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1 UNITED STATES OF AMERICA

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3 NUCLEAR REGULATORY COMMISSION

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5 SOURCE TERM APPLICABILITY PANEL

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7 WEDNESDAY

8 DECEMBER 12, 2001

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10 ROCKVILLE, MARYLAND

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12 The Panel met at the Nuclear Regulatory
13 Commission, Two White Flint North, T2B1, 11S45
14 Rockville Pike, at 8:30 a.m., Brent Boyack
15 facilitating.

16
17 PANEL MEMBERS PRESENT:

18 DANA POWERS, ACRS

19 THOMAS KRESS, ACRS

20 BRENT BOYACK, Facilitator

21 DAVID LEAVER, EPRI

22 JAMES GIESEKE, Consultant

23 BERNARD CLEMENT, CEA France

24 JEAN-MICHEL EVRARD, CEA France

25

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1 ALSO PRESENT:

2 JASON SCHAPEROW

3 STEVE LaVIE

4 HOSSEIN NOURBAKHSH

5 * indicates unintelligible word(s) due to
6 accent.

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

(8:34 a.m.)

1
2
3 MR. BOYACK: We have the panel here, so we
4 might as well begin. A full day of activities today
5 requires thinking, concentration, attention, skill,
6 background, experience.

7 Let me just quickly review what we are
8 going to do using the fantastic diagram here. We will
9 be projecting up on the screen here momentarily, I
10 guess, information. We have a number of tables to
11 fill in, both by way of numerical values, if we are
12 able to, and also by way of rationale.

13 So, as we go through, I proposed yesterday
14 that for each numerical entry in the table that I go
15 ahead and ask if, in the case of the source terms, if
16 the given source terms are applicable. We also have
17 durations that we have to handle. That is the one
18 exception. If the answer is yes, then we will go
19 ahead and record the value and also the reason why.

20 Anyway, if the answer is not yet, as we
21 discussed yesterday, then we will go ahead and talk
22 about whether we are able to specify a new value. If
23 yes, we will record the rationale for that. If no,
24 then we will talk about why, and we will get that
25 down, and also at that point try to go ahead and get

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1 some information down about what might be done in the
2 way of research.

3 So probably what we are going to do now is
4 take our first break.

5 (Laughter.)

6 You know, I tested this even before you
7 came in (referring to electronic equipment).

8 (Whereupon, the foregoing matter went off
9 the record at 8:37 a.m. and went back on the record at
10 8:39 a.m.)

11 MR. BOYACK: I am going to have to work on
12 this a little bit, but I am going to ask Jason to help
13 me.

14 For just a moment, what I would like to do
15 is the following: Let's go ahead, the first thing we
16 had to do is work on the duration of the phases: gap
17 release, early in-vessel, ex-vessel, and late in-
18 vessel for PWR releases in containment.

19 So, if Jason will just lead you through
20 questions about the timing on those four areas, I will
21 see if I can recover the capability here (referring to
22 electronic equipment). I will just unplug everything
23 and start from scratch, because that worked this
24 morning when I came in.

25 MR. SCHAPEROW: All right, let's start

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1 with the duration of the gap release. The duration of
2 the gap release, as we talked about, is, at least as
3 I suggested and NUREG 1465 says, it is the duration
4 from basically the beginning of the accident up
5 through the point of significant release of fission
6 products from the pellet.

7 Right here it says we've got half-an-hour.
8 I guess I would like to see if anybody would like to
9 suggest that that value is sensible or if anybody
10 disagrees with that value.

11 MR. POWERS: It seems to me that you have
12 the choice of either collapsing that value down or
13 increasing the release fractions of the halogens and
14 the alkaline metals. That depends a lot on how you
15 are going to use the gap release. When it was
16 originally conceived, it was, as I said, a "no, never
17 mind." Now it has assumed a larger significance.

18 It seems to me that I would tend to say,
19 let's make sure the gap release is that release that
20 will happen in a fuel-handling accident, because that
21 is where it gets used.

22 MR. LEAVER: But isn't there a fundamental
23 difference between the release that you get in a fuel-
24 handling accident and the first half-an-hour or so of
25 a severe accident? I mean those are two different

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1 things, if they're going on. The fuel-handling
2 accident, the fuel is cold and what comes out is what
3 was already there; whereas, in the severe accidents,
4 it's that maybe and some.

5 MR. POWERS: Don't argue with your bet.

6 MR. LEAVER: So I'm wondering, in the case
7 of, if we are talking about a severe accident here,
8 which certainly that is one thing we are talking about
9 for sure, do we even need to distinguish between this
10 first half-hour and the next hour-and-a-half? What's
11 the point? I mean, I can tell you from a
12 calculational standpoint it doesn't make much
13 difference. The main thing is how much comes out and
14 over what period of time.

15 Now certainly you need to define a gap for
16 the other non-LOCA accidents, like the main steamline
17 break and fuel-handling accident and those kinds of
18 things, but I am not sure that this gap release,
19 thinking in terms of severe accidents, to me that is
20 a different thing.

21 MR. POWERS: But that's what I said.
22 Let's not think about severe accidents because, when
23 we did, we gave that short shrift. Now we find that
24 it does get used, and it gets used in things like
25 fuel-handling. So why don't we tailor the gap release

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1 to reflect what happens in a fuel-handling accident
2 rather than tailoring it for a severe accident, where
3 it is a "no, never mind"?

4 MR. SCHAPEROW: I guess I would like to
5 point out that the original expert elicitation, or
6 remind people - you folks did it -- that there was a
7 never a question on gap release. The first question
8 was, what's the release from the core before lower
9 head failure? At least, basically, it is released
10 from the fuel into the --

11 MR. LEAVER: Are you talking about 1150
12 now?

13 MR. SCHAPEROW: Yes, that is what I am
14 looking at here. The distributions are something
15 called F-core, which is a release from the fuel into
16 the RCS. I think that maybe the best way to proceed
17 or the path of least resistance may be just to try to
18 repeat this kind of a thing.

19 I kind of agree with Dave that we could
20 tackle the gap one outside of this meeting.

21 MR. CLEMENT: I understand from
22 yesterday's discussion from the presentation and then
23 the questions that this question of gap release, you
24 say, for what we call in France * this accident up to
25 * was maybe not so clear for high burnup fuel.

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1 I heard also that experiments are planned
2 in the future to get the best values for high burnup
3 fuel.

4 I think it is not so important for
5 accidents, but if you have to put a value that is
6 corresponding to this gap release more accurate than
7 this one are probably not so bad. I mean, we know
8 that experimental programs will be done. Maybe it is
9 best to answer the questions by then. If people who
10 are in charge of these problems, okay, that's not our
11 severe accident system, need more accuracy, then we
12 have to design more accurate experiments other than
13 the typical ones. So I don't know.

14 But I understand, too, from yesterday that
15 there are still incentives for high burnup, but I do
16 agree that this is not so important at the end of the
17 day on the final release for our severe accident
18 system. I mean, it is actually now what you want to
19 do with that.

20 MR. SCHAPEROW: Go ahead, Hossein.

21 MR. NOURBAKHSH: Just one comment: These
22 values are core averaged. When we are talking about
23 high burnoff, basically, all we need -- previously,
24 high was conceived like 40; now we want to extend it
25 to just like 50, roughly. If high burnup is 75, the

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1 core average would be like 50.

2 If you look at, if you don't mind, I will
3 show you these two, which are basically some
4 calculations in 6703, based on FRAPCON. FRAPCON only
5 gives you the fission factor. This is high burnoff.
6 This is as a function of *. This is core average
7 release, if you average it over the core.

8 So what we are using right now in 1465 is
9 5 percent, and the authors of this NUREG are actually
10 saying these values are still based on ANSI standards.
11 I mean one of them is 200 percent higher, 11.4. So
12 these are relatively *.

13 So these are what we use, and they are not
14 being used for fuel-handling. For fuel-handling, it
15 would not be based on their peak rod. These are the
16 type of values we are looking.

17 If you plot the same thing based on high
18 burnup, this is what we have. This is now peak rod
19 release based on the burnoff. So these values that
20 fuel-handling regulations is struggling with, they
21 want it to extend to 75, and they don't know most of
22 the data on here.

23 So fuel-handling actually does not use
24 1465, let's say, those fractions. They are looking at
25 high burnoff individual rods.

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1 MR. KRESS: They are assuming peak
2 rod because that is the one that is going to have the
3 accidents.

4 MR. NOURBAKHS: Peak rods, exactly, and
5 we are assuming that the peak rod is going to fail.
6 When you are averaging these, these values are only
7 1/10th of the core maximum has that high values. So
8 you are not going to provide that much conservatism if
9 we assume the same 5 percent that we have before on
10 the core average.

11 The only thing is that we don't have data
12 that will extend this. The question is whether these
13 values could be extrapolated to 75. Right here, these
14 values should be extended to -- basically, this is up
15 to 40. Now we can move to 75 peak rod temperature.

16 We don't have data on more than 62 on
17 this. These are calculations, by the way, of the
18 FRAPCON, but they are usually higher than fission
19 gas --

20 MR. KRESS: Is this the gap inventory that
21 is shown there?

22 MR. NOURBAKHS: Yes, what is in the gap.

23 MR. KRESS: That's in the gap?

24 MR. NOURBAKHS: We are assuming it is
25 released.

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1 MR. KRESS: And you have that? That is a
2 calculation using FRAPCON?

3 MR. NOURBAKSHSH: FRAPCON, exactly, except
4 that FRAPCON, from what I understand, reading that,
5 will only have fission model.

6 MR. KRESS: Sure.

7 MR. NOURBAKSHSH: So in order to get iodine
8 and cesium, they did their ANSI. I mean it is ANS-
9 540, and then they used that for scaling, applied that
10 to scaling with this.

11 MR. KRESS: That's reasonable.

12 MR. NOURBAKSHSH: Then the argument is
13 whether the diffusion of iodine and cesium is much
14 higher than 5.4, whether that should be -- if we
15 assume that the fission is similar to normal gases,
16 this would come down.

17 MR. KRESS: So the only thing you are
18 correcting is the birth rate of the decay then?

19 MR. NOURBAKSHSH: Exactly.

20 MR. KRESS: I would have been tempted to
21 look at a distribution of burnups. You say one-third
22 is a high burnout, and one-third is somewhere else?

23 MR. NOURBAKSHSH: It is 20/40/75, if I
24 remember correctly.

25 MR. KRESS: Okay. I would add up the

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1 total inventory of all those.

2 MR. LEAVER: Do you mean like a burnup
3 average, a mass average or a --

4 MR. KRESS: I would give it a mass average
5 inventory.

6 MR. LEAVER: Yes.

7 MR. KRESS: That would give me my release
8 facts.

9 MR. NOURBAKHS: I think that is what they
10 are.

11 MR. LEAVER: I think Hossein is saying he
12 thinks it is roughly --

13 MR. KRESS: That is what I would use.

14 MR. NOURBAKHS: What they did, the
15 FRAPCON gives you the inventory, too.

16 MR. KRESS: Okay. So this is average over
17 the whole core?

18 MR. NOURBAKHS: Average over the core.

19 MR. KRESS: Okay, that is what I would use
20 then for the fractional time; for the time duration,
21 that is something else. I would have guessed that
22 would have been from the time the first fuel fails to
23 the time the last one fails.

24 MR. NOURBAKHS: And that is something I
25 mentioned about that last time we spoke of the

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1 calculation, I believe 10 years ago. When I look at
2 look at France, I mentioned 10 seconds, but I really
3 meant 10 minutes. I went back and checked it. It is
4 between 6 -- depends on the sequence. It is a
5 variable. But the whole time, for the large break
6 LOCA-type accident, you really don't have a
7 temperature homogenization by natural circulation
8 basically. So the old calculations still may be
9 valid. I mean the new modeling is not going to impact
10 that much between maximum and the minimal.

