the build base
9 analysis and I would like to note that Sandia National
10 Laboratories has also supported this activity.

11 What I will try to do very quickly is
12 summarize the content of the NUREG and then actually
13 Dr. Gallucci will address the public comments and also
14 note how changes were made. And again, we would like
15 to have the ACRS endorsement to publish the NUREG.

16 In terms of background, Dr. Busalike
17 (phonetic) discovered it. It did start as a Reg Guide
18 drafted guide 1136 and after the Commission approved
19 the withdrawal of the rule, we recognized that we need
20 the technical basis that was developed for the draft
21 reg guide to support the staff reviews of exemption
22 requests. And therefore, the NUREG was developed to
23 retain the technical work and support the NRC staff
24 reviews.

25 It has been referenced in the Regulatory

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1 Guide 1.189 and the ACRS has been briefed frequently
2 on this topic. What are the objectives of the NUREG
3 is to provide the technical basis and deterministic
4 guidance for justifying manual actions that manual
5 actions about feasible and reliable and to be used as
6 a reference guide. In terms of scope, it addresses
7 feasibility and reliability criteria but it does not
8 address control room evacuation type actions and also
9 this -- the third bullet here does not establish
10 defense-in-depth criteria. We note that during the
11 public comment it was pointed out that as you
12 substituted the Appendix R criteria with this NUREG,
13 and it does not.

14 In terms of status, we are briefing the
15 ACRS today and we are planning to submit to the
16 NUREG's publication in September of '07. So what is
17 the approach? The approach is to develop
18 deterministic criteria on the basis of, and I'm noting
19 here all four different bullets. First of all, we
20 build on the inspection guidance and insights and
21 experience that were developed through the inspections
22 that have been done through the years on manual
23 actions. So that was a primary resource for
24 developing the criteria.

25 Also, a big aspect is the input from human

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1 factors guidance and the related documents and I'm
2 referencing here some. The review and insights and
3 experience that we have developed from reviewing PRAs,
4 the IPREE reports, the NUREG-6850 for quantification,
5 fire quantification study and also the HRA development
6 activities and applications.

7 And the final note here is that in many
8 respects the NUREG criteria were implicitly used by
9 the NRC staff and inspectors and therefore, it is not
10 a new position, a staff position that has been noted
11 sometimes in the comments. The last comment here is
12 that we are working with EPRI to develop a risk-
13 informed approach for those plants that are going to
14 use an NFPA 805 and this work is started this month.

15 I think the committee's interest today is
16 more on what are the comments and how the NUREG was
17 revised, so I don't plan to go into any kind of depth
18 in citing what are the criteria, what is the content
19 of the NUREG but I do note that it contains both
20 feasibility and reliability criteria and first, it has
21 two divisions, the criteria documented and the
22 technical basis for those criterias is also
23 recommended and then we provide guidance for the
24 implementation. And the guidance, actually -- the
25 content is actually the same with Reg Guide 1136 and

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1 where the differences are in the Reg Guide we had
2 recommended a factor of two to be used as a time
3 margin, kind of a universal factor and that was -- has
4 been changed because we recognize that there are many
5 different ways that you can demonstrate that you have
6 extra time for example, or you may come in with a
7 conservative analysis, et cetera. However,
8 demonstrating that extra time needs is needed to be
9 available to cover the variability and uncertainty of
10 the fire conditions and the manual actions that are
11 going to be taking place is still emphasized in the
12 report.

13 And the other change is that licensees can
14 justify their approach for addressing the availability
15 and the uncertainties. They don't have to use a
16 specific time margin factor. These changes were done
17 as a result of public comments and also Commission
18 recommendation in the SRM Of January `05.

19 What are the criteria? I mentioned here,
20 time is -- so in order to implement a human action,
21 you have to come to estimate time for -- needed to
22 implement the action and it has -- the time
23 estimations have to address both feasibility and
24 reliability and when you do time estimation with
25 respect to the feasibility, you have to take into

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1 account all of the unrelated uncertainties with those
2 uncertainties that are foreseeable for example, the
3 type of the fire, it's slow, fast, et cetera with the
4 possibility that you may have to take a human action
5 in a toxic environment, the indications, et cetera.

6 So when you estimate the time for the
7 feasibility you have to address availability and
8 uncertainties that are, epistemic type of
9 uncertainties when, however for the availability, you
10 have to take into consideration the unknown, the fact
11 that you may not have your best crew. Your crew may
12 be doing something else and they have to -- and
13 therefore, it may take a little bit more time to
14 prepare for doing the action, et cetera. The
15 environmental factors, if you would like to have human
16 actions, you would like to make sure that the
17 environment under which the human action is going to
18 be performed has to be according to the guidance we
19 have for human actions, the lighting, the toxic
20 environment, humidity, et cetera has to be addressed.
21 The functionality and accessibility of the equipment
22 has to be insured. The available indications must be
23 available so that for both the diagnostic the need to
24 make -- to diagnose the need for the action and also
25 communicate with appropriate staff and also to respond

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1 back to the staff.

2 Communications, another issue, I don't
3 think I really have to go down this unless there are
4 specific questions from the committee but these are
5 the criteria.

6 DR. APOSTOLAKIS: Well, one thing that
7 strikes me when I see all this is that we are asking
8 the reviewer, and of course the licensee who is
9 preparing the request, to make an awful lot of
10 judgments regarding all these factors which are, of
11 course, legitimate factors. And at the same time, we
12 have in another context, developed ATHEANA which, in
13 fact, does a very good job identifying scenarios and
14 deviations from the expected scenario and so on. It's
15 really very surprising that this kind of guidance here
16 does not take advantage of work that the agency has
17 done in a different context and doesn't even say that,
18 you know, you may want to use event trees to identify
19 the various possibilities, the various contexts that
20 ATHEANA has defined. And I'm wondering why that is.

21 I mean, it would be -- why this context
22 which is real life regulation rely on judgments of
23 people but when we do a PRA, we develop all sorts of
24 tools to help people structure their judgments and
25 make a better job, do a better job, and also we make

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1 the life of the reviewer much easier when the reviewer
2 has in front of him or her trees with an
3 identification of the various conditions. So I'm
4 wondering why that is.

5 MS. LOIS: I'll try to answer and then
6 probably Ray and Sunil may have a better answer for
7 you. ATHEANA starts with a PRA and yes, identifies
8 context but identifies context but identifies context
9 with respect to specific scenario and the specific
10 human action that has to be performed for addressing
11 that specific scenario. Here this is a deterministic
12 evaluation and it's been structured so that all -- it
13 would have to address all human actions that may be
14 implemented. So it's not an NFPA 805 kind of analysis
15 where you go into the specific area, "This is my
16 scenario, this is my area and therefore, what is the
17 context under this scenario?" So that's going to be
18 done by this collaborative effort for 805.

19 However, and this is what I tried to say
20 before, all of the insights to the ATHEANA development
21 and the reviews of IEEEs and the expertise that has
22 helped us out and you're familiar with expertise,
23 Sandia, et cetera, we believe that we have brought in
24 those aspects when we built the availability concept
25 and the time margin and the feasibility and also in

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1 the criteria here about demonstrations and how
2 licensees can -- what are the criteria for
3 demonstrating the feasibility and availability of the
4 action. So it is a deterministic approach that has
5 been building tremendously on the risk-informed
6 approach but it's the deterministic approach.

7 DR. APOSTOLAKIS: I think what you're
8 saying is that that the application is different and
9 that's true. In the intended use of ATHEANA, you
10 would have a PRA, so you will have your sequences and
11 so on and you look at human actions. But the concept,
12 though, still applies, because you can say, "I have a
13 fire in this location". Essentially, you're asking is
14 what can happen next. What are the events that would
15 follow that fire and where so the operator manual
16 actions come into the picture to save the day? And it
17 seems to me that this kind of analysis would be helped
18 a lot by having those diagrams, you know, some sort of
19 event tree.

20 Another thing is that if we say that some
21 regulation is not risk-informed, that does not mean
22 that we are excluding automatically all the methods
23 that have been developed under the PRA factor. And
24 event tree is just a systematic way of structuring
25 sequences, scenarios. And it seems to me it can

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1 equally well be applied to a deterministic analysis ad
2 in a probabilistic analysis because now you are asking
3 both -- as I said earlier, both the analyst and the
4 reviewer to make a lot of judgments regarding -- and
5 these may be dependent, too, and I'm sure that it's
6 mentioned someplace that, you know, if you have this
7 communication, we can go this way and so on, but I
8 think it would have been helpful to borrow -- to have
9 borrowed from those things. Sunil, you have something
10 to say.

11 MR. WEERAKKODY: No, I agree with pretty
12 much everything you said, Dr. Apostolakis. What I
13 wanted to say was, you know, just the use of the word
14 ignition frequency got me into a lot of trouble right
15 there, okay?

16 DR. APOSTOLAKIS: If you think that's a
17 lot of trouble, Sunil --

18 DR. MAYNARD: You haven't seen anything.

19 MR. WEERAKKODY: And here's the vision the
20 Agency has in terms of curing fire protection. We
21 envision that there will be a set of 805 plants and
22 then there will be a set of plants who would maintain
23 their deterministic basis. And this document is for
24 those people who want to maintain deterministic. So
25 unless -- even though technically, I agree with

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1 everything you say, unless you have the capability to
2 basically say everybody should adopt 805, which Dr.
3 Gallucci likes to do but we can't do it, we have to
4 have that deterministic part available. And that's
5 why -- but I would say, Dr. Apostokalis, that one of
6 the key things you said in terms of modeling, I wasn't
7 closely molding the development of each guidance but
8 if you put the factors you consider in developing an
9 HRA, and you look at these factors, I think you're
10 going to find a lot of correlation and consistency.

11 One final thing, with respect to the
12 judgment, I remember after the last meeting that in
13 the trade press there was a lot of concern as to the
14 judgment, the need for judgment on clarity. I again,
15 agree there's going to be a lot of judgments. That's
16 what happens when you try to replace a passive feature
17 with the operator manual actions. So in my view,
18 there are going to be cases where it's all very clear
19 that an operator manual action is safe or safe enough.
20 That's fine. Then there are going to be a number of
21 cases where we could show that it's not acceptable and
22 then there's going to be some middle degree but I
23 can't see -- I mean, we have tried very hard to make
24 it as easy as possible but there's still going to be
25 some judgment. I agree, again, I have --

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1 DR. APOSTOLAKIS: Again, it seems to me
2 that implicit in your answer is that if we are in
3 Appendix R space or deterministic space, then we don't
4 even look at the methods PRA that's developed and I
5 think that's not the way to look at it. I mean,
6 you're not going to do a probabilistic analysis but to
7 structure the scenarios using some event trees is not
8 being risk-informed. It's just making your life
9 easier. So that is my main point.

10 DR. MAYNARD: I think that that's a tool
11 that should be available but not required for this
12 situation. I really would rather see simple as
13 opposed to more complex -- I believe that this NUREG
14 and the criteria set out, I think, overall was very
15 good. I think these are the things that need to be
16 considered. My concern is in the level of detail that
17 it's going to take to justify a lot of these things.
18 And I appreciate your comments about some are going to
19 be obvious and some are going not be obvious. And my
20 concern is that if, even for the obvious ones, if we
21 go to requiring far too much, we're going to get
22 bogged down not only with the licensee but also the
23 regulator on trying to process these things. And the
24 NUREG has a lot of detail on some things that I'm not
25 sure how they'd be addressed anyway.

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1 I mean, you talk about having to take team
2 dynamics into account and a number of things like that
3 that, you know, depending on who is reviewing it and
4 what guidance is out there, you know, I can see
5 getting bogged down in a lot of things, where I would
6 like to have some assurance that this is going to be
7 kept to a reasonable of effort for the given situation
8 that's having to be reviewed there.

9 DR. APOSTOLAKIS: But my point, Otto, is
10 that by using those diagrams, you do make it simple.

11 DR. MAYNARD: But I don't think you should
12 be required to do that for --

13 DR. APOSTOLAKIS: But it's not even
14 mentioned, they are not even mentioned that these may
15 be tools that will help you structure all these
16 judgments.

17 DR. MAYNARD: I wouldn't mind if there are
18 tools that are available. I just --

19 DR. APOSTOLAKIS: There should be.

20 DR. MAYNARD: -- not requiring them for
21 everything. It is a way to approach it and deal with
22 it because some of these things are going to be fairly
23 simple. Some of these things you should go through
24 the check list and say, yeah, yeah, yeah, yeah, and
25 "Yes, we can easily do it. We've got five hours to do

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1 it. We can do it in 30 seconds, no big deal". But
2 others are going to be far mor complicated and you may
3 need some of those tools to demonstrate it.

4 DR. APOSTOLAKIS: Yeah, but it's not that
5 you always have to do this. I mean, screening and
6 looking at the cases, it's obvious what you should do.
7 It's part of the game. I mean, there's no question
8 about it. Okay, you have one more slide?

9 MS. LOIS: Yes, in terms of comments, I
10 guess there were --

11 DR. APOSTOLAKIS: Is Ray going to cover
12 this?

13 MS. LOIS: Yes, Ray will cover that and
14 what I would like to note is that we haven't done
15 substantial changes in the NUREG. We've done some
16 clarification changes to clarify things and also with
17 regard to technical comments that came in, we've
18 change the content as well.

19 DR. APOSTOLAKIS: Well, I have a few
20 comments on the report itself, the NUREG itself and I
21 guess this is the time to ask them.

22 MS. LOIS: I probably --

23 DR. APOSTOLAKIS: Not on the comments, on
24 the report itself.

25 MS. LOIS: Sure.

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1 DR. APOSTOLAKIS: There's something I
2 don't understand on page 17. Well, you don't have to
3 go there. "Operator manual actions can be used to
4 satisfy paragraph III.G.1 requirements since these
5 areas do not contain redundant safety shutdown plans".
6 What do you mean by that?

7 MR. WEERAKKODY: There are -- let me take
8 an actual situation. Let's say you have a plant which
9 has a high pressure injection Train A and a high
10 pressure injection Train B. Okay, they're in two
11 separate crews. However, you postulate a fire where
12 you may have to take an action to trip one of the
13 pumps. Okay, so in other words, you have done your
14 separation. You meet the regulation but you still
15 need to do some operator action, maybe walk into some
16 cabinet and then take an action and in terms of making
17 sure that that action can be done, you could use this
18 as a guidance but the bigger question is operator
19 manual actions, they're not allowing II.G.2 but they
20 are allowing II.G.1 and III.G.3 like control room,
21 okay. So did I answer your question, kind of?

22 DR. APOSTOLAKIS: Kind of, yeah. But
23 that's not a very important question. I have a couple
24 of other questions that I think are a little more
25 substantive. So we talked about the scenario and all

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1 that. Now, when it comes to judgments, there is a
2 very detailed evaluation in the appendices especially
3 and basically the examples point to the factor of two
4 as an appropriate or sufficient margin. Although the
5 Commission don't specify and you don't. We just say
6 this is what came out of this.

7 What's troublesome about this is that we
8 all know that these judgments are biased, not because
9 people are bad people. Most likely it seems to me
10 when a licensee does this, they will rely a lot on
11 their operators. And by the very nature of the
12 operators, we tend to be optimistic, again, not
13 because they are bad people. That's how they think.
14 "Oh, sure, I can do that", which of course in a real
15 situation may not be so easy to do.

16 And there was a study sponsored by the NRC
17 a long time ago, at Oakridge National Laboratory, that
18 came up with a conclusion that -- I can in fact --
19 that study found that the median response time for
20 inadvertent safety injection and particular human
21 action, based on operating experience is about three
22 times larger than the value estimated by the
23 operators. So the operators under-estimated by three
24 times again because of this intrinsic bias that things
25 will be okay. Then we have the study that the staff

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1 did on estimating the frequency of pipe failures when
2 we were looking at the risk informing 5046. And they,
3 in fact, "corrected" in quotation marks, the expert
4 judgments and that was part of their final proposed
5 curves. They corrected them for biases. And yet,
6 here, we just go with those judgments and then we say,
7 you know, roughly a factor of two will be satisfactory
8 because in the exercises that the staff did which
9 involved PRA analysts, that's what they found. So
10 again, this is a problem with judgments and especially
11 in this case. I mean, the other case we're talking
12 about, there was specific actions in specific
13 scenarios, under specific conditions.

14 Now, we are talking about, you know,
15 having a whole list of bullets that they have to take
16 into account and pass judgment. And that worries me,
17 that, you know, they may think they are conservative,
18 when, in fact, they may not be. And I wonder how we
19 can handle that. I mean, and the other thing, of
20 course is, which is related also to my comment about
21 event trees, as an agency, it seems to me it would be
22 nice to have consistent approaches to various problems
23 when they involved the same underlying issues. So we
24 can't use event trees here and then not here because
25 this is deterministic. We cannot correct expert

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1 judgments here because it just so happened that a
2 statistician was part of the team and he was sensitive
3 to it and not do it here, when, in fact, what we're
4 talking about here is the real regulatory activity of
5 the agencies, not just a study. I mean, this is what
6 people will do.

7 So this inconsistency bothers me a little
8 bit. It bothers me a lot, not a little bit.

9 MR. WEERAKKODY: What I'm going to
10 address, Dr. Apostokalis, is your question about --
11 and you were mentioning this and in fact said, "Can
12 you give some assurance". If you look at your
13 comments in the following context, you would
14 understand where the staff is on this. We had
15 operator manual actions 20 years ago or 15 years ago,
16 you know, some plants in III.G.1, III.G.3.

17 We didn't have a NUREG. Inspectors used
18 their judgment to make sure that the licensees
19 complied with the rule. The rule simply said you
20 should be able to, I can't remember the exact words,
21 shut down the plant and reach your or stand by your
22 shutdown, whatever the tech spec said. That's what we
23 operated on. And there is always going to
24 inconsistency at the inspector level.

25 The next level comes in when we went to

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1 the proposed rule. Both the Agency and the
2 stakeholders got sensitive to this issue more and more
3 and then we created the list that in my view, this is
4 again a personal option. That should have been
5 sufficient for inspectors. Okay.

6 But then again, we get hit with more
7 guidance. So now we write a book and there are still
8 going to be judgments within the book and if I write
9 another book, there's going to be more guidance.

10 And here's how this would play out in the
11 regulatory exemption space. First off, if you have a
12 licensee who has a large number of factions because
13 you have compact spaces, lack of separation. What the
14 Agency and regions, they don't go the exemption rule.
15 They just fix the plant with the barriers where they
16 should be and forget it. Don't come to us for
17 exemptions because if they come for any exemptions for
18 that kind of scenarios, that judgment is going to play
19 a significant role and depending on the staff, I mean
20 we try very hard to be consistent, but let's say three
21 years down the line, okay, I can't give any assurance.
22 I don't know if I'll be in a different job. The staff
23 may be doing different jobs. This book would be
24 there. There will be judgment.

25 But if you look at whether it relates to

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1 the PRA experience or deterministic space, the
2 judgment is there. You cannot get away with it.
3 However, there are clear cases where a -- test III
4 manual actions, no combustibles, have plenty of time.
5 So you don't run into these margin issues and the
6 staff doesn't ask a lot of questions. The staff has
7 the latitude to use their brains and ask the questions
8 to get reasonable assurance. There will be judgment
9 there. There are no assurances. The staff experience
10 level will prompt them to ask the right question. If
11 the margin is too low, it is like containment
12 pressure. If you say you have to meet 48 and you come
13 in 47.9, there are going to be a lot of questions. If
14 you come in at 20, less questions. The same thing
15 applies here. I don't --

16 DR. APOSTOLAKIS: Sunil, you are making
17 the case that this necessarily will involve judgment.

18 MR. WEERAKKODY: Yes.

19 DR. APOSTOLAKIS: This is not contested.
20 It's true. What is contested is that precisely
21 because there are a lot of judgments, we have
22 developed tools to try to structure those judgments
23 and reduce the biases and these tools are not used to
24 the extent they should be used, in my view anyway, in
25 this report. That's really the issue.

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1 MR. WEERAKKODY: Okay. That's --

2 DR. APOSTOLAKIS: But maybe we can go on
3 with Ray's presentation.

4 MR. WEERAKKODY: No, I agree with that.

5 DR. APOSTOLAKIS: Because we have to
6 finish -- I understand NEI would like to address us.

7 CHAIRMAN SHACK: Just to be fair, George,
8 if you look at page B-8, they do in fact discuss your
9 factor of three in that Oak Ridge report and one of
10 their arguments here is that they are doing this
11 demonstration which gives them a little bit more and
12 they're still adding the factor of two on that because
13 they feel that there's an optimism there.

14 DR. APOSTOLAKIS: Where is that
15 discussion?

16 CHAIRMAN SHACK: At the bottom of page B-
17 8, section B.2.2.4.

18 MS. LOIS: So all of these actions have to
19 be demonstrated --

20 CHAIRMAN SHACK: Right.

21 MS. LOIS: -- for their reliability and
22 you add time to that.

23 CHAIRMAN SHACK: And we haven't gotten
24 away from the judgments, but at least these people
25 have considered this problem and that's their judgment

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1 that the two was still sort of right.

2 DR. APOSTOLAKIS: I just don't see that
3 factor of three anywhere.

4 CHAIRMAN SHACK: Go down to the last
5 paragraph on B-8.

6 DR. APOSTOLAKIS: On B-8.

7 CHAIRMAN SHACK: They said it took 30
8 minutes and it took almost 90. That's a factor of
9 three, although they don't say a factor of three.

10 DR. APOSTOLAKIS: The last paragraph says,
11 "For the same reasons as cited above..."

12 CHAIRMAN SHACK: No. "However, in extreme
13 cases as a high as a threefold increase has been
14 observed."

15 DR. APOSTOLAKIS: On B-8?

16 CHAIRMAN SHACK: Page B-8, bottom line at
17 least on mine.

18 DR. APOSTOLAKIS: Not on mine.

19 CHAIRMAN SHACK: Okay. Well --

20 DR. GALLUCCI: It's the third paragraph in
21 section B.2.2.4.

22 CHAIRMAN SHACK: Right. Whatever page
23 number that's on.

24 DR. GALLUCCI: In mine, it's the middle of
25 B-8.

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1 DR. APOSTOLAKIS: The second paragraph of
2 B-2.2.4.

3 DR. GALLUCCI: Third paragraph. "However,
4 in extreme cases..." B-2.2.4.

5 DR. APOSTOLAKIS: Yeah, okay. And that
6 doesn't surprise me because of the people who
7 participated.

8 CHAIRMAN SHACK: Right.

9 DR. APOSTOLAKIS: But just saying that,
10 yeah, it has been observed, what does that do? How
11 does that help me?

12 CHAIRMAN SHACK: Well, then they go onto
13 argue what's different about their case and again you
14 can accept or not accept that. But they present at
15 least a discussion of the issue is all I'm saying.

16 DR. APOSTOLAKIS: I think there is
17 overkill here, but I'm pretty sure as Erasmia
18 mentioned knew about it at least. The question is not
19 it's determined by and the fundamental problem that I
20 have is this utilization, this inconsistency between
21 this approach and what we're doing now. That's really
22 -- Ray, why don't you go ahead?

23 DR. GALLUCCI: Okay. My part -- Ray
24 Gallucci from Office of Nuclear Reactor Regulation.
25 I'm going to go over the highlights of the public

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1 comments and the responses to these public comments.
2 I'm not going to go into all of them obviously for
3 time purposes. Next slide please.

4 There were 110 total comments. The
5 breakdown is shown there. The one shown in red are
6 the ones that I'm going to discuss today as in our
7 opinion these were the key comments, but obviously we
8 received comments on all these different areas. Go
9 ahead to the next slide.

10 The first comment, "Area was operator
11 manual actions versus the passive features for fire
12 protection." The theme of the comments, "By allowing
13 industry a compliance strategy through submission of
14 a massive number of exemptions or a complicated array
15 of dubious operator manual actions in lieu of
16 qualified passive fire protection features as intended
17 by law, NUREG-1852 diminishes the defense-in-depth for
18 fire protection of safe shutdown systems and increases
19 the risk to the public's health, safety and security."

20 The NRC response, "NRC has granted plant-
21 specific operator manual action exemptions in the past
22 where criteria such as those in NUREG-1852 were met.
23 Plant-specific exemptions cannot be applied
24 universally. The appropriate regulatory vehicle
25 remains the issuance of an exemption under 10 CFR Part

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1 50.12." Next slide.

2 Comments related to regulatory footprint
3 and this again ties -- Some of these were already
4 covered by Sunil.

5 DR. BANERJEE: Excuse me. In the previous
6 slide.

7 DR. GALLUCCI: Go back one.

8 DR. BANERJEE: Do you actually
9 substantively address the issue there or are you just
10 skating around it? I mean, the issue is that there
11 are and many chemical plants and all one uses passive
12 fire protection systems.

13 DR. GALLUCCI: And it's the same type for
14 plants. The preference is to use passive protection
15 features. However, there are situations where you can
16 see where if you have a lot of time and a very simple
17 manual action where all would have to do is step
18 outside the control room, press a button and step back
19 in. The fire is far away, somewhere else in the
20 plant. It's conceivable that the manual action could
21 provide just as much safety as the passive feature.
22 There are situations -- And those are the ones for
23 which exemptions would be granted.

24 DR. BANERJEE: So is it not -- Maybe
25 that's what you responded, but the responses that you

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1 are having qualified passive fire protection features
2 required in plants where a fast response is required.

3 DR. GALLUCCI: That would be applied. A
4 manual action, if --

5 DR. BANERJEE: But isn't that something
6 that --

7 DR. GALLUCCI: If you have a limited time
8 frame to do this, these manual actions are unlikely to
9 be feasible, let alone reliable, and an exemption
10 would not be granted and our understanding is that
11 licensees are not even attempting to do operator
12 manual actions in those situations. If they are,
13 they're going to have to go back and replace them with
14 passive fire protection features if they aren't
15 already doing so.

16 DR. BANERJEE: Okay. So it's sort of
17 included in the statement that --

18 DR. GALLUCCI: This is a summary. The
19 statement is longer. This is a summary.

20 DR. BANERJEE: And you go through all this
21 stuff in some detail.

22 DR. GALLUCCI: Yeah. I mean if you --

23 DR. BANERJEE: Fine. I think that's fine.

24 DR. GALLUCCI: Okay.

25 DR. BANERJEE: Carry on.

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1 DR. GALLUCCI: Next one, regulatory
2 footprint and as I was saying, Sunil covered some of
3 this because a lot of these related more towards what
4 went on with the rulemaking and how the NUREG will be
5 used in regulatory space. But we address these
6 anyway. "Theme of comments. Will suppression and
7 detection be required when applying for an exemption?
8 Also the NUREG should reflect that NRC exemptions of
9 certain types of operator manual actions."

10 The NRC response. "RIS 2006-10 regulatory
11 expectations with Appendix R, III.G.2 operator manual
12 actions describes the corrective actions for failures
13 to have a required fire barrier and use of operator
14 manual actions as an interim compensatory measure."
15 That really is the regulatory footprint as coming from
16 the RIS and not from the NUREG. "RIS 2006-10 not
17 NUREG-1852 addresses regulatory requirements including
18 the need for fire detection and automatic
19 suppression." So we didn't really get into re-
20 explaining this issue in our comment response. We
21 refer to the RIS. Next slide please.

22 Demonstration and time margin. These are
23 the two key criteria for feasibility and reliability,
24 demonstration mainly for feasibility, time margin for
25 reliability and this had the majority of comments, a

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1 mixed bag between technical comments and regulatory
2 related comments and the theme, "The NRC has
3 previously accepted use of nominal values and best
4 estimate codes for plant response to fire events.
5 Sufficient margin exists in these analyses which
6 assume that all fire damage occurs and consequently
7 evaluate all manual actions in the timing."

8 Staff response. "The NUREG guidance is
9 flexible on treating uncertainties. However, remember
10 that a tradeoff exists between the realism of the
11 demonstration and the uncertainties to address in the
12 time margin and these two criteria are inherently
13 interrelated. Shown in red, red indicates that there
14 was a change to the NUREG as a result of the comment
15 and the NUREG has been enhanced to address
16 consideration of uncertainties in the demonstration to
17 justify adequate operator manual action time."

18 DR. BANERJEE: How many of these comments
19 came from the public at large and how much from
20 industry?

21 DR. GALLUCCI: Five came from the -- Five
22 came specifically from NIRS. No other came from the
23 public. The other 105 came from industry.

24 DR. APOSTOLAKIS: What did you say again?

25 DR. GALLUCCI: Five came NIRS, Nuclear

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1 Information and Resource Service, Paul Gunther's
2 organization.

3 DR. APOSTOLAKIS: They were supposed to be
4 --

5 DR. GALLUCCI: Yes and 105 came from
6 various industry sources.

7 DR. APOSTOLAKIS: But there were some
8 comments that what they're doing were use of safety.

9 DR. GALLUCCI: That was from the public.
10 That was from Paul Gunther and these are comments --
11 His comments, all except one of his comments, were
12 comments that had come in before with regard to the
13 rulemaking.

14 DR. BANERJEE: And were the industrial
15 comments mainly that you are putting too stringent
16 regulation or what was it?

17 DR. GALLUCCI: It was a mixed bag of some
18 things were too stringent. Others that this is not
19 appropriate for the regulatory process. So you're
20 probably not surprised. The public thinks operator
21 manual action shouldn't be allowed at all. Industry
22 thinks they should be allowed and we're right in the
23 middle of trying to strike a balance.

24 DR. BANERJEE: So those previous comments,
25 which were sort of saying that should have more

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1 automatic actions, detection, suppression, stuff like
2 that, that came from the public?

3 DR. GALLUCCI: Yes. Regarding your
4 comment on passive features came from the public.

5 DR. BANERJEE: Interesting.

6 DR. GALLUCCI: They would be prefer to see
7 passive features and no --

8 DR. BANERJEE: And industry wants us to
9 have more operator manual.

10 DR. GALLUCCI: Industry would like to be
11 able to use operator manual.

12 DR. BANERJEE: Thank you.

13 DR. MAYNARD: I'd like to address that
14 issue just a little bit. Well, if there was going to
15 be used by industry to go and rip out all their fire
16 protection and replace it with operator manual
17 actions, then I would be very concerned with that.
18 This is not going out and ripping out everything and
19 reducing the level of safety. It's dealing with the
20 constraints that people have to deal with right now
21 based on designs, old designs, and stuff and they've
22 been relying on operator actions and various aspects
23 for some time. This isn't going to reduce the level
24 of current safety that's out there right now. It's
25 not taking something that's in place and reducing it.

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1 It's taking a better approach at dealing with issues
2 to where the design can't support what the current
3 requirements and stuff are.

4 DR. BANERJEE: But about new designs then?
5 Is it going to -- Are you going to urge them to move
6 away from these OMAs?

7 DR. GALLUCCI: For new reactors, the
8 preference is for passive features and the new
9 reactors are being designed to be pretty much
10 redundant trains or three hour barriers completely
11 separated. This will have the advantage of designing
12 the new plant, not going back to plants that were
13 existed. Browns Ferry happened after most of the
14 plants had been built.

15 DR. MAYNARD: And recognize that the
16 regulator has control of this because this is an
17 exemption to the regulations. This isn't an automatic
18 right that the licensee has to take advantage of.

19 DR. BANERJEE: The only reason I bring
20 this up is we are going to face Browns Ferry, right,
21 and there are some issues as to the separation of
22 trains and things. Can you address that?

23 MR. WEERAKKODY: Yes, I can address that.
24 Browns Ferry is operating now. They had a number of
25 questions with respect to their fire protection

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1 program. What they did was we raised the issue to
2 them before the restart. They identified all their
3 critical operator manual actions. They put all them
4 in the corrective action program. I'm not saying they
5 have fixed them, but they have done and they are
6 working to fix them by March 2009. In the meantime,
7 they have -- measures.

8 DR. ARMIJO: Could you provide kind of a
9 number of how many operator manual actions are
10 included for, let's say, Browns Ferry. Because my
11 concern is if there were few difficult areas that you
12 couldn't have passive systems and you had a few
13 exemptions for manual actions in those cases, that
14 should be no problem. But if somebody has hundreds in
15 a plant, there is something wrong.

16 MR. WEERAKKODY: Yes, there is something
17 wrong.

18 DR. ARMIJO: And so the question is a real
19 case, Browns Ferry, where do they sit?

20 MR. WEERAKKODY: I don't know the number.
21 Phil, can you give some specifics on how many? Phil
22 Qualls reviewed the fire protection program at Browns
23 Ferry.

24 MR. QUALLS: Hi, this is Phil Qualls. I
25 can't give you the exact number. It's, let's say,

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1 numerous, probably on the order of 100 or more for
2 Browns Ferry Unit 1. However, because of the issue of
3 feasibility and reliability, these were closely
4 inspected, random sampling, I suspect, but closely
5 inspected by the region prior to start up of Unit 1.

6 MR. WEERAKKODY: Exactly. We put a lot of
7 effort on Browns Ferry before the restart, a number of
8 inspections.

9 DR. MAYNARD: Are these necessarily 100
10 different operator actions or -- My gut tells me that
11 there's probably fewer actual operator actions, but it
12 is dealing with maybe two or three. The same action
13 may take care of three or four different items in an
14 area.

15 MR. WEERAKKODY: Phil, can you give some
16 context based on the issue at Browns Ferry?

17 MR. QUALLS: Well, I hate to just address
18 Browns Ferry because in some cases it will be the
19 action will be very similar, rearranging power
20 supplies and such. But it's fire area dependent. In
21 many cases, there will be different areas, different
22 actions, depending on what may be affected in that
23 fire area.

24 And one of the reasons that we had some of
25 these issues is there were numerous manual actions

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1 coming up in the early 2000s that were just clearly
2 not possible and there was no guidance and no standard
3 for people to review with. You know, if I made the
4 judgment that someone could not do a local manual
5 start of a diesel generator with no control power,
6 something, they had no procedure and no -- that was an
7 actual finding. What's our basis for saying they
8 can't do it? They've never practiced it. What's our
9 real basis for saying that that's not feasible or
10 reliable?

11 DR. APOSTOLAKIS: You say they never
12 practiced it?

13 MR. QUALLS: No sir. On what basis?

14 DR. APOSTOLAKIS: So what is my basis for
15 saying that it's not feasible. I think you have your
16 basis.

17 MR. QUALLS: You have it. I'm an
18 inspector. What's the guidance? That's what they
19 need. We didn't have any written guidance.

20 DR. APOSTOLAKIS: So you're saying with
21 this NUREG now you will have the guidance.

22 MR. QUALLS: We would have some kind of
23 standard to evaluate things by. That's why -- I've
24 been in this since Day 1 on this issue and that's why
25 I've contributed a lot to developing it. We needed

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1 a standard.

2 DR. GALLUCCI: Next slide please.

3 DR. APOSTOLAKIS: Can you finish in eight
4 minutes?

5 DR. GALLUCCI: Yes. Continue with
6 demonstration and time margin. The theme of the
7 comments, "Due to a lack of clear quantitative
8 guidance, both utility analysts and regulators will
9 default to the factor of two inferred in Appendix B
10 which is the summary of the expert solicitation to
11 determine time margins that was conducted during the
12 rulemaking. The panel consisted entirely of NRC and
13 their contractor staff, mostly PRA practitioners,
14 thereby not providing the necessary diversity for
15 practical assessment and implementation of nuclear
16 plant operator manual actions."

