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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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SOURCE TERM APPLICABILITY PANEL

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WEDNESDAY

FEBRUARY 20, 2002

+ + + + +

ROCKVILLE, MARYLAND

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The Panel met in Conference Room 4-B-6,
One White Flint North, Rockville, Maryland, at 8:30
a.m., Brent Boyack, Moderator.

PRESENT:

BRENT BOYACK

BERNARD CLEMENT

JIM GIESEKE

TOM KRESS

DAVID LEAVER

DANA POWERS

JASON SCHAPEROW

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

(8:46 a.m.)

1
2
3 MR. BOYACK: All right, let's go ahead and
4 begin then.

5 What I would like to do is just review for
6 a moment what we are going to do today. There's also
7 been a few questions that have been asked about
8 procedure, and I think those would be worthwhile
9 covering.

10 Let me first deal with the matter of the
11 documentation that will be produced as the product of
12 this activity. Most of the people are aware that ERI
13 is pulling together a document that has pieces coming
14 from various individuals. I've just given the tables;
15 most of this, compiled some front-back parts. Then
16 after this meeting I believe I will have the major
17 piece of work to do, which is to get the tables and
18 the associated chapter or chapters that talks about
19 that information.

20 After we do that, then the document will
21 be compiled and it will be sent to the panel members
22 for review and comment. You should feel entirely free
23 to review that, comment on it as you feel appropriate.

24 We will have to do our document updates
25 and revisions by email, .pdf files, Word files, et

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1 cetera, whatever you can work with, so that you can
2 work with all the document and provide your comments.
3 Those in general will be incorporated, and then they
4 will have to go back, and what we'll do probably is
5 any changes made could be put in color. So that when
6 you get the file back, you can look and see what has
7 been changed since you last saw it.

8 MR. LEAVER: Just regular text editing
9 would highlight that.

10 MR. BOYACK: Well, there is that
11 possibility of doing that, but I find that they're
12 awfully hard to read sometimes.

13 MR. LEAVER: Oh, okay.

14 MR. BOYACK: Because they have --

15 MR. LEAVER: So you've done this before?

16 MR. BOYACK: I guess they have a mechanism
17 where you can just have the changes shown, and that
18 would work, mostly just to do that. The real key is
19 that the changes will be highlighted in a way that you
20 can easily discern them.

21 Now we'll work on the schedule and talk a
22 little bit about that tomorrow.

23 The second question that came up was a
24 little bit about whether we are going to refine the
25 BWR tables specifically, and that portion of the BWR

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1 tables in which we have multiple entries, one for each
2 individual. What I have tried to do is explain what
3 I perceive to be the NRC policy or priorities. I will
4 go ahead and say this now. So if it doesn't agree
5 with what Jason feels, then he will go ahead and
6 correct me.

7 We have had a very ambitious set of
8 objectives for this meeting. That is, the PWR source
9 term applicability, the BWR source term applicability,
10 and MOX source terms, if you will. We have had three
11 meetings to accomplish this. Of course, the first
12 meeting was very much of a startup meeting. We made
13 good progress in the second meeting. We have made
14 good progress in this meeting.

15 The NRC has basically told me that what
16 they want is the panel's input on all three areas. So
17 we haven't eliminated anything. We have worked on the
18 PWR; we've worked on the BWR; we'll be working on MOX
19 today and tomorrow. But we do have a definite time
20 limit, and that time limit is three o'clock tomorrow
21 afternoon, when we all turn into pumpkins.

22 So what will happen is that we will go
23 through the MOX today and as much as we need tomorrow.
24 If there is any time left, then we can come back and
25 talk about these, the BWR and PWR -- we have

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1 individual values -- to see if a little more
2 discussion brings you to single values as a panel. So
3 time will be the determining factor on whether or not
4 we come back and look at PWR and BWR anymore.

5 The real key is to get to the end, to get
6 the panel's input on PWR and BWR. What we have done
7 thus far in each of those areas is satisfactory to the
8 NRC, as I understand it.

9 Now the question is, well, who will go
10 ahead and process these multiple inputs to come up
11 with source terms, say, for the BWR, and the answer to
12 that is the NRC staff will do that. We will not do
13 that as a panel. We will not do that as authors of
14 the report, unless we are able to come back and come
15 to these single items.

16 MR. NOURBAKSHSH: So the report will have
17 what regarding tables?

18 MR. BOYACK: It will have, essentially,
19 the tables regenerated in the form that we've
20 generated them. My guess is that we will not name the
21 individuals, but we will show their values.

22 MR. GIESEKE: So then I presume that the
23 NRC will take that -- I assume they want to do another
24 one of these sorts of reports --

25 MR. BOYACK: I don't know the answer to

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1 that.

2 MR. GIESEKE: -- tables with single values
3 in them?

4 MR. SCHAPEROW: I think what we are going
5 to need to do is look at the needs area, because a lot
6 of the numbers are based on best judgment, and there's
7 an idea that they may even go back and do some code
8 calculations and maybe even a few more experiments,
9 particularly in the MOX area.

10 The two ideas that we have been discussing
11 at great length is ideas of improved, better data,
12 more recent data, better data, and the second idea
13 being the effect of burnup. We are going to try to
14 think this through on our conclusions in both areas.

15 It seems to me that the major effect we
16 are seeing is that of the more recent data and the
17 better data, the more recent data being better
18 instrumented and better analysis. So that's one
19 issue.

20 The other issue is the burnup issue. It
21 seems to be much less of an issue as far as changing
22 the numbers. We will need to sort through that after
23 our meeting. I don't think we are going to have time
24 to do that in this meeting

25 MR. LEAVER: There is data for burnup, and

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1 there really isn't for the MOX. That is the problem.
2 You might not see much of a difference for MOX if you
3 had the data.

4 MR. SCHAPEROW: We will have to wrestle
5 with that after the meeting. We certainly aren't
6 going to be able to resolve that today or tomorrow.
7 I guess there is a far outside chance we may be able
8 to call another meeting in a few more months. I doubt
9 it, though. I don't know. That's in the back of my
10 mind as a possibility, if people are available and
11 all.

12 But I think we really just need to get
13 through MOX as best we can, and the NRC is going to
14 try to draw conclusions and provide directions on
15 programming. It would be nice to be able to publish
16 another document like that, but I'm not sure we're
17 quite there yet. I don't know if that's disappointing
18 or not.

19 The thing is again this issue of what we
20 call back-fed, or whatever you've got, and now we've
21 got some higher numbers in certain areas, not as a
22 result of higher burnup, but as a result of improved
23 insights from recent experiments. But we have to
24 wrestle with that issue a little bit.

25 I don't know if you have anything to add,

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1 Jay, in that regard.

2 MR. BOYACK: Let me return then to the
3 activities for today. We are going to be working on
4 the MOX area today, MOX source term.

5 The procedure is that we are going to
6 first -- well, second -- bring up the table that we
7 talked about yesterday. That's the table which we
8 will go ahead and try to list the differences, the
9 characteristics that have differences between the MOX
10 and the LEU. If we see any research needs, we can
11 identify them at the time, but it is not absolutely
12 necessary. We will go through that table.

13 Now once we get that information down,
14 which sort of serves as a foundation, common
15 viewpoint, then we will go see if we are able to do
16 the source term tables. Now prior to that, we have
17 two other pieces of information, very brief.

18 One of them was Steve Nesbitt wanted to
19 just make a few points about MOX. Steve, you are
20 willing to arrange for somebody to come in and talk
21 about power --

22 MR. NESBITT: We said we would do that on
23 the last document.

24 MR. BOYACK: So that will be tomorrow
25 afternoon?

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1 MR. NESBITT: Right.

2 MR. BOYACK: Now by that time, we will
3 have very little time to go back and do anything with
4 the tables, if it's in effect. Now the primary factor
5 there was that you heard us talking about the fact
6 that the additional power would lead to additional
7 releases, and that may have been affecting one or two
8 of the people's input regarding source terms. So it
9 would help if we could have that before the time in
10 time to react.

11 Now before I turn the time over to Steve
12 Nesbitt for just a moment, is there anything else that
13 anybody wants to bring forward to the panel before we
14 continue on?

15 (No response.)

16 Okay, Steve, you have a few comments?

17 MR. NESBITT: Yes. First, there was a
18 couple of follow-up items from yesterday. There was
19 a question about the kind of power history that the
20 MOX fuel assemblies would see, we think, in our
21 folders, and we operate on them.

22 There is some information on that,
23 although it doesn't present it side by side with the
24 LEU fuel, but the power histories are generally
25 similar. There is some information about that in the

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1 Fuel Qualification Plan, particularly I think it's
2 Figure 8-2.

3 That kind of leads me into a bigger thing
4 that I wanted to talk about. I had been under the
5 impression that you, as a panel, had been provided the
6 Duke, COGEMA, Stone & Webster Fuel Qualification Plan
7 for mixed oxide fuel for review as a part of this
8 activity. Based on the discussion yesterday and last
9 night, I guess now I understand you didn't get that.
10 Maybe everybody didn't get it or all that kind of
11 thing.

12 There's a fair amount of information in
13 there in terms of our overall approach for getting
14 regulatory approval for use of MOX fuel here in the
15 United States that I didn't bring out in the
16 discussions back in December because I thought it was
17 kind of inherent there in material that you may not
18 have seen. I guess I want to cover a couple of things
19 there. I promise I'll be brief.

20 But the fundamental basis for our
21 application, upcoming application, to get approval to
22 use mixed oxide fuel in the United States is that
23 mixed oxide fuel is very similar to uranium fuel, not
24 identical, and some of those aspects of differences we
25 brought out in December, and you're well aware of.

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1 One of those differences that bears on
2 what you're doing being the fact that obviously the
3 plutonium is in very small, dispersed, plutonium-rich
4 particles throughout the fuel rather than being
5 completely homogeneous. But recognizing that there
6 are some differences there, fundamentally, it's
7 ceramic oxide fuel with similar characteristics,
8 predominantly uranium.

9 When it comes to source term, I am going
10 to tell you something that I think everybody in this
11 room knows, but I'm going to tell you anyway. Pardon
12 me if I'm preaching a little bit.

13 Here in the United States we employ a
14 fundamentally conservative approach to using source
15 terms for the analysis of design basis actions. We
16 use a source term from a core melt event for accidents
17 that don't give you core melt. That is consistent
18 with the conservative deterministic philosophy that we
19 used to license nuclear power plants, and it served us
20 very well.

21 As Dave Leaver pointed out to me a couple
22 of minutes ago, it is water under the bridge, and
23 we're certainly not proposing to change it.
24 Nevertheless, it is a major conservatism that we need
25 to keep in mind, I think, as we move forward.

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1 Alternative source term, we at Duke Power
2 view as predominantly a good thing. As I have
3 discussed, we are planning to move forward with
4 application of alternate source term for our plants in
5 the near-term.

6 It offers -- and the words are quoted from
7 NUREG 1465 -- "a more realistic portrayal of the
8 amount of fission products present in containment from
9 a postulated severe accident."

10 NUREG 1465 also says, "Release fractions
11 are intended to be representative or typical rather
12 than conservative or bounding values. The release
13 fractions are not intended to include all potential
14 severe accident sequences, nor to represent any single
15 sequence." I think everybody knows that, but I think
16 it's worth a reminder every once in a while.

17 So what are you guys going to do today and
18 tomorrow on MOX fuel? Well, the way I see it, the
19 fundamental question before your panel is: Is the
20 NUREG 1465 alternate source term reasonably
21 representative of plants that are operating with some
22 fraction of the core being mixed oxide fuel, in light
23 of the inherent uncertainty in a representative source
24 term that's derived from a combination of experiments
25 and calculations that model complicated, interrelated

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1 phenomena in the thermal hydraulic and chemical and
2 mechanical area, and given that there is a fundamental
3 conservatism that's inherent in how we apply these
4 source terms in regulatory space that we shouldn't
5 lose sight of?

6 So, with that being said, I don't presume
7 to answer the question for you. You all are going to
8 answer the question.

9 MR. KRESS: I don't understand your
10 fundamental conservatism. The reason I don't
11 understand it is because primarily I'm interested in
12 preserving a level of risk that's acceptable. I do
13 that by this somewhat stylistic approaches and DBAs,
14 and then couple them with some sort of switch term, to
15 design a system that's robust against all accidents.

16 I don't know that putting in a source term
17 like we put in, or coupling in that manner, is
18 conservative or not. In fact, it very well may not
19 be, if I'm trying to preserve a level of risk that's
20 acceptable from the standpoint of really looking at
21 the risk. I can't make that connection between the
22 design basis phase and this phase. I don't know that
23 we're conservative at all.

24 MR. SCHAPEROW: I would like to further
25 suggest that this is what the agency uses to

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1 demonstrate their protection of the public against a
2 severe accident without core cooling. This is it. We
3 also do have evacuation plans, but I tend to agree
4 with Tom in this regard.

5 MR. NESBITT: And I'm not challenging
6 that. I think I'm agreeing with it.

7 MR. SCHAPEROW: Oh, okay.

8 MR. NESBITT: But what I'm saying is that
9 that's not all we use it for. I mean, we use it to
10 determine, for example, whether the results of a loss
11 of coolant accident are acceptable or not from a dose
12 perspective. You might argue that, well, we're not
13 really just looking at loss of coolant accidents.
14 We're really looking at anything that might happen.

15 MR. SCHAPEROW: That's right. This is a
16 long-term loss of coolant accident that we're looking
17 at.

18 MR. NESBITT: Yes, but we look at it in
19 both contexts, and in risk base I agree with
20 everything you said, Tom. We do think it's important,
21 and we have a lot more risk insights now into how our
22 plants operate than we did when the original licensing
23 basis was constructed back in the sixties and
24 seventies. We have probabilistic risk assessments and
25 safety goals, and all that kind of stuff, that give us

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1 more information about how we stack up in that area.

2 Again, I'm not trying to answer a question
3 for you all. That's what your panel is going to do.
4 I'm throwing out, I guess, the way that I see the
5 question, which is that, given what the alternate
6 source term is used for, is what we've got appropriate
7 for application to MOX fuel? If not, are there
8 adjustments that can be made? And if that's not the
9 case, is there additional work that can be done to
10 fill the gaps?

11 I wasn't here at the first meeting, and
12 maybe that's what the NRC told you, or maybe they told
13 you something else, but I guess I'm throwing it out
14 because I wanted to have an understanding, if
15 possible, that that is what you all are doing or maybe
16 you all are doing something else. Maybe that's a
17 question for the NRC more than it is for you all.

18 MR. KRESS: I think what we're doing is
19 actually trying to carbon copy what was done in the
20 past with regular fuel, in the sense that we've
21 developed the design basis source term that somehow
22 comes out of information about how a core melts and
23 how these fission products get into a containment, and
24 what those quantities might be, representative of a
25 range of accidents. Then we are going to take those

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1 and apply them in the design basis phase.

2 Nobody has proven to me that that's the
3 best way to regulate. It turns out that it's pretty
4 good because, if you go back and look at all the
5 plants that resulted, the design that resulted from
6 this, they've been pretty safe from a risk standpoint.

7 So we are taking a leap of faith, but
8 that's probably a good way to do it, and, in fact, may
9 be a conservative way from the standpoint of, is there
10 a design that's realmly something like the risk
11 acceptance criteria?

12 So what I think we're doing is we're just
13 going back and repeating that. The only difference is
14 MOX may have a different set of fission product
15 releases over a range of accidents. We're just going
16 to repeat the same process. We didn't know if it was
17 going to work the first time, and we don't know if it
18 is going to work this time, but it might. The proof
19 of the pudding is going back and doing a complete risk
20 analysis to show that you didn't really achieve it.

21 See, the problem is what I envisioned
22 going on is -- we'll take Chapter 15, "Range of DBA
23 Accidents." We'll use a new source term, if somebody
24 comes up with it, and it shows me all of the triggers
25 of merit that you have to meet.

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1 MR. NESBITT: Hopefully.

2 MR. KRESS: Hopefully.

3 MR. NESBITT: Or not.

4 MR. KRESS: If you're not, you'll have to
5 change something in the design of the plant --

6 MR. NESBITT: Right.

7 MR. KRESS: -- like the leak tightness of
8 the fuel or the containment or something, or you may
9 have to do something, back to sprays, or whatever.
10 But it looks to me like the source term is not a stone
11 plate in meeting those Chapter 15 figures of merit.
12 The possible exception is the leak tightness or the
13 containment.

14 MR. NESBITT: And the controller.

15 MR. KRESS: And the controller. Those are
16 the drivers.

17 So what we're going to do here, coming up
18 with a source term, assuming it is going to be higher,
19 it can give you some grief because you're going to
20 have to show that the end leakage of the petroleum is
21 maybe different than you thought or the leakage is the
22 same. I think that's about the only -- it's not going
23 to do much to your equipment qualifications or much to
24 your isolation. It's not going to do anything to
25 ECCS.

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1 So what's going to happen is you're
2 clearly changing the risk significantly if you have a
3 much higher source term. You can really change the
4 risk significantly, although affecting the design
5 basis phase is relatively insignificant. So I have a
6 real problem with going in on the design basis phase
7 only. I think you're going to have to come forth with
8 here's the design basis phase; we need all these
9 things, plus, here's our risk analysis to show that we
10 did get out --

11 MR. NESBITT: And that's exactly what I
12 wanted to add, and that's laid out in our Fuel Qual
13 Plan. In addition to addressing the design basis
14 accidents, it is our intent to perform full level 3
15 PRAs for --

16 MR. KRESS: Well, that's what I was
17 leading to. You will need --

18 MR. NESBITT: For a side-by-side
19 comparison of the risk involved.

20 MR. KRESS: Yes. Whatever we use in the
21 way of thinking and models and data to develop our
22 design basis source term, you will need those models
23 in thinking, in doing your risk analysis. That's
24 where I think a lot of this is going to be most
25 useful, because I think you can meet these Chapter 15,

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1 no matter what we come up with, because we're not
2 going to do that much to it. But when you go to do
3 your risk, you can't just use the map; you can't use
4 it. It doesn't have the right fission product release
5 for what you've got in it. I think that's where what
6 we're doing is going to be useful to you. It's going
7 to tell you what you have to do to do your risk
8 analysis better for this.

9 This is the perspective that I thought I'd
10 throw in. So I see the thinking and the models and
11 the data we're using here, it's probably going to be
12 more useful to you than the actual source term we come
13 up with.

14 MR. MARTIN: I'm Bob Martin. I'm the
15 Project Manager for the Nuclear Reactor Regulation
16 here in Rockville, focal point for communications
17 regarding MOX. Several of other NRR members are with
18 us today: Steve Lavie and Jay Lee.

19 The report referred to earlier, the Fuel
20 Qualification Report, is one that Duke has submitted
21 to us. Our most recent revision of it is April 2001.
22 They submitted it for information to the NRC staff.
23 It has been useful as an information reference for us
24 since then. I have a few copies in my office, which
25 I'll share with you today. I'll send them to

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1 reproduction and I'll have copies for you tomorrow.

2 I have a recent summary of minutes,
3 summary of a meeting we had here regarding research
4 activities; also, information that's on the public
5 record. I'll make copies of that and provide it to
6 you before you leave.

7 MR. SCHAPEROW: I appreciate that. I'm
8 pretty certain that I mailed it at least to the panel
9 members. It was a while ago. It was months ago I
10 sent it to the panel members, that's true. I can go
11 check. I think I have a pile still in my office. I
12 can go check on the break.

13 MR. BOYACK: All right, Steve, was that
14 your comments or do you have any others?

15 MR. NESBITT: Yes, that was basically it.
16 A specific question came up yesterday about the power
17 profiles for the LTAs and the MOX fuel assemblies.
18 There is a figure in that report -- I think it's
19 Figure 8-2 -- that shows some additional information
20 on that. I don't think it's any earth-shattering fact
21 that's going to change any conclusions of the panel.

22 MR. BOYACK: All right. Now if I recall
23 from yesterday, what we said we would do first is that
24 we would go through a few moments where we talked
25 about various characteristics that we thought were

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1 important, go ahead and indicate the LEU behavior, the
2 MOX behavior. If I understood that right, this is the
3 type of thing that we might do: MOX assemblies in the
4 core, zero in LEU and 40 percent in the MOX case; the
5 plutonium in the two cycles, 1 percent in LEU, 3
6 percent in MOX; cladding with zircaloy, M5. This was
7 just my attempt to take a few things and start to list
8 them.

9 So that's what I would like to do now, is
10 to have you identify the characteristics that you
11 think are worthwhile taking into account, and then we
12 will go ahead and just distinguish between the LEUs
13 and the MOX.

14 MR. CLEMENT: I think the most important
15 difference between the two fuels is the microstructure
16 of MOX as compared to LEU. Because in MOX you have
17 two phases, too many phases for the fuel. You have
18 the plutonium-rich agglomerates which are roughly of
19 the size, say, of 16 micrometers, and inside are
20 uranium-rich matrix.

21 That means that, in fact, nearly all the
22 fission will concentrate in the plutonium-rich
23 agglomerates, and this is where fission products will
24 be created. As a consequence, if we speak of local
25 burnup, local burnup in the plutonium-rich

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1 agglomerates will be very high for the same average
2 burnup on the pellet. Maybe it's difficult to get an
3 answer.

4 MR. KRESS: And not only that, your
5 distance between fission products is very small --

6 MR. CLEMENT: Yes.

7 MR. KRESS: -- and we have a chance for
8 them to interact with each other where they didn't
9 have in the --

10 MR. CLEMENT: And a high concentration of
11 fission products.

12 MR. KRESS: Yes, exactly.

13 MR. CLEMENT: There is a very high
14 concentration of fission products in the plutonium-
15 rich agglomerates. This will impact on where are the
16 fission products because you know there are several
17 different phases. So this will impact on where are
18 fission products -- I mean whether they are dissolved
19 in the matrix, whether they are in metallic
20 precipitates, whether they are in the gray phases. I
21 don't know if you've got the same phases with
22 plutonium or whether they are in the grain boundaries.

23 So, as a summary, you could say impact on
24 the repartition of fission products in different
25 phases. So, generally speaking, different repartition

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1 of fission products in the different phases.

2 MR. BOYACK: Did I capture it -- well, go
3 ahead.

4 MR. CLEMENT: This is also influenced by,
5 I will say, plutonium in thermochemistry. That's not
6 exactly the same as uranium thermochemistry. So when,
7 for instance, we have to calculate the repartition of
8 fission products in the different phases and in the
9 solvent test matrix and grain boundaries and grain
10 phase, in metallic precipitates, we have to take into
11 account all the thermodynamic equivalents, including
12 specific plutonium thermodynamic properties.

13 MR. KRESS: Which depends on the local
14 concentrations.

15 MR. CLEMENT: The local concentration.

16 MR. KRESS: Yes, I agree with you. That's
17 the main difference; that is going to affect things.

18 MR. CLEMENT: So specific plutonium
19 thermochemistry, I'd say.

20 MR. BOYACK: Is that MO or MAL?

21 MR. KRESS: MO.

22 MR. CLEMENT: I don't know.

23 MR. KRESS: One word.

24 MR. CLEMENT: It should be also the
25 influence of the surrounding matrix to look at the

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1 gases. If you look at the gases, you will very
2 quickly have bubble indication, bubble correlations,
3 bubble issues, and so on. Then when they come out the
4 boundaries, you could have resolution of bubbles in
5 the matrix also.

6 MR. BOYACK: If you want me to summarize
7 that one, you're going to have to help me.

8 (Laughter.)

9 MR. CLEMENT: How could I do that?

10 MR. KRESS: The fact that you have a high
11 concentration of fission products locally means you've
12 got a lot of xenon and krypton there. It actually
13 makes little bubbles easier than it would be if it was
14 distributed. So you can make the bubbles easier, and
15 they're local, and they're not stable or they might
16 move. They can move down temperature gradients and
17 thermal gradients, and as they move, they're
18 encountering a different chemical environment, and
19 they can go back into solution or not, or whatever
20 happens to them. I don't know what happens to them.

21 MR. CLEMENT: All these differences in
22 structures could impact on the fuel degradation
23 processes. That, in turn, could impact on the fission
24 product careers.

25 MR. BOYACK: So what is --

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1 MR. CLEMENT: So fuel degradation
2 processes might be different, could be different, and
3 fuel degradation processes impact on fission
4 trajectories.

5 MR. BOYACK: So is there anything that you
6 understand currently about the difference between LEU
7 and plutonium that I could put?

8 MR. CLEMENT: Well, make the comparison
9 with differences between high-burnup fuel and
10 moderate-burnup fuel. In high-burnup fuel it is much
11 more easy to have -- for instance, you have liquid
12 zircaloy, having access to fuel for dissolution into
13 actions, and so on, and less impacts on fuel
14 degradation and less, also, impacts on fission
15 products release kinetics.

16 Here for MOX I don't know, but I'm just
17 saying that, as soon as your structure is different,
18 degradation process is linked to interactions with
19 other materials, may be different.

20 MR. BOYACK: Okay.

21 MR. CLEMENT: And fission product release
22 kinetics may be affected.

23 MR. BOYACK: And may affect which kind of
24 kinetics?

25 MR. CLEMENT: May affect the fission

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1 product release kinetics.

2 MR. BOYACK: Okay.

3 MR. POWERS: Let me ask a question and
4 reflect my own ignorance maybe. Suppose we have a 16-
5 micron particle of plutonium in a sea of uranium, and
6 we have a fission event there. The recoil will push
7 the fission product maybe about 4 microns? So it
8 comes to rest not in the UO₂, but in the uranium
9 lattice by far and away most of the time.

10 With 16 microns, if you figure anything on
11 the outer 4 microns, it can push at least half of its
12 fission products out into the lattice. That turns out
13 to be seven-eighths of plutonia can push half of its
14 fission products out into the lattice.

15 MR. CLEMENT: Yes, I agree with you there.
16 I've seen some calculations of the zero state for
17 reactivity in accidents where they calculated a
18 significant amount of gases that are uranium by recoil
19 processes. That has to be taken into account.

20 MR. POWERS: And it means that the uranium
21 lattice adjacent to the inclusion is positively
22 bombarded by high-energy, high-mass particles. So it
23 surely must be structured so it doesn't look anything
24 like the lattice, the bulk lattice?

25 MR. KRESS: I think that's wrapped up in

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1 one. I think you're right.

2 MR. BOYACK: What I've listed so far are
3 microstructure, thermochemistry, fission product
4 concentration, fuel degradation processes, and is
5 there anything else you want to summarize out of these
6 last points that Dana made in a way that I can get
7 them down?

8 MR. KRESS: I think the effects of these
9 things on the microstructure and restructuring the
10 microstructure -- I'm not sure how to say it, but what
11 Dana is saying is you're changing that microstructure
12 in a different way by the fissioning process that you
13 would in a regular LEU fuel.

14 MR. CLEMENT: Changes in the uranian
15 lattice.

16 MR. KRESS: Yes.

17 MR. SCHAPEROW: It seems like a lot of the
18 area wouldn't be affected, though, because it is a
19 very concentrated effect. There are probably large --
20 it seems like there might be large -- not large
21 swaths, but there are areas between the inclusions
22 where you would have it completely intact, where you
23 don't have any fissioning at all.

24 MR. KRESS: Something's got to give. You
25 kind of have a structure there that's a little bit

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1 rigid.

2 MR. POWERS: What I was wondering is, if,
3 in fact, you push all or some significant fraction of
4 the fission products, maybe it's half, some
5 significant fraction into the host lattices, then in
6 those lattices there is no fission intake in place to
7 any great extent in that host lattice, but the fission
8 products are starting to move their grain boundaries
9 much like they would in any -- so you develop an
10 interconnected microstructure from a little island of
11 highly-disrupted areas. Does that mean anything other
12 than you get the interconnected porosity leading to
13 the gap quicker than you would in straightforward
14 urania fuel?

15 MR. KRESS: I think the evidence is in the
16 porous tests, which shows that you take a MOX fuel
17 element and run it through the temperature of
18 transient, and you get more and earlier release. So
19 it's something about MOX fuel is reflecting this in
20 basically more easily-released fission product.

21 MR. LEAVER: But, Tom, there was another
22 VERCORS test of fuel, too, that had the same result.

23 MR. CLEMENT: That's right, but if you
24 look at the data that we have for gas-releasing
25 operation, this is also an indication that it tends to

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1 be higher in MOX fuel than for low-enriched uranium
2 fuel for the same burnup. So this is an indication
3 that the repartition of fission products is not the
4 same main operation. So it is not the same before
5 starting of an accident.

6 MR. LEAVER: You're talking about RT 1
7 versus RT 2?

8 MR. CLEMENT: No, I'm talking about what
9 people just do by puncturing the gases after
10 degradation and measuring the amount of other gases.

11 MR. LEAVER: Right, right, the EDF data,
12 yes.

13 MR. CLEMENT: They are different for a
14 different burnup level. That means that the
15 repartition of fission products, this is only for
16 gases, but --

17 MR. LEAVER: Right.

18 MR. CLEMENT: -- but, generally speaking,
19 it is different. This will affect the subsequent
20 fission products released. That's why a big
21 difference. Maybe it's not always pessimistic, but if
22 it turns out that trapping in metallic agglomerates is
23 more efficient, this would be less pessimistic.
24 That's very complicated.

25 If you'll remember during our last

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1 meeting, Dana has explained to us in his presentation
2 several things about what happens in microstructures
3 when you have vacancies for oxygen, on/off, and so on;
4 explained the possible wall of barium buffer for
5 oxygen potential, and so on, and if you change a
6 repartition of the various things and the
7 concentrations, and so on, you will change that. So
8 we cannot just say that the fission products are the
9 same. It will be affected anyway.

10 MR. KRESS: We've got experimental
11 evidence that MOX fuel releases more and earlier.
12 Certainly I don't want to argue experimental evidence.
13 These are really believable reasons as to why the MOX
14 fuel may behave different in a fission product release
15 standpoint. All we're doing is explaining the data.

16 MR. LEAVER: Yes, we certainly have that
17 evidence in the RT 1 versus RT 2, but then you didn't
18 see it in the HT 1 versus RT 7. All I'm saying is
19 that I just think we need to understand why you're
20 seeing it in one test and not the other before we take
21 this too far.

22 MR. KRESS: I don't understand why you say
23 that. What are you looking at that tells you this?

24 MR. LEAVER: I'm looking at a slide that
25 was presented by Bernard yesterday.

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1 MR. KRESS: Which slide are you talking
2 about?

3 MR. LEAVER: I'm looking at, it's the last
4 slide, the third bullet.

5 MR. CLEMENT: Yes, that slide I mentioned
6 yesterday the sentence is not correct. The contrary
7 effect on RT 7 compared to RT 1, what is collected is
8 release of volatile FP. Volatile FP in RT 7 is not
9 earlier than in HT 1, as a conclusion.

10 MR. BOYACK: So if you take the second
11 bullet and insert "not," "is not earlier" --

12 MR. CLEMENT: No, no, the third bullet.
13 The third bullet.

14 MR. LEAVER: The second bullet is okay.

15 MR. BOYACK: Oh.

16 MR. LEAVER: What he's saying in the third
17 bullet is it's not the opposite; it's the fact that
18 you didn't observe this earlier release.

19 MR. KRESS: And that's where the "not" is.

20 MR. CLEMENT: Somewhere it should be the
21 release of volatile FP in RT 7 is not earlier than in
22 HT 1.

23 MR. KRESS: I don't think that tells me a
24 lot. It tells that it depends on the temperature of
25 transient you're going to. You could release in both

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1 of them at about the same time, if you had the right
2 temperature, and one of them may get released faster
3 than the other. So you might get released more in a
4 given timeframe. That's not implied in that
5 statement.

6 MR. BOYACK: Let me ask Bernard, what I
7 put up there for fission product release is your
8 conclusion from the French test; that is, large
9 amounts of fission products released earlier if it's
10 plutonium?

11 MR. CLEMENT: Released earlier in RT 2
12 tests. A large amount of volatile fission products.
13 You should have volatile fission products. Okay.

14 MR. KRESS: Fission product release tends
15 to be a continuous thing. When you say, when does it
16 start releasing, it's hard to say when it started.
17 This is a continuous thing.

18 MR. CLEMENT: But at a given time in this
19 transient, you find more --

20 MR. KRESS: One is higher than the other
21 during a given time in the transient. I think that's
22 a general statement.

23 MR. LEAVER: Certainly the RT 2 versus RT
24 1 suggests that, and there is the EDF data that was in
25 the slides that Steve Kollie presented at the last

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1 meeting on the fission gas being factor two or three
2 greater in the gap.

3 I think Bernard has said that the French
4 are still trying to explain what happened with RT 2
5 versus RT 1 and the fact that it apparently didn't
6 happen in RT 7 versus HT 1, which is kind of
7 interesting.