11 For an AG sequence, which is typical of a
12 terminated large break LOCA accident, it was not 27
13 minutes.

14 MR. KRESS: So the half-an-hour is not
15 that far off?

16 MR. NOURBAKHS: Unless we are asking
17 whether in that period of time the burnup is going to
18 impact that.

19 MR. KRESS: Well, you know, it doesn't
20 matter. The only thing it is going to add is the
21 amount of heat, and I don't think it is going to add
22 that much.

23 MR. NOURBAKHS: It is not that much.

24 MR. KRESS: So it is the half-an-hour is
25 probably still pretty valid. It looks like, in my

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1 mind, right now, that Ralph Meyer was probably right;
2 there is basically no change in the gap release.

3 MR. NOURBAKHSH: As for that application.

4 MR. POWERS: I absolutely do not accept
5 that. I don't even accept this argument.

6 MR. KRESS: Okay.

7 MR. POWERS: Either you are going to say
8 here is the effect of burnup and then allow people to
9 use it as they will for the particular core they have
10 or you have to specify one of these tables for every
11 core that exists, because you're going to go on
12 averaging, some magic averaging, over the burnups. It
13 is going to change for every core.

14 MR. LEAVER: But if you put new fuel in
15 every two years, and you leave the fuel in for, what,
16 three, maybe four cycles -- I am not sure what the
17 fuel management scheme is -- you know roughly, if the
18 peak burnup is 75,000, that the average is certainly
19 not 75,000. It's probably something more like, what,
20 50? I mean, maybe it's 55. Maybe it's 45. I don't
21 know, but is it really so different from one core to
22 another that we can't --

23 MR. POWERS: He says that he has to
24 average. There's some averaging scheme. Why not let
25 him do it, as opposed to Tom doing it, for the core

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1 that he has?

2 MR. LEAVER: Yes, we were going to, I
3 guess you guys were going to try to get some
4 information on average burnups in the next day or so?
5 We discussed that yesterday. I don't know if
6 anything's --

7 MR. SCHAPEROW: Yes, I guess I would like
8 to take a fallback position on what I had in my
9 slides, which is the NRC will take a look at the gap
10 release fraction for high burnup fuel within the next
11 year, based on the Holden tests. I think this is a
12 point of contention.

13 Maybe we can come back to it in a little
14 while. I would like to move up to the in-vessel. I
15 think that may be a bit more trackable.

16 MR. POWERS: Can you agree on a definition
17 between the two?

18 MR. SCHAPEROW: I think the definition --
19 I would like to repeat, I would like to read one
20 sentence out of 1465. Maybe the definition no longer
21 applies.

22 "The gap activity phase ends" -- oh, this
23 is on page 8. Let me pass this out. This may be used
24 for reference today. I have plenty, if there's not
25 enough copies.

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1 If you'd like, on page 8, in the first
2 full paragraph, the paragraph on page 8 that starts,
3 "The gap activity release phase," if you go down a few
4 sentences, it says, "the gap activity phase ends when
5 the fuel pellet bulk temperature has been raised
6 sufficiently that significant amounts of fission parts
7 can no longer be maintained in the fuel."

8 MR. POWERS: What does that mean? That's
9 useful.

10 (Laughter.)

11 MR. SCHAPEROW: That's the definition.

12 MR. LEAVER: Does that nail it down for
13 you?

14 (Laughter.)

15 MR. LEAVER: The problem with this concept
16 of gap activity is it is mixing apples and oranges.
17 It is sort of implying that this definition of gap
18 activity is the right thing to do for fuel-handling
19 accidents, but it is also saying it is part of a
20 severe accident, and they are really two different
21 things.

22 I am not sure that the concept of a
23 duration for this portion, early portion, of the
24 release, as part of a severe accident really even is
25 necessary.

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1 MR. SCHAPEROW: Well, actually, it goes on
2 further to say that, "A review of STT Source Term Code
3 Package results indicates that significant fission
4 product releases from the fuel will commence no
5 earlier than 30 minutes for PWR's." That is a very
6 significant volume of work that was done by Battelle.
7 It is six volumes or so.

8 MR. BOYACK: I would like to offer at
9 least the following comments:

10 The first of them is we are engaged here
11 in extending the applicability of NUREG 1465, and 1465
12 shows a gap release. I don't understand the
13 underpinnings of it, but at least it is there. It
14 says that there is a gap release. The definition that
15 was just read on page 8 seems to me, if not to be
16 precise, at least it's workable for a panel like this,
17 if they choose to say that significant is
18 approximately "X" percent of the releasable inventory,
19 and then you use your expertise to say approximately
20 when that occurs.

21 So I offer that not out of a great
22 understanding, but as a possibility that, one, we
23 ought to hold NUREG 1465 approach. Now if we want to
24 defer it, as the NRC suggests, Jason, that's fine with
25 me, and you go on to the next one. But it does appear

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1 to me that we ought not to spend too much time trying
2 to redefine all of the 1465 things. The objective was
3 not to go ahead and essentially go back pre-1465 and
4 redo it.

5 MR. KRESS: A problem with that is this
6 half-an-hour because you calculate how long it takes
7 the fuel to get up to the temperature of the first
8 burst, and then you calculate how long it takes the
9 fuel to get up and light off the zirc oxidation.

10 MR. LEAVER: Right, the zirc oxidation.

11 MR. KRESS: That is the half-hour.

12 MR. LEAVER: Right.

13 MR. KRESS: And that is where we come
14 from. That is no longer applicable now because, in
15 the case of the low burnup fuel, the fission product
16 released doesn't even start until you lit off the
17 oxidation. Now it is starting much lower because of
18 the burnup effect. You are now releasing fission
19 products during that heatup time. You no longer have
20 this luxury of just saying, we'll go to the point
21 where the oxidation ramp sets off. We just don't have
22 that anymore.

23 There is no way to define this. Where is
24 the temperature where significant fission products
25 can't be held anymore? You can't define it.

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1 MR. LEAVER: What you're saying is another
2 reason perhaps for not trying to distinguish between
3 this early period and then the latter portion of the
4 early in-vessel release, but just consider it starting
5 earlier and then figure out what the magnitude is for
6 the high burnup fuel and have it be some kind of
7 uniform release over that period.

8 MR. SCHAPEROW: For the high burnup, no
9 distinguishable path --

10 MR. LEAVER: I think that is what I heard
11 Tom say, and that kind of makes some sense.

12 MR. BOYACK: Now I've got to know how to
13 spell "distinguishable".

14 MR. KRESS: Pretty good.

15 MR. BOYACK: All I am doing here is just
16 testing the process a little bit here. Some of this
17 stuff we will wipe out and others we will keep, when
18 you get to a point of a decision about how to proceed.

19 It seems to me the first question you have
20 to answer is, are you going to go ahead with the gap
21 release phase?

22 MR. LEAVER: I am not sure that is the
23 first question.

24 MR. KRESS: I still like this duration
25 being given by the time between the first fuel failure

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1 to the last one.

2 MR. LEAVER: Do you mean the first clad
3 failure to the last clad failure?

4 MR. POWERS: That could be days.

5 MR. LEAVER: Yes, that could be forever.
6 I mean, a lot of clad may never fail. At least some
7 of it may not. You may have releases from the center
8 of the core.

9 MR. KRESS: Every piece of fuel in that
10 core gets up to the clad failure temperature very
11 quickly, according to NUREG 1465. Plant failure
12 temperature is what, 1200?

13 MR. POWERS: Yes.

14 MR. KRESS: It all gets up there pretty
15 fast.

16 MR. POWERS: I don't think so. I think
17 the stuff that is out around the core barrel has a
18 hard time getting to that temperature.

19 MR. KRESS: Might as well forget about it
20 then.

21 MR. POWERS: It still would be a
22 substantial period of time to get for the second one.
23 I mean it is not days. It is an hour.

24 MR. KRESS: Well, I have never seen the
25 calculation.

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1 MR. LEAVER: Or you want to say 80 percent
2 of the clad maybe or something like that.

3 MR. POWERS: If you say 80 percent, then
4 you are down to a half-hour.

5 MR. LEAVER: If you want to stick with
6 this half-hour, how much, what fraction of the total
7 inventory is noble gases that gets released in this
8 half-hour?

9 MR. KRESS: That is something we don't
10 know, the calculation, the FRAPCON calculations for
11 the average. I don't know; it is probably pretty close
12 to it.

13 MR. LEAVER: Right now 1465 says 5
14 percent. So, presumably, there was some margin in
15 that. So what you are saying is that, because of the
16 high burnup, if you look at the average, which we
17 still don't know but we think it is in the
18 neighborhood of 50,000, given the fact that there was
19 some margin in the 5 percent, we probably wouldn't
20 change the 5 percent.

21 MR. KRESS: That would be my guess.

22 MR. POWERS: That's his vote.

23 MR. LEAVER: What?

24 MR. POWERS: That's his vote.

25 MR. LEAVER: That's his vote.

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1 MR. POWERS: When I look at the Japanese
2 experiments on reactivity insertion, where they have
3 tried to measure the amount of fission gas that gets
4 released, I see numbers up around 20 percent. I
5 acknowledge that those experiments involve putting a
6 pulse of heat in, but it is not clear to me that that
7 pulse of heat is all that different than the more
8 tracked amount of heat that we are going to put in.

9 So I come up with much higher noble gas
10 numbers. In fact, I would argue the gap release
11 fraction would be more like 15 percent.

12 MR. KRESS: I suspect the reactivity
13 insertion accidents doing damage to the bulk of the
14 fuel --

15 MR. POWERS: I wouldn't argue that a bit,
16 but I don't see how I can ignore them when I do
17 reactivity insertion accidents with low burnup fuel
18 and I get 5 percent --

19 MR. LEAVER: You get what?

20 MR. POWERS: Five percent noble gas
21 release. Then I go to a high burnup and I get 20
22 percent. Gee, maybe I'll just scale those suckers.

23 MR. KRESS: That is a little tougher to
24 explain, except it is probably easier to damage the
25 fuel at a higher burn level.

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1 MR. POWERS: I don't know whether it is
2 easier to damage fuel; it is that there is more damage
3 there and you are adding to it.

4 MR. LaVIE: Steve LaVie.

5 The reactivity insertion accident, you
6 have got to recognize how that is used in regulatory
7 space. In that particular accident we assume the gap
8 activity from those pins that have exceeded the clad
9 burst temperature, which is 180 cal per gram is burn,
10 it's assumed, will have released its gap contents.

11 We then look to see whether or not any of
12 the pellet reached the heating melt point, and then
13 that is added. I believe the Japanese data is looking
14 at the total. So in our regulatory space we have
15 already taken care of that total, because if we do get
16 to melt temperature, it is added to the gap release.

17 MR. POWERS: That doesn't have anything to
18 do with the question. The question is --

19 MR. KRESS: Well, it gives you an
20 explanation for why the extra might be there.

21 MR. LaVIE: Why the Japanese have 20 and
22 we are only looking at 5 here. This is the only gap.

23 MR. KRESS: That may be an explanation for
24 why that extra --

25 MR. POWERS: It's not an explanation of

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1 the issue.

2 MR. KRESS: No, I guess it's not, but a
3 fuel explanation.

4 MR. BOYACK: Let me just explain that a
5 few moments ago my comment to Jason was that the NRC's
6 going to have to decide what they want on this. The
7 panel can discuss it for a period of time, but it has
8 been my sort of position that there are certain parts
9 of the problem that the NRC owns by way of specifying
10 what they are after.