17 The response. "NUREG Appendix B provides
18 an example of how (1) expert panel developed a time
19 margin. It's an example. A six person panel
20 consisted of a former senior reactor operator, two NRC
21 regional fire inspectors, one human factor specialist
22 and two PRA practitioners with sufficient expertise
23 considered to provide one reasonable method to address
24 time margin. Only two of the six were actually PRA
25 practitioners. NRC reviewers will not default to the

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1 factor of two time margin. The appendix is not
2 binding. Nonetheless, the licensee still needs to
3 consider time margin."

4 DR. APOSTOLAKIS: Why don't you give any
5 guidance to the licensee as to what kind of a panel
6 they should have to come up with these evaluations?

7 DR. GALLUCCI: We don't even know if a
8 licensee would want to use a panel to do this. We
9 happened to do this because we were trying to develop
10 a surrogate for the reliability in an HRA, so there's
11 nothing -- there's no specifics as to how the licensee
12 should develop a panel. It's their choice.

13 DR. APOSTOLAKIS: No, there isn't, but if
14 you tell them, there will be, that's what I was
15 saying.

16 DR. GALLUCCI: We could offer suggestions
17 but we leave it to them.

18 DR. APOSTOLAKIS: The reason why I'm
19 saying this is because it's most likely that they will
20 use their own engineers and their own operators. But
21 if you tell them to also use maybe a PRA or an HRA
22 expert, then maybe some of these biases will not be
23 there. We've done that. We've done that in the past
24 in other context. You know, they're telling us who
25 the panelists will be, which one was that --

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1 CHAIRMAN SHACK: 5069.

2 DR. APOSTOLAKIS: Yeah, 5069, so it's not
3 unheard of to say, you know, that --

4 DR. GALLUCCI: We could list the
5 functional backgrounds for the panelists. The key is
6 if they submit a time margin that they use, they will
7 have to tell us what their panelists were and what
8 their capabilities were, so if they do it strictly
9 with operators and not consider any human factors
10 people, we would be --

11 DR. BANERJEE: I guess you don't want to
12 be too inbred. Really, the concern here is that the
13 --

14 DR. APOSTOLAKIS: It will be the utility
15 personnel. I mean, they're not going to create a
16 panel from outside but at least within the
17 organization to make sure that there are people like
18 HRA to have some idea of what is going on.

19 MS. LOIS: Here I believe that we can use
20 the ATHEANA tools and we have developed an expert --
21 the code for conduct and an expert on it and some --

22 DR. APOSTOLAKIS: I understand.

23 MS. LOIS: -- a lot of that can be
24 borrowed and integrated here.

25 DR. APOSTOLAKIS: Some guidance here to

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1 alert people to the fact that there may be some biases
2 but if you do this, maybe, you know, it will not be
3 that bad.

4 MR. WEERAKKODY: I think, you said, if we
5 could do it without overstepping, obviously, our
6 boundary now, if I use the right words, but that's a
7 good idea, like you said earlier, we could incorporate
8 those as suggestions.

9 DR. APOSTOLAKIS: What does "could" mean,
10 Sunil?

11 MR. WEERAKKODY: The reason I didn't want
12 to say we will do it is --

13 DR. APOSTOLAKIS: I know that I have never
14 heard anybody here say, "We will do something". We
15 always think about it. But my question is, my
16 question is, what does it mean? I mean, you're asking
17 us to write a letter blessing this.

18 MR. WEERAKKODY: Oh, I see.

19 DR. APOSTOLAKIS: If we gave you some time
20 to do it, would you be too unhappy?

21 MR. WEERAKKODY: No.

22 DR. APOSTOLAKIS: No, okay.

23 MR. WEERAKKODY: And we will -- what we
24 will be looking for is, you know, quickly, do this
25 quickly so we could get you something. We will do it.

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1 DR. APOSTOLAKIS: I understand what you
2 are looking for.

3 MR. WEERAKKODY: We will do it, how is
4 that?

5 DR. APOSTOLAKIS: Great, great.

6 DR. GALLUCCI: Okay, next slide? Okay,
7 this is a public comment. "Operator manual actions in
8 terrorism", this comment was raised several times
9 during the rulemaking itself. The theme, "The NUREG
10 fails to account adequately for mitigating responses
11 to aircraft impacts and other forms of terrorism.
12 Broad industry non-compliance with physical fire
13 protection does not lend public confidence to the
14 Commission's assertions that plant operators can and
15 will control and contain the consequences of terrorism
16 causing significant fires.

17 In NUREG CR-2859, Argon experts state that
18 the claim that these fire explosion effects do not
19 represent a threat to nuclear power plant facilities
20 has not been clearly demonstrated." And the response
21 on the next slide, "A February 2002 NRC order required
22 licensees to examine the effects from extensive losses
23 due to fires, explosions and identify mitigated
24 strategies using resources already existing or
25 reliably available. NRC inspections conducted" --

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1 DR. APOSTOLAKIS: Don't read it.

2 DR. GALLUCCI: Don't read it.

3 DR. APOSTOLAKIS: Read in the results. I
4 mean, summarize what it says, otherwise we'll never
5 finish it. We can read it as well as you can. Can
6 you just tell us the essence of it? I mean, what is
7 the essence of the --

8 DR. GALLUCCI: Terrorism has been
9 considered and the probability of a fire coincident
10 with that is considered low based on studies and the
11 NRC continues to monitor plants for the effects of
12 security concerns.

13 DR. APOSTOLAKIS: And I don't think
14 Appendix R -- this really refers to Appendix R,
15 doesn't it? And that was developed apparently --

16 MR. WEERAKKODY: This is beyond Appendix
17 R but it was a public comment so we thought we ought
18 to scope --

19 DR. APOSTOLAKIS: No, you should respond
20 but all I'm saying you can summarize it. Okay, shall
21 we move on?

22 DR. GALLUCCI: Continue. Okay, NUREG 1852
23 versus fire safe shutdown. Comments, "Feasibility
24 criteria requires safe shutdown analysis when they
25 should only support such analysis. Verifying that

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1 equipment be available requires safe shutdown analysis
2 specifically for operator manual actions." The
3 response, "To the extent that the safe shutdown
4 analysis already addresses equipment needed to conduct
5 the operator manual actions that analysis suffices,
6 and a change to the NUREG, the NUREG now emphasizes
7 the functionality of equipment and cables needed to
8 implement operator manual actions".

9 Next slide. Comments on fire design
10 basis, the theme. NUREG 1853 reclassifies post-fire
11 safe shutdown as an abnormal operating occurrence,
12 thereby imposing the radiation dose requirements from
13 10 CFR Part 20, Section 1201. Fire with post safe
14 shutdown and manual operation occurs at a frequency
15 much less than one per year. Two ANSI standards
16 classify post-fire safe shutdown as a quote `special
17 event'." The NRC response, "ANSI 51.1, 52.1
18 classifies fire as an abnormal operating occurrence
19 within normal radiation exposure limits. And
20 initiating event is just the single abnormal
21 occurrence or condition that can trigger an accident
22 scenario and exclude subsequent failures that comprise
23 the scenario frequency".

24 So the claim that the initiating event is
25 much less than one is incorrect. The scenario may be

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1 for much less than one but the initiating event is
2 typically on the order of .1 to .21 per year per a
3 plant. So we consider the classification correct.

4 Next slide. Continuing with fire design
5 basis, "NUREG requirements exceed those for other
6 design basis events and EOPs, Emergency Operating
7 Procedures." The response, "Unlike the EOPs which;
8 one, generally assume no plant damage; two, involve
9 mostly control room actions and; three, are integral
10 aspects of regulations and design basis analysis.
11 Operator manual actions in III.G.2 areas constitute a
12 deviation from regulatory requirements.

13 They are postulated in lieu of redundant
14 train separation or alternative safe shutdown.
15 Nonetheless, NUREG has been revised to recognize that
16 specific operator manual actions may need to meet the
17 guidance to varying degrees. That is some of the
18 factors within the criteria may not always be
19 relevant", and that would be based on looking at the
20 specific manual action and its circumstances.

21 Next slide, please.

22 DR. APOSTOLAKIS: Ray, do you -- would you
23 mind moving down to defense in depth?

24 DR. GALLUCCI: Skip, keep going? Okay,
25 defense in depth. The theme of the comments, "Defense

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1 in depth considerations exceed the minimum
2 requirements from the boundary conditions in a post-
3 fire safe shutdown analysis. Many are theoretical in
4 nature and very difficult to apply." The response;
5 "RIS 2006-10 not this NUREG addresses defense in depth
6 for post-fire response including passive fire
7 protection through highly reliable operable fire
8 barriers. Reliance on typically less reliable
9 operator manual actions still requires that adequate
10 fire safety be maintained." So defense in depth is
11 really the subject of RIS 2006-10 and that's your fire
12 detection, automatic suppression considerations, not
13 the feasibility and reliability criteria.

14 DR. APOSTOLAKIS: What did the comment
15 mean by "many are theoretical in nature"?

16 DR. GALLUCCI: I assume they were talking
17 about the -- what -- the variability in fire, just
18 what will be your boundary conditions during a fire,
19 how bad will it be, where might the smoke go, et
20 cetera. That would be what I would think.

21 Next slide. Continuing with defense in
22 depth, this is the last slide, "Reference to reg guide
23 133, Appendix A requiring post-fire safe shutdown
24 procedures is a new Staff Position, inconsistent with
25 generic letter 8610, Staff Position 532. The NUREG

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1 reinterprets the administrative and detection
2 suppression echelons of defense in depth." Our
3 response, "The generic letter position addresses the
4 use of procedures for areas requiring alternate
5 shutdown capability, that's III.G.3, does not address
6 fire brigade activities. NRC expected licensees to
7 comply with III.G.2. The NUREG criteria are
8 consistent with NRC guidance and requirements.

9 NRC still requires post-fire safe shutdown
10 procedures. The QA program requirements of the
11 referenced reg guide and an ANSI Standard 3.2, 1982's
12 reiteration of the need for safe shutdown procedures
13 gives guidance on operator manual action feasibility
14 and reliability and supportive of the statements in
15 the NUREG." That's the highlights of the comments.

16 DR. APOSTOLAKIS: Thank you. Any comments
17 or questions to the staff? Thank you very much, and
18 now we have Mr. Marion.

19 MR. MARION: Good morning. My name is
20 Alex Marion. I'm the Executive Director of Midland
21 Engineering (phonetic) and I thank you for the
22 opportunity to offer two comments on this issue. We
23 have been actively engaged with the NRC staff in
24 trying to establish a coherent consistent approach to
25 evaluating the feasibility of operator manual action

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1 since June 2002. We originally agreed upon
2 straightforward acceptance criteria and also agreed on
3 the appropriate regulatory vehicle to capture or
4 document the acceptance criteria so that going
5 forward, the NRC and the utilities had a clear
6 understanding of what criteria had to be satisfied to
7 demonstrate feasibility of operator manual actions.

8 And the regulatory vehicle was rulemaking
9 with the draft regulatory guide. And there were some
10 discussions this morning about what happened with that
11 rulemaking and now from our perspective, we see that
12 draft regulatory guide which was the subject of
13 significant critical comments from all stakeholders,
14 has taken the form of a NUREG document and the concept
15 of reasonable, coherent, practical acceptance criteria
16 has evolved into an exercise that regrettably has gone
17 beyond the original concept. It's become an academic
18 exercise.

19 I always worry when I have this vision of
20 an expert panel thinking about what a fire brigade has
21 to do at a nuclear power plant to execute their
22 responsibility of putting out a fire. Moreover a key
23 aspect of this involves the regulatory process and
24 quite frankly, it's confusing. The NRC indicates in
25 their presentation this morning that the NUREG is an

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1 extension of the standard review plan.

2 And that says to me that that's guidance
3 for NRC staff reviewers. But unfortunately, as we all
4 know, that guidance also becomes a reference document
5 for NRC inspectors and we talked this morning about
6 the judgment factors that come into play on a lot of
7 these acceptance criteria that we have before us. So
8 I don't believe that this document will address the
9 issue or the concern that the NRC has relative to the
10 extent to which utilities are crediting operator
11 manual actions in their fire protection programs.

12 One of the things I would like to do is
13 we've developed a document at NEI on the regulatory
14 process and what I would like to do if it's acceptable
15 to the chairman, make copies of that available to you
16 folks and I'll send it up this afternoon when I get
17 back to the office.

18 DR. APOSTOLAKIS: Is this an alternative
19 to the NUREG?

20 MR. MARION: No, this is a document that
21 captures the regulatory -- that discusses the
22 regulatory process from the legislation that
23 established the NRC to all of the NRC guidance
24 documents and regulations, et cetera, and it's a good
25 tutorial on the regulatory process, at least we think

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1 it is.

2 We're also disappointed that some of the
3 significant comments that had been submitted by NEI on
4 behalf of the industry as well as other industry
5 representatives, have not been adequately
6 dispositioned and I understand the staff is trying to
7 differentiate between technical comments and process
8 comments. But unfortunately, there isn't an activity
9 that the NRC is involved in which does not have
10 technical aspects as well as process aspects.

11 So I encourage this committee to consider
12 both elements, if you will. The issue that Sunil
13 Weerakkody expressed about the staff concern relative
14 to the licensee's reliance on operator manual actions
15 as an alternative to the specific requirements in the
16 regulations the passive fire protection features, is
17 not going to be addressed by this particular NUREG
18 document. The concern in our mind is a separate issue
19 that needs to be addressed by NRC assuring compliance
20 by individual plants to NRC regulations.

21 And we recognize that the fire science and
22 technology and understanding has evolved over the
23 years, so what may have been acceptable 15, 20 years
24 ago, may not be acceptable today. That has to be
25 dealt with in some mechanism other than a NUREG

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1 document.

2 There is a current inspection procedure
3 that's been on the books for a couple of years that
4 contains a practical set of acceptance criteria for
5 demonstrating the feasibility of operator manual
6 actions. And we have always felt that the inspection
7 procedure is where you document the acceptance
8 criteria. Now you have this book. And I can tell you
9 from a utility perspective if you look at the
10 inspection guidance to evaluate what the NRC is going
11 to look for. Now you've got to look at this book that
12 has additional judgment in play and it's not going to
13 address any issues. It's not going to address this
14 issue.

15 There's going to be as much confusion, I
16 speculate and this is a personal thing, probably more
17 confusion going forward if this NUREG document is
18 published in its current form with its intended use.
19 Operator manual actions are credited in a number of
20 programs as you're all familiar with operating
21 procedures in a nuclear power plant. Normal operating
22 procedures, abnormal operating procedures and
23 emergency operating procedures credit operator manual
24 actions when the situation in the plant calls for it.

25 Why we're treating fire protection so

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1 special has never been clear to the industry and I
2 think we need to be very careful because you're
3 setting situations where you have double standards and
4 double expectations that may result in a condition
5 where there may be some confusion in responding to a
6 fire or a projected fire or a planned fire as opposed
7 to responding to a plant condition that's happening
8 right now. So we need to keep that in mind as we go
9 forward.

10 There is a theme here that comes across
11 that suggests that for plants that have not
12 transitioned to 805, are going to have a different
13 threshold of acceptability to overcome in terms of NRC
14 acceptance going forward. But the intent appears to
15 be driving utilities into 805. And I would like to
16 make this very, very clear.

17 805 in itself is not a solution. It is
18 not a solution to fire protection issues. All 805
19 does is provide a framework for licensees to apply
20 risk-informed and performance-based approaches to deal
21 with these issues. Dealing with the issues and
22 finding the resolution has not been established yet in
23 lot of cases. So let me make it clear, I'll say it
24 once again; 805 is not the solution.

25 At this point, I -- what we proposed to do

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1 is once we see this next version of the NUREG
2 document, we'll take a review of it and send a letter
3 to the NRC on areas that we had commented on that were
4 not specifically addressed to our satisfaction, and I
5 don't have any specifics. I can't develop any
6 specifics at this point because we haven't seen the
7 next version of the document.

8 But fundamentally, I would like to make a
9 request that this committee consider our comments and
10 not endorse the publication of this NUREG at this
11 particular time for the reasons and the points that I
12 made in my brief comments and at this point, this
13 completes what I have to say. I'd be more than happy
14 to take any questions.

15 DR. APOSTOLAKIS: Well, I'm a little
16 curious why you think this is, I don't know, too
17 theoretical and so on. I mean, aren't the elements
18 that -- at least that are in the report important to
19 operator actions? I mean, shouldn't they consider
20 environmental effects, all sorts of --

21 MR. MARION: As I recall from that one
22 slide and I didn't bring the slide with me, that had
23 the elements of the acceptance criteria, the only one
24 that we were really concerned about was the time
25 margin factor which in the draft was treated as a

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1 penalty. I don't know how it's being treated in the
2 final document, but we agree in concept with the
3 others because they're consistent with what is already
4 delineated in the inspection procedure.

5 DR. APOSTOLAKIS: Basically, what they are
6 saying is that the time available should be
7 significantly greater than the time required to
8 diagnose and perform the action. And in their example
9 it's a factor of two but they say that --

10 MR. MARION: They say that's not going to
11 change. Well --

12 DR. APOSTOLAKIS: So that's where the main
13 disagreement is?

14 MR. MARION: One of the areas. The other
15 area was the -- significant disagreement was the
16 expectation that you would have detection suppression
17 in the areas where you --

18 DR. APOSTOLAKIS: Yeah, I remember that.

19 MR. MARION: I don't know if that's in
20 here or not.

21 CHAIRMAN SHACK: That's a different issue.

22 DR. APOSTOLAKIS: Yeah, that's a different
23 issue whether they should be but you do agree -- you
24 do agree that there should be some margin. I mean, if
25 I do a calculation and I find exactly 10 minutes, I

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1 mean, that would be a source of --

2 MR. MARION: Absolutely, but establishing
3 a factor of two margin is just ludicrous. Okay,
4 because here's the scenario; the utilities will
5 determine the extent to which the amount of time they
6 need to execute an operator manual action and
7 personnel will be trained on executing that action.
8 And whatever that time is, is the time that they can
9 demonstrate as adequate. Now for someone to come in
10 now and say, "Well, it says 20 minutes, so we'll throw
11 in an additional 50 percent and have to consider 30
12 minutes", I mean, what's the basis. We've already
13 demonstrated that you can execute the action in 20
14 minutes and I agree that if the NRC does a review of
15 the utilities program, the operator manual actions,
16 and they don't have a clear demonstration of the time
17 to execute the action, then that needs to be
18 addressed, but it is being addressed. Now, you can
19 identify antidotal cases that have been found over the
20 years and we can always argue about those.

21 DR. APOSTOLAKIS: But at the same time,
22 though, surely you agree that there are uncertainties
23 in these things, so by putting this margin there, the
24 staff is trying to account for these uncertainties.

25 MR. MARION: Theoretically, I agree with

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1 uncertainty as a concept but where I'm coming from is
2 you've got personnel assigned at a nuclear power
3 plant. An individual walks into an area and discovers
4 a fire. The first action is call the control room.
5 The fire brigade is dispatched and people are going to
6 put the fire out. Theoretical situations and
7 uncertainty don't come into play because the personnel
8 involved in that decision from the time it's
9 identified, until it's mitigated and the plant is
10 recovered, are fully trained on taking those actions
11 to deal with that fire.

12 So academically, you come in here and you
13 say, "Okay, you've got people, you've got humans
14 involved, so the individual may not be feeling well,
15 he might -- he or she might have had an argument with
16 their spouse, and you know, where do you stop? And
17 where do you capture all that in a practical effective
18 manner to give you confidence that people can execute
19 these actions? And that's my point.

20 I think we've gone beyond, well, beyond
21 what was originally intended.

22 DR. APOSTOLAKIS: Well, at the same time,
23 I mean, one can say that when you say they call the
24 control room, the fire brigade comes, puts out the
25 fire, that's as theoretically as anything I've heard

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1 of.

2 MR. MARION: I would --

3 DR. APOSTOLAKIS: That's academic as
4 anybody's. They come in and put out the fire and we
5 all go home and be happy. Thank you.

6 MR. MARION: I would fall back -- I would
7 fall back on the operating experience. The NRC has
8 collected a database of fire events at nuclear power
9 plants and I'm not familiar with the current
10 statistics but a few years ago all the fires were
11 extinguished within 20 minutes or so.

12 DR. APOSTOLAKIS: That should be a factor.

13 MR. MARION: Yeah, and there wasn't an
14 issue of people not being able to get there and do
15 what has to be done and execute the mission, that's my
16 whole point. Okay, so we need to maintain a balance
17 of some sort but this --

18 DR. APOSTOLAKIS: No, I agree. If you
19 have evidence of this type, certainly then it should
20 be part of the evaluation, but to say they would come
21 and put it out and everything will be cozy, I mean,
22 come on, we don't know that. Anyway -- okay, thank
23 you very much. Any other comments?

24 DR. MAYNARD: So how do you see this
25 playing out? If we were to say don't issue it and it

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1 wasn't issued or whatever, what -- time line-wise,
2 what do you think would --

3 MR. MARION: I would like to have -- to go
4 back to where we were five years ago. Happy
5 anniversary, incidentally, it has been five years
6 June, I forget the specific date. But five years ago,
7 we met with the staff and we said, "These are the
8 criteria". We all generally agree the adequate and
9 sufficient, currently captured in an inspection
10 procedure, okay. I forget, Chris, do you remember the
11 number seven?

12 MR. PRAGMAN: 71111.05 Tango.

13 MR. MARION: 71111.05 Tango.

14 DR. APOSTOLAKIS: Mike, can we get that
15 procedure today?

16 MR. MARION: And that is in place.
17 Operator manual actions have been reviewed and
18 accepted by the NRC over the years. That inspection
19 procedure is being used by inspectors to evaluate the
20 feasibility of operator manual actions that are being
21 credited by plants today. Going forward is the
22 question. If a utility decides to develop a new
23 manual action to respond to some situation at the
24 plant, then clearly if it's a pre-1979 licensed plant,
25 it has to submit an exemption. If it's a post-1979,

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1 they can do an evaluation to determine the adequacy of
2 that. And the evaluation that they will use and the
3 criteria they will use will be in that inspection
4 procedure.

5 That process is in place. I look at this
6 NUREG and I don't see it adding a whole lot to that.
7 That's the whole point. It just makes it a little
8 more complicated.

9 DR. APOSTOLAKIS: That's interesting. I
10 would like to see that procedure today. Any other
11 comments or questions for Mr. Marion?

12 MR. IBERRA: Mr. Chairman, do you want any
13 more question of the staff?

14 CHAIRMAN SHACK: No, I do think we need to
15 see the inspection procedure.

16 MR. WEERAKKODY: We will send it to you.

17 CHAIRMAN SHACK: Do you have any comments
18 on the adequacy of that inspection procedure compared
19 to the --

20 MR. WEERAKKODY: Are you asking the staff?

21 CHAIRMAN SHACK: Yes.

22 MR. WEERAKKODY: Yes, sir. The inspection
23 procedures for the inspectors to rely on to make sure
24 what we call the feasibility, it's a feasibility of in
25 our view a temporary measure that's not complying to

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1 regulation. In our view, if you are relying on an
2 operator manual action in a fire area where a fire, if
3 propagates, can take out both your plants, if you look
4 at the operator manual action as the permanent
5 solution, we hold the licensee to a high standard and
6 the word "reliability" comes in. So the big
7 distinction you would find between what's in the
8 inspection guidance and what's in this NUREG is we are
9 looking for higher level of assurance so that this
10 plant, when this becomes a permanent fix, you know,
11 this action is good for the next 60 years, okay, or 70
12 years or 40 years or 50 years daily operation. So in
13 our view, if the guidance is adequate as a temporary
14 measure, so then we tell inspectors, we tell them,
15 "Use the inspection guidance to make sure that the
16 operator manual action is good enough as a temporary
17 measure". If the licensee wants to rely on it
18 forever, then they need to come in for an exemption.

19 CHAIRMAN SHACK: Any other questions?

20 DR. MAYNARD: I have one other quick
21 question for -- I understand -- how does it, or does
22 it apply at all to where a plant finds they're non-
23 compliant. Let's say we find a fire barrier that
24 doesn't -- for some reason, doesn't meet the
25 requirements on it, put compensatory measures in. I

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1 take it the compensatory measures for that time period
2 would not have to fall under this NUREG. I mean, if
3 you wanted an exemption to handle that later, you
4 might, but there's no way you're going to be able to
5 do that type of analysis and demonstration and
6 everything to put the compensatory measures for a
7 deficiency.

8 MR. WEERAKKODY: I agree, yes.

9 CHAIRMAN SHACK: If there are no other
10 questions, we're almost on schedule. It's time for a
11 break until 10:15.

12 (Whereupon, a short recess was taken.)

13 CHAIRMAN SHACK: We are now back into
14 session. Our next topic will be the maximum extended
15 load and line limit analysis plus (MELLLA+) and the
16 supporting topical reports and Professor Banerjee will
17 take us through this.

18 DR. BANERJEE: Okay. Can you hear me
19 through the mike there? All right. So let me
20 introduce this by saying that the Thermal Hydraulics
21 Phenomena Subcommittee met on May 24th and 25th and
22 there were several presentations made and you see this
23 pile here. This is only the tip of the iceberg. It
24 doesn't contain the GE things.

25 In any case, we had to consider a number

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1 of GE topical reports, staff SERs, all this related to
2 the MELLLA+ and the methods proposed for the analyses.
3 This is a pretty complex subject and we could have
4 taken at least two or three more days on this. So we
5 are going to capsule all this in one or two hours
6 now. In any case, what -- I'm sure that you all know
7 about, but what you will see is that it's being
8 proposed that operating region be enlarged so that a
9 reactor can be operated at about, for a BWR, 120
10 percent of the originally licensed power down to about
11 80 percent of the flow.

12 There are, I think, several advantages to
13 this which should be made clear right at the beginning
14 because it gives the operator a lot of flexibility and
15 actually in that sense, I think, enhances safety quite
16 a bit. Now there are also, of course, down-sides
17 associated with it and we need to consider these and
18 the staff have really done a pretty good job at
19 reviewing these topicals and coming up with the safety
20 evaluation report.

21 At the subcommittee meeting, and I'm going
22 to just briefly talk about this so the main committee
23 with so little time has some understanding of what
24 concerned us, early on in the presentations the
25 subcommittee was concerned about the enlarged

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1 operating domain coming closer to various limits and
2 they asked the staff and General Electric to take,
3 say, one specific plant and show us where the
4 different limits were and how much margin we were
5 cutting into.

6 So I hope that the staff and General
7 Electric will show us this because it's a complex
8 issue. At some points, it's the critical power issue.
9 Some points, it's instability. Some points in this
10 operating domain, it is maybe LOCA due to lower more
11 sump cooling. So to get a pretty idea of what these
12 margins are, that was the first issue and how much we
13 are cutting into them.

14 The second issue that the subcommittee
15 dealt with was that this enlarged region led to higher
16 void fractions beyond the normal operating range and
17 several associated issues arose. One was how good is
18 the reactor physics associated with it, how good are
19 the correlations for void fraction, how good are the
20 critical power ratio correlations being used. In
21 particular, the path shapes are very different and we
22 were interested to know whether there was testing with
23 these different path shapes and all these sorts of
24 things and this is for the committee to discuss. The
25 staff dealt with this by asking for some additional

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1 margins. What we would like to know is whether these
2 margins were sufficient really. If they were more
3 than sufficient, that's also important. So this is
4 for the committee to discuss.

5 The third major issue which I don't think
6 is a real issue anymore was because of the operation
7 at this, let's say, the rod line which comes from 80
8 percent to about 55 percent brings you closer to the
9 region of instability and whether the measures taken
10 to deal with this instability are sufficient or not.
11 The proposal is to add to what is called Solution 3 a
12 certain additional measure which is called a
13 confirmation density which they will talk about. This
14 committee has never reviewed any of this and I don't
15 know why, either the TRACG calculations or this
16 confirmation density methodology. We should have. We
17 have not and I'd like to go on the record as saying
18 this is very surprising to me.

19 Anyway to deal with this, the staff also
20 required and I think with reason an automatic backup
21 system which then makes assurance doubly sure. So I
22 don't know if there is an issue here, but it was
23 certainly something we discussed.

24 The fourth major issue I would say is that
25 the enlarged region leads to more severe conditions

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1 during ATWS and instability is related to ATWS. It
2 brings you closer to the regions where you can get
3 instabilities and brings you into a power flow region,
4 let's say, if you had an ATWS with certain things
5 which could lead to an instability, power flow region
6 where potentially your oscillations could grow more
7 rapidly so, let's say, that root mean square of these
8 oscillations if we looked at them and to a large
9 amplitude.

10 There were some calculations done with
11 TRACG which showed that actions such as reducing water
12 level and therefore, increasing the inlet temperature
13 due to the condensation of steam into the feedwater
14 would mitigate this. But the timing in some cases was
15 pretty short. It was about two minutes. There is an
16 issue here as to whether these calculations are right
17 or wrong. There is no validation of this because
18 there are no experiments in this region. There's been
19 no confirmatory analysis of any significance done.
20 The reasons for this, the staff will say due to not
21 having a code which would do it which is a really big
22 hole right now, the staff not having a code to be able
23 to use this which is why we've been pushing TRACE.

24 And finally, even with ATWS itself, there
25 are some issues as you'll see with higher containment,

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1 over-pressures and all sorts of other things, possible
2 re-criticality which the staff had dealt with. In all
3 these, there are measures being taken to deal with.
4 So if all these measures are okay, then at least on a
5 plant-specific basis, I think we can have some
6 assurance of safety.

7 The one point which I have and I think the
8 subcommittee had some concern about was that GE and
9 the staff were thinking of dealing with ATWS
10 instability on a generic basis. Whether this is
11 justified or not, you have to decide and see what you
12 feel. This was on the basis I thought of very scanty
13 evidence, but that was my personal opinion. But
14 you'll see the data and see what you think about it.

15 So I think without further ado, I'm going
16 to turn this over to NRR to introduce it and then GE
17 to take over at that point.

18 MR. CRANSTON: Good morning. I'm Greg
19 Cranston, the Branch Chief for the Reactor Systems
20 Branch. This morning we're going to start the
21 presentation on MELLLA+ and supporting topical reports
22 with GE. So I'll turn the meeting over to GE.

23 MR. KINGSTON: Thank you, Greg. My name
24 is Rick Kingston. I'm the GE Project Manager for the
25 Licensing in the Regulatory Affairs group and we have

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1 a support team here. They have all been involved in
2 this. I would like to introduce them now. Patricia
3 Campbell is our Director of Washington Regulatory
4 Affairs. P.T. Tran is the Project Manager for New
5 Project Introductions and MELLLA+. Scott Bowman is
6 the Manager for Methods and Software Development.
7 Jose Casillas is a Consulting Engineer for BWR Plant
8 Performance. Randy Jacobs is the Manager of Transient
9 Analysis. Brian Moore is the Manager of Methods and
10 Software. And Jens Andersen is a Consulting Engineer
11 for Thermal Hydraulic Methods.

12 As Dr. Banerjee mentioned, two weeks ago
13 we were here with the staff presenting a two-day
14 review of MELLLA+ and the associated topical reports.
15 Let me start this for you. What we are doing today is
16 seeking the ACRS acceptance for use of the methodology
17 in the MELLLA+ report and the supporting topical
18 reports in conjunction with plant-specific
19 applications for EPU and MELLLA+.

20 Just a brief review of where we are and
21 how MELLLA+ came about. This was the original reactor
22 operating domain and we recognized for that domain we
23 needed an additional flow window to help the operators
24 maneuver in that range.

25 (Off the record comments.)

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1 MR. KINGSTON: If you're at 100 percent
2 power or 100 percent flow it's very difficult to
3 maneuver other than with pulling control rods. Thank
4 you. And moving rods at high power release is a
5 discrete very rapid change in power that's not good
6 for the fuel. Moving control rods is also not a
7 simple maneuver. It requires a lot of people in the
8 control room. So it's much better to have a flow
9 window where you are able to adjust the reactivity
10 changes by adjusting flow. And we'll see that a
11 little bit more in a later slide.

12 We then added the increased core flow
13 window. Increased flow again, improves your ability
14 to maneuver the plant. The added MELLLA, which MELLLA
15 is the Maximum Extended Load Line Limit Analysis, that
16 provided an additional flow window for maneuvering
17 which is a big help to the utilities and let them run
18 the plant much more efficiently.

19 DR. CORRADINI: If I may just interject
20 for just background, the light green, the yellow and
21 the blue have all been accepted and procedures
22 accepted and current plants using.

23 MR. KINGSTON: That's correct. I believe
24 almost all of our plants today use MELLLA+ at the
25 MELLLA state. When we went to the -- We started on

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1 the power uprates. What we did is to we went ahead
2 and just extended this MELLLA line five percent more
3 power, 105 percent power, which was the stretch power
4 uprate.

5 Then EPU is what we're looking at today,
6 extended power uprate, to 120 percent. The increased
7 core flow just goes along that way. This is actually
8 achievable flow that you're able to get at that high
9 power. It's a larger pressure drop into bundles and
10 the recirculation pumps couldn't keep it at the
11 increased core flow power.

12 So where we are again is at this 120
13 percent original license power and 100 percent flow.
14 We're back at the situation we were initially in terms
15 of there's no maneuvering room in that window and so
16 we're -- the topical reports should implement MELLLA+
17 to give us that maneuvering room. As Dr. Banerjee
18 said, the MELLLA+ window extends from about 80 percent
19 core flow down to 55 percent core flow and then flat
20 along to the 100 percent flow.

21 DR. BANERJEE: I think you should point
22 out that the reasons for that precipitated drop
23 thereof and going to the natural circulation line.

24 MR. KINGSTON: Yes. We have that on the
25 next slide.

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1 DR. MAYNARD: So far, this is all being
2 done through this analysis to gain these margins or
3 are we also changing any type of set guides? I'm
4 trying to get an understanding. Basically, it seems
5 to me like we're reducing margin. We're doing better
6 analysis, fine-tuning the analysis, but we're really
7 not doing anything physically in the plant to maintain
8 margin.

9 MR. KINGSTON: Well, the margins, the
10 SAFDLs on the fuel are really not changing. We're
11 keeping essentially the same margin that we had
12 originally.

13 DR. GALLUCCI: I think we'll come directly
14 to your question in a couple of slides and the short
15 answer is that fuel performance has improved and
16 that's an enabler for this as well.

17 DR. BANERJEE: More subdivision of the
18 fuel.

19 DR. MAYNARD: Okay.

20 DR. CORRADINI: So, before we leave this
21 slide since this is a nice graphic to talk from, so
22 let's go back to the light green, the blue and the
23 yellow.

24 MR. KINGSTON: Yes.

25 DR. CORRADINI: You don't have to go back

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1 again.

2 MR. KINGSTON: Okay.

3 DR. CORRADINI: So those are design goals
4 that you now say current plants are operating. Do all
5 current plants have approval to operate in that full
6 window?

7 MR. KINGSTON: In the MELLLA+ window?

8 DR. CORRADINI: No, in the ELLLA, MELLLA
9 and ICF.

10 MR. KINGSTON: Yes.

11 DR. CORRADINI: Okay.

12 MR. KINGSTON: I think almost everyone --

13 MR. CASILLAS: Let me say --

14 DR. CORRADINI: Because let me tell you
15 why I'm asking that question that way because my next
16 question is going to be the purple is a design goal
17 but every plant has to get blessed within that design
18 goal. So my first question is, let's go back to the
19 first three things, have all plants been blessed.