8 MR. KRESS: Look at this curve here, in
9 the asterisked line, which compares RT 1 and RT 2, and
10 look at the fission product cesium released for RT 2
11 and the one for RT 1. You can clearly look at that
12 and say, oh, yes, the RT 2 started earlier and
13 released more, but that's because down at this level
14 of RT 1 you're probably releasing, but you're just not
15 picking it up within the uncertainty of your ability
16 to measure. It's releasing. So you can't really say
17 one started earlier than the other. It's just if you
18 compare the curves all alone there, one is higher than
19 the other. And I think you can say that for RT 7,
20 too.

21 MR. LEAVER: Well, there's not a curve for
22 RT 7 and HT 1. All we have a statement.

23 MR. KRESS: I'm reading between the lines.

24 MR. LEAVER: Yes.

25 MR. KRESS: We had an RT 7 curve in the

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1 previous handout last time that showed the iodine and
2 the cesium release, and clearly for that time of
3 transient you're getting more and earlier release than
4 you would have --

5 MR. LEAVER: I was just going on the basis
6 of the statement on this slide, which says that it's
7 the same.

8 MR. KRESS: Yes.

9 MR. CLEMENT: Maybe it would be better to
10 say higher release rates than "it starts earlier." So
11 higher release rates.

12 MR. KRESS: Higher release rates would be
13 a better way to say that. I think that's pretty clear
14 and related, and these earlier things that Bernard
15 talked about are relatively good explanations for why.
16 It would be hard to convert those things into some
17 sort of model, but it helps your thinking on why this
18 might be.

19 MR. POWERS: Suppose that we accept the
20 stipulation that the release rates of fission products
21 are higher in the case of MOX.

22 MR. BOYACK: Volatile fission products?

23 MR. POWERS: Volatile fission products.
24 But let's just concentrate on the volatiles, cesium
25 and iodine, things that release completely,

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1 essentially, during the core degradation process. So
2 you can release it faster, but you can't release more
3 than 100 percent.

4 MR. KRESS: Yes, that's exactly right.

5 MR. POWERS: But you want a source term
6 that reflects that it's faster. Does that say that,
7 instead of having the in-vessel release portion of the
8 source term to be one period with a constant release
9 rate, one ought to have two periods?

10 MR. KRESS: You're representing the
11 transient as a matter of two. You might do all right
12 with just shortening the overall transient time and
13 still having the uranial --

14 MR. POWERS: As a first approximation, the
15 input that you need to melt MOX is about the same as
16 what you need to melt low-enrichment uranium. I can't
17 imagine it's wildly different. The melting point may
18 be a little bit different.

19 You go through this, so that that overall
20 time period has to be about the same. I mean, I can't
21 say how --

22 MR. KRESS: To the end of the accident
23 when the stuff falls down.

24 MR. POWERS: Yes, penetrates the vessel or
25 something like that.

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1 MR. KRESS: That time period is about the
2 same.

3 MR. POWERS: So you are kind of fixed on
4 that.

5 MR. KRESS: Yes.

6 MR. POWERS: But if you want to have a
7 higher rate, you're also kind of fixed on releasing
8 100 percent. You can't release more than 100 percent.
9 So it looks to me like if we want to reflect higher
10 rates of release, we have to do something about
11 breaking up the interval.

12 MR. KRESS: Part of this is you may
13 release 100 percent from 40 percent of the core, but
14 not 100 percent from the rest of the core.

15 MR. SCHAPEROW: Are you suggesting that
16 the fission product release may be the main thing
17 that's affected by going to MOX and not fuel
18 relocation nor head failure timing, and things like
19 that? This is the one big effect that, if any effect
20 is affected --

21 MR. POWERS: My order of approximation it
22 would be that, that the entropy is roughly the same.
23 That does not address the issues of reactivity events,
24 but if I'm talking about just a conventional LOCA
25 analysis or transient analysis, I mean the first

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1 order, the amount of heat that I've got to get into
2 things is about the same. The amount of clad I've got
3 is about the same. The steam reaction, the boildown,
4 is going to be about the same.

5 So, I mean, I can't even see wild
6 differences in the core degradation process. There
7 may be differences that develop when the clad
8 interacts with the fuel because you've got little
9 islands that are incapable of holding a lot of
10 interstitial oxygen, but you've got a fission process
11 that's generating interstitial oxygen, so they're
12 pushing the oxygen out into the UO2 lattice. They
13 haven't dropped down the melting points on you, and
14 make a zirconium attack on the fuel a little bit more
15 aggressive.

16 But in the heatup from the point at which
17 the clad balloons and ruptures to the point you get to
18 wild temperature escalation where the clad goes
19 molten, it's kind of hard to say why.

20 MR. BOYACK: Any other similarities or
21 dissimilarities you want to talk about? I was
22 checking with Steve here before the meeting started.
23 In his handout of last meeting, if you looked at the
24 core layout, the interior 36 units right around the
25 central core are all LEU, and then from there on you

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1 have your 40 percent, whatever constitutes the
2 totality of the 40 percent of MOX, then out just a
3 little bit from the center periphery. So I just
4 wanted to note that, since we talk about core
5 progression and melt appears to be coming from the
6 center outwards.

7 MR. NESBITT: And, Brent, let me throw out
8 one other thing. I don't consider this a major
9 factor, but I think it is something that ought to be
10 remembered. In the time period before melt sequence,
11 the decay heat from the MOX fuel is lower than the
12 decay heat from the uranium fuel. It's not a big
13 deal. It's just a 10 percent. I think we are talking
14 about differences that are in general on the level of
15 nuances.

16 MR. BOYACK: So your statement was a few
17 percent less?

18 MR. NESBITT: Yes. I have presented a
19 graph I think that gave a little more detail.

20 MR. KRESS: The decay heat matter may be
21 more important for the MOX than it is the LEU because
22 they're going to be about the same. If I look at some
23 of the data, you think about how a core heats up and
24 goes into its oxidation transient, then a lot of the
25 release, the MOX fuel, is going to be during the decay

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1 heatup time, whereas in the low-enriched LEU fuel you
2 generally get very little. Unless it's very high
3 burnup, you get very little release during that
4 period. Release really comes about during the severe
5 oxidation transient.

6 So there's a qualitative difference in the
7 release timing because you're releasing earlier, and
8 it's coming out during the decay heat whereas --

9 MR. LEAVER: Don't you think that
10 oxidation is started, though? If you look at this
11 curve, the temperature --

12 MR. KRESS: Which curve are you talking
13 about?

14 MR. LEAVER: This one that shows the delay
15 of RT 1 versus RT 2 --

16 MR. CLEMENT: Oxidation is not typical of
17 a severe accident test, that kind of test. The
18 oxidation takes place during the one-hour plateau at
19 1500 degrees.

20 MR. LEAVER: The temperature scale is cut
21 off on mine.

22 MR. CLEMENT: This is oxidation takes
23 place at low temperature during this one-hour plateau,
24 and at the end you have got the tallying that this is
25 fully oxidized. So this oxidation phase is not rather

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1 typical of a real accident. Just recall people wanted
2 to measure fission released during this heatup with an
3 oxidized carrier. That's where that kind of trend is.

4 MR. KRESS: His ramp rates going up to
5 that are typical of the decay heat ramp rate. You can
6 see during that first ramp rate he's starting to
7 release significant amounts of cesium and iodine with
8 VI 2 during that first ramp-up rate. You wouldn't get
9 that with the LEU fuel. It would wait and start
10 releasing somewhere --

11 MR. LEAVER: Except you are getting it in
12 RT 4, and that's --

13 MR. CLEMENT: No, but not before --
14 there's a difference in the fuels.

15 MR. LEAVER: Well, it had zirc oxide in
16 it, though, right?

17 MR. CLEMENT: There's some uranian
18 fragments that have oxidized as shards.

19 MR. KRESS: I don't think that that
20 particular transient, an LEU fuel of a moderate burnup
21 of about 30,000, you would start releasing that cesium
22 until you got at least halfway into that flat part.
23 Somewhere in there you'd start releasing it.

24 MR. CLEMENT: This releases is more --

25 MR. KRESS: Yes.

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1 MR. CLEMENT: Whether it is high in MOX,
2 it's much more --

3 MR. KRESS: So there was a qualitative
4 difference in the release as it's related to the core
5 heatup transient.

6 MR. LEAVER: Well, it looks like the mixed
7 oxide, the volatile release will occur at lower
8 temperatures.

9 MR. KRESS: Well, it will start faster at
10 lower temperatures.

11 MR. LEAVER: Yes.

12 MR. CLEMENT: What we'll see on this test
13 , RT 2 as compared to RT 1. So, as I mentioned
14 before, RT 7 is different. At the time being you
15 don't know why. What we have listed at the beginning
16 is just articulation of all the different effects that
17 may affect the fission product release, and they are
18 different. This explains this difference and this
19 explains also why RT 7 is different from RT 2.

20 MR. LEAVER: It would be nice to have that
21 explanation of why you don't see this effect in RT 7.

22 MR. KRESS: I still think you see a faster
23 release rate in RT 7 than you would in LEU fuel. I
24 still think you see that. I'm mining my memory from
25 the slide that we saw last time.

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1 MR. LEAVER: I've got it here.

2 MR. KRESS: Oh, you've got the RT 7 slide
3 from last time?

4 MR. LEAVER: Yes, it's in this package, if
5 you want it.

6 MR. KRESS: I didn't bring it.

7 MR. LEAVER: I'm not sure which slide
8 you're talking about, but this is package.

9 MR. KRESS: I didn't bring the package
10 with me.

11 MR. LEAVER: I don't know about two time
12 intervals because I think in a kind of a stylized
13 release such as we're doing here, whether we want to
14 try to get that complicated, but there is certainly
15 some evidence, at least if you look at RT 2, that we
16 could argue that the interval should be shorter than
17 what's in 1465 now for the volatiles.

18 If you say by 1.3 hours, or whatever it
19 is, for PWR, UO2 fuel may be half that or two-thirds
20 of that for MOX fuel, but, of course, MOX fuel is only
21 40 percent of the core. So take that into account.

22 MR. BOYACK: Tom, do you want to speak
23 into the mike in a sense that all the people can hear?

24 MR. KRESS: The slide I have doesn't have
25 the scales on it. So we have to kind of think what

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1 the scale might have been.

2 Given this temperature transient here and
3 this release rate of cesium and iodine, I think if I
4 had posed the same temperature transient on LEU fuel,
5 the release would have actually had the same
6 characteristics in the sense that it would come out
7 later and lower.

8 MR. LEAVER: You're saying that maybe the
9 temperature profile of the two tests would explain why
10 they're the same?

11 MR. KRESS: Yes, because there's a big
12 difference on release.

13 MR. LEAVER: Yes.

14 MR. KRESS: That's exactly right. It
15 could explain a lot of it.

16 MR. LEAVER: What?

17 MR. KRESS: It could explain a lot of it.

18 MR. LEAVER: It could. We just don't have
19 it. We don't have it.

20 MR. KRESS: Yes. We have the profile; we
21 just don't have the scale for it. I can probably
22 guess what the scale is, but I'd be guessing.

23 MR. POWERS: Suppose we had all kinds of
24 data, every bit of data you would want to have from
25 MOX that was generated using reactor grade plutonium.

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1 Would that help you on understanding what was grade
2 plutonium?

3 MR. KRESS: Yes, I love data. If I had
4 reactor grade plutonium and the kind of data that
5 Clement is producing with his temperature transients
6 and release rates, if I had it for at least two
7 elements separated far enough apart in their release
8 rates, I could make a correlation for the MOX that I
9 could translate into a whole core.

10 MR. POWERS: What I'm asking you is,
11 suppose I got you this data, everything you asked, but
12 I got it for reactor grade plutonium. Now I ask you
13 to calculate the behavior of fuel made with weapons
14 grade plutonium.

15 MR. KRESS: Oh, reactor grade meaning end-
16 of-cycle EO2 matrix plutonium?

17 MR. POWERS: Fuel plutonia with an initial
18 substantial amount of 240 isotope versus only about 6
19 percent of --

20 MR. LEAVER: Oh, okay. So you're saying
21 MOX fuel but reactor grade, okay.

22 MR. KRESS: I don't know, I don't think I
23 have a way to translate that into the weapons grade.
24 I think it would be different.

25 MR. POWERS: So you're saying you didn't

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1 really do it on MOX made with reactor grade plutonium?

2 MR. KRESS: It's better than nothing, but
3 I would rather have particular needs, which I presume
4 is weapons grade. It's better than not having any.
5 If I didn't have any, I would take it and presume it
6 was representative, but I wouldn't be able to stand up
7 in court and back that up.

8 MR. NESBITT: Could I add I think a piece
9 of information that might bear on that? The plan for
10 production of weapons grade MOX fuels to adjust the
11 master mix of the blend such that the amount of
12 fissible plutonium in the plutonium-rich particles is
13 equivalent to the reactor grade MOX that is used in
14 France and that the data which you are seeing is from,
15 I know that doesn't address everything that you could
16 possibly raise, but the intent there is to make the
17 power profile within the microstructure be as similar
18 as possible to the reactor grade MOX experience.

19 MR. SCHAPEROW: One of the outcomes of the
20 meeting is hopefully to identify not just the need for
21 more experiments, but how much they're needed;
22 confirmatory or pre- are essential before we're able
23 to say, hey, let's go ahead and license. It's a
24 question of the degree of need. That's it. We would
25 like to assess that.

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1 MR. KRESS: It would be nice to take one
2 of their pieces of fuel using their MOX and replicate
3 one of these tests to see that there's no difference
4 in behavior.

5 MR. BOYACK: This seems to me to be one
6 area where I think I would like to give an action item
7 to the panel members, and that is on the research
8 needs, where you can sit down and focus individually
9 for a time on research needs. You would focus on data
10 that you could then process into code. We could send
11 that by way of a letter, because I think that would be
12 really a little more structured than what we do here,
13 and I think it would be very helpful.

14 MR. KRESS: I think significant data
15 already exists in this program that the French have,
16 and if we could somehow purchase it, it would go a
17 long way. I think a replicate experiment using the
18 real fuel they're going to use with one of these tests
19 to show that there's not much difference would give
20 you a lot of confidence in at least that these can be
21 extracted to their tradition.

22 I think probably looking at the matrix of
23 tests they have, they've probably got enough data that
24 I can do a lot with, if we could somehow purchase it
25 from them.

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1 MR. LEAVER: Tom, let me follow up on that
2 point. Bernard, though you obviously can't share data
3 that is proprietary to some agency in France, in your
4 opinion does a substantial amount of quantitative
5 information exist on some MOX tests in France?

6 MR. CLEMENT: For MOX behavior in severe
7 accidents that you call meltdown, I think that most of
8 the information is in France. Other people did not
9 perform experiments.

10 The other source of data is what happens
11 in reactor accidents where you have an international
12 corporation, for instance, where people look at also
13 what happens to MOX, what is the MOX structure, what
14 will be the impacts, and so on.

15 MR. KRESS: We are focusing just on LOCAs
16 now, and there is need for reactor and source, too.

17 MR. CLEMENT: Yes, that's right.

18 MR. LEAVER: Jason, I'm surprised that the
19 NRC hasn't been poking around at least if the French
20 have a lot of data. Hasn't somebody from here been at
21 least involved in that or --

22 MR. SCHAPEROW: I'm sure Lee has. He's
23 not here right now, so I really can't speak for him.
24 He's been our contact and working with the French.

25 MR. LEAVER: That's got to be the most

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1 cost-effective way to get some data compared to
2 running our own tests.

3 MR. SCHAPEROW: Well, actually Tom did
4 point out one advantage of doing your own test, which
5 is we can use weapons grade levels.

6 MR. LEAVER: Yes, but even there, I mean,
7 maybe the purpose of such tests would be to confirm
8 what the French have done. We haven't really used the
9 French data.

10 MR. CLEMENT: Data you will get for the
11 studies performed for reactivity-initiated accidents,
12 that you an use for severe accidents, mainly concern
13 the initial repartition of gases in the fuel, where
14 they are looking at or they focus on gases, but not on
15 fission products, and they are looking at, where are
16 the gases before the transient? This can be a bit of
17 usable source. What happens during the transient is
18 not apt to give an initial repartition and study the
19 initial repartition of gases. You can use that in the
20 zero state form. So your accident rises, but only for
21 gases, not the detail of all the fission products.

22 MR. BOYACK: Okay, so what I wrote, using
23 Tom Kress's name, of course, liberally, is that you
24 believe that a good deal of data exists from French
25 tests, and if acquired by the NRC, could be used for

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1 correlation and development, and could be used for
2 appropriate code tools.

3 MR. KRESS: That's exactly my position.

4 MR. LYMAN: Can I just raise something I
5 raised at the last meeting, I think, for the record?
6 I don't think it's clear that the specs for the
7 microstructure ECSs as selected in the existing Fuel
8 Qualification Plan in a sense -- you know, it's a
9 process that's used in France. We need to clarify --

10 MR. KRESS: Yes, that's why I wanted this,
11 using actually their spec --

12 MR. POWERS: They told us that the review
13 of the MOX fuel fabrication facility, they said that
14 the spec was different.

15 MR. NESBITT: With respect to the
16 plutonium-rich particle size and distribution and
17 things like that, is it the same?

18 MR. POWERS: They claim -- all I know is
19 that --

20 MR. NESBITT: I can't speak to that
21 meeting because I wasn't there.

22 MR. POWERS: Somehow somebody's going to
23 tell the truth on this or I'm going to get really
24 irritated.

25 MR. LYMAN: Here is the spec. The spec is

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1 the means concerning which particle distribution shall
2 be less than 13 microns. I think, from what I've
3 seen, it's smaller --

4 MR. NESBITT: That's a different issue.
5 That's the difference between actual manufactured
6 parameters versus the spec. Of course, you don't
7 manufacture the fuel exactly on the spec. The spec
8 specifies an upper limit for these parameters. You
9 can't manufacture anything that way. It's just not
10 physically possible from an engineering perspective to
11 do what you're talking about.

12 MR. BOYACK: I am going to interrupt for
13 a moment here. What I need to understand from the
14 panel, whether this is germane to what we are trying
15 to do. I understand it is an issue, but I'm not sure
16 it is an issue for the panel as we deal with trying
17 to --

18 MR. KRESS: It is an issue if you want to
19 take the French data and say it's applicable to
20 theirs.

21 MR. BOYACK: Okay. Why don't you continue
22 then? That's fine. I just wanted to make sure that
23 it was applicable to what we were doing.

24 MR. LYMAN: Let me just finish. Here's a
25 spec that says that 95 percent of the plutonium

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1 required will also have an effective diameter of less
2 than 100 microns. That's where the fuel qualification
3 comes in.

4 But, according to a report from the IPSN,
5 2 percent of the clusters for the U.S. fuel may have
6 a mean size higher than 100 microns --

7 MR. BOYACK: You're going to have to keep
8 your voice up because I can't understand you. You
9 said what?

10 MR. LYMAN: That 2 percent of the clusters
11 have a mean size higher than 100 microns for just
12 France, while the DCS factor would be 5 percent, at
13 least no more than 5 percent the number greater than
14 microns. So that's one difference in the spec.

15 MR. NESBITT: I have no idea what document
16 you are referring to, but the spec's the same.

17 MR. LEAVER: Yes, it sounds like the IPSN
18 you're referring to was some observation about the as-
19 manufactured fuel. That's not a spec; that's for
20 sure.

21 MR. BOYACK: Okay, I would like to
22 continue on now. All right, let's return -- any more
23 difference --

24 MR. LYMAN: I'm sorry, let me just
25 clarify. The IPSN, this is a record by Shumanz. It

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1 said a maximum of 2 percent of the clusters may have
2 a mean size higher than 100 microns, according to the
3 fabrication specifications.

4 MR. NESBITT: I have no idea what the IPSN
5 document you're talking about is or anything. I can
6 assure you that, as far as particle size is concerned,
7 we're using the same specification as the current one
8 using --

9 MR. LYMAN: Well, can you get confirmation
10 of that?

11 MR. NESBITT: We have.

12 MR. LYMAN: Then why is there a
13 difference?

14 MR. BOYACK: Okay, so are there any other
15 characteristics?

16 (No response.)

17 Let me tell you, of course, what we'll do
18 is actually finish this statement and we'll take a
19 break. Then we'll come back and start filling in the
20 source term tables.

21 So is there anything else, any other
22 characteristics that you wanted to have in mind
23 regarding differences between LEU's behavior and MOX
24 behavior that would potentially affect the source
25 code?

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1 MR. POWERS: It seems to me I guess there
2 are two things that weigh heavily in my mind. Every
3 attempt that we have undertaken to predict fission
4 product release adopting a first-principles approach
5 has floundered. And it flounders on the challenge
6 that you do one experiment, you get one result; you do
7 another experiment, you get a different result. In
8 order to do that, people bring up more parameters than
9 Carter's got pills, and new phenomenon to explain each
10 of these things.

11 Then in the face of that difficulty, we
12 have gone to a far more empirical approach, which is
13 take some data of variable quality, put it on a plot,
14 dream up some straight line you can run through it,
15 and run through and explain why things deviate from
16 the straight line, sometimes by a lot. Convince
17 yourself that the straight line is the one you want.
18 Derive some parameters from it and say that's what it
19 is.

20 Now the process is probably not that
21 horrible when you look at fission products that are
22 released early in the transient. That would be the
23 cesium and iodine. I don't think we run into any
24 problems on that.

25 The process probably has some real

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1 questions if you go to the more refractory materials.
2 As I have repeatedly said, I simply don't understand
3 tellurium.

4 But, despite that history of being unable
5 to use first principles to predict fission product
6 release, I keep coming back to this. It seems to me
7 I need to understand better how the oxygen potential
8 varies as I come from the bulk urania approaching one
9 of these inclusions, and whether I get to the point
10 that, because plutonia has less ability to sustain an
11 excess of oxygen, I am saturating out my ability to
12 buffer that oxygen potential with moly.

13 It becomes a concern because, when you
14 look at what are the inventory differences likely to
15 be, they are all fairly small except for the one
16 element that we really don't understand very well, and
17 that's the ruthenium behavior.

18 MR. KRESS: I don't know how you measure
19 this, but it looks to me like it would be minimal to
20 fill out the calculations, this part of it, if you
21 have a good solid state chemistry code.

22 MR. POWERS: Well, it seems to me that,
23 whenever you try to do solid state calculations, I've
24 always ended up one parameter short. It doesn't
25 matter how much physics I put in. I always end up one

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1 parameter short.

2 We've had some luck doing it when we've
3 made mass spectropic measurements of fission product
4 release. That certainly helped. The problem we've
5 always run into in doing that is that what we observe
6 by putting fuel in a high vacuum, heating it up, any
7 of the fission products coming off seems to bear no
8 resemblance whatsoever to what we get when we put fuel
9 into a reactor and heat it up and measure what's
10 coming off of it.

11 It's very frustrating. I don't want to
12 overemphasize getting first principles, stated in
13 first principles approach, because I've never seen it
14 work yet. We keep edging toward more and more closely
15 to first principles, but we still have a model that
16 basically relies on root diffusion. We just don't
17 have the diffusion proficients to put into it.

18 MR. KRESS: That's exactly right. We can
19 extract some out of this data. That's what I would do
20 with the data. I would extract the diffusion
21 proficients out of it or as many of the elements as we
22 have transients for.

23 MR. BOYACK: Anything else?

24 (No response.)

25 Let's take 15 minutes. Let's come back at

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1 20 after 10:00, and at that time we will go ahead and
2 start on the source term tables. We'll begin with
3 duration.

4 (Whereupon, the foregoing matter went off
5 the record at 10:05 a.m. and went back on the record
6 at 10:28 a.m.)

7 MR. BOYACK: I have in my hand four copies
8 of the updated MOX Fuel Qualification Plan dated April
9 16, 2001. I would like the panel members to have
10 access to this during our discussions.

11 What I would like you to do is forgo lunch
12 and read this during the lunch hour. I don't need to
13 read it, so I will be going to lunch.

14 Tomorrow we'll talk about action items,
15 but let me go ahead and formalize one action item that
16 I mentioned a few moments ago. That is, we would like
17 the panel members to send a letter to Moshen Khatib-
18 Rahbar with your input regarding not data needs. I
19 guess we call it data needs. Research needs, yes, is
20 a better word. This is specific to MOX.

21 The current thoughts are that what we
22 would do then is that we would create an appendix in
23 the report and we would include those letters. So be
24 aware that they would have public distribution and be
25 in the document.

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1 MR. LEAVER: Is this a letter from all --
2 signed, one single letter, coordinated?

3 MR. BOYACK: No, individual.

4 MR. LEAVER: Individual.

5 MR. BOYACK: I've handed out this table.
6 We found out that neither of us knows how to get the
7 NRC machines to print landscape, no matter how many
8 times we tried. So the first column is cut off a
9 little bit, but I think you can go ahead and figure
10 out what it was we were covering or trying to cover
11 there.

12 That, of course, is a table that just
13 gives you a little bit of the characteristics. Really
14 the terms are all showing up in the MOX behavior, and
15 the contrast comes from the statement.

16 So now what we want to do is see what we
17 can do with these tables. If the pattern follows
18 yesterday, I did update the tables so we have the
19 named individuals here, and of course I'll attribute
20 whatever received to the wrong individual after I get
21 past the first person, the first entry. But you guys
22 kept me straight yesterday; I'm hoping that you'll
23 keep me straight today.

24 If we come up with needs in a particular
25 area, then we can do that. Otherwise, the letters

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1 will be the primary vehicle for doing that.

2 Now when I presumed this -- as soon as I
3 say the first person, Dave Leaver, what do you think
4 about the duration for the various phases, gap
5 release, early vessel, ex-vessel, late vessel, then
6 we'll maybe want to have a few more pieces of
7 discussion. But if not, we'll continue on.

8 I have listed up at the top here the NUREG
9 1465 times. That's where the table came from. We may
10 have to struggle through this first one, but let's go
11 ahead and give it a try and see what you have to say.

12 MR. LEAVER: Well, I guess one general
13 thing I have to say is I'm struggling with how to
14 characterize not only my own estimates, whatever they
15 may turn out to be here, but for the whole group how
16 to characterize these estimates in the sense that, if
17 we are not careful about how we communicate this and
18 how we present it, how we characterize it, that one
19 could pick up a document that's produced at some
20 future point and misinterpret what it's saying.
21 Because I really don't believe that we have a basis
22 for estimating these numbers.

23 Having said that, we can certainly make
24 estimates, and in the process of making these
25 estimates we can discuss what we know and what we

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1 don't know in a manner similar to what we've done this
2 morning, and that's a very valuable process. But I
3 think that needs to be captured, the fact that maybe
4 more important than the numbers themselves are the
5 caveats and the statements of what we know and what we
6 don't know.

7 So, having said that, I have no problem
8 with talking about numbers or directions that numbers
9 could go, but I would maybe, Brent, urge you as the
10 facilitator to make sure that in the end that this is
11 -- I think, for example, these estimates are different
12 in terms of our certainty, or lack thereof, compared
13 to what we did for burnup. Now we struggled with
14 burnup, but here we really don't have a lot of data.

15 So you just need to be careful you don't
16 have a table with a bunch of numbers and somebody
17 picks this up and says, "Oh, here's the answer."
18 Because I don't believe that in the end that that's
19 what we're going to do here.

20 MR. BOYACK: Okay, let me ask a few more
21 questions about how to handle this. Let me tell you
22 what I intended to do. Then it may be that with your
23 input then I do something more or change direction.

24 My thought is this: that I would go
25 through the discussion portions of each of the

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1 transcripts, and as I read those, I'm going to flag
2 those, cut them out and paste them into a separate
3 document. That will become the raw material for me to
4 create the text for the chapter that contains these
5 tables in their fullness. So, as you express
6 reservations, I will capture reservations, and I will
7 make those very clear in the text. Now you'll have a
8 chance to review that.

9 What we would also have to do is in the
10 concluding chapter, which Moshen is putting together,
11 then we would have to pull out a few of these key
12 points and punch them home in the concluding section,
13 too, of the report. So that was how I envisioned
14 handling this process-wise.

15 After the draft had been prepared, you
16 would, of course, have the chance to review and say
17 there's some things you didn't capture here that I
18 want captured, and then we would, of course, capture
19 this on the review stage.

20 There were a couple of comments. Moshen
21 and Jason?

22 MR. KHATIB-RAHBAR: Yes, one important
23 thing I think for the record is the importance of the
24 ECCONO's report, not my report or Glenn's report. So,
25 therefore, you folks have to stand behind it.

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1 MR. SCHAPEROW: Yes, it's going to
2 receive, hopefully -- we're going to send it out for
3 your close scrutiny after we get it put together.

4 MR. BOYACK: My guess, that will be two
5 assignments. It has to be because you have to see
6 what comments other people put in.

7 MR. SCHAPEROW: So we'll make sure
8 everybody's views are correctly represented in the
9 report. But the particular issue at the table, I
10 think Dave's got a good point on the people not taking
11 this thing and running too far with the table itself.

12 I would like to suggest that one
13 improvement, there would be a big footnote or a big
14 thing either at the end of the title or right at the
15 very bottom of the footnote saying " This table, the
16 numbers are uncertain because of `X', because of the
17 lack of data. So somebody doesn't walk away with the
18 table and try to start implementing it all over the
19 place.

20 MR. BOYACK: We can certainly do that. So
21 did I understand you? What we did is reach -- we'll
22 should put a footnote at the bottom of the table that
23 says, "This table is no darn good."?

24 MR. SCHAPEROW: I would say it's based on
25 what, the presentations on lost data from IPSN which

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1 lacks a Y axis or something. I don't know. I mean,
2 whatever the --

3 MR. BOYACK: Dave has given a very clear
4 statement of it, and everybody here understands it.
5 That is, we had this discussion on the way over to the
6 other building. That is that, when you're dealing
7 with opinion, informed, expert opinion, the quality of
8 that opinion is highest when it's informed by a good,
9 solid database, which the members understand
10 relatively the same way.

11 What we're lacking here is that database.
12 It's only a partial one. It's a sparser set of data
13 than exists for the LEU. So in a relative sense it's
14 less, and people know just less about MOX in a subject
15 that's already difficult. Is that a fair statement?

16 MR. SCHAPEROW: That's true.

17 MR. BOYACK: Yes. So that's what I heard
18 him say, and what I think the thing we have to do is
19 capture that in the text.

20 Now the next statement is this question of
21 somehow making sure that it's captured in the table.
22 I made a pretty blunt statement, but I did that for a
23 point. I wanted to force the issue of, how do you --
24 you can qualify it in the text. You can put a page-
25 long qualifying statement in the text in the table.

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1 How do you handle that? I mean at some point you
2 basically say it's no darn good.

3 MR. SCHAPEROW: You don't have to go that
4 far, but another statement a little less strong may
5 serve the purpose. It's for consideration if somebody
6 can put some words --

7 MR. BOYACK: We do that in the text. Now
8 I just don't know quite what to do on the note with
9 the table, but maybe somebody will be able to suggest
10 some wording for me.

11 MR. LAVIE: "Data preliminary; requires
12 confirmation."

13 MR. LEAVER: Something to that effect. We
14 may be able to come up with a way to say that that
15 we're comfortable with after we talk through this.

16 Let me ask a slightly different question
17 before we get into numbers. I assume there's some --
18 this is, I guess, partly addressed to Steve and maybe
19 to Jason, or whoever -- I assume there is some
20 schedule driver here where the licensee, Duke, DNS,
21 whatever the acronym is, DCS --

22 MR. NESBITT: It will be us for the use of
23 MOX. We will be the licensee.

24 MR. LEAVER: Okay, so it will be a license
25 amendment, and part of that license amendment is going

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1 to have to be a calculation of a radiological design
2 basis axle, for which you're going to need release
3 fractions. If things go reasonably well -- obviously,
4 you have to use your crystal ball here with all these
5 other issues that we're talking about that could
6 affect the schedule on this -- when would you like,
7 when do you need to know this? When does the NRC need
8 to know? When do you need to know?

9 MR. NESBITT: Our schedule is to submit a
10 license amendment request for use of large quantities
11 of mixed oxide fuel at the end of 2003. To clarify
12 that, the request would go to the NRC at the end of
13 2003. The fuel use would not begin until 2008 at the
14 earliest.

15 MR. LEAVER: So if you're going to submit
16 a license amendment at the end of 2003, you would need
17 to be doing the calculation, say --

18 MR. NESBITT: In 2003.

19 MR. LEAVER: -- in early 2003, something
20 like that, 2003?

21 MR. NESBITT: Uh-hum.

22 MR. LEAVER: Okay. So I guess it's fair
23 to say we have of the order of 12 to 18 months where
24 presumably there could be some work done to try to
25 supplement this sparse database and come up with

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1 something that people feel is acceptable for this
2 calculation.