11 So Jason listened a little bit more to the
12 argument and departed. It is my speculation --

13 MR. KRESS: Did he have a disgusted look
14 on his face?

15 MR. BOYACK: -- no -- that he has gone
16 upstairs to try to pull down Tinkler or somebody else
17 to get a little bit of guidance on this, because there
18 are some areas where I am just not sure whether we are
19 going to be able to work through it by discussion,
20 because in part it is the definition of the end use
21 that is going on.

22 You notice the silence here. I had
23 claimed you had maybe gone up to check with somebody,
24 but --

25 MR. SCHAPEROW: No, I went to get these,

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1 though.

2 MR. LEAVER: I guess I am interested,
3 Dana, in what you said about reactivity insertion
4 accidents. I don't know what data it is that shows 4
5 or 5 percent for low burnup and 20 percent for high
6 burnup, but that is interesting. I mean, do you know
7 more about that? If you would like to share it with
8 us?

9 MR. POWERS: The problem is, when I bring
10 it up, people say, oh, well, that's reactivity
11 accidents and go off into never-never-land about
12 reactivity accidents and that they are different from
13 gap release.

14 MR. LEAVER: Well, they are different.

15 MR. POWERS: In that case my response
16 is measure the thing.

17 Well, you can't measure it. There is no
18 way to measure gap release. So you have got to derive
19 either from code calculations or inferentially.

20 The problem is, I think, that the existing
21 codes are just terribly deficient in how they treat
22 gaps. I mean the ones that are routinely used. So
23 any calculation that comes out, I just blow off.

24 MR. KRESS: And I think you are right that
25 this is a kind of measure of what is available to get

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1 out with the gap, even though it is a different kind
2 of accident.

3 MR. POWERS: So, I say, okay, well, maybe
4 I don't take the whole thing, because I don't think
5 the NRC wants this source term to smack of being
6 bounding for every conceivable situation. They want
7 some kind of a mish-mash in there.

8 I mean, it is reasonably valued -- you
9 know, it is a word I just hate, "reasonably," because
10 nobody ever tells me what their reason is, but I
11 think, like everybody else, I have kind of sense for
12 it. It shows the noble gas has to go up.

13 They asked me about the more condensable
14 species, and I said, look, the condensed species are
15 released from the gap because they are vapors. So
16 what you really need to know is what the temperatures
17 are and the vapor volumes. Those didn't change. That
18 vapor volume is dominated by the fill gas. So I will
19 come back and say, well, the gap release fractions for
20 cesium and iodine are the same as before.

21 MR. BOYACK: Let me ask a couple of
22 questions. I am going to primarily ask the NRC.

23 I guess Jason actually went upstairs to
24 garner a few more pieces of documentation. Do you
25 want to tell us what that is about first?

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1 MR. SCHAPEROW: Yes, I would. I went up
2 and pulled the work done by Battelle with the Source
3 Term Code Package. It is a series of six volumes.
4 Jim's name is No. 2 on each volume, I think, here.

5 MR. KRESS: You've got all six volumes?

6 MR. SCHAPEROW: Oh, yes. I haven't read
7 every one of them, but I have skimmed them. The idea
8 of a start time for the events of release or an end
9 time for the gap release of this certain -- you get it
10 to this certain temperature and you start releasing
11 significant amounts of fission products.

12 The sequences in here, I am just looking
13 at the PWR. The first two sequences I come across are
14 seal LOCAs, reactor coolant pump seal LOCAs. That
15 implies it takes a while to empty out the RCS to start
16 heating the fuel up.

17 I think the assumption that some of us are
18 going under is that maybe a 2-inch break or maybe 5-
19 inch break, a bigger break where the thing empties out
20 pretty quickly, and then you start getting heat up and
21 melting, heat up and degradation.

22 So I am almost wondering if we should be
23 tackling the timing issue because, again, as I look at
24 the expert elicitation we did back in the late
25 eighties, I don't see the timing issue in here either

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1 really. That is another thing that was done kind of
2 later when we were putting together NUREG 1465. I
3 don't know if you folks want to tackle that.

4 MR. LEAVER: The timing issue?

5 MR. SCHAPEROW: Yes. What was elicited
6 here was the release fractions, the release fractions
7 and the deposition amounts in the RCS.

8 MR. LEAVER: I think we've got to say
9 something about the duration of the release. It is
10 fundamental --

11 MR. SCHAPEROW: All right.

12 MR. LEAVER: -- to the design basis for
13 the systems that respond to the accident.

14 MR. SCHAPEROW: I think what we need to do
15 is we need to list what sequences we are talking
16 about, what is being considered. Because I think if
17 you go to the large-break LOCA, you will get a very
18 fast timing and the gap release will be
19 indistinguishable from the --

20 MR. LEAVER: Well, we are talking about
21 low-pressure sequences --

22 MR. SCHAPEROW: We are talking about other
23 sequences --

24 MR. LEAVER: -- but we are also bearing in
25 mind other sequences that may take longer. So we

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1 don't miss something that is important. We talked
2 about that yesterday. I don't think that has changed.

3 MR. SCHAPEROW: I am just wondering if it
4 will be useful to list the sequences that we are
5 considering.

6 MR. BOYACK: We can certainly do that easy
7 enough just by an overhead transparency.

8 MR. SCHAPEROW: Right.

9 MR. KRESS: NUREG 1150 doesn't go to the
10 sequence.

11 MR. SCHAPEROW: Pardon?

12 MR. KRESS: NUREG 1150 doesn't go to the
13 sequence.

14 MR. SCHAPEROW: No, it says high oxidation
15 and low oxidation.

16 MR. KRESS: It is just high pressure, low
17 pressure, high oxidation, low oxidation.

18 MR. SCHAPEROW: That is true, but what
19 David is suggesting is that we should be tackling the
20 timing issue.

21 MR. LEAVER: Here's a list of sequences.

22 MR. SCHAPEROW: Okay, that what was
23 considered for the in-vessel duration.

24 MR. LEAVER: Right.

25 MR. SCHAPEROW: All right. All right.

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1 MR. LEAVER: It is not a bad list.

2 MR. SCHAPEROW: All right, why don't we go
3 ahead and put this up. I think we will need, at least
4 for me I will need to spell it out, what these things
5 are, because it is written in ERA lingo.

6 MR. LEAVER: I think I know what most of
7 them are.

8 MR. SCHAPEROW: Oh, you do?

9 MR. LEAVER: Roughly. I mean, you can
10 tell small breaks, large breaks, the VC points.

11 MR. SCHAPEROW: They are in these two
12 volumes.

13 MR. BOYACK: Why don't you just refer to
14 page 8 again of the document? I think that is where
15 you are.

16 MR. SCHAPEROW: Yes, page 8. Page 8 has
17 got a list of the sequences. They are in these two
18 volumes.

19 MR. NOURBAKHS: Some of them, we had the
20 actual audit books to check these numbers.

21 MR. SCHAPEROW: Do you have a blank slide
22 and a pen? I will go ahead and write them up.

23 Here they are. In the front of the
24 chapter here is all the sequences. Shall I do them
25 all or just the low-pressure ones?

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1 MR. LEAVER: It wouldn't take long to do
2 them all.

3 MR. SCHAPEROW: All right. Shall we take
4 a five-minute break while I do this?

5 MR. LEAVER: Actually, people have this
6 list, don't they? I'm not sure you have to write it,
7 do you?

8 MR. SCHAPEROW: Well, what they are.

9 MR. GIESEKE: Is this list going to be
10 different than the 1465 list?

11 MR. BOYACK: No, it's the same list. I
12 think what he is saying is, what are those accident
13 sequences? The VSIC quench was an interfacing systems
14 LOCA. That is what he was after.

15 MR. SCHAPEROW: Maybe you can help me with
16 this, Hossein.

17 MR. BOYACK: Hossein probably knows what
18 they are off the top of his head.

19 MR. SCHAPEROW: Yes, I don't even see a
20 correspondence between the VMI report and the page 8
21 table here.

22 Why don't you help me put this list
23 together here?

24 MR. NOURBAKHS: What do you want it to do
25 here?

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1 MR. SCHAPEROW: I want to do each of the
2 -- these are the ones you considered?

3 MR. NOURBAKHSH: They are same as that.

4 MR. SCHAPEROW: The same as that, yes.
5 All right, let's do the first one. CML, I guess we
6 all know what that is. That is the --

7 MR. LEAVER: Brent, have you got one of
8 your earlier PERC reports here, the ones that look --
9 somebody sent me -- I didn't bring them.

10 MR. BOYACK: Oh, I sent you the --

11 MR. LEAVER: Two of them. They were
12 for --

13 MR. BOYACK: I sent you PDF files that
14 described --

15 MR. LEAVER: No, I had hard copies.

16 MR. BOYACK: Oh, you are after the full
17 program. No, I didn't bring those with me.

18 MR. LEAVER: Nobody has them here?

19 MR. BOYACK: Well, the NRC has them
20 because I sent them to Jason.

21 MR. BOYACK: These are for high burnup
22 fuels, is that correct? These activity insertion
23 accidents?

24 MR. LEAVER: I think it was activity
25 insertion accidents.

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1 MR. BOYACK: And PWR.

2 MR. LEAVER: Yes, and PWR.

3 MR. SCHAPEROW: All right, Richard pointed
4 out that on page 6 of the 1465, these are the PWR
5 ones. It looks like the biggest LOCA is a 3-inch LOCA
6 for O'Conee. For what it's worth, I think it is the
7 time that that takes to drain the vessel and heat up
8 the fuel that's going to make a difference here.

9 MR. KRESS: So somebody took all these
10 numbers and ended up with 1.3 hours. What did they
11 do, add them up and average them?

12 MR. SCHAPEROW: Actually, for the in-
13 vessel, there's a listing of the time. It's a lower
14 head failure on page 8.

15 MR. BOYACK: Table 3.4?

16 MR. SCHAPEROW: Yes, Table 3.4.

17 MR. LEAVER: I see the sentence down at
18 the -- I don't know if these 1465's are all consistent
19 in the way their format is, but in the lower, the very
20 bottom of the left column, it says, "representative
21 times for the duration of the in-vessel release phases
22 have been selected to be 1.3 hours or 1.5 hours per
23 PWR and BWR plants, respectively, as recommended by
24 Reference 17."

25 I don't know what -- oh, Reference 17 is

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1 probably 5437.

2 MR. SCHAPEROW: That's Hossein's work.

3 MR. LEAVER: 5437? Yes. So they are
4 called representative. I don't know if -- that
5 probably doesn't --

6 MR. KRESS: Well, he probably took those
7 sequences and weighted them by frequency and got the
8 frequency weighted average.

9 MR. SCHAPEROW: It looks like some sort of
10 an average because 90 minutes is right in the middle
11 of all the stuff that's there.

12 MR. LEAVER: I mean, I can tell you from
13 the standpoint of the impact on the dose, if this
14 duration were shorter, conceivably you could have a
15 system, mitigation system like a spray system, which
16 is a short-duration system, and if this release,
17 instead of being 1.5 hours was 45 minutes and you had
18 a 45-minute spray system, that would work pretty well.

19 So I think there's something to be said
20 for not making the release too short, even if we think
21 that there are some sequences where it would be short,
22 because it gives the possibility that the plant could
23 come up with a system, or the designer could come up
24 with a system for mitigating this accident that would
25 work fine for a shorter release, but not so fine for

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1 a longer release.