20 MR. CASILLAS: Well, let me say that the
21 light green, the ELLLA, every plant has that approved
22 and has been using. Everybody but two or three plants
23 do not have the blue and also everybody except a
24 couple of plants do not have the increased core flow.

25 DR. CORRADINI: Okay, and the reasons

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1 there will probably then spill over to the purple, but
2 the reasons are potentially equipment that would have
3 to be changed that the utility, the licensee, decided
4 not to do and therefore they take those limits in
5 terms of what they can operate in. Is that correct?
6 Do I have that approximately right?

7 MR. CASILLAS: Yes, and in the case of the
8 increased core flow, that is true. That is the use of
9 added equipment margins and so if you do not have it,
10 you will not have the increased flow and the MELLLA,
11 if you do not, if you just have ELLLA and are able to
12 accommodate your operation, that's all that a few
13 plants, that all the plants have ELLLA. But a couple
14 of them do not need the MELLLA and so they do not have
15 it.

16 DR. CORRADINI: So can we just -- I know
17 I'm backing up a bit, but just for the sake of broad
18 because I think it does apply to the purple, is it a
19 matter of nobody wants to spend the money to get
20 blessed for the MELLLA and they don't need the
21 flexibility or is it it requires equipment changes?
22 What are some of the reasoning that I wouldn't want to
23 have the flexibility in the blue region?

24 MR. CASILLAS: It would require equipment
25 changes.

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1 DR. CORRADINI: Okay. Such as?

2 MR. CASILLAS: The instrumentation for the
3 -- the added instrumentation for detecting local power
4 changes.

5 DR. CORRADINI: Okay. Fine. All right.

6 DR. BANERJEE: I think you should point
7 out and I'm sure they will that to get to the focal
8 region there are things that have be done, of course.

9 DR. CORRADINI: Right. The reason I asked
10 the question was to lead to this one which is the
11 purple is a design goal and a methodology which we are
12 looking at to consider as good, bad, indifferent. But
13 still, every plant has to come in and submit a safety
14 evaluation report to be allowed to operate in any part
15 of the purple. They may not be able to operate in the
16 purple.

17 DR. BANERJEE: They are asking us to
18 approve certain dispositions on a generic basis.

19 DR. CORRADINI: Right.

20 DR. BANERJEE: So that they are not plant
21 specific and they'll clarify that.

22 MR. KINGSTON: What we're asking is our
23 MELLLA+ licensing topical report is a process for
24 qualifying a plant to operate in the MELLLA domain.
25 So we are asking for approval of that process and

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1 every plant that goes into MELLLA+ would have to go
2 through the processes in that topical report.

3 DR. BONACA: Well, it seems to me that the
4 first big step that you do, have to make, is the one
5 to the red region, I mean, the EPU.

6 DR. ARMIJO: The response provided by the
7 Mr. Casillas had double negative and I just want to
8 make sure that the record is correct. You said that
9 everybody but two or three plants do not have approval
10 to operate in that MELLLA and ELLLA regions. Is that
11 a correct statement, everybody except two or three
12 plants do not?

13 DR. CORRADINI: Do, I thought he meant.

14 MR. KINGSTON: Yes. All but two or three
15 plants.

16 DR. ARMIJO: Okay. So it's important that
17 the record reflects that. Thank you.

18] DR. MAYNARD: I understood it the way you
19 heard it, Mario.

20 DR. BONACA: I understood it that the
21 majority.

22 MR. ANDERSEN: The majority of the plants
23 are approved to operate with MELLLA?

24 MR. KINGSTON: Yes, that's correct.

25 That's good.

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1 DR. CORRADINI: That double negative.

2 DR. BANERJEE: And perhaps you will come
3 to DSSCD and then you can tell us how many plants have
4 DSSCD right now and how many don't.

5 MR. KINGSTON: I can't tell you that.

6 DR. BANERJEE: When you go through that,
7 you'll tell us.

8 DR. CORRADINI: And just to get to Mario's
9 point -- I want to get back to Mario's point. It's
10 key. So in the red region now, we're just starting to
11 go into it, so to speak, by a case-by-case basis.

12 DR. BANERJEE: Yes. Right.

13 DR. BONACA: But what I was trying to say
14 before was that the big step as far as plant
15 modifications is to go the red region.

16 MR. KINGSTON: Yes.

17 DR. BONACA: From there to the MELLLA+,
18 it's more of an analytical, I mean, it's fuel
19 improvements and not necessarily plant modifications
20 anymore. My understanding is that you will not have
21 further modifications to the plant except to the --

22 MR. KINGSTON: It's just principally the
23 fuel performance that allowed us to go to the higher
24 power.

25 DR. BONACA: Okay.

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1 MR. ANDERSEN: Just one. Yesterday we had
2 a presentation from Vermont Yankee which is operating
3 at 120 percent.

4 MR. KINGSTON: That's correct.

5 MR. ANDERSEN: And they claim they had
6 sufficient margin without MELLLA+. In fact, they're
7 operating and have been operating for --

8 MR. KINGSTON: Plants can operate without
9 MELLLA+. It's just more efficient and easier for them
10 and better human factors to use the flow window.

11 MR. ANDERSEN: What's the penalty they're
12 paying right now for not having MELLLA+ and operating
13 at 120 percent? What are they doing now that they
14 wouldn't have to do?

15 MR. KINGSTON: Their reactivity, and,
16 Jose, help me, their reactivity adjustments are much
17 more complicated to do to make sure you stay in the
18 allowed domain.

19 DR. BANERJEE: They have to use rod
20 adjustments rather than flow adjustments.

21 MR. ANDERSEN: Maybe four percent low or
22 something like that.

23 MR. KINGSTON: Which means now you would
24 have to go significantly down in power before you make
25 your rod adjustments.

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1 DR. ARMIJO: In their case, this dotted
2 line for the achievable flow does not go down to 100
3 percent. It's about 104 percent or thereabouts. So
4 they have a little bit of flow margin.

5 DR. CORRADINI: You're talking in the
6 yellow.

7 DR. ARMIJO: Right.

8 DR. BANERJEE: Yes, the Yankee.

9 DR. CORRADINI: Got it.

10 DR. BANERJEE: Vermont Yankee. But in
11 general, I think you can make a case which the
12 subcommittee understood that this operation in this
13 extended region makes it perhaps more safe to operate
14 the plant.

15 MR. KINGSTON: Yes, that's correct.

16 DR. BANERJEE: In that sense, it adds
17 positively to safety.

18 MR. KINGSTON: And if you were to poll our
19 utility operator colleagues and ask them if adjusting
20 fore reactivity they would rather use control rods or
21 the flow window, I think they would all want to go
22 with the flow. No pun intended and we have some
23 scenarios we can go through and you see how these
24 adjustments were made.

25 DR. CORRADINI: And just one last thing

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1 which I know you're going to cover because I remember
2 a lot of questioning in the subcommittee, the kink at
3 55 percent --

4 MR. KINGSTON: Yes.

5 DR. CORRADINI: -- and the kink at 80
6 percent involves some physical phenomena that I think
7 the rest of the committee wants to at least
8 appreciate.

9 MR. KINGSTON: The 80 percent kink, that
10 was the minimum practical flow at which 120 percent
11 power could be utilized and you're not going to be
12 able to get, with lower flow than that, you're not
13 going to be able to get, you're not going to be to
14 stay at 120 percent power.

15 DR. BANERJEE: Well, but what is the
16 limitation there. Is it CPR? Low flow CPR, right?

17 MR. KINGSTON: That's what I --

18 DR. BANERJEE: But I think the problem
19 that we ran into in the subcommittee meeting was to
20 show where it's a CPR limit. That point I presume is
21 a CPR limit.

22 MR. KINGSTON: Possibly.

23 DR. BANERJEE: And what is a limit, say,
24 at the 55 percent point which I presume is getting
25 close to an instability.

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1 MR. KINGSTON: That's the stability point.

2 DR. BANERJEE: This is what we wanted to
3 clarify.

4 MR. KINGSTON: Right.

5 DR. BANERJEE: For specific plants because
6 it's very plant-specific. So take any one plant and
7 show us.

8 MR. KINGSTON: The 55 percent was
9 stability margin in sump cooling concerns.

10 DR. BANERJEE: Right, but what wasn't
11 clear is, perhaps it will become clear in your
12 presentation because we specifically asked for this,
13 was whether it's a LOCA limit in some cases, whether
14 it's a stability limit in some cases. We want to
15 understand how we are cutting into the margins.

16 MR. KINGSTON: We'll talk -- In two slides
17 we have that.

18 DR. BANERJEE: Okay.

19 MR. KINGSTON: Three slides, excuse me.
20 The flow window benefits are here. You can read them
21 as well as I can. The plant really like MELLLA now
22 and they want MELLLA+.

23 Now we can go through some applications
24 with the flow.

25 DR. BANERJEE: The vibration thing is

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1 interesting. Can you go back to that? You didn't
2 speak of that to the subcommittee. Can you -- The
3 previous slide had this vibration rate.

4 MR. KINGSTON: That's right.

5 DR. BANERJEE: Now can you tell us whether
6 this is something which is verified that you know that
7 this will give you less problems with things like
8 steam dryers and things?

9 MR. KINGSTON: Jose, do you want to take
10 that?

11 MR. CASILLAS: This has to do with not the
12 dryers but more of the internal components where the
13 higher recirculation systems would be involved, the
14 jet pumps and instruments and so on. But where the
15 velocities would be quite a bit less at the lower --

16 DR. BANERJEE: But is the steam dryer
17 vibration or the acoustic wave dependent on the
18 velocity?

19 MR. CASILLAS: No. Well, up at the top --

20 DR. BANERJEE: Do you know that?

21 MR. CASILLAS: At the top of the vessel,
22 we have mostly steam flow and the steam flow is not
23 changing. So a dryer --

24 DR. BANERJEE: Wouldn't matter. Because
25 the 120 percent would give you the problem anyway.

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1 MR. CASILLAS: Correct.

2 DR. BANERJEE: So that's why I was a bit
3 confused about that.

4 MR. CASILLAS: But the vibration is in the
5 internals.

6 DR. BANERJEE: It's a different vibration
7 occurring.

8 MR. CASILLAS: Yes.

9 DR. BANERJEE: Not the steam dryer
10 problem.

11 MR. KINGSTON: Right. All right. This is
12 a typical BWR power flow map with the MELLLA
13 boundaries shown. During a start-up, the plant would
14 follow the red curve shown, would go up but low pump
15 speed past the cavitation interlock and then go with
16 flow up the curve and then the control rod motion,
17 they would increase power and then continue with flow
18 up to uprated power.

19 Now these are a little bit trickier. We
20 adjusted these so it didn't look like people were
21 going over 100 percent power. This is after you start
22 it up, you have some equilibrium xenon burning in and
23 you have a reactivity loss. So when you have the flow
24 window available, what you can do is this red line is
25 effectively a horizontal line because as your

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1 reactivity is decreasing you can increase your flow to
2 stay at 100 percent power and that is much preferable
3 to trying to move control rods at high power. It's a
4 much smoother, much slower, much softer practice for
5 the fuel.

6 Now the next one is where you have a power
7 increase from Gad burnout. Now the BWRs have Gad
8 aluminate in them and the fuel does get more reactive
9 as you proceed into the cycle for awhile and this is
10 the one that is drawn a little. As you would start to
11 have a reactivity increase, you would move backwards
12 along the flow line. Of course, you wouldn't go down
13 in power, but as your reactivity increased you would
14 back down on flow to stay at 100 percent power again
15 using flow only, not having to move control --

16 This is reactivity loss from fuel burn-up
17 which is much likely xenon burning in and you'd be
18 going up in flow to compensate for the reactivity
19 loss.

20 DR. BANERJEE: Plus what you are doing is
21 you're adjusting your void fraction, right?

22 MR. KINGSTON: That's correct.

23 DR. BANERJEE: You're getting higher,
24 higher and higher which is what brings up the issues
25 related to the high void fractions.

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1 MR. KINGSTON: That's correct.

2 And then even with the flow window,
3 periodically you have to make a major rod pattern
4 adjustment to keep the burn-up even in the core and in
5 that case, you would come down this line in -- come
6 down in flow along a rated rod line and then make your
7 control pattern adjustment to gain your reactivity and
8 then go back up to full power at flow. Without the
9 window, you would have to be doing these in small
10 steps to avoid getting into an unallowed domain and
11 this makes life much easier, much safer, much more
12 efficient for the plant operator.

13 So if you look at the 120 power uprate in
14 MELLLA+, what's going on? What are the margins and
15 why can you do it? The answer is really -- It's the
16 fuel performance and what we have plotted here is some
17 of the limiting factors in a power flow map and where
18 you have them. These points are actual plotted data
19 from our ATWS test facility and this shows the
20 difference between this is steady state power/critical
21 power ratio. This margin here is the margin that's
22 used when you have anticipated operational occurrence
23 and --

24 DR. BANERJEE: Can you explain the
25 vertical spread of the points?

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1 MR. KINGSTON: Probably Jens can.

2 MR. ANDERSEN: I can explain it because we
3 have -- This is Jens Andersen from GNF. We have run
4 tests at various subcoolings. We have run tests at
5 various peaking distributions in the bundle. So these
6 represent data with different power distributions
7 inside the bundle.

8 DR. BANERJEE: Right. Now with the sort
9 of power distribution that might obtain in a higher
10 void core where you might have periods where the power
11 has quite -- the distribution has quite a complex
12 shift or maybe even a higher power region towards to
13 the core exit at some point. Where would those points
14 fall? Would they be on the lower side of this?

15 MR. ANDERSEN: When you are limited by
16 critical power which tends to be towards the end of
17 the fuel cycle where your power shape tends to be top-
18 peaked, top-peaked power shape has a lower critical
19 power than a bottom-peaked power shape and we test
20 both power shapes.

21 DR. BANERJEE: So that would be the
22 lowest. Would they be the lowest then, the top-peaked
23 shapes?

24 MR. ANDERSEN: The top-peaked power shape
25 would be at the bottom. The particular data that are

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1 shown here are for a mid-peak power shape. But the
2 top-peaked would probably be along the bottom of the
3 boundary of these data.

4 DR. CORRADINI: Could you repeat? You
5 said it and I guess I didn't appreciate what you meant
6 by it that the difference between, let's say, the 100
7 percent or the 120 and the lower limit line of all
8 that critical power data is therefore and was it AOs?

9 MR. ANDERSEN: Yes.

10 DR. CORRADINI: But I don't -- Could you
11 kind of expand that just briefing so I understand what
12 you mean by that?

13 MR. KINGSTON: We -- Part of the design
14 criteria is that we cannot exceed 0.1 percent of the
15 rods in transition boiling for steady state and for
16 AOs. And so this is the margin then between steady
17 state and AOs that we have.

18 DR. BONACA: But now you do have a trip
19 set point, right? So that's just a margin for an
20 overshoot? How do you get there? It's just simply
21 margin.

22 MR. KINGSTON: If you have an anticipated
23 operational occurrence, that is where you start eating
24 into this margin and that's our delta CPR or above the
25 safety limit.

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1 MS. ABDULLAHI: This is Zena Abdullahi,
2 NRC NRR for now. GDC-10 requires that the -- will not
3 be violated during to steady state, normal steady
4 state operation and anticipated transient operation.
5 Therefore, during steady state, the critical power
6 correlation predicts what's called a safety limit MCPR
7 and those data are from the GEXL correlation data.
8 They did testing at different power shapes so they can
9 have the correlation that would allow them to
10 calculate what the steady state value is where 99.9
11 percent of the rods would avoid boiling transition.

12 Now if you have a transient, then that
13 delta is what will determine what your operating
14 limits should be, so that if you do have a transient
15 and the pressurization transient and the power peaks
16 up, then your CPR should be such that you still do not
17 violate 99.9 percent of your fuel rods should avoid
18 boiling transition.

19 MR. KINGSTON: And that's why we do our
20 calculations, to calculate what that operating limit
21 delta is.

22 MS. ABDULLAHI: Yes. So basically that
23 margin is not really a margin. It's meeting the delta
24 CPR required to meet GDC-10.

25 DR. BANERJEE: So the margin under normal

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1 operating conditions.

2 MS. ABDULLAHI: Right.

3 DR. CORRADINI: It's a limiting condition.

4 I mean, what I just heard the discussion say is that
5 you have a particular event that occurs in the --
6 potentially once a year.

7 MR. KINGSTON: A range of events.

8 DR. CORRADINI: A range of events. Let's
9 pick the pressurization event that when it occurs it
10 creates essentially a change in pressure which creates
11 a change in the CPR which means you have to stay where
12 you are or else you're in trouble because you don't
13 need your 0.1 percent.

14 MR. KINGSTON: That's right.

15 MR. ANDERSEN: That's correct.

16 DR. CORRADINI: Okay. Got it. Thank you.

17 DR. BANERJEE: Go ahead.

18 MR. KINGSTON: Okay. As you mentioned,
19 Dr. Banerjee, the bypass voiding and core in it and
20 the subcooling are controlling here at the 55 percent
21 line. You see the steady constant decay ratio line as
22 a region you want to avoid. And then, of course, you
23 have the nodal heat limit, your heat generation rate
24 limit, at the end here.

25 DR. CORRADINI: Which is "over here"

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1 meaning to the flow -- I don't know what you mean by
2 --

3 MR. KINGSTON: To the right.

4 DR. CORRADINI: Which implies what?
5 Because we were just talking peak temperature? The
6 linear heat generation limit is just essentially a
7 temperature mode, yes?

8 MR. KINGSTON: It's temperature exchange
9 in transient analysis, too. It's the strain, the
10 center line melt.

11 DR. CORRADINI: Okay. Got it.

12 DR. BANERJEE: Thanks a lot.

13 DR. CORRADINI: This is very helpful.

14 DR. BANERJEE: Yes, it is. Now, this is
15 sort of a generic case you've shown, right?

16 MR. KINGSTON: Yes.

17 DR. BANERJEE: I guess each plant will
18 have different --

19 MR. KINGSTON: Depending on its geometry,
20 its configuration, what generation of plant it is,
21 what other options it has, how much bypass it has, all
22 of those figure in the calculations.

23 DR. BANERJEE: In these operational
24 transients, how close would you get in terms of, let's
25 say, the horizontal part of the line to the CPR limit

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1 because it gets you to --

2 MR. KINGSTON: You're asking how close we
3 make the delta CPR to the actual --

4 DR. BANERJEE: Yes, what is the delta CPR?
5 At the moment, it's 1.5 or something, right, or 1.4?
6 I don't know.

7 MR. ANDERSEN: Typically, you have a
8 safety limit which is the margin you need to have
9 safety limit minimum critical -- It would be
10 somewhere in the order of 1.07 to 1.09 which means a
11 seven to nine percent margin that you need to have to
12 avoid one percent of the -- boiling sensation. Then
13 as Rick mentioned, you analyzed all the events and you
14 say how much change do you get in your critical power
15 ratio during these AOO events and typically the
16 limiting events are the pressurization events and that
17 puts an additional delta CPR on top of the safety
18 limit and that takes you maybe up to 1.4 which is a
19 typical operating limit and so that's how much margin
20 the fuel needs to have and it's designed -- the fuel
21 and the core design are designed to meet those limits.

22 Now typically, plants like to have a
23 couple of extra percent margin just to allow them
24 flexibility in operations and they don't like to
25 operate at the limit. The rest of the margin, if you

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1 have it, you can use to optimize the rate of your
2 power distribution in the core which gives you better
3 fuel economy.

4 DR. BANERJEE: But I think the thing to
5 point out here is that while the safety limit CPR and
6 the operating limit CPR is maintained, of course, much
7 more of the core is at these conditions because in
8 some sense the power distribution is really much
9 flatter. So this one percent number, I guess, comes
10 into that calculation, right?

11 MR. KINGSTON: 0.1 percent.

12 DR. BANERJEE: 0.1 percent, yes. Okay.
13 I think we should continue.

14 MR. KINGSTON: Okay. As you mentioned,
15 what's changed?

16 DR. BANERJEE: Can you just go back just
17 for the record and state one thing.

18 CHAIRMAN SHACK: You're contradicting
19 yourself here.

20 DR. BANERJEE: Sorry. I am.

21 (Off the record comments.)

22 DR. BANERJEE: But I think you should
23 point out that, of course, the core is somewhat faster
24 in some ways that adversely affects stability as well
25 in this case, right?

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1 MR. KINGSTON: Yes, the MELLLA+ does and,
2 in fact, the DSSCD was developed to address an issue
3 where MELLLA+ is having an adverse effect on the
4 potential performance and we have that extra safeguard
5 in place.

6 As I mentioned, the fuel performance is
7 what's changed to allow MELLLA+. This table here is
8 for GE fuel. The other fuel vendors have been
9 increasing their performance with their fuel just as
10 GE has. So the effects are comparable. You see
11 what's happened. We've gone from an 8X8 lattice
12 design to a 10x10 which gives us more rods, smaller
13 diameter rods. It helps with cooling. It helps with
14 surface area and heat flux. So it helps with your
15 margin.

16 DR. BANERJEE: -- doesn't like this slide.

17 MR. KINGSTON: And you see some of the
18 numbers higher there and how they've improved.

19 (Off the record comments.)

20 DR. BANERJEE: Carry on.

21 MR. KINGSTON: All right. Also on the
22 pressure drops, essentially unchanged. From GE fuel,
23 the stability of the two phase to single phase
24 pressure drop, an introduction of parlene cross
25 (phonetic) has also helped with fuel performance and

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1 we have a little excerpt from one of our documents
2 here and the terms here are a little bit -- BOEC is
3 beginning of equilibrium cycle, middle of equilibrium
4 cycle and end of equilibrium cycle. This was done on
5 an equilibrium basis and there is these decay ratios
6 are essentially unchanged from the 8X8 to the GE14.
7 Question?

8 DR. CORRADINI: So something magical
9 happens there that I don't need to know about that the
10 two phase pressure drop went down because you're
11 upping flow.

12 MR. KINGSTON: Yes.

13 DR. CORRADINI: And everything all is
14 hunky-dorey.

15 MR. ANDERSEN: I can answer that question.
16 We introduced the --

17 DR. CORRADINI: I missed that. I'm sorry.

18 MR. ANDERSEN: In a 10X10 fuel we have
19 about 14 -- at about two-thirds length. So you have
20 increased flow area in your part of the bundle.

21 DR. CORRADINI: Okay. Thank you.

22 MR. CASILLAS: Let me clarify. The
23 pressure drop change refers to the flow and the power
24 for the specific bundle. So when we've had more rods
25 you would expect more pressure drop. But we've

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1 decreased it. But in terms of power uprate if the
2 bundle operates at a higher power, it will have higher
3 pressure drop.

4 DR. CORRADINI: Okay. Fine. Thank you.

5 MR. KINGSTON: One of the concerns that
6 was examined was potentially changing core condition
7 as we move up the MELLLA+ line and here you can see a
8 comparison of how the void fraction changes with
9 different scenarios. The top scenario here is 105
10 percent power, 80 percent flow. That's like the
11 stretch power uprate. Brian, maybe I'll have you --

12 MR. MOORE: This is Brian Moore. I can
13 just try to talk through this. So you have a stretch
14 power uprate at the MELLLA line and then if you
15 proceed up the MELLLA line to an EPU condition, the
16 changes that you'll see are that the core average
17 voids are essentially unchanged.

18 Then as you proceed MELLLA+, you're
19 starting to increase the core average voids. So in a
20 whole, the void content in the core is higher. But
21 because we are constrained in terms of bundle
22 performance in terms of the CPR, the peak exit void
23 fraction is bounded. So it cannot increase. In
24 general, the core average void content increases, but
25 on the peak bundle it does not.

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1 You'll also notice that the potential for
2 bypass voiding because you have reduced moderation
3 because of the higher exit void fractions from the
4 bulk of the core, you have more energy being deposited
5 to the liquid that's between the channels. Therefore,
6 the potential for bypass voiding starts to increase.

7 The other parameters shown, core pressure
8 drop or inlet enthalpy and feedwater temperature, show
9 that for different given scenarios we're not changing
10 ultimately our departing drastically from our current
11 database of performance either at the original MELLLA
12 line or with the EPU conditions. So MELLLA+ does not
13 introduce core conditions in general that are
14 drastically different of what we have been able to
15 support, to demonstrate that.

16 MS. ABDULLAHI: This is Zena. I just want
17 to add here. I want to point out this. We didn't
18 address in our slides later on that we'll cover.
19 Because of the proprietary information, I have to omit
20 it. I never thought GE would present these things and
21 our slides basically because it's an open session did
22 not bring any of this information back that we had
23 during the subcommittee.

24 DR. CORRADINI: So this is one and only
25 chance?

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1 MS. ABDULLAHI: This is your chance.

2 (Off the record comments.)

3 MS. ABDULLAHI: I want to point out that
4 the main thing to understand here is I guess that
5 they're saying that assuming that my operating limit
6 remains the same, that I don't change my operating
7 limit, as from 105 to 120 to 80, that means then what
8 bundle power can I operate under so that it's fixed in
9 the operating limit. But that doesn't mean that when
10 you actually operate and have an actual plant that
11 wants to operate at that condition, they may have to
12 change the bundle power.

13 DR. CORRADINI: So can I --

14 MS. ABDULLAHI: It's a constraint that is
15 a design goal, but is not a constraint that you
16 generally expect to happen. We went through in our
17 section and said that there were cases where you had
18 the bundle power increased in order to operate there.
19 Go ahead.

20 DR. CORRADINI: So may I ask a question
21 just to clarify. So let me frame it slightly
22 differently but I think I get it which is they have
23 some fictitious nominal reactor out there that they've
24 done a calculation on. Any particular reactor may
25 have to manipulate this to fit within their

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1 constraints of flow and bundle design, etc.

2 MS. ABDULLAHI: There's no limit on that.

3 PARTICIPANT: You can expect the same
4 trends, whatever fixed --

5 DR. BANERJEE: The trick to keep this peak
6 exit within the limits is you have a flatter core,
7 right? That's the reason you can do that.

8 MR. CASILLAS: Yes, that's correct. In
9 the case of the 105 percent power, it would be very
10 easy to do. In the case of the 120 and 80 percent
11 flow, it would be very difficult, it would be much
12 more difficult.

13 DR. BANERJEE: Yes, it comes at the cost
14 of stability with the flatter core, right? That's why
15 eventually you have to put your --

16 MR. CASILLAS: Well, in the normal
17 operation, the stability margins are the same as
18 before.

19 DR. BANERJEE: Yes.

20 MR. CASILLAS: It's only if you depart
21 because of a pump trip or something --

22 DR. BANERJEE: Sure. I mean, the
23 stability point doesn't change.

24 MR. CASILLAS: Right.

25 DR. BANERJEE: But you come close to that.

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1 Eventually, the core is more unstable.

2 DR. ARMIJO: All of these void fraction
3 data are for the GE-14 design. Is that correct
4 that's what we're seeing and if you had a different
5 fuel design, say another supplier's fuel design, there
6 would be different fractions here.

7 MR. ANDERSEN: I can answer that question.
8 For the same power and fuel, you will get roughly the
9 same void fractions and the reason is that if you
10 compared all fuel design, they have roughly the same
11 flow area in the bundles. They have roughly the same
12 phenolic diameters. So for the same power flow
13 conditions, you're going to get very similar void
14 fractions.

15 DR. BANERJEE: But you know, we are going
16 to -- for the committee, we are faced with Hope Creek
17 and Susquehanna and Browns Ferry and they will have a
18 mixture of GE and other fuel. So remember that.

19 DR. CORRADINI: So if I could just reflect
20 what Sam said. So in your guys' subcommittee with
21 Vermont Yankee, they have chosen not to do this
22 because they have flexibility, a little bit of
23 flexibility, in the 120 region. Is that what you
24 said?

25 DR. ARMIJO: I said they are operating

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1 right now.

2 DR. CORRADINI: Whether they choose to go
3 forward or not but --

4 DR. ARMIJO: They would like to have more.

5 DR. CORRADINI: Their flexibility is on
6 the higher flow side. Okay, thank you.

7 DR. ARMIJO: But my other question is
8 really addressing other fuel designs because the
9 difference is some -- I don't know if everybody has
10 part link rods now, but you have that feature. You
11 have water rods in some designs. You have water rods
12 in other designs and so I'm trying to understand, is
13 this viewed as fairly generic for the modern fuel
14 that's out there today or is it just this is a
15 specific design.

16 DR. BANERJEE: I think we'd have to
17 consider it on a plant specific basis for sure.

18 MS. ABDULLAHI: Yeah.

19 DR. BANERJEE: Fuel design specific basis.

20 MS. ABDULLAHI: This is Zena. For the --
21 I don't think GE is telling you that every plant that
22 they -- you know, every bundle will have a peak of
23 87.5. I mean, that is not what GE is telling you. I
24 mean, I have a case of Brunswick data for EPU MELLLA
25 and I had 93 exit void fraction. Okay, so what

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1 they're doing is if I reach the design goal, this is
2 what I'm going to get is what they're going to say and
3 this is what my voids would be.

4 Now, every plant, they have to analyze the
5 -- simulate the core steady state condition, transient
6 analysis, all of that would have to be done and then
7 whatever comes out will come out. Regulatory-wise we
8 don't calculate what the void is, we don't put a
9 limit. We don't put a limit on the bundle. It's the
10 calculated thermal and make sure you meet it.

11 MR. KINGSTON: And, of course, the MELLLA
12 plus LTR is a process that you go through that
13 includes these kind of checks to qualify and you know,
14 the modeling would be --

15 DR. BANERJEE: Am I right that you're
16 saying this only to give us an idea that you're not
17 far outside what you're doing now?

18 MR. KINGSTON: That's right.

19 DR. ARMIJO: But a lot of these
20 calculations have to be done every reload.

21 MR. KINGSTON: Yes.

22 DR. ARMIJO: So let's say you have a plant
23 with a mixed core, how would you do these
24 calculations?

25 MR. KINGSTON: Brian could probably answer

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1 that the best.

2 MR. MOORE: Yeah, this is Brian Moore
3 again. During a vendor transition, we will be able to
4 do a best estimate simulation of the other vendor's
5 fuel in the same way that we're doing a best estimate
6 modeling of our own fuel. So we get enough
7 information from them regarding thermal hydraulic
8 performance, nuclear performance, of course, we are
9 modeling the exact design. We're not imitating or
10 making approximations on what's happening in their
11 fuel, but we're doing it to the best of our -- to the
12 best of the ability of the methodology.

13 DR. ARMIJO: But how would you get
14 information on CPR correlations?

15 MR. MOORE: As a part of the vendor
16 transition, of course, we are -- you know, if we are
17 not modeling the core, we must monitor to the thermal
18 margin. So a part of that transition is getting
19 information from the other vendor under protected
20 terms and sometimes there's, you know, additional
21 margin. They're not going to give us their critical
22 power database. We have a method by which we're able
23 to simulate the critical power sometimes involving us
24 preparing and submitting critical power correlations
25 specific to that fuel type to the staff for review.

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1 So you'll have the information to monitor their
2 critical power performance as well.

3 MR. KINGSTON: And as Brian mentioned,
4 typically there's additional margin on that
5 correlation compared to just a correlation. Some of
6 the key safety analyses are shown here and a
7 comparison is shown on what the impact of MELLLA plus
8 is. On containment, there is no impact to the long
9 term response. There's no change to the K heat and
10 the small effect on the short term analysis.

11 DR. BANERJEE: Containment in the sense of
12 loads during what? Is it --

13 MR. KINGSTON: LOCA loads.

14 DR. BANERJEE: LOCA loads, not ATWS loads.

15 MR. CASILLAS: Also ATWS loads.

16 Containment. That's further down.

17 DR. ARMIJO: Now, when you say no impact,
18 you're assuming you're already at the EPU level.

19 MR. CASILLAS: Yes, that's right.

20 DR. ARMIJO: You're just looking at the
21 effects of flow.

22 MR. KINGSTON: No, the impact of MELLLA
23 itself on the --

24 DR. ARMIJO: Right, MELLLA plus.

25 MR. KINGSTON: And the rest there you can

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1 take a look at and ask questions if you have them.

2 DR. CORRADINI: I'm trying to read your
3 last one to understand it because that's the one
4 eventually I want to understand better than the
5 others, sorry.

6 MR. KINGSTON: We have another slide on
7 stability. This item, as you know, was one of quite
8 a bit of discussion two weeks ago and we've listened
9 to the concerns, Dr. Banerjee's concerns. We have a
10 slide on that. I will approach that. Are there any
11 questions on any of these other impacts? In general,
12 they're relatively small. Where this is an impact
13 it's on stabilities, you know, we've gone to DSSCD to
14 address that point.

15 DR. BANERJEE: With the backup safety.

16 MR. KINGSTON: Yes.

17 DR. BANERJEE: Was that offered by you or
18 was that requested by the staff, the backup?

19 MR. KINGSTON: I don't know.

20 MR. CASILLAS: That was GE's. That was
21 part of the design -- in how the design of MELLLA
22 plus. We were very, very aware of this behavior.

23 MS. ABDULLAHI: Finished?

24 MR. CASILLAS: Yes.

25 MS. ABDULLAHI: Okay, what we said is that

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1 you can't have an inoperable system.

2 DR. BANERJEE: An automatic backup system.

3 MS. ABDULLAHI: We didn't tell them it has
4 to be an automatic backup. It was a question of you
5 cannot have an inoperable system because there's no
6 time for operator action. And from there it was
7 developed through the process was this backup an auto
8 system was conceived, I think and then one plant came
9 up with the auto.

10 MR. CASILLAS: The CD was a GE system to
11 go with MELLLA plus.

12 MS. ABDULLAHI: Right, yes.

13 MR. CASILLAS: Right, and the question is
14 only what would you do if you don't have the CD system
15 available for whatever reason. And the simple
16 approach is you exit the MELLLA plus. You just do not
17 operate that. And that's one. You can have also an
18 automatic system also.

19 DR. BANERJEE: Are you going to address
20 stability in your presentation?

21 MS. ABDULLAHI: Because this was one-hour
22 open session --

23 DR. BANERJEE: Yeah, so you're not.

24 MS. ABDULLAHI: -- everything we covered
25 in the closed for the sub, we didn't really -- we were

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1 just going to do an overview now but if you close any
2 section we will be happy to pick up out old slides and
3 go over it.

4 DR. BANERJEE: Well, I could, I think,
5 tell the main committee that with regard to the
6 stability issue, the subcommittee went over it in some
7 depth and we can explore it if you like more. And I
8 think which methodologies that were offered and all
9 the CD plus the automatic backup I think we were quite
10 relatively satisfied with that. I mean, we can reopen
11 this at any point that you need.

12 DR. MAYNARD: I just have a quick question
13 on the -- I'm not familiar with the margins, BWRs, the
14 LOCA less than 100 degrees PCT change expected. How
15 close to the limit is that? I don't know if 100
16 degrees putting it real close or whether you --

17 MR. GANT: You know, this was also
18 presented at the subcommittee, some example results.
19 You know, I think we see PCTs in the 1800 --

20 DR. BANERJEE: Quite a big margin.

21 MR. GANT: -- range. I mean, some plants
22 can be higher than that, you know. Some of the older
23 plants are LOCA limited so you would have --

24 DR. MAYNARD: Okay, I'm just not that
25 familiar with the BWR operating margins.

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1 DR. BANERJEE: The major issues that came
2 up were, of course, uncertainty with minimum CPRs
3 which the staff dealt with by adding some margin to
4 the requirements. They'll probably speak to that.
5 LOCA was not a big issue. There were some issues
6 related to ATWS, as I said, plant specific issues
7 which were resolved on a plant specific basis but
8 really it was whether we can dispose of the ATWS
9 instability on a generic basis is going to be
10 something that you have to consider.