3 Probably what we do here, I mean if we do
4 come up with a table, that table has numbers in it, it
5 would be characterized as, in some sense, as
6 preliminary or provisional or to be confirmed, and
7 probably it would be necessarily then conservative
8 because generally, if you don't have data, you want to
9 try to err on the conservative side. I think that's
10 what the French have done, is they tended to choose
11 enveloping sequences and round numbers up, such that
12 they feel that what they have is adequate because they
13 do have plants operating with mixed oxide fuel, and
14 obviously somebody over there must feel that their
15 licensing basis is acceptable.

16 So, all right, having said all that --

17 MR. BOYACK: Just to help to wordsmith a
18 statement here, which I've now put up a strawman:
19 Panel member inputs are based upon partial and
20 preliminary data regarding MOX characteristics and
21 behavior available to the panel at the time the source
22 term input was prepared.

23 MR. LEAVER: That's close enough. Yes,
24 that's close enough.

25 MR. BOYACK: All right.

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1 MR. LEAVER: So I think on the gap release
2 it seems to me that the release is going to occur
3 sooner than LEU.

4 MR. POWERS: When you say the release is
5 occurring sooner, do you mean that the clad breaks
6 more easily?

7 MR. GIESEKE: Yes, that's what that means,
8 I think.

9 MR. LEAVER: I think it means the clad
10 breaks sooner and that there is more fission gas
11 either in the gap or near the edge of the pellet that
12 can be released quicker than LEU.

13 MR. POWERS: And then, typically, the M5
14 clad is less extensively oxidized in the normal
15 operation.

16 MR. GIESEKE: Someone made the comment
17 that the M5 clad was more, a little ductile and
18 might --

19 MR. KRESS: The internal pressure is
20 dominated by the fuel gas and not the fission gas. So
21 you don't have much pressure difference. The M5's
22 likely to be more ductile.

23 MR. LEAVER: Are you thinking that the
24 clad may not rupture as quickly?

25 MR. POWERS: What about its melting

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1 temperature?

2 MR. GIESEKE: About the same.

3 MR. LEAVER: Why wouldn't the gas pressure
4 be greater in this, in mixed oxide?

5 MR. POWERS: It doesn't matter, but they
6 charge the rod with 100 -- they put 100 atmospheres of
7 helium in there, so you can release an awful lot of
8 fission gas and not change that very much.

9 MR. LYMAN: There are still unanswered
10 questions about the embrittlement of --

11 MR. POWERS: What I know is that there has
12 been a claim by a German investigator looking at a
13 Russian-Niobium cladding, that it embrittles at 7
14 percent oxygen instead of 17 percent oxygen. People
15 manufacturing the M5 say, well, it may well be for the
16 clad he's looking at, but it isn't so for our clad.

17 I know that the NRC has got M5 on its list
18 of things to do, but I don't know what they've done.

19 MR. NESBITT: If I can interject, the NRC
20 has approved M5 clad in several plants. We have it
21 operating.

22 MR. POWERS: Yes, but all that approval
23 has been based on a regulatory decision that needs
24 confirmation. That means, in other words, that they
25 can come back and say, "Whoops!"

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1 MR. NESBITT: You can say that about
2 anything.

3 MR. POWERS: Yes, yes.

4 MR. NESBITT: But I don't think there's a
5 probable issue out there. Well, I'll let NRR, if they
6 want to chime in --

7 MR. POWERS: So far as I know, the biggest
8 part of the differences in results comes from a
9 different measurement technique than the rule
10 specifies for measurement technique. So they really
11 can't --

12 MR. BOYACK: So what I hear is competing
13 effects. More fission gas, successful release relates
14 to potential for cladding that is less essential to
15 failure.

16 MR. LEAVER: Let me ask on the cladding,
17 is the use of M5, which we've I guess discussed
18 yesterday, people tend to think is maybe a little more
19 ductile than earlier generations of clad, is that a
20 licensing basis requirement or will it be, Steve?

21 MR. KRESS: It can be. Right now they use
22 the percent oxidation as a substitute for that.

23 MR. POWERS: The regulation is written for
24 Zirlo. So if you're going to use M5, you've got to
25 come in with an exemption request. So we'll come in,

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1 and people will expressly look at it. We will
2 presumably get around to changing that regulation one
3 of these days, so you don't have to do that, but you
4 have to come in and say, "I'm going to use M5."

5 MR. LEAVER: Do you mean the codified
6 regulation specifies Zirlo --

7 MR. NESBITT: Zirlo is a trade name of
8 Westinghouse. We will apply at the same time, if the
9 regulations haven't been changed by that time, at the
10 same time that we submit a license amendment request
11 for using zircaloy, we will submit an exemption
12 request similar to what's been submitted and granted
13 for other plants for use of the M5 clad.

14 MR. KRESS: The figure of merit for the
15 regulations that has to do with the productivity is
16 the percent of oxidation. That's why it's in there.
17 That percentage is strictly applicable only to Zirlo.

18 MR. LEAVER: And that's this 17 percent?

19 MR. KRESS: Yes, that's why that number is
20 there.

21 MR. LEAVER: So your license amendment
22 actually, presumably, then, you had to get a license
23 amendment to use M5 and you said it's in a --

24 MR. NESBITT: No, we had an exemption. We
25 submitted an exemption request that was approved by

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1 the NRC.

2 MR. LEAVER: And so you, as part of the
3 license amendment or a previous exemption, will do the
4 same for --

5 MR. NESBITT: Yes, it's pretty standard
6 now in the industry to submit and get these things
7 approved.

8 MR. LEAVER: On the gap release, if we
9 have this rather large LOCA, when does the first rod
10 pop?

11 MR. KRESS: Normally it's when the hot rod
12 gets up to 1200.

13 MR. LEAVER: Right, and that's pretty
14 damned fast with no ECCS. ECCS doesn't come up.

15 MR. KRESS: It starts from the original
16 temperature of 600 --

17 MR. LEAVER: Right.

18 MR. KRESS: -- and .1 degree per second,
19 I think is the decay heat, and see how long it takes
20 you to get up to 1200. I didn't do the calculation,
21 but you can do it. Six hundred degrees at .1 degree
22 per second is 6,000 seconds, and 3600 seconds to an
23 hour. Wow. There's something wrong with that. Well,
24 I don't think you start from 600. You start at the
25 maximum plant temperature; 600 is the coolant

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1 temperature. So you've got to adjust that. I don't
2 know what the starting temperature is.

3 MR. LEAVER: Yes, I've seen this
4 calculation for a BWR but I haven't seen it for a PWR.
5 It's like maybe 20 minutes or something.

6 MR. KRESS: Actually, .1 is probably
7 wrong. It's more like one degree per second. It's
8 probably more like one degree per second anyway. So
9 I was off by a factor of ten.

10 MR. LEAVER: Or maybe a half degree per
11 second.

12 MR. KRESS: Yes.

13 MR. SCHAPEROW: I guess I would like to
14 kind of remind the panel what I recall NUREG 1465 as
15 being the determinant of the gap release timing. We
16 did a guillotine grade calculation. We did several of
17 them, and we came up with timings of about 10 to 30
18 seconds to the time of first fuel rod rupture, but
19 then the end of this gap release here, that half an
20 hour, is meant to represent the time at which large
21 quantities of fission products start coming out of the
22 fuel, and that was not based on a large break LOCA.
23 That was based on like a 2-inch LOCA or a station
24 blackout.

25 MR. GIESEKE: You got up and drew pictures

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1 with your pen.

2 MR. CLEMENT: Generally, you're right. I
3 remember our discussions for this duration for high-
4 burnup fuel. We have shortened it just in order that
5 the next phase, late in-vessel release starts earlier.
6 This was the rationale for shortening it. It was not
7 because of gap release by itself. It was so that the
8 early vessel release starts earlier. This is what you
9 have done for high-burnup fuel.

10 MR. LEAVER: That's not what this table
11 says though.

12 MR. CLEMENT: The end-point of the gap
13 release phase is defined as a raise of significant
14 fraction products and this process is accelerated with
15 high-burnup fuel. This is what is written in the
16 table.

17 MR. LEAVER: But the next sentence says,
18 "The shortened time reflects the quality of
19 understanding the fuel has restructured, putting more
20 gas near the periphery and accelerating the release
21 kinetics of volatile fission products."

22 MR. CLEMENT: But that is the following
23 phase; early in-vessel release will be accelerated.
24 So that's why you have shortened the duration of the
25 gap release phase.

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1 MR. SCHAPEROW: The acceleration refers to
2 the earlier in-vessel phase, which is starting a lot
3 earlier. Significant quantities of fission products
4 come out earlier. That's what that's saying.

5 MR. GIESEKE: Then they're saying, with
6 the higher burnup, this is moved up here, which has
7 the effect of shortening this.

8 MR. KRESS: I think what we are doing is
9 taking the little bitty part, the fission product
10 release, versus time. We've got a little bump, and
11 then you go out, and then it starts coming in. We're
12 taking that little bump and making a straight line out
13 of it, and we're intersecting with this other and
14 trying to get the same quantity in there over a
15 timeframe that I don't know what the timeframe
16 actually means, but because of what we're doing.

17 Now we're saying, instead of the little
18 bump and the little gap and something, you get a
19 little bump that intersects this gap. We're now
20 trying to figure out how to make that look like a
21 straight line.

22 MR. GIESEKE: We're moving this one back
23 and forth, moving this intersection point to shorten
24 it mainly.

25 MR. KRESS: And I think Bernard is right,

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1 that's how we did do some of that.

2 MR. BOYACK: I'm going to relieve Dave in
3 making a number, a figure, just for a minute. I'm
4 going to ask to guess. I can see on this one we need
5 the discussion. So, Jim, your comments on the gap
6 release arrangement, and then I'm going to come back
7 and ask for a number.

8 MR. GIESEKE: I think we've talked molten.
9 They had to do it, the difference in the cladding, the
10 fact that the gap release time is not defined or is
11 defined by the rate of release during the early in-
12 vessel, which moves it back. We're talking about the
13 intersections of the curves. What other issues are
14 there?

15 MR. BOYACK: What was that gap release
16 time?

17 MR. GIESEKE: If you read the definition
18 of gap release, what we say is postulate that it's two
19 curves. Here's one curve. Here's your gap release as
20 you fail the rod. Then the ones that have failed take
21 off like this. So we're saying here's the gap release
22 time.

23 What we're saying in this case is that the
24 early in-vessel release rate is increased, so we're
25 going to put this line up higher. That means that

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1 this time is shorter from here to here. I think
2 that's what the French were talking about. It's
3 basically reducing the gap release time by raising the
4 rate in the early in-vessel. Does that make any
5 sense?

6 MR. BOYACK: Yes, I think when you think
7 about it. I think also you have a higher fraction of
8 fission products either in the gap or at the edge of
9 the pellet in the MOX field.

10 MR. LEAVER: That's the next question,
11 yes, when we get to the percentage of it.

12 MR. BOYACK: Oh, okay, you're saying
13 that's a refraction issue not a duration issue.

14 MR. LEAVER: Yes, not a duration issue.

15 MR. BOYACK: Okay, I hear you.

16 MR. LEAVER: Right.

17 MR. BOYACK: Any other comments? Jim?
18 Yours were on the definition of gap. Anymore? You
19 don't have to come up with the number yet.

20 MR. GIESEKE: I have a question to put out
21 here. I presume -- what did we say, we have 40
22 percent? What's our ratio of the --

23 MR. BOYACK: Forty percent of oxygen.

24 MR. GIESEKE: That's primarily - well, now
25 we're tying it into where you put these in the core,

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1 but that's not in the center region.

2 MR. BOYACK: There's 36 fuel centers in
3 the center that are LEU --

4 MR. GIESEKE: Yes.

5 MR. BOYACK: -- and then it's distributed.

6 MR. GIESEKE: Yes, and it's outside of
7 that. So the onset of gap release would come at the
8 same time probably because that would occur in the
9 middle, and there's no MOX fuel there anyway.

10 MR. LEAVER: It's a start, but we're after
11 the duration period.

12 MR. GIESEKE: We're after the duration,
13 and that's defined by the early in-vessel, I think.

14 MR. LEAVER: Well, the early in-vessel is
15 certainly going to come out fast, I mean if you
16 believe the RT 7.

17 MR. GIESEKE: Yes.

18 MR. LEAVER: Or RT 2. RT 2.

19 MR. GIESEKE: Yes.

20 MR. LEAVER: Not RT 7.

21 MR. BOYACK: Anything further?

22 MR. LEAVER: That's enough. Go on.

23 MR. BOYACK: I am just going to move this
24 along here.

25 MR. POWERS: I see no reason for any

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1 dramatic change in the start of gap release. That's
2 usually not part of the source term. They usually
3 specify that externally, but it's specified in 1465.

4 Now the issue of whether you shorten it
5 down or not is one of whether you think that the
6 fission product release is more rapid, starts at a
7 lower temperature and is more rapid in the case of MOX
8 fuel or not. I think we have a test that suggests it
9 is and a test that suggests it isn't, but prudence
10 would say, yes, let's shorten down the duration of gap
11 release a little bit, just to reflect that it's
12 possible that we have a shorter duration there and we
13 get into fission product release more rapidly, and ask
14 people to go confirm that. But that's one of the
15 areas you need experimental data.

16 Then the next question is, well, how much
17 more to shorten it down? Of course, I haven't got a
18 clue how to do that, but we didn't have a clue on that
19 for high-burnup fuel either. So we suggested let's do
20 a little bit. It can't be too much. So we suggested
21 dropping it down to .4 hours and let it go at that.
22 So it doesn't sound to me like that's a bad
23 prescription for the process at all.

24 MR. BOYACK: Sounds reasonable.

25 MR. KRESS: You've basically said we

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1 didn't have much more data for the LEU, for shortening
2 the LEU period? Is that what I heard you say?

3 MR. POWERS: Well, what we had in the case
4 of the LEU was a physical understanding and
5 substantial data that says, yes, the release starts
6 earlier here, and we needed to shorten it down. Here
7 we have equivocal information, debatable information,
8 to suggest it all starts earlier and be faster. But
9 just to be prudent fellows, maybe we ought to reflect
10 that, shorten it down a little bit.

11 I mean what you're shortening down is
12 you're saying that nothing has changed really about
13 the gap release. It's just at the point where you're
14 started getting bigger releases due to the fission out
15 of the fuel starts earlier; that's all. Since that
16 marks the end of the gap release, that means ipso
17 facto the gap release is shortened.

18 Now you're going to be very careful. You
19 ought to reduce what you call the gap into the tori by
20 the amount of shortening, which is a 20 percent
21 shortening. Somehow that strikes me within the
22 uncertainty range that we have here. In fact, I will
23 later argue that I think the existing gap inventories
24 that we've got for MOX are conservative for MOX. I
25 mean there's enough margin there that there's no point

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1 in changing that.

2 Even if it does feed the gap more, and I
3 think the evidence from Halden is that, indeed, MOX
4 fuel during normal operations is feeding the gap more;
5 there's a little higher inventory in it, but it's
6 still within that 5 percent range. So I don't see any
7 reason to get too excited about changing that gap
8 release fraction.

9 MR. BOYACK: Tom?

10 MR. KRESS: I give the .5 as the time when
11 the first clad, when the first failed fuel fails.
12 That may be a wrong view, but I see no reason, just
13 because it's MOX in there, to change the .5 at all.
14 I would start -- that's the duration. The gap release
15 starts at zero, zero time, because we're just looking
16 at the duration of that.

17 What happens is you fail with the first
18 fuel, and then you fail with the next one, and
19 probably moving radially outward failing more and more
20 clad as you go along, until you fail most of them, and
21 then it starts dropping off, and you get this bump.
22 The duration of that bump is probably equivalent to --
23 I don't know how fast that spreads across the core.
24 So I think that's why we went to some artificial
25 plant, and that was, how long does it take to start

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1 getting significant release from the in-vessel plants?
2 Because I don't think we have this core melt
3 progression data to tell you the real number.

4 My question is now, when do I start
5 getting significant release from the in-vessel phase?
6 In the first place, I don't know what the word
7 "significant" means. I don't exactly know when it
8 starts because I have a feeling that the middle of the
9 core where the LEU is is heating up first compared to
10 where the MOX is. So the initial release you're
11 getting from the early in-vessel is probably coming
12 from the ordinary LEU fuel that goes through the same
13 kind of heatup rate and transient that it had in the
14 regular core.

15 So I think that's when you're first going
16 to start getting the significant, unless the MOX,
17 which is just heating up slower and is faster release,
18 wins the race compared to this. And I don't have any
19 idea without having good models and heatup rates as
20 distributed across the core, given that's the function
21 of the power distribution across the core. My guess
22 is I don't have enough information to change either
23 one, .5 or the 1.3.

24 MR. BOYACK: As we began this discussion,
25 I should have reminded us of what the definitions are,

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1 and Steve Nesbitt has reminded me that I ought to
2 remind you of that. But let's just take a look at
3 what the definition is, because it ought to be the
4 same definition. That I think is true. So this is
5 out of NUREG 1465.

6 We know when the gap activity phase
7 begins, and that's when the fuel cladding failure
8 begins. There's no discussion about whether that's
9 later because of the M5 cladding, but that's not a
10 matter because we're going with the duration here.

11 This phase involves the release of
12 radioactivity that has been collected in the gap
13 between the fuel pellet and the cladding. The process
14 releases to the containment of 2 percent of the total
15 inventory of the more volatile nuclides, particularly
16 noble gases, iodine, and cesium.

17 Now the gap activity phase ends when -- so
18 you've got failed fuel, and now it ends, the fuel
19 failed cladding, when the fuel pellet bulk temperature
20 has been raised sufficiently that significant amounts
21 of fission products can no longer be retained in the
22 fuel. So I guess I read that as now you've got the
23 temperature where you start to migrate and move the
24 fission gases out into the coolant through the
25 ruptured clad. When we finally get to that point,

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1 that's what you were pointing out, that occurs.

2 So I guess the basic question is, is there
3 something different, sufficiently different, about a
4 MOX core that you begin to get significant amounts of
5 fuel -- pardon me -- fission products coming out of
6 the fuel. We talked about the fact that at the center
7 of the core you've got LEU. So I don't know how far
8 out that progresses.

9 MR. KRESS: It's a race. It depends on
10 which one wins the race. The stuff in the middle is
11 going to come out at sort of the same timing that the
12 molten core did. The stuff with the MOX is going to
13 come out according to its temperature transient and
14 the earlier release. So it's a race because you've
15 got cosine power distribution and they're heating up
16 at different rates. So you have a different thermal
17 transient for the different parts of the core.

18 My guess is, looking at some sort of data
19 like this, my guess is that the MOX at its cosine
20 power distribution probably wins that race. So you
21 start getting significant release earlier. But this
22 is a speculation on my part, and I don't have enough
23 information on all these things to change these
24 numbers.

25 MR. CLEMENT: I have a question. Should

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1 we concentrate on the exact loading that will be made
2 in the future years within this core with MOX fuel or
3 should what we put in our tables reflect the
4 differentials between MOX fuel and low-enriched
5 uranium fuel, generally speaking? That's a question.

6 MR. GIESEKE: Very good question.

7 MR. KRESS: What if the next application
8 doesn't load it the same way? It could be loaded in
9 the center.

10 MR. CLEMENT: I could imagine that in
11 several years one could change the core refinements.

12 MR. KRESS: Given that comment, I would
13 change 1.3 -- I mean the .5 and make it shorter. I
14 don't know how much shorter to make it. Just like
15 Dana, I have no idea, but .4 may be a reasonable
16 guess.

17 MR. SCHAPEROW: I think we should try to
18 limit the scope of this. I don't propose that we
19 prepare a MOX table for our core with all MOX in it.
20 Even this particular application is years away. I
21 don't know that we need to do that.

22 I think we're going to capture the logic
23 and the ideas, even considering the MOX setup the way
24 it is and the Duke Power proposal. I am a little
25 nervous -- that's very ambitious, and I appreciate

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1 people's intentions. I just am not sure that's --

2 MR. NESBITT: I think when I presented the
3 loading pattern information earlier, last meeting, I
4 think I made it clear, but I'll reiterate this point
5 now. These are the designs that we have analyzed now
6 about how we would load, how we currently think we're
7 going to load MOX fuel in 2008, or whatever. It's not
8 carved in stone. I don't think it's going to change,
9 quite honestly, based on our overall fuel management
10 scheme and things like that and our overall approach,
11 but I'm not prepared to sit here and swear on a stack
12 of Bibles.

13 MR. SCHAPEROW: How about the 40 percent?

14 MR. NESBITT: Well, I think that's pretty
15 much -- we haven't submitted an application yet. I
16 don't think that -- again, I think that we're probably
17 not going to go over 40 percent, for a number of
18 reasons. But is it wise to speculate on that and
19 paint ourselves in a corner two or three years before
20 we submit an application on that point? I don't think
21 so. I'm trying to give you all a picture of our best
22 guess, our best guesstimate of how we're going to plan
23 to use this fuel, based on our state of knowledge at
24 this point in time.

25 MR. GIESEKE: What's the current practice

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1 other places regarding that 40 percent?

2 MR. NESBITT: What is that now?

3 MR. GIESEKE: What is the current
4 practice, like in France or other places, regarding
5 this 40 percent? Do they find that to be --

6 MR. NESBITT: Different countries use
7 different amounts of plutonium in the core based on
8 various reasons. For example, in Belgium they use
9 something on the order of 10 to 15 percent because
10 that's how much plutonium they have available that
11 they need to get rid of that, and that's why they're
12 using it. In France they've chosen to go with 30
13 percent. In some of the German cores they're at like
14 38 percent.

15 Our value of 40 percent is based on, first
16 of all, a desire to get as much plutonium disposed of
17 as quickly as possible, consistent with the overall
18 goals of the program, and our desire to keep the plant
19 characteristics and operation reasonably consistent
20 with what they are right now with uranium fuel.
21 Because the more MOX you put into the core, the more
22 the characteristics of the core change, and that
23 drives the characteristics of the plant.

24 That's another thing, when we do all of
25 the licensing basis, safety analyses, we might find

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1 that -- I'm throwing out a speculation here -- we
2 might find that for some reason we can only get a 35
3 percent. Maybe we find out we can get a 45 percent or
4 something like that, but, based on the work that we've
5 done now, which is pretty good, I think, that's the
6 ball park.

7 MR. GIESEKE: But it sounds like, when you
8 consider other places, like the other countries, and
9 look at our goals that we need here in this country,
10 the 40 percent is probably a good rule of thumb for a
11 long time out into the future, I mean to guide us.
12 It's probably not going to make any difference whether
13 it's 50 or 20 or 30.

14 MR. BOYACK: Let me clarify what Jason was
15 saying. My understanding of what Bernard said was
16 that we just distribute the 40 percent uniformly
17 across the core, not that you have a fully MOX core.
18 In your statement, I believe you were talking about a
19 full MOX core.

20 MR. NESBITT: Let me say one other thing
21 on that. How far do you want to take it? A full MOX
22 core is taking it all the way.

23 MR. CLEMENT: I was thinking about this
24 matter. So I was wondering whether we have to reflect
25 the differentials between MOX fuel and any fuel in

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1 general and not go into the detail. You can have this
2 MOX fuel that we put in the periphery, let it flow
3 into the center, and so on, given the uncertainties
4 that we have.

5 MR. KRESS: Brent, do you have this curve,
6 if you could put it back? We had it a while ago.

7 MR. BOYACK: Yes.

8 MR. KRESS: Could we put that back on the
9 screen a second?

10 MR. BOYACK: Yes.

11 MR. KRESS: This is the RT 1 and RT 2.
12 Looking at it, it bothers me considerably with respect
13 to this gap release. This is ordinary LEU fuel and
14 this is cesium release. This is the MOX cesium
15 release. If we're talking about a significant
16 quantity of fission products, and we'll just use
17 cesium as ours, because the iodine comes out about the
18 same, and so does the krypton. Let's just draw a line
19 and say that's significant. You could draw it
20 anywhere, but just say, the difference between
21 significant in this line and this ramp heatup rate is
22 like the heatup of the core. The difference between
23 this significance and that significance is like a half
24 an hour. You're talking about a half-an-hour
25 difference. You say, well, we have a half an hour for

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1 the --

2 MR. GIESEKE: I think that is a very good
3 point, yes.

4 MR. KRESS: That bothers me. I don't know
5 what to do with it. But it's the only piece of data
6 I've got.

7 MR. GIESEKE: This is not across the
8 entire -- this is 40 percent.

9 MR. KRESS: I know, but I'm just
10 reflecting the MOX and the other fuel. The 40 percent
11 doesn't matter because, if you get that from 40
12 percent of the fuel, it's a significant matter.
13 That's why I say you could draw it any way you wanted
14 to.

15 MR. CLEMENT: With this transient, whereas
16 you would get cladding ruptures, these represent
17 ruptures at that time. That means that once you get
18 the cladding rupture, at that time you already have
19 significant adjustment. This is less than 30 minutes.
20 Because you have to take care of it here. The
21 cladding opens at the beginning of the experiment.

22 MR. KRESS: The claddings are ruptured in
23 both those experiments.

24 MR. BOYACK: So what I hear Bernard saying
25 is that with this MOX fuel, that if you have a

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1 significant release at the time you have sufficient
2 fuel failing, then it will come out. I mean, it will
3 come out as soon as it's spilled. The question is,
4 how long until you have sufficient failures to --

5 MR. CLEMENT: I agree with what Dana said,
6 that we need to have more data. What you could do
7 today is to reflect the fact that release will start
8 earlier.

9 MR. LEAVER: It could start earlier. I
10 mean, someone read from 1465, and it was jogging my
11 memory. It's stylized actions, but it is true, I
12 believe, that the release, the gap release, is assumed
13 to begin when the rods are popped. So there is no
14 delay there.

15 So one could argue, if you look at this --
16 I mean, this would probably be too conservative, but
17 you could say that the significant release starts
18 basically at time zero.

19 MR. KRESS: What I think Bernard is saying
20 is true. If you follow that temperature around until
21 you get to about 1200, then the first fuel pops, and
22 now you haven't released the fission products up to
23 there, even though this line says there's fission
24 product release, because that's already for failed
25 fuel.

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1 So what has happened is the fission
2 products are redistributing themselves inside the fuel
3 during that heatup ramp to some extent, but they are
4 not being released. Now you pop the fuel, and you've
5 still got to diffuse these -- you get rid of the noble
6 gases and the stuff in the gap, and then, actually, as
7 the fuel is starting to diffuse now, the other stuff,
8 there's some time, as it's still heating up, there's
9 some time before you get to this part. This curve
10 will look different in the lattice. It will start
11 after the pop. It will come up here somewhere. So
12 there will be a time before you reach a significant
13 amount on this curve, and this would have been offset
14 over this way. So both of these curves will be offset
15 in a real accident over in this direction.

16 I think one could compare that distance
17 right there, though, as a change.

18 MR. LEAVER: Isn't that about a half an
19 hour?

20 MR. KRESS: It's about 15 minutes or so.
21 These are half-hour marks here. I'm thinking more
22 like half an hour. So we didn't drop it down to .25,
23 but maybe we should have.

24 MR. GIESEKE: Then you get into the
25 progression of the mount regularly.

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1 MR. KRESS: Yes, there's that issue, too.

2 MR. GIESEKE: There's that issue that
3 comes into play. That may be slower than the -- so
4 maybe it's better not to go all the way down to .25,
5 but to pick a place in between. So you're arguing for
6 .3 instead of .4?

7 MR. KRESS: Yes, I think it's shortened
8 more than we said.

9 MR. BOYACK: So where did you end up, Tom?

10 MR. KRESS: .3, which, you know, I
11 hesitate to throw that up there, though, because that
12 could start giving people trouble. A .3 duration of
13 gap release can cause significant problems to have to
14 deal with it. If it's not allowed, I hate to --

15 MR. SCHAPEROW: One of the ways I think
16 about this, and maybe this isn't quite right, but the
17 beginning of the gap release, the beginning of that
18 half-hour period is the clad failure for a large grade
19 LOCA. The end of the gap release, the end of the .5
20 hours, is clad failure for a small break LOCA, which
21 is basically the time -- not long after that you start
22 getting significant releases from the pellet.

23 I think that gap release timing does, in
24 fact, reflect the thermal hydraulics issue. How long
25 does it take to heat up for a very typical or

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1 relatively fast severe accident scenario?

2 I'm appealing to Jim in this regard. He's
3 had a lot of experience in this area on the heatup for
4 these different scenarios: small break LOCA, station
5 blackout, and --

6 MR. SCHAPEROW: It's a pretty short period
7 of time.

8 MR. LEAVER: Thirty minutes.

9 MR. BOYACK: Let me come back to Dave now,
10 and see if you are ready to give me a figure.

11 MR. LEAVER: Is that what we want to do
12 here?

13 MR. BOYACK: I thought so.

14 MR. LEAVER: I mean, first of all, we had
15 one test which suggests quite a bit earlier release
16 from the fuel, maybe a .2, .3 kind of number, but
17 that's one test. We have another test that doesn't.
18 We also have the fact that the fuel, the MOX fuel, I
19 guess would tend to be toward the outside of the core,
20 which means it probably wouldn't see the same
21 temperature transient as the LEU fuel, which is more
22 toward the center of the core.

23 We also have maybe at most half the core
24 that's mixed oxide. We also have recognized that this
25 30-minute gap duration is for a very, very unlikely

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1 accident, large pipe breaks.

2 MR. BOYACK: As an individual, you're
3 allowed to say, "No opinion."

4 MR. LEAVER: I'm trying to understand what
5 we're going to do with this number, I guess. What are
6 we doing here?

7 MR. KRESS: We are going to fix the thing
8 about closure time.

9 MR. LEAVER: You mean make it slam close
10 faster?

11 MR. KRESS: Yes, which is a bad thing--

12 MR. LEAVER: I think that's a bad idea.

13 MR. NESBITT: That's what we use the 10
14 seconds for, though.

15 MR. KRESS: Oh, we use the 10 seconds.

16 MR. NESBITT: Yes, that's right. This is
17 for the dose calculation.

18 MR. KRESS: This is just a dose
19 calculation. We aren't going to do anything with it.

20 MR. LEAVER: It's okay to talk about these
21 things because I think that some of the things we talk
22 about are necessary to understand when we make
23 estimates of release fractions, but really this number
24 doesn't have a huge effect unless we make zero; then
25 it might. But it has to do, I think, with questions

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1 like, how quickly do you have to actuate drawdown
2 systems, systems that drawdown the back in secondary
3 containment, and how quickly would you have to actuate
4 sprays in the primary containment? Those sorts of
5 questions I think are relevant, but as long as it's
6 tens of minutes, a couple of tens of minutes, then it
7 probably isn't going to have much effect, if any, on
8 plant design.

9 But we could change the .5 to .4. That's
10 not going to matter, even .3, but if you get much
11 lower than that, then I think you could have an
12 impact. Frankly, I don't see all these -- there's
13 some competing effects here, and if there's a change,
14 I guess my judgment at this point, which probably
15 isn't worth a whole hell of a lot because there's
16 nothing like some good, solid data; in the absence of
17 data, one is very uncertain, but I would say, if we're
18 going to change this .5 number, in my view, it
19 wouldn't be much of a change. So I guess I kind of
20 end up where Dana was at the beginning, which is, we
21 could say .4, just to acknowledge that maybe things
22 happen a little faster.

23 MR. BOYACK: Jim?

24 MR. GIESEKE: I like the .4 number. I
25 hate to go over to .2 or .3 based just on this one

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1 curve, but I think there's an indication it should go
2 down from the .5. I think .4 is enough to reflect the
3 direction of change.

4 MR. BOYACK: Okay, Dana, you've already
5 given your value. Any other comments?

6 MR. POWERS: No.

7 MR. BOYACK: Okay, Tom?

8 MR. KRESS: I still like my .3, as a
9 reflection of the differences between MOX and the LEU.

10 MR. BOYACK: So you're basically looking
11 at the VERCORS RT 2 test?

12 MR. KRESS: I'm mentally integrating those
13 with the raw heatup to a failure of a clad and a
14 subsequent other heatup to start releasing fission
15 products. I don't know how to make that mental
16 integration, but it does look to me like the
17 difference I see on there between those two tests
18 would be reasonable representation of the differences
19 in this mental integration.

20 I shortened it some, but not as much as we
21 have up there. So I still like the .3.

22 MR. BOYACK: That's the RT 1 and RT 2
23 tests?

24 Okay, and, Bernard?

25 MR. CLEMENT: I'd say .4. There's

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1 uncertainties, obviously. As you've written, you can
2 start based on VERCORS experiments, but also I would
3 say there is some insights from gas release
4 measurements that tend to say that the release will
5 start earlier.