2 MR. KRESS: Well, my feeling is that for
3 this high burnup fuel, you don't release them at all,
4 the nobles and volatiles during the adiabatic heatup,
5 which would release none of the release tanks during
6 that period, at least very little, but that's with
7 high burnup fuel.

8 MR. LEAVER: Which is some fractional
9 portion of the core.

10 MR. KRESS: Which is only a portion of the
11 core.

12 MR. LEAVER: Right.

13 MR. KRESS: So you want to start releasing
14 from the high burnup fuels during the adiabatic
15 heatup. That's the start. This is going to come up
16 on some sort of a ramp, and I don't know where you're
17 going to say the start is because there is no
18 definitive demarcation for it.

19 Then, as you continue in the adiabatic
20 heatup, you are going to start releasing the lower
21 burnup fuel. Then when you get in and drive off the
22 oxidation kinetics, you are going to start releasing
23 from the regular burnup fuel that is in there.

24 So what you have done by including high
25 burnup is you have stretched out the timing over a

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1 longer period actually. You will end up releasing
2 basically 100 percent, I think, at the end point.

3 MR. KRESS: A hundred percent what?

4 MR. SCHAPEROW: From the high burnup fuel.

5 MR. KRESS: From the high burnup. I don't
6 know how much, what fraction you release from the
7 lower burnup, but that is a calculation I haven't made
8 yet. Normally, it releases about the same fraction to
9 the low burnup fuel that you did previously. So you
10 have to weigh that fraction in the 100 percent by how
11 much of this is in the core. That is why I needed
12 this distribution.

13 MR. LEAVER: Yes, that's right.

14 MR. KRESS: So what we are going to do is,
15 because some fraction of the fuel is releasing more
16 than it did before, we are going to up the source
17 term; it is going to start earlier, and it is going to
18 stretch it out in time, is the view I have of what is
19 going to happen.

20 MR. LEAVER: It is going to stretch it out
21 in time, because it is going to start, the high
22 release, maybe start a little sooner?

23 MR. KRESS: Yes.

24 MR. LEAVER: That's what you mean,
25 stretching it backwards?

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1 MR. KRESS: Yes, backwards. Start it
2 earlier.

3 MR. LEAVER: Right.

4 MR. KRESS: And you will end up releasing
5 from the lower burnup fuel about the same time you
6 move forward because it is driven by the zirc
7 oxidation phase. That is the way I would view this
8 thing.

9 I'm going through answering the questions
10 in my mind --

11 MR. LEAVER: Yes, I think you've kind of
12 given a qualitative explanation.

13 MR. KRESS: Qualitative. Now how to put
14 numbers on it --

15 MR. LEAVER: Right, right, but that's what
16 we have to do.

17 MR. KRESS: The first number, I don't have
18 it yet, is where it starts, because the start is
19 significantly released from the high burnup fuels when
20 it starts. This doesn't come up and suddenly start.
21 It is slowly rising up, because of the kind of heat
22 that is coming out. I don't know where you make the
23 demarcation on how you decide to do that, but that is
24 the first thing I think we have decide: How do you do
25 that?

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1 One way to do it is arbitrarily like we do
2 in structural mechanics, is you plot the release of
3 high-burning fuel versus time, and it does come up on
4 an angle, but it kind of gets a little straight edge.
5 You draw that straight point down to where it meets
6 the timeline and just say that's the start, and forget
7 about this other one. That is the way they do in
8 structural mechanics.

9 MR. LEAVER: When you actually calculate
10 doses, controlled doses, offset doses, that effect
11 that you just described would be pretty small.

12 MR. KRESS: Pretty small.

13 MR. LEAVER: So you could assume a uniform
14 release, if you wanted to, and it wouldn't really --

15 MR. KRESS: Normally, the source term does
16 take the total time and reduce it on a straight-line
17 basis --

18 MR. LEAVER: Right.

19 MR. KRESS: -- and that would be a way of
20 doing that.

21 MR. LEAVER: Yes. But what burnup would
22 you say this -- maybe it is a gradual sort of thing
23 and there's no good answer to this, but what burnup
24 would you say you would see this accelerated effect
25 that you described?

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1 MR. KRESS: Oh, somewhere around 60 or 70.

2 MR. LEAVER: But if we are trying to
3 figure out what -- if we knew the distribution burnup
4 over the core, then at what point would you start to
5 say, well, above burnup of "X", I would see this
6 effect? Say 60?

7 MR. KRESS: Once again, that is a
8 continuous function.

9 MR. LEAVER: Yes, it is a continuous
10 function, but I'm not sure we are smart enough to --

11 MR. KRESS: To factor that into it.

12 MR. LEAVER: Yes, yes.

13 MR. GIESEKE: A while ago, Tom, you were
14 talking about the onset of release. Did you attribute
15 that to the failures of rods at the higher burnup
16 levels?

17 MR. KRESS: That was for the gap release.

18 MR. GIESEKE: The gap release for the old
19 case.

20 MR. KRESS: Yes, I just assumed the gap
21 release failed with rods, and that is generally said
22 to occur at a roughly given temperature.

23 MR. BOYACK: You are back far enough that
24 we are missing the pickup (speaking of the
25 microphone).

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1 MR. KRESS: The gap release I think is
2 assumed to happen when you fail the clad, and that's
3 a stress calculation.

4 MR. GIESEKE: So what we are saying, then,
5 is regardless of the burnup level, that the initiation
6 of release is the same time?

7 MR. KRESS: Just for the gap.

8 MR. GIESEKE: Yes, just for the gap, but
9 it's --

10 MR. KRESS: But then you've got real
11 problems with the in-vessel release.

12 MR. GIESEKE: Okay.

13 MR. KRESS: Because it used to have a
14 line. It didn't start releasing until you lit off the
15 zircaloy oxidation.

16 MR. GIESEKE: Yes.

17 MR. KRESS: And you no longer have that
18 line, is my problem.

19 MR. GIESEKE: That's right, you no longer
20 have that line. But if you are talking just -- that
21 is, presumably, the end of the gap release anyway,
22 right, when that lights off?

23 MR. KRESS: That is the way they define
24 the end of the gap release, I think.

25 MR. GIESEKE: Yes. Okay.

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1 Now if we follow the same kind of logic
2 and we just look at the failures, they are going to
3 occur probably over the same time period, but because
4 of the burnup level, they are going to be different
5 amounts, is that true?

6 MR. KRESS: For the gap. That was what my
7 earlier speculation was. Dana didn't particularly
8 like it, but --

9 MR. GIESEKE: So you questioned the
10 timing? What is the reason for the timing difference
11 then?

12 MR. KRESS: I have already left the gap
13 release and said I'm going to leave it for Jason, and
14 I am focusing on the in-vessel. I forgot about the
15 timing of the gap altogether, and I am just focusing
16 on the in-vessel release: What does it start and what
17 is its duration?

18 MR. LEAVER: If we could somehow
19 generically take into account this portion of the core
20 that has a burnup that is higher than what we have
21 traditionally been thinking about, what went into
22 1465, then we could perhaps come up with some increase
23 in the magnitude of release. It is now 40 percent.
24 So, say, now we think it is something a bit higher
25 than that. Actually, that 40 percent is released into

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1 the plate.

2 In this document I know there may be some
3 disagreement on the details on this. I'm sure there
4 will be, but I am reasonably certain that the thought
5 that went into this was that, for a 40 percent release
6 to containment, that that means --

7 MR. KRESS: Ninety percent release.

8 MR. LEAVER: Yes, or 80. I don't know,
9 75, 80, 90 percent, something like that, from the
10 fuel, and then some retention in the RCS. It was kind
11 of a mish-mash of sequences in terms of whatever that
12 term is called for retention in the RCS.

13 So, anyway, if we knew what fraction of
14 the core was sort of pushing the limit on where we
15 thought this increased burnup effect would occur, we
16 could estimate increase on this 40 percent, say, to 44
17 percent, or whatever the heck it is. Then, if we were
18 able to do that, I think we could assume a uniform
19 release from 30 seconds, or whatever the onset is,
20 over the duration of two hours or 1.8 hours, or
21 whatever the total is.

22 I think that would define what was needed
23 to do the calculations of the release transport and
24 the dose calculations, and whether you had some
25 different release rate in the first 30 minutes than

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1 you did in the next hour and a half would make no
2 difference at all to the calculation. I don't think
3 we have to worry about that, even though they do
4 distinguish that in 1465 now.

5 What I am hearing you say, which makes
6 sense, is that you think that with high burnup fuel
7 you are less able to distinguish those two periods
8 because there is a higher release hurdle earlier.

9 It seems to me I am sort of with you, Tom;
10 the more fundamental question is: I'm even past the
11 duration. What's the effect on the total release
12 obtained from high burnoff fuel? What do we want to
13 say that is?

14 MR. KRESS: The question there always
15 comes down to how much you want to assume gets plated
16 out.

17 MR. LEAVER: Right. Right. Well, also
18 the distribution of burnup in the core.

19 MR. KRESS: And whether the burnup affects
20 that plate. It possibly could because it may change
21 the total aerosol concentration that is released, and
22 thus, enhancing its plate-out. So it may be that
23 higher burnup fuel does plate it out more, but, by the
24 same token, you are starting a release over a longer
25 period of time, so the concentration may not go up

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1 that much because you are spreading it out over a
2 longer period of time. So I don't really know what
3 happens in the plate-out. I would almost be tempted
4 to use what was done in the previous one for the
5 plate-out. I don't think we have places for
6 selecting --

7 MR. LEAVER: Yes, I am not sure we know
8 exactly what was assumed because it was kind of a
9 mish-mash, but I seem to have, as I said, in my head
10 there is roughly this factor of two. I don't remember
11 whether that was discussed at meetings or whether that
12 is actually in the -- I don't think it is in 1465.

13 MR. KRESS: No.

14 MR. GIESEKE: I think we are trying to
15 confuse ourselves here a little bit because we are
16 trying to define the regions like the gap release and
17 the in-vessel release in terms of the amount that is
18 released, and really --

19 MR. LEAVER: The fraction of the core --

20 MR. GIESEKE: Yes. And shouldn't that be
21 defined independently by thermal hydraulics somehow
22 rather than in terms of the amounts released? I mean,
23 Tom is concerned because the gap release is higher
24 now, which clouds the boundary between the gap and the
25 in-vessel release, and we have talked about the

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1 amounts of release and mitigation or deposition in the
2 primary system affecting the amounts. I think, can't
3 we define all these durations strictly in terms of
4 thermal hydraulics or significant events like fraction
5 of the core, rods failed, something like that?

6 MR. KRESS: You can do it, except thermal
7 hydraulics doesn't help you on deciding when the in-
8 vessel release starts and it doesn't help you in
9 telling you how much deposition you are going to get
10 from the primary system, because both of those things
11 are more than just thermal hydraulics.

12 MR. GIESEKE: Yes, but if you can't define
13 the thermal hydraulics for the basis, you could never
14 define the rest of it.

15 MR. BOYACK: Let me ask a couple of
16 questions. I've now listened through one full meeting
17 and a second, and the one thing that is becoming
18 evermore clear to me is that the source term is not
19 precisely logic, single-logic-driven. So there is one
20 of the key factors right off, was that there wasn't a
21 single transient which you could support by a single
22 set of calculations, tie it to a set, predefined or a
23 defined set of non-logical behaviors, sort out the
24 predicted release, no matter how good or how bad the
25 methods were, and say, that's it.

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1 So, as we talk today, what I sense is this
2 sort of struggling because now nobody is very, very
3 comfortable with that. They may not have been
4 comfortable with it some time ago. But that is the
5 reality.