11 Now, we also have to consider all of the
12 methods we can use in this. I mean, this is an
13 enormous thing we are looking at on one hour.

14 MR. KINGSTON: Right, for the stability,
15 the ATWS instability --

16 DR. BANERJEE: This slide we don't have
17 it?

18 MR. KINGSTON: No, this was one we just --
19 we worked with Zena five minutes before the meeting.
20 It looks like a paragraph. But you can read the
21 option there. In effect, until there is a -- you
22 know, the staff feels comfortable with the bounding
23 generic solution, you know, there is a confirmation of
24 what it is, we would do this, the instability on a
25 plant specific basis.

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1 DR. BANERJEE: Plant specific, yeah, are
2 you asking for a disposition on at generic basis or on
3 a plant specific basis? We don't have any problems
4 with a plant specific basis.

5 MR. KINGSTON: Well, yeah, and what this
6 is until we can get a generic disposition, we will
7 continue on a plant specific basis and we'll continue
8 to work you know with the codes and with the
9 comparisons to generate a data set that we can bring
10 to you and demonstrate that we do have a bounding
11 generic case.

12 DR. BANERJEE: Yeah, sure.

13 DR. CORRADINI: But there's a set of
14 conditions, if I remember, after all the discussion,
15 there was a set of conditions of general principles,
16 first general principles that must be mitigated. It
17 can't be unmitigated. Right?

18 MR. KINGSTON: Right, that's right.

19 DR. CORRADINI: And then within the
20 mitigated category, depending upon the plant, the
21 specifics, you'd have to look at it, but no -- but
22 isn't that -- am I remembering correctly?

23 DR. BONACA: Well, I thought that for the
24 unmitigated case, we made a point of the frequency of
25 this event being 10^6 or lower. And the fact that the

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1 ATWS was really closed as a ISG because on a frequency
2 basis.

3 DR. CORRADINI: The unmitigated.

4 DR. BONACA: The unmitigated, that's
5 right.

6 DR. CORRADINI: But even the mitigated is
7 a low enough frequency. It's not within the design
8 base anyway, even the mitigated.

9 DR. BANERJEE: Well, ATWS is a special
10 event anyway.

11 DR. CORRADINI: Right, but I just want to
12 make sure I've got it right though, that unmitigated
13 is off the table. Mitigated is what we're talking
14 about and there it's on a specific basis, depending on
15 how it effects that plant staff design in the MELLLA
16 plus region.

17 DR. BANERJEE: Right, now.

18 DR. CORRADINI: Right now.

19 DR. BANERJEE: I mean, they may
20 disposition it on a generic basis in the future,
21 right?

22 DR. CORRADINI: Did I remember right?

23 MS. ABDULLAHI: Yeah, originally what NRC
24 was willing to approve was it's low frequency and the
25 assumptions in the mitigated -- there's no unmitigated

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1 anyway. There always is going to be -- unmitigated is
2 more to see the variability of parameter changes and
3 response. It's all let's say academic, to pick up
4 those specific parameters that you want to assume in
5 the mitigated as limiting parameters.

6 The agreement was they did one generic
7 mitigated analysis. We accepted that generic
8 mitigated analysis as telling us that they bound --
9 that it was bounding enough and that mitigation action
10 was effective under MELLLA plus operation. There were
11 some applicability ranges that they had to meet. If
12 they don't meet those applicability ranges they have
13 to reanalyze and applicability ranges were if we
14 change the fuel design, because our position was based
15 on G14 fuel design, generic.

16 If you change the bundle power flow ratio,
17 the power density, so there were a certain set of
18 applicability ranges that if in fact, a plant does not
19 meet those, they would do an analysis. Other than
20 that, we generically dispositioned.

21 DR. ARMIJO: Well, but hold on. There is
22 nobody right now who is excluded by this 52.5
23 megawatts per million pounds per hour; is that
24 correct?

25 MS. ABDULLAHI: That's per million.

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1 DR. ARMIJO: What you're saying is that
2 anybody who is using GE14 is generically approved; is
3 that correct?

4 MS. ABDULLAHI: The way it was now, the
5 way it was -- this limitation is new. This is new.
6 It's being response to the committee.

7 DR. BANERJEE: To the subcommittee.

8 DR. ARMIJO: But the question is whether
9 it really means anything.

10 MS. ABDULLAHI: The generic disposition?

11 DR. ARMIJO: Right, in the sense that if
12 I read this, I would say anyone who is using GE14 is
13 automatically covered by this generic analysis; is
14 that correct?

15 MS. ABDULLAHI: Now it's slightly
16 different. Now what it's trying to say is that you
17 will do a plant specific analyses unless you could
18 show, that was the intention now. This was supposed
19 to be different.

20 MR. KINGSTON: The intent was you do a
21 plant specific analysis until there's an approved
22 generic.

23 DR. ARMIJO: Unless, you know, unless you
24 have specific changes, but if you don't, you're using
25 GE14 and everybody satisfies the 52.5 megawatts per

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1 million pounds per hour, then you don't have to do
2 anything.

3 Mr. Marche-Lueba: This is Jose Marche-
4 Lueba. The language in the red sentence says each --
5 the red sentence over there says, "Each plant safety
6 analysis report". It means each plant application
7 must include a specific analysis. So they will do at
8 least one per plant. Now, what they are trying to
9 say is that after the 10th plant, maybe plant 11 we
10 have enough information to know that plants of this
11 type don't need to do it any more. That's the way we
12 intend that to read.

13 DR. BANERJEE: Yeah, I can tell you what
14 the concerns of the subcommittee were in this just to
15 summarize it. If you look at one of those -- it's not
16 here but you have a line which was a red line on one
17 of the slides that somebody showed. You were in an
18 ATWS instability situation in an area of domain, if
19 you like, where you would expect because of this
20 MELLLA plus operation, that your instabilities grow
21 faster, will come more rapidly, whatever and the
22 subcommittee was concerned, even though this was a
23 very low frequency event, to dispose of it generically
24 without having more experience in running this and
25 seeing what effect the mitigative actions would be.

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1 At the moment it looks like the mitigative
2 actions can be done within two minutes, then it's
3 fine. But we don't know if this had to be done in 30
4 seconds or 40 seconds, what it would be on a plant
5 specific basis. Even though we agree that some of
6 these calculations were done conservatively,
7 nonetheless, you know, this is in a regime where these
8 codes have not been tested all that much. We don't
9 understand this regime very well. I have a paper on
10 reflux which I'll give to Jens which shows that the
11 rewetting velocity goes down by a factor of two when
12 you have these oscillations. Okay, so it's an open
13 issue still in my mind. So I think if you're going to
14 do a plant specific analysis, fine.

15 DR. ARMIJO: Without further specificity
16 as to the conditions at which this specific or plant
17 specific calculation would be done, I don't think this
18 means anything because I can always select the
19 conditions at which I do this calculation and show
20 that I can satisfy the acceptance criteria.

21 You have to specify the limiting
22 conditions at which this calculation needs to be done.

23 MS. ABDULLAHI: Okay, if you would notice
24 the applicability ranges, I'm not going to tell you
25 that these words are perfect. This is we were all

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1 scrambling the last minute, okay, but I can tell you
2 what are the conditions that we find important.

3 One these are fuel design -- number one
4 cause is M+SAR must include ATWS instability analysis
5 that satisfies the ATWS acceptance criteria. That is
6 the beat. Maybe we should put that first. That is
7 the new important one.

8 DR. BANERJEE: No, you can view that
9 second. The intent is important so it satisfies Said
10 with the rewording. We don't want to waste much time.

11 MS. ABDULLAHI: Well, we would leave that
12 first but the list that you have underneath there, the
13 one, the two, the three, the four, the five, these are
14 parameters that we wanted to be checked in general,
15 okay. It's anybody's turn -- after a certain time you
16 way that I need the auto analysis for Type 4 plants,
17 okay, and that has been provided. These are what we
18 think are important parameters that would give them
19 the checklist that they are okay.

20 Axial power radial distribution effects
21 the ATWS stability, so they would have to show that
22 the assumed cases meet that. They would have to show
23 the bundle power flow ratio, that they meet that. So
24 this is really not -- this has increased our
25 applicability ranges today also, okay, or whatever

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1 analysis is accepted in the future. And I would also
2 like to --

3 DR. BANERJEE: Zena can you do this?

4 MS. ABDULLAHI: Separately.

5 DR. BANERJEE: Yeah, separately because we
6 don't have the time right now.

7 CHAIRMAN SHACK: Yeah, we're at 11:30
8 already.

9 DR. BANERJEE: Yeah, so we need to finish
10 this presentation and between whatever is needed, I
11 mean, when we write the full committee letter, we
12 would need to have an understanding of what is the
13 limitations.

14 DR. ARMIJO: And we'll get a copy of this?

15 MS. ABDULLAHI: For the record, what I
16 understand you're requesting is that we clean it up,
17 make it more clear, provide you a written -- proposed
18 written ATWS instability limitation that would be
19 clear enough that an ATWS instability analysis would
20 be to follow on a plant specific basis.

21 DR. BANERJEE: Yeah, and I don't know what
22 Bill wants to do, whether this can be just something
23 that can be given to the committee at the time it's
24 considering its letter or it's up to you how you want
25 to deal with that.

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1 CHAIRMAN SHACK: Well, I mean, if we feel
2 this is necessary, we can describe in the letter that
3 this limitation has to be applied. I mean, I'm not
4 drawing any conclusions at the moment.

5 DR. BANERJEE: Yeah, we don't know.

6 CHAIRMAN SHACK: But if we have this, we
7 can certainly include the restriction in the letter.

8 DR. BANERJEE: Okay, let's move on. Okay,
9 thank you. Maybe this next Slide 12 is useful, yeah,
10 we want to talk about that, yeah.

11 MR. KINGSTON: And Brian, I'll let you
12 take this one.

13 MR. MOORE: Sure. The -- as we're
14 calculating all these different conditions and events
15 for MELLLA plus, the question arose first by GE, is
16 your methodology capable of analyzing these
17 conditions? And the staff was also very uniquely
18 interested in this. And particular attention was
19 paid, attention to void fraction, bypass voiding,
20 handling of uncertainties relevant to this condition,
21 and other items. And in the end, there was a request
22 by the staff for a particular set of validation data
23 pertinent to operation at EPU and MELLLA plus and GE
24 was able to provide information relevant to many of
25 them and others we did not have readily available. So

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1 what we were able to do is encoded in the LTR and also
2 was presented to the subcommittee was determine
3 reasonable assurance by increasing your uncertainties
4 what is the additional margin that you would want to
5 add.

6 And for instance, for the safety limit,
7 you know, that analysis concludes you need about a .01
8 to address those uncertainties. In the end we landed
9 on a .02 which, you know, is sort of double the
10 margin, there's plenty of margin there to address EPU
11 condition and also to address, for instance, questions
12 of on the void correlation, a .01 operating limit or
13 additional margin was provided.

14 For MELLLA plus, again, since we don't
15 have plants operating there yet, additional margin,
16 what this does is pushes the fuel farther back from
17 the expected conditions of where you would, you know,
18 if you were operating on the limit and had your worst
19 case transient, et cetera, you're pushing that off and
20 providing additional --

21 DR. BANERJEE: The .03 is because of the
22 lower flows in the MELLLA plus projection with the
23 same power? I mean, just a physical reason for it?

24 MR. MOORE: Well, I think because we don't
25 have a lot of benchmarking, if you consider it in

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1 steps, you go to EPU and then you -- most of the time
2 you go to EPU and then you go MELLLA plus, we don't
3 have some of this benchmarking data yet at EPU
4 conditions. So we're obtaining that now. Once we get
5 that, then you can say that perhaps, we can reduce the
6 margins down to that incremental additional -- the
7 staff is being prudent here to say there's plenty of
8 margin that needs to be provided for that --

9 DR. ARMIJO: But for a plant like Vermont
10 Yankee at EPU conditions, if they decide to implement
11 MELLLA plus, the impact would be only at .01 change in
12 the safety limit MCTR.

13 MR. MOORE: Because they already have
14 under their EPU license approval they already have a
15 .02 additional margin.

16 DR. ARMIJO: So that's what this means.

17 MR. MOORE: That's my understanding, yes.

18 MS. ABDULLAHI: Excuse me, say that again.

19 MR. GANT: It would be a .01 on the safety
20 limit and an additional .01 on the operating.

21 DR. ARMIJO: Not the way I read this.
22 We're talking about a plant like Vermont Yankee that's
23 operating at extended power uprate. If they were to
24 go ahead and implement MELLLA plus, the impact would
25 be just simply a change of .01 in the safety limit and

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1 CPR. That's it.

2 MS. ABDULLAHI: The thing is, when we
3 reviewed the Vermont Yankee, we had a .02 applied but
4 we didn't have the .01 for OLMCPR applied at the time.

5 DR. ARMIJO: Oh, I see, so this is --

6 MS. ABDULLAHI: So what I mean, they come
7 for MELLLA plus if the data is all fixed up. They
8 will get .01 from EPU to MELLLA plus and they will get
9 a .01 on the OLMCPR which comes --

10 DR. ARMIJO: So if they come back for a
11 reload analysis, you will catch them with this
12 additional .01 operating limit?

13 MS. ABDULLAHI: No, the --

14 DR. BANERJEE: MELLLA plus.

15 DR. ARMIJO: No, without MELLLA plus.

16 MS. ABDULLAHI: The reload, we don't do
17 anything. The reload is approved in GSTAR 2 which is
18 GE goes off and does the reload on their own. Only
19 when we have an application in-house can we do the
20 regulatory.

21 DR. ARMIJO: I want to make sure I
22 understand. If GE had and provided all these other
23 data where there's mikes, would these MELLLA plus
24 limitations disappear or be reduced?

25 MS. ABDULLAHI: They can go or they can

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1 come back higher depending on what the data tells us.

2 DR. ARMIJO: Right assuming the data --
3 the other thing is, are those blanks, do they mean
4 that you're -- the staff is never going to see that
5 data or that GE is going to provide it later?

6 MR. KINGSTON: No, no, that means we left
7 it as a blank. It means something we owe and we're
8 going to bring to the staff to review. And these are
9 all, you know, underway. We're gathering gamma scan
10 data and this other data at plants, you know.

11 DR. ARMIJO: So that's within some time
12 period that you would come back to the staff with the
13 data.

14 MR. MOORE: Yes, we've committed to the
15 staff to get them a good portion of the gamma scan
16 data and on pressure drop and some information on void
17 fraction by the end of this year. The data that we've
18 obtained so far which was presented to the
19 subcommittee indicates that there's no need for
20 additional margin, so it's a good result, but we're
21 continuing to pursue, you know, getting this and it
22 will be then evaluated by the staff for the final
23 determination.

24 DR. BANERJEE: Okay, let's move on. Did
25 you want to say anything about the bypass voiding or

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1 you can summarize it then?

2 MR. CASILLAS: If you have a question on
3 it.

4 DR. BANERJEE: No, no, I don't.

5 MR. MOORE: We're just simply saying that
6 there are other limitations with regard to the methods
7 that are included in the safety evaluation and you
8 know, many of those are GE specific process items.
9 The awareness of bypass voiding and what it does or
10 needed to bound it with your coritizon (phonetic) on
11 a regular basis and addressing calibration issues for
12 stability set point determination, there's other items
13 as well. I didn't want -- feel it was necessary to
14 list them.

15 DR. BANERJEE: No, I think it's fine. We
16 asked you to focus on two or three of the major
17 limitations.

18 MR. KINGSTON: Just recapping the MELLLA
19 plus flow window, it's very beneficial in needing to
20 efficiently operate the plants at EPU power levels and
21 again, we're seeking the ACRS acceptance of the use
22 for the methodology in the MELLLA plus report and the
23 supporting topical reports in the plant-specific
24 application for EPU and MELLLA plus.

25 DR. BANERJEE: Okay, thank you very much,

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1 a nice presentation. We'll turn it over to the NRC
2 now.

3 MR. CRANSTON: This is Greg Cranston
4 again. The NRC, for this next portion it will be the
5 NRC staff presentation. The lead reviewer is Zena
6 Abdullahi. And she has assistance from Oakridge
7 National Laboratory consultants and Jose Marche-Lueba.

8 DR. BANERJEE: Are we in open session or
9 closed session now?

10 MS. ABDULLAHI: Open.

11 DR. BANERJEE: So please, Zena, try to
12 finish by 12:15.

13 MS. ABDULLAHI: Okay, I'll speak faster.
14 Jose will speak even faster.

15 DR. BANERJEE: No, he can't speak faster.
16 As it is we have trouble understanding what he says.

17 Mr. Marche-Lueba: I'll tell you what,
18 I'll stay quiet.

19 MS. ABDULLAHI: Okay, this is an open
20 session, so what we did is we -- since the data
21 doesn't belong to us, we are presenting basically a
22 much more overview than we did in the subcommittee
23 meeting but I believe we provided you with also the
24 subcommittee slides and so we have also provided you
25 with an ATWS instability proprietary version and a

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1 non-proprietary version. We may cover the non-
2 proprietary but the proprietary we cannot cover or
3 talk of it unless GE does a waiver again and I don't
4 think they will in this case.

5 Okay, I think GE on the -- before I go
6 into the detail, I want to point out that these
7 topical reports had an extensive number of people
8 reviewing it. We spent a lot of energy and I think GE
9 also spent a lot of time and energy as well, and one
10 of the reasons we did this is because we felt that as
11 you can see from the out-power flow map, the plant was
12 designed initially within the blue -- within the green
13 zone of what was called the original license thermal
14 power 100 and 100.

15 And it progressively changed and each
16 progression had some impact. So when we went through
17 the EPU we thought that, oh, okay, this is a major
18 impact, let's pay attention, 20 percent above. And
19 now we're talking about 20 percent above the original
20 license thermal power and then the core flow, lower
21 core flow. So we took this LTR quite seriously.

22 What we are approving is revision 2 of the
23 LTR which means revision 1 took into account many,
24 many REI changes and incorporated and methodology
25 changes. So what we're coming to you to ask you for

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1 approval, we're telling you that we have spent -- we
2 have taken it seriously and there is sufficient
3 changes made within the process being asked that
4 plants will implement when they do EPU. So -- and we
5 have -- we have -- NRR now feels there is sufficient
6 assurances that plants can meet the regulatory and
7 safety requirements.

8 DR. BANERJEE: but you have also put a
9 fairly large number of limitations.

10 MS. ABDULLAHI: We did.

11 DR. BANERJEE: And the subcommittee saw a
12 certain set of limitations but I now notice that there
13 is a document saying -- are there any changes to these
14 limitations that you've made since the subcommittee
15 meeting?

16 MS. ABDULLAHI: No, this document,
17 actually we sent you May 23rd, and I think our meeting
18 was May 24. And the reason we sent you this is --
19 I'll give you a little bit of background. I'll speak
20 fast because we don't have much time.

21 In general, whenever we write an SCR,
22 that SCR is issued to the vendor for comments, both
23 proprietary or technical comments. That's one aspect.
24 Another aspect is that from the Maine Yankee lesson
25 learned, you want to make sure that licensees and fuel

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1 vendors understand how they apply that limitation. So
2 there has to be a resolution and understanding on both
3 sides.

4 Limitations were issued to GE. GE had
5 sent us a large number of comments. We have reviewed
6 those comments. We agreed on some of them which is
7 just a question of clarification purposes. Some cases
8 we have been at it for a long time and GE can attest
9 to that. And but since these agreement was done after
10 we issued you the SCR, we felt it's important that we
11 give to you the changes, submit the changes to you.

12 DR. BANERJEE: But since the subcommittee
13 meeting there have been no changes.

14 MS. ABDULLAHI: No, but there are one
15 particular limitation that we are still working on but
16 I don't think that particular limitation will effect
17 the conclusion.

18 DR. BANERJEE: Is that tech spec?

19 MS. ABDULLAHI: Yeah, it's mostly tech
20 specs.

21 DR. BANERJEE: Is that a tech spec related
22 to ATWS?

23 MS. ABDULLAHI: Yes.

24 DR. BANERJEE: We would like to be
25 informed of that if there's any change because we are

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1 very interested in this.

2 MS. ABDULLAHI: We could do that by
3 submitting it to you or do you want us to give you an
4 idea now, because it's a question of timing?

5 DR. BANERJEE: No, just carry on your
6 presentation. We'll come to this at the end.

7 MS. ABDULLAHI: Yeah, but the only thing,
8 that limitation was giving it to you because we made
9 changes which differs in Chapter 12 of the SCR, so you
10 needed to know, that's all.

11 DR. BANERJEE: We'll revisit your
12 limitations at the end.

13 MS. ABDULLAHI: Okay, this is the inter-
14 related topical reports that support MELLLA plus.
15 MELLLA plus had an impact on instability. As a result
16 of it, GE had developed a specific methodology called
17 DSSCD in which stability is detected and suppressed.
18 Because in order to demonstrate that when stability
19 occurs the safety limited minimum critical power ratio
20 would not be exceeded, GE also submitted TRACG G for
21 DSSCD. TRACG G is actually --

22 DR. BANERJEE: So we never reviewed that?

23 MS. ABDULLAHI: Yes, yes, Dr. Banerjee,
24 right. Those two topical reports were approved but
25 you haven't --

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1 DR. BANERJEE: Without review by ACRS.

2 MS. ABDULLAHI: Without review, however,
3 the person who approved it and reviewed it was Tai
4 Han, who is not here. However, Jose, who was the
5 technical had, during the subcommittee provided you
6 with any information. This is the reason why we
7 included in the subcommittee meeting the second on
8 DSSCD.

9 DR. BANERJEE: But I think this is
10 important enough that things like this have to come to
11 ACRS.

12 MS. ABDULLAHI: I think that's a
13 management issue.

14 MR. CRANSTON: This is Greg Cranston,
15 Branch Chief for systems.

16 DR. BANERJEE: How are we going to deal
17 with this otherwise?

18 MR. CRANSTON: Yeah, we can do that if you
19 desire. We also made a brief presentation, it was
20 very brief, in conjunction with the standard review
21 plan that had to do with reactor stability where we
22 covered a general overview of this approach.

23 DR. BANERJEE: Yeah, I remember that,
24 yeah.

25 MR. CRANSTON: So if the ACRS would like

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1 to see something --

2 DR. BANERJEE: These are pretty major
3 items, you know. And I was just going through it to
4 understand what converting studies have been done with
5 TRACG G. Whether it was explicit, what the Courant
6 numbers were. There were a huge number of issues
7 there which should have been -- perhaps you dealt with
8 it, we never saw it. I mean, if we had access to it,
9 we would have gone over it with a fine tooth comb for
10 sure.

11 MS. ABDULLAHI: I think that's a comment
12 for the record, and NRR.

13 CHAIRMAN SHACK: That's up to the
14 Committee to decide whether we can proceed without
15 doing that, so just go ahead at the moment.

16 MS. ABDULLAHI: Yes, we did cover, because
17 we knew it was important, we included in our
18 subcommittee meeting. Now MELLLA+ LTR defines the
19 scope of work and the analyses that will be provided
20 on plant-specific basis. In the subcommittee, I
21 provided you with a table that specified with fuel-
22 dependent analysis will be provided on plant-specific
23 basis. I could not present it here, because that
24 would be proprietary information. But if you look to
25 the subcommittee, you will find out.

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1 Plant-specific application, as mentioned
2 earlier, will, in fact, be submitted, and it will come
3 to the ACRS member for each plant. So if Brunswick
4 decides to implement MELLLA+, Brunswick application to
5 MELLLA+ will come to the subcommittee, and then
6 approval will go through that process. So you will be
7 able to look at it and decide from there.

8 And now, the interim methods LTR, NEDC-
9 33173P, supports both the plant-specific MELLLA+
10 topical report, and the EPU applications. So that is
11 how they are all interconnected, and this is what this
12 slide is trying to explain.

13 Now MELLLA+ approval is contingent upon
14 compliance with the limitations specified in the Staff
15 SER approving the latest versions of the three LTRs,
16 basically.

17 DR. ARMIJO: The yellow box for the
18 interim methods invokes the earlier approval of TRACG?

19 MS. ABDULLAHI: No. Say that again?

20 DR. ARMIJO: It invokes the earlier
21 approval of TRACG for stability calculations that ACRS
22 had not reviewed.

23 MS. ABDULLAHI: You mean the TRACG for
24 DSSCD?

25 DR. ARMIJO: Right.

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1 DR. BANERJEE: No, he's talking about
2 interim methods.

3 DR. ARMIJO: These interim methods that
4 are supporting these applications.

5 MS. ABDULLAHI: Right.

6 DR. ARMIJO: This NEDC-33173P.

7 MS. ABDULLAHI: Yes.

8 DR. ARMIJO: Implies prior, or invokes
9 prior approval of TRACG.

10 MR. MARCHE-LUEBA: There are TRACG
11 calculations which are included, to justify the
12 conclusions from that LTR. So you are correct.

13 DR. BANERJEE: That's what my concern was
14 always.

15 MR. MARCHE-LUEBA: Now the TRACG report
16 that you did not get to review is this one right here.

17 DR. ARMIJO: Correct.

18 MR. MARCHE-LUEBA: 33147P, that's
19 exclusively for use with the DSSCD application. There
20 are other reports on validations of TRACG that allow
21 you to use with ESBWR, there's another report for ATWS
22 instability calculation. There's another application
23 for calculation of the divom curve for TRACG. So the
24 only TRACG LTR you didn't see is four calculations
25 specifically for DSSCD.

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1 DR. ARMIJO: Okay.

2 DR. BANERJEE: Which is a very important
3 part of this.

4 MR. MARCHE-LUEBA: It is. That's why --
5 we even though these reports have already been issued
6 and approved, we intended to present to the
7 subcommittee because we thought you would be
8 interested. The judgment from the staff point of
9 view, from the DSSCD point of view, is a minor
10 incremental change versus solution three.

11 DR. BANERJEE: But we understand because
12 you're adding CD to it.

13 MR. MARCHE-LUEBA: Right. Solution III+,
14 and, therefore, at the management level, we decided
15 that ACRS probably doesn't want to be bothered with
16 this minor incremental thing. TRACG, they should have
17 noticed that you would -- we agree with your
18 statement.

19 MS. ABDULLAHI: Okay. What I tried to do
20 overall here is just basically define with MELLLA+ is.
21 I'll skip that part at this point because he has the
22 right, good job of that. And the SC covers all this
23 information. I'll just present what fuel dependent
24 analysis that are affected, the details of that we
25 covered during the subcommittee meeting, and I believe

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1 that slides are available.

2 We were going to discuss ATWS instability
3 impact, but I suppose we could skip that for now. And
4 then we'll cover some parts of the interim methods.
5 I'll pass power flow map, slide four, pass slide six,
6 let's go to slide 7.

7 From our review, we found that yes,
8 MELLLA+ does affect fuel dependent analysis. And one
9 of the reasons it affects, obviously, is because of
10 the fact that MELLLA+ would be EPU++ in a sense that
11 you would be at 20 percent higher power level, and
12 then you would have a lower flow conditions. So, in
13 a way, we thought about it as EPU++, so anything that
14 deals with fuel dependent in terms of a rod lining, or
15 in terms of bundle conditions, then it would affect.

16 Some other effects are impact on stability
17 response, impact on ATWS response, impact on ATWS
18 instability response, impact on the ECCS-LOCA
19 response, and the impact on the SLMCPR. These are
20 just some of the main ones.

21 Now for the stability response, you have
22 the DSSCD protection system specifically designed for
23 MELLLA+ operation, and we found that that was very
24 acceptable. The ATWS response was a very big review,
25 and there's been --

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1 DR. BANERJEE: Let ask you something here.
2 Did you -- were you able to use something like TRACE
3 to look at the stability, as well? I'm sort of
4 accepting that TRACG is okay, since you approved and
5 we've never seen it.

6 MS. ABDULLAHI: I had --

7 DR. BANERJEE: But did you do anything
8 else?

9 MS. ABDULLAHI: I had an ISL report that
10 was supposed to circulate. Did you see that one? I
11 made one colored copy, and it was supposed to move
12 from member to member. But I gave you a CD, and that
13 CD contains actually the ISL report.

14 DR. BANERJEE: But what the -- there was
15 confirmatory analysis done of this?

16 MS. ABDULLAHI: Yes. And I could jump to
17 that.

18 DR. BANERJEE: That's all right, but say
19 yes or no.

20 MS. ABDULLAHI: Yes.

21 MR. MARCHE-LUEBA: Not necessarily TRACE.
22 You also use frequency Domain Lapulco for stability,
23 outside the ATWS domains.

24 MS. ABDULLAHI: For the record, that is
25 the ISL report we received, and with effort we tried

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1 to do a confirmatory. Our intention in SOW included
2 instability, and included ATWS isolation, isolation
3 ATWS.

4 DR. BANERJEE: And what code was used
5 here?

6 MS. ABDULLAHI: TRACE-PARKS, PARKS-TRACE.

7 DR. BANERJEE: Successfully coupled for
8 this, but not for ATWS?

9 MS. ABDULLAHI: No, it was ATWS, and it --
10

11 DR. BANERJEE: Why wouldn't it work for
12 ATWS instability then?

13 MS. ABDULLAHI: At the time, okay, we were
14 told that in order for it to model ATWS at the time,
15 it would need to be perturbed. We had to put in the
16 power perturbation from some other code.

17 DR. BANERJEE: And if it's coupled to
18 PARKS?

19 MS. ABDULLAHI: At the time, PARKS was not
20 settling in --

21 MR. MARCHE-LUEBA: Research has been doing
22 some research on Purdue, use of Purdue at Penn State
23 on getting TRACE-PARKS to work for stability, and they
24 have had to -- they have several versions of TRACE
25 that are able to do it. And we do have some slides

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1 that shows the --

2 MS. ABDULLAHI: Yes, we can handle that.

3 DR. BANERJEE: Let me ask you this
4 question; imagine that we are going to be faced with
5 MELLLA+ for different plants with maybe mixed fuels,
6 and all sorts of things in the future. How are you
7 going to do confirmatory analysis?

8 MS. ABDULLAHI: We have a slide on PARKS-
9 TRACE. You told us to go to Research, find out what
10 to do. We went, we talked, they gave us information,
11 so if we go through this, we'll go to those slides.

12 DR. BANERJEE: Okay.

13 MS. ABDULLAHI: And you should have those
14 slides there.

15 We haven't performed ATWS confirmatory
16 analysis, and the intention at the time was to see
17 what was the impact on isolation ATWS. And we have
18 determined a couple of very important things at the
19 time, which is the operator actions was not being
20 modeled by the code that was being used, and the
21 resolution was that GE would actually use a TRACG
22 calculation to model the depressurization if the heat
23 capacity temperature limit is reached.

24 We have also reached -- actually, I think
25 we made it a lot more safer in that GE has agreed -

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1 now I don't know, this is proprietary, it's one of the
2 limitations. Randy, is it proprietary, heat load?

3 MR. GANT: No.

4 MS. ABDULLAHI: Okay. Good. We had to
5 write a letter recently on proprietary, things we
6 believe, so I'm being careful.

7 One of the many important things that we
8 have come through this review with GE is that the
9 actual boron concentration will be increased so that
10 --

11 DR. BANERJEE: Enriched.

12 MS. ABDULLAHI: Enriched, Boron-10, so
13 that the heat load will remain the same to the
14 original license thermal power.

15 DR. BANERJEE: That's been agreed on.
16 Correct?

17 MS. ABDULLAHI: We agreed on that.

18 MR. MARCHE-LUEBA: For the plants that
19 need it.

20 DR. BANERJEE: For the plants that --
21 they're not --

22 MS. ABDULLAHI: It's an option for plants.

23 DR. BANERJEE: Okay. Can we move on?

24 MS. ABDULLAHI: Okay. Well, we covered
25 all of this issue in the subcommittee, and we

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1 satisfied ourselves that with these changes, that
2 would work. I only want to add a few things in
3 conclusion. One of them is that we did perform a
4 comprehensive review, because of the reactor condition
5 and plant response being outside the current
6 experience base. We had some significant findings.
7 We have proven Version 2. We have performed
8 confirmatory analyses, where feasible. And we also
9 have looked at the methodology being used in order to
10 get assurances --

11 DR. BANERJEE: Before you go off so
12 quickly for the main committee, I'd like to say that
13 the reactor physics confirmatory analysis was quite
14 comprehensive and excellent. The thermal hydraulic
15 confirmatory analysis was not.

16 MS. ABDULLAHI: TRACE doesn't work at the
17 time.

18 DR. BANERJEE: Well, something has to be
19 done about it.

20 MS. ABDULLAHI: It works now. Let me run
21 to that particular TRACE --

22 MR. GANT: We have some slides on that.

23 MS. ABDULLAHI: That was supposed to be
24 thermal hydraulic. The staff concludes that the
25 expanded operating domain defined by the MELLLA+ upper

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1 boundary does adversely impact fuel dependent
2 analysis. However, without plant modification, some
3 BWRs cannot implement MELLLA+ operation and meet the
4 safety and regulatory requirements.

5 What that means is, if you have a peak
6 pressure, and you don't have enough SRV capacity, then
7 you would have to do some plant mod, increase the
8 throat of the SRV, put another SRV in, or whatever you
9 have to do to be able to survive. Other thing is, the
10 option available to them increased the boron so that
11 you would not have early shutdown.

12 Now the extent of the expanded operating
13 domain, BWRs can implement and meet the safety and
14 regulatory requirement will be highly plant-specific;
15 which means, that if you have a plant that is going
16 back to Otto's last question, is LOCA-limited. Okay?
17 And LOCA is impacted by the low flow condition, maybe
18 would not go all the way. You may have to go less to
19 maybe 90 or 80. If the plant -- and another thing is,
20 while they are design goals, it's possible that plant
21 when you have this high operating domain with much
22 lower flow conditions, that that particular plant may
23 not be able to operate at that power level, so that it
24 can hit that bundled condition, and meet the operating
25 limit, so that it may have to reduce it. So there are

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1 a lot of plant-specific conditions.

2 The main objective of our review was to
3 define what analyses are affected, are we going to get
4 it on a plant-specific basis? First, we want to get
5 a feel of what the change impact would be, and then
6 are we going to get it on a plant-specific basis?
7 And, basically, MELLLA+ operation is acceptable with
8 the limitations specified in the Staff SERs.

9 Now for the methods, we also have done
10 quite an extensive review of the methods.

11 DR. BANERJEE: So I think for the
12 committee, the issue will be do we want to write one
13 letter, two letters, one on methods, one on MELLLA+.
14 Look at it from that point of view.

15 MS. ABDULLAHI: Yes. The method is
16 basically ensuring that when you predict a certain
17 calculation, you predict that the PCP is this amount,
18 or you predict that your SLNCPR is this value, how
19 much can you rely on that?