6 MR. POWERS: I just did kind of a crude
7 little calculation over here. I said, suppose I've
8 got these little nodules of plutonium-enriched
9 materials and around them are halo points. How many
10 of them do I have up to next to the fuel clad gap?
11 Is there a direct release pathway? There's no
12 incubation at all. It turns out a bunch.

13 MR. KRESS: You used a distribution
14 function?

15 MR. POWERS: The linear distance is
16 occupied by a halo around the perimeter. So you're
17 feeding fission products in there pretty fast.

18 MR. KRESS: As soon as you fail the clad.

19 MR. POWERS: Yes, you're getting a little
20 bit as soon as you fail the clad. It is not a huge
21 amount, but it gets your attention.

22 MR. KRESS: That tends to tell me that the
23 duration distance might be even shorter.

24 MR. POWERS: Yes, it may depend a little
25 bit on how you see the progressive in the loading

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1 thing, but you can make it shorter. Myself, I think
2 you've got a much bigger challenge trying to get these
3 types of tables in this kind of approach to the source
4 term reflect higher release rates; that is, getting
5 material into the containment earlier, for the
6 engineered safety features to deal with for the early
7 in-vessel release. I think that's much more
8 challenging mental gymnastics that you're going to
9 have to do there.

10 MR. KRESS: Yes, that's a big assignment.

11 MR. POWERS: What you're going to come
12 down and see this next phase, what gets really
13 released during this next phase really is cesium and
14 iodine. Everything else, who cares?

15 MR. KRESS: And maybe a little bit of
16 tellurium.

17 MR. POWERS: The only reason tellurium has
18 any dose effectiveness at all is it decays to iodine.

19 MR. LEAVER: No, there's some - but, yes,
20 it's actually even cesium doesn't contribute much
21 relative to iodine. Iodine is really the thing that
22 gives you the dose.

23 MR. POWERS: The cesium only works -- I
24 mean the 137 only works on a long-term basis.

25 MR. LEAVER: Yes, long-term. For example,

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1 a two-hour dose, that's all iodine.

2 MR. BOYACK: Let me ask, these gas release
3 measurements, do they have a name of a series of
4 tests?

5 MR. POWERS: I would just look at the
6 Halden data.

7 MR. BOYACK: Doesn't EDF have some data,
8 too, on that?

9 MR. POWERS: Yes, I mean there are a
10 variety of reports that have come out of Halden, and
11 they're continuing to generate more. They're running
12 MOX and they're loading up the gap a little bit. As
13 I say, the significance to attach for a boiling water
14 reactor operated in Norway by a Finnish crew or a PWR
15 located in the southern part of the United States, a
16 little lost on me, but it gives you some information.

17 MR. BOYACK: Okay, let's move on into
18 early in-vessel, and just remind you -- see, I'm a
19 quick learner, Steve -- that the definition of the
20 phase, we have the start of this phase defined by the
21 end of the previous phase.

22 So what we say is, "During the early in-
23 vessel release phase, fuel as well as other structural
24 materials in the core reach sufficiently high
25 temperatures that reactor geometry is no longer

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1 maintained, and fuel and other materials melt and
2 relocate to the bottom of the reactor pressure vessel.
3 During this phase, significant quantities of volatile
4 nuclides in the core inventory, as well as small
5 fractions of the less volatile nuclides, are estimated
6 to be released into containment. The release phase
7 ends when the bottom head of the reactor pressure
8 vessel fails, allowing molten core debris to fall into
9 the concrete molten reactor pressure vessel."

10 Now we've somewhat compromised that in
11 some of the other discussions as we moved stuff back
12 and forth, I guess, but that's the latter two. So on
13 this one I think it's clear.

14 Okay, guess who's first?

15 MR. GIESEKE: The issue, since it is
16 defined from the end of this to melt-through, I don't
17 have any reason to change the melt-through from that
18 endpoint. Since we start a little earlier, we just
19 add a little bit of time, the tenth of an hour, to the
20 early in-vessel duration time to account for the
21 earlier start, which is basically what we did with the
22 high-burnup issue.

23 MR. BOYACK: So you're actually offering
24 me a number of 1.3?

25 MR. GIESEKE: 1.4 I believe is a tenth

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1 added onto 1.3.

2 MR. BOYACK: Okay, Dana?

3 MR. POWERS: I agree 100 percent with Jim.
4 I see no evidence of a profound change in the core
5 degradation scenario. Perhaps it will, and if I was
6 going to highlight an area that I would be interested
7 in seeing how things go, it is experimentally, this is
8 one of the areas that I would like to see experiments
9 done with some of these, because I can imagine all the
10 troubles that you had getting relocation correctly
11 modeled in the code, that if we're changing fuel
12 chemistry and oxygen potentials and clad fuel
13 interactions with this MOX fuel, there's a potential
14 here.

15 But in the absence of having some real
16 data on that, maybe there's some insights from the
17 VERCORS experiments because they did seem to melt
18 things out in interesting fashions, but that was
19 explained, that they were still looking into that, and
20 they pre-oxidize on clads. So it's a little too early
21 for me to get excited about that.

22 The core degradation scenario is going to
23 about the same. If you stipulated that, you would
24 come out where Jim is coming out. We know that the
25 effect of that is that I am going to have a lower

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1 release rate of cesium and iodine into the
2 containment, when, in fact, if anything, the data say
3 it's the same release rates or higher release rates.

4 So now I'm caught on a -- I have a dilemma
5 here. I mean the formalism is set up for one type of
6 fuel, and then I try to apply it to a different
7 phenological area. How do I properly reflect what's
8 going on here?

9 The only thing I can come up with on that
10 is that, okay, the timing, you have to be very careful
11 with the timing on this. You've simply got to accept
12 Jim's argument that it is now 1.4 long.

13 What I don't think I have to accept is
14 that the release rate is constant during that
15 interval. So I can say, why can't I have a triangular
16 or some other kind of release rate during that period?
17 I've got to do something to reflect what I think I
18 know, and I can't do it living with the existent
19 formulas on it.

20 MR. SCHAPEROW: Are you talking about
21 release rate from fuel or release rate from the
22 reactor? It seems that there might be a couple of
23 things to kind of smooth things out on the release of
24 the systems, such as steam flows and --

25 MR. POWERS: Not if you specify a large

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1 break LOCA as our groundrules. There ain't no guide
2 at all.

3 MR. LEAVER: There's no transport. I mean
4 it's very, very short, a minute or two.

5 MR. SCHAPEROW: That's considered here,
6 including station blackout.

7 MR. POWERS: Your groundrule at the start
8 of this was a large break LOCA.

9 MR. SCHAPEROW: Or a low-pressure
10 sequence.

11 MR. POWERS: A low-pressure sequence.

12 MR. LEAVER: You're right. Certainly the
13 high-pressure sequences, there is a delay, but I think
14 we probably should be looking at the low-pressure kind
15 of open system.

16 MR. SCHAPEROW: The movement throughout
17 the core, the time it takes to propagate throughout
18 the core, maybe that's --

19 MR. POWERS: I mean, that's another view
20 of the thing.

21 MR. SCHAPEROW: But that's not enough to
22 spread it out maybe over two hours, but --

23 MR. POWERS: That's another view, is to
24 say that this release rate is determined by the
25 propagation of damage, has nothing to do with what's

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1 going on in the fuel itself. It's really the movement
2 of burn front, and that's just not going to change
3 very much. So, yes, I will stipulate for you that
4 that's an alternate view.

5 MR. BOYACK: I have two questions for you,
6 Dana. The effect will be, this is no evidence of
7 profound change. This effect will be a lower release
8 rate of cesium and iodine into containment because?

9 MR. POWERS: Take the same release
10 fraction and divide it by a larger time. That's the
11 problem I'm getting into here. I'm very attracted to
12 what Jason says, which is, no, no, no, release rate is
13 just driven by how the damage propagates through the
14 core, and you're not really seeing anything due to the
15 fuel at all.

16 MR. SCHAPEROW: Again, I don't have a lot
17 of experience there. Jim may have more.

18 MR. BOYACK: Then the second one was that
19 this conclusion is not consistent with data. Just
20 tell me what data.

21 MR. POWERS: Well, the data that I'm
22 trying to reflect is the VERCORS data that we have
23 seen with all the equivocations that Dave Leaver puts
24 in. You've got one that goes one way and one goes the
25 other. So it's a work-in-progress there.

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1 Maybe it would help me puzzle this out.
2 Is, in fact, the release rate we're reflecting in this
3 early in-vessel, the release from the fuel that we see
4 or is it damage propagation rate? Jason may be right,
5 it may be damage propagation, in which case leave it
6 the same, you know.

7 MR. SCHAPEROW: Although I've seen actual
8 no core calculations or any test results that show, it
9 only takes about 20 minutes to go from one end of the
10 fuel rod to the other --

11 MR. POWERS: It's not one end to the
12 other.

13 MR. SCHAPEROW: All right.

14 MR. POWERS: It's this way that counts.
15 It's always this way that counts. I mean it's always
16 this way that counts.

17 MR. BOYACK: Is the 1.4 something I can
18 retain or do you want me to change it?

19 MR. POWERS: No, no, I mean, I think
20 you're boxed into that because I just don't think
21 we're in any position to say that the core degradation
22 is wildly different. It's not that big of a change.

23 My only concern is the relocation story,
24 just because, Bernard can tell you, we have fought
25 like crazy to get the codes to predict properly where

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1 fuel relocates, and it is intimately tied to the phase
2 diagram and how much of the fuel is oxidized and how
3 much of it is interacting with the zirconium. In the
4 end, what the code guys do, they throw up their hands,
5 the thermodynamicists, and they put in a temperature,
6 and they adjust that temperature until they can match
7 data.

8 Well, what that says is you've got to have
9 the data because we need to do a MOX degradation test
10 in order to confirm this is a very subtle change to
11 things or this is a big change. Unfortunately, what
12 we're seeing is subtle effects in the experiments.

13 He can tell you, he can explain to you the
14 differences they observed between FPT-1 and FPT-3.
15 All it is is changing a little bit of the steam flows
16 and all the ramping. I mean, you get big things on
17 this relocation business, and relocation is what marks
18 the end of this.

19 MR. BOYACK: Tom?

20 MR. KRESS: Would you just back up and
21 remind me what our old number was for the duration?
22 That was for LEU fuel without burnup?

23 MR. BOYACK: That's 1465.

24 MR. KRESS: That's 1465? I'm not going to
25 add the .1 to it because I can't see any reason why

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1 the duration of the gap has anything to do with how
2 long it takes the core to melt down and go to the
3 bottom. So I'm going to keep the 1.3. I have no
4 reason to change it. I think the core melt process is
5 about the same.

6 MR. POWERS: If you don't add to it, Tom,
7 you're shortening it because it's the sum of those
8 two.

9 MR. GIESEKE: You're saying that the total
10 of the first two is invariant?

11 MR. POWERS: Yes.

12 MR. GIESEKE: Well, then you've got to
13 change the second one. You change the first one, and
14 you've got to add.

15 MR. KRESS: I am not saying the sum of the
16 two are invariant.

17 MR. GIESEKE: Well, you just said that.

18 MR. KRESS: I'm saying the 1.3 is
19 invariant. I can do whatever I want to with the gap.
20 The 1.3 is how long it takes it to heat up and melt
21 down. It had nothing to do with the gap. It is
22 independent of the gap.

23 MR. POWERS: It is .5 plus 1.3, is the
24 time it takes to heat up and melt down. You have to
25 add the two.

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1 MR. GIESEKE: Yes, it's additive. That's
2 the way the table is built. Do you want to change the
3 table?

4 By definition -- he read the definition to
5 you, right?

6 MR. KRESS: I want reality. I think it
7 takes a certain amount of time to heat up and melt the
8 core. It doesn't have anything to do with gap
9 duration.

10 MR. BOYACK: All we're saying is you've
11 used up four-tenths of an hour -- pardon me -- three-
12 tenths of an hour in your first thought here.

13 MR. POWERS: In the original table it says
14 it takes 1.8 hours to heat the core up and penetrate
15 the vessel.

16 MR. KRESS: Okay, I see what you're
17 saying. I'll make it 1.4, too, because I want the
18 endpoint to come out the same.

19 MR. POWERS: Then you have to go to 1.5.

20 MR. KRESS: I would do the 1.5.

21 MR. BOYACK: You were the one that had the
22 shorter period of time for the first interval. So
23 they're saying, if you go to 1.8 and hold that
24 constant, then this has got to be 1.5. That's all
25 they're telling you.

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1 MR. KRESS: Okay, make it 1.5 to be
2 consistent.

3 As far as if we end up with a total
4 release fraction, which is going to come out of MOX,
5 some of it, and some of it is going to come out of
6 LEU, and they're going to come out at different rates
7 and possibly different total amounts because the
8 release of the MOX fuel is going to go higher than the
9 LEU, and then you're going to factor in the 40
10 percent. I think once you end up doing that and
11 getting a total amount, that probably it's just as
12 legitimate to draw a straight line for that as it was
13 to draw the straight line in the first place. It's
14 just a different straight line. It goes to a
15 different level.

16 MR. BOYACK: Bernard?

17 MR. CLEMENT: 1.4, for the same reasons as
18 for high-burnup fuel, as recalled by Dana.

19 MR. BOYACK: Okay.

20 MR. CLEMENT: And, also, the same remark
21 as Dana, we need more data about degradation
22 experiments with also measurements over the associated
23 short-term, because putting back fission products
24 release kinetics, I agree with you it would probably
25 not be constant during this time in general.

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1 MR. BOYACK: Is this a correct statement
2 of the needs or a reasonably close one?

3 MR. CLEMENT: Yes, if I come back to high-
4 burnup fuel, we said bundle experiments, bundle
5 degradation tests, because you want to look at
6 degradation. You cannot do that in a VERCORS test
7 with three curves.

8 MR. POWERS: What about the PHEBUS test?

9 MR. SCHAPEROW: You can't do that. If you
10 want to understand degradation, you've got to have a
11 few rods.

12 MR. POWERS: A few rods?

13 MR. SCHAPEROW: Yes, it would be nice to
14 have 100, but we'll take 21, if that's all we can get.

15 MR. BOYACK: Okay, Dave?

16 MR. KRESS: I think a single straight line
17 is sufficient.

18 MR. BOYACK: Pardon me? Go ahead and just
19 state it for me.

20 MR. KRESS: Constant release rate is a
21 sufficient representation of this phase.

22 MR. POWERS: You're putting the model out
23 of business. You're putting your model out of
24 business here.

25 MR. KRESS: We'll have to apply the model,

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1 though, to get the input.

2 MR. SCHAPEROW: Do you want to say it's
3 because of the mix of MOX? It's because of the mix of
4 MOX and LEU fuel in the core.

5 MR. POWERS: From the MOX, but it's not
6 from the LEU, I don't think.

7 MR. KRESS: It was not 100 percent before
8 from the LEU.

9 MR. BOYACK: Okay, Dave?

10 MR. LEAVER: I would like to I guess
11 reflect the fact that at least in the RT 2 the
12 volatiles come out faster or at a lower temperature.
13 So I guess I don't want to increase the 1.3 hours.
14 I'm not sure if this result is, in fact -- we can
15 generalize, and there's certainly some question about
16 that because of the other test, and we really don't
17 have a good explanation for that, but I'm not even
18 sure we can generalize to low volatiles.

19 We have a single duration for all fission
20 products, but, even with that, this is very, RT 2 is
21 a very interesting result, and it's hard to ignore.
22 So I guess I'm not fixated on keeping the total
23 interval the same. It would seem to me, at least in
24 the case of the volatiles, that the release could
25 occur faster. It's probably not constant and probably

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1 what we're looking at is maybe the interval is the
2 same, but it's a nonlinear shape. But that's way too
3 complicated to even try to figure out. So I would
4 just say I will stay with 1.3 hours, which makes the
5 overall interval slightly less than for the LEU.

6 MR. SCHAPEROW: That suggests core
7 degradation is faster, heatup, and everything --

8 MR. LEAVER: No, I'm saying that the
9 volatile releases occur at lower temperatures.

10 MR. GIESEKE: No, the definition for this
11 is until it knocks through the bottom head. You want
12 to change the definition?

13 MR. LEAVER: No, I don't want to change
14 that. I don't want to change that. I want to reflect
15 the fact that between the time when this starts, which
16 we've sort of generally said may be a little sooner
17 than 30 minutes, that the volatiles, at least based on
18 this one test, and certainly we need some
19 confirmation, but the volatile fission products appear
20 to come out faster.

21 MR. GIESEKE: No one denies that. I agree
22 with you 100 percent, but you're saying that it melts
23 through faster.

24 MR. LEAVER: No, I'm not saying that.

25 MR. GIESEKE: Then you have to change the

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1 definition. The definition is until it melts through.

2 MR. LEAVER: Then let me pull out 1465 and
3 we'll see.

4 MR. GIESEKE: He just read it to you.

5 MR. BOYACK: Yes, I just read it to you,
6 and that is, "This release phase ends when the bottom
7 head of the reactor pressure vessel fails."

8 MR. LEAVER: All right, but we also, I
9 think, generally, at least some people have said, and
10 I believe that the release rate is not constant. When
11 we apply this to calculations, we have no basis for
12 assuming anything other than a constant release rate.
13 So if you're going to assume a constant release rate
14 and you want to reflect the fact that it really isn't
15 constant, and that they do come out earlier, then --

16 MR. GIESEKE: I am going to say that when
17 I talk about the release rate.

18 MR. LEAVER: What are you going to say?
19 It's not constant?

20 MR. GIESEKE: I'm going to say it's not
21 constant. It comes out faster. It comes out not
22 linearly.

23 MR. LEAVER: So you're going to have some
24 kind of nonlinear release rate?

25 MR. GIESEKE: Yes, when we get to that.

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1 MR. LEAVER: Well, how are you going to
2 decide on that?

3 MR. GIESEKE: Well, I don't know. I'll
4 just say it is. I can't define it, but when I get to
5 putting the number in there for how much is released,
6 I am going to say it doesn't come out uniformly over
7 the time period. I think that's the place to take
8 care of this issue, unless you want to break this
9 time, I mean this period, into two parts or something
10 like that.

11 MR. POWERS: That is one way to do it, but
12 if one believes that this rate of release is really
13 driven by the propagation of core damage, rather than
14 release from the fuel, then there's no reason to do
15 that.

16 MR. GIESEKE: Yes, that's true.

17 MR. BOYACK: The point is, David, that if
18 you want to stay with this, there's no problem. It's
19 just that I'm going to call out that it's --

20 MR. LEAVER: Yes, it is a little difficult
21 to do this and not talk about release fractions at the
22 same time. Let's go on and talk about that, and then
23 we can revisit this as necessary. That's fine.

24 MR. BOYACK: All right. One more, and
25 then lunch.

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1 Dana, ex-vessel?

2 MR. POWERS: The ex-vessel release is
3 really composed of two parts. One is the melt-
4 concrete interaction and the continued degradation of
5 that fraction of the fuel that didn't degrade up to
6 the point of vessel failure.

7 The melt-concrete portion of it is
8 determined largely by how much zirconium metal is
9 present in the core debris. Consequently, all those
10 things, nothing seems to have changed. I just don't
11 see any change here. So I just can't justify changing
12 from the original value. That's two hours.

13 MR. BOYACK: Could you just go through the
14 two parts again, compose the two parts?

15 MR. POWERS: It is the degradation and
16 expulsion of that portion of the core that did not
17 degrade during the in-vessel release. That's roughly
18 half the core. My own number, it's half the core.
19 The rest of it is due to the melt-concrete
20 interaction.

21 Since I didn't believe the core
22 degradation changed in the vessel by any profound
23 amount, and I certainly don't believe that the melt-
24 concrete interaction changes by any profound amount,
25 I can't change the time.

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1 Now if what we find is that there is some
2 substantially different interaction of clads with MOX
3 fuel than what we have seen with low-enrichment
4 uranium fuel, which I will agree is entirely possible,
5 then those numbers could change. Fortunately, I think
6 they all go shorter. So I think we're reasonably
7 conservative with these numbers.

8 MR. KRESS: Shorter is worse, isn't it?

9 MR. POWERS: Not by the time you've gotten
10 out to this point. What you're really playing with is
11 the long-term release at this point. The worse two
12 hours are now over. You're working on the tail at
13 this point. So how long does your tail take?

14 Now the other thing is that you have to
15 remember melt-concrete interactions puts up formidable
16 amounts of nonradioactive aerosols. So it has an
17 inherently limiting effect on the short-term. I mean,
18 you get big particles at this point. So it kind of
19 marks the end of real high concentrations in the
20 containment atmosphere at this point.

21 That's right; you know, it's kind of a
22 mixed bag on whether you want to cover up with water
23 because, if you put up all this concrete stuff, it
24 really sweeps out the aerosol big particles for you.

25 MR. KRESS: That's sprays, isn't it?

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1 MR. POWERS: Sprays are real nice. I like
2 sprays.

3 MR. BOYACK: Okay, Tom?

4 MR. KRESS: The same. I buy every bit of
5 what Dana said. That's just my view exactly.

6 MR. BOYACK: Did you ever hear that before
7 or was that a unique statement, "I buy his view
8 exactly."?

9 MR. POWERS: Tom and I tend to be the
10 structuralists on the Committee, and what we disagree
11 with is over some of the details of philosophy because
12 he thinks more about these things, as they make my
13 head fuzzy.

14 (Laughter.)

15 But I would say that we tend to vote alike
16 far more often than we vote disparately.

17 MR. BOYACK: Do you have "possums"?

18 MR. POWERS: I didn't hear you.

19 MR. BOYACK: Do you have "possums"?

20 MR. POWERS: No, I almost never have a
21 possum. But when I do have to eat armadillo, I do put
22 molasses on it.

23 (Laughter.)

24 MR. BOYACK: Okay, Bernard?

25 MR. CLEMENT: I would say two. I would

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1 say no reason to change now. Parameters that could
2 impact would be the amount and composition of melt
3 that goes through the reactor lower head.

4 Here we come to the point of degradation
5 experiments. If degradation experiments show large
6 differences, not minor but large differences, core
7 calculations will be needed, and at that time maybe
8 duration could be changed.

9 MR. POWERS: You can envision things that
10 would change radically. Because the M5 doesn't
11 oxidize very rapidly, the interoxide could be quite
12 thin in a fairly aggressive attack, get a large
13 homogenization, and slumping much quicker, so that you
14 get things on the lower head path.

15 On the other hand, it could go completely
16 the other way and melt off the clad, it slumps down,
17 and you're left with a lot of fuel.

18 MR. CLEMENT: That's what I call a large
19 difference.

20 (Laughter.)

21 MR. BOYACK: Okay. All right, Dave?

22 MR. LEAVER: I agree with what Bernard
23 said.

24 MR. BOYACK: Jim?

25 MR. GIESEKE: The same.

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1 MR. BOYACK: The same as what?

2 MR. GIESEKE: We'll make it, "See DL."

3 How's that?

4 (Laughter.)

5 MR. BOYACK: Now you guys were too quick
6 on that one, which gives me a chance to finish the
7 last one.

8 MR. POWERS: Already he proves to be an
9 unreliable person.

10 (Laughter.)

11 MR. BOYACK: Well, that's true. But what
12 this will do is shorten the time to get through the
13 last one.

14 MR. KRESS: Now you've made him mad and
15 he's going to be obstreperous and hard to get along
16 with.

17 (Laughter.)

18 Talking about the suspension and
19 revaporization, those things are suspending in the
20 primary system, which I think we talked about height
21 of what got released.

22 MR. GIESEKE: Talking about what?

23 MR. KRESS: Height of what got released.
24 That's the way I read it.

25 MR. BOYACK: Let me interrupt just for a

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1 minute. I am being fed material up here, which helps.

2 Back to NUREG 1465, it really is the right
3 thing to do. It is just to talk about the definition.

4 "The late in-vessel release phase
5 commences at vessel breach, proceeds simultaneously
6 with the occurrence of the ex-vessel phase. However,
7 the duration is not the same for both phases. During
8 this release phase, some of the volatile nuclides
9 deposited within the reactor coolant system earlier
10 during the core degradation and melting may revolatize
11 and be released into the containment."

12 MR. KRESS: That is what I said?

13 MR. BOYACK: Yes.

14 MR. KRESS: Now in the previous case, we
15 had about 25 percent of what was released that was
16 available to do this. Now we're going to, I'm going
17 to increase the release fraction, so that I'm going to
18 have more deposited and more to revaporize.
19 Therefore, it is going to heat up faster, I think it
20 will heat up faster. At least the contribution from
21 what's on the wall is going to be more. The
22 combination of steel heat coming from other places,
23 but I think this is maybe driven mostly by the decay
24 heat that's on the walls. I think that's about it.

25 So my duration is going to be shorter for

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1 this because it's going to be more there and it's
2 going to heat faster. How much shorter is it going to
3 be?

4 MR. SCHAPEROW: More fission products
5 deposited.

6 MR. KRESS: Yes.

7 MR. BOYACK: More deposited?

8 MR. KRESS: Yes. What was the duration
9 before?

10 MR. BOYACK: Ten hours.

11 MR. KRESS: Ten hours? For the main in-
12 vessels, 10 hours? I'm going to back off on what I
13 just said. I didn't realize it was 10 hours. I
14 thought it would be like three hours. This change in
15 the amount deposited, it's 10 hours. I don't
16 understand that 10 hours.

17 MR. LEAVER: Hossein, where did that 10
18 hours come from?

19 MR. SCHAPEROW: It says right in there it
20 has to do with the amount revaporized.

21 MR. NOURBAKHS: We made a couple of
22 calculations. One, SPCP calculations, but for
23 extended hours, to look basically at how much, because
24 only the revaporization of the release from in-vessel
25 -- we have only one or two calculations, and Gei Wu

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1 did some adjustments, but he used that.

2 MR. KRESS: RCS piping over a 10-hour
3 period with insulation on it?

4 MR. POWERS: I did some calculations, and
5 what we found is the -- I mean, this was really to
6 demonstrate that revaporization was a possibility.
7 Initially, we put cesium hydroxide down on the surface
8 and looked at its heatup and revaporization. It came
9 off quite quickly. I would say over the course of 45
10 minutes to an hour. It was very quick.

11 Somebody said, "But I don't really believe
12 in cesium hydroxide." I said, "Suppose we make it
13 cesium monoborate," and you'll see why I picked
14 monoborate. They came off pretty quantitatively over
15 the course of three hours.

16 And I said, okay, suppose it's cesium
17 pentaborate. So I'm knocking down the cesium partial
18 pressures here with each of these steps, and it came
19 out over the course of about 10 hours to the extent of
20 about 25 percent on the material.

21 That range, we said, well, we have no idea
22 what the surface deposit is going to be.

23 MR. KRESS: You're assuming that the whole
24 pipe heats up over this time and it's insulated, and
25 there's none of this heat lost?

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1 MR. POWERS: No, we had heat loss roughly,
2 I think we were losing something on the order of 2
3 megawatts. I mean we had a lot of heat loss.

4 MR. KRESS: Cesium pentaborate,
5 significant vapor pressure?

6 MR. POWERS: Well, significant vapor
7 pressure? We were getting substantial vaporization,
8 which I take as partial pressure is 10 to the minus 6
9 atmospheres. I think we were certainly hitting it by
10 the time we got to 800, 900 degrees centigrade. Now
11 we never melted the pipe. We did melt some internals.
12 Upper internals were melting out on us, but those
13 weren't doing it. All that happened was that stuff
14 was going on down and depositing back on the pipes.
15 There was a natural convection calculation.

16 MR. KRESS: And this is where the 10 hours
17 came from?

18 MR. POWERS: Yes, what we came up with
19 was, I mean our conclusion was, what revaporizes
20 depends crucially on what you assume to be the
21 chemical form. We don't know. We argued that this
22 thing will fight like crazy to go to the least
23 volatile form it possibly can, and because it was a
24 PWR, we had the borate available to react with, so we
25 did.

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1 We had the Elrich experiments that
2 suggested it could very well form a silicate. We had
3 the British experiments that said it could equally
4 well react to form a chromate. All those things had
5 repercussions somewhere within the range we were
6 looking at. So we said, gee, it could go anywhere
7 between, we said, three and ten hours.

8 Then Marty Plies took on the MAP code, and
9 he said, I want to get into this game, too. He looked
10 at Peach Bottom. What he was really looking at there
11 was the heatup of the piping system in the drywell due
12 to the core debris down below. He really wasn't doing
13 a natural convection calculation.

14 He had the revaporization going on for 50
15 hours. So you can get any number you want to. I
16 suspect the authors of 1465 looked at all this and
17 said, "Ah, 10 hours."

18 MR. KHATIB-RAHBAR: If you look at the
19 MELCOR calculations, if you look at the MELCOR
20 results, Dana, you can run the code as long as you run
21 to get revaporization. There's no end in sight.

22 MR. POWERS: That's right. I mean, it
23 starts and it goes forever.

24 MR. SCHAPEROW: In NUREG 1465 it doesn't
25 talk about a stopping point. It says, "the time at

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1 which 80 percent of the revaporization happened."
2 There are some words to that effect.

3 MR. BOYACK: What it says here is,
4 Reference 17, "After review of the source term
5 uncertainty methodology used in NUREG 1150 estimates
6 the late in-vessel release phase to have been a
7 duration of 10 hours." What I detect is it was just
8 sort of pick a time.

9 MR. POWERS: In other words, a number that
10 gives you a long-term tail on the source term to
11 reflect what we thought was legitimate physics. The
12 problem is, one of the biggest the NRC bought into the
13 PHEBUS experiments, is to have a reasonably prototypic
14 test as far as composition, to have a reasonable idea
15 of what the chemical composition was in the piping
16 system. Because I can turn the revaporization off
17 completely. You let me pick the fission product
18 chemical form, and I can turn it to zero or I can have
19 it all come off in a half an hour, as long as you give
20 me that flexibility.

21 MR. KRESS: Given all that, I'm going to
22 keep 10 out.

23 (Laughter.)

24 I can't change that.

25 MR. GIESEKE: There's not strong enough

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1 variation to change it.

2 MR. POWERS: Victoria has been run out for
3 fairly limited periods of time, and Victoria finds
4 many interesting things that we just never pursue, for
5 the FPT-1 test in setting up, or FPT-0 test, for
6 setting up the instrumentation, where we came back and
7 recommended instruments be saved at the end of the
8 test because we were calculating the cesium iodide was
9 decomposing on the surface and you were getting iodine
10 gas coming off or gaseous iodine coming off, after
11 they had shut down the experiment, but still had flow
12 from the system.

13 This is after they've gone through the
14 core degradation, and they turned the test off, but
15 they keep the flow going through the system. What we
16 saw was the iodides on the surface were getting torn
17 up, and we were getting long-term revaporization.

18 MR. BOYACK: I'm going to move on now
19 because Dave's hungry, not to say me.

20 MR. CLEMENT: Ten. No reason to change
21 associated with MOX fuel.

22 MR. BOYACK: Dave?

23 MR. LEAVER: I would agree with Bernard's
24 statement.

25 MR. GIESEKE: "See BC."

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1 MR. LEAVER: Revaporization calculations,
2 why wouldn't you want to -- I mean even iodine I guess
3 there can be different forms, but certainly you expect
4 to be cesium iodide, that would be and that is most of
5 the heat, I mean a substantial fraction of it. So
6 that would be -- you're right, absolutely, the
7 chemical form has a huge impact, but that would be a
8 good one to do.

9 MR. POWERS: For 1150 we did cesium
10 iodide, tin telluride, nickel telluride, ruthenium
11 dioxide, cesium molybdenate, cesium urinate, and the
12 answer is they revaporize as they see fit. You can
13 actually get a chromatic graphic effect. It just kind
14 of migrates down the piping system. It depends on the
15 size of leach you have. I means, like I say, give me
16 flexibility on the fission product chemical form and
17 I can get you any result you want. You let me know
18 what result you want; I'll get it for you.