6 I ask myself the question on something
7 like gap release, do we need to really worry so much
8 about tagging it to a bunch of non-logical events or
9 can you conceivably take the approach that says, okay,
10 what we'll do is we will take half-an-hour, we'll
11 leave it there, and we just won't change it, and
12 during that time we will recognize that there is going
13 to be, since it is not changed, not tagged now to the
14 onset of the zircaloy oxidation, but we do have some
15 insight phenomenologically now that there is going to
16 be larger releases quicker. Just leave the time the
17 way it was, and then embed that new physical insight
18 or these physical insights about high burnup into your
19 source terms. So there is one possible approach.

20 Now the second possible approach, which I
21 am not sure would be any better, and that is that,
22 instead of starting at the front end, we go to the
23 back end. I've heard some discussion about this.
24 Where there's some discussion and you say, well, we
25 kind of know the transient of high burnup fuel and we

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1 think there is going to be higher release fractions by
2 the time we get to the end, and then we can try to
3 march forward.

4 I don't think we --

5 MR. LEAVER: You mean march backwards?

6 MR. BOYACK: March backwards, I'm sorry.

7 MR. LEAVER: Right.

8 MR. BOYACK: We could march backwards
9 through the problem, but with the idea that we can
10 build upon successes at the end and come forward.

11 Now Jason's got both a curious look and --

12 MR. SCHAPEROW: I think I understand the
13 second one. That's when we go right at the iodine in-
14 vessel release magnitude.

15 MR. LEAVER: Right, exactly.

16 MR. SCHAPEROW: I think that would be most
17 fruitful.

18 MR. LEAVER: Me, too.

19 MR. SCHAPEROW: I think that is where we
20 have maybe our most experience and are most
21 comfortable in that area.

22 MR. LEAVER: And I think it is the most
23 significant number that we are going to decide.

24 MR. SCHAPEROW: Yes, and the in-vessel
25 release magnitude --

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1 MR. BOYACK: Well, you are talking about
2 in-vessel.

3 MR. SCHAPEROW: -- and then work back from
4 there.

5 MR. BOYACK: Okay. So I was actually
6 going to the far end --

7 MR. SCHAPEROW: No.

8 MR. BOYACK: -- but you're saying, no,
9 that's no problem. To me, it does not matter. If
10 there is one place, any place, that we could start and
11 work backward, that would be fine.

12 But my other thought, listening to all
13 this, was that it would be possible just to set the
14 gap release time the same as it was, and then just
15 embed the phenomenological knowledge about high burnup
16 and drop it into the source term. I'm not worried
17 about the timing because it really is going to all --
18 whether it is a half-an-hour gap release and 1.3 hours
19 on early in-vessel, containment-wise it doesn't seem
20 to matter.

21 MR. SCHAPEROW: Yes, I tend to agree with
22 Dave Leaver that, given our need, given our
23 application of this for the design basis LOCA
24 analysis, that we don't really need to distinguish
25 between the gap and the early in-vessel. We should

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1 just lump it together for now.

2 MR. GIESEKE: I don't have any trouble
3 with Brent's suggestion of holding it to the half-an-
4 hour if we can make a statement or an understanding
5 that burnup does not affect the things that affect
6 that decision, the previous decision. What determined
7 it before was the takeoff of the zircaloy reaction
8 basically, and the onset of that was fuel rod
9 failures. So that defines it in terms other than the
10 amount released.

11 What was stated in the report was that the
12 two regions are defined by the amount released, which
13 I think is a mistake to define it in terms of the
14 amount released, rather than tying it to
15 phenomenological effects in the core, which in fact
16 lead to the changes in release. Does that make any
17 sense at all?

18 I can see if we can that the progression
19 of the accident is the same, independent of burnup, or
20 what happens in the core when the rods fail, when this
21 zircaloy reaction takes off, which are the controlling
22 factors -- if those are independent of burnup, then we
23 should be able to retain our definitions, or at least
24 some understanding of the two kinds of releases. The
25 amounts are going to change maybe several times, you

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1 know, up to four times, what Dana was saying, from 5
2 to 20 percent, you know, but that's laid over the same
3 kind of a timescale, which is defined by other events
4 and not by the release. Does that make any sense?

5 MR. KRESS: No.

6 MR. GIESEKE: Oh, okay.

7 MR. KRESS: If you think about what is
8 going on, there is some time for blowdown and there is
9 time for blowoff and residual water until you start
10 uncovering the core. If you start uncovering the
11 core, the tops of it start heating up, and so the core
12 -- this is behind down here -- the core will start
13 heating up at some rate, which is mostly adiabatic
14 heatup but a little cooler. It is about half the
15 adiabatic. This is something like 1 K per second.

16 You come up here until it gets up to a
17 temperature, so that is generally thought where the
18 zircaloy fires off. This ramp goes up very fast.
19 This is something like 40 K per second. It really
20 changes quite markedly.

21 Now if you superimpose on that low burnup
22 fuel, like 30,000 or 40,000, what you get is you get
23 somewhere right about here you get a little fission
24 product release action in here. You get a little zap.
25 That's the gap. Then you don't get anything until you

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1 get way out here. Then all at once it starts coming
2 up just a little bit. It comes up and this thing sort
3 of hits a temperature and just lots of little things
4 here. It just comes up here, and once this thing
5 happens, it kind of cools. So that is your general
6 fission product released for low burnup fuel.

7 Now what happens when you take -- which
8 there is some still in the coal, even in high burnup.
9 Now let's take a real high burnup. You come up. You
10 probably hit this thing about at the same time because
11 it doesn't hurt this heatup ramp much because it's not
12 that much decay, heat change. So you're going to hit
13 this at about the same. There's probably going to be
14 a little more because burnup gives you a little more
15 in there, and it may come just a little earlier
16 because the stress is higher, but it is not going to
17 change this much. It is going to do this, and I'm
18 going to superimpose that curve.

19 Somewhere around about here, and I am not
20 sure exactly where in this adiabatic heatup, this
21 thing is moved down to right here, and it is starting
22 to do this.

23 MR. GIESEKE: Move down to where the --

24 MR. KRESS: Pardon? This is overlapping
25 this thing. I am not sure what this temperature is

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1 because that takes a real fine calculation. But this
2 will go on up higher because it is superimposed on
3 this ramp, and these two got time for this high burnup
4 fuel. So it will go up. This may be 50 to 70 percent
5 of the volatiles. This is like 100 percent of the
6 volatiles here, because it had more time --

7 MR. GIESEKE: Why does the release take
8 off before the --

9 MR. KRESS: Burnup has an effect on when
10 the release, how easy it is to release. This is
11 burnup like 70,000.

12 MR. LEAVER: Structural effect --

13 MR. KRESS: Structural effect on release.

14 MR. GIESEKE: Okay, so you're saying
15 that --

16 MR. KRESS: So this curve still happened,
17 or some fraction of the fuel, this curve will happen
18 with a high burnup fuel. Now how you look at that,
19 you can get a total release. If you know this curve
20 for each fraction of the fuel, you can get a total
21 release. It is weighted by the amount in it.

22 Where do you decide it starts? Well, I
23 would say you draw this line here down and say it
24 starts right here, if you know this curve. That would
25 be my idea of a start, and that is the end of the gap.

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1 Now this ramp right here is no quiet ride
2 because what you want to do is -- this is not the
3 total fraction; this is the fraction of the fraction.
4 So you really get the total by some weighted average
5 of this, and the total may be right down here, and it
6 ends up, that total ends up arriving better. So you
7 start it here, and you draw this line instead. So
8 you've got the total; you've got a ramp rate; you've
9 got a start time, and you've got a gap and a start.
10 That is the way I would do it if I had all this
11 information.

12 MR. GIESEKE: Well, you are doing what I
13 was asking them to do, which is defining the release
14 regions in terms of phenomenological effects rather
15 than defining them in terms of released amounts.

16 MR. KRESS: Right.

17 MR. GIESEKE: The way we have done it
18 before, we have defined the regions in terms of
19 release amounts rather than in phenomenological --

20 MR. KRESS: I feel strongly that that's
21 what is going on. Now the question is: How do we
22 quantify it? Because previously the source term
23 people had in front of them umpteen dozen
24 calculations. It told them all this timing, and the
25 guy went through it and said, okay, you made good

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1 judgments, and said, I'll take this and this and this.
2 He had a lot of information to do it.

3 We do not have the equivalent of the
4 information for the high burnup fuel. We just don't
5 have it. We have a real problem in doing something
6 other than what I said earlier: It starts earlier.
7 It goes on a different route that is stretched out in
8 time. We can say those things, but to put numbers on
9 them is going to be difficult because somebody has to
10 do some calculations.

11 MR. SCHAPEROW: Would you mind if I just
12 marked, made one mark on this?

13 MR. KRESS: Well, use a different color of
14 pen.

15 MR. SCHAPEROW: Oh, okay. Good idea.

16 (Laughter.)

17 The point that I was trying to make
18 earlier was that the scenarios that we are considering
19 is a seal leak or even a two-way break --

20 MR. KRESS: Yes, it starts way back.
21 Actually, it starts way back there.

22 MR. SCHAPEROW: Well, nothing will happen
23 for a long time.

24 MR. KRESS: That is exactly right.

25 MR. SCHAPEROW: You won't have any release

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1 for a long time, and the temperature is also going to
2 be low

3 MR. KRESS: Yes, you're exactly right.

4 MR. SCHAPEROW: So I think a lot of this
5 gap release timing is due to this assumption that the
6 start of the gap release is for a large break LOCA,
7 and the start of the early in-vessel is for a 2-inch
8 LOCA.

9 MR. KRESS: Yes.

10 MR. SCHAPEROW: I think that half-an-hour
11 is the difference between a large break LOCA, gap
12 release start time, and a 2-inch LOCA start time, gap
13 start time. I think we are getting thermal hydraulic
14 benefits where we are getting that half-hour.

15 MR. KRESS: You could take the gap release
16 off and everything else still holds that I ad up
17 there.

18 MR. SCHAPEROW: Yes.

19 MR. KRESS: And you could deal with the
20 gap --

21 MR. BOYACK: If you sort of were
22 considering, covered by this representative scenario,
23 five, six, or seven of these that are listed on page
24 8, now this is the timing for early in-vessel, but, in
25 effect, let's see, at 1.3, 60, 70 minutes, there were

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1 some that were larger and some that were smaller as
2 far as timing, right?

3 MR. SCHAPEROW: I guess I'm hearing that
4 the -- oh, I'm sorry.

5 MR. BOYACK: I just don't think it matters
6 too much -- you are trying to be representative -- as
7 long as it will be appropriately used in downstream
8 applications. So the gap release also appears to me to
9 be in the same park; that is, if you use
10 representative sequences, there's a bunch of them.
11 Some of them are very short, like a large break LOCA;
12 some of them extend out a little while, like your much
13 smaller break LOCAs. One could continue on and use
14 roughly the same timing, because it is just
15 representative.

16 MR. SCHAPEROW: I guess I'm hearing, I
17 think I am hearing from Tom and Dave that the sum of
18 the gap in early in-vessel release phases should still
19 be about 1.8 hours, and also from Jim. I think I am
20 hearing that.

21 MR. BOYACK: 1.8 or 1.3.

22 MR. SCHAPEROW: The sum, the sum of the
23 gap in the early in-vessel release phases should still
24 be about 1.8 hours.