20 I'm going to skip fast to Item 13.

21 DR. ARMIJO: I have a question.

22 MS. ABDULLAHI: Yes, sir.

23 DR. ARMIJO: If we're going to write two
24 letters, why would we do that? Are there two
25 applications, or just one application?

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1 DR. BANERJEE: Well, let Zena speak to
2 that, maybe. I have a view of this, but I don't --

3 MS. ABDULLAHI: Go ahead.

4 MS. HONCHARUK: This is Michelle Honcharuk
5 with NRR. We do have in-house two separate
6 applications for review. The interim methods came in
7 under one cover letter from GE, and the MELLLA+ came
8 in under another, so we've been tracking them with two
9 different review schedules, two different tag numbers,
10 and whatnot.

11 As far as a preference, whether one or two
12 letters, if you're able to issue one letter in a
13 timely fashion that covers both, that's fine. But if
14 there is some sort of holdup on one or the other
15 because of some outstanding issue, then we would
16 request that you do separate them out, so that we can
17 move along closure path for the one where there aren't
18 any issues.

19 DR. BANERJEE: Right. We may write a
20 letter on methods, if we wish, and not on MELLLA+. Or
21 we could write two separate letters, whatever. Any
22 combination is possible.

23 MR. CRANSTON: This is Greg Cranston. The
24 other comment I wanted to make, too, is that there's
25 plants that are submitting applications where if the

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1 methods was approved, we'd be using that in
2 conjunction with their EPU. They may not be going for
3 MELLLA+ right away, and, therefore, if we had the
4 methods through the process, and there was something
5 associated with MELLLA+ that we wanted to pursue
6 longer, then that wouldn't hold up any of those
7 plants.

8 MS. ABDULLAHI: In the methods review, we
9 basically looked at extension of the neutronic methods
10 to high void, impact of bypass voiding on the
11 reliability of neutron monitoring systems, adequacy of
12 available correlation, and model qualification
13 databases.

14 We did do a confirmatory code-to-code
15 comparison, both on the thermal mechanical. We did a
16 FRAPCON calculation on thermal mechanical, and then we
17 also did the HELIOS comparison on the code-to-code.

18 DR. BANERJEE: Are you going to talk about
19 the FRAPCON results, or give some indication --

20 MS. ABDULLAHI: Roughly, I do, but we did
21 have a section, a thermal mechanical section during
22 the subcommittee.

23 DR. BANERJEE: I mean for the full
24 committee.

25 MS. ABDULLAHI: Yes, I have some vague

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1 part -- the SC has a whole section on the FRAPCON
2 table, and data, and everything else. So the
3 conclusions of our review are basically, there would
4 be a .02 applied to the SLMCPR, and a .03 will be
5 applied for EPU, and a .03 will be applied to the
6 MELLLA+.

7 DR. CORRADINI: These are -- just to be
8 back to when you discuss at the subcommittee, these
9 are additive.

10 MS. ABDULLAHI: These are additive. On
11 cycle-specific basis, the SLMCPR is calculated on
12 cycle-specific basis.

13 DR. BANERJEE: They're like a Delta CPR in
14 some ways.

15 MS. ABDULLAHI: Right. It's after you
16 have your cycle-specific value, you'll up this adder.
17 And we think this is quite significant margin. And
18 licensee, I'm sure will be happy to tell you that it
19 is --

20 DR. CORRADINI: Too much.

21 MS. ABDULLAHI: Yes. But it's based on
22 some sort of a judgment, and data, looking at old
23 data, picking up 95 of that data, perturbing it in
24 single parameter, pin peaking, and bundle peaking, and
25 then coming out with a .01 from there. And then

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1 that's how we -- it's not like pick it up from the
2 lower kind of parameter.

3 DR. BANERJEE: There were some Monte Carlo
4 calculations done or something. Right?

5 MR. GEHIN: This is Jess Gehin, Oak Ridge.
6 A part of this came from the code-to-code confirmatory
7 to get some basis on the possible errors introduced
8 from the high void fraction operation, without the
9 lack of the data that staff would like to have to get
10 a basis to see -- to feed those uncertainties into the
11 calculation of the Delta CPR to come up with these.
12 So there's a process that was followed to quantify
13 these SLMCPR adders. And then, actually, the values
14 were actually increased over what came out of that
15 process.

16 MS. ABDULLAHI: Let me add a
17 clarification, since this is an important part. What
18 you have is, in the SLMCPR process, you would have -
19 the core will be modeled at certain steady state
20 conditions, where you would model at the beginning of
21 cycle, middle of cycle, end of cycle. And there's
22 quite a lot of statistical involved. Among those are
23 uncertainties, specific uncertainties that you apply,
24 which are pin peak and uncertainty bundle, bundle
25 uncertainties, four bundle uncertainties, core flow

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1 uncertainties, and you perturb around the steady state
2 condition, and then you see how the number of --
3 whether you would meet 99.9 percent of the fuel
4 bundles were not experiencing void and transition.

5 Within those you have a case where you
6 have a certain uncertainty in the bundle and the pin
7 which you would obtain from gamma scan, and it was
8 obtained from gamma scans in the past. So those were
9 not available, and GE then did a conservative
10 approach, which is okay, gamma scan will take a while
11 to obtain for GE-14, for the new fuel design, the new
12 peak and clad factors, all these other things that
13 affect the SLMCPR. Am I proprietary?

14 MR. GANT: Yes.

15 MS. ABDULLAHI: Am I getting close? Back-
16 out, then. You want to go ahead and do it?

17 BM: Yes. We would like you not to
18 discuss the process --

19 MS. ABDULLAHI: Which you came up with.

20 BM: That's correct.

21 MS. ABDULLAHI: I close it at that point.
22 All I'm saying is that we did come out through a
23 process how we achieve this .01 and .02.

24 DR. BANERJEE: Yes, the subcommittee
25 understands that, but unless we're going to --

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1 MS. ABDULLAHI: Thank you. Yes, so now we
2 also looked at the Findlay-Dix correlation, we went to
3 the source document, and we looked at the conditions
4 that we have today in the core.

5 DR. BANERJEE: You know our concern about
6 that, of course.

7 MS. ABDULLAHI: Right.

8 DR. BANERJEE: Because this is a drift-
9 flux correlation.

10 MS. ABDULLAHI: Right.

11 DR. BANERJEE: Which is being used outside
12 its development range physically, so there's no
13 physical basis for this. This is purely --

14 DR. CORRADINI: Mathematical correlation.

15 DR. BANERJEE: It's purely a curve fit, at
16 this point.

17 MS. ABDULLAHI: Right. And the data is --
18 we found it quite limited, and so GE and the staff
19 agreed that assuming a certain percent of uncertainty,
20 and then propagating that uncertainty over, then we
21 came up with this adder.

22 DR. BANERJEE: Well, this has more
23 implications than that, because it goes into the ODIN
24 code, which is used for ATWS. So I think we shouldn't
25 pass over this too lightly.

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1 MS. ABDULLAHI: Pass over? You mean,
2 explain it?

3 DR. BANERJEE: Yes, because it is not --
4 something like TRACG does it more mechanistically,
5 and this -- I'm more concerned about things like ATWS.

6 MS. ABDULLAHI: Okay. Well, this .01 is
7 applied to the operating limit.

8 DR. BANERJEE: Yes, that's right.

9 MS. ABDULLAHI: And as a result of it, you
10 are getting not only a margin on the safety, you're
11 also getting a margin on the operating limit through
12 the void reactivity coefficient. You're saying if I
13 am off my voids fraction by this amount, how does that
14 affect my reactivity, void reactivity?

15 DR. BANERJEE: What correlations are you
16 using for the bypass voiding?

17 MS. ABDULLAHI: Calculation of the bypass
18 voiding?

19 MR. MARCHE-LUEBA: Same separation.

20 DR. BANERJEE: But you can also do bypass
21 voiding with TRACG. Right?

22 MR. MARCHE-LUEBA: That's correct.

23 (Simultaneous speech.)

24 MR. MARCHE-LUEBA: Dix-Findlay is used for
25 ATWS, is used for most of the AOOs, and is used for a

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1 steady state in PANACEA to calculate, so when you're
2 talking about a CPR correlation, CPR does not involve
3 a fraction, but a calculation of CV in PANACEA is --

4 DR. BANERJEE: It fits back into all the
5 reactor physics. Right?

6 MR. MARCHE-LUEBA: It fits into the
7 reactor physics. Correct.

8 MS. ABDULLAHI: And there are RAIs that
9 staff is reviewing in sufficient detail TRACG right
10 now, and that issue of the coupling with Findlay-Dix
11 is being reviewed there.

12 DR. BANERJEE: There's been a remark made
13 - I don't know, public or not - but that this is
14 straining the database that was existing in the 70s
15 and 80s, and the correlations perhaps beyond their
16 breaking points. And I don't see that 60s or 70s or
17 reflux models that Graham Wallis and Novak Zuber
18 developed was state-of-the-art then, necessarily need
19 to be applied to something else, sort of crucial right
20 now, where your reactor physics becomes very dependent
21 on what's happening there.

22 MS. ABDULLAHI: I think in terms of
23 thermal hydraulic and conversion to TRAC -- a couple
24 of comments I want to make about this now. Because of
25 MELLLA+, we did this detailed evaluation. And because

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1 of MELLLA+, now GE actually has taken a big effort of
2 gamma scan data that it's developing and getting, and
3 it's already showing us some preliminary data, so I
4 consider that a positive.

5 Secondly, in terms of the transition, most
6 BWRs who go to MELLLA+ may probably transition to
7 TRACG. And, in fact, I think we had some limitation,
8 or some discussion of that in the SC, because they get
9 a margin. It's a best estimate. ODIN had some, how
10 do you put it, conservatism. It has some conservatism
11 in - can I discuss the conservatism? I don't know.
12 But it has some conservatisms. All codes were not as
13 good, but they used to have a lot of conservatism
14 applied. New codes you refine, and you reduce the
15 conservatism, so many plants will probably transition
16 to TRACG.

17 DR. BANERJEE: There's a good physical
18 reason for doing it?

19 MS. ABDULLAHI: Yes, but there you want to
20 have the benchmarking to be improved, as well. So the
21 void quality correlation, basically, our conclusion is
22 a .01 will be added until we resolve the data
23 supporting the correlation. And now, the thermal
24 mechanical, I did not --

25 DR. BANERJEE: How will you get this data,

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1 because at this high void fractions, making
2 measurements is extremely difficult. It's like
3 Heisenberg's Uncertainty Principle. I don't see how
4 you can get the data, unless you use neutron
5 scattering, or something.

6 MS. ABDULLAHI: Well --

7 DR. BANERJEE: Will you submit the data to
8 us to look at with a critical eye?

9 MS. ABDULLAHI: Actually, if a review -
10 any review you suggest to get follow-up, I think you
11 have the right to --

12 (Simultaneous speech.)

13 DR. BANERJEE: GE, can you speak, please,
14 what you can tell in open session about this?

15 MR. ANDERSEN: Okay. The question is on
16 the void fraction?

17 DR. BANERJEE: Yes. How do you get it?

18 MR. ANDERSEN: Well, the void fraction
19 data, I mean, we presented some of it at the
20 subcommittee, and the proprietary information were
21 presented. The void fraction data would derive from
22 bundled data. We have 4X4, 7X7, 8X8 bundled data,
23 most of these data were taken using gamma attenuation.
24 Some data were taking using quick closing valves that
25 measured the liquid content between two different

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1 valve locations. The range of the data is large
2 enough to cover current operation.

3 It is correct that we don't have any void
4 fraction data for 10X10 fuel, but if you look at the
5 range of the parameters that exist in the bundles,
6 it's not significantly different from the range that
7 was used in the original data.

8 MS. ABDULLAHI: I think I totally
9 disagree, obviously, as the staff. We went through --
10 extensively gone through the source documents, and we
11 looked at the type of data. We're talking about the
12 raw bundled data, we're talking about the CHEESA data,
13 we're talking about data that even when you do have
14 data, the parameters which those data are based on are
15 not lined up. It's like you may have a void up to 95,
16 but the flow is this amount, and then here might be
17 equivalent raw diameter here. You don't have it all
18 lined up. We even went out of our way to look at the
19 world data and try to check if the Dix-Findlay data
20 fits the world data.

21 DR. BANERJEE: But I think the main thing
22 is that high void fractions, you're really looking at
23 the liquid fractions, because that's what is doing the
24 moderation. And, of course, also the bypass. But in
25 this case the issue is what is the uncertainty in the

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1 liquid fraction, and that is substantial, of course,
2 because even with quick closing valves, if you close
3 one valve slightly differently from the other, you
4 capture quite a different amount of liquid. And gamma
5 at this range is very insensitive, so if you are going
6 to fill in this database, that's why I was saying it's
7 a little bit Heisenberg's Uncertainty Principle - how
8 are you going to do it? I mean, the only way that I
9 know of to do it is by using either neutron
10 scattering, or neutron absorption in this range. I
11 know of no -- you may know other methods, but I don't
12 know of any other in this high void fraction, so how
13 are you going to fill it in? Maybe you should just
14 take this and say forget it. We'll never be able to
15 do anything with it.

16 DR. ARMIJO: That may be a practical
17 option, because it may be less -- you're going to
18 spend a lot of time and money chasing this, and it may
19 not work.

20 DR. BANERJEE: I know, and what is sort of
21 worrying is that you guys have been dismantling your
22 facilities. You had this beautiful facility that
23 maybe with neutrons you could have done something.
24 But now, what are you going to do? Do you have an
25 answer?

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1 MR. ANDERSEN: Well, I can't make any
2 specific commitments for GE. And while there is some
3 disagreement as to what is the adequacy of the range,
4 we do agree that if you account for the additional
5 uncertainty that Zena is discussing, that would be
6 covered by the .01 increase in the operating limits.
7 And so we have agreed to take that additional margin
8 until we obtain such data to justify a removal of that
9 margin.

10 DR. BANERJEE: The question was, how do
11 you get the data, if you try to get it?

12 MR. ANDERSEN: Well, that's a different
13 issue. What we do do, is that we do perform full-
14 scale data of the pressure drop, which is what allows
15 us to know what the flow distribution is in the core.
16 We do perform full-scale data for the critical power,
17 which is what allows us to determine the margin to
18 thermal limits, and we do do the gamma scans, which
19 provide us information on the power distribution
20 uncertainties. And that is what you need in order to
21 justify your margin to the thermal limits.

22 Now you could postulate that there are
23 compensating errors, and your void fraction may be
24 wrong, so that's why we agreed to stay with the
25 additional margin of .01. That's how we get

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1 additional data.

2 MS. ABDULLAHI: Yes. And, in fact, we did
3 ask GE, actually, and they are working on and
4 submitted some information we asked them to do, to
5 back-calculate from their pressure drop data low flow
6 condition to back-calculate what the void fraction
7 would be, and then get it on an axial level so we can
8 see how at low flow condition they -- Dix-Findlay
9 performs axially, not average, so we see what impact
10 a half part would have, et cetera. And so, they may
11 do stages in their submittal.

12 What we did in the thermal mechanical is,
13 we performed the FRAPCON calculations, and the staff
14 -- of a GE-14 fuel design. We looked at the internal
15 rod pressure, and the thermal overpower, which is the
16 fuel center line -- affects the fuel center line melt
17 acceptance criteria. And the mechanical overpower,
18 which the acceptance criteria is that you would meet
19 the 1 percent geometric strain acceptance criteria.

20 Now on a separate review, the Staff in the
21 ESBWR had actually found out, also, that they -- that
22 GSTRM under-predicts by as much as, if I recall
23 correctly, 425 degrees the fuel center line
24 temperature. They also found that the FRAPCON
25 calculation in their case was consistent with a prime,

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1 which is a new GE methodology.

2 DR. BANERJEE: That's not being asked to
3 be approved in the methods. Right?

4 MS. ABDULLAHI: No, we're not approving
5 it. This is just to tell you that anything that will
6 change the method in the future, we will just let you
7 know now so that what you approved, if we amend, or
8 change, we have given you a forewarning that this is
9 what we'll do. That's all the purpose of GSTRM work.

10 DR. BANERJEE: But is GSTRM in the package
11 of methods that you're asking us to approve?

12 MS. ABDULLAHI: Yes, it is.

13 DR. BANERJEE: So what --

14 MS. ABDULLAHI: What conclusions did I
15 reach?

16 DR. BANERJEE: Yes.

17 MS. ABDULLAHI: The conclusions we
18 basically reached is that a fuel center line
19 temperature - a couple of conclusions. Let's go to
20 the next slide. Did you get there?

21 The fuel center line temperature, we found
22 that their uncertainty treatment compensates for it.
23 Therefore, we're not going to take any further action.
24 We also found that their qualification database here
25 is very limited in that especially, the internal rod

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1 pressure data is up to 20, I think, gigawatt
2 days/metric ton. Fuel center line temperature was
3 only up to 30, and the data itself is 25 years old,
4 and it does not represent what you expect the fuel
5 rods to be today.

6 DR. BANERJEE: In fact, your consultant,
7 Carl Beyer, was at pains to point this out to the
8 subcommittee.

9 MS. ABDULLAHI: Right. We pulled him in
10 because when we saw that, we asked them to do a Part
11 21 evaluation, they came back with an answer to the
12 Part 21 evaluation. We were not comfortable with the
13 conclusion of it, so then we pulled Carl in to weigh-
14 in on his outlook. And he confirmed that, in fact, he
15 had concerns also, from what he saw.

16 The conclusion is Part 21 will be
17 reopened. We'll ask them to reopen the Part 21. We
18 will write them a letter. We feel, at this point, the
19 concern lies on two-fold. One is the rod internal
20 pressure calculation not under-predicting at the end
21 of the life. The second one is that GE needs to
22 update its gamma scan, or raw puncture, but their
23 internal rod pressure calculations, benchmarking has
24 to be done and updated. We have commitment from GE,
25 and some conversation back and forth since 2005 on

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1 this.

2 DR. BANERJEE: Shouldn't they be comparing
3 this with --

4 MS. ABDULLAHI: World data?

5 DR. BANERJEE: Yes. More modern data.

6 MS. ABDULLAHI: That is another issue that
7 came up, is that they take GSTRM and they go back --
8 since the gamma scan or whatever data they're going
9 to take will take a while, that they take GSTRM and,
10 in fact, compare with the data they're using now for
11 PRIME and re-evaluate, re-benchmark using new data.
12 So that's --

13 DR. BANERJEE: PRIME replaces GSTRM.
14 Right?

15 MS. ABDULLAHI: For MELLLA+, it's required
16 that when NRC approves limitation, and this is how
17 limitations work, it's like when NRC approves PRIME,
18 which is the new code, then the plants will transition
19 to PRIME. So that is the long-term solution for EPU
20 MELLLA+. On the other hand --

21 DR. BANERJEE: So what is the limitation
22 on this currently, that they have to have a certain
23 very conservative calculation?

24 MS. ABDULLAHI: There's nothing on it
25 right now on GSTRM, except the transitioning, and the

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1 commitment to perform benchmarking. But it's going to
2 be addressed in this Part 21 follow-up work. That's
3 why we present it to you, because the SC does not
4 contain this, in terms of how we concluded in our
5 review.

6 DR. BANERJEE: Well, what does ACRS do
7 with the methods part of it?

8 MS. ABDULLAHI: The methods we have --

9 DR. BANERJEE: This will be excluded from
10 that, until you resolve Part 21?

11 MS. ABDULLAHI: Yes. We have a statement
12 in there, I think we have a limitation in there
13 dealing with a Part 21, which says the conclusion of
14 the Part 21 will be applicable. There is a little
15 clause in there that we may have to work with it, but
16 there is some discussion. We discuss the Part 21, but
17 it says that we're expanding. Now we are closer to --

18

19 DR. BANERJEE: So what you're saying is if
20 we concur with the staff SC on this, including the
21 limitations, then this issue will be handled under
22 that limitations.

23 MS. ABDULLAHI: Yes, separately. It will
24 be concluded separately, but we will provide you with
25 whatever conclusions we reach.

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1 DR. BANERJEE: Right. Right, eventually,
2 but right now, we have two letters to write. Right?

3 MS. ABDULLAHI: In terms of your letter
4 right now, this Part 21, already there's a limitation
5 there that says the conclusion of the Part 21 will be
6 applicable.

7 DR. BANERJEE: Okay.

8 MS. ABDULLAHI: And what we presented to
9 you is what we think our conclusion is right now, as
10 of now.

11 Staff reviewed the applicability of GE
12 methods to EPU and MELLLA+. The staff determined that
13 some of the analytical method used to predict the EPU
14 conditions need additional validation data. Hence,
15 additional margins were applied in some of the methods
16 as an interim. And, basically, that concludes my
17 overall slides. If we have time, we would like to go
18 to the TRACE-PARKS discussion.

19 DR. BANERJEE: Can you do it in five
20 minutes?

21 MS. ABDULLAHI: Jose, speak fast, faster?

22 MR. MARCHE-LUEBA: I can only show you
23 some plots, so if you wanted to see data - we can skip
24 the word slides, go directly to the plots. So thanks
25 to Tony Ulses, which got a degree from public

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1 university was ready for the -

2 DR. BANERJEE: Who is this?

3 MR. MARCHE-LUEBA: Tony Ulises made this
4 calculation.

5 MR. ULSES: Of the Office of Research, I
6 actually ran this calculation within the last week
7 since we spoke last, I guess a week and a half since
8 we spoke last.

9 MR. MARCHE-LUEBA: Okay. And so --

10 DR. BANERJEE: And you had a Ringold's
11 deck.

12 MR. ULSES: Yes. We had a Ringold's deck
13 that we've been using.

14 DR. BANERJEE: Okay.

15 MR. MARCHE-LUEBA: Research has been doing
16 some work on developing this. And you used a special
17 version of TRACE. Right?

18 MR. ULSES: Well, we're using a version of
19 TRACE, I don't want to call it a special version of
20 TRACE. I mean, as we look at these things, if we have
21 a question about a model, I mean the code, we'll have
22 to take a look at it, obviously. Right now, we took
23 the version of TRACE that we are currently evaluating
24 for ESBWR applications for AOOs, I guess the short
25 answer to that question.

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1 DR. BANERJEE: Okay.

2 MR. MARCHE-LUEBA: The purpose of this
3 slide is to show you that TRACE can't do the job. It
4 still has not done the job. This is the first step
5 into the ATWS stability transient that we were talking
6 about.

7 DR. BANERJEE: Can you show the earlier
8 part of it?

9 MR. MARCHE-LUEBA: Yes.

10 DR. BANERJEE: So you get into fairly
11 severe oscillations within very -- which is what I
12 would have expected.

13 MS. ABDULLAHI: This is all original
14 license thermal power. This is not MELLLA+ or
15 anything.

16 MR. MARCHE-LUEBA: 150, 200 percent, which
17 is not --

18 DR. BANERJEE: Right. That --

19 MS. ABDULLAHI: Compared to a thousand.

20 MR. MARCHE-LUEBA: Yes, we worry about the
21 one thousand.

22 MR. ULSES: Well, the point I want to make
23 here also on this calculation, Dr. Banerjee - I mean,
24 this again, this is not MELLLA+. This isn't a U.S.
25 design BWR. I mean, this is actually -- I think this

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1 is --

2 DR. BANERJEE: I realize this is just
3 stability.

4 MR. MARCHE-LUEBA: Yes. In this part, you
5 will have gotten a SCRAM up here on all high power,
6 right in 10 seconds, 10 seconds from the -- I wanted
7 to -- this is a blow-up of that figure that shows the
8 nice behavior of the limit cycle, so TRACE is doing a
9 decent job of modeling this. It has the proper
10 numerics, it has the proper models to do the job.

11 DR. CORRADINI: And is that one curve or
12 two curves?

13 MR. MARCHE-LUEBA: This is only one curve.

14 DR. CORRADINI: One curve, so what's the
15 effect -- I'm sorry for asking a detailed question,
16 but I see a dark blue line, and a thin blue line. Is
17 it just my eyes?

18 DR. BANERJEE: It's your eyes.

19 MR. ULSES: It's the resolution.

20 DR. CORRADINI: Okay.

21 DR. BANERJEE: You've got two minutes to
22 finish.

23 MR. MARCHE-LUEBA: This is what the flow
24 did after - following the pump trip. And if we didn't
25 blow-up, but you can see the quality of the flow and

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1 the flow outer face as they're supposed to be, and it
2 follows isolation. So that was basically what we
3 wanted to show you, that we did spend a week trying to
4 get the stability case running. To do it right, our
5 estimate is it would take six months.

6 DR. BANERJEE: It's a question of we're
7 getting a lot of these -- this is not going to be
8 disposed of generically, so in a sense --

9 MR. MARCHE-LUEBA: That is correct.

10 DR. BANERJEE: -- by the time you start to
11 get plant-specific applications, we should be in the
12 position to the consummatory analysis, I think.

13 MR. MARCHE-LUEBA: It takes a lot of time
14 to do plant-specific data, it doesn't take us much to
15 run it.

16 DR. BANERJEE: Well, you know what the
17 plant-specific applications are that's coming in.
18 Right?

19 MR. MARCHE-LUEBA: We would have to be --

20 DR. BANERJEE: There are three or four of
21 them. Right?

22 MR. MARCHE-LUEBA: We'll have to start
23 working on them.

24 DR. BANERJEE: Yes. Anyway, let's -- do
25 you have any last parting comments to make? Thank

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1 you.

2 MS. ABDULLAHI: The comment I have is, the
3 Brown's Ferry Deck is here. And if you notice, we are
4 recommending that research assessment include reactor
5 core fuel performance analysis at MELLLA+ condition.
6 Okay? We, or the staff, or the reviewer of this
7 generic analysis do understand that, and anybody who
8 is doing an analysis would like to see the actual
9 analysis confirmed. And the tool I think we do
10 recommend that we do get those analysis provided, and
11 research, instead of worrying - this is now personally
12 speaking - instead of worrying about new reactors that
13 we don't have it, a bird in the hand is better than
14 two on a tree.

15 DR. BANERJEE: We understand.

16 MS. ABDULLAHI: We should spend time on
17 operating reactor. This is a deck of Brown's Ferry,
18 deck, and I would like to see that effort be done so
19 that staff have good confidence and a code be frozen
20 for operating BWRs. That's my two-year, three-year
21 frustration talking. And I would also like to
22 recognize that the TRACE work was also done by a lot
23 of other people with Research, with Tom Downer, and
24 Joe Stodemayer. And who were the other involved? You
25 were involved.

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1 MR. MARCHE-LUEBA: The University of Penn
2 State have been working on this for the last year.

3 DR. BANERJEE: Well, Downer has left
4 Purdue right now.

5 MR. MARCHE-LUEBA: Yes.

6 DR. BANERJEE: They've self-destructed at
7 Purdue.

8 (Laughter.)

9 DR. CORRADINI: You're on the record.
10 Let's just leave it, that he's left Purdue.

11 CHAIRMAN SHACK: Can we move on?

12 MS. ABDULLAHI: I'm finished. Thank you
13 very much.

14 DR. BANERJEE: Thank you. Thank you. All
15 right. So I guess the Full Committee will have to
16 consider whether to write two letters or one letter,
17 whether we feel MELLLA+ is ready for a letter, even,
18 right now.

19 CHAIRMAN SHACK: Well, it's hard to write
20 a letter on MELLLA+ without approving the methods that
21 you're using to analyze.

22 DR. BANERJEE: We have to start with the
23 methods. The issue is, of course, that there are --
24 we've not even really touched on the limitations,
25 that there's been a lot of discussion of that in the

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1 subcommittee meeting. So the Full Committee will have
2 to decide whether they want to go forward with all
3 these limitations, and all these things with MELLLA+,
4 as well as the methods.

5 With regard to the methods, I think the
6 reactor physics stuff was pretty well verified and
7 confirmed. You got a good warm feeling about this.
8 I don't know if the rest of the subcommittee felt that
9 way. We found that staff had done really excellent
10 work on confirmatory analysis.

11 With the thermal hydraulics, I think GE
12 presented a fairly convincing case about TRACG, by and
13 large, but there was very little confirmatory analysis
14 done, which probably is frustrating to the staff.
15 They would liked to have done it, but they couldn't do
16 it.

17 And then with regard to the fuel, the
18 staff started to do some confirmatory analysis. They
19 recently only brought in Carl Beyer to look at this,
20 and did some FRAPCON runs and things like that. If
21 that is excluded in some way, you'd have to look at
22 the language in detail. Then the sense of it is
23 they've got that handled in some way right now. So
24 you have to decide, and we can have a separate
25 discussion on this.

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1 Are there any issues and questions you'd
2 like to bring up, either for GE or the Staff right
3 now?

4 CHAIRMAN SHACK: On that fuel thing, I
5 mean, I do read the thing that when they include the
6 uncertainties, they get an adequate prediction. I
7 mean, you may have desires for a better model, but
8 living with their penalties, they seem to get
9 acceptable results. Is that a correct conclusion?

10 MS. ABDULLAHI: Yes. These are
11 significant margins that is included. And the reason
12 is because of the fact that we're going outside the
13 experience base, that we're taking these prudent
14 approaches.

15 DR. BANERJEE: And the other thing which
16 we should consider is that the staff and GE didn't
17 speak to it, but some of these events like ATWS, which
18 is outside the design basis, are also very low
19 probability, but they did speak about this in the
20 subcommittee meeting.

21 All right, sir. I'm going to turn this
22 back to you.

23 DR. MAYNARD: I have one - and I apologize
24 if I missed this. Implementation of MELLLA+, does it
25 result in any set point changes? Do we reduce reactor

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1 trip set points, add run backs or anything?

2 DR. BANERJEE: Zena or Jens?

3 MS. ABDULLAHI: Set point changes in --
4 yes, there would be scram set point changes, there
5 would rod block set point changes. There would be --

6 I suppose other issues that we were bringing up is
7 they may even have to deal with changes on the SRVs.
8 But when you design the core, you want to operate at
9 that bundle of power, you do the analysis to support
10 it, and you find you can't meet the requirement, then
11 you have to make changes. What I believe it doesn't
12 need is changing your turbine. They've already done
13 that. In other case, the EPU part was mostly done, is
14 the impact of the reduced flow that they have to deal
15 with now.

16 DR. ABDEL-KHALIK: But that's an output of
17 the plant-specific analysis.

18 MS. ABDULLAHI: Yes.

19 DR. BANERJEE: However, as was mentioned,
20 the methods part of it impacts all the EPUs. I mean,
21 we really need to deal with that. MELLLA+ maybe is
22 going to come along a little bit later, but EPU is
23 right on top of us right now.

24 MS. ABDULLAHI: In terms of set point, I
25 was talking about flow dependent scram set points and

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1 stuff like that. GE, do you want to comment on that?

2 DR. MAYNARD: My question on set points,
3 I know you would have to change some set points just
4 to actually take advantage of MELLLA+. I'm talking
5 about for safety margin, are we changing some set
6 points to gain some margin outside of just actually
7 what it takes to physically be able to operate in
8 those conditions?

9 MR. JACOBS: This is Randy Jacobs. No, we
10 primarily need to change the flow biased set points to
11 move them away from the power flow map boundary, so we
12 can extend it. But we're not trying to reduce set
13 points to get better margins that way.

14 DR. ABDEL-KHALIK: The language that the
15 staff and GE agreed to with regard to the plant-
16 specific ATWS stability, is this going to be made
17 available to the committee before we start
18 deliberation?

19 CHAIRMAN SHACK: Yes.

20 MS. ABDULLAHI: On NRC's part, yes, we'll
21 work with GE to get there. And I suppose GE agrees
22 with me on that.

23 DR. MAYNARD: Again, I think we can also
24 have -- if we don't have that, that could be something
25 we could specifically put in our letter, that that's

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1 what we would expect.

2 CHAIRMAN SHACK: We want it to say,
3 whatever it does say, we can put in what we want it to
4 say.

5 DR. BANERJEE: Okay.

6 DR. BANERJEE: Okay. Then I think we can
7 finish this session. Thank you very much for your
8 patience and very good presentations. I read the
9 transcript of the thermal hydraulics meeting. That
10 must have been an enjoyable event.

11 (Laughter.)

12 DR. BANERJEE: How did you read it? I
13 just got the transcripts.

14 CHAIRMAN SHACK: I got it from Zena.
15 Well, her summary, I should say, or Ralph's summary,
16 whoever put it together. It was an excellent summary
17 that came out very quickly, so I appreciate that very
18 much, because it sort of got me a little bit ahead of
19 the game here.

20 I'd like to break for lunch. If can come
21 back at 1:30, for our PHEBUS presentation.

22 (Whereupon, the proceedings went off the
23 record at 12:35:31 p.m., and went back on the record
24 at 1:31:28 p.m.)

25 CHAIRMAN SHACK: Back in session. Dr.

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1 Kress.

2 DR. KRESS: Okay.

3 CHAIRMAN SHACK: That was quite a
4 protracted introduction.

5 DR. KRESS: Yes, aren't you going to tell
6 everybody what my qualifications are, or anything?

7 CHAIRMAN SHACK: No, they might leave.

8 (Laughter.)

9 DR. CORRADINI: I can tell he doesn't like
10 people on the right.

11 DR. KRESS: This briefing is what it is,
12 and there's no letter or any obligation we have. What
13 it's for --

14 DR. APOSTOLAKIS: Except for paying
15 attention.

16 DR. KRESS: Yes, pay attention,
17 definitely, because you'll find out this is very, very
18 interesting stuff. I don't think you will --

19 DR. BANERJEE: And also because you're
20 spending a lot of money.

21 DR. KRESS: Yes, that's right, but it's
22 well worth it. This is a remarkable program. I would
23 characterize it as a severe accident source term
24 program. Those are hard to do, not many of them left.
25 This one has been going on for a number of years, and

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1 NRC is a participant in this international program
2 being conducted at Cadarache. They're finding out
3 some very interesting things about source term, and I
4 think this is mostly for getting us up to speed in the
5 severe accident area, so that we can be aware of
6 what's going on, and what the new results may be
7 telling us.

8 So with that non-introduction, I'll it
9 over to Richard Lee.

10 MR. LEE: Well, thank you, Tom. And I
11 also have the pleasure to introduce to you Bernard
12 Klement from the Institute of Radiological Protection
13 and Nuclear Safety from France. And Bernard has been
14 involved with the PHEBUS project since inception, the
15 design of it, the conduct of experiments, and also
16 analysis, so he's basically know practically all the
17 things happen in the experiment, as far as all the
18 analysis that has been done. So thank you for showing
19 up.

20 DR. APOSTOLAKIS: Is he spending some time
21 with you?

22 MR. LEE: No. He came in for a different
23 meeting, the discussion on the following project that
24 you will hear at the very end of this meeting here.

25 DR. KRESS: You don't want anything out of

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1 us, like a letter, or just a name --

2 MR. LEE: No, I just wanted to make sure
3 Mike pay attention, that's all.

4 DR. APOSTOLAKIS: Even if the letter says
5 this is the greatest thing the NRC ever did? You
6 still don't want a letter? That's putting you on the
7 spot.

8 (Laughter.)

9 MR. LEE: Okay. You can ask Farouk, then.
10 I think we also sent the committee a short write-up
11 about a month ago, and I think all members have
12 received a copy of it. You will see that the
13 introduction gave a quite lengthy introduction to
14 severe accident your agency has undertaken since the
15 TMI, to set background so you know why we participate
16 in this project.