19 MR. BOYACK: I would like the result on
20 the late in-vessel.

21 MR. POWERS: Obviously, I'm going to stick
22 with 10 hours. I'm going to have you put a caveat in.
23 Dave is right that, if releases are qualitatively the
24 same, in-vessel releases are qualitatively the same,
25 the dominant source of heat really is the iodide. If,

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1 however, we see substantial amounts of release of
2 either the ruthenium or the barium and strontium in-
3 vessel, they can accelerate the revaporization
4 release. But right now I don't see strong bases for
5 doing that. I can see bases for enhancing the
6 molybdenum release in-vessel; it just doesn't carry
7 enough heat to do anything. They've got to be
8 different than --

9 MR. LEAVER: They are already 2 percent.

10 MR. POWERS: They've got to get up around
11 20 percent.

12 MR. LEAVER: For MOX?

13 MR. POWERS: You get up to those levels
14 and then you start pulling with the heat a little
15 more.

16 MR. LEAVER: What basis do you have for
17 saying for MOX fuel strontium barium is 20 percent?

18 MR. GIESEKE: He says it has to get to 20
19 before it will affect his heating.

20 MR. LEAVER: Oh, okay.

21 MR. KRESS: No, no, I'm saying you're
22 going to release that --

23 MR. LEAVER: You're saying that? Why are
24 you saying that?

25 MR. KRESS: Why? Integrating a fission

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1 product release model that puts barium and strontium
2 in relation to the cesium, and I'm releasing all the
3 cesium. I'm releasing all the cesium from the MOX.
4 And the question is, how much of the barium strontium
5 am I releasing? I've got a mental model of how
6 related to cesium, and then it gets up to about 15, 20
7 percent, my mental model.

8 MR. POWERS: The reason you get interested
9 in things like strontium, and whatnot, is because it's
10 beta. When you put so much of that heat actually in
11 the deposit --

12 MR. BOYACK: Those of you who would like
13 to go to lunch now can do so, but we're going to be
14 coming back at one o'clock. Those of you who would
15 like to stay and talk may do so.

16 (Whereupon, the foregoing matter went off
17 the record for lunch at 12:17 p.m. and went back on
18 the record at 1:11 p.m.)

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1 A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

2 (1:11 p.m.)

3 MR. BOYACK: When we left, I had finally
4 worked out through Tom the opportunity to go ahead and
5 lead, if you would. We're on noble gases.

6 MR. CLEMENT: Okay, noble gases. So I'm
7 wondering for gap release whether --

8 MR. BOYACK: I was just going through not
9 putting numbers.

10 MR. CLEMENT: Two pieces of information.
11 The first one is on the French side what is assessed
12 for MOX fuel for design basis large break LOCA, as
13 first presented last time by Jean Schiliva. In that
14 case, it's 0.05 for MOX up to 37 EON base per ton. So
15 37 is not so far from what we are dealing with today.

16 So we could either keep the 0.05 like that
17 or increase a little bit to reflect differentials with
18 boron-rich uranium fuel with the same burnup. So I'm
19 not so sure about can we come in with 0.05 or 0.07, as
20 we did for high burnup.

21 MR. BOYACK: I think as we start these
22 discussions it's fair to let other people go ahead and
23 offer their comments.

24 MR. SCHAPEROW: Would there be any value
25 in putting up the PWR high-burnup table that you had

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1 before?

2 MR. CLEMENT: It was 0.0 --

3 MR. SCHAPEROW: It just seems like we're
4 going to -- we seem to be heading down that road.

5 MR. BOYACK: Did you say from the high-
6 burnup?

7 MR. SCHAPEROW: I've heard a lot of
8 statements about how this may have quite similar
9 behavior and it may burn up fuel. We have these
10 rates. There may be a little earlier degradation in
11 some cases. I don't know. Maybe I'm drawing too big
12 a conclusion from that.

13 MR. POWERS: I think at our last meeting
14 we got presented some information on the gap
15 inventories. Similarly, there's literature on this.
16 It seems to me that, yes, it's pretty clear that the
17 gap inventories can be a little higher, but they're
18 all within the 5 percent level. I don't see any
19 reason to -- I mean, remember these guys are keeping
20 their average burnup in the 40s. That's about where
21 that table came from. We were thinking 38 at the time
22 we put that table together; 38, 40, I mean that's all
23 kind of the same number. You're not going past the
24 transition where you get a change in structure. You
25 may be feeding it a little more, but you're still --

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1 I mean, there's supposed to be margins within that 5
2 percent, and I think there is.

3 MR. SCHAPEROW: I take back my comment
4 then. I just saw we were starting to move toward down
5 the road of a high-burnup fuel behaves like a MOX
6 fuel --

7 MR. POWERS: I think you've got more
8 arguments when you get to the in-vessel release, but
9 for the gap --

10 MR. CLEMENT: 0.05 for gap releases and
11 0.95 for early in-vessel.

12 MR. BOYACK: Ninety-five, right, and then
13 00, I can take it from there.

14 MR. NOURBAKHS: That .95 indication is
15 100 percent.

16 MR. CLEMENT: Okay. When we expressed our
17 position from the French point of view, we always give
18 the total release for that. So that means in-vessel
19 and early in-vessel and late vessel, the .95. We
20 don't make the distinction.

21 MR. BOYACK: Okay, let's see, so, Dave, I
22 guess what I did there, there was a rationale that was
23 given, but I was sitting back and listening in awe.

24 MR. LEAVER: Bernard's .95 is a total
25 release. So to be consistent with what you were doing

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1 yesterday, you will want to make that notation.

2 MR. BOYACK: Thank you. Okay, Dave?

3 MR. LEAVER: Yes, .05. I think that there
4 is some data. Patrick Lampah presented at the last
5 meeting showing higher fission gas inventory, but
6 there is some margin in the 5 percent. So I think
7 Dana's point is a good point. I think any change that
8 I could make would be sort of the same as the high-
9 burnup. I have trouble with the .07. So while one
10 could make arguments that the .05 should be increased,
11 I think that there's enough margin.

12 Do you want to do the early in-vessel,
13 too?

14 MR. BOYACK: As long as we've got started,
15 sure.

16 MR. LEAVER: Yes, on that one, I feel I
17 need to -- since the release seems to start sooner,
18 and I know there's this question about, is it a core
19 degradation-driven release or a fuel release, and I
20 need to think about that point, but I'm not sure that
21 you could argue that the core degradation is faster,
22 but maybe it's a little bit faster.

23 But I guess initially my thought is that,
24 if you take the 40 percent release, total of 40
25 percent, I guess it's 35 percent for early in-vessel,

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1 roughly, where that came from was a release of perhaps
2 up to 70 percent of the iodine from the fuel and
3 retention of about half of it, which I think is an
4 okay way to think about it.

5 I think in the case of MOX probably
6 that --

7 MR. NOURBAKHS: This is noble gases.

8 MR. LEAVER: What's that?

9 MR. NOURBAKHS: This is noble gases.

10 MR. LEAVER: Oh, I was thinking iodine.
11 I'm sorry. Okay. Yes, all right, I was thinking
12 iodine.

13 MR. BOYACK: I probably should have backed
14 off. Why don't we just finish the gap release and
15 then take these discussions one at a time?

16 Jim?

17 MR. GIESEKE: I can go with the .05 since
18 that's the same as -- a little bit higher number,
19 which it might be; .05 is a good number.

20 MR. BOYACK: And just for the heck of it,
21 Dana, could you quickly rattle off your rationale
22 again?

23 MR. POWERS: Well, the rationale is based
24 on the database we've seen, limitations to the burnup
25 that are to be imposed, and the fact there's probably

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1 margin in the 5 percent level. I haven't seen data
2 suggesting that I will be much above 5 percent on the
3 gap inventory.

4 MR. BOYACK: Tom?

5 MR. KRESS: .06. I don't know how much
6 margin is sufficient, and if we had a margin of 4,
7 maybe we'll have more inventory in there. Maybe we
8 ought to increase it to reflect that we think there's
9 more inventory in the gap for MOX fuel, and I
10 arbitrarily just made it a little bit, just to
11 indicate that there's more in there. The .06 is no
12 different than .05. It's just an indicator.

13 MR. BOYACK: Anybody have any statement
14 about needs at this point?

15 MR. CLEMENT: When we have discussed about
16 this point for high-burnup fuel, we have stated that
17 for future LOCA experiments that will be performed in
18 various spots it would be worthwhile to have in many
19 cases a measurement of release for gases and also for
20 other fission products. If there are LOCA experiments
21 with MOX fuel, I think the same requirement is to be
22 done.

23 MR. POWERS: Yes, it seems to me it's a
24 logical thing to say. We are going to get some Halden
25 data, and that will give us fission gas, but it didn't

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1 give us anything else.

2 MR. BOYACK: Okay, let's go now to the
3 early in-vessel phase. Dave?

4 MR. LEAVER: Why do we have this chart up
5 over here, Brent?

6 MR. BOYACK: Which one do you want?

7 MR. LEAVER: Yes, that one, yes.

8 I think for the MOX fuel it seems we have
9 this data point of an earlier volatile release. I
10 guess if one were to just sort of simplistically say
11 that roughly half the core is MOX, and we believe this
12 number for LEU of .63, and we say, to be conservative,
13 the MOX would release 100 percent of the nobles in
14 this period, which is what we originally said in 1465
15 for LEU, which I think was conservative, but I think
16 this approach here for the high-burnup fuel, the UO2
17 fuel, is a good concept. I don't know about the
18 number.

19 Then I would say pick a number that is an
20 average of the two, which would be, say, .78 or .80,
21 for a total of 85 percent during this period of gap
22 plus early in-vessel.

23 MR. NESBITT: Can I interject a question?
24 Are you all looking at the core in its entirety when
25 you do these MOX ratings or are you looking at the MOX

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1 fuel --

2 MR. LEAVER: We should be looking at the
3 core in its entirety, and assuming that maybe half or
4 a little less than half of it is MOX.

5 MR. NESBITT: If that's what you all are
6 doing, I think you need to make it clear because I was
7 kind of assuming the other way around. I thought you
8 were coming up with the source term for the MOX fuel
9 in a partial MOX fuel core and you would rely on some
10 sort of integration, depending on how much fuel is in
11 there of each type.

12 MR. LEAVER: I would propose that we do
13 this, think about this the way we did the high-burnup,
14 which is it's for the total core, where we have a
15 qualification here, which is that the kind of
16 fractions you are talking about of the core are MOX,
17 something in the range of 25 to 50 percent. So at the
18 outside it would be 50 percent. Now if somebody wants
19 to come in with a core of 100 percent MOX or 80
20 percent MOX, then maybe this wouldn't apply.

21 MR. CLEMENT: That means we have to make
22 the arranging here. So which burnup should we
23 consider for the LEU fuel? I'm sorry, but --

24 MR. BOYACK: No, that is an excellent
25 question. I hadn't thought about that.

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1 MR. SCHAPEROW: It is going to vary. It
2 is vary over a number of years.

3 MR. LEAVER: What were you licensed to for
4 your LEU fuel --

5 MR. NESBITT: What are we currently
6 licensed?

7 MR. LEAVER: No, what would you be when
8 your mixing in MOX? Still the same?

9 MR. NESBITT: Who knows?

10 MR. LEAVER: Huh?

11 MR. NESBITT: Who knows? I mean, I'm
12 serious. I have no idea.

13 MR. KRESS: The 65 will probably still
14 apply.

15 MR. SCHAPEROW: I would like to make a
16 point that in the earlier assessment of release
17 fractions for PWRs, built into that was an assumption
18 that about 70 percent of the core would heat up to
19 these high temperatures before lower head failure. So
20 we have a smaller number there than we used to.

21 MR. LEAVER: No, we still have 70 percent.

22 MR. SCHAPEROW: Okay, but you just gave
23 him .80.

24 MR. LEAVER: Yes.

25 MR. SCHAPEROW: So you're suggesting in a

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1 MOX core a larger percentage of the core would be
2 involved with heatup and relocations --

3 MR. LEAVER: No, what I'm trying to
4 reflect is my concept, right or wrong, and for which
5 there's data to the contrary, is that the volatile
6 fission products come out faster in the MOX fuel,
7 which means, if we're going to sit there and hold it
8 for this period of 1.3 hours, or whatever that
9 interval is, it's easier for me to visualize that you
10 could get to essentially all the nobles released.

11 MR. GIESEKE: Only in a fuel that's failed
12 and melted.

13 MR. LEAVER: Well, yes.

14 MR. GIESEKE: Which is -- I don't know
15 what we said before --

16 MR. LEAVER: Right.

17 MR. GIESEKE: -- 60, 70 percent of the
18 core. I think we used 70 percent of the core. That's
19 the basis for our numbers. The first two total the 70
20 percent because 70 percent of the fuel was molten and
21 30 percent was still standing at the end of this time
22 period. So we put 100 percent release --

23 MR. LEAVER: Still standing meaning what?
24 Does that mean the clad is still intact or?

25 MR. GIESEKE: Yes, pretty much so, but

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1 that's insignificant compared with the release you get
2 if you melt it in any case. Because we say if the
3 clad fails, you only get 70 percent without melting
4 it. If we melt it, then you get basically 100 percent
5 or the rest of it.

6 Go ahead. I'm sorry. It's not my turn to
7 talk.

8 MR. BOYACK: If you want, I think we could
9 go around. See, I have no objection --

10 MR. LEAVER: I am not saying 70 percent of
11 the core is molten. I mean, TMI, you released about
12 55 percent of the noble gases, and you did not have 55
13 percent of the core molten. You don't have to melt
14 fuel to release noble gases.

15 MR. GIESEKE: That's right, but you have
16 to fuel the clad.

17 MR. LEAVER: Yes, you do. I think it's
18 conservative to assume 100 percent, but who knows what
19 the hell it is. But at this point I think, in the
20 absence of data, this being provisional, preliminary,
21 it's probably not a bad idea to be a little
22 conservative.

23 MR. BOYACK: It's always difficult, a
24 little more difficult, for the first person to have to
25 go ahead and give a number, which is fine. I'm glad

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1 to have it. But what I would like to do is move
2 through, and then there's nothing, absolutely no wrong
3 -- it's actually good if during the course of
4 discussion other points are made and the person comes
5 back and says, "Hey." Tom's done that once or twice.
6 So let's do that.

7 So, Jim, your comments?

8 MR. GIESEKE: I am going to depending
9 on --

10 MR. BOYACK: The way the wind is blowing?

11 MR. POWERS: He's a flexible person.

12 MR. KRESS: What do you do when you find
13 out you're wrong?

14 (Laughter.)

15 MR. POWERS: Resist like a son-of-a-gun.

16 (Laughter.)

17 MR. BOYACK: Okay, Jim, you said -- now
18 it's your turn.

19 MR. GIESEKE: I am going to say 65
20 percent, .65 here, which is kind of an estimate of how
21 much of the fuel is going to be either melted down or
22 the cladding failed to release, or we figured 7
23 percent of the claddings failed, something like that.
24 So I figured 65 is a good estimate.

25 MR. BOYACK: Dana?

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1 MR. POWERS: 0.65, for exactly the same
2 reasons Jim was articulating there. I am taking about
3 half the core as melting over this, actually melting
4 and slumping, but there's another fraction of it
5 that's suffered some substantial thermal insult, and
6 that gets after the fission gases pretty good here.
7 So .65 looks like a decent estimate to me.

8 What I believe is that this number is
9 driven more by core damage than anything about the
10 details of fuel microstructure and things like this.

11 MR. LEAVER: As opposed to an iodine or
12 cesium?

13 MR. POWERS: Yes. It seems to me that it
14 will allow me to integrate over 1.3 hours; a lot of
15 the kinetics just aren't very important to me. As to
16 whether you're melting it or not internally, I take
17 half of it as melted, and a third of what remains has
18 gone through some substantial thermal insult.

19 MR. BOYACK: Tom?

20 MR. KRESS: I am thinking.

21 MR. BOYACK: Okay, that's all right. We
22 can wait.

23 MR. KRESS: It's .6523.

24 MR. BOYACK: Two extra decimal points,
25 whoa.

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1 (Laughter.)

2 MR. KRESS: You didn't type that in, did
3 you? .65 is going to be all right with me, and it's
4 for the same reasons. I was assuming about half the
5 core was MOX and about half of that would undergo the
6 high temperature melt, and that half the MOX would
7 release all of its noble gas, and then you've got the
8 other half of the core as LEU, and some bigger
9 fraction of it, like most of it, is going to go
10 through the high temperature melt. It's going to
11 release similar to what we had in the other one.

12 When I put all this together, it came out
13 close to 65. So I just said 65 is a good enough
14 number.

15 Whatever Gieseke says is probably right,
16 and he didn't even have to go through all of this
17 machination. He just did this, and there it is.

18 MR. POWERS: That seems to be what he did
19 for the source term code package stuff, wasn't it? He
20 just made up new graphs?

21 MR. NESBITT: Pardon me for an
22 interjection. It seems to me an implicit assumption
23 that you're looking around a 50 percent MOX core in
24 these numbers. I ask that you make that implicit
25 assumption evident in the report.

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1 MR. POWERS: My number does not depend on
2 what fraction of the core is MOX.

3 MR. KRESS: Well, mine did because I
4 assumed that MOX that underwent the full temperature
5 transient released all of its fission products, noble
6 gases. But I'd assume some of it didn't -- well,
7 including the full transient, because some of the
8 residual fuel is left in there. So that split was on
9 account of an arbitrary number. I don't know how much
10 is going to go through it and how much isn't.

11 MR. LEAVER: Are you assuming that all of
12 the LEU fuel undergoes the transient, but only half of
13 the MOX will? I mean, that's your rough concept?

14 MR. KRESS: It was more like 70 percent of
15 the LEU.

16 MR. LEAVER: Seventy percent of the LEU?

17 MR. KRESS: Yes.

18 MR. LEAVER: And about half of the MOX?

19 MR. KRESS: Yes. And that 70 percent
20 released -- you know, this number has implicit, the 63
21 has implicit, a fraction also.

22 MR. LEAVER: Right.

23 MR. KRESS: So I have to convert that.

24 MR. LEAVER: Right.

25 MR. KRESS: Then when I did all that, it

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1 come out to about 65. It came out, and I don't
2 remember what it was, but it was close enough to 65 to
3 sound like it was a good number.

4 MR. LYMAN: Can I make the suggestion, as
5 a member of the public, that you reconsider whether it
6 should be based on a partial MOX core or not? Because
7 I think for understanding what you're doing, if you
8 want anyone who is reading this report to be able to
9 understand it, I think you want to isolate the MOX
10 portion, particularly the MOX. I mean because
11 otherwise everyone is using almost a different core
12 fraction in their minds. It's going to be very hard
13 to obtain.

14 MR. KRESS: That's an interesting thought.

15 MR. BOYACK: It's a reasonable point.

16 MR. KRESS: You'd get entirely different
17 numbers if you did that.

18 MR. NESBITT: I hate to agree with Ed, but
19 in this case I think he's right.

20 MR. KRESS: Or we could say a constraint
21 on these numbers is that 50 percent of the core is
22 MOX. That could be a constraint on the numbers.

23 MR. GIESEKE: I think we established it's
24 more likely to be 40 percent.

25 MR. KRESS: Forty is the same as 50.

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1 MR. GIESEKE: Oh, I see, now you're saying
2 it doesn't make any difference, which is what I would
3 have said --

4 MR. KRESS: Between 40 and 50, it doesn't
5 make any difference, but between 50 and 100 it
6 probably makes some difference. That would work. We
7 were just considering 100 percent MOX.

8 MR. BOYACK: The issue has been raised,
9 and the point has been made, that from the standpoint
10 of trying to discern the effect of MOX alone, if one
11 considered a MOX core, totally a MOX core, and then
12 went through this process, you would have a very clear
13 insight, if you had a MOX core.

14 MR. KRESS: Then somebody could take their
15 fractions and adjust these by the fractions they
16 actually have; that would make some sense.

17 MR. NESBITT: You don't have to assume
18 it's all MOX. You just have to assume that your
19 release fractions are based on MOX.

20 MR. GIESEKE: Look at what we did without
21 MOX. You get 70 percent through early in-vessel and
22 no MOX at all. Here we're saying 70 percent through
23 in-vessel with MOX. So it doesn't make any difference
24 in this case, but this is noble gases, and it's good
25 to have the conversation because down the road, as you

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1 go down the list of groups here, you're going to get
2 into situations where you care about it.

3 MR. BOYACK: So what happens is that, if
4 you give a straight MOX composition, then somebody
5 downstream has to do the integration.

6 MR. KRESS: What they're going to do
7 downstream, I think, is take the old source term and
8 take the MOX source term and add them together related
9 by the fraction of MOX. That's what they're going to
10 do. I don't know if it is the right thing to do, but
11 it makes about as much sense as anything.

12 MR. BOYACK: Well, but it would be easier
13 for us to work through as a panel a straight MOX, I
14 think.

15 MR. KRESS: Yes, at least you're thrusting
16 with straight MOX, rather than factoring in these
17 percentages. It makes some sense to me to do it that
18 way.

19 MR. GIESEKE: The problem is yesterday we
20 weighted it according to percentage of high-burnup.

21 MR. KRESS: Now that's harder to do.

22 MR. GIESEKE: Because they're all going to
23 be the same, and it's not an a priori variable,
24 variable.

25 MR. KRESS: Yes, but you're right, we

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1 could have assumed it was all high-burnup and let them
2 factor in the fraction of the other two.

3 MR. BOYACK: Bernard, was this your
4 initial suggestion sometime ago?

5 MR. CLEMENT: I was raising the question.
6 It was a thought, yes.

7 (Laughter.)

8 MR. SCHAPEROW: I'm the one who suggested,
9 what happens when we go all the way to 100 percent?

10 MR. BOYACK: Well, to me, it's the
11 customer that's going to use it. So I can go either
12 way. But I do sense some simplicity. Not only that,
13 but it seems to me that you have a longer life, shelf
14 life, for the information if it's MOX totally, because
15 then as there are these changes downstream, you just
16 adjust accordingly.

17 MR. KRESS: And people wouldn't have to
18 make this integration or wouldn't have to figure out
19 how we made this integration ourselves.

20 MR. CLEMENT: But this is different than
21 from high-burnup because for high-burnup you cannot
22 imagine having a whole core with high-burnup fuel.
23 You cannot imagine that. The proportion of MOX may
24 vary.

25 MR. SCHAPEROW: It would help to

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1 streamline neutronics though.

2 MR. KRESS: I don't think so.

3 MR. LEAVER: Constrained by what --

4 MR. SCHAPEROW: The neutrons, the
5 fissioning rates, the decay fraction, or whatever
6 affects control --

7 MR. LEAVER: Do you mean in terms of what
8 fraction of the assembly is going to be MOX?

9 MR. SCHAPEROW: -- controller reactor.

10 MR. KRESS: He's talking about the delayed
11 neutrons and control. You can still control them.
12 You could have a whole core of MOX if you wanted to.

13 MR. LYMAN: You are not doing a whole
14 neutronics analysis.

15 MR. KRESS: No.

16 MR. LYMAN: All you're doing is a release.
17 It's not like you're studying a whole MOX core and
18 then have to do the whole regimen for a whole MOX
19 core. It's this particular calculation.

20 MR. KRESS: So you wouldn't have to
21 confuse that --

22 MR. LYMAN: You're not putting information
23 about the spectrum anyway.

24 MR. SCHAPEROW: I would have to talk with
25 somebody else in my office before we went that far.

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1 That's a change to the original intent of the -- it's
2 not a big change, but I can make some calls now if you
3 want to take a break.

4 MR. KRESS: It might be worthwhile because
5 it makes some sense.

6 MR. SCHAPEROW: This is kind of a big
7 change for me to just say let's do it.

8 MR. LEAVER: We have a lot of questions in
9 our minds about core damage progression in MOX, and I
10 guess I take just a little bit that there's not much
11 basis for taking comfort in doing these estimates
12 because of lack of data, but I do take a little bit of
13 comfort in the fact that realistically I expect this
14 core to be mostly LEU. So even if there are some
15 significant differences in some of these phenomena for
16 a MOX core degradation, it's less than half the core,
17 and so I figure, gee, I can't be too far off in sort
18 of trying to imagine an LEU core with some MOX
19 assemblies. Now if you say 100 percent MOX or 90
20 percent MOX core, I'm even more uncomfortable.

21 MR. NESBITT: You can have it both ways.
22 You can say these are the release fractions we assume
23 for the MOX fuel with the implicit assumption that MOX
24 is 50 percent or less of the fuel in the core. You
25 can have it both ways.

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1 MR. LEAVER: That would be okay.

2 MR. BOYACK: I'm a happy camper. I can go
3 any way. Dana, any thoughts?

4 MR. POWERS: I am going to be making such
5 modest adjustments to the original PWR table that have
6 more to do with the other features than the MOX-ness
7 of the fuel. For instance, I will be adjusting the
8 tellurium releases a little bit back toward what they
9 originally were because of the M5 clad. The other
10 release fractions I think are, the important ones --
11 that is, the cesium and iodine releases in-vessel --
12 are driven by the extent of core degradation so much
13 that it is really fairly inconsequential to me whether
14 you look at those things as the MOX fuel alone or the
15 entirety of the fuel.

16 Now if that entirety of the fuel was very
17 high-burnup fuel, that would be a problem, but I don't
18 think that's the case. No matter how they run the
19 reactor, at any one time the low-enrichment uranium
20 fuel won't be a lot of it -- I mean you're only toying
21 with 60 percent of the core, so maybe 20 percent of it
22 could be very high-burnup. So it really doesn't
23 influence me one way or another.

24 MR. BOYACK: So it doesn't really, in fact
25 -- we've got now three options: continue as we

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1 started; full MOX core, and the last one was just the
2 MOX fuel assembly release fractions in one of these
3 cores that has about 60 percent LEU.

4 MR. SCHAPEROW: How is that different from
5 how we started?

6 MR. NESBITT: Because you don't have to
7 smear your release fraction to account for this much
8 of the fuel is uranium and this much is MOX, uranium
9 is going to do this, and this much is going to be
10 melted, and MOX is going to do this; this much is
11 melted.

12 MR. KRESS: If you did that, your release
13 fractions would be the same as if you assumed the
14 whole core was MOX, I think.

15 MR. CLEMENT: It depends on how we would
16 consider the values. If, from indications that we
17 have that we can have higher release rates with MOX
18 fuel, generally speaking, if we consider that, roughly
19 speaking, for an intermediate burnup, MOX fuel behaves
20 roughly like a high-burnup of LEU fuel. If you make
21 the average, I think we should come to values that are
22 not so different from the high-burnup fuel, given the
23 uncertainties we have right now because of the lack of
24 data.

25 MR. KRESS: The high-burnup fuel, I think

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1 we would call one-third of the fuel high-burnup. The
2 MOX we're calling it half the core. So you might get
3 numbers that are a little higher for the MOX, if the
4 effect of the MOX is about the same as the effect of
5 high-burnup fuel.

6 MR. GIESEKE: I can't imagine that you're
7 going to know anything close enough to know the
8 difference between .3 and .5 for the MOX, except for
9 Tom Kress, who makes it .6523.

10 MR. KRESS: If they're going up, I can go
11 up.

12 MR. SCHAPEROW: Why don't we continue as
13 we were doing, and I will go to see if I can get some
14 further guidance as to whether we can switch over to
15 just considering MOX and not worrying about the rest
16 of the core. Okay?

17 MR. NESBITT: Make sure they understand
18 that it's straightforward to transform it to the whole
19 core if you've got the MOX numbers and the LEU
20 numbers.

21 MR. SCHAPEROW: Well, maybe. I'll be back
22 in a few minutes.

23 MR. GIESEKE: Who had the lead on the next
24 one?

25 MR. KRESS: I think Dana's the one.

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1 MR. GIESEKE: The next number is .3.

2 (Laughter.)

3 MR. KRESS: I think Dana's point suggests
4 that he would go back and change the 1465 numbers for
5 LEU fuel, and then if those were changed and we did a
6 full MOX, and you let somebody agglomerate those by
7 the percentages, then you would have a coherent
8 system. But let Dana say, what he's going to do now
9 is, rather than go back and fix the 1465, he's going
10 to factor that into what he says this is. It's going
11 to confuse the heck out of a lot of people because
12 they're going to say, "Where in the heck did that come
13 from?" As long as you've got enough of your rationale
14 up there, I think it could be figured out. But I
15 would rather, to be rational, say 1465 numbers ought
16 to be changed to this, and, oh, by the way, if you had
17 a full MOX core, it ought to be this, and you guys
18 figure out how to put them together.

19 MR. BOYACK: Did Tom have that right? Is
20 the 1465 numbers that you would say also needed to be
21 adjusted?

22 MR. POWERS: Well, where the adjustment
23 becomes dramatic is on the large release fractions
24 because 1465 is essentially degrading 100 percent of
25 the core in-vessel for noble gases, and then did

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1 something else for the others. It just looks strange.
2 Now I'm just correcting that strangeness.

3 The only place that it stands out, that it
4 looks really peculiar, is, in fact, the noble gases.
5 There's one other area where things will look a little
6 peculiar, and that is I think we do have some hint
7 that the noble metal releases for the MOX fuel are a
8 little bit higher than what we've done for low-
9 enriched uranium. That distinction that we choose to
10 draw between moly and ruthenium for the high-burnup
11 fuel we may want to preserve.

12 MR. BOYACK: Well, let's continue on with
13 ex-vessel with the noble gas and give me whatever you
14 want on that.

15 MR. POWERS: This is Dana. Still .3. Oh,
16 I'm sorry, I must have been listening to my own self
17 talk.

18 MR. KRESS: It doesn't add up to 100
19 percent.

20 MR. POWERS: It should. Do I have to do
21 the 35?

22 MR. KRESS: Yes, you do.

23 MR. POWERS: So I've got 5 percent on the
24 gap and I've got 65 on the in-vessel.

25 MR. KRESS: Oh, oh, oh, okay.

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1 MR. POWERS: Only in Tennessee does it not
2 add up to 100.

3 MR. KRESS: Well, we use 3.0 for 5.

4 MR. POWERS: Yes, see, that's the problem.
5 You integrate it around the circle, and you've got 14
6 percent.

7 MR. KRESS: I have to figure out how to
8 make mine add up to the same thing, and I've got a .06
9 up there.

10 MR. BOYACK: You surely do. I think you
11 end up with .29.

12 MR. KRESS: That makes it .29? Oh, crap.
13 (Laughter.)

14 MR. BOYACK: How could you know such a
15 thing?

16 MR. KRESS: No possible way. I'll make it
17 .3 and say I'm done but don't know how to add
18 (Laughter.)

19 MR. BOYACK: Tom plans to be rigorous on
20 his demanding 1.0.

21 MR. KRESS: In reality, people would use
22 .3 there anyway. So we might as well put in .3.

23 MR. POWERS: They'll use your .29.

24 MR. KRESS: Well, you're right. I
25 wouldn't. I'd use .3. I'd use .3, and they'd say,

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1 "Hey, but you're adding up to more than one," and I'd
2 say, "So what?"

3 MR. LEAVER: 0.15.

4 MR. BOYACK: We're compensating for the
5 errors which you know exist.

6 MR. LEAVER: So we're down to zero, are
7 we? Nothing left?

8 MR. BOYACK: Now on the round robin, Dana,
9 you --

10 MR. POWERS: Do I get to do them all or do
11 I have to do them one at a time?

12 MR. BOYACK: Whatever way you want to do
13 it.

14 MR. POWERS: I want to do them all.

15 The gap release is 0.05, the same
16 rationale as for the noble gases, and coupled with the
17 fact that I fundamentally believe that that gap
18 release of the condensible fission products is driven
19 by the amount of gas you've got to flow out during the
20 gap release. You can put all the inventory you want
21 in there, and you ain't going to get it in the gap
22 release if you can't vaporize it.

23 Now comes an interesting number. This one
24 deserves some explanation: 0.325 Okay, what you
25 notice right off the bat is that it's a smaller

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1 release fraction than where you had the PWRs and you
2 say, "Hold it, how can that possibly be?" I mean we
3 have all this evidence that we get faster release,
4 more intense release fractions, for these halogens
5 coming out. We can get them for cesium, but I can
6 zoom the halogens about the same. "How can you come
7 up with a lower release fraction, you ding-a-ling?"

8 And it's real simple. I get these higher
9 release fractions. I have higher concentrations of
10 the piping system. I'm putting more on the piping
11 system. So less is getting out. A smaller fraction
12 is getting out during this phase. I'll get it later
13 because I'll jack my late in-vessel release up in
14 response to the higher heat rates that I've got on the
15 piping system.

16 MR. BOYACK: So higher deposition.

17 MR. LEAVER: Just you are talking about
18 higher concentration of aerosol?

19 MR. POWERS: That's right, the vapors in
20 aerosol. I mean, if I'm going to release it faster,
21 then I'm going to increase those concentrations in
22 there, and especially for aerosol physics, it's going
23 to go roughly to the square of the concentration, and
24 I'm going to reflect that.

25 MR. GIESEKE: But I don't think there's

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1 going to be more aerosol. I think that's all
2 structure and stuff, is the aerosol, by tons.

3 MR. POWERS: Sure, and this fission
4 product goes right on the surfaces of those, binds up
5 to it and goes onto the surface.

6 MR. GIESEKE: But it's not going to
7 deposit any faster than it ever did? It's not a
8 concentration effect on aerosol deposit because
9 aerosol concentration is the same.