25 MR. BOYACK: But isn't that early in-

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1 vessel, that's actually the duration of the phase
2 then? You add them up to come to the --

3 MR. SCHAPEROW: That's correct.

4 MR. LEAVER: When you do the calculation,
5 you add them up and you get the total.

6 MR. BOYACK: So the actual elapsed time
7 for the end of early in-vessel as shown on the 1465
8 table is 1.8 hours?

9 MR. SCHAPEROW: That is correct.

10 MR. POWERS: That assumes that burnup does
11 not effect degradation?

12 MR. SCHAPEROW: That's correct.

13 MR. POWERS: And you have no evidence that
14 that is true?

15 MR. BOYACK: Now a while ago, Dana, you
16 were filling out tables. I wonder if you literally
17 have them all filled out for us now. So would you
18 like to comment? Not yet?

19 MR. KRESS: The question is, my figures
20 and values are driven by that double, triple line
21 heatup curve, and Dana has said that's what you get
22 for low-burning fuel, and the question is whether
23 burnup will affect that double-wide curve, which it
24 very well could.

25 MR. GIESEKE: Affect it in what sense?

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1 Make it move, shift left or right, or --

2 MR. KRESS: I don't know. If you had a
3 lot of foaming, for example, it would hold fuel up --

4 MR. LEAVER: And it could either go left
5 or right or up or down. What would the effect be?
6 You've shifted it to the left due to burning.

7 MR. KRESS: No. No, all I'm talking about
8 now --

9 MR. GIESEKE: Yes, he's shifted way to the
10 left. He's shifted --

11 MR. KRESS: That curve is not really
12 affected by burnup. I am just using the old curve.
13 That's what you get from low-burning fuel.

14 MR. LEAVER: Right.

15 MR. KRESS: I don't know what happens with
16 high-burnup fuel.

17 MR. LEAVER: But I thought your double-
18 line curve was intended to be sort of a representation
19 of what happens for higher burnup?

20 MR. KRESS: No, that's what you get for
21 low burnup. I don't know what you get for high burnup
22 because I have never seen the tests or even the
23 calculation. Dana surmises there might be changes due
24 to things like foaming and the changes in thermal
25 conductivity, and changes the candling behavior and

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1 the fuel -- you know, it doesn't change the decay heat
2 enough or it doesn't, in my mind, change the zircaloy
3 steam reaction enough to really affect those first two
4 lines very much, but --

5 MR. CLEMENT: We have seen that in very
6 few experiments on these small pieces of fuel that it
7 is able to relocate earlier at lower temperatures.

8 MR. KRESS: Yes, that's the kind of thing;
9 this thing may cut off earlier.

10 MR. CLEMENT: But this is another picture
11 for the whole core that is much more complicated.
12 Because if you have a foaming, it might affect one
13 region.

14 MR. KRESS: Right.

15 MR. CLEMENT: You could have other
16 fissions in other regions.

17 MR. KRESS: And that is what Dana is
18 speculating, that kind of stuff. They have seen it
19 relocate at earlier temperatures. So you may cut that
20 thing off sooner, but it may still be in there
21 releasing fuel, fission products, anyway. So I don't
22 know what happens to that curve, that fuel.

23 MR. CLEMENT: It might affect also the
24 overall behavior of the degradation in this whole
25 thing because, as Dana said yesterday, once it becomes

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1 comes a molten pool, whether it comes from the fuel or
2 another process --

3 MR. KRESS: Then it doesn't matter.

4 MR. CLEMENT: -- it doesn't matter, but
5 what you don't know is what is the amount of fuel you
6 will get in your molten pool. It is different also
7 than the experiment or the accident. What is the
8 amount? I think that is a general problem. I assume
9 it is not so much things, but you can imagine that
10 fuel burnup will affect this degradation, the
11 degradation of the fuel in the in-vessel release.
12 Giving numbers, it would be 1.3, 1.4, 1 --

13 MR. KRESS: That's going to be a real
14 problem.

15 MR. CLEMENT: I don't think you can do
16 that.

17 MR. KRESS: Yes, that is going to be a
18 real problem.

19 MR. LEAVER: Yes, that is very difficult.
20 That is for sure. But we do know that it's not -- if
21 we make that duration shorter, then we have the
22 possibility that we're being non-conservative, which
23 really bothers me. I mean, I can tell you that that's
24 not a good idea.

25 Now if you make it longer, well, that

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1 possibly might also be non-conservative. I don't know
2 that we have a basis for knowing whether it is shorter
3 or longer. I would almost rather leave the same.

4 MR. BOYACK: Let me ask the question this
5 way: You talked about the risk of making it shorter
6 I think because --

7 MR. LEAVER: No, it is just that it could
8 be non-conservative.

9 MR. BOYACK: Well, but you are thinking in
10 terms of the previous case of, I'll call it, the
11 normal burnup fuel and high burnup, and you say, if I
12 take a given transient scenario, then there is going
13 to be a release earlier. So we maybe accept that.

14 But if we also think in terms, then, that
15 we are doing with this "representative" scenario,
16 which has a multiple scenarios in it, some of which
17 run longer, and then it doesn't seem to me that there
18 is any basis for either shortening or lengthening your
19 time. You just leave it the same.

20 MR. KRESS: What the old source term did
21 was basically most of the fuel maybe could be
22 described in this code, and there were several
23 sequences where this varies. So there are sequence
24 variations.

25 So what they did was --

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1 MR. BOYACK: Again --

2 MR. KRESS: They said this was the start
3 of in-vessel release, and then they sort took two or
4 three of these curves and do a line up, and the total
5 amount was about the same; it was just spread out. So
6 they took a line up to the total amount. That is the
7 1.3 hours. From here to here is the 1.3 hours.

8 MR. NOURBAKHS: That is vessel failure.

9 MR. KRESS: What?

10 MR. NOURBAKHS: 1.3 is vessel failure.

11 MR. KRESS: Well, this is when vessel
12 failures --

13 MR. NOURBAKHS: No, that's much earlier
14 than vessel failure, when we release some of the
15 water --

16 MR. KRESS: But you know it took about
17 what, a half-an-hour, for the vessel to fail up to
18 this point. So it is like this distance here plus a
19 little bit of time added for vessel failure. Now
20 you're going to have to make it this length of time
21 right here, plus vessel failure. So I think there is
22 a difference in timing.

23 MR. BOYACK: Okay, the panel needs a
24 break. Come back at 10 after.

25 (Whereupon, the foregoing matter went off

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1 the record at 9:55 a.m. and went back on the record at
2 10: 16 a.m.)

3 MR. BOYACK: Let's reconvene.

4 During the break I talked with my NRC
5 colleagues a little bit about how to proceed, and the
6 key idea here is to use this day to move through
7 marking up the table. I don't have it shown right
8 now.

9 A lot of the discussion this morning has
10 revolved around the difficulties of the timing of gap
11 release, which is somewhat affected then by the high
12 burnup fuel. So the answer that was given to me and
13 the proposal to you is that we deal with the duration
14 or the period from the start of the transient scenario
15 to the early in-vessel period; that is, we just deal
16 with that as a single item. So if we had done the
17 same thing on NUREG 1465, it would be a duration of
18 1.8 hours.

19 Then we deal with the releases, release
20 fractions, at the end of that period of time. Now if
21 you want to change 1.8 hours to 1.8972, that would be
22 okay, but I would like to keep that discussion fairly
23 brief, and basically, to the end, is there any reason
24 to believe that the vessel failure would be any
25 different if you had high burnup fuel, the timing of

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1 vessel failure? That is, is there a reason for
2 changing it from 1.8 hours to 1.-something hours?

3 So, first off, is there any concern,
4 issues, or discussion about the concept of now going
5 to early in-vessel, skipping all the releases
6 associated with gap release, that is, dealing
7 specifically with early in-vessel and the fractional
8 releases associated with the timing through periods
9 one and two early in-vessel? Any comments?

10 MR. POWERS: Yes. I think you are
11 ignoring how the thing gets used.

12 MR. BOYACK: Go ahead and just continue
13 discussion. Let me ask you this: Do you see another
14 way through this?

15 MR. POWERS: What I would tend to do is to
16 say, okay, let's follow your logic individually and
17 then by integration collectively. That is, you had a
18 logic thing, applicable or not applicable --

19 MR. BOYACK: Yes.

20 MR. POWERS: -- and if it is applicable,
21 change the numbers or not change the numbers. Do
22 that. If in the integration you find that people are
23 unwilling or unable to make decisions based on the gap
24 release, in-vessel release dissector, then you can
25 say, okay, lump them together, and then can you make

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1 your decisions?

2 MR. BOYACK: Are you talking about just
3 bypassing the gap release timing issue?

4 MR. POWERS: No, I don't talk about it
5 explicitly.

6 MR. BOYACK: You would go to that first?

7 MR. POWERS: Uh-hum.

8 MR. BOYACK: Okay. So let's take a moment
9 and see if we can proceed, if that is all right. We
10 will give it one try and see if it works.

11 So, basically, the statement is, let's do
12 a logic diagram and ask the question first: Is the
13 0.5 hours for gap release timing applicable? And I
14 might just ask the people to go around the table and
15 give their answer. Now would you like me to start
16 over here with Tom first?

17 MR. KRESS: Sure.

18 MR. BOYACK: Oh, Tom, the question is: We
19 are following the logic diagram upon the screen. Is
20 the 0.5 hours applicable for high burnup fuel for gap
21 release time?

22 MR. KRESS: The basis on which it was
23 chosen is not applicable.

24 MR. BOYACK: Jim Gieseke?

25 MR. GIESEKE: Same statement.

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1 MR. POWERS: Is?

2 MR. GIESEKE: Not applicable because the
3 end-point is defined as the onset of significant
4 release, and we know that is moved up when you have
5 high burnup fuel.

6 MR. KRESS: Yes, that is my basis.

7 MR. GIESEKE: Yes, that is the same as --

8 MR. BOYACK: I don't want to get this
9 wrong. Okay, it says: Not applicable because end-
10 point defined as release of significant fission
11 products. That now occurs earlier in high burn fuels.
12 Is that the statement?

13 MR. CLEMENT: The same statement: The
14 end-point failure with high burnup fuels.

15 MR. BOYACK: So really what I am hearing,
16 Tom, you are saying that you would go with Dana's --
17 that was the underlying basis?

18 MR. GIESEKE: I agree, that is what I was
19 basically saying.

20 MR. EVRARD: The same statement because
21 there is an overlapping between the gap release and
22 the release of fission product.

23 MR. BOYACK: Would you like to disagree?

24 MR. LEAVER: No, no, I think that is
25 right.

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1 MR. BOYACK: Okay, so the first thing I am
2 going to do is I am just going to do this. So 0.5
3 hours not applicable. Okay?

4 All right, now the next thing is --

5 MR. GIESEKE: You need to put an "n" on
6 "not."

7 MR. BOYACK: "Not"? All right. Okay, are
8 we able to specify a new value?

9 MR. KRESS: I would add some calculations.

10 MR. BOYACK: Okay. So the question I ask
11 is that this 0.5 hours was not a single point on a
12 single transient, but it was representative point on
13 a bunch of transients. So are you still not able to
14 specify a new value?

15 MR. KRESS: Now you can I don't have those
16 transients.

17 MR. BOYACK: All right.

18 MR. KRESS: And they are not the same for
19 this high burnup fuel as they used to be.

20 MR. BOYACK: Jim?

21 MR. GIESEKE: No. A similar statement.
22 It is not defined from what we know.

23 MR. BOYACK: Dana?

24 MR. POWERS: Whereas I think Tom and Jim
25 are precisely correct, I think we can specify a new

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1 value, and I think it is remarkable in that you
2 haven't got a whole lot of room here. So my tendency
3 is to say, yes, I only want to reflect that it is
4 earlier, but it can't be too much earlier. So I have
5 a tendency to put down .4 hours, simply to reflect
6 that things are earlier. In fact, I would cut it in
7 half or 90 percent, but it is going to cut it some.
8 So to reflect some, I would say .4 hours.