17 Now following the TMI accident, we found
18 out that TID-14844 source term that was developed back
19 in 1962 really did not give the results that when we
20 compared the predictions from the TID source was and
21 what we find at TMI are completely different. For
22 example, the iodine release was very, very low. If
23 you use the TID source term, that is not what you will
24 get.

25 And then the Commission then asked

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1 Research, can we develop a more realistic source term?
2 And then if this source term can be smaller, and can
3 be used for reactor licensing. And the answer from
4 the Research staff is that we don't have enough
5 information to develop this source term, but it is
6 possible to develop such a more understanding on the
7 source term itself, and the Commission told Research
8 to do so. And at that time, Chairman Ahon directed
9 Research to proceed with the research on source term.
10 And at that time, the budget estimate was about \$50
11 million that the Research told the Commission, but
12 they said no.

13 (Laughter.)

14 DR. CORRADINI: That was in 1950 dollars?

15 MR. LEE: This is 1980s.

16 (Off the record comments.)

17 MR. LEE: For example, the PBF and so
18 forth are very, very expensive.

19 DR. APOSTOLAKIS: What does system-level
20 modeling mean? The very last sub-bullet.

21 MR. LEE: Basically, is that, for example,
22 I'm going to go into more of this. We can talk more
23 on the phenomenological, separate FAC test.

24 DR. APOSTOLAKIS: Can you remind me the
25 first bullet, the mechanistic understanding did not

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1 exist.

2 MR. LEE: Because in the TID-14844, it's
3 basically some very crude experiment that we did using
4 fuel fragments and look at the releases. And the
5 development was based on that, and the TID source term
6 for determining the iodine release. Most of them are
7 in gaseous form. So you have a very large gaseous
8 iodine going into the containment, and the aeros form
9 is very small, and you will see that later in the 90s
10 when we revised the source term, that composition
11 change based on further understanding, based on the
12 research we had done subsequent to the TMI.

13 Now to put it in perspective, at that same
14 time, after TMI there was a Sandia siting study was
15 done, and it was NUREG-2239 published in 1982. And
16 then, basically, that study was undertaken to answer
17 the questions that if we really know the source term
18 better, can we do the consequence analysis better?
19 And for that study, what they did is that they assumed
20 a very large source term, they assumed a very low
21 source term, and then looked at the consequence. And,
22 of course, the results show that the source term
23 affects the consequence. So that is nothing
24 surprising, but this also tells you that it's
25 worthwhile to undertake severe accident research. And

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1 as you know now, that siting study was coded by people
2 taking parts out of it, depends you pick the worst 95
3 percentile of the releases, worst source - how do you
4 call it, the source term so you can calculate very
5 large postulated debt, so the Commission, as you know
6 now, has directed staff to redo this analysis based on
7 20 years of --

8 DR. APOSTOLAKIS: So what did NUREG-1150
9 use, the Sandia study?

10 MR. LEE: No.

11 DR. APOSTOLAKIS: It was a different
12 evaluation? What --

13 MR. LEE: It was a different evaluation.
14 You will see that.

15 DR. APOSTOLAKIS: No, it was more than
16 that.

17 MR. LEE: It's more than that. The source
18 term code package after the TMI, we developed a source
19 term code package. So, basically, the source term
20 code package linked between models to examine the
21 releases, the transport in the primary system into the
22 containment, so you have different modules now. It's
23 the first set of things that we linked together all
24 the source term calculation into containment, and into
25 the --

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1 DR. APOSTOLAKIS: So when you refer to the
2 source term package, and you're saying 14844, is this
3 a stylized source term for licensing purposes?

4 DR. KRESS: Is no longer exists, George.

5 DR. APOSTOLAKIS: What?

6 DR. KRESS: It no longer exists. He's
7 giving you history.

8 DR. APOSTOLAKIS: I understand that.

9 DR. KRESS: It's been replaced by MELCOR.

10 MR. LEE: Yes. It's a computer code for
11 calculation, so you can systematically calculate
12 different sequence for --

13 DR. APOSTOLAKIS: That's what it was, for
14 licensing.

15 DR. KRESS: No. No.

16 MR. LEE: It was used for NUREG --

17 DR. KRESS: It was part of the NUREG-1150
18 background.

19 DR. APOSTOLAKIS: What was part, the --

20 MR. LEE: This code was used for the
21 analysis of source term.

22 DR. APOSTOLAKIS: 14844.

23 MR. LEE: 14844 is a report, based on
24 sudden experiment. There's no analysis. It's not a
25 calculation.

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1 DR. APOSTOLAKIS: And that was for
2 licensing purposes, or what?

3 DR. KRESS: They used it for siting.

4 DR. CORRADINI: That is the background
5 document for current plant siting, is it not?

6 DR. POWERS: Nearly all of them are
7 licensed originally on 14844.

8 DR. APOSTOLAKIS: Okay.

9 MR. LEE: That's what it's for.

10 DR. APOSTOLAKIS: Okay.

11 MR. LEE: Original licensing.

12 DR. APOSTOLAKIS: Okay.

13 MR. LEE: And plants now can use that
14 model, or they can use the new one.

15 DR. KRESS: And they talk about -- George,
16 when they talked about the fission products that go
17 into containment, that you have to meet 10 CFR 100 at
18 the site, that's what they originally used.

19 DR. APOSTOLAKIS: Exactly.

20 MR. LEE: Correct. That's what it is, for
21 Part 100.

22 DR. APOSTOLAKIS: And now they have the
23 option to use MELCOR.

24 DR. KRESS: 1465.

25 MR. LEE: 1465.

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1 DR. KRESS: Is the option. No option to
2 use MELCOR.

3 DR. APOSTOLAKIS: Oh, no option.

4 MR. LEE: No.

5 DR. KRESS: Well, they might want to if
6 they want to do a risk --

7 CHAIRMAN SHACK: Yes, a full-fledged Level
8 3 PRA.

9 DR. CORRADINI: You're talking only
10 siting.

11 DR. POWERS: It's used in an awful lot of
12 things.

13 DR. KRESS: It's used for containment.

14 DR. CORRADINI: Maybe I -- I didn't mean
15 to phrase it that way, but I guess what I was saying
16 is that for an advanced plant, ESBWR, 1465 is the
17 equivalent of 14844.

18 DR. KRESS: Yes.

19 DR. CORRADINI: For that application. And
20 your point is, there are other applications that 1465
21 is useful for.

22 DR. KRESS: Exactly.

23 MR. LEE: Yes. We're going to go into
24 that a little bit. So after the source term code
25 PakNet was developed, we use it for the 1150.

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1 Actually, a lot of results were used to synthesize the
2 NUREG-1465 source term, as well, too. Okay? And if
3 you look at the next viewgraph, compared to the WASH-
4 1400 study, you will see that this is the -- WASH-
5 1400, these are the points. And you will see that for
6 PWR, is basically -- the WASH-1400 envelope this
7 uncertainty that you see from the 1150 studies. Okay?
8 And you can see that a group of different isotopes,
9 classes that are predicted for --

10 DR. APOSTOLAKIS: So in a sense that was
11 more conservative. Right? The reactor safety study
12 was more conservative.

13 MR. LEE: Yes.

14 DR. APOSTOLAKIS: But not really
15 outrageously conservative.

16 DR. KRESS: It depends on where you are on
17 that uncertainty band.

18 DR. APOSTOLAKIS: Well, I mean they're
19 consistently above the 95th. I mean, it's not that
20 they're way out there. They are conservative.

21 DR. CORRADINI: One is the upper limit --

22 DR. POWERS: It's the wrong scale, George,
23 so being a little bit above is a factor of three.
24 Above the 95th percentile.

25 DR. CORRADINI: I should know this, but I

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1 can't remember. So everything from yellow to red is
2 the various release categories, so PWR-1 release is
3 equivalent to -- I should know that, but I'm not
4 asking that right now. In the reactor safety study,
5 the little triangles that you point out there is the
6 highest release category, because there were nine
7 release categories in the reactor safety study, were
8 there not?

9 MR. LEE: I believe that is the --

10 DR. POWERS: Yes, this particular plot
11 comes out of NUREG-1150, and they're trying to compare
12 similar categories.

13 DR. CORRADINI: So this was a similar
14 release category?

15 DR. POWERS: Right.

16 DR. CORRADINI: Okay.

17 DR. POWERS: The way they bin things up.

18 DR. CORRADINI: Okay.

19 DR. POWERS: I mean, the issue was at the
20 time people thought that the reactor safety study
21 might have been overly conservative. And, certainly,
22 in the case of the PWR, for this particular category,
23 and it turns out for all the categories - yes, you
24 could argue the reactor safety study was pretty
25 conservative. It turns out not to be the case with

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1 BWR.

2 MR. LEE: And as you can see, the next
3 one, as Dana said, you can look at the -- because in
4 the BWR there's a lot of zirconium, so there's huge
5 source term releases at the expense of part of it, so
6 you see that WASH-1400 is over here, and the spread is
7 pretty big.

8 DR. APOSTOLAKIS: What's the reason for
9 that, again?

10 MR. LEE: In most of the coding, so when
11 you develop the source term codepackage, when you do
12 the calculations you melt and freeze the lower head,
13 and you go out into the containment, you have melt-
14 proof core-cooling actions, and it's a very vigorous
15 in action, so you have more fission particle releases
16 from the expensive part of it.

17 DR. KRESS: It's like I said, it was the
18 bad actor, and core is zirconium, not fission
19 products. It drives the steam oxide reaction that
20 melts the core, it drives the core-concrete
21 interaction, and creates the potential for FCI. This
22 person would know if it's -- so bad actor, so as long
23 as you don't get that zirconium down to the core.

24 DR. CORRADINI: So you said it, and I just
25 want to make sure. This is release into containment.

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1 DR. POWERS: No, these are releases to the
2 environment.

3 MR. LEE: These are into the environment.

4 DR. CORRADINI: Oh, excuse me.

5 MR. LEE: This is environment.

6 DR. ABDEL-KHALIK: And where do these big
7 bars come from?

8 DR. KRESS: This is expert elicitation
9 results.

10 DR. ABDEL-KHALIK: Okay. So there is no
11 data, so far.

12 DR. KRESS: Well, it's based on data to a
13 large extent.

14 DR. POWERS: These are all mechanistic
15 calculations done with a source term code package for
16 NUREG-1150, where they propagated the uncertainties in
17 key parameters through the calculation, and you get --
18 the result is an uncertainty band.

19 MR. LEE: That's what you did.

20 DR. POWERS: And it shows you the
21 magnitude of the uncertainty at conclusion of 1150.

22 MR. LEE: That's what it is.

23 DR. APOSTOLAKIS: But a good part of it is
24 expert judgment.

25 DR. POWERS: Whether it's expert judgment,

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1 or -- depends on what -- they identified lots of key
2 uncertain parameters, both in the accident initiation,
3 and in accident progression. They assembled panels to
4 elicit information. Now what the panelists did, some
5 cases they used their expertise. Be generous and say
6 they used their expertise. In some cases,
7 particularly in the source term panel, there were
8 extensive -- Dr. Kress was on it. I mean, there were
9 extensive analyses done, both by the industry and by
10 the non-industrial experts that results in
11 distribution functions that were actually propagated
12 to the 1150 calculation.

13 DR. CORRADINI: So I guess just to clarify
14 for Said, so since I was in the middle of it for the
15 containment one, Dana's point is, let's pick something
16 - let's take core-concrete interactions. So in core-
17 concrete interactions, there might have been an
18 uncertainty on the heat transfer between the molten
19 material and the concrete. So they got a bunch of
20 people in a room, and we argued for an extended period
21 of time. People ran away, did their own calculations.

22 DR. POWERS: Three days worth of
23 arguments.

24 DR. CORRADINI: Three days, and then came
25 back with their own calculations, argued some more.

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1 And basically came to a range of values for what that
2 heat transfer coefficient would be. That that went in
3 in a regimented way into the source term code package,
4 which then computed the effect, and then all the down
5 stream effects for source term blah, blah, blah, blah.
6 Is that approximately --

7 DR. POWERS: Yes. What they used the
8 source term code package for was to create a response
9 surface. And then the PRA generates what? I think
10 typically they ran about 2 million sequences for each
11 reactor, something on that order, and they could
12 locate them on this response surface. And then they
13 would subsequently bin them, and all the magic stuff
14 that gets done in these things. And come back and,
15 presumably, identify which of those parameters really
16 made a difference. And needless to say, source term
17 issues just came up bingo, right to the top of the
18 list.

19 MR. LEE: Okay. So that's why NRC
20 undertook a very extensive research program in many,
21 many areas and phenomenologically look at the type of
22 experiment we have done, steam oxidation of cladding,
23 fuel melting experiment at PBF, very expensive
24 experiment. They also did the full length heat
25 transfer experiment in Canada, so we're looking at 12

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1 foot long rods versus a 3 feet long rods that are used
2 in PBF. The core debris interactions with concrete
3 experiment was done at Sandia, of course, at Argonne,
4 too. And hydrogen research at Brookhaven. We did a
5 lot of work with the Russians, and then development of
6 models, I did Corcoran, Vanessa and so forth.

7 The direct containment heating was issues
8 that were resolved in the 90s. We did a lot of
9 separate effects experiment, and integral effects
10 experiment, as well at Sandia, Argonne, and Purdue
11 University. And we are -- most of these issues has
12 been basically - as far as U.S. is concerned, is
13 finished.

14 And this is also - if you look at the
15 phase diagram research that was done, basically, it's
16 telling you that before that, the melting temperature
17 is very high, like 3100 degree K. And we found out
18 that the experiment shows that these points are not
19 lined up in these lines here, as we predicted. The
20 mixtures melting temperature is much lower, so
21 currently, for example, in MELCOR using for the fuel
22 melting is like 2800, fuel relocation is like 2500 K.
23 And these experiments carried out not just in many
24 other -- for example, this is -- particularly, this
25 measurement is at the Transuranic Institute in

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1 Germany, and this plot is developed by the FCK.

2 Now we also know that the core melt
3 progression is not a uniform, when we do the source
4 term code package. In general, the core melt
5 progression is very uniform, but TMI showed that this
6 is really not the case. And, also, that the number of
7 nodes you use affects how the melt progression,
8 progress. For example, the source term code package
9 at that time was a March code. And usually, we melt
10 the core in about 30 minutes, now they use the melt
11 core calculations, takes hours, three, four, five
12 hours before the core melt.

13 DR. APOSTOLAKIS: Between what and what?

14 MR. LEE: From the onset of the falling
15 down the core.

16 DR. APOSTOLAKIS: So core uncovering?

17 MR. LEE: Core uncovering to melting the
18 fuel.

19 DR. APOSTOLAKIS: The full core?

20 MR. LEE: Yes, relocating it into the
21 lower plenum. Now we did -- if you look at some of
22 the experiment, we show you one of this experiment
23 that was done at Sandia. You will see the aerosol
24 production. There's a lot of aerosol experiments were
25 carried out in different area, different labs, too.

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1 And you can see from Sandia's, that you can see gas
2 generation here. You can see the aerosol here, and
3 you have see melt expulsion.

4 The recent experiment that we are doing
5 now at Argonne, you cannot see it because usually they
6 are not visual-type experiment, you cannot see the
7 MCCI phenomenon. So we're just showing you what it
8 looks like in one of the old experiment that was
9 conducted at Sandia.

10 Now, basically, by the time we conclude
11 the NUREG-1150 report in 1990, that we know that the
12 fuel melt releases from fuel for fission products, we
13 cannot use trace-irradiated fuel, or dosimensions that
14 we put into fresh fuel and try to do the releases
15 measurement. The Germans have undertaken such
16 experiment, and we found out that when we did it with
17 the irradiated fuel, the behavior is completely
18 different because when you dope the fuel, the
19 initialization of the fission products where it's
20 located, it's very different. Also, you don't have
21 the network of power for fission products come up when
22 you have irradiated fuel. So we know that the
23 kinetics are higher in irradiated fuel.

24 We also know that molten cladding and
25 actions with fuel. And in the past, we have ignored

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1 the retention of fission products in the cooling
2 system, but in the one we're doing, NUREG-1150, we do
3 know that we have to take that into account. We also
4 know that the retention, whatever chemical species or
5 fission products deposit in later time can also come
6 up.

7 In term of aerosol physics area, I think
8 the NRC research really set the stage for the aerosol
9 physics monitoring for the whole entire field, because
10 before that, they were using the Mormon methods. And
11 if you look at the aerosol behavior, you have a fresh
12 aerosol coming out. There's aged aerosol which is
13 starting to grow, so you really have a bi-modal
14 distribution. But if you use the Mormon method, and
15 you combine the super position, the highest maximum
16 value is the middle of the distribution, and actually,
17 there's no aerosol size in that range. So went to a
18 section of methods, and subsequently the aerosol where
19 were used in the chemistry, in the chemical industry
20 or other application, they adopted that method. So
21 NRC set the stage for aerosol physics.

22 DR. BANERJEE: What is new about this?
23 What was the innovation?

24 MR. LEE: The innovation is that we found
25 out the methodology how to model aerosol physics has

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1 to be changed from the old method.

2 DR. BANERJEE: What is the old method, and
3 what is the new method? Just a matter of interest --

4 MR. LEE: The old method is a moment
5 method, so basically, it's waiting -- if you have a
6 distribution look like this, and you have a
7 distribution look like this.

8 DR. BANERJEE: Right, right.

9 MR. LEE: So you add it up, it's in the
10 middle. But in the containment, the fresh aerosol has
11 a size distribution, and you look at maximum, it's at
12 the lower end. We have one in the higher end.

13 DR. CORRADINI: It would be the equivalent
14 of energy groups in neutron in reactor physics. In
15 the original aerosol physics, they had essentially --

16 DR. BANERJEE: Friedlander was doing this
17 a long time go.

18 DR. CORRADINI: Right. But they
19 essentially had -- in the old days, they essentially
20 had one -- the equivalent of one energy group, or two
21 energy groups. And now the sectional method is they
22 have 100 energy groups, or 1,000 energy groups, so
23 they have 1,000 length scales, and they track the
24 length scales and all the physics that goes with the
25 length scales. Basically, that's it.

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1 DR. BANERJEE: It's been in the literature
2 for a long time.

3 DR. CORRADINI: It's harder with all the
4 chemistry, it's quite harder.

5 DR. BANERJEE: You mean John Seinfeld and
6 people like that weren't doing this before?

7 DR. CORRADINI: I don't know those people,
8 but I think I know who Richard is speaking about,
9 Profession Lioka, a number of people that were at
10 Sandia. I'm trying to think of the gentleman who
11 wrote MEROSE for MELCOR.

12 DR. POWERS: Gil Barden.

13 DR. CORRADINI: Gil Barden.

14 DR. APOSTOLAKIS: Friedlander from UCLA
15 was part of it.

16 DR. CORRADINI: Right.

17 DR. BANERJEE: Yes. Shelley was doing
18 this stuff a long time ago. But, nonetheless, you
19 adopted it for use.

20 DR. POWERS: To be absolutely accurate,
21 they just revolutionized the field.

22 DR. BANERJEE: They did?

23 DR. POWERS: Oh, yes. Yes, I mean the
24 whole business of calculating the dynamic equation,
25 everybody was using moments methods in the past, and

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1 now nobody uses moments methods. Though,
2 interestingly, I saw a paper trying to resurrect it
3 just recently, but --

4 DR. BANERJEE: I guess if you get enough
5 moments, you get the same thing.

6 DR. POWERS: Well, no. You almost never
7 can because we always have situations of fresh aerosol
8 coming in, and it does just what Richard says, is the
9 moments method puts the mean right where you have no
10 particles.

11 DR. BANERJEE: Right.

12 DR. POWERS: So you always get the wrong
13 answer.

14 DR. BANERJEE: But if you get higher and
15 higher moments, eventually you get the --

16 DR. POWERS: Yes. This is whether it's
17 convergent or not. And they're never convergent.

18 MR. LEE: I think this is akin to in the
19 thermal hydraulics area when we are doing Appendix K,
20 and as you embark on developing all the tools for
21 instrumentation, because there are no instrumentation
22 out there that can measure the superheat, for example,
23 that we developed at Lehigh University, other laser
24 other of these are methods that we look at droplet
25 sizing and so forth. And the drag test that we use in

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1 measuring the moment of flux going through the bundle
2 and so forth.

3 DR. BANERJEE: There were a lot of
4 experiments.

5 MR. LEE: It's a very intensive experiment
6 that we did and depending on the minor that one. And
7 this is one area in severe accident that NRC took the
8 lead, and other people adopted our work.

9 And also, in iodine behavior, we know that
10 particulates as was a gas, both of those exist, so you
11 have to deal with both --

12 DR. APOSTOLAKIS: Which isotope is this?

13 MR. LEE: We're talking about iodine.

14 DR. APOSTOLAKIS: Which isotope?

15 MR. LEE: 131. And then we talk about --
16 we know that in the area of revaporization and
17 resuspension of materials, of deposit materials, we
18 know that you can have prolonged releases of fission
19 products during the late in-vessel part of it. And I
20 am sure that PHEBUS is still looking at that at this
21 time.

22 DR. KRESS: It might be of interest to
23 note that with respect to the aerosol physics, the
24 only code that doesn't use that method is the MAPP
25 code, which is used by everybody in industry to do the

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1 calculation.

2 DR. CORRADINI: Which is a moment.

3 DR. KRESS: No, it's more of an empirical
4 method.

5 DR. CORRADINI: But isn't it derived or
6 calibrated --

7 DR. KRESS: It's related to the moment
8 method. It's not a bad -- I don't mean to be
9 derogatory. I can do a pretty good job.

10 DR. CORRADINI: We didn't sense that.

11 DR. KRESS: It can do a pretty good job,
12 actually.

13 DR. POWERS: Provided you have the answer.

14 DR. KRESS: Yes. Provided you already
15 have the answer, right.

16 MR. LEE: And MAPP is also used
17 extensively in Europe's nuclear industry, over there
18 at the utilities.

19 Now also, experiment was done at Sandia
20 looking at Cesium Hydroxide interaction with Stainless
21 Steel. And noted that at high temperature, even
22 though you have a protective layer, it does not
23 prevent the Cesium to crack the stainless steel. But,
24 of course, in the inert atmosphere argon, you don't
25 see any attack.

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1 DR. ABDEL-KHALIK: What do these pictures
2 show? What is it that we're looking at here?

3 MR. LEE: The Cesium, this is the initial
4 Cesium. These are some -- Dana, these are --

5 DR. POWERS: They're small stainless still
6 coupons in the pathway.

7 MR. LEE: And you expose it to Cesium
8 Hydroxide under certain temperature, and the flow
9 comes in here, and they expose it. These are excess
10 temperatures here with steam. And you can see this
11 one here at high temperature, start to -- the
12 stainless steel start to degrade. And this is under
13 inert conditions.

14 Just telling you that there's a lot of
15 experiments to study about different fission products
16 interaction with surfaces. Stainless steel is one of
17 it. I don't know whether they have done any on
18 Inconel. And this is showing how the Cesium and
19 Silicon interactions in the layers of the Stainless
20 Steel. You can see that here, Cesium forms this
21 Cesium Silicate Oxide, and they also found the same
22 type of materials compounds at the TMI.

23 DR. ARMIJO: Is that an appreciable amount
24 of Cesium, or just a small amount of the total that
25 can get tied up with the --

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1 MR. LEE: There's plenty of Cesium in the
2 system, so you can tie it up with it.

3 DR. POWERS: Probably about ten times over
4 --

5 MR. LEE: Ten times more than --

6 DR. POWERS: More Silicon than what you
7 need to have for Cesium.

8 MR. LEE: The next viewgraph show you that
9 our predictions of aerosol versus data. And these are
10 very large scale multi-component containment models,
11 and you can see that the predictions versus the data
12 show that we did very well.

13 DR. ABDEL-KHALIK: And these are totally
14 a priori calculations.

15 MR. LEE: Yes. As a matter of fact, these
16 are blind calculations. And as a matter of fact, the
17 characterization of the aerosol that was introduced in
18 the volume was not quite well characterized, but
19 despite of that, you can see the prediction versus the
20 data. So just telling you that our modeling of the
21 aerosol calculations are pretty well. And the other
22 one is another multi-component showing you at
23 different compartments, the MELCOR prediction versus
24 the data. And, Randy, I don't remember what CSE --

25 MR. GANT: Containment Spray Experiments,

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1 I think is what that stands for. Very old test
2 facility.

3 DR. CORRADINI: These are the old Hanford
4 tests.

5 MR. LEE: Okay. Now we come to 1995. We
6 published NUREG-1465, alternative source term to the
7 TID-14844, and the synthesis of those thing was based
8 on, we used a lot of analysis that was done back in
9 using the source term code package. And still some
10 additional MELCOR analysis, too, but not that many to
11 synthesize this source term. And you can see now
12 there are different pole phase of it. There's a gap
13 release, there's in-vessel release, and ex-vessel, and
14 the late releases that are coming from revaporization
15 of fission product that were deposit onto the circuit.

16 DR. CORRADINI: Can I ask a question
17 that's a little bit off topic, but just so I
18 understand? So just to link back to MELLLA+, stay
19 with me. My question really is, is there a difference
20 in assumptions? So in their case, when they were
21 going over their critical power ratio, and if .1
22 percent of their rods went above critical power ratio,
23 they assumed fuel failure. What was released? Just
24 the gap release?

25 DR. ARMIJO: Yes.

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1 DR. CORRADINI: Okay. That was my
2 question.

3 DR. ARMIJO: Nothing melted.

4 DR. CORRADINI: Nothing else.

5 DR. KRESS: I'd like to point out that
6 putting together this NUREG-1465 out of the NUREG-1150
7 results was done to a great extent by our good friend,
8 Hossein Nourbaksh. You did a fine job, Hossein.

9 MR. LEE: And then we also did research at
10 -- Tom Kress, at that time, was at the Oak Ridge.

11 DR. KRESS: Who?

12 MR. LEE: Someone.

13 DR. POWERS: You were saying he was still
14 useful in those days.

15 MR. LEE: We were looking at the chemical
16 form of the --

17 DR. KRESS: I did real work back then.

18 MR. LEE: -- of the gaseous iodine. We
19 did a lot of calculations. We synthesize this last
20 statement over here, the 5 percent gaseous iodine was
21 being gaseous, and 95 percent being particulate. And
22 there is a separate report that was published for this
23 conclusion here. So, actually, 1465 really entailed
24 many, many research put together into synthesizing the
25 source term, the so-called alternative source term.

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1 This is just showing you one of the
2 samples from the boiling water reactor. Okay? And
3 you can see there's a duration related to the full
4 phase of the releases. These first two columns here
5 actually used in the Reg Guide 1.83 for design-basis
6 source term analysis to comply with the siting Part
7 100. These are -- for PWR there's another table for
8 that, and these are the one that they're using.

9 DR. CORRADINI: And if you lined up 14844
10 along that, if I remember correctly, noble gases were
11 100 percent, halogens were what, 50 percent, or 25
12 percent?

13 MR. LEE: I think --

14 DR. KRESS: Fifty.

15 DR. CORRADINI: Fifty?

16 DR. KRESS: I think it was closer to --

17 DR. CORRADINI: And all the solids, all
18 the lanthanides, alkaline metals and such were 1
19 percent, or of that order?

20 DR. KRESS: Yes.

21 MR. LEE: The TID don't have too many
22 specifications on that.

23 DR. CORRADINI: So except for the alkaline
24 metals, which is higher here, everything else here by
25 investigation has been reduced as an alternative

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1 source term. Is that --

2 MR. LEE: I think basically, the total
3 amount really don't differ that much between the TID
4 and this one. What's important is the timing part.

5 DR. CORRADINI: Right. Yes, I understand
6 that part. I understand. But the way you phrase it,
7 I just wanted to make sure it's in that same bin, is
8 that if I did it for siting, it would be the sum of
9 the first two columns. And that would be compared to
10 14844, which --

11 MR. LEE: That's the one they use.
12 Correct.

13 DR. CORRADINI: Thank you.

14 MR. LEE: You can use that. You can
15 grandfather it, you don't have to do anything with
16 that. You can stay with the 14844 source term, or you
17 can use this one. It will be the first two.

18 DR. CORRADINI: But or the advanced
19 reactors, they have no choice. They will go with
20 this.

21 MR. LEE: I believe that's what I was
22 told, yes. And this is -- a lot of people -- I mean,
23 some utilities are using this for many relief from the
24 tech spec requirement and so forth. Changes were made
25 after this publications for the diesel generator

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1 start-up time. Remember, that we give them relief in
2 that area, starting very fast, we said now you can
3 delay it longer, so it's better for the equipment's
4 performance, and probably improve the plant safety.

5 DR. CORRADINI: If I might ask just one
6 other connected question. Then the signing criteria
7 is such that you still must assume a certain leap
8 rate, which is the same.

9 MR. LEE: Those are the design, whatever
10 the plant is. Dose remain the same.

11 DR. KRESS: Remember this is in design-
12 basis space.

13 MR. LEE: These are design-basis accident
14 --

15 DR. KRESS: You do something different in
16 PRA space.

17 MR. LEE: We're talking about design-basis
18 accident. These are used for design-basis accident.
19 But for MELCOR example, we don't need to use any of
20 this. We calculate - it depends on the whole sequence
21 so we have all the phenomena that we can calculate.

22 So at the completion of 1150, at that time
23 we said the understanding of severe accident is
24 adequate for regulatory needs, but we need to refine
25 more in terms of laboratory analysis, that we need to

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1 know more about specifics area.

2 Now we also found out that we were doing
3 all these in-pile testing, they are very expensive, so
4 we couldn't afford to do too many of those tests. Now
5 if you look at the Sandia experiment that we done with
6 Cesium, you can put Iodine, and then you have a
7 surface, but there are so many combination you can do
8 that it's not possible to do all the chemical species
9 that you know that can exist. So it's really very
10 intensive, so we couldn't do all the separate effects
11 experiment.

12 Then we went into doing -- we developed a
13 Victoria code as you remember back in the 90s. We
14 look at the calculation, there are so many chemical
15 species that the code is predicting, we don't know
16 which one is more important than the other, so
17 basically, we need to have some guidance on what are
18 the prototypic source term you can find. We should be
19 focusing on for the system level code by MELCOR. So
20 it came up, and what came along back in the '89 time
21 frame is that the French invite us to join 2:10:46)
22 project. So we saw the opportunity that we would be
23 able to get some prototypic data from that facility,
24 so we at least know what type of chemicals form off
25 the fission products, and what are the ones that we

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1 should focus on for the code.

2 If you look at the current strategy now,
3 if I may go to the next one, this show you the
4 programs that are involved with this past many years.
5 Some of them are coming to conclusion, like this one
6 here is finishing up this year. And what is the
7 output from this program, and what we use it for
8 validation, and what it is used for application. So
9 this show you the experiment, the validation, and the
10 application.

11 PHEBUS is the one that we were constantly
12 talking today. The OECD MCCI is still ongoing at
13 Argonne. This one came to a conclusion, and this one
14 already finished. And there are two codes that we are
15 maintaining now, is the MELCOR and then we have for
16 new action is the TEXAS code. And the usage of this
17 thing is shown here for the ARTIST. For example, we
18 are using it for the auxiliary test action, and we are
19 concluding that part very soon. So today, I'm going
20 to only talk about the PHEBUS part of it.

21 I think based on the information I've sent
22 you, I think you pretty know what the PHEBUS facility
23 is about. Am I correct? The facility is located in
24 Cadarache in France, south of France. And the main
25 objective of this, the test is really looking at the

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1 source term and fission products behavior in
2 containment, that is the main focus. But we also got
3 a lot of information about fuel degradation, because
4 of the tremendous amount of measurement that they did
5 after the test was completed. And you will see in
6 later part of the presentation.

7 There are certain -- the way that the
8 PHEBUS project ran, there was very extensive number of
9 people involved, different groups of people involved
10 with the analysis for a very long time in order to
11 understand what's happening. And it turned out to
12 work very well in terms of what we have observed
13 throughout this past 15 years of our involvement with
14 the project; even though a lot of meetings, sometimes
15 you have no idea where it is going. Many, many
16 presentation that has no bearing on any of the
17 analysis they were doing, but you have to sort through
18 those. In time, things start to fall out, and you
19 have some idea where it is, what the conclusions are.

20 There is a steering committee meeting, a
21 committee in charge of -- it's a management board,
22 basically. They are a scientific working group that
23 specialists in certain area that focus on certain
24 aspect of the experiment. Like, for example, the
25 bundle interpretation, they focus on degradation of

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1 the bundle, looking at the behavior of the experiment.
2 The prediction versus actual what happened. Because
3 before the test, they do a lot of cold calculation to
4 see what the outcomes, how much melt you will have in
5 this bundle, because they also need to go to the
6 regulatory bodies to get approval for the tests before
7 they're conducted.

8 And there is a whole group looking at just
9 containment chemistry. And then another group look at
10 the circuit which is the primary system, and the
11 containment aerosol, what does it mean the results?
12 And there are two meetings per year. The steering
13 committee, the management will only meet once a year
14 to approve all the recommendation that come out from
15 the other groups.

16 And this is the facility. It's 1:5000
17 scale of the French 900 megawatt electric PWR.

18 DR. KRESS: You don't want to know what
19 the scaling parameters were, Sanjoy?

20 DR. BANERJEE: I want to know.

21 DR. CORRADINI: We were waiting for this.

22 DR. BANERJEE: Tell us.

23 MR. LEE: Okay. But now you can elaborate
24 on it.

25 MR. KLEMENT: Yes, there are several parts

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1 that are scaled on this factor. First, the amount of
2 fuel, and that's also the amount of fission products
3 that are in the fuel. For the containment part, what
4 is scaled down at this factor is volume of the
5 atmosphere. The calculation between the atmosphere
6 and the sump water, and also, I need to explain maybe
7 with that - of course, for the scaling, the volume is
8 too small as compared with the surfaces here, so we
9 have introduced these cool surfaces here on which the
10 incoming steam will condense on these surfaces. And
11 this is scaled down to the same factor. These
12 surfaces here are slightly overheated to prevent any
13 steam condensation.

14 There is another part that is scaled down
15 at the factor. Here is the model of a steam generator
16 U-tube. While given the number of U-tubes you've got
17 in a steam generator, here it was scaling down terms
18 in one single U-tube here of 20 millimeters in
19 diameter. The height is not to scale down. We have
20 seen that most of the fission product deposition is in
21 the rodding part, so it was not too tight around the
22 U-tube like that. This is basically how it was done,
23 the scaling.

24 DR. CORRADINI: So to summarize, a typical
25 containment is 50,000 cubic meters divide by 5,000.

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1 MR. KLEMENT: Yes.

2 DR. CORRADINI: So that's the volume
3 scaling. But all the other scaling that they've been
4 doing is mainly time scaling, trying to get it from
5 Point A to Point B in approximately realistic timing
6 for fission product deposition.

7 DR. BANERJEE: But also, for surface area
8 per unit volume is important. Right? As well as
9 transit time in this, probably. What are the non-
10 dimensional groups that arise?

11 MR. KLEMENT: Okay. We have performed
12 five experiments. Okay?

13 DR. POWERS: You're eminently predictable.

14 MR. LEE: Okay. You can answer this.

15 MR. KLEMENT: Okay. We have performed
16 five experiments. Okay? Imagine all the number of
17 reactor sequences with different configurations for
18 the transport. We do not want to simulate that, so we
19 have always simulated one kind of sequence here for
20 the circuit, for the hot leg, steam generator, and the
21 cold leg, corresponding to a large cold leg break. So
22 it is also a sequence for which the retention in the
23 primary circuit Particulate system is not so high.
24 Most of it is in the steam generator, so we didn't
25 attempt to simulate everything that was happening in

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1 the reactor cooling system.