10 MR. POWERS: Yes, but the partial pressure
11 of vapor, it's interacting with those structural
12 materials and things like that's higher.

13 MR. GIESEKE: Then more also has to go out
14 with the gas phase, because the only way to get the
15 partial pressure higher is to get it in the gas phase.
16 It's not absorbed --

17 MR. POWERS: Initially, and then I'm going
18 to go through the cooler section, and it's all going
19 to condense out to aerosols, but those are going to go
20 out. It's the initial deposition on the particles
21 that's going to go up.

22 MR. GIESEKE: Okay.

23 MR. BOYACK: Ex-vessel?

24 MR. POWERS: Okay, let's see if I can find
25 my ex-vessel number. Ex-vessel is 0.20, and late in-

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1 vessel is 0.20.

2 MR. BOYACK: Okay, Tom?

3 MR. KRESS: I am going to be consistent
4 and stick to my .06, but it's going to give me trouble
5 later.

6 (Laughter.)

7 The same rationale I gave before.

8 MR. BOYACK: It's easier this time because
9 now you don't have to --

10 MR. KRESS: Yes.

11 MR. BOYACK: You can say it's just on the
12 surface sometimes.

13 MR. KRESS: Yes, that's right, I can.

14 MR. BOYACK: Okay, early in-vessel?

15 MR. KRESS: I'm going to go by Dana's
16 argument about the higher fraction deposited makes up
17 for the amount released. I think it's too confusing.
18 I buy Jim's argument that most of those aerosols were
19 already there. I don't know how to do the
20 partitioning between vapor and gas phase just yet
21 because they go through a temperature grading. So I'm
22 going to stick with the amount that I think gets
23 released, and I think I'm going to heavily weigh it to
24 large break LOCAs, so I don't get a lot depositing all
25 over, because the original had about 50 percent of it

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1 deposited, I remember was built into the .25.

2 We're on the halogens. It's .35 in early
3 in-vessel. What's implied to me, that about .7 is
4 really the release fraction. I think that release
5 fraction has to be higher because that was for LEU
6 fuel and now we've got 50 percent of it as MOX, and I
7 think you're going to release all of the iodine for
8 the MOX that only goes to transient.

9 Once again, I'm stuck with how much of the
10 MOX is residual fuel and how much is not. But I
11 assume I'm talking about 50 percent core melt as a
12 substantial core melt quantity, which is what we did
13 at one time, or 70 percent I think was what Jason said
14 we used. So if I use 70 percent for both the LEU and
15 70 percent for the MOX, and say the MOX is going to
16 release all of its fuel, all of its iodine, then
17 that's a .7, but half of that is going to deposit out
18 if I be consistent with the core. That gives me .35.
19 I have to add that to the .35, the .35 we had before,
20 but only half of that because half of .35 is like .17.
21 So .35 plus .17 gives me the number I want.

22 MR. BOYACK: .52?

23 MR. KRESS: I would make that .6, round it
24 up. That's the number I want to go with.

25 MR. BOYACK: I wasn't quite able to get

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1 the mathematical formula down.

2 MR. KRESS: Never mind. Just say that
3 this factors in the fraction of the MOX that undergoes
4 the transient as well as the fraction of the LEU, and
5 that the MOX that undergoes the transient releases all
6 of its iodine.

7 MR. BOYACK: Let's see, we were continuing
8 down ex-vessel.

9 MR. KRESS: Ex-vessel, okay.

10 MR. BOYACK: You've got .34 left.

11 MR. KRESS: No, I've got that .34.
12 There's something screwy in my math here. Why don't
13 you go on to the next guy and let me do my math over
14 again?

15 MR. BOYACK: All right. Bernard?

16 MR. CLEMENT: Okay, so I want to give the
17 same values as before, .05 for gap release and then
18 .95 for the remaining.

19 Now source term, in fact, you release all
20 of the remaining in the early in-vessel, as we did in
21 the faster to make the repartition move on, because
22 you don't have the same hypothetical.

23 MR. BOYACK: Now is that a regulatory
24 approach or do you believe that it's all released?

25 MR. CLEMENT: No.

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1 MR. BOYACK: Two questions in there; one
2 answer. Yes, you believe it's all released? Or it's
3 a regulatory approach? Which is it?

4 MR. CLEMENT: No, it's not a regulatory
5 approach.

6 MR. BOYACK: Yes, it's what you think
7 physically happens?

8 MR. CLEMENT: It's a thing that physically
9 -- I mean a large amount of iodine is released. We
10 think that for the situation of a hot leg break, that
11 is an envelope scenario for that. All of the iodine
12 could be as vapor, so that we can make the hypothesis
13 of a very small retention, so that we come out for
14 reasonably enveloped situations for the mentioning of
15 events dependence to 100 percent release.

16 MR. NOURBAKSHSH: What time duration?

17 MR. CLEMENT: In our case for the time
18 duration, it corresponds to the .95 during the early
19 in-vessel phase. That's what's taken.

20 MR. NOURBAKSHSH: Yes, but how much do you
21 use for your duration --

22 MR. CLEMENT: That doesn't matter so much
23 because you will see if you have to recommend your
24 population or not, but this is not within a few hours
25 of your actions. That's a much longer time. So we

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1 consider a shorter duration, but it doesn't matter so
2 much.

3 When we take into account this early
4 release of iodine, then we apply the content and
5 performance, and so on.

6 MR. BOYACK: Based on this?

7 MR. CLEMENT: Based on this.

8 MR. BOYACK: What time?

9 MR. CLEMENT: What time? I don't have the
10 exact time, but it corresponds to the duration of the
11 early in-vessel, and even shorter. Even shorter.
12 Then you apply the measure of the performances of the
13 containers.

14 MR. BOYACK: Okay, Dave?

15 MR. LEAVER: I think for the same reason
16 I said on noble gases -- oh, gap, yes, .05.

17 On early in-vessel, again for the same
18 reason as I said on noble gases, I think that for the
19 MOX that there's a faster and higher release, but it's
20 only a portion of the core. I guess, based on the
21 calculations we've done, I would estimate this effect
22 being slightly in the other direction from what Dana
23 did. So that if the release is larger, while you will
24 get a bit more deposition, it's not enough to make up
25 for the larger release, and in fact you will get

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1 larger release from the fuel and you will get larger
2 release to containment.

3 So if you use numbers like half the core
4 being LEU, half being MOX, in the case of the LEU we
5 get melting and/or significant thermal damage to 70
6 percent of the core, which is where the .35 number
7 came from, roughly. Then I would say that number may
8 perhaps be more like .4, but there would be some
9 modest increase in deposition, so I'll go with a
10 number in between, .375.

11 MR. BOYACK: See what you started, Dana?

12 Well, that's all right. There was a
13 rationale there. But for me, it's sort of staying
14 awake and engaged, being kind of a fun guy for the
15 rest of you and giving you somebody to laugh at, sort
16 of.

17 Okay, let's go on to ex-vessel.

18 MR. LEAVER: Yes, I mean you could round
19 up the .375 to .4, but I'd just as soon have it be
20 .375 for the moment.

21 MR. BOYACK: Yes, that's fine. Ex-vessel?

22 MR. LEAVER: I have no basis for using a
23 different number other than it shouldn't add up to
24 more than one. Make it .2 then, and then make that
25 .2. What's that add up to?

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1 MR. BOYACK: 4, .775 -- is that .825? No,
2 wait a minute. Yes, .825. I get .825 out of that.

3 MR. LEAVER: Yes, that's okay. You can
4 actually make ex-vessel .25 because I wouldn't have
5 any basis for changing the number that we came up with
6 for the high-burnup fuel.

7 MR. BOYACK: Okay, Jim has now been
8 working out his numbers, right?

9 MR. GIESEKE: Yes. .05. Down here,
10 following through what we did before, if we have, oh,
11 I don't know, we talked before for the noble gases of
12 maybe 70 percent of the core being involved. I think
13 that's what we did before when we did the .35, like
14 Dave has said. So we're going to release from that
15 essentially all of it to get .7 out, but transporting
16 -- I assume we're going to retain half of it again,
17 like we did before, rule of thumb. So I have to put
18 .35 in that spot right there.

19 Now just to comment, I don't think that
20 the increased fission products, if there are any,
21 which there aren't in my case anyway, would affect the
22 transport significantly.

23 Okay, go down to the next one. So down
24 here it looks to me, from what we had before, we're
25 releasing about 80 percent of the material that leaves

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1 the vessel one way or another, and I don't see any
2 reason to change that. So I'll hold that at 25
3 percent, .25 again, and come down here, and I don't
4 see any reason to change that, .2 again.

5 MR. BOYACK: Okay, Tom, have you reworked
6 your numbers?

7 MR. KRESS: Yes. I'm going to still be
8 weird and stick with a .06 just as an indicator.
9 Early in-vessel, my numbers work out to be about .45
10 instead of .06.

11 Then ex-vessel is about, well, because I'm
12 releasing more in-vessel in places, it comes down to
13 be about .15.

14 Late in-vessel turns out to be about .2
15 that we had before.

16 MR. GIESEKE: So you think 90 percent of
17 the core is involved with the damage molten in -- to
18 get your .45 number?

19 MR. KRESS: My numbers were 50 percent of
20 the core as being MOX and --

21 MR. GIESEKE: But if you look at the known
22 gases, which we've already said that we're only
23 involving like, what, 70 percent of the core --

24 MR. KRESS: Let me redo my numbers again
25 because I don't think that's right either.

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1 MR. GIESEKE: The rest of it is still
2 standing relatively undamaged.

3 MR. BOYACK: While he's doing that, can
4 somebody, would somebody care to hold forth on whether
5 or not there are any data needs or needs that go along
6 with this particular area, halogens for MOX fuel?

7 MR. POWERS: Everything's necessary. We
8 don't know how that stuff degrades. We don't know how
9 it releases. That's right. We probably don't even
10 know what the inventory is very well.

11 MR. BOYACK: I mean the statement's great.
12 Now I've got to figure out how to translate that.

13 (Laughter.)

14 That would just go across the board,
15 right?

16 MR. POWERS: Yes. I don't think you need
17 to say that with respect to the melt-concrete
18 interactions.

19 MR. BOYACK: With respect to what?

20 MR. POWERS: The melt-concrete
21 interactions, because I think we understand how the
22 halogens are behaving down there, and any MOX-ness of
23 the fuel has been wiped out as soon as we melt it, put
24 it on concrete.

25 MR. BOYACK: Okay, so basically okay in

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1 these areas here?

2 MR. GIESEKE: The one above there, the
3 early in-vessel --

4 MR. BOYACK: Okay, you started to say on
5 early in-vessel, Jim?

6 MR. GIESEKE: I think it may be worth
7 noting there that we said before, dealing with noble
8 gases, how important the damage progression was, and
9 the same things drives a lot of this, at least from my
10 perspective, the damage progression. So I think
11 that's particularly important there.

12 MR. BOYACK: So we're talking about noble
13 gas releases as a function of the manner in which
14 they --

15 MR. POWERS: Halogens.

16 MR. GIESEKE: We said that before, and I'm
17 saying again here for halogens that melt progression
18 or damage progression is crucial to --

19 MR. POWERS: As would be expected.

20 MR. GIESEKE: Yes.

21 MR. BOYACK: I must be getting tired.
22 Just give me a few words, and I'll write them down.

23 MR. GIESEKE: Damage progression
24 information is crucial.

25 MR. BOYACK: That's a few words. I can

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1 get that.

2 MR. POWERS: And what I would say down in
3 the ex-vessel is the core concrete is okay, but any
4 part due to the continued damage of the vessel fuel,
5 we've got the same problem as the air ingress. If not
6 in spades, we don't have any air ingress data.

7 This is no different than our basic
8 uncertainty about revaporization. There is nothing
9 peculiar about MOX here. We have very poor
10 information about revaporization, nothing peculiar
11 about that, lack of information here with respect to
12 MOX.

13 MR. GIESEKE: I think air ingress is
14 important here. If you're going to cite it
15 specifically in the other, it certainly is important
16 in the next one.

17 MR. POWERS: Yes, it's very important down
18 here.

19 MR. BOYACK: Jason must be having an
20 interesting discussion on this, but if he stays away
21 long enough, we'll be done.

22 MR. GIESEKE: Did you want to add air
23 ingress on the --

24 MR. BOYACK: On the last one?

25 MR. GIESEKE: -- on the last one?

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1 MR. BOYACK: I didn't realize that's what
2 you were telling me.

3 MR. GIESEKE: The late in-vessel, which is
4 what we were saying.

5 MR. BOYACK: I had air ingress up above.

6 MR. POWERS: Well, the revaporization, it
7 really plays a number on iodine, if you get it. If
8 you get air in iodines, it turns all of the iodines
9 into iodine gas.

10 MR. BOYACK: Is the air ingress data, it's
11 not the amount of air; it's the effect of the air on
12 the -- okay? Everybody but Tom can take a break.

13 MR. KRESS: Good idea.

14 (Laughter.)

15 MR. BOYACK: Do you need a little bit more
16 time?

17 MR. KRESS: Yes.

18 MR. POWERS: He's doing a new correlation.

19 MR. KRESS: No correlations.

20 MR. POWERS: He's going to have a whole
21 code here for us.

22 MR. BOYACK: Why don't we come back at
23 2:30?

24 (Whereupon, the foregoing matter went off
25 the record at 2:18 p.m. and went back on the record at

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1 2:34 p.m.)

2 MR. KRESS: The number I come up with for
3 early in-vessel is .35.

4 MR. BOYACK: I believe that.

5 MR. KRESS: I don't believe that.

6 MR. BOYACK: I trust you.

7 MR. KRESS: I don't understand it, but it
8 is.

9 MR. BOYACK: That's a good number.

10 MR. KRESS: And for ex-vessel, I'm
11 assuming that's what went down with the melt and got
12 out with the MCCI, and that's only about .15.

13 MR. BOYACK: All right.

14 MR. KRESS: And late, .2.

15 MR. BOYACK: Okay, so we changed one
16 number?

17 MR. KRESS: Yes.

18 MR. BOYACK: That's good.

19 MR. KRESS: And it all adds up now.

20 MR. BOYACK: And you gave everybody a
21 break, too.

22 MR. KRESS: Yes. I don't know how it came
23 out that way, but it did. I took 70 percent of both
24 the MOX and 70 percent LEU, undergoes the melt, of the
25 MOX, what gets released from the fuel is all of it;

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1 what gets released from the LEU is about .7, and then
2 that gives us the release. I assume about half of it
3 plated out, and it adds up to these numbers.

4 MR. POWERS: So the way you were doing the
5 numerical evaluation of the electrical interval, I
6 think that's not a suitable approximation.

7 MR. KRESS: I think you're probably right.

8 MR. POWERS: I know you were linearizing
9 it to make it easier, but I don't think you can
10 linearize it that way. I think you should have done
11 an asymptotic expansion.

12 MR. KRESS: As part of that resumption,
13 we'll now have an announcement from Jason.

14 MR. SCHAPEROW: Okay. Well, I'm kind of
15 curious as to how far you got.

16 MR. KRESS: Well, we're down to outgoing
17 metals.

18 MR. SCHAPEROW: I grabbed somebody else
19 with more experience and expertise in this area,
20 Charlie Tinkler, and we discussed it a little bit. He
21 made two very good points.

22 One was, when we get to the low volatiles,
23 what do we do, because we've broken it up into a bunch
24 of groups now? We're starting to go into more --
25 we've broken plutonium out, for example, in a separate

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1 group.

2 MR. KRESS: I think we're going to throw
3 up our hands when we get to low volatiles.

4 MR. SCHAPEROW: Well, the other point was
5 that, I guess we kind of talked about, was the
6 usefulness of 100 percent MOX for a table for that.
7 If we did something like that, we would need a clear
8 path to get to a different percentage of MOX.

9 MR. KRESS: You ratio it by the amount of
10 MOX that's in the core.

11 MR. SCHAPEROW: Well, if the panel's
12 willing to agree on that and write it down on one of
13 the tables, fine. It's just that it's not obvious to
14 me how you go from 100 percent MOX core to a 40
15 percent MOX core, but maybe that's me actually.

16 MR. KRESS: You take the MOX table and you
17 modify it by .4 and add to it the LEU table that we
18 had before and modify it by .6.

19 MR. SCHAPEROW: We don't really have --
20 which LEU table.

21 MR. KRESS: The L-1465.

22 MR. SCHAPEROW: I'm not sure we can --
23 write that down. That's fine. If that's what you
24 want to do, that's fine.

25 MR. BOYACK: We can do anything we want?

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1 MR. SCHAPEROW: We can do 100 percent MOX
2 fuel table if we write down how to multiply what to
3 get to the 20 percent MOX table.

4 MR. KRESS: If we tell how to use it.

5 MR. SCHAPEROW: It's just that nobody is
6 going to build a core with 100 percent MOX fuel. I
7 mean nobody's going to put that in a core.

8 MR. KRESS: Yes, but it's more
9 illustrative, in my mind, what the differences are
10 between a MOX core and a non-MOX core, even though
11 people know you're not going to have a full MOX core.
12 It's illustrative of what the differences are.

13 MR. POWERS: I mean you could look at it
14 as an assembly, an average assembly.

15 MR. KRESS: That's the way you could view
16 it.

17 MR. SCHAPEROW: We're not objecting to
18 that. All we're saying is we'd like to have a clear
19 path to get to a 40 percent MOX table. It sounds like
20 it's fairly clear in your mind what to do, but I'm not
21 there yet, and Charlie didn't understand either.

22 MR. POWERS: He's just saying a simple
23 weighting.

24 MR. SCHAPEROW: If you do a simple
25 weighting and the rest of the panel says that's fine,

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1 then that's fine, because then I can use a 40 percent
2 MOX table or a 60 percent MOX table, or whatever
3 somebody might do.

4 MR. BOYACK: Let me just get a reading
5 from everybody. A reading? Any comment? The
6 suggestion is that we do this for MOX I guess assembly
7 is what was said. That's what I put down. The idea
8 was that downstream somebody would weight on an
9 assembly fractional basis the MOX and the LEU. Now
10 for high-burnup fuel elements, you could do that.
11 Somebody's going to have to go back and redo or accept
12 1465 values, which the panel would redo, if they
13 were --

14 MR. SCHAPEROW: It sounds like we're
15 moving away from that anyway.

16 MR. BOYACK: Well, what I'm saying is that
17 the high-burnup fuel source term, in effect, has those
18 changes integrated into it. That's for high-burnup
19 fuel. For the regular burnup fuel you don't have
20 anything that reflects that change now. It's just
21 what NUREG 1465 would cover.

22 MR. LEAVER: Do you mean for LEU fuel it's
23 not high-burnup? But I think the industry is -- I
24 mean, you know, anybody that does alternate source
25 term is probably going to do high-burnup from now on.

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1 I mean everybody doing high-burnup.

2 MR. BOYACK: So the question is, and this
3 is just a question for the panel -- they've left it up
4 to us, right, as long as we provide a clear pathway?

5 MR. SCHAPEROW: Exactly.

6 MR. POWERS: The trouble is I think Jason
7 and I think a little bit -- because it's not clear to
8 me what the pathway is. If I have a loading pattern
9 in which the center of the core is uranium fuel and
10 then I have a checkered pattern, checkerboard pattern
11 out there, I can do this 40/60 split provided the
12 numbers have been developed anticipating a 40/60
13 split.

14 Because my concern is this: that when I
15 do the in-vessel release and I damage like 50 percent
16 of the core, that's predominantly no more uranium
17 fuel. Then when I degrade the peripheral region,
18 which has a mixture of MOX and whatnot in it, the
19 fraction is just different out there. So I have to be
20 very careful about how I formulate the numbers.

21 MR. NESBITT: Just assume that the MOX and
22 the uranium are equally dispersed in the core.

23 MR. POWERS: Just have a complete
24 checkerboard?

25 MR. NESBITT: Yes. It's not going to make

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1 that much difference.

2 MR. POWERS: For my numbers it will make
3 almost zip difference for the major releases because
4 I'm not getting that big of change.

5 MR. KRESS: We do have to make some
6 decision on how much of each of those we're going to
7 participate in now, like we did before. I think the
8 source term represents a substantial core melt. We
9 have to define what that is. I think Jason said it
10 was 70 percent, didn't he?

11 MR. SCHAPEROW: That's what the panel
12 proposed as the amount prior to lower head failure,
13 because --

14 MR. LEAVER: I don't think that number is
15 stated anywhere, but we --

16 MR. KRESS: Yes, it's stated.

17 MR. LEAVER: -- we backed it out of the
18 idea that, if you get about 35 percent of the iodine
19 release keeping roughly, retaining a factor of two in
20 the RCS, that you must have gotten significant thermal
21 damage to about 70 percent of the core.

22 MR. KRESS: I think we ought to make that
23 an explicit observation because either that or say do
24 it for a full core melt and say, whatever -- do the
25 same thing as we're doing for the MOX, say whatever

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1 fraction of the core you think melts, you adjust these
2 to that.

3 MR. LEAVER: NUREG 1465 has always been
4 sort of --

5 MR. KRESS: I think we'd better put the
6 fraction in because the other one has the fraction in.

7 MR. LEAVER: It did, and also I think it's
8 consistent with the notion of 1465. We consider a
9 spectrum of sequences, but when we talk about
10 phenomena, we sort of go back to a low-pressure
11 sequence. In the case of the high-burnup, we assumed
12 that we had roughly a third of the core high-burnup,
13 which is kind of in a generic sense.

14 It seems to me it's consistent if we say,
15 okay, what we're looking at here is a mixed oxide
16 situation which at the present time in the United
17 States we can be representative or typical if we
18 assume that about half of the core, and it wouldn't be
19 any more than that, are MOX assemblies and we'll just
20 intersperse them. I think that's a good notion,
21 rather than try and -- what are you shaking your head
22 for?

23 MR. LYMAN: The public and the licensee
24 are here, and what you're talking about is just making
25 -- we're just talking about it, and you're providing

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1 intermediate steps so that people can read the report
2 and understand what you're talking about. You're
3 talking about mixing an intermediate step in some
4 obscure way, so that no one is ever going to
5 understand what you're talking about.

6 MR. LEAVER: What's obscure about half the
7 assemblies being MOX and half being UO2?

8 MR. LYMAN: Because some of the
9 assumptions you are making are a little bit obscure as
10 far as our relationship --

11 MR. NESBITT: Look at what he was trying
12 to do. It would have been a real simple calculation
13 if you were just --

14 MR. KRESS: It was a simple calculation.
15 It's just a matter of keeping track of where
16 everything was.

17 MR. NESBITT: And if you just had to
18 consider the MOX core for that, it would have been
19 very straightforward.

20 MR. KRESS: Yes, so my algorithm would be
21 let's focus on strictly MOX systems and assume -- go
22 ahead and put the 70 percent in, and make that very
23 explicit that we're only talking about each assembly
24 of MOX, only about 70 percent of it participates in
25 this melt, because that's in the old table, and it's

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1 going to use the two tables together.

2 Then just say this MOX fuel undergoes the
3 core transient just like the LEU would, and use a
4 fission product release relationship that's in our
5 head or something and say what fraction of release you
6 get from that MOX fuel only, and then that's the
7 number we put up there. Then if somebody wants to use
8 it, they have to go in and say, now how much MOX fuel
9 do I have, and how much LEU do I have, and
10 conglomerate this table with the high-burnup when we
11 dealt with that before, just simply by weighting the
12 fractions, which assumes a homogeneous distribution
13 and that each part of the core undergoes a similar
14 type of thermal transient.

15 That I think would be highly transparent
16 to most everybody. The only nontransparent in there
17 is we're only assuming 70 percent of it participates.
18 We can make that very explicit.

19 MR. GIESEKE: I can see that and I can go
20 along with that. It's important to point out that
21 there's an assumption made in doing that, and the
22 assumption is that the mechanics, if you want to call
23 it that, of the fuel damage is the same regardless of
24 the amount of MOX fuel in your core, and it's the same
25 for both kinds of fuel, the MOX and the --

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1 MR. KRESS: That's kind of consistent with
2 the design basis accident source terms anyway.

3 MR. GIESEKE: Okay, but I think it may be
4 important to write that down because that is implicit
5 if you go that way, to just state that the assumption
6 is the same, I mean the assumption regarding, I guess
7 progression and damage are the same for MOX --

8 MR. LEAVER: So if we did this and just
9 tried to come up with a source term for a MOX
10 assembly, would we also be saying in the same breath
11 that this is applicable for up to half the core being
12 MOX and nothing beyond it?

13 MR. KRESS: No. No, that's not necessary.

14 MR. LEAVER: Not necessary?

15 MR. KRESS: Because I don't think it makes
16 that much difference.

17 MR. GIESEKE: Or you could say what I just
18 said, and it doesn't make any difference, I think.

19 MR. KRESS: I think the more MOX you've
20 got in there, the more accurate it is, frankly. It's
21 the other way around. The more MOX you've got in
22 there, the more homogeneous the core is, so the more
23 good our assumptions are.

24 MR. BOYACK: We've got to have a decision
25 and go forward here, and it's really not mine to make.

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1 So I'm going to just quickly poll the panel to see
2 whether the majority of it says go one way or the
3 another.

4 Tom, full MOX, right, with a condition
5 where you're listing that?

6 MR. KRESS: Yes, I say go with the MOX.

7 MR. CLEMENT: The way of arranging, so the
8 problem is the special distribution. If your MOX
9 assemblies and your LEU assemblies are separated, you
10 should just arrange by the fractions, you will have
11 some bias. In my opinion, it depends on what you want
12 to do with these tables, which degree of accuracy you
13 want to attain.

14 We were discussing this morning about 1.3
15 or 1.4 halos and things like that. If you want to go
16 down to this degree of accuracy, this is a difficulty.
17 In my opinion, when you look at what is a source term
18 at the end of the day, it's not worthwhile to discuss
19 one halo experience. So it depends on what you want
20 to do with these tables, because if you want to have
21 a deterministic and real fuel average, I mean you have
22 to make a mechanistic goal much more than what we have
23 up to now.

24 So I am wondering whether we are
25 not discussing the details that are far away from what

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1 we are able to do.

2 MR. KRESS: I think we are, and I think
3 that's one reason I want to go to just the MOX.

4 MR. CLEMENT: That's the way of our
5 approach for the evaluation of source term, where we
6 are systematically introducing some conservatism, so
7 that this conservatism -- we're always asked to cope
8 with such situations as we are debating now. When you
9 have enough conservatism, you can just make the
10 weighting that you propose without any trouble.

11 MR. KRESS: I think a distributed MOX core
12 that's other than homogeneous would give you a more
13 source term than what we're using the other way. So
14 I think we're biasing it in a direction that's
15 conservative, I think, if we just use the full MOX.

16 MR. LEAVER: I guess I could go either way
17 because I don't think it's going to make much
18 difference, frankly, in the number. But I'm
19 uncomfortable with the notion that somehow we're
20 coming up with numbers that could be applied to a core
21 that's a significant majority of MOX assemblies,
22 because I don't -- that makes me more uncomfortable
23 than thinking of it as a majority of LEUs.

24 MR. BOYACK: That is this point made a
25 little earlier that we have less insight into this

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1 whole area of MOX fuel. Now you're asking the panel
2 members to make a larger extrapolation because they
3 don't have this information for a full MOX core. Is
4 that --

5 MR. LEAVER: I guess another way of saying
6 it is, with a core that's a majority of LEU
7 assemblies, if I'm wrong a bit on the MOX, then that
8 makes that effect less significant.

9 MR. BOYACK: Okay, Jim?

10 MR. GIESEKE: Sure.

11 MR. KRESS: Sure what?

12 MR. GIESEKE: I'll go with the MOX, just
13 look at the MOX. I think that makes the data more
14 understandable and more transparent in the long run,
15 because then you can build it up any way you want.

16 I think there is some concern that -- so
17 I'm voting with Tom basically, but there is some
18 concern I have whether it's okay just to state the
19 assumption that core degradation is the same in either
20 case. Then I think it would cover a wide range.

21 The MOX doesn't affect -- the MOX
22 degradation mechanics is the same as LEU.

23 MR. BOYACK: You may have held forth
24 already, Dana, but let me -- so what I've heard is two
25 MOX, one I can go either way.

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1 MR. CLEMENT: For me, it doesn't matter so
2 much.

3 MR. BOYACK: It really doesn't; I
4 understand that.

5 MR. CLEMENT: Yes, because you have seen
6 for high-burnup fuel proposed values that were in
7 general higher, in general, than this panel. That
8 means they introduce some, let's say, some more
9 conservatism. Also, for the separation in different
10 phases, in our approach we don't think it's worthwhile
11 for this source term to go into so much detail.

12 MR. BOYACK: Right.

13 MR. CLEMENT: So that I would say,
14 whatever the solution you propose that is
15 concentrating on MOX, given our approach, I think I
16 will get the same values, except some exceptions.

17 MR. BOYACK: It's almost an abstain, yes.
18 Okay.

19 Dana?

20 MR. POWERS: I'm very sympathetic with
21 Dave Leaver's view, from I don't understand much to I
22 don't understand anything.

23 (Laughter.)

24 On the other hand, maybe the purpose is to
25 say, look, here's the best guess. Go out and get some

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1 experimental data, and at least we know what we're
2 refining. That could be a legitimate value. You
3 would at least know what you were looking for. Quite
4 frankly, I think that's the biggest purpose of this
5 exercise, is really to define what you don't know and
6 then set about going after that.

7 So I guess I could do either one of them.

8 MR. BOYACK: Okay. All right, so
9 basically all I heard was two MOX and two either one
10 of them. I think that's what I --

11 MR. KRESS: That's four for MOX, right?

12 MR. BOYACK: Well, it's close enough.

13 (Laughter.)

14 MR. BOYACK: Okay, so the approach, now I
15 want down the information, though, so that it is
16 clearly characterized. So this is a full MOX core?

17 MR. KRESS: No, assume the MOX is
18 distributed uniformly.

19 MR. BOYACK: Okay.

20 MR. KRESS: So that all parts of the core
21 undergo a similar thermal transient, those parts that
22 participate.

23 MR. GIESEKE: No, I don't agree with that.
24 There's outer and inner. It's the same whether it's
25 MOX or LEU.

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1 MR. KRESS: That's what I mean.

2 MR. GIESEKE: Yes.

3 MR. BOYACK: That's what he meant, yes.

4 MR. GIESEKE: But not all parts of the
5 core --

6 MR. LEAVER: LEU and MOX undergo the same
7 thermal transient, yes.

8 MR. KRESS: So we don't have to
9 differentiate. Then I would say we do have to
10 explicitly include the fraction of each of these that
11 we think undergoes the definition of a substantial
12 melt, and I would be consistent and use the 70
13 percent, 70 percent of each participates in the melt.

14 MR. GIESEKE: The numbers that we're going
15 to put in our tables assume 100 percent MOX.

16 MR. KRESS: The table is going to have 100
17 percent MOX in it.

18 MR. SCHAPEROW: This is how you come up
19 with the different fractions of MOX.

20 MR. KRESS: Yes.

21 MR. GIESEKE: It is more than just a MOX
22 assembly because you have to deal with the retention.
23 I mean you're assuming a full core release.

24 MR. LEAVER: Yes, but I'm not assuming a
25 full core of MOX. I'm estimating the release

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1 characteristics for the MOX assemblies, period, okay.
2 And this is in a core.

3 MR. GIESEKE: It's got to be in a full
4 core because of the losses and the effect of
5 concentrations on losses. You don't want to say
6 it's --

7 MR. LEAVER: I understand. It's a full
8 core accident, yes.

9 MR. GIESEKE: A full core accident.

10 MR. LEAVER: It's a full core accident,
11 right.

12 MR. GIESEKE: And it's a full MOX core
13 accident, the numbers we're going to give. You're
14 going to take releases and multiply it by the number
15 of assemblies, and that's the --

16 MR. LEAVER: It's a release fraction.

17 MR. GIESEKE: It's a fraction.

18 MR. KRESS: When you get to considering
19 deposition and things like that, that might be in your
20 mind how much because --

21 MR. GIESEKE: That's what I'm saying.

22 MR. KRESS: But I think we're going to
23 just throw a number in there, like half.

24 MR. BOYACK: I don't understand, I've got
25 to tell you. Assume MOX is distributed uniformly.

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1 Release fractions stated apply no matter what the
2 fractional split between LEU and MOX. Somehow that
3 doesn't connect with me.

4 Dana made the statement that this is a
5 50/50 core, and I sort of get the same thing.

6 MR. KRESS: What I'm going to do is take
7 a MOX assembly; I'm going to run it through a
8 temperature transient for a core melt that represents
9 temperature transients of severe accidents. From that
10 full MOX assembly, I'm going to estimate the
11 fractional release that comes out for each of these
12 things, and we'll multiple each of those by 70
13 percent. That's the number I'm going to put in.