9 Tom and Jim are correct; the right way to
10 do it is to do a calculation. Unfortunately, I think
11 that is a very difficult calculation to do right now.
12 In the end you need a good set of VERCORS or VERCORS-
13 like data or something like that to calibrate your
14 model and decide exactly what it is, but the fact is
15 it is going to be a relatively small change because
16 there is just not much you can do to it.

17 MR. BOYACK: Okay. Bernard?

18 MR. CLEMENT: Okay, there are some data
19 from the LOCA experiment with high burnup, but we have
20 not yet finished to analyze this data or derive it
21 sufficiently to evaluate it. However, this should be
22 the way to define this duration.

23 MR. BOYACK: Let me just clarify. So you
24 say there is some data from VERCORS experience still
25 under analysis, but then did you tie to Dana's

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1 statement or --

2 MR. CLEMENT: It depends the degree that
3 you are seeing in it there.

4 MR. GIESEKE: Depending on how much
5 uncertainty you are willing to live with in your
6 selection of a number, this is 4 but maybe not .4. I
7 don't know how accurately --

8 MR. BOYACK: Is there anything that I
9 should add from this data for VERCORS experiments
10 still under analysis that would clarify what that does
11 or are you just reflecting uncertainty about it?

12 MR. CLEMENT: I cannot give any figure
13 about uncertainty.

14 MR. BOYACK: Well, personal uncertainty
15 about whether it would go earlier, later.

16 MR. CLEMENT: I cannot give a number
17 today.

18 MR. BOYACK: All right.

19 MR. KRESS: The adiabatic heatup period
20 probably lasts about a half-an-hour to an hour. You
21 can see it in some of these calculations. I don't
22 know if it is in these things. An adiabatic period
23 lasts half-an-hour to and hour.

24 If we think this early release starts
25 during the adiabatic heatup periods, it is more likely

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1 to be near the hot end of it than the cold end of it.
2 So Dana's .4 hours is probably about right. You can
3 make some guesses. If your half-an-hour was right
4 before and you are starting earlier, it is not going
5 to start much earlier. So I think Dana has made a
6 real good guess there on .4 without having any real
7 calculations. It is certainly not going to be much
8 slower than that.

9 MR. POWERS: It is difficult to imagine
10 cutting it in half.

11 MR. KRESS: Yes.

12 MR. POWERS: But, on the other hand, you
13 want to reflect that it is earlier.

14 MR. KRESS: Yes, and that is a pretty good
15 guess, I think.

16 MR. POWERS: Okay. Jean-Michel?

17 MR. EVRARD: When you pass it down to the
18 root core and when the gap release is at the beginning
19 of the severe accident, I think it is somewhat
20 difficult to define a limit between gap release and
21 pellet release. So I will say it is difficult.

22 MR. BOYACK: So am I to conclude from your
23 statement that you would prefer to see this, remove
24 the boundary between gap release and early in-
25 vessel --

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1 MR. EVRARD: Yes.

2 MR. BOYACK: -- and just deal with the
3 whole duration?

4 MR. EVRARD: In France we distinguish
5 between the design basis LOCA, so it is clear. In
6 seal accidents we make no clear distinction between a
7 gap release and what is for sure because it is a
8 continuous process.

9 MR. BOYACK: My brain just went.

10 MR. LEAVER: It's an "l." That will
11 probably be the only thing that is right about what I
12 am going to say.

13 Now I think it seems to me it is earlier,
14 but considering the fact that it is only a fraction of
15 the core that is in this higher burnup range, and I
16 don't know whether we are talking about a continuous
17 change or whether there is something, some kind of
18 step function things going on in there, it is still
19 only a fraction of the core. So that in itself would
20 suggest that, while the release comes out faster, it
21 is not a great deal faster because most of the core
22 isn't any different than what was evaluated in NUREG
23 1465. So I would say that I think it would be
24 appropriate to reflect the fact that it is earlier.

25 MR. KRESS: Did I hear somebody say it

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1 might be a third of the core, the high burnup?

2 MR. LEAVER: I have heard a third, a
3 fourth. It depends on what we say by what is high
4 burnup, but I have heard a number of people saying
5 that the average burnup -- oh, I can't remember.

6 MR. KRESS: But, anyway, if it is a third
7 of the core, it is pretty good fraction.

8 MR. LEAVER: Yes, but it is still, that is
9 still a fraction.

10 MR. KRESS: Yes, but it is not like 10
11 percent.

12 MR. LEAVER: Well, a third of the core
13 wouldn't be 75,000, but a third of the core might have
14 higher burnup than what we have traditionally been
15 thinking.

16 I also think that it is not going to the
17 matter to the way that licensees apply this whether we
18 distinguish between a gap duration and an in-vessel
19 release duration. So agonizing over the right number,
20 whether it is .4 or .45 or .35, is really not going to
21 have very much effect at all.

22 MR. BOYACK: Will not be a large impact on
23 loss, let's see, if the --

24 MR. LEAVER: I would say it even more
25 strongly. It is not that it is not only a large

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1 impact, it is a small, possibly negligible impact on
2 the way that this is applied.

3 MR. BOYACK: That is it? Okay. So the
4 question is, what we do on this, but, basically, what
5 I hear from the U.S. participants, who are probably
6 going to make a stronger statement, is that -- I
7 shouldn't even be summarizing this. But, basically,
8 I heard a couple of people that said, okay, maybe this
9 0.4 hours would be fine. I heard I guess David say --
10 he didn't say a value, but he says as long as it is --

11 MR. LEAVER: If the group felt strongly
12 that they wanted to have a value for this and retain
13 this distinction between gap release and early in-
14 vessel release, I think .4 is not an unreasonable
15 number. I keep using the word "reasonable" and
16 "unreasonable," and I agree with Dana that it is
17 maddening, but I don't know what else to say.

18 (Laughter.)

19 I don't know what else to say.

20 MR. POWERS: You can't find a better word
21 to go with it.

22 MR. LEAVER: Yes.

23 MR. BOYACK: All right.

24 MR. LEAVER: Yes, it is hard to argue with
25 somebody who is reasonable, right?

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1 (Laughter.)

2 MR. POWERS: With the exception of Tom,
3 everybody's kind of reasonable.

4 (Laughter.)

5 MR. BOYACK: Okay, so let me ask the
6 question this way: If I put 0.4 as the timing for the
7 gap release, is there anybody that will walk out of
8 the meeting?

9 MR. POWERS: Is that an option?

10 (Laughter.)

11 MR. LEAVER: It's tempting.

12 MR. BOYACK: Okay, let's see, so we had --
13 I am just going to highlight that. If I were to clean
14 up the language, not here, but to use these as the key
15 elements of the statement, which is that basically the
16 half-hour is not applicable because the point defined
17 as release of significant fission products and now
18 that occurs earlier with high burnup fuel. Possible
19 to specify new value, basically, with the logic that
20 it could be earlier, but not too much earlier, and
21 that 0.4 hours seems reasonable.

22 I would probably move some of this logic
23 that Dave offered, because of the earlier fraction of
24 the core. Therefore, most of the core would still be
25 represented by the NUREG 1465 value.

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1 MR. POWERS: Well, it seems to me I would
2 also reflect what Jim and Tom say, because I think
3 they are literally correct: that what you need to do
4 is be able to do a valuable calculation. In order to
5 do that calculation, you really need data from
6 experiments like VERCORS to calibrate that model for
7 the high burnup fuel.

8 What you are doing in setting that .4 is
9 to reflect the qualitative sense that, instead of
10 extensive release, it is now earlier. That all you
11 are doing right now. To get something really good,
12 you need to do what they say, which was do some
13 calculations with a code that has been calibrated
14 against responsible data, which I think VERCORS
15 probably provides the kind of data that Tom certainly
16 needs for his view to do that calculation in a way he
17 would feel good about it.

18 MR. BOYACK: Is there an "s" on the end or
19 just "VERCOR"?

20 MR. SCHAPEROW: I think there is an "s."

21 MR. POWERS: The French a long time ago
22 decided that "s'es" were there for decorative
23 purposes.

24 (Laughter.)

25 MR. BOYACK: Okay, "See needs," the needs

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1 being that new calculation of the code must be
2 validated with applicable data such as is being
3 generated in the VERCORS's experiment.

4 Okay, I think we can all go home now.

5 (Laughter.)

6 MR. POWERS: My tables look more extensive
7 than that. Do all numbers flow from that?

8 MR. BOYACK: Let me ask, I'm curious about
9 how long this might take, but what about the early in-
10 vessel phase, the duration now, that if you want to
11 think it through to duration, we can subtract off 0.4,
12 but is this something we can rapidly do or do we just
13 need to go back and work on the fractions now?

14 MR. LEAVER: Well, this worked pretty
15 well. Do you want to try it?

16 MR. BOYACK: Yes, let's give it a try.
17 Like many of these, it is finding the right technique,
18 right, after the discussion? The discussion was
19 necessary first.

20 So now I am going to try to just do this.

21 MR. POWERS: I'm not even going to try to
22 guess what he is doing.

23 (Laughter.)

24 MR. KRESS: This time we will go around
25 the table, I suspect?

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1 MR. BOYACK: Yes, would you do that, sort
2 of an alternative approach, and then we can start
3 right at the head of the table on the third approach,
4 and then we could go both ways two at a time.

5 (Laughter.)

6 So now we are on the early in-vessel,
7 having experienced rather marvelous success on the gap
8 release. We get to start with Dave Leaver.

9 MR. LEAVER: Okay. Well, you recognize,
10 of course, you are changing a living strategy by the
11 order in which you do these.

12 (Laughter.)

13 MR. BOYACK: I was just going to write
14 that down.

15 MR. LEAVER: I think, again, that the
16 impact of the high burnup on any of these parameters
17 -- in this case, the duration of the early in-vessel
18 release -- you have to recognize that it is only a
19 portion of the core. That is one factor.

20 So I would say, if you would think of it
21 in terms of a third, you are probably not too far off
22 on that, whether it is a third or a fourth, or
23 whatever it is.

24 I also think that this number of 1.3 hours
25 was intended to be a representative number -- I think

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1 that is the word that is used in 1465 -- over a
2 spectrum of accident sequence types. So I don't see
3 a strong basis for changing -- I am not saying that
4 1465 is right necessarily, but if we use the concept
5 of trying to do a delta, I don't see any basis for,
6 strong basis for changing the 1.3 hours.

7 MR. BOYACK: I am going to write that down
8 in just a minute, but it did occur to me that what I
9 at least should have done is made sure we all agree
10 with the definition of the end of the phase.

11 MR. GIESEKE: Yes, I was going to
12 interrupt, but I decided not to.

13 MR. BOYACK: So if you go to page 8, on
14 the righthand column, the first full paragraph
15 beginning, "During the early in-vessel release phase,"
16 go down halfway, there's a statement: "This release
17 phase ends when the bottom head of the reactor
18 pressure vessel fails, allowing molten core debris to
19 fall ont the concrete below the reactor pressure
20 vessel."

21 MR. LEAVER: Yes, I would have a comment
22 on that. I think that 1465, that may have been the
23 thought process that people went through when they
24 came up with the numbers. In my mind, I think more in
25 terms of a recovered accident, because that is what is

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1 used for the design basis.

2 So you've got to have some kind of
3 injection, recovery of ECCS and injection. So that,
4 to me, is more kind of what defines the end-point for
5 early in-vessel release as opposed to the bottom head
6 failing in the vessel.