2 DR. BANERJEE: The steam generator has a
3 realistic surface to volume ratio.

4 MR. KLEMENT: Yes. And these, in fact,
5 are only transfer lines. Okay? And, in fact, it
6 appears that most of the deposition is here in this
7 part. It's really small here, very small here, so the
8 reactor transfer line, and there are also deposition
9 here just above the core where all the fission -- the
10 logic part of the fission product emitted as vapors
11 condense to aerosol. But this also happens in the
12 reactor core, in the upper plenum of the core. But
13 these are only transfer line with low deposits, so
14 they are not scaled down.

15 DR. BANERJEE: So why doesn't things
16 deposit in those lines?

17 MR. KLEMENT: Well, they are heated.

18 DR. KRESS: And they're high flow.

19 DR. POWERS: And particles don't like to
20 settle very fast.

21 DR. KRESS: No.

22 DR. CORRADINI: But there is no -- I guess
23 the other thing, I was reading the summary that was
24 provided to us, and I couldn't remember. There is no
25 carrier gas once you get out of the degradation state

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1 of the test bundle, and you come into the red area.
2 You add no carrier gas, it's just the steam and --

3 DR. KRESS: Steam and hydrogen.

4 DR. CORRADINI: -- and hydrogen that
5 carries it out. Okay.

6 DR. KRESS: And fission gases.

7 DR. CORRADINI: Right, and fission gas.

8 MR. LEE: And, of course, the facility is
9 extensively instrumented. And they tell you that the
10 very concentrated point is at Point C because this is
11 the point before you enter the steam generator, and
12 the point it exit the steam generator into the
13 containment, so they tried to characterize these two
14 points as much as they can. Of course, there's a lot
15 of other instrument in the containment, as well.

16 And this is about the size of the cup over
17 there, is about the size that you are contain, 21
18 rods. There are 20 fuel rods here, and there's a
19 control rod in here. These are several cadmium or is
20 a boron carbon rod. Except one test that's not of the
21 bundle, is a derivative test so none of these thing
22 apply.

23 This is showing you the camera
24 denseotometer measurements looking into the
25 containment vessel.

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1 DR. BANERJEE: So what does the
2 denseotometer show there?

3 MR. KLEMENT: The mass spectrometer.

4 DR. BANERJEE: Spectrometers.

5 MR. KLEMENT: Spectrometers, on line gamma
6 spectrometers.

7 DR. BANERJEE: So you actually know what
8 species are deposited by their gamma signatures.

9 MR. KLEMENT: Yes.

10 MR. LEE: It depends, right. Different
11 one.

12 DR. BANERJEE: I was wondering what a
13 denseotometer was.

14 MR. LEE: Is not denseotometer. I'm
15 sorry. Is a gamma --

16 DR. KRESS: Well, we have gamma
17 denseotometers to measure the aerosol concentration.

18 DR. BANERJEE: They do?

19 DR. KRESS: They do, yes.

20 DR. POWERS: Optically.

21 DR. KRESS: They use optical, that's
22 right.

23 DR. BANERJEE: Gamma denseotometer
24 wouldn't show much with an aerosol.

25 DR. KRESS: No.

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1 DR. POWERS: You can -- I mean, we often
2 do it.

3 MR. LEE: What do you say?

4 DR. POWERS: I mean, we've done gamma
5 densesotometry on aerosol.

6 DR. BANERJEE: Well, if the aerosol is
7 emitting a gamma, that would --

8 DR. POWERS: Yes, to look at the
9 attenuation in some circumstances. We've done that.
10 It's easier to do optical, but it's --

11 DR. BANERJEE: Yes.

12 DR. POWERS: But some cases, you have to
13 use gamma.

14 DR. BANERJEE: I should get you guys to
15 use some other methods than gamma. Anyway, carry on.
16 There are fairly high atomic number aerosols. Right?

17 DR. KRESS: Some of them, yes.

18 DR. POWERS: You betcha.

19 MR. LEE: Yes.

20 DR. BANERJEE: So the gammas would be --

21 DR. CORRADINI: Like Uranium. That's the
22 one that comes to mind.

23 MR. LEE: And this is -- also, you can see
24 that the extensive sampling of Maypack and impactors,
25 filter, and all sort of things that measuring. When

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1 they go into different phase of the study of the
2 aerosol behavior in the containment, you see these are
3 instrumentation. These are the listing of all the --
4 I think, did we miss anything on that?

5 In terms of the test, these are the five
6 tests that has completed. The last test was deleted
7 because of there was not enough budget to do it, so
8 this test was deleted.

9 DR. CORRADINI: Can I ask a question
10 there, because that wasn't listed on the table of the
11 report. Number 5, but was -- is now the current test
12 series concluded, and you've now moved to separate
13 effects test? Is that they way I read the report?

14 MR. LEE: Correct.

15 DR. CORRADINI: Okay.

16 MR. LEE: What happened is now these are
17 integral tests, so basically, there's a lot of the so-
18 called phenomenological - you cannot unfold all the
19 findings from PHEBUS, so they need to characterize
20 this more, so we've moving to the separate effects
21 test to understand better the characterization and so
22 forth. We will discuss those later.

23 DR. CORRADINI: Thank you.

24 MR. LEE: This first test is using fresh
25 fuel, and then irradiated for, I think, was it two

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1 weeks or ten days?

2 MR. KLEMENT: Ten days.

3 MR. LEE: Ten days. And this show you
4 different condition about the steam flow rates, what
5 type control rods we use, and what is the sump pH
6 control of different tests.

7 DR. ARMIJO: Were the fuel rods in the
8 high burn-up, were they pre-irradiated in power
9 reactors, and then refabricated?

10 MR. LEE: These came from the PWR, yes.

11 DR. ARMIJO: So they were not
12 refabricated. They were segments.

13 DR. POWERS: They were the actual fuel.

14 (Simultaneous speech.)

15 DR. POWERS: Yes, they start off at the
16 right length.

17 MR. LEE: They are all one meter long.

18 DR. ARMIJO: Yes.

19 MR. LEE: Yes, so they just it out from
20 there. And these are the burn-up when they took it
21 out from there. And then were irradiated for about
22 seven days, ten days, depends on -- put back all these
23 short life isotope, iodine especially into the -- so
24 you can do measurements.

25 DR. ARMIJO: And the one test you did with

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1 boron carbide for the control rod, was that sort of
2 like a BWR-type of --

3 MR. LEE: It's supposed to simulate the
4 BWR, but this applicable for the PWR, as well, too,
5 because lot of PWR are moving into 4C instead of using
6 the cadmium rod. But the intent is to try to give
7 some idea about boiling water reactors. The French
8 don't have boiling water reactors, so whoever thinks
9 they're going to get it, they're going to be
10 disappointed.

11 The irradiation, as I mentioned to you
12 around eight days. There are many temperature
13 plateaus for calibration before moving to active
14 degradation. And usually, the degradation phase takes
15 about one to two hours. And then they will terminate
16 the test, shut off everything, and then move into the
17 extensive modeling and measurements in the containment
18 vessel. The aerosol phase is about a day, sometimes
19 it's longer. And then they do a very short washing
20 phase to remove the aerosol deposit close to the
21 bottom of the containment vessel, and the chemistry
22 phase takes in usually about two, three days.

23 Now if you look at that, these are the
24 plateaus that I'm talking about. You have calibration
25 plateaus. I think they stay there to look at the

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1 coupling between the powering, the driver core power
2 versus the -- a lot of calibration that they were
3 doing before they moved to active degradation phase
4 over here. And you can see the temperature escalation
5 at different level in the bundles are shown here. And
6 this is the transition. And then after this part,
7 that's where the driver of the reactor core shutdown,
8 but not at this point. I think you isolate the bundle
9 from the --

10 MR. KLEMENT: I would note it's after one
11 hour or something like that, that it is isolated.

12 MR. LEE: After this part.

13 MR. KLEMENT: Yes. This part, between the
14 reactor shutdown, and the isolation is in this part,
15 during which we can see revaporization of fission
16 products from the deposits, for instance. Because we
17 still have some steam flow, no more fission product
18 emission from the core, and in this period of the test
19 we can evidence what happens as revaporization of
20 deposits in piping.

21 MR. LEE: Okay. And you can see here the
22 oxidation, the hydrogen production coincides with the
23 cladding oxidation. And you will see condition of
24 oxidation into relocating of the debris. This is for
25 the first test. These are tomography --

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1 DR. ABDEL-KHALIK: If you go back two
2 slides, the red graph where the clad oxidation takes
3 place, where the peak is, is this an exothermic
4 reaction that starts at 1500 C?

5 DR. POWERS: It's a very exothermic
6 reaction.

7 DR. ABDEL-KHALIK: That starts at 1500?

8 DR. POWERS: Well, I mean, exothermic
9 reactions are going on all the time, and it's only a
10 matter of rate. Okay? You can detect it here,
11 manifestly detect it. But, I mean, the oxidation of
12 Zirconium goes on at any temperature above zero
13 degrees Kelvin. It's just at a rate --

14 DR. ABDEL-KHALIK: Right. But, I mean --

15 DR. POWERS: There's no magic threshold.

16 DR. BANERJEE: But it's accelerating after
17 the --

18 MR. LEE: We see.

19 DR. ABDEL-KHALIK: All right. It should
20 be thinking of the 1200C.

21 DR. BANERJEE: Yes, 1100 it's starting to
22 accelerate.

23 DR. ABDEL-KHALIK: Okay. Thank you.

24 DR. POWERS: What happens, it starts going
25 so rapidly at those spikes that now the rate gets

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1 limited by your ability to supply steam, and not any
2 chemical kinetics going on at the surface.

3 DR. ABDEL-KHALIK: Okay.

4 DR. POWERS: And it's literally cooking
5 itself, you get this tremendous spike.

6 DR. ABDEL-KHALIK: Okay.

7 DR. ARMIJO: Isn't the steam ballooning at
8 the same time?

9 DR. POWERS: It has done big balloon.

10 DR. ARMIJO: It's already --

11 DR. CORRADINI: Ballooned a long time ago,
12 yes.

13 MR. LEE: These are tomography that was
14 done for each of the tests. Initially, it looks like
15 the bundle, and you will see that at the end FPT0, 1,
16 2, 3 - do you have some for four? Okay. We didn't
17 show it here, and you can see that FPT0, that was the
18 first test they did. They really melt the heck out of
19 it.

20 (Laughter.)

21 MR. LEE: There's a huge void in the
22 middle here, and then they pull back. The next test
23 is like this, and this one here, the melt, some of
24 them actually reached almost to the foot valve that
25 isolate this loop from the driver core, because you

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1 don't want anything to melt through the foot valves.
2 It will melt and go out into the --

3 DR. BANERJEE: The colors indicate
4 density? And this is after the experiments.

5 MR. LEE: Yes. They pulled the bundle out
6 very slowly, and then they measure it. And this is
7 basically -- how do you call it, reconstruction of the
8 tomography, that they will take slides after slides
9 and you'll see.

10 This is also a tomography of the bundle.

11

12 DR. BANERJEE: This is a tomograph.
13 Right?

14 MR. LEE: Reconstruction digital,
15 digitally put together. I think at one time, a few
16 years ago, they show you they can rotate this whole
17 thing. I didn't have that.

18 DR. CORRADINI: So instead of a body, you
19 took a fuel bundle.

20 DR. BANERJEE: What's interesting is that
21 you've got a computer program that renders the colors,
22 as well. Right? So that it's shining on top and
23 stuff like that.

24 MR. LEE: Is that right?

25 MR. KLEMENT: No, this is just to show to

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1 people who don't know how it looks like after an
2 experiment.

3 DR. BANERJEE: Yes, but you got reflected
4 light.

5 MR. KLEMENT: Okay. Just a computer
6 program, yes.

7 DR. BANERJEE: That's a rendering program.

8 MR. KLEMENT: Sure.

9 MR. LEE: This is a computer
10 reconstruction. This is actually the slides that they
11 took at different elevations. And the elevations
12 start from low to high, and this corresponds to over
13 here. By looking at the color, you can see the voids,
14 what are the mass related to it, and you can even see
15 the semblance of the fuel rods and so forth. And,
16 basically, they took all these to do the other
17 compositions.

18 And here it shows you something about
19 Uranium and Zirconium interactions. Okay? Basically,
20 you can see that these are no longer a circular, I
21 mean sharp interface between Zirconium and Uranium, so
22 you can see that they're interacting. This didn't
23 show up too well. This is supposed to show the march
24 into the Uranium, so it's lower than melting
25 temperature of the fuel. And these are gamma

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1 measurements here?

2 MR. KLEMENT: Gamma measurements, yes.

3 MR. LEE: Okay. These are gamma scanning
4 of the bundle afterwards, and they're looking at
5 whether Iodine is remaining in the bundle. And you
6 can see that in the lower part here, if you look at
7 the core, power is a cosine shape. You will see that
8 most of them are retained over here, this part here,
9 but all these move out, and some of them deposit here.
10 This is the top of the fuel bundle, and this is the
11 space before we go out into the circuit.

12 DR. BANERJEE: That's quite a soft gamma,
13 so it comes through?

14 MR. KLEMENT: Yes.

15 DR. BANERJEE: And you actually see it?

16 MR. KLEMENT: Yes. You have to make the
17 measurement a short time after the experiments.

18 DR. POWERS: That's not all that soft.

19 DR. BANERJEE: No, it's not. But soft
20 compared to what we --

21 DR. POWERS: Yes, it's not like Tritium.

22

23 MR. KLEMENT: Okay. This for the Cesium,
24 and you can see that a lot of them are deposit over
25 here. It's not as volatile as the Iodine, that we see

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1 the deposit is much larger here.

2 DR. BANERJEE: This still has a harder
3 gamma than this, doesn't it?

4 MR. KLEMENT: Harder gamma and longer
5 half-life.

6 DR. BANERJEE: Yes.

7 MR. KLEMENT: Much better for the
8 measurement.

9 DR. BANERJEE: Yes.

10 MR. LEE: There's a two Cesium peak.
11 Right?

12 MR. KLEMENT: No, only one.

13 MR. LEE: Only one? This is --

14 MR. KLEMENT: Two for Iodine.

15 MR. LEE: Two for Iodine, yes. Sorry.

16 And this one show you the Ruthenium, but what we need
17 to point out here is that Ruthenium did get released
18 from the fuel, but again all deposit on the top over
19 here. So 100 percent of that remains inside this fuel
20 bundle, and the top part of the bundle.

21 Basically, if you look at this one, it's
22 pretty flat. So, basically, whatever release from the
23 fuel get deposit very close to where the release is,
24 and keep on going. But after here is all captured.

25 Now we like to look at how the cold

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1 prediction versus the experiment --

2 DR. BANERJEE: What's the volatile species
3 of Ruthenium?

4 DR. KRESS: Ruthenium oxide.

5 DR. CORRADINI: It goes to the oxide it's
6 what?

7 DR. KRESS: It's volatile.

8 DR. CORRADINI: Oh.

9 DR. KRESS: Ruthenium itself is not very
10 volatile.

11 MR. LEE: The metal is not volatile, it's
12 the oxide. This is a prediction of what observed in
13 PHEBUS versus MELCOR. And I don't remember which test
14 this is for, but in general, you see the prediction is
15 pretty reasonable.

16 DR. BANERJEE: So what algorithm does
17 MELCOR use? Is it just some sort of cuff fit, or is
18 there some --

19 DR. CORRADINI: I feel the audience ready
20 to pop up, the audience getting nervous.

21 DR. KRESS: It gives you three options.

22 DR. BANERJEE: All right.

23 DR. CORRADINI: Good, better, best.

24 DR. KRESS: One option is a strictly
25 empirical one, was the original one. It's not real

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1 good. One option came out of VICTORIA, that looks at
2 araneus-type behavior. And another option was one
3 called the Bridge --

4 MR. LEE: Was it causal booth you're
5 talking about?

6 DR. KRESS: No, I was thinking about the
7 --

8 DR. CORRADINI: There's somebody behind
9 you that can help you.

10 MR. LEE: Okay. Randy Gant is here.

11 DR. BANERJEE: So when you said araneus
12 that means there's some kinetics there.

13 MR. GANT: Yes. I'll just add a few
14 words. My name is Randy Gant. I probably did that
15 calculation, but I don't remember, but we routinely --
16 as someone mentioned, we have -- Tom mentioned it.
17 We have several options in the code, but the option we
18 generally exercise routinely, because it's a little
19 more physics-based, is the so-called booth diffusion.

20 DR. KRESS: That's the one I was trying to
21 remember.

22 MR. GANT: And it includes a diffusional
23 component, which transports through the fuel grains.
24 And there is also a volatility component that
25 basically looks at the assumed vapor pressure of the

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1 volatility of the thing that's being released. And
2 that's what was done here.

3 DR. ARMIJO: What's your starting point
4 on, let's say, for Iodine and Cesium in the pellet
5 before the experiment starts? Is Cesium Iodide or
6 Iodine and Cesium separate, or what?

7 MR. GANT: This is quickly going to get
8 very detailed, and it kind of addresses some of the
9 limitations in the model. And because the model
10 doesn't have extremely elegant speciation
11 capabilities, based on what we're seeing from the
12 PHEBUS tests, we make an assumption about the
13 speciation in order to capture the right volatility of
14 the material. And so, for example, when we look at
15 Cesium and Iodine, I can tell you, that was released
16 under the assumption of Iodine would be assumed to be
17 pretty much Cesium Iodide.

18 Cesium, the balance of the Cesium based on
19 our observations from PHEBUS, is assumed to be Cesium
20 Molybdate, which has quite a bit different volatility
21 from either Cesium Hydroxide or Moly-metal. And we
22 find that from the distribution of these things that
23 they've been observed in the PHEBUS test, that is our
24 strongest suspicion, that Cesium and Moly are
25 combining, at least on release. And there's some

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1 evidence that late in time any deposited Cesium
2 Molybdate might be respeciating to come off as the
3 Cesium coming back off again as Hydroxide if there's
4 steam around.

5 DR. ABDEL-KHALIK: If you're making
6 assumptions about speciation based on experimental
7 observations, would you consider these calculations to
8 be a priori?

9 MR. GANT: Well, I think we assume that
10 these experiments are producing pretty prototypic
11 conditions here. There are regions of the test bundle
12 that are steam rich. There's regions of the test
13 bundle that are bathed in Hydrogen, and that on the
14 net what we're seeing is on average what you're going
15 to see being released from the core. And absent a
16 dynamic speciation model like VICTORIA, that's pretty
17 much what we're left with, is to make an assumption on
18 what that basic speciation is going to be.

19 DR. BANERJEE: If you married VICTORIA to
20 MELCOR, would you get roughly those numbers?

21 MR. GANT: Well, I would hope so. I mean,
22 we're matching the observations, so we hope we
23 wouldn't deviate much from that. There are other
24 models, perhaps ELSA - Bernard might speak to this.
25 There are other models that are not as numerically

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1 burdensome as a full-blown chemistry model, such as
2 VICTORIA. And I guess these are some of the things
3 we'll be contemplating in terms of --

4 DR. BANERJEE: Well, let's put it another
5 way. Does VICTORIA predict the sort of speciation
6 that you see in the experiments?

7 MR. GANT: I'm going to pass that to Dana,
8 because I'm not sure that all of the chemical species
9 are in VICTORIA to capture this.

10 DR. POWERS: Yes. Well, VICTORIA would
11 calculate this test very well, as far as the
12 speciation. The question you're really getting at -
13 let's start back at Ground Zero with Sam's question.
14 The presumption is that within the fuel grain you have
15 atomic species, and those diffuse to the surface. And
16 then they respeciate at the surface of the grains.
17 And it's that vapor species that transport through the
18 pore models. So VICTORIA makes an assumption, doesn't
19 make an assumption, makes a calculation of what the
20 oxygen potential and the chemical potentials are at
21 the grain surface. And to be honest with you, we used
22 to inhibit the Molybdenum potential deliberately
23 because we kept predicting the Cesium Molybdate, and
24 they did the experiment. We said well, let's not do
25 that any more, so it will predict Cesium Molybdate for

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1 these experiments.

2 Now you asked me, what if I did a
3 different kind of experiment, say one at 100
4 atmospheres instead of 2 atmospheres. And suppose I
5 was in an environment that was very Hydrogen rich,
6 would you predict the same speciation? No, VICTORIA
7 will give you different speciation there. But then
8 you emerge from the fuel region into the transport
9 region where all these things kind of mix together.
10 They go right back to the Molybdate.

11 The question we're wrestling with now is,
12 does it do further changes, and we rather suspect yes.
13 And Richard will talk to you more about the separate
14 effects experimentation to talk about the further
15 change.

16 DR. CORRADINI: So I guess that kind of
17 was maybe the wrong question. When I was reading the
18 report, what you gave us, and then kind of a couple of
19 summaries, it seemed that there was a surprise about
20 the - was it FP-3? I wanted you to kind of try to
21 explain that, because I didn't understand it. You had
22 -- was it essentially BWR control material, and there
23 was a big change into -- now I'm going to have to look
24 it up. The Iodine release. Can you kind of explain,
25 because the way -- there was a summary paragraph that

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1 said this was like remarkable, or surprising, or
2 there's some word that you seldom see in a research
3 report.

4 MR. LEE: What happened for that one with
5 the B4C, is that the Boric Acid from the B4C was
6 steam and turned into Boric Acid, so it's basically
7 capture all the sites that Iodine can go, so Iodine
8 has no place to go, so they found a gaseous iodine, so
9 that's what they see during the degradation phase of
10 it, they see a very large gaseous iodine going into
11 the containment.

12 DR. CORRADINI: So now that led me to my
13 question about scaling, not scaling in terms of length
14 scales or time scales, but scaling in terms of
15 compositional. Was that experiment over-rich in B4C
16 relative to a typical core, or is that something --
17 because the one thing you started off with in terms
18 you led with, was is geez, Iodine isn't where it used
19 to be. We think it's here now, but that one test
20 showed a totally different shift. And I was curious
21 about was there some distortion in that experiment
22 that you then would say well, that was just a
23 distortion relative to the chemical amounts available.
24 Do you see my question?

25 MR. GANT: Richard, can I take a first

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1 shot at that and point out; before you go generalizing
2 that particular result to American BWRs, it's a bit of
3 a mistake to characterize --

4 DR. CORRADINI: I wanted to understand
5 what was happening. I thought there was just too much
6 B4C.

7 MR. GANT: The physical form of these B4C
8 is not at all like in the American boiler with control
9 blades and the steel tubes. And this is more along
10 the lines of the new fuel control materials that
11 they've been using in Europe. I believe this is
12 coming into use in American PWRs, where the control
13 material is not silver-ended Cadmium, but it's a
14 pretty chunky lump of Boron Carbide, quite a bit more
15 robust than the typical boiler blade arrangement. And
16 so, this pellet of Boron Carbide will have a tendency
17 to stand in hot steam a lot longer than you'll see in
18 the BWR blade. And that's producing a lot more
19 reaction with the steam. And then I just wanted to --

20 DR. CORRADINI: No, I understand.

21 MR. GANT: I kind of wanted to clarify
22 that, because it's not really a BWR test. It's --

23 DR. CORRADINI: Advanced control material.

24 MR. GANT: Advanced control material.

25 DR. ARMIJO: But there's a lot more Boron

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1 in some of the modern PWR fuel. They put zirc
2 diboride on the pellets. Would it behave in a similar
3 way, do you think?

4 MR. LEE: I think, but not to allude to
5 you the scaling aspect of the B4C, because we have a
6 lot of discussion about it, what is it really scaling
7 in terms of was it a BWR, was it PWR?

8 MR. KLEMENT: Yes. Before performing the
9 experiments, we have a lot of discussion about scaling
10 of this test with Boron Carbide with three different
11 aspects, so as compared to the amount, you choose the
12 amount of Boron Carbide, of course. And, also, the
13 amount of Boron Carbide as compared to the amount of
14 stainless steel, because here you have a very
15 different ratio between boiling water reactor with
16 much more steel than in pressurized water reactors.
17 And the effect of that, you will have more dissolution
18 of Boron Carbide by steel, and more liquid metal going
19 down in the core before having oxidation by the Boron
20 Carbide.

21 So the test was the pressurized water
22 reactor situation, then the boiling water reactor
23 situation. The other point is the ratio
24 between the Boron Carbide and the fuel, so the ratio
25 between the Boron Carbide and the fission products.

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1 And if I remember well, we are here for the scaling
2 in-between what is the ratio in an assembly with
3 control rods, and what is the ratio for the in-between
4 this bundle. But, anyway, if you look at the amount
5 of Boron that is emitted, it is largely nexus, as
6 compared with the amount of fission products.

7 MR. LEE: So it's very large, and I think
8 people shouldn't jump to conclusion that what we see
9 in the very large gaseous Iodine, release in the
10 containment is not the prototypic expectation.

11 DR. CORRADINI: That's fine. That helps.
12 Thank you.

13 MR. LEE: Okay. Because this is a very
14 small bundle, it's very peculiar for that part.

15 DR. BANERJEE: But your Iodine release
16 numbers are significantly higher than the prediction.
17 Right?

18 MR. KLEMENT: No, it's not.

19 DR. BANERJEE: No?

20 MR. KLEMENT: No.

21 DR. BANERJEE: Why don't you just predict
22 100 percent?

23 DR. CORRADINI: Okay.

24 DR. BANERJEE: What difference would it
25 make?

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1 DR. CORRADINI: From a licensing
2 standpoint, I think that's the background that Richard
3 was showing in terms of what is assumed, which is an
4 upper limit. This they tried to drive out the
5 material.

6 MR. LEE: Yes. This earlier Dana alluded
7 to. There is also optical transmission measurements.
8 It's a qualitative measurement on the aerosol coming
9 out of the pipe. I believe it's in the point C area?

10 MR. KLEMENT: Yes.

11 MR. LEE: We install a so-called optical -
12 what is it?

13 MR. KLEMENT: On-line.

14 MR. LEE: Is on-line aerosol monitor that
15 was developed at Idaho, and we installed it to look at
16 the aerosol transmission, interrupting the optical
17 transmission. And you can see that it's qualitatively
18 coincide with clad ruptures. You will see the signal
19 goes down, with the control rod this go down, too, and
20 the clad oxidation where there's a lot of aerosol
21 comes out, but it's a very qualitative
22 instrumentation.

23 This show you something that the transport
24 is really occurs mostly after the excursion in terms
25 of the aerosol got into the containment, and you will

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1 see the high radiation that was caused after this peak
2 over here, because you need to have time from the
3 circuit, so it will carry into the containment before
4 you see the radiation, that will increase this.

5 The other one, it tells you what PHEBUS
6 finding, very important point, has to do with the
7 aerosol. One of the crucial assumptions that we use
8 in aerosol calculation is that we don't make any
9 difference in terms of looking at different type of
10 aerosol. They're just using it pretty much the same.
11 We see that it all put together. This is what PHEBUS
12 is showing.

13 DR. KRESS: Is that log-normal?

14 MR. LEE: This is a --

15 DR. KRESS: It's its own --

16 DR. POWERS: Kind of. There don't have
17 enough data points there to fit log-normal.

18 CHAIRMAN SHACK: Or you have little enough
19 data that a log-normal will fit.

20 DR. POWERS: Or you can take that point of
21 view.

22 MR. LEE: So, basically, for most element,
23 all the aerosol behavior are pretty much the same. So
24 this is a very fundamental assumption we make in
25 aerosol calculation.

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1 DR. BANERJEE: What is with the microns?

2 DR. ARMIJO: I'm sorry. What's an
3 aerodynamic diameter, as opposed to just a diameter?

4 DR. POWERS: That diameter that's here
5 with the same aerodynamic properties and unit density.

6 DR. KRESS: I think aerodynamic diameter
7 means how does it fall, how fast does it fall,
8 compared to a sphere of the same density.

9 DR. BANERJEE: It must be based on some
10 measurement. Right?

11 DR. KRESS: Pardon? You have to measure
12 it, yes. You can measure it, though, with an
13 impacter, specially made impacter.

14 DR. POWERS: The only way you can collect
15 the aerosol, you're going to collect it based on
16 aerodynamics.

17 DR. KRESS: Yes.

18 DR. BANERJEE: The usual devices which --

19 DR. KRESS: Yes. Whatever you get --

20 DR. BANERJEE: We use the --

21 DR. KRESS: Also back out of that the
22 aerodynamic behavior.

23 DR. BANERJEE: Separational spray dried
24 stuff.

25 DR. KRESS: The sizing actually has built

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1 into it, the aerodynamic behavior.

2 MR. LEE: Yes. It's just that in heat
3 transfer we use the diameter, which show you the
4 surface because we're interested in how to --

5 DR. CORRADINI: This is that?

6 MR. LEE: Yes, and also that. But in
7 aerosol, they use this definition. But this show you
8 multi-components aerosol. They all mixed together,
9 and from PHEBUS we find out that these are the
10 distribution. And I think we use that in the code.

11 So, in other words, what we are showing
12 you here is a very, very small fractions of the data
13 that are coming out from PHEBUS. The data is really
14 extensive, and the analysis takes a long time. And if
15 you look at some of the reference we give you in the
16 publication of the design, the conclusion that they
17 have reached many years ago on PHEBUS was FPT-1 and
18 FPT-0. I think when we get to the end of the program,
19 we have to re-evaluate the entire set of data, maybe
20 we come to different conclusions. So I'm just telling
21 you that interpretation of it has not ended. It's
22 still going on.

23 DR. BANERJEE: But what is the sort of
24 take-home message. Looking at the data you've shown
25 us, it suggests, at least, that your first

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1 approximately, everything up to Moly is more or less
2 released. Maybe it's half, maybe it's two-thirds, but
3 roughly all of it. Is it that most of it is not or
4 whatever on the steam generator tubes, and the top of
5 the core, in the dry regions? What are you seeing, in
6 broad terms, the overview.

7 DR. KRESS: Most severe accidents don't
8 pass through the steam generator tubes.

9 DR. BANERJEE: That's what you see?

10 DR. KRESS: Most of them -- so you've got
11 to discount that as where most of the stuff goes. A
12 large break, or a medium-size break may occur in the
13 hot leg or cold leg, and it may go through the steam
14 generator, it may not.

15 DR. BANERJEE: It may not.

16 DR. KRESS: So you have to look at where
17 it goes.

18 DR. BANERJEE: So what you're finding is
19 that quite a bit of it comes out in the upper plenum
20 or something?

21 DR. KRESS: Well, I think the finding is
22 that the release equations that are in MELCOR are
23 reasonably good.

24 DR. BANERJEE: Right.

25 DR. KRESS: And that you can use those

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1 then to determine what goes in containment. And I
2 think they're also finding out that their containment
3 behavior, with the possible exception of Iodine, is
4 pretty good for the aerosols.

5 MR. LEE: For aerosols physics that we
6 have now, these are very good, whatever we --

7 DR. KRESS: And I think one thing that's
8 a little question is the speciation of Iodine.

9 DR. BANERJEE: But, Tom, to a first
10 approximation isn't all the Iodine being released? I
11 mean, otherwise, you're just asking --

12 DR. KRESS: No, no. It depends on the --

13 DR. POWERS: Why don't you go ahead.
14 He'll show you what happens to it.

15 DR. BANERJEE: All right.

16 DR. KRESS: And a full core melt is not
17 exactly like these, so you're thinking most of the
18 melt down scenarios to get 20 percent, 30 percent.
19 But if it progresses to core on the floor, then you
20 might get a lot more of it.

21 DR. CORRADINI: But, I guess another way
22 to say it to Sanjoy is that, I guess the reason I
23 asked the question about FP-3, and these guys
24 explained what I missed was just the way the Iodine
25 was released is very big, is a very big deal. So what

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1 they're concluding is to how it's partitioned, even if
2 100 percent got out and you cooked the core for God
3 knows how long, how it comes out chemically is very
4 important.

5 DR. BANERJEE: As to where it goes.

6 DR. CORRADINI: Yes. Yes.

7 DR. BANERJEE: Okay.

8 DR. KRESS: The longer you cook the core,
9 the more gets out. And the faster -- paradoxically,
10 the faster you can eat up the melt, the less you're
11 going to release.

12 MR. LEE: Okay. This show again about
13 MELCOR comparison with hydrogen production, so you see
14 that it's really not bad. See non-releases --

15 DR. ABDEL-KHALIK: I guess I have a
16 question about integral experiments of this type, in
17 general. They work great when they work, in a sense,
18 when your results match the model. But let's say you
19 did this, and MELCOR was way off from the experiment,
20 how would you use the results of this experiment?

21 MR. LEE: I think, basically, you need to
22 understand what the experiment is showing you first.
23 And, also, the use of the MELCOR itself also make a
24 big difference in terms of the user, how good are they
25 in doing modeling. For example, when we were looking

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1 at the CSI FET-1 standard exercise, there was a group
2 of user from Sandia and the European, German, all
3 these, and they used the MELCOR code. And you will
4 see the trends going one way, and then later during
5 the exercise, some eastern Europeans joined, and they
6 used MELCOR, and the prediction from MELCOR went
7 completely in a different fashion. So it has user
8 effects, you have to understand what you ask, your
9 assumptions. First, of course, you need to understand
10 what is happening in the test. I will say that not
11 every prediction shows perfect things. I selectively
12 show you the good ones.

13 DR. KRESS: The other thing --

14 MR. LEE: There are many -- there are some
15 didn't do as well, but we have to understand why.

16 DR. BANERJEE: Right.

17 MR. LEE: Showing all the one that
18 predicted well, but understand why we did it.

19 DR. POWERS: But I think save setting up
20 your follow-ons, I mean, there are things that happen
21 in the test that you can't explain. And you can run
22 the MELCOR code until you're blind in the face, if it
23 doesn't have that physics, it's not going to predict
24 it.

25 MR. GANT: Richard, back up a slide, and

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1 I want to make a point that bears on your question.
2 That particular signature of the integral, integrated
3 release of hydrogen. To get that right, we had to get
4 a lot of things right. We had to get the oxidation
5 kinetics right. That's number one. We have to get
6 the bundle heat-up right. That's number two. A
7 curious -- when you see that signature kind of roll-
8 over, there's another thing you have to get right, and
9 that is the thing that is oxidizing, actually is
10 molten Zirconium trapped behind the oxide shell that's
11 forming. And it's the breach of that shell, and the
12 release of that molten oxidizing metal that actually
13 starts that curve rolling over. So you've got to get
14 that modeled right, and then you see out at the end
15 where it starts to pick up again. That's due to a
16 resumed oxidation down low in the bundle that is
17 precipitated by relocating hot material from up high
18 in the bundle down low, and re-igniting that
19 Zirconium. So in order to get that, we had to look at
20 a lot of things, timing of fuel rod degradation, the
21 arrival of hot molten material in the bottom of the
22 bundle, many self-consistent signatures. And when you
23 start to get all of those right, things fall into
24 place. No way to get that integral curve without
25 getting a whole lot of other things straight.