14 MR. BOYACK: Okay, MOX assembly
15 temperature transient for a core melt. Then you're
16 going to --

17 MR. KRESS: I'm going to use some sort of
18 fission product release relationship and get the
19 fission product, the releases of all the fission
20 products from that temperature transient for the full
21 assembly, but then I'm going to multiply each of them
22 by 70 percent. That's what gets released from the
23 core, the fractional release from the core.

24 MR. GIESEKE: Seventy percent is only
25 applicable at the end of the early in-vessel. It's

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1 not applicable at the gap early in-vessel --

2 MR. KRESS: I'm assuming 30 percent of the
3 fuel is residual fuel that doesn't participate in this
4 release. I think that's consistent with what we
5 assumed for the other.

6 MR. GIESEKE: At the end of the early in-
7 vessel.

8 MR. KRESS: Yes, but then it might --

9 MR. GIESEKE: Not at the beginning of the
10 early in-vessel?

11 MR. KRESS: Then it might do something
12 else.

13 MR. GIESEKE: I'm saying that's only at
14 that one point in time. It's not true at the junction
15 between gap and early in-vessel because that's a
16 different definition. That's the matching of the
17 curves and such, and that might be 20 percent; it
18 might be 40 percent; it might be, you know, some other
19 number of the amount of core that's been involved at
20 that point. But when you get to the end of the early
21 in-vessel, you're saying 70 percent, is all I'm
22 saying. The 70 percent --

23 MR. KRESS: All you're worrying about is
24 the timing. I think the timing is almost independent
25 of all this.

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1 MR. BOYACK: What is the nature of this,
2 "assume MOX is distributed uniformly."?

3 MR. KRESS: I am assuming that it doesn't
4 matter where it is in the core. I am assuming that
5 equal amounts of MOX and LEU are everywhere in the
6 core. It's more that the core is uniform in terms of
7 how much LEU and how much MOX is located where.

8 MR. LEAVER: What he doesn't want to do is
9 have to worry about the fact that MOX is out on the
10 outside of the core.

11 MR. KRESS: And LEU is in the middle.

12 MR. LEAVER: Yes. He doesn't want to
13 worry about that.

14 MR. LEAVER: No, because when I do then
15 make this assumption, I think I bias things on the
16 high side of fission product release.

17 MR. GIESEKE: I don't think you want to
18 say equal amounts. That assumes 50/50.

19 MR. KRESS: That's right, you don't want
20 to say equal amounts.

21 MR. GIESEKE: Homogeneously distributed?
22 You want to say homogeneous?

23 MR. KRESS: Uniformly distributed is what
24 I wanted to say.

25 MR. BOYACK: All this sounds to me to be

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1 the same thing. I am just not quite sure. Tell me,
2 if you built that core, what are you going to do?

3 MR. POWERS: My suspicion is that what Tom
4 is saying is that, when you go to apply this, assume
5 that MOX is uniformly distributed. Multiply the
6 results it gives you times that fraction that's MOX.
7 Multiply the results from a different table times that
8 fraction that is LEU.

9 MR. KRESS: That is exactly what I am
10 saying. That is exactly what I mean with that.

11 MR. BOYACK: Okay, would you say that one
12 more time, and I'll try to get it down?

13 MR. LEAVER: You want to say, assume MOX
14 assemblies are distributed uniformly throughout the
15 core.

16 MR. KRESS: That's good.

17 MR. POWERS: I would predicate it by
18 saying, when you go to apply the results of these
19 tables.

20 MR. BOYACK: Okay, now that's where I'm
21 at. The application --

22 MR. POWERS: When you go to apply these
23 results, the results of these tables, define the
24 fraction of MOX fuel in the core to be "f."

25 MR. KRESS: No, no, just define it to be

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1 whatever you want it to be.

2 MR. POWERS: "f."

3 MR. KRESS: What?

4 MR. POWERS: "f."

5 MR. KRESS: No, no, I meant define it to

6 be whatever it is.

7 MR. POWERS: It's "f."

8 (Laughter.)

9 MR. KRESS: Oh, you said "f." I thought
10 you said, "High."

11 MR. POWERS: No, "f."

12 MR. KRESS: "f"? Okay, I'm sorry.

13 (Laughter.)

14 MR. POWERS: It is the sixth letter in the
15 alphabet.

16 MR. KRESS: Okay.

17 MR. POWERS: And preferably a lowercase
18 "f."

19 MR. BOYACK: Okay, now go on.

20 MR. POWERS: Okay. Define the fraction
21 that is urania fuel, conventional fuel, to be one
22 minus "f."

23 MR. BOYACK: Oh, great.

24 (Laughter.)

25 MR. POWERS: Multiple the results in these

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1 tables for MOX fuel by "f." Add that to the results
2 for the appropriate conventional fuel multiplied by
3 one minus "f."

4 MR. KRESS: Very good. That's exactly
5 what I had in mind.

6 And that's highly transparent, right?

7 MR. LYMAN: And if the licensee thinks
8 that's too conservative and they want the MOX
9 differently --

10 MR. KRESS: Then they can justify how to
11 do it.

12 MR. POWERS: They can also do that.

13 MR. SCHAPEROW: The only problem I have
14 with that is that I don't have the results for
15 conventional fuel.

16 MR. KRESS: Yes, we do. It's that other
17 table.

18 MR. SCHAPEROW: Can you show me that? I
19 don't know which table you're talking about. We have
20 a lot of tables.

21 MR. KRESS: It is the high-burnup PWR
22 table that we just developed yesterday and the day
23 before.

24 MR. POWERS: Not high-burnup.

25 MR. SCHAPEROW: Tell me which table it is.

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1 That's all I ask.

2 MR. POWERS: It's the appropriate one.

3 MR. KRESS: It's the appropriate one.

4 It's the 1465 adjusted for Dana's problem.

5 MR. POWERS: For high-burnup fuel, the
6 values are those in the tables generated by the panel.
7 What are they for conventional?

8 MR. KRESS: I don't think any choice but
9 to go back to 1465, although I think they're wrong.

10 MR. POWERS: No, I mean, it seems to me
11 that you did the high-burnup fuel, you had a two-
12 thirds mixture of conventional fuel and a one-third
13 mixture of fuel up around --

14 MR. KRESS: You have an algorithm to
15 adjust that back. There is an algorithm we could
16 adjust that table back to what we --

17 MR. POWERS: There is an algorithm that we
18 could, except we qualitatively changed things.

19 MR. GIESEKE: You can never go back to
20 1465.

21 MR. POWERS: Yes, stay away from 1465 --

22 MR. GIESEKE: Because we've said there are
23 changes that have occurred in the meantime, and we
24 even cite in there that a new view of the releases at
25 this point in time, as compared with what had been put

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1 in 1465, and that was kind of the basis which was then
2 adjusted for high-burnup. So I'm not sure there's any
3 way to get back anymore.

4 MR. KRESS: Let me ask you something. If
5 we use 1465, would it be conservative --

6 MR. POWERS: No.

7 MR. KRESS: -- except for tellurium?

8 MR. POWERS: No, because we jacked up some
9 releases on some of the low volatiles a lot. In the
10 face of quantitative release of cesium and iodine for
11 the worst two hours, no, it doesn't make any
12 difference at all.

13 We've got a comment back here.

14 MR. NESBITT: If the licensee who has a
15 core composed of all LEU fuel, it's not high-burnup,
16 can use 1465 --

17 MR. KRESS: Why can't they use it here?

18 MR. NESBITT: -- then we can use 1465 for
19 the portion of our core that's LEU fuel if it's not
20 all high-burnup. But if we go to high-burnup fuel,
21 we'll use whatever you all came up with.

22 MR. KRESS: That's my feeling. Even
23 though we think 1465 is wrong, I think in regulatory
24 space you have to use it, and it won't make much
25 difference. It's a way to go that gets us out of this

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1 conundrum.

2 MR. POWERS: Let me ask you a question.
3 You keep talking about 70 percent core damage. What
4 fraction of that core melts and penetrates the lower
5 head?

6 MR. KRESS: I'm assuming all --

7 MR. LEAVER: What did you say, Tom?

8 MR. KRESS: I'm assuming all --

9 MR. LEAVER: I don't think so.

10 MR. POWERS: See, I was assuming about 50
11 percent of the core. I mean I think I can track back
12 on a lot of work the NRC has done and come to that
13 conclusion, that about 50 percent of the core comes
14 down --

15 MR. KRESS: This will impact on what you
16 do for ex-vessel and late in-vessel, I think.

17 MR. POWERS: Then there is some 20 percent
18 that's damaged, thermally-insulted, but it hasn't
19 melted. It hasn't melted in the core now.

20 MR. KRESS: Well, whatever those things
21 turn out to be, and I'm not too fixed on it yet, I
22 think we ought to make it explicitly clear what we're
23 assuming and talk about the ex-vessel releases and the
24 late vessel, what substances go into them, partially
25 for design basis accidents, I'd probably just say all

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1 of it goes out. All of the full 70 percent goes out
2 to participate in MCCI, and there's 30 percent left in
3 the core to do whatever it's going to do.

4 MR. POWERS: Do I have to do that or is
5 that part of the variability in the results?

6 MR. KRESS: It's part of the variability
7 in the results. The 30 percent that's left, my
8 assumption would be that it doesn't do anything,
9 because I think that's the assumption we've been
10 making previously. It's just left behind, and that
11 part of the core doesn't participate in any way in any
12 of it.

13 MR. LEAVER: Are you saying it's intact?

14 MR. KRESS: It's left in there and doesn't
15 raise fission --

16 MR. LEAVER: If that's true, then I don't
17 see how you are going to be able to melt 70 percent of
18 the core. I mean, you may melt -- even Dana's 50
19 percent seems to me to be high. I think it would be
20 more like 30, 35 percent.

21 MR. KRESS: That's pessimistic. This is
22 the design basis phase. I think if you looked at all
23 the severe accidents --

24 MR. LEAVER: Early in-vessel release is
25 design basis, but once you go beyond that, it's not.

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1 No, it's not.

2 MR. KRESS: Yes, sure, it is.

3 MR. LEAVER: No, it's not.

4 MR. KRESS: None of this is based on a
5 single accident sequence or specified accident
6 sequences. It's all an agglomeration of accident
7 sequences. In all design basis --

8 MR. LEAVER: But the word "design basis"
9 means something very specific, and the staff has
10 stated that that portion of 1465 that's up to the
11 early in-vessel is to be used for the radiological
12 design basis accident calculation.

13 MR. KRESS: Sure.

14 MR. LEAVER: And no one has ever said that
15 the ex-vessel release or the late in-vessel release is
16 design basis.

17 MR. KRESS: No, I didn't intend for it to
18 be that. If you're going to use it for anything, you
19 would use it in a design basis sense.

20 MR. LEAVER: But no one's contemplating
21 using it in a design basis sense. The only thing
22 people are contemplating using is the release up to
23 the early in-vessel.

24 MR. KRESS: If I had my way, we would get
25 regulations that had to do with late containment

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1 failure and land contamination, and we would use it in
2 a design basis --

3 MR. LEAVER: Well, if and when, yes.

4 MR. BOYACK: Is this here this 70 percent?
5 Is that where you're taking issue?

6 MR. LEAVER: I was taking issue with the
7 assumption that 70 percent of the fuel is molten and
8 the other 30 percent is pristine in the vessel. I
9 don't think that's realistic. I don't see how that
10 could possibly happen. I don't think it matters, but
11 I think it's certainly reasonable to think of -- I
12 like Dana's word of "thermal assault" or core damage,
13 if you will. Seventy percent of the core is badly
14 damaged. Some portion of that is truly molten, and
15 some portion is shards, debris, in a pile somewhere.

16 MR. BOYACK: Can you live with that, Tom?
17 Seventy percent of the core is badly damaged?

18 MR. KRESS: I don't care because the
19 question is what participates in MCCI, but that's not
20 part of the design basis generally.

21 MR. BOYACK: Right.

22 MR. KRESS: So I don't care what they do
23 with it.

24 MR. POWERS: Well, the next question I
25 have is, why do I have to assume that the 30 percent

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1 that's left in the fuel in pristine suffers nothing in
2 the subsequent phases of the accident?

3 MR. LEAVER: I think that's a good
4 question. I think that it's hard to argue that the
5 late in-vessel, that that would heat up and undergo
6 further damage.

7 MR. KRESS: Well, one asks yourself, in
8 choosing design basis events, does one factor in
9 everything or does one try to have a risk and
10 frequency in mind in choosing it, and one concept is
11 that air ingress accidents that might influence --
12 if that stuff's left in there and the bottom of the
13 head's off, you're either going to cool it and it's
14 going to stop releasing or you're going to get air
15 ingress in there, and you're going to have an air
16 zirc reaction that's going to heat it up and drive up
17 everything off.

18 The question is, do I know enough about
19 the accident to make some argument that it ought to be
20 considered in design basis space, or is its frequency
21 low enough that I can relegate it to severe accident
22 space and say, "I don't have to make the designer or
23 the licensee deal with it, the design basis space?
24 It's a judgment call usually, and it is a question of,
25 is this going to make -- is my system robust enough

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1 with what I have or do I have to make it more robust?

2 You know, I could anticipate all sorts of
3 things. Like I would add in what fraction of this 70
4 percent that means some fraction of the iodine didn't
5 get released to the side. I might say all the iodine
6 because the minute it hits core-concrete interaction,
7 it's going to come out real fast. So it might as well
8 be part of the in-vessel release except for it doesn't
9 get plated out.

10 So you can make all sorts of assumptions,
11 and I think these assumptions here are just consistent
12 with what the old design basis source term is.

13 MR. BOYACK: Let's take a quick look at
14 what I have down under the approach and see if there's
15 anything else that needs to be done.

16 Assume MOX assemblies are distributed
17 uniformly throughout the core. Whether MOX or LEU
18 assembly, it undergoes the same thermal transient.
19 MOX assembly passes through a temperature transient
20 that represents the core melt. Core disruption -- is
21 that better? That creates -- that damages.

22 Estimate fission product releases for a
23 full --

24 MR. LEAVER: Fuel.

25 MR. BOYACK: Pardon me?

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1 MR. LEAVER: Probably the word "fuel"
2 would be better than "core."

3 MR. BOYACK: Estimate fission product
4 releases for a full MOX assembly. At the end of the
5 early in-vessel --

6 MR. LEAVER: Release fractions.

7 MR. BOYACK: -- release fractions. Okay,
8 thank you.

9 MR. LEAVER: You're normalizing this. So
10 it doesn't matter how many assemblies.

11 MR. GIESEKE: Isn't the third one of those
12 bullets covered by the second one?

13 MR. BOYACK: I didn't think so. I thought
14 there was something explicit that I had asked a
15 question about, and it says this is what we're doing.
16 So somewhere I think we -- at the end of the early in-
17 vessel phrase, release 70 percent of the core's badly
18 damaged, some molten and some otherwise damaged.
19 Thirty percent of the core doesn't participate in the
20 release through the end of this phase.

21 Anything else?

22 MR. GIESEKE: I still think the third one
23 is covered under the second one. Otherwise --

24 MR. BOYACK: Does it matter?

25 MR. GIESEKE: -- I would like for you to

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1 add to the third one that says, "LEU assemblies pass
2 through a temperature transient that damages the
3 fuel."

4 MR. BOYACK: So, okay, you want me to also
5 put the --

6 MR. GIESEKE: Well, if you're going to put
7 one, you have to put the other because --

8 MR. LEAVER: We're just estimating MOX.

9 MR. GIESEKE: Yes, but what happens --

10 MR. BOYACK: But the release fractions
11 that we're presenting are for a full MOX assembly.
12 That's all they are. They aren't for the LEU. That
13 was the point.

14 MR. GIESEKE: Oh.

15 MR. BOYACK: So the fission product
16 release fractions developed are for a full MOX
17 assembly.

18 MR. KRESS: I don't know what the "full"
19 means. It's just for a MOX assembly. It's not a
20 single one.

21 MR. LEAVER: Get rid of the word "a" and
22 put "MOX assemblies."

23 MR. BOYACK: Assembly can be one fuel --
24 it's the same thing.

25 MR. LEAVER: Right, for MOX fuel.

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1 MR. BOYACK: Yes, for MOX fuel.

2 Anything else that's needed post to end of
3 early in-vessel?

4 MR. NOURBAKSH: I have a comment. Is
5 that definition of 1465 source term, early release by
6 definition is up to the vessel failure. So that
7 assumption is 70 percent is implicitly, is one of your
8 conclusions, is not explicitly by definition of LEU
9 source early release.

10 See, you bring the end time of the vessel
11 failure. So it is an implicit kind of conclusion that
12 you make that 70 percent should damage before the
13 vessel failure. You saw that explicit definition of
14 that source.

15 MR. KRESS: But making it explicit makes
16 that clear. I mean, it's the same practical -- you
17 get the same result. You get the same result. You
18 might want to clarify that and say the 70 percent is
19 a result of how much it takes to melt through the
20 vessel. That might be a clarification. In practice,
21 it's the same thing. It just assumes the same.

22 Terminate the in-vessel phase.

23 MR. BOYACK: Okay? Are we all clear?

24 MR. POWERS: I'm still unclear what
25 happens after the vessel has been breached.

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1 MR. KRESS: You no longer have steam going
2 out. You've probably got some pretty hot fuel left in
3 there, and it didn't get down yet because you need 70
4 percent of it to get down. That fuel's, I think it --

5 MR. LEAVER: Are you asking what happens
6 to the 30 percent that's up in the vessel?

7 MR. POWERS: Yes.

8 MR. KRESS: I think when the bottom --
9 when the hole gets in the vessels, whatever kind of
10 hole you get, you're going to expel a lot of the 70
11 percent because I think most of it is molten. Most of
12 it is going to go down to the core concrete.

13 MR. POWERS: Well, I understand that you
14 think that most of it is molten, but I certainly don't
15 think so.

16 MR. KRESS: Do you think a substantial
17 fraction of it is crusted and --

18 MR. POWERS: I think a substantial
19 fraction of it is fuel rods that are oxidized to some
20 extent, but not been hot, grading out to when you get
21 to the complete perimeter they're in pretty good
22 shape. They may have ruptured their clad, but
23 otherwise not much has happened to them by that time.

24 MR. KRESS: That's the 30 percent?

25 MR. LEAVER: No, that's a portion of the

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1 70 percent.

2 MR. POWERS: If I take a look radially,
3 starting at the center of the core, and I go out about
4 70 percent of the distance, that's gone. Okay. It's
5 slumped --

6 MR. KRESS: It's 70 percent of the --

7 MR. POWERS: Seventy percent of the radial
8 distance.

9 MR. KRESS: πr^2 squared is --

10 MR. POWERS: Point seven times .7 is .49.
11 So it's about half the volume of the core that has
12 slumped down and hit the vessel head. There is an
13 uncertain range on that I will agree to; it depends on
14 the accident. It is probably higher in this
15 particular accident than others, but it's a good
16 number and I think it meshes with other studies that
17 the NRC has done.

18 From that .7 to the perimeter, the
19 degradation goes from rod stubs all the way up to
20 almost pristine fuel. I suspect that it's broken its
21 clad, has a hole in its clad, but by the time you get
22 to that outer row of assemblies, it's pretty much
23 intact fuel at the time of vessel rupture. Okay?

24 Now I want to know what happens after
25 that. Does Saran Wrap get put over this thing and

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1 nothing happens?

2 MR. KRESS: My assumption is not that
3 you've got 70 percent of the radius, but you go out
4 far enough that you capture 70 percent of the fuel.
5 That's what it takes to melt the vessel, and the 30 of
6 the fuel is around the periphery. Pretty much like
7 you say, it hasn't melted yet. It's probably damaged,
8 and it may have even released some of its, well,
9 evolved to fission products, but it's there. You have
10 a hole in the vessel. You've probably gotten rid of
11 all the steam and water by now, and whatever melt,
12 this hole goes down to the core concrete, and now
13 you've got this stuff sitting around the edge which is
14 undergoing decay heatup, but doesn't have much of a
15 way to cool itself except by radiation.

16 I don't know what happens to it. I think
17 it might continue to heat up and continue to melt and
18 fall down in what residual lower head there is and
19 continue to release its fission products.

20 MR. BOYACK: I am going to ask a question
21 here. I hope you can satisfy my curiosity.

22 An hour and a half ago, we were marching
23 through tables at a pretty rapid pace without these
24 definitions. It appears to me that, although we're
25 talking about MOX specifically, and trying to come

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1 through this prescription, we were doing without this
2 prescription before, right or wrong. Was it wrong?
3 Because now we're into a level of defining the
4 scenario that could have been applicable to what we
5 were doing before also. No matter what the fuel mix
6 is, we could have had this definition.

7 So I'm curious. We were going through the
8 process before, coming up with answers. Now we're
9 having a rather protracted scenario description. Is
10 it necessary to go forward? And if so, why is it
11 different from what we were doing an hour and a half
12 ago?

13 MR. KRESS: That's exactly what I was
14 doing.

15 MR. BOYACK: So the specificity is showing
16 that others were doing different things?

17 MR. KRESS: Probably. I don't know what
18 the others were doing, but that's exactly what I was
19 doing.

20 MR. POWERS: I was thinking about 50
21 percent core melt, some damage, and that broke through
22 the vessel head. Then after that, I had the rest of
23 the core coming down over a two-hour period.

24 MR. BOYACK: Okay.

25 MR. POWERS: And that was augmenting the

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1 core-concrete interaction. For 10 hours I was running
2 gas up through the piping system revaporizing stuff.

3 MR. KRESS: That is probably more
4 realistic than what's going on in what I was saying.

5 MR. BOYACK: Then what I would like to do,
6 then, is sort of see if we can't just get down. So
7 this is a 50 percent of the volume of the core, right?
8 What you had was 50 percent of the volume of the core?
9 Fifty percent of the core doesn't participate in
10 release through this --

11 MR. POWERS: Some fraction of it --

12 MR. BOYACK: Okay, so why is it not within
13 this 50 percent?

14 MR. POWERS: You've got 50 percent of the
15 core that penetrates the vessel.

16 MR. BOYACK: This is the 50 percent that's
17 going to come down? Okay.

18 MR. POWERS: The residual part of it --

19 MR. BOYACK: And will be released
20 immediately upon failure of the lower vessel, right?

21 MR. POWERS: Uh-hum.

22 MR. BOYACK: The remaining percent of the
23 core, 50 percent of the core remaining in the vessel,
24 some portion is also damaged.

25 Now at this point I think what you said

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1 was, for the next phase, so for the ex-vessel phase,
2 the 50 percent discharged, released, in the core
3 concrete interaction, and then what did you say about
4 the rest of the --

5 MR. POWERS: Understand that some portion
6 has been damaged, but during the ex-vessel phase 100
7 percent of the core eventually ends up on the floor.

8 MR. BOYACK: Okay. Then you had a last
9 statement, which was to do with the gas flows, and
10 this was the late phase, right? That's called the
11 late in-vessel phase? What do we call it?

12 MR. POWERS: It's late in-vessel.

13 MR. BOYACK: Just let me go with this for
14 a moment.

15 MR. POWERS: This is the 10-hour period
16 where you're taking the material off that you put on
17 the piping system, you're revaporizing fractions of
18 it.

19 MR. BOYACK: Deposited material, okay. Is
20 revaporized?

21 MR. POWERS: Uh-hum.

22 MR. GIESEKE: Why don't we call that --
23 oh, I don't know what to call it -- RCS internals, as
24 in the piping system?

25 MR. POWERS: Yes, you can say RCS. A lot

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1 of it's on the upper core structures.

2 MR. GIESEKE: That makes it a little bit
3 more applicable to a TWR.

4 MR. BOYACK: Okay, Tom, can you live with
5 that?

6 MR. KRESS: Well, I can live with it
7 except your "some portion" in the bullet halfway up.
8 I don't know what that portion is.

9 MR. BOYACK: Oh, right here?

10 MR. KRESS: Because what I think you're
11 saying is that that's going to be added into the early
12 in-vessel release.

13 MR. POWERS: That's right.

14 MR. KRESS: So I need to know what that
15 portion is, and I think your intent was to make it 20
16 percent or something like that?

17 MR. POWERS: In fact, what I did was 30
18 percent of the fuel was involved and it released half
19 of its inventory in the volatile materials.

20 MR. BOYACK: Okay, I was typing.

21 MR. KRESS: I said 15 percent, and the
22 other 35 percent was part of the core concrete that
23 went over a longer time.

24 MR. POWERS: Thirty-five percent probably
25 lost the gap release, but it hadn't released very

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1 much. Then it collapses down into the reactor cavity
2 and it releases everything. It does that over a two-
3 hour period.

4 MR. BOYACK: So if you were asking, some
5 portion of the 50 percent of the core main vessel was
6 also damaged and participates in the early in-vessel
7 release. Did a number come out of that?

8 MR. POWERS: What I had said, what I had
9 been doing was saying 30 percent of the core loses on
10 average half of its volatile inventory. So if I look
11 at the core and ask something like the, say, cesium
12 content, how much had come out of the core, not onto
13 the containment, but had come out of the core, it
14 essentially amounted to a 65 percent release fraction
15 of the core as a whole.

16 MR. BOYACK: Is this 30 percent of the 50?

17 MR. POWERS: No.

18 MR. GIESEKE: No. It's of the total core.
19 It's 30 percent of the total core, but it comes out of
20 the 50 percent left standing, so to speak.

21 MR. BOYACK: Give me some words.

22 MR. POWERS: Three-fifths of the remaining
23 core releases one-half of its volatile inventories.

24 MR. KRESS: Yes, I don't know whether one-
25 half --

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1 MR. POWERS: Well, a straight line from
2 100 percent release to zero release for that part of
3 the diagram.

4 MR. BOYACK: So is that three-fifths of
5 the main core loses one-half of its volatile
6 inventory? Is that what was said?

7 MR. POWERS: That's what I heard.

8 MR. BOYACK: Yes, that's what you heard.
9 You said it so well. Does this do it?

10 MR. GIESEKE: I have a little bit of a --
11 well --

12 MR. BOYACK: Does this put everybody on
13 the same description?

14 MR. GIESEKE: Well, that's basically where
15 I came up with the 65 percent in the very first place,
16 is this kind of logic. I don't know if we want to --
17 I guess we could say --

18 MR. BOYACK: The reason a prescription
19 like this is good is, when it goes in the report, if
20 something changes markedly, then people can adjust
21 accordingly.

22 MR. GIESEKE: I guess my question is if
23 you want to use something other than -- well, I guess
24 volatile inventory is as good a way as anything.

25 MR. BOYACK: You're going to get another

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1 chance to change this. As long as we're communicating
2 all right about it --

3 MR. GIESEKE: Yes, it's close enough.

4 MR. BOYACK: I can't print this because
5 Jason's got all my disks. We went back again to
6 reprint again. So I don't have a transfer media until
7 tomorrow on this. What I can do is I can just keep it
8 where we can get at it.

9 So now we go back -- first off, tell me,
10 is it going to affect duration?

11 MR. GIESEKE: From my perspective, it's
12 build on this. Any numbers I give you are built on
13 this basic assumption anyway.

14 MR. BOYACK: Okay, for you the answer is
15 no. I'd like you to think about that and whether
16 anybody needs to change the duration input you gave
17 me.

18 MR. KRESS: I am still bothered about the
19 three-fifths of the remaining core and one-half of its
20 fission products.

21 MR. POWERS: It's not one-half of its
22 fission products. This is half of the volatile --

23 MR. GIESEKE: That's important because
24 that's the point I was trying to fuss with, and then
25 I just said, well, as long as he carries the word

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1 "volatile" with it every place he goes, if that's
2 maybe noble gases, you know, if you look at it that
3 way --

4 MR. KRESS: It still bothers me. I don't
5 know whether one-half -- I understand what Dana is
6 saying, but it seems awfully arbitrary to me.

7 MR. GIESEKE: It is.

8 MR. POWERS: Anything we do on this is
9 going to be completely arbitrary.

10 MR. KRESS: I think you're right, but both
11 the three-fifths and the one-half seem arbitrary to
12 me. I'm convoluting two arbitrary things to get
13 another arbitrary thing, and that's why it's bothering
14 me.

15 (Laughter.)

16 MR. BOYACK: The real key is it's
17 arbitrary, but it's very specific.

18 MR. KRESS: Oh, I agree it's specific, and
19 specificity is very important.

20 MR. POWERS: I think I'd go through the
21 actual analyses that have been done in the last 10
22 years and show you that thinking about 50 percent of
23 the core is not a bad, as core melt, it's not a bad --
24 it fits the definition of 1465. It may not be
25 bounding, but it's a pretty severe situation. I can

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1 find accidents that initially melt a lot less, and I
2 can find a few, not too many, that melt more.

3 Now among the ones that melt more tend to
4 be these large breaks. So I don't think the 50
5 percent is all that arbitrary. I think there's a
6 basis for that.

7 As I say, the 50 percent, all I'm doing is
8 saying, look, the outer ring of assemblies may have
9 ruptured its clad, but it hasn't released -- and lost
10 its gap inventory, but it hasn't done very much now.
11 So since I don't know all the details of release, I
12 will assume that, starting at my .7 radius to my .9
13 radius, it's essentially linear. Half of linear, I
14 mean it's roughly half. You can do it very exactly,
15 but you're kind of fooling yourself.

16 MR. BOYACK: So, Tom, are you just feeling
17 that it's a different value? I mean, because we need
18 the prescription to have people doing the same thing.
19 So are you just feeling it's different values or what?

20 MR. KRESS: This three-fifths of the
21 remaining core losing one-half of its volatile
22 inventory, where does that go? Does it go through the
23 primary system that undergoes plate out or does it go
24 straight into containment, in your mind?

25 MR. POWERS: It's part of the in-vessel

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1 release.

2 MR. KRESS: So half of it plates out, or
3 whatever our assumption is on the --

4 MR. POWERS: I was using basically half
5 plate out.

6 MR. KRESS: So three-fifths of 50 is 30,
7 and if I added that to the original 50, I would have
8 gotten 80, and 80 percent --

9 MR. GIESEKE: I am seeing the same thing.
10 I mean, I don't know where you're going to 80 --

11 MR. KRESS: We used 70 percent before to
12 calculate the release in-vessel.

13 MR. POWERS: No, it is 50 percent plus
14 half of three-fifths, which is essentially 15. So you
15 come up with -- so if I take --

16 MR. KRESS: So 15 plus 50; 65 instead of
17 70? I don't see that that's substantially different.
18 It just gives a better rationale for why you would use
19 70 or in this case 65. So I'll go along with what
20 he's saying if --

21 MR. BOYACK: Do I have to do some
22 rewording here?

23 MR. KRESS: No, no. I think it's --

24 MR. POWERS: The issue is what you do
25 after the vessel ruptures.

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1 MR. KRESS: That's right, and you were
2 asking me what I did with the 30 percent, and I said,
3 I don't know. This gives you some rationale for what
4 to do with it. It all goes in over a two-hour period
5 to MCCI or something, and it gives you a rationale for
6 dealing with the ex-vessel part of it. From that
7 standpoint, it's a fairly good specification. It
8 doesn't violate my general rule of 70 percent very
9 much. It's 65 instead of 70.

10 MR. BOYACK: Well, that's good because the
11 uncertainty is much bigger than that, right?

12 Okay, so are we ready to go on?

13 MR. POWERS: Yes.

14 MR. BOYACK: That's the folder file. I'm
15 kind of thinking it would be good if people had a copy
16 of that.

17 Okay, so the duration we said was all
18 right.

19 MR. KRESS: Yes, I don't see that any of
20 this change affects my concept of the duration.

21 MR. BOYACK: Okay, let's go to the noble
22 gases. I'm starting to get tired because I can tell
23 I can't remember who did what, but we'll just start
24 over here. I guess that's how we started last time.

25 Dave, do you want to change any of the

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1 values based upon now this new definition?

2 MR. LEAVER: Okay, and this is now all
3 MOX, and we've kind of come up with a some sort of a
4 standard core damage progression model, which I think
5 is very reasonable. It's a badly damaged core, but
6 it's in the representative or typical range, somewhat
7 conservative in terms of the amount of damage, when
8 you look at the probablistically important sequences.

9 I guess the only thing I would do is I
10 might just lower my 80 percent a bit, maybe make it
11 70, 75 percent, and then increase the ex-vessel to 20
12 percent.

13 MR. BOYACK: Okay, Jim?

14 MR. GIESEKE: I like it right now.

15 MR. BOYACK: Okay, Dana?

16 MR. POWERS: Okay.

17 MR. BOYACK: That's right. Tom? Here
18 comes the moment.

19 (Laughter.)

20 MR. POWERS: He likes them the way they
21 are.

22 MR. KRESS: We're still on the gap
23 release.

24 MR. BOYACK: Oh, actually, I thought we
25 went through the whole thing with these others.

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1 MR. KRESS: Did you?

2 MR. BOYACK: Yes. So you can just go
3 through the whole smear here.

4 MR. KRESS: My gap release was designed to
5 say 40 percent of the core was high and it was MOX,
6 and the other 60 percent was LEU. Now I'm going to
7 all MOX. My gap release would go up considerably to
8 about .1 if I'm just using all MOX.

9 I think the inventory in there is -- you
10 know, if you multiply .1 by 40 percent and add that to
11 -- no, that's not right. .6 was a combination of .4
12 times some number plus .6 times some number. .6 times
13 .05 is .03. So the .6 is .03 divided by .4. So it
14 goes up to about .7 or .75, somewhere around there.

15 MR. BOYACK: Do you want that 5 there?

16 MR. KRESS: No. Let's make it 7.

17 MR. BOYACK: Okay.

18 MR. KRESS: And that's to reflect what I
19 think the inventory change will be --

20 MR. BOYACK: Okay, early in-vessel?

21 MR. KRESS: Early in-vessel?

22 MR. BOYACK: Yes, you get the whole thing
23 now.

24 MR. KRESS: Well, I'm going to take .65
25 for sure because that's the amount that participates

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1 in essential the melt. Now the question is, am I
2 going to release any of these noble gases from that
3 other part of the fuel that didn't? I think surely it
4 gets damaged to the point that it's going to release
5 some noble gases. So I'm going to go back up to the
6 .93 because I think the .07 takes care of --

7 MR. BOYACK: So everything goes out?

8 MR. KRESS: Goes to .93, yes.

9 MR. BOYACK: And the next two go to zero?

10 MR. KRESS: Yes.

11 MR. CLEMENT: Don't change .05, but you
12 could add this, we'll say that the margin is reduced.
13 This is the original for the experiments. I don't
14 change the .05.

15 MR. BOYACK: Okay, so --

16 MR. KRESS: He's saying that it is always
17 the same.

18 MR. CLEMENT: Yes, but you can indicate
19 that now margin is reduced.

20 MR. BOYACK: For the .05?

21 MR. CLEMENT: Yes. Then for the other,
22 .95, no change, because basically in our studies we
23 consider 100 percent participating to the release. So
24 never mind for the 40 or 60 percent. So no change.

25 MR. BOYACK: Okay, noble gases are done.

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1 I have to color code or I'll lose track of what I'm
2 doing.

3 How are you doing, Jim? Are you ready to
4 go on to the halogens?

5 MR. GIESEKE: Yes. I don't see any reason
6 to change because I kind of made these assumptions
7 when I did it in the first place. They're close
8 enough.

9 MR. BOYACK: Dana? Anything you want to
10 do with the .325?

11 MR. POWERS: I put my .325 in there to
12 reflect a belief that the releases of halogens from
13 the fuel are a little more rapid than they would be
14 for conventional fuels. As a consequence, the partial
15 pressure in and immediately above the core region was
16 a bit higher. Consequently, the driving force for
17 fission product halogen condensation on the
18 particulate and structures was a bit higher, and you
19 got less out. The precise numerical value I think is
20 not so important as the indications that, release
21 things more rapidly; you deposit them more rapidly.

22 MR. BOYACK: In effect, we're just
23 employing the logic for everybody now that you were
24 employing before? That's why your number doesn't need
25 to change?

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1 MR. POWERS: Well, I mean, it would seem
2 like it ought to change because now you're doing a
3 full MOX fuel, but since I think the overall release
4 fractions tend to be driven more by damage progression
5 for these volatile materials than by the details of
6 kinetics, the only place I reflect that as higher
7 kinetics is in the fraction of the deposits. So I
8 kick up the fraction of the deposit, and consequently,
9 I kick up the fraction that subsequently revaporizes
10 in the late in-vessel phase.

11 MR. BOYACK: Okay, so your ex-vessel
12 number and your late in-vessel?

13 MR. POWERS: I guess I'd just leave them
14 alone.

15 MR. BOYACK: Okay. Tom?

16 MR. KRESS: My number is going to be the
17 same, and I'll tell you why. The .65 fraction that we
18 essentially assumed undergoes the transient, releases
19 all of it, and you get .65, plus you add the gap
20 release, which is basically another .5 or so. I
21 finally just played it out, and it leaves me with .35
22 running the vessel and .35 on the other right now.

23 MR. BOYACK: Okay, so those numbers stay
24 the same?

25 MR. KRESS: Uh-hum.

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1 MR. NESBITT: The gap release phase for
2 Tom is now, I think, inconsistent with that for the
3 noble gases.

4 MR. KRESS: Oh, yes, I would convert that
5 to 7 also. Thank you very much. You know, once
6 again, that's hardly distinguishable from the 5.

7 MR. NESBITT: Well, I agree, but --

8 MR. KRESS: But just to be consistent and
9 to show that I think there's more in the gap inventory
10 because of its MOX fuel.

11 MR. BOYACK: Any comments now that I need
12 to change? Any different numbers?

13 MR. CLEMENT: No.

14 MR. KRESS: Now ex-vessel, this is the 50
15 percent of the core -- I mean the three-fifths of the
16 core that went down and released half of its content.
17 The other half is going to get released very quickly.
18 So it's that number that. It's coming up to be .15,
19 I think.

20 MR. BOYACK: Okay, and late in-vessel?

21 MR. KRESS: Well, I've got half of the --
22 I've got .35 plated out. I don't think it all gets
23 released, because once it starts releasing, it
24 releases its heat source. So I'm going to stay with
25 my .2, just to be consistent with the things that were

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1 late in-vessel before.

2 MR. BOYACK: Okay. This is where we left
3 off. And, Dana, it follows your lot on alkali metals
4 now.

5 MR. POWERS: Okay, it's 0.05 to begin. I
6 am conceding that the inventory can be a bit higher,
7 but I still think the .05 has enough margin to reflect
8 that, especially when they're limiting the burnup to
9 something around 40. So I just don't see any reason
10 to change that.

11 MR. BOYACK: Okay. Early in-vessel?

12 MR. POWERS: Early in-vessel release, I
13 have 0.30.

14 MR. BOYACK: Okay.

15 MR. POWERS: Ex-vessel, 0.25.

16 MR. BOYACK: Okay.

17 MR. POWERS: And the late in-vessel
18 release, 0.15. Some of this may need a little
19 explanation.

20 MR. BOYACK: All right.

21 MR. POWERS: My general belief is the
22 deposition of cesium in retention of the piping system
23 is a little better than for iodine.

24 MR. BOYACK: And the fractional release
25 is --

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1 MR. POWERS: The fractional releases are
2 about the same, but it strikes me that there is more
3 chemical diversity available to cesium to deposit on
4 the parent piping system, and that it forms more
5 refractory compounds, so the revaporization is less
6 efficient. So that you see some bias down from cesium
7 and iodine here.

8 MR. BOYACK: Okay, now one of the general
9 statements -- I don't know quite where to shuffle them
10 into the thing here as to which phase. So if there is
11 something that you feel like you want in the report,
12 I need to have the phase or I get lost immediately,
13 and then I loss track of the conversation.

14 MR. POWERS: I would say down in the late
15 in-vessel, just say more refractory surface species,
16 so the extent of revaporization is less than for
17 iodine.

18 MR. BOYACK: Okay. All right, Tom?

19 MR. KRESS: Believe it or not, my numbers
20 are just about like Dana's, but I would put the .07 in
21 there just to be consistent, and the rest of the
22 numbers are about the same. The difference --

23 MR. BOYACK: The same as?

24 MR. KRESS: As Dana's. The difference in
25 the total doesn't make any difference substantially,

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1 and I agree with him on -- no, .15. I agree with him
2 it does revaporize as easy.

3 MR. BOYACK: Bernard?

4 MR. CLEMENT: .05 for gap releases, and
5 then .65 for releases, the usual.

6 MR. BOYACK: Dave?

7 MR. LEAVER: I'd say .05. I think the
8 cesium is, for the same reason as I said on noble
9 gases and iodine, I think it should be a bit higher
10 than what we used for the LEU. So I would say .3
11 would be a reasonable estimate there, and I'd say .3
12 for ex-vessel and .1 for late in-vessel. Actually, I
13 would, yes, I would say .15 for late in-vessel.

14 MR. BOYACK: Jim?

15 MR. GIESEKE: .05. Looking and comparing
16 with iodine again, and accounting for transport and
17 deposition differences, I get -- I'll round down; I
18 had a little bit more, but I'll round down to .30 and
19 make your averaging easier. I had .3 and .1.

20 MR. BOYACK: What about research for the
21 alkali metals?

22 MR. POWERS: What?

23 MR. BOYACK: Research.

24 MR. POWERS: Oh, research.

25 MR. BOYACK: This is for anybody who cares

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1 to hold forth.

2 MR. POWERS: Well, it seems to me that we
3 do have a couple of data points for the cesium
4 release, and there's still some work to sort out what
5 all the peculiarities of those data points. That
6 effort to sort that out is clearly needed to be done.
7 What you have, then two points make a straight line,
8 and Tom can build his model.

9 MR. KRESS: That's right. I can do it
10 like that.

11 MR. POWERS: And you don't have to worry
12 about scattering the data that way.

13 MR. KRESS: That's right.

14 MR. POWERS: When you just have two
15 points.

16 MR. BOYACK: This is VERCORS test?

17 MR. POWERS: Yes. Don't do any more
18 tests. Just sort out what you've got.

19 (Laughter.)

20 MR. KRESS: If we do a third test, I'm in
21 trouble.

22 MR. POWERS: Yes.

23 (Laughter.)

24 MR. KHATIB-RAHBAR: Coming back to the
25 VERCORS tests, the one that was not presented

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1 yesterday were RT 1 comparison to RT 2. This data you
2 have already presented in public. You have a paper
3 that was presented this exactly, this comparison.

4 MR. KRESS: It's RT 7.

5 MR. KHATIB-RAHBAR: RT 7 is the one you
6 have in place.

7 MR. KRESS: That's the one I need because
8 it's got the whole range of fission products in it.

9 MR. KHATIB-RAHBAR: It was already
10 presented, and I believe that your institute has
11 indicated to NRC that they will providing those data
12 to us.

13 MR. KRESS: Right, that's fine with me.

14 MR. KHATIB-RAHBAR: It's just a matter of
15 timing. So we will have access to that.

16 MR. CLEMENT: We hope it will be soon.

17 MR. KHATIB-RAHBAR: Soon, yes.

18 MR. BOYACK: Any other research needs for
19 any of the other phases? Any other research needs in
20 this area that have occurred to you?

21 MR. KRESS: There was this question of
22 validating the VERCORS data with the real fuel, but
23 after listening to all of it, I'm of the opinion that
24 it's applicable to what they're going to use and we
25 don't have to run this.

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1 MR. CLEMENT: The data will be exactly the
2 characteristics of the tests that has been used
3 because it's important.

4 MR. BOYACK: Okay, tellurium, right? Did
5 I hear somebody groan?

6 (Laughter.)

7 Was that you who sort of let that out?

8 MR. KRESS: Yes.

9 MR. BOYACK: Well, you get the first shot
10 at this one as it turns out.

11 (Laughter.)

12 I'm ready to stand up for a second.

13 (Whereupon, the foregoing matter went off
14 the record at 4:05 p.m. and went back on the record at
15 4:06 p.m.)

16 MR. KRESS: Tellurium was a tough one for
17 me because if I just look at its volatility, it
18 actually gets released as much as the halogens, but
19 then there's this business that it gets tied up with
20 the metallic elements in the fuel, and then it's not
21 as volatile as you think it is.

22 My opinion is that eventually this gets
23 tied up in metallics. It eventually gets released
24 anyway from that fuel that undergoes the damage part,
25 and I would put it exactly the same as the halogens,

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1 which is .3. I think we used .35 for the halogens
2 here.

3 The gap, I think it's probably the same as
4 -- I think it's zero in the gap. I think it's tied
5 somewhere else in the fuel.

6 MR. BOYACK: So you're referring back to
7 what, the halogens?

8 MR. KRESS: For the early in-vessel, I'm
9 referring back to now. I forgot when we were talking
10 about gap. I'm still going to use the zero gap
11 release, but for the halogens early in-vessels I would
12 still use the .35.

13 MR. BOYACK: Okay.

14 MR. KRESS: I think ex-vessel tellurium is
15 probably less releasable than the -- it's going to get
16 released ex-vessel, so I think the .15 is good there.

17 Late in-vessel, I think once it gets tied
18 up with on the surfaces, it's not going to get
19 released there. So I'd go down to .1. That's about
20 it, I guess.

21 MR. CLEMENT: Gap release zero, and then
22 for the early in-vessel, but, in fact, total release,
23 .7.

24 MR. BOYACK: Dave?

25 MR. LEAVER: Gap release zero. I guess

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1 early in-vessel, on LEU I think there certainly was a
2 strong feeling that tellurium was -- the 1465
3 tellurium estimate ought to be increased. There may
4 be some disagreement as to how much, but I think that
5 notion applies here, but I felt that the 30 percent
6 number that a number of people came up with was
7 uncomfortably high. So I was in the range of 10 to 15
8 percent. So I guess here I would say maybe the upper
9 end of that, .15.

10 MR. BOYACK: Okay.

11 MR. LEAVER: And I'll go with .4 ex-vessel
12 and .2 for late in-vessel.

13 MR. BOYACK: Jim?

14 MR. GIESEKE: I think it needs to be a
15 little bit there; .005 perhaps.

16 (Laughter.)

17 Put a little in there. What's wrong? You
18 don't want to put a little in there? How about .3,
19 .4, and then .2, which are basically the same numbers
20 as we used for the high-burnup.

21 MR. BOYACK: Dana?

22 MR. POWERS: Like Jim, I'd like to reflect
23 a little bit in the gap. What I put in is .005. Now
24 with the proviso that I don't understand tellurium at
25 all, here's somewhat how my thinking goes:

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1 We're going to use M5 cladding. That
2 means we've got no tin. To form tin, telluride should
3 be released in the tellurium. It's my impression that
4 the MOX fuel runs a little higher in oxygen potential
5 than conventional fuel because the plutonium nodules
6 have a less capacity to sustain and buffer oxygen
7 that's being liberated by the fission process.

8 So I suspect that this manifests itself in
9 seeing a little higher releases of molybdenum, a
10 little higher releases of ruthenium than what we're
11 used to. The same phenomenon ought to lead to a
12 little higher releases of tellurium than we're used
13 to.

14 On the other hand, we're going to have
15 higher concentrations of the reactive forms of
16 tellurium in the flow out of the core. To propose
17 that I have any capacity to doing this integral in my
18 head is to overstate my capacities by a lot.

19 MR. KRESS: My assumption there was just
20 aerosols plated up --

21 MR. POWERS: I just didn't want it to
22 reflect the potential of reacting with the upper
23 structures, and you might not see too much movement of
24 this material. So I took the in-vessel release, and
25 this is the release to the containment. You have a

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1 higher release fraction than the fuel itself. But to
2 the containment, I have .1.

3 MR. KRESS: You're really plating this
4 stuff out?

5 MR. POWERS: Yes, I plated out a lot of
6 it.

7 Okay, the ex-vessel release, I had .40.
8 As I said, tellurium is the one thing during melt-
9 concrete interactions I think I understand. I don't
10 understand in-vessel at all, but I understand ex-
11 vessel a lot. So I think it gets released, oh, fairly
12 extensively ex-vessel.

13 MR. KRESS: I'd like to change my .15 for
14 ex-vessel to .4. I agree with Dana on that and the
15 rest of the people. I don't know how I came up with
16 .15.

17 MR. POWERS: The reason I'm fairly
18 confident on this is that, when you put a melt on
19 concrete and let it chew away for a while, there's a
20 strong smell of rotten eggs, and that rotten eggs is
21 the gypsum used in the concrete, which is the calcium
22 sulfate being turned into hydrogen sulfide and
23 vaporized out. While sulfur chemistry and tellurium
24 chemistry are sufficiently close that you know they
25 should be volatile, we have done experiments

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1 explicitly looking at tellurium release because of a
2 bet Dick Vogle intemperately made with me on the
3 release of tellurium during melt-concrete
4 interactions. He said it couldn't be released. I,
5 having smelled the rotten eggs, knew that it would be
6 released. So we did the experiment, and we found
7 VANESSA matched exactly the release, and we were
8 getting a slow, steady, and what would be eventually
9 complete release. So I'm fairly confident on that.

10 Now the late in-vessel release, I get .2.
11 That's because I put a lot of tellurium out of fuel
12 and I put it on the piping system, and then I believe
13 that with reactors that have air filter containments
14 you'll get air in there and you will turn any
15 tellurides into TeO that's volatile and it will come
16 out.

17 MR. KRESS: Can you add up when you look
18 at where everything is?

19 MR. POWERS: I hope not.

20 MR. KRESS: Well, let's see, you've got --
21 how much have you got?

22 MR. POWERS: What Tom's asking is, have I
23 vaporized more off the piping system than what I had
24 to vaporize? And I don't think so. No, I released
25 essentially 60 percent from the fuel itself.

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1 MR. KRESS: And 40 percent ex-vessel?

2 MR. POWERS: Yes.

3 MR. KRESS: And that's 100 percent
4 failure?

5 MR. POWERS: Right, and I put 50 percent
6 of the core inventory on the piping system, and I
7 subsequently revaporized a fraction of that. I think
8 my mass balance is okay. Now the quality of the
9 numbers, of course, is not worth one spit.

10 MR. NOURBAKHS: All of the tellurium
11 comes from core-concrete interaction?

12 MR. POWERS: I get about 60 percent
13 release from the fuel during the in-vessel transient,
14 60 percent of the core inventory; 50 percent of the
15 core inventory, which is five-sixths of that released,
16 deposits on the piping system. Ten percent of the
17 core inventory actually comes in the containment.
18 Subsequently, in the late in-vessel phase, about 40
19 percent of that deposited material subsequently
20 revaporizes and comes into the containment.

21 MR. NOURBAKHS: So all of the releases
22 are overlaid water or --

23 MR. POWERS: Oh, I see what you're asking.
24 Was there any transient for that degraded fuel?

25 MR. NOURBAKHS: Yes.

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1 MR. POWERS: I really didn't --

2 MR. NOURBAKHS: You made that assumption
3 such a release of tellurium is there.

4 MR. POWERS: You're right, and I just
5 didn't correct these numbers to try to horse that out.
6 See, there's a big debate on what happens with the
7 rest of this residual fuel. If you let air come in
8 and interact with that residual fuel, and it's very
9 rapid, it gets so hot that it melts down very quickly,
10 and almost nothing gets released. It doesn't have
11 time to get released before it gets down.

12 If, on the other hand, you meter in the
13 air, it comes in very slowly, and the clad just melts
14 off, so that you expose fuel to the oxidizing
15 environment, then you get a lot off. I have tried to
16 model that with things like the MELCOR code. As I
17 assumed dictated the results. I mean, if I had real
18 good high flows in there, I could get the stuff to
19 melt, flow out, and never had a chance to release
20 anything. If I slowed down the flow a lot, it had a
21 chance to burn off the clad and release lots. It's
22 so-so good. I mean, your assumptions are dictating
23 things.

24 And that's why we had hoped that the
25 PHEBUS program would be able to do an air ingress

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1 accident, so that we could have some idea how the
2 competition between things is working. I mean, there
3 doesn't seem to be able way to do this in my capacity
4 to model these things. I just don't know.

5 MR. NOURBAKSH: You have the same case
6 for high-burnup?

7 MR. POWERS: It's almost exactly the same
8 case there, except you've got, with the high-burnup
9 conventional clads, as opposed to the M5 clads, you've
10 got a little thicker oxide coating, so you know it's
11 a slower oxidation process, unless you get a
12 breakaway.

13 I don't discount it. I mean, I think it
14 is one of the premier uncertainties in the late phase
15 of the accident. Is it consequential enough to
16 investigate? Well, it has more interest now that we
17 worry about spent fuel pools because the same
18 phenomenon happens there. If you melt down fast, your
19 releases are going to be low. If you melt down slow,
20 your releases are going to be high.

21 MR. BOYACK: Are there any comments on
22 research needs?

23 MR. LEAVER: A couple of questions.

24 MR. BOYACK: Sure.

25 MR. LEAVER: It sounds like what you were

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1 saying is that you don't believe that tellurium has
2 tin telluride, and therefore, it will tend to have a
3 higher deposition velocity than what you had -- you
4 had written that short paper yesterday where I think
5 you were thinking in terms of tin telluride, is that
6 correct?

7 MR. POWERS: Yes, well, my argument in the
8 paper goes that in the gas phase it's tin telluride,
9 and in the condensed phase it's silver telluride. It
10 can never react with the surface to form nickel
11 telluride.

12 Here you've got no tin telluride because
13 you're working with a niobium clad, and there is a
14 niobium telluride, but I don't think it's whompingly
15 stable the way tin telluride is. There are other
16 tellurides that could form. I mean I could be just
17 dead wrong on this. This could come out just the same
18 as we assumed for the high-burnup fuel with
19 conventional cladding.

20 You do have the silver indium cadmium
21 control rods, which can -- I mean cadmium telluride is
22 a real nice compound, real stable, but we just don't
23 see that much of it. We see more silver telluride,
24 but only in the condensed phase. We never seen it as
25 a gaseous species.

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1 So I come saying, well, it looks to me
2 like it is more likely to have deposition in the upper
3 internals and primary piping system for this case than
4 with conventional clads.

5 MR. LEAVER: Okay. Another question is,
6 how much do we know to say that the oxygen potential
7 is, in fact, higher for mixed oxide fuel than urial --

8 MR. POWERS: I really don't -- I'm
9 reasoning that we're going to have some evidence that
10 you get a little higher ruthenium movement. The only
11 way I can move ruthenium around in these MOX fuels is
12 if there is more oxygen available.

13 MR. LEAVER: Do we have such evidence for
14 higher ruthenium in oxygen --

15 MR. POWERS: Yes.

16 MR. LEAVER: What is that?

17 MR. POWERS: It's a VERCORS test.

18 MR. LEAVER: Okay. I wasn't aware of
19 that.

20 Do you know which test is that, Bernard?
21 The evidence for more ruthenium, higher ruthenium
22 release in MOX than in UO₂, do we have such evidence?
23 I wasn't aware of that.

24 MR. CLEMENT: I don't say so.

25 MR. LEAVER: Well, yes, we talked about

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1 this yesterday, and the 15 percent is like it's
2 different for these different numbers, and he wasn't
3 specific about any of these things. But, I mean,
4 that's an important point if that's true. Is there
5 higher ruthenium release for MOX than there is UO2.

6 MR. CLEMENT: It's too early to say that.

7 MR. LEAVER: Okay. I thought maybe you
8 were thinking that if we visualized the mixed oxide as
9 these 30, 40, 50 micron particles with a lot of local,
10 more concentrated fission events and, therefore,
11 fission products in the smaller volume, that you just
12 would tend to see higher oxygen potential, at least
13 for the fission products. That's not what you're
14 saying?

15 MR. POWERS: No, I mean my reasoning goes
16 this way: PuO2 has inherent desire to go to PuO2
17 minus X. We have never ever seen PuO2 plus X. I
18 guess I said that too strongly. To my knowledge,
19 there is one report in the literature of a 2 plus X
20 forming.

21 So that means you can't accommodate a lot
22 of interstitials in the plutonium where what happens
23 is the interstitials get balanced by the vacancies.
24 But you're forming oxygen when you fission things. I
25 mean you've got to put it someplace. So there's only

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1 one place for it to go, and that's over into the
2 oxygen lattice, the uranium lattice.

3 So if I take this thing up and I have a
4 lower yield of molybdenum in these systems anyway, I
5 no way to buffer it. So I reach my buffering
6 capacity. I have seen these higher releases of
7 ruthenium, and I said, well, if I'm moving ruthenium
8 around, I'm sure I'm moving tellurium around. That
9 was the rationing.

10 MR. NESBITT: In the discussion yesterday
11 we talked about ruthenium, but it was in the context
12 of the predicted quantities produced by the fission
13 yields. That was one of the elements that had a
14 significantly higher production in the MOX than LEU.
15 So there might be some confusion about what that was
16 about. That was just the amount that gets produced in
17 the fuel matrix. It does not have anything to do with
18 what happens to it once it gets produced in terms of
19 being released.

20 MR. POWERS: It's about a 15 to 20 percent
21 increase in production. In this world that's not very
22 significant.

23 MR. NESBITT: It was higher. It was like
24 74 percent higher.

25 MR. POWERS: A factor of two isn't going

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1 to make any difference to us. It increases the
2 activity a little bit, but that's all. Roughly a
3 factor of 74 percent.

4 MR. LEAVER: I would maybe make a comment.
5 There is, in one of Bernard's slides he presented
6 yesterday, a statement that in RT 7, which is a
7 reducing environment MOX test, right, that there was,
8 quote, "low, but significant release (less than 15
9 percent) of niobium, lanthanum, europian, ruthenium,
10 moly, cerian, neptunian.

11 What Bernard said yesterday was that these
12 six or seven elements all had different numbers, all
13 less than 15 percent, so to think of it as between 10
14 and 15 is really not right because it's different for
15 different elements. What he just said a moment ago is
16 they're still trying to, I guess, define those
17 numbers.

18 MR. CLEMENT: It is less than 15. It is
19 less than 15.

20 MR. LEAVER: It's less?

21 MR. CLEMENT: It's not more than 10. It's
22 less than 15. That's all.

23 MR. LEAVER: Ten to 15. That's right.
24 That's what I said. It is less than 15. That doesn't
25 mean it's more than 10.

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1 MR. CLEMENT: No.

2 MR. LEAVER: It just means it's less than
3 15.

4 MR. CLEMENT: Yes.

5 MR. LEAVER: Now ruthenium, as I recall,
6 there was from the fuel, well, some fairly significant
7 releases, perhaps I remember 6 and 7 percent.

8 MR. CLEMENT: We didn't give any figure
9 for this test for ruthenium.

10 MR. LEAVER: No, for the UO2.

11 MR. CLEMENT: Oh, for UO2, yes. Yes.

12 MR. LEAVER: Yes. So I just don't see any
13 data that would suggest that you get higher ruthenium
14 releases -- maybe you do, but I don't see any data
15 that suggests higher ruthenium releases from MOX fuel.

16 MR. CLEMENT: At least from this data
17 there is no change in the order of magnitude. Okay?

18 MR. LEAVER: Yes, okay.

19 MR. CLEMENT: For these data.

20 MR. BOYACK: Okay, on tellurium now, what
21 we're looking for I think is more complete exposition
22 on data needs in your letters, but is there anything
23 else that you want to flag here for the tellurium
24 group in the way of data needs?

25 MR. POWERS: Well, for the tellurium, we

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1 just need to know what it's doing. The problem is
2 it's virtually impossible to measure it.

3 MR. CLEMENT: Still on tellurium, I think
4 it's important to assess, not forget to assess for gap
5 releases and for other points, the effect of the
6 absence of tin, to look, to confirm or not the
7 hypothesis because this may change things.

8 MR. POWERS: It may be that something else
9 steps in and acts in the same way, in which case if
10 you get release, you'll get it out.

11 MR. KRESS: I know that for regular LEU
12 fuel, we took some tests, just took the clad out.
13 There wasn't any clad there. But tellurium got
14 released just at the same rate, in fact a little
15 faster than the iodine. So with LEU fuel, if you
16 don't have the clad there, why, you get it released.

17 I'm assuming the M5 clad would act like,
18 for tellurium, like there wasn't any clad there, but
19 Dana may be right; there may be other things in the
20 fuel that could latch onto it for MOX, as opposed to
21 LEU.

22 MR. GIESEKE: So it sounds like there may
23 be a different, significant difference between MOX and
24 the other, the M5 clad and the other cladding for
25 tellurium. So it warrants experiments to check

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1 into --

2 MR. KRESS: It warrants experiments with
3 M5 clad in MOX fuel.

4 MR. GIESEKE: Yes.

5 MR. BOYACK: Okay, tomorrow we have four
6 groups to take care of, and there was some discussion
7 at lunchtime with Jason that it looks like we can go
8 through these reasonably well. We've had good
9 progress today in the afternoon on this.

10 MR. LEAVER: I don't know. I mean, low
11 volatiles are going to be tough. At least up to this
12 point we've thought of these elements as volatile,
13 which they are, but now they're not.

14 It may take more than an hour on each of
15 them?

16 MR. KRESS: It may take six months. I
17 don't know how --

18 MR. LEAVER: The difference may be that
19 there can be no answers.

20 MR. KRESS: Yes, I think that's the tough
21 part.

22 MR. CLEMENT: It depends how we agree to
23 take into account the uncertainties that are much
24 higher on these groups, because anyway it will be more
25 difficult to have a precise and definite value with

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1 actual --

2 MR. BOYACK: I propose to bring those up
3 tomorrow in any case.

4 MR. LEAVER: The problem is that for
5 something like say iodine or cesium, you can to some
6 degree take uncertainty into account, and though not
7 all of us did, you can increment it, and in doing so
8 you may increase the amount by 10 percent or 20
9 percent, or something like that.

10 For the low volatiles, you could take
11 uncertainty into account and increase the release by
12 a factor of 100 or 50, and that can be, begins to be
13 a very significant effect on dose and really gives you
14 a source term that's just greatly different than what
15 people have been using for UO2 fuel, and I'm not sure
16 that necessarily solves any problems or is what we
17 want to do. We can say things are uncertain, but for
18 the low volatiles, now you're talking orders of
19 magnitude instead of 10 or 20 percent.

20 MR. KRESS: And I think RT 7 sheds some
21 light on that.

22 MR. LEAVER: If we had --

23 MR. KRESS: If we have the results for the
24 low volatiles.

25 MR. LEAVER: Right.

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1 MR. KRESS: It would be useful --

2 MR. LEAVER: Richard is not here. He said
3 something.

4 MR. KRESS: He said those will probably --
5 he said there are negotiations are underway, and his
6 understanding was that that RT 7 data will be released
7 soon to NRC. He didn't say when, but they will. They
8 are talking about getting it, and they will probably
9 get it.

10 MR. LEAVER: I think it was going to be
11 soon.

12 MR. KRESS: Yes, it sounded like probably
13 soon, but they didn't give a time. So that's going to
14 be available, but it won't be available in time for
15 us.

16 MR. CLEMENT: I can confirm that
17 discussions are underway. We don't know when it will
18 be finalized.

19 MR. KRESS: We can do a lot better when we
20 get that data, but until we get it, well, I think
21 we're kind of in the dark on these.

22 MR. BOYACK: Tomorrow the way the day's
23 going to unfold is, evidently, they have a real
24 challenge scheduling rooms here. So there's a group
25 that's coming in here at 11:45 tomorrow. They'll be

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1 here until 1:15. It's a Toastmasters' group, so
2 you're welcome to stay and participate in giving
3 talks, if you wish.

4 (Laughter.)

5 But there will be that.

6 I'm going to take 45 minutes earlier. I
7 have a meeting to go to, and Jason Schaperow will take
8 over the discussion here at 11:00.

9 MR. LEAVER: Do we need to go two-thirds
10 of a day tomorrow?

11 MR. BOYACK: Well, that was where I was
12 starting to ask some questions. It's not clear from
13 your answer where we'll end up tomorrow.

14 The thing that Jason had said, which was
15 where I was starting to go, was that it would be nice
16 of there were any time left tomorrow where the panel
17 towards the end of the day could take a little bit of
18 time and say, to reflect a little bit about the
19 meetings thus far, what we've learned about PWR, high-
20 burnup fuel, and BWR, and if there were any set of
21 bottom-line items that sort of come to mind through
22 this learning process, this learning/doing process, to
23 get those down, which would be made available to most
24 thus far to ponder and put in the final report.

25 MR. LEAVER: Bottom-line, what does that

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1 mean?

2 MR. BOYACK: Summary, conclusions, things
3 that have been learned. Just what has been learned by
4 going through this process in the source term
5 applicability on the three areas?

6 So I think the answer is that we'll
7 probably use all the time available. You're going to
8 leave at 1:00, I believe, was it?

9 MR. LEAVER: I think if I need to get
10 there an hour and a half ahead, I probably need to
11 leave about 2:00, maybe 2:30.

12 MR. BOYACK: Okay, that would be fine. I
13 think we'll be done by 2:30.

14 So, with that, any other questions or
15 comments? Then we'll turn off the tape machine.

16 (Whereupon, the foregoing matter went off
17 the record at 4:36 p.m., to reconvene the following
18 day, Thursday, February 21, 2002.)

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