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1 DR. ABDEL-KHALIK: Right. I mean, in my
2 own mind, what's the process? Do you do the separate
3 effects and understand all the details first, and then
4 do an integral experiment that hopefully works, and
5 then we tell you, yes, you've done it right. You
6 understand the --

7 MR. GANT: It is hard-fought ground.

8 DR. ABDEL-KHALIK: But if you do the
9 integral effect experiment first, and if it misses,
10 then you're lost.

11 MR. GANT: Yes.

12 DR. ABDEL-KHALIK: You have no way of
13 using that information.

14 DR. BANERJEE: Sometimes you can figure it
15 out. I mean, I remember these loft tests where each
16 time we did a pre-prediction, we would always miss it.
17 And we got it perfectly in the post-prediction.

18 MR. GANT: Well, this type of thing was
19 preceded by scads of work on oxidation, of cladding,
20 of material interactions between molten Zirconium and
21 Uranium and Zirconium Oxide. There's tons of
22 supporting separate effects phenomenological insights
23 that had to come together before you could build an
24 integral model like that.

25 DR. BANERJEE: So let me ask you, is this

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1 a pretest or a post-test?

2 MR. GANT: Oh, I'll tell you. That's a
3 post-test.

4 DR. BANERJEE: Post-test. What was the
5 pretest like?

6 DR. POWERS: Actually, it was very close
7 to this.

8 DR. BANERJEE: Okay. Then you will --
9 there is no unexpected phenomenon.

10 DR. POWERS: Despite Randy's claim of all
11 the work he did, this is one of the easiest things to
12 predict.

13 DR. BANERJEE: What is the hardest one?

14 MR. GRANT: Easy for him to say.

15 DR. KRESS: That's easy for you to say.

16 DR. BANERJEE: What's a hard one?

17 MR. LEE: Well, this is the Iodine
18 predictions. I'm sure there are many other things.
19 There's tons of them.

20 DR. POWERS: There you go.

21 MR. LEE: Look at the Cesium deposit.

22 DR. BANERJEE: I was going in the wrong
23 direction.

24 MR. LEE: And this is the Cesium deposit
25 in the steam generator. Are those things that come

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1 down and so forth.

2 MR. KLEMENT: The peaks.

3 DR. ARMIJO: The wiggles.

4 MR. LEE: All those wiggles up and down.

5 MR. KLEMENT: No, this is just because the
6 steam generator tube is gamma scanned after having
7 been cut, and this is the location of the cuts.
8 That's all.

9 DR. ABDEL-KHALIK: Is the location of
10 what? I'm sorry.

11 MR. KLEMENT: Of the cut.

12 MR. LEE: They cut the steam generator to
13 --

14 MR. KLEMENT: The pipe like that, it's too
15 long to be gamma scanned, so we cut it in two pieces,
16 and these are just the location of the cuts.

17 DR. ABDEL-KHALIK: So these sharp peaks
18 are not real.

19 MR. KLEMENT: No, forget about those sharp
20 peaks.

21 DR. ABDEL-KHALIK: Okay.

22 MR. LEE: So, in general, you can see -
23 we're just looking in general at the shape of the
24 deposit, was more than just --

25 DR. BANERJEE: What's the most interesting

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1 is when your calculation doesn't agree with your data,
2 because then you haven't really figured out why. Is
3 there something like that --

4 MR. LEE: Well, they spent a lot of time
5 on that, really. And that's why it took a long time,
6 and if they keep on calculating --

7 DR. ARMIJO: Were there any other codes or
8 event used in Europe or elsewhere that did similar, or
9 better than --

10 MR. LEE: I don't know about better.

11 MR. KLEMENT: Well, there are many other
12 codes, which some of them also calculate the whole
13 sequence of the experiment, such as MELCOR, that
14 equates to the equivalent of MELCOR that is AZTEC in
15 Europe. Some other codes are only able to calculate
16 fuel degradation, a number of codes. And what is
17 interesting, which I mentioned, that there was an
18 international standard problem on this test, PHEBUS
19 FPT-1, so it was a post-test calculation. And we have
20 had interesting figures. For instance, for fission
21 products transport in the circuit, we have, I think it
22 was responsible for this exercise, something like more
23 than 12, maybe 15 MELCOR calculations by different
24 user. And the same with AZTEC, it was different
25 users. So we are really able to look at the ability

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1 of the code, looking at the best calculations. And,
2 also, you have a kind of measure of the user effects,
3 which was really interesting.

4 DR. KRESS: This is an indication of
5 aerosol deposition, rather than chemical interactions.

6 MR. KLEMENT: Yes.

7 DR. KRESS: The temperature is decreasing
8 as you go along.

9 MR. KLEMENT: Sure.

10 DR. KRESS: But the temperature doesn't
11 matter that much, because it's --

12 MR. KLEMENT: So that aerosol, that's
13 aerosol.

14 MR. LEE: Because the Iodine behavior
15 shows that it's a mixture, because you see there's a
16 slope here this way, and there's another slope. And
17 if you go back to the other one, basically, is as
18 exponential decay, basically is telling you that this
19 form is mostly the aerosol Iodine, which is this one.

20

21 From the PHEBUS, we found that the fuel
22 relocation takes place at the lower temperature. And
23 I believe we have also adjusted for that for our code,
24 so did other codes. There was -- Randy, when did we
25 do that, four, five years ago?

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1 MR. GANT: Yes. That's been at least four
2 years ago.

3 DR. KRESS: And it's now 2600 K?

4 MR. GANT: We liquify fuel at 2800 K
5 respecting the eutectic between Zirconium Oxide,
6 Uranium Oxide. But we failed the fuel rod, that is,
7 change it from a fuel rod to a slumped geometry at
8 2500 K, representing this kind of non-equilibrium
9 interaction of Uranium, Zirconium, and Zirc Oxide.

10 MR. LEE: And we found our codes,
11 including other codes tends to over-predict the
12 deposition in the circuit. As I mentioned, the
13 finding for the aerosol tells you that the models we
14 use are very good. That is a very important finding
15 that is size-independent.

16 DR. KRESS: That's really helpful.

17 MR. LEE: Yes. Tells the fundamental
18 assumptions are correct.

19 DR. POWERS: What you develop is an acute
20 suspicion of the CFD which the codes do better than
21 the CFD codes.

22 DR. BANERJEE: Anything is better than
23 that.

24 MR. LEE: And in MELCOR, and I believe in
25 AZTEC, and also -- we use very large nodes for the

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1 containment. It appears that you look at the previous
2 predictions, calculations are pretty -- calculate the
3 PHEBUS containment very well. You also see that
4 PHEBUS using two or three million nodes CFD analysis
5 for containment, which we don't know why, but it's
6 telling us you really don't need to do those type of
7 calculation.

8 We know the effects on Iodine behavior in
9 the sump, shows what we have learned previously. We
10 also know that Cesium formed is not Cesium Hydroxide,
11 is mostly Moly, and we adjusted for that. But also,
12 the Cesium eliminate the deposit at a later time when
13 the steam comes, we may have Cesium Hydroxide come out
14 from the system.

15 We have evidence of revaporization, but
16 this part is a difficult problem to study. I think
17 your -- after you terminate your driver core power,
18 and I don't know how much, how good is this part of
19 the data coming out from this, because you need to do
20 more experiment on it to find --

21 DR. BANERJEE: Are the French -- they have
22 their own codes. Right? The AZTEC.

23 MR. LEE: The AZTEC is the code now.

24 MR. KLEMENT: Yes. In fact, AZTEC is the
25 code that is jointly developed by the French and

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1 Germans. And now it's used in European projects and
2 European networks. It's becoming the European code.

3

4 DR. BANERJEE: And what is the basis of
5 the code?

6 MR. KLEMENT: Well, it's a system-level
7 code, so the -- I would say the requirements are,
8 which is the same for the MELCOR, and the capabilities
9 are roughly the same. Being different from one thing
10 to another, but they are roughly the same.

11 MR. GANT: They're very similar in
12 capabilities. One difference I could say is that the
13 AZTEC code is a -- I don't want this to sound bad.
14 It's an amalgam of many codes that have been -- that
15 they use the data -- it's like source term code
16 package in a way, but it's a much more sophisticated
17 method of integrating the database of these different
18 tools. And so, that's kind of how AZTEC is put
19 together, compared to MELCOR; not that MELCOR is not
20 an amalgam of various separate models, but very
21 similar capability.

22 DR. BANERJEE: So what are the -- is there
23 some basic model which is different, different
24 physics, different understanding?

25 DR. POWERS: I would hope the physics are

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1 about the same.

2 MR. GANT: I'm having trouble thinking --

3 DR. BANERJEE: That's what I'm trying to
4 probe.

5 MR. KLEMENT: For example, for aerosols,
6 the basis is the same. The basis is what is in there
7 for instance, so the same basis. For aerosol
8 physics --

9 DR. BANERJEE: Simply a matter of style,
10 not of substance.

11 MR. KLEMENT: There's one difference about
12 chemistry in the primary circuit, where we have
13 calculation of chemistry in AZTEC, as it was in
14 VICTORIA, that is not in MELCOR. This is one
15 difference, for instance.

16 DR. BANERJEE: So it sort of is an amalgam
17 of MELCOR and VICTORIA?

18 MR. KLEMENT: This part was not coming
19 from VICTORIA, no. It's not amalgam. It's --

20 DR. BANERJEE: Oh, so it's an amalgam of
21 --

22 MR. KLEMENT: Yes.

23 DR. BANERJEE: -- whatever,

24 MR. LEE: Similar type.

25 MR. KLEMENT: Yes.

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1 MR. LEE: Treatments of chemicals.

2 MR. KLEMENT: VICTORIA.

3 MR. LEE: But we don't put that in our
4 code.

5 DR. BANERJEE: And the numerics are the
6 same?

7 DR. POWERS: I think the numerics are very
8 different, very different.

9 DR. BANERJEE: You use two million nodes
10 for the containment.

11 MR. KLEMENT: No. Never.

12 But, you know, many people make -- there
13 are many partners in the PHEBUS FP program, so many
14 people make calculations, and sometimes we see some
15 calculations in the containment. And we see very
16 detailed calculations that are of no use.

17 MR. LEE: Just lots of calculations, and
18 even some of them use a parameter code, but using one
19 million nodes of --

20 MR. KLEMENT: Not one million, five
21 hundred.

22 MR. LEE: Five hundred.

23 DR. BANERJEE: Five hundred million? No.

24 MR. KLEMENT: No.

25 DR. POWERS: Five hundred, for a lump

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1 node.

2 MR. LEE: For the lump parameter type
3 codes. But the CFDs are in the millions. Okay. And
4 one big observation that we found out from test after
5 test from FTP-1, except FPT-4, which is the test,
6 there is a steady state gaseous Iodine appearing in
7 the containment throughout these four period. I mean,
8 this period. Look at this one here. In the aerosol
9 phase, and in the chemistry phase. And if you go back
10 here and you look at the -- if you look at back of the
11 test matrix, they are tested some acid, doesn't matter
12 if some of them are basic. One of them is basic,
13 three of them acid. Some of them have silver, one
14 test doesn't have silver because it's Boron Carbide.
15 There are cases that the sump is condensing, and some
16 cases the sump is evaporating. And FPT-3 as earlier
17 we mentioned, very large amount of gaseous Iodine came
18 in the containment, but if you look at the later part
19 here, in the aerosol phase and chemistry phase, you
20 see a steady state. So our expectation is that if you
21 have good, high pH, if you have silver there, you
22 should not be seeing a steady state gaseous Iodine.
23 So we came to realize that this gaseous Iodine steady
24 state that we're observing is coming from a source
25 that has nothing to do with the sump. So the pH

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1 controlling the sump doesn't do anything here, because
2 if you look at the condenser up there, the Iodine goes
3 to the condenser. It can come back out from it,
4 depends on the conditions that is occurring in the
5 containment. If you have evaporation from the sump,
6 there's a higher rate of flux, so you remove the
7 Iodine, and you deposit it back onto the condenser.
8 So you have a situation that we observed that the
9 steady state gaseous Iodine is coming from a source
10 that is not from the sump.

11 DR. KRESS: But, eventually, that Iodine
12 that's airborne would make its way to the sump. There
13 are processes that would carry it to the sump, and so
14 it may make a difference whether the sump is acid or
15 basic in a very long time. Because if it does make
16 its way to the sump, it acts like a little bypass
17 cleanup system to the containment. And you would
18 expect to see eventually, it all end up in the sump.

19 DR. POWERS: Eventually, you'll see it all
20 decay.

21 DR. KRESS: It decays faster than this
22 little thing -- that may very well be.

23 DR. POWERS: Notice the time scale over
24 there.

25 DR. KRESS: Yes, it depends on the speed.

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1 You're right. Thanks for pointing that out.

2 DR. CORRADINI: So not being that good at
3 source term, that seems like a big deal considering
4 all that was said about what happens. So what was
5 going on in TMI that isn't occurring in FP-1, 2, 3?
6 In other words, I thought TMI had an enormous
7 partition of a gaseous Iodine, versus what was in the
8 water.

9 MR. LEE: I think in the TMI most of the
10 Iodine went into the water.

11 DR. CORRADINI: Right.

12 MR. LEE: And then transmitted from the
13 tank into auxiliary feed building.

14 DR. CORRADINI: No, I understand that.
15 But the partition -- I mean, unless I misunderstand
16 what you're telling me, one in twenty is still sitting
17 inside the atmosphere.

18 MR. KLEMENT: No.

19 MR. LEE: This is percent.:

20 DR. CORRADINI: Oh, this is percent.

21 Excuse me.

22 MR. LEE: It's percent.

23 DR. CORRADINI: Excuse me. I'm sorry.

24 DR. BANERJEE: So maybe .2 percent, at
25 most.

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1 DR. CORRADINI: But what was the partition
2 at TMI, though? I thought it was like 100,000.

3 DR. POWERS: It was all in the sump.

4 DR. ABDEL-KHALIK: So if you're thinking
5 about the chemical effects of the sump blockage issue,
6 what would you advise people to do?

7 DR. KRESS: Get rid of the --

8 DR. POWERS: Get rid of the buffer.

9 DR. ABDEL-KHALIK: Right?

10 DR. KRESS: Yes. Does it make any
11 difference?

12 MR. LEE: I think our opinion now is that
13 from the onset of the accident, you really don't need
14 the buffering. Maybe in the late phase, much longer
15 time. And if you want to spray the containment, the
16 question remain is that whether you need to add the
17 buffer into the spray or not, and what effects that
18 has on the -- is long-term evolution of gaseous Iodine
19 in the containment.

20 DR. BANERJEE: There could be other
21 reasons you need the buffer, as they pointed out.

22 DR. POWERS: Like what?

23 CHAIRMAN SHACK: Unless you like to make
24 Calcium Phosphate.

25 DR. BANERJEE: One of the things that came

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1 up at the meeting was, why don't you just remove the
2 buffer? And there were people from NRR who said that
3 all the implications of that have to be assessed,
4 because --

5 CHAIRMAN SHACK: Well, I agree with that.

6 DR. BANERJEE: It's not that
7 straightforward, they explained to us.

8 DR. CORRADINI: But isn't the buffer for
9 the containment spray the only purpose is to remove
10 Iodine from gaseous Iodine?

11 MR. LEE: Is the retention of gaseous
12 Iodine.

13 DR. CORRADINI: That's why I'm having --
14 (Simultaneous speech.)

15 DR. CORRADINI: I don't mean to -- this is
16 what my question was about. I thought at TMI they
17 sprayed the beJesus out of it, and that was one of the
18 reasons it stayed in the sump. Am I off base?

19 DR. POWERS: No, it went into the water
20 immediately. TMI, all the Iodine release was through
21 the water filled pressurizer.

22 DR. CORRADINI: Oh, right. Okay.

23 DR. POWERS: It wasn't released to the
24 atmosphere.

25 DR. CORRADINI: So the containment spray,

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1 although on, would have had no effect.

2 DR. POWERS: Been no effect. Cleaned up
3 the -- made it nice, and took all the pollen out of
4 the air.

5 DR. BANERJEE: So one of the sump screen
6 solutions has been one of the plants is turning up
7 their spray. We had five plants present, and each had
8 a different way to - or four plants. Each had a
9 different way to handle the problem, all very
10 creative, by the way. Hopefully, they'll appear and
11 present to the Full Committee, maybe in July.

12 DR. ABDEL-KHALIK: But this is a very
13 significant finding. I mean, this is --

14 (Simultaneous speech.)

15 DR. BANERJEE: I think they know some of
16 this, though.

17 MS. HART: This is Michelle Hart. I'm
18 with NRR. Mike Scott, who's the head of the branch is
19 doing GSI 1.91 did have to leave, but we are aware of
20 these responses of this result. And, of course, it
21 does cause issues in my particular, I'm the dose
22 analyst. Because all of our current guidance, Reg
23 Guide 1.183 is based on NUREG-1465, which says well,
24 your pH has to stay above seven, that's why the
25 species are the way they are. So we are interested in

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1 seeing what happens with the follow-on results to make
2 sure we understand this fully, and we can model it
3 correctly, because currently we don't model it with a
4 steady state Iodine concentration in the containment.
5 Our models aren't set up that way.

6 And for the near-term, GSI 1.91 does need
7 to be resolved by the end of the year, including
8 chemical effects, and so this will not be able to be
9 figured out within that time frame, is our thinking.

10 DR. CORRADINI: But if I understood what
11 you just said, you're saying because you don't
12 understand the physics behind what you see from the
13 four tests, one doesn't want to jump to make a change
14 in another issue?

15 DR. POWERS: The problem --

16 MS. HART: That's part of it. The problem
17 is also that when we say okay, take the pH out of the
18 sumps, then they're all going to come in with license
19 amendments, and we have no way to evaluate whether
20 they've calculated the re-evolution, or the amount of
21 Iodine in containment correctly within the next five
22 months, six months.

23 DR. POWERS: The problem is inherent to,
24 this is a phenomenological experiment. Somebody has
25 to take this result and say now, what do we get a real

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1 reactor accident? The problem is, steady states are
2 lovely. You love to get them. They tell you that you
3 have a source, and you have a sink, and they're
4 operating at the same rates. Unfortunately, they
5 don't tell you anything about the sources and the
6 sinks. You cannot find -- the problem is a steady
7 state obscures information, so we don't know what the
8 sources are, or what the sink is. We're pretty sure
9 the source is not the sump, because we've perturbed in
10 just about every way you can think of. We made it
11 acid, we made it base, we put silver in it, we
12 evaporated, we cool it down. Yes, we do see some
13 fluctuations in the steady state due to things like
14 changing the evaporation and the condensation, and we
15 think that has to do with the flux of steam taking
16 Iodine on to surface as we're pulling it off.

17 Now you have to take that phenomenological
18 result and say what happens in a reactor accident. We
19 don't know how to do that right now. And this comes
20 back to Said's point, is that when you do an integral
21 test, the problem is you can't do enough perturbations
22 to tell you what is mechanistic, or give you a handle
23 on what the mechanisms are. And so that leads to the
24 next slide, and I'll let Richard pick up from there.

25 MR. LEE: Just a year or two ago, I think,

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1 they launched a follow-on program to PHEBUS because
2 there's findings from PHEBUS that we could not sort
3 out because of the integral nature of it. The EPICUR
4 program was the Iodine chemistry, and we think that is
5 essential for us to answer the questions related to
6 that so-called steady state Iodine behavior that we
7 see in PHEBUS. And there is also another program
8 that's been launched by OECD, has to do with ECL,
9 another Iodine program that they want to do
10 measurements. So we are trying to make sure that
11 these two programs gave us enough information for us
12 to validate the model that we already put together,
13 because, for example, the -- if you want to do the
14 analysis of the steady state Iodine behavior, the
15 paint behavior, and so forth, we don't have the
16 information in order to validate the model that we
17 have developed at this time.

18 And, also, there are some disagreement
19 between, or maybe different view between the French
20 and the Canadians about how Iodine evolved from
21 surfaces and paint. One thought it was a surface
22 effect, one thought it was more of a - how do you call
23 it - atmosphere effect. Right? So we need to sort
24 those out.

25 DR. BANERJEE: So which are the ACL tests?

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1 MR. LEE: None of the ACL. These are all
2 the French follow-on.

3 DR. BANERJEE: Only the French.

4 MR. LEE: But I'm just pointing out to you
5 that currently, the OECD launch another program based
6 on the Canadian testing. Canadian has done a lot of
7 Iodine chemistry area for -- I mean, 30, 40 years, so
8 they know - they have the view about how Iodine
9 behave. And they are very strong in the Iodine
10 modeling and experimentation area, so we have to pay
11 attention to what they're doing, because we tried to
12 see, to make sure that these two views are --

13 DR. BANERJEE: What is their view?

14 MR. KLEMENT: Anyway, because the
15 Canadians are participating to this program, and we,
16 the French, are participating to the Canadian
17 programs.

18 MR. LEE: So maybe you can talk about your
19 view on the paint behaviors, versus the Canadian view.

20 MR. KLEMENT: Well, there is one thing
21 that we have in our models, is just when you have
22 inorganic Iodine in the atmosphere, we consider an
23 absorption of this inorganic Iodine onto the surfaces.
24 Then chemical reaction on to the -- with the surfaces,
25 and the absorption of organic Iodides is being a

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1 reaction on the surfaces.

2 There is one point that may be solved by
3 the Canadian experiments, too, that is the influence
4 of steel, and whether the surface was wet before being
5 dry because it seems that could have an influence. So
6 this will be part of the Canadian experiments, and so
7 on. But, basically, for us, it's more surface
8 reaction. Then you can also imagine that your
9 solvents, you're getting solvents that come out in the
10 boundary layer that react with Iodine, and so on.
11 That's when the modeling at the end, once you have
12 understood probably one single, simple model will be
13 enough, if you are sure you are not missing anything
14 to be put in AZTEC or MELCOR, or something.

15 MR. LEE: Basically, the Canadians put a
16 lot of -- they think the solvent in the paint is very
17 important in terms of Iodine behavior.

18 MR. KLEMENT: We don't say it is not
19 important, but we say -- we are trying to model it
20 more, in a more full manner, without going into the
21 detail of the reactions.

22 MR. LEE: So it's the degree of modeling,
23 there are differences between the two. So we want to
24 test out the way that they did it, the way the
25 Canadian does it, and see which one is the one that we

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1 should adopt, so we can do the analysis to understand
2 what happened in PHEBUS. And then we can use the
3 model to extrapolate to the full size plant. So we
4 can look at what is the steady state Iodine that can
5 develop in a prototype reactor, under prototype
6 reactor conditions.

7 DR. POWERS: It's interesting, if things
8 go as we currently think they'll go, subject to change
9 based on the experiments. If the steady state Iodine
10 concentration goes up in reactor accidents relative to
11 what you see in the experiments.

12 DR. BANERJEE: Have the Canadians done any
13 reactor tests with NRU loops?

14 MR. KLEMENT: Have done reactor tests, but
15 not --

16 DR. BANERJEE: Not on --

17 MR. LEE: They did --

18 DR. POWERS: They have done irradiated
19 tests. In their RTF program, they would irradiate
20 solutions with a Cobalt-60 source and look at the
21 Iodine vaporization, and how it interacted with
22 surfaces. That's not what they're proposing to do
23 here. It was a more microscopic test, more
24 mechanistic test.

25 MR. LEE: They also did some fuel release

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1 tests, too, in the --

2 DR. POWERS: Well, they did fuel release
3 tests, and quite a few things like that.

4 MR. LEE: A few of them they did. We
5 worked closely with them at the time when we were
6 developing the VICTORIA code. The Canadian with also
7 with UK, very closely.

8 The CHIP program that's shown here is
9 really to look at the release of gaseous Iodine from
10 RCS. Remember, I guess - I don't know whether you
11 recognize it or not, the PHEBUS piping is really not
12 stainless steel, it's Inconel. So we need to ask a
13 little bit questions about the scaling aspect of that,
14 so we want to look into that a little bit more, so
15 it's stainless steel versus inconel. And then on the
16 other one, those are - they want to look at the Boron
17 Carbide stainless steel behavior, basically looking at
18 the control rod. The MOZART test is looking at the
19 cladding oxidation in air, is basically they are
20 trying to expand the database that low temperature
21 experiment that we have done at Argonne a few years
22 ago. They want to do some experiment to overlap the
23 range, and then did some more in that area. What have
24 you done recently?

25 MR. KLEMENT: Well, we had done most of

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1 the experiments on Zircaloy-4, and we will start
2 experiments on Zirlo.

3 MR. LEE: Okay. And then the last
4 facility is the replacement for the test that was --
5 is located in Grenoble. They shut down all those
6 facilities, or they're building a new facility. The
7 CEA is building at Cadarache, so they're going to want
8 to do some MOX fuel, and also high burn-up fuel,
9 similar to the HIVI-type tests, but it's for high
10 burn-up, is for MOX, and also for high burn-up. This
11 won't start until 2009 and 2010.

12 DR. KRESS: I may still be around.

13 MR. LEE: Sure. So in summary, you will
14 see that I think PHEBUS provide a lot of information
15 for us to validate the code. And then the follow-on
16 program will provide even further information to sort
17 out all the findings from PHEBUS try to untangle at
18 this time. And, of course, NRR is always interested
19 in what does it do to the alternative source term they
20 use in the DBA analysis, especially the -- is there
21 anything changes this, does the Cesium form different,
22 the Iodine, the Iodine behavior in the containment.
23 And then we need to sort out the steady state gaseous
24 Iodine behavior in the containment. And I told you
25 that we have models developed based on the -- we are

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1 waiting for the results from the EPICUR tests to give
2 us some additional data for validation of the models.
3 Once we put it together, we check the results using
4 PHEBUS, and then we're going to extrapolate it to the
5 prototype reactor so we can tell where there is a
6 problem or not for us.

7 So I think that's about it. And these are
8 references for study. We can summarize it for you the
9 next meeting. Those are the references I believe that
10 you have been provided.

11 DR. KRESS: Your engineering.

12 MR. LEE: I'm telling you all these --

13 DR. APOSTOLAKIS: Not any more.

14 DR. KRESS: Oh, he doesn't have it any
15 more?

16 DR. APOSTOLAKIS: The European thing, but
17 Theo was involved, but not any more.

18 DR. KRESS: Not any more.

19 MR. LEE: At one time was the editor.
20 Right?

21 DR. APOSTOLAKIS: One of the editors. He
22 has some classrooms now.

23 (Simultaneous speech.)

24 DR. APOSTOLAKIS: Do I want to hear it?

25 MR. LEE: That is the end. Do you have

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1 any questions?

2 DR. APOSTOLAKIS: It's a very good job.

3 DR. KRESS: Yes, thank you very much.

4 DR. CORRADINI: Very good.

5 DR. KRESS: Appreciate that. Any
6 questions anybody? I'm about to turn it back over to
7 our esteemed Chairman.

8 DR. MAYNARD: Just a comment, not so much
9 on PHEBUS, but to some of the results. I'm glad to
10 see that the NRR staff responsible for generic issue
11 1.91 is following this, and paying attention to it.
12 I think it is extremely important that we do all that
13 we can. I know the constraints, I know we have some
14 requirements to resolve it, GSI 1.91 by a certain
15 date. I understand some of the issues that Dana was
16 talking about. There is also some of the regulatory
17 aspects, if we go to removing requirements to have
18 this. But the bottom line, I think we owe it to the
19 public that we do everything we can to make sure our
20 solution to 1.91 doesn't decrease safety, if we have
21 information available to us now that could enhance
22 that resolution, so I think we really need to work
23 hard on that.

24 DR. KRESS: On this gaseous Iodine steady
25 state, I would be tempted to think it might be coming

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1 off of the condenser, and I have asked the question,
2 how long does the water stay there before it drops off
3 into the pool? And if it stays there a significant
4 amount of time, and it's not prototypic of some of the
5 real reactor conditions. I don't know where else it
6 would come from.

7 DR. CORRADINI: Because it would rain out.

8 DR. KRESS: It's a question of a film, and
9 how fast the film flows down. And I don't think you
10 have the equivalent condition in the containment.

11 DR. ABDEL-KHALIK: That is very, very
12 short compared to the 100 hundreds or so that you're
13 talking about here.

14 DR. CORRADINI: Well, I guess, Dana, you
15 said something, I didn't remember how you finished the
16 answer about it. You said you've done some estimates,
17 and you would guess that it would be higher in
18 containment. And I don't remember why you -- what the
19 reason was.

20 DR. POWERS: I didn't tell you my reason.

21 DR. CORRADINI: Will you tell us?

22 DR. POWERS: No.

23 DR. CORRADINI: Proprietary.

24 DR. POWERS: It's what you would expect at
25 this point, Mike, because I'm just guessing at what's

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1 going on. But, essentially, it boils down to the fact
2 that no matter where I inject the containment, I have
3 a much more torturous path to get things down to the
4 sumps, than I do in the PHEBUS experiment, so I have
5 far more material loaded on more surface area in the
6 reactor. So I have more source, about the same
7 sinking, because I'm sinking largely by homogenous
8 destruction, the Iodine, so it's about -- my sink term
9 is about the same as in the reactor, but my source
10 term is a little bigger.

11 DR. CORRADINI: But then that means that
12 in all the models to-date, once you split out what is
13 gaseous versus what is tied up with Cesium, or
14 whatever, there's no physical model that trades that
15 out.

16 DR. POWERS: We trade it.

17 DR. CORRADINI: Oh. So then -- but the
18 gaseous -- the way you're explaining it, I'm just
19 trying to understand, the way you're explaining is,
20 it's in solutions sitting on some wetted surface, and
21 it's, essentially out-gasing.

22 DR. POWERS: In my modeling it didn't have
23 to be wet.

24 DR. CORRADINI: Oh.

25 DR. POWERS: Okay? And that's one of the

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1 key issues that's going to be looked at first and
2 foremost in the ACL experiments, because they're going
3 to look at surfaces as a function of the ambient
4 humidity. And that's one of the contentions on
5 whether you get irreversible deposition, or reversible
6 deposition on dry surfaces or not.

7 DR. CORRADINI: In these experiments, is
8 there going to be some sort of active spraying to look
9 and see if you actually try to remove it with some
10 sort of --

11 DR. POWERS: We presume we know how to
12 move Iodine gas with a spray droplet.

13 DR. KRESS: Is there going to be any
14 consideration of radioactivity --

15 DR. POWERS: Oh, the self-dosing effect?
16 No, I think we -- certainly, the experiments they do
17 at Cadarache are irradiated solution, and they can
18 even irradiate it. The Canadian test will probably
19 not do that. We haven't really designed that.

20 DR. CORRADINI: So let me just ask one
21 other question. If .1 percent became 1 percent, is it
22 worth having the containment spray have the sodium
23 hydroxide there to knock it down? How large would it
24 have to get that you actually cared about having the
25 sodium hydroxide in the water?

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1 DR. POWERS: It's not the level of
2 concentration in the atmosphere. It's the magnitude
3 of loading on the surface, because if I pull it out of
4 the atmosphere, then I turn the spray off, it just
5 comes right back in until I depleted my sources.

6 DR. CORRADINI: Right. But since it's
7 gaseous, and it's not being tied up chemical -- I
8 guess what I'm still back to is, I'm trying to
9 understand, if it's not being traded off and getting
10 held by some other chemical -- by chemically reacting
11 to something else, you're saying either I put it there
12 and it re-evolves, if I stop doing whatever I'm doing.

13 DR. POWERS: I think it's very difficult
14 to get things from the sump back to the atmosphere.

15 DR. CORRADINI: But once you put it there
16 --

17 DR. POWERS: What's on the surfaces, and
18 the amount of loading I have there, it's going --
19 again, this is totally speculation on my part. How
20 much I put on the surfaces early in the accident, if
21 I spray those surfaces, or spray that atmosphere and
22 take out some of the gases there, doesn't matter, come
23 right back up, as soon as I stop spraying.

24 DR. CORRADINI: Right.

25 DR. POWERS: And it will keep going that

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1 until the combination there of decay and depletion
2 reduce those sources.

3 MR. LEE: Basically, if you deplete, make
4 the concentration over the surface to balance it.
5 That's what we think we're observing in PHEBUS.

6 DR. KRESS: PHEBUS didn't find anything on
7 the containment walls, did it?

8 MR. LEE: No, containment walls is heated,
9 so you don't see anything on the containment
10 deposited. Right?

11 MR. KLEMENT: We have seen some Iodine
12 coming out from the steel walls, yes.

13 DR. KRESS: You think that might be the
14 source, as opposed to the condenser?

15 DR. POWERS: It is not a source that you
16 can discount. You can't throw it away. And, in
17 particular, up in the particular locations, flow
18 patterns up there during the injection phase is very
19 complicated. After injection, it's even more
20 complicated, so you can't throw it away.

21 DR. KRESS: It's not necessarily true --

22 DR. POWERS: I don't think that's --

23 DR. KRESS: It's not necessarily true that
24 the condensation carries everything.

25 DR. POWERS: But I think if you're going

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1 -- the smart money is going to bet on the condensers.
2 But you can't throw it away right now.

3 MR. LEE: So, basically, we said that the
4 sump in PHEBUS has great access to the containment,
5 and we see that the sump is not active in doing the
6 Iodine partitioning stuff. Other things it's doing.
7 And for comments related to working with NRR, research
8 work, we work very closely with NRR and NRO now,
9 because they split. Closely with on site since the
10 inception of it.

11 DR. KRESS: Did you actually have
12 measurements of how much Iodine is in the sump as a
13 function of time?

14 MR. KLEMENT: Yes.

15 DR. KRESS: You have to be able to
16 calculate potential source, back into the atmosphere
17 from --

18 (Simultaneous speech.)

19 DR. KRESS: It may be really small, like
20 you say.

21 DR. POWERS: What they do, they have a
22 very nice setup. They have a gamma spectrometer looks
23 through the solution. They have one that looks at the
24 bottom, and so when the silver iodide precipitates
25 down, they can see that, and they can see the

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1 depletion from the solution. It's actually pretty
2 good.

3 DR. KRESS: May be useful to --

4 MR. LEE: They will see the Iodine when
5 they wash it from the elliptical surfaces into sump,
6 you see it actually goes out. You can correlate those
7 directly.

8 DR. KRESS: That was that little blip you
9 had on the end.

10 DR. POWERS: That has more to do with, in
11 that particular test, they dropped the temperature of
12 the sump, and so there was less vaporization from the
13 sump, so there's less flux putting it back under the
14 condenser. So the steady state concentration crept
15 up, and they've done it the opposite way, and it goes
16 down.

17 DR. KRESS: I see.

18 MR. LEE: And you see one test that the
19 evaporation rate is high, the rate goes down, so you
20 see that it adjusts itself, basically.

21 DR. POWERS: You know, you try to pull
22 things out of these integral tests, but in the end
23 stage, right, integral tests are a long way to go to
24 separate effects tests, like EPICUR.

25 DR. KRESS: They're there to tell you if

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1 you're missing something important. And maybe this
2 steady state Iodine tells you you might be missing
3 something.

4 DR. POWERS: Well, it told us we did miss
5 something important. I mean, it's not that we didn't
6 know the paint was important, we didn't know it was
7 this important.

8 MR. LEE: So, basically, I think we're
9 looking for between a year or two we're going to sort
10 out this stuff.

11 DR. KRESS: Sounds good.

12 CHAIRMAN SHACK: Well, again, thank you
13 very much for the presentation. We're going to take
14 a 15-minute break, and come back at 4:00.

15 (Whereupon, the proceedings went off the
16 record at 3:42:56 p.m.)

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