7 MR. BOYACK: Okay, what I am going to do
8 is just now try to catch -- would you summarize what
9 your thought was on the timing? You were saying you
10 see no reason to change it from, I guess a duration of
11 1.3 or the total timing, 1.7, now, but you will have
12 to make that a clear point again. I thought you heard
13 you say you see no reason --

14 MR. LEAVER: Well, I would say no reason
15 to change the total of 1.8. So if we change the gap
16 duration to .4, then I would just say, because in my
17 mind the thing that really ends this release is not
18 vessel failure; it is a recovery which is taking place
19 somewhere around this time of 1.7, 1.8 hours, or 1.6
20 hours, however you want to define it. I don't think
21 high burnup has anything to do with that. That is an
22 operator action and a system kind of function. So I
23 guess I don't see a strong basis for changing the 1.8
24 hours.

25 MR. BOYACK: Okay. Jean-Michel?

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1 MR. EVRARD: If the end of the release is
2 defined as a bottom rupture or fracturing of the
3 system, I think the high burnup fuel in a fraction of
4 the core would have a very low impact.

5 MR. CLEMENT: So high burnup may have an
6 impact on the fuel movements before.

7 MR. BOYACK: Yes.

8 MR. CLEMENT: I mean on the lower
9 pressure. So different scenarios of the relation.
10 However, I think that 1.3 hours is a good amount of
11 magnitude, given the different possible scenarios.
12 One of the possible impacts is from failing, as
13 already mentioned.

14 MR. BOYACK: I would just ask you, after
15 I have concluded, you may want to take a look at what
16 I have put up for your words, and if they turn out to
17 be wrong, you can enhance them or correct them for me.

18 Dana?

19 MR. POWERS: Well, I think my view is
20 almost exactly what Bernard said, that I remain
21 concerned that degradation may change with the high
22 burnup fuel, but that can be deduced really only by
23 experimental investigations that change the modeling
24 we have, because that is a very integral sort of
25 undertaking.

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1 So my tendency is to say that the existing
2 analyses probably are not applicable, but in the face
3 of that I would keep the 1.8 hours as the value, the
4 sum, in other words, in the in-vessel and ex-vessel,
5 or in-vessel and gap release, with the strong codicil
6 that we really do need to do kind of bundled-type
7 degradation experiments to see if things change any
8 significant way in the degradation of these high
9 burnup fuels.

10 I am very sympathetic to Dave's point that
11 what really gets at interest here is intervention
12 steps.

13 MR. LEAVER: Is what?

14 MR. POWERS: Intervention steps. It is
15 something that we have never really investigated a lot
16 of. So quenching-type experiments may get very
17 interesting as well, and there are source term
18 consequences, but we aren't dealing with that. That
19 may be a mistake.

20 MR. LEAVER: Bundle experiments, would you
21 consider PHEBUS to be a bundle experiment?

22 MR. POWERS: Oh, yes. Yes. Yes, I think
23 that the utility of CORAR-type experiments for these
24 kinds of investigations are pretty low because you are
25 really looking at types of degradation that go beyond

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1 what CORAR can do. Yes, you don't get as big a bundle
2 as you would probably ultimately like, but that is
3 just the practicalities of the world, and PHEBUS is a
4 decent enough experiment. An experienced team that
5 knows how to do the experiments --

6 MR. LEAVER: Is it decided that PHEBUS
7 will do a high burnup experiment?

8 MR. CLEMENT: What we envisage for the
9 future program, we have the high burnup issue, yes.

10 MR. LEAVER: But that's not -- funding
11 hasn't been collected? What about a quenching
12 experiment? Wouldn't that be a good idea?

13 MR. CLEMENT: Quench experiments will also
14 be done. Quench experiments --

15 MR. LEAVER: That's also on the radar
16 screen for the future? Okay.

17 MR. BOYACK: Okay, Jim?

18 MR. GIESEKE: I also recognize the need
19 for experimental information, and in view of the range
20 of accidents that we are talking about and the
21 uncertainties in calculations, I think we should stick
22 with the -- the 1.8 is a reasonable estimate.

23 MR. LEAVER: There's that word again.

24 MR. GIESEKE: I wouldn't say it's
25 unreasonable.

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1 (Laughter.)

2 MR. POWERS: Ergo a not unreasonable
3 suggestion,.

4 (Laughter.)

5 MR. BOYACK: Tom is ponying up to the
6 microphone to make a statement.

7 MR. KRESS: Getting around to me next, and
8 I plan on being unreasonable.

9 MR. BOYACK: Good.

10 MR. KRESS: The 1.3 duration, which is
11 shown up here, should have a half-an-hour added to it,
12 to make that duration 1.8.

13 MR. LEAVER: Why is that?

14 MR. KRESS: It is because in-vessel
15 release starts about a half-an-hour earlier with the
16 high burnup fuel than it did with the old fuel. The
17 old fuel still starts at the same time and ends at the
18 same time. So you have to add a half-an-hour to that
19 1.3.

20 Now then you go back and add the .4 to
21 that 1.8, to get a total of 2.-something.

22 MR. BOYACK: You caught me playing with
23 the computer. So I got caught.

24 MR. KRESS: I am dealing first with the
25 1.3.

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1 MR. BOYACK: Okay, so first --

2 MR. KRESS: And that should be 1.8, in my
3 opinion. That is not the same 1.8 the other people
4 are using.

5 MR. BOYACK: So it is the duration of the
6 phase itself?

7 MR. KRESS: Yes.

8 MR. BOYACK: Should be 1.8 hours. And the
9 reason?

10 MR. KRESS: The reason is that the release
11 of significant amounts of fission products starts
12 about a half-an-hour earlier with the high burnup fuel
13 than it did with the regular fuel.

14 MR. POWERS: But up there we said that
15 only --

16 MR. GIESEKE: But before the gap release,
17 you're saying?

18 MR. KRESS: After the gap release.

19 MR. POWERS: But we only moved the gap
20 release up a tenth of an hour.

21 MR. GIESEKE: We might let you add a tenth
22 of an hour, but you can't add half-an-hour because it
23 starts before the accident starts.

24 MR. LEAVER: I thought we took that into
25 account when we speeded up the gap release.

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1 MR. KRESS: I don't care what the gap
2 release does. I am saying that the early in-vessel
3 starts a half-an-hour earlier than it did before, and
4 it ends at the same time it did before. So there is
5 a half-an-hour missing in there somewhere.

6 MR. POWERS: Where is the half-an-hour
7 coming from? Where is that? I don't know where the
8 half-hour came from.

9 MR. KRESS: I calculated it.

10 MR. POWERS: Oh, oh.

11 MR. KRESS: It is the duration of what I
12 all the adiabatic heatup, which is not truly
13 adiabatic, but I call it that anyway.

14 MR. LEAVER: Is that the zirc oxidation
15 phase? Is that what you mean?

16 MR. KRESS: No, no. It is prior to the
17 zirc oxidation. It runs about an hour --

18 MR. LEAVER: A degree per --

19 MR. KRESS: -- at a degree per second. At
20 a degree per second, it runs about a half-an-hour. At
21 a half-a-degree per second, which is not -- 1 degree
22 is adiabatic. Half a degree is cooler. It runs about
23 an hour. That is where I got my half-an-hour to an
24 hour.

25 I am saying that the release of the high

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1 burnup fuel starts at about the middle of that, which
2 is about a half-an-hour. I am using the one hour
3 because it is not truly adiabatic. So that is where
4 I get the half-an-hour from. It starts about in the
5 middle of that.

6 MR. LEAVER: But if 1465 says that the 1.8
7 hour ends when the bottom head of the pressure vessel
8 fails, why would that be delayed by half-an-hour
9 because of adiabatic cooling?

10 MR. KRESS: It's not.

11 MR. LEAVER: It's not?

12 MR. KRESS: You didn't understand what I
13 said. If you take the old 1.3, what that is is the
14 start, basically, it is the start of the zircos
15 heatup, the runaway zirc, to the time of in-vessel
16 melt. The reason it is that is because that is when
17 fission product release started with the old fuel. I
18 am saying it starts --

19 MR. LEAVER: That is where it really took
20 off.

21 MR. KRESS: Yes, and I am saying now it is
22 starting a half-an-hour earlier.

23 MR. LEAVER: So you are saying it starts,
24 instead of starting -- it starts at 30 seconds?

25 MR. KRESS: It still ends at the same time

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1 and starts a half-an-hour earlier.

2 MR. GIESEKE: So it starts before the gap
3 release starts?

4 MR. KRESS: I don't know. I am
5 forgetting, I am just going to ignore what you guys
6 did with the gap release. I am dealing with the in-
7 vessels.

8 MR. BOYACK: Let me ask the question
9 another way. Assuming this representative event
10 starts at time zero, how long does it take for the
11 vessel to fail in this representative vessel, the
12 collection of things that you are using? Just combine
13 the two periods, the start of initiating then to
14 vessel failure.

15 MR. KRESS: It takes about the same amount
16 of time that we had before.

17 MR. BOYACK: Right. Okay.

18 MR. KRESS: But the in-vessel release part
19 of the effort occupies a bigger component of that
20 amount of time.

21 MR. BOYACK: Oh.

22 MR. KRESS: If we don't reflect that
23 properly, we are going to miss something.

24 MR. BOYACK: Well, I am tracking your
25 arithmetic here, and so prior on NUREG 1465 that

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1 period of time was 1.8 hours.

2 MR. KRESS: 1.8 hours.

3 MR. BOYACK: And are you saying that that
4 total time is still roughly the same?

5 MR. KRESS: I'm saying it is still roughly
6 the same, but the duration, the 1.3, is bigger. The
7 duration of that phase occupies a bigger part of it.

8 MR. BOYACK: So if that is the case, then
9 what you are saying is up here on this other, that .4
10 -- I mean, you've got fixed end-points. Now you are
11 just deciding how to divide up the two pieces.

12 MR. KRESS: Uh-hum.

13 MR. BOYACK: So what I hear you saying is
14 that you are looking for the earlier phase to be very,
15 very short.

16 MR. KRESS: Or the two phases overlap, is
17 what I'm saying.

18 MR. BOYACK: Oh, okay.

19 MR. KRESS: You're talking about durations
20 up there and totals, and they don't necessarily add up
21 to the same amount if they overlap. That is why I am
22 saying I'm just ignoring what you guys did about the
23 gap release, and I am looking at the in-vessel part.

24 MR. BOYACK: So --

25 MR. KRESS: The total amount of time from

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1 the start of the accident to when you melt through the
2 vessel is the same.

3 MR. BOYACK: Okay.

4 MR. SCHAPEROW: So you are okay with 1.8
5 hours?

6 MR. KRESS: A fraction of that is occupied
7 by in-vessel release has to increase by about a half-
8 an-hour over the 1.3.

9 MR. POWERS: Tom, let me ask you just one
10 question. It is kind of distressing, but I think I
11 actually understand you.

12 (Laughter.)

13 MR. KRESS: Wonderful.

14 MR. POWERS: What you are saying is that,
15 if I had my magical microscope and I could look at
16 this spore rod by rod as it moves through temperature
17 transient, that, indeed, we get kind of a collective
18 rupture and start a gap release in a bunch of rods,
19 kind at the same time. But a couple of those rods
20 almost immediately were screaming up in temperature.

21 MR. KRESS: Ah, ha, you've got what I'm
22 talking about.

23 MR. POWERS: They, very shortly after they
24 have ruptured, go into the start of what we call in-
25 vessel release.

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1 MR. KRESS: Uh-huh.

2 MR. POWERS: There are others that are
3 lagging and engage in gap release, and they languidly
4 creep up to the temperature at which they start
5 getting -- but there is a substantial overlap and
6 there is a complete distinction that has been drawn
7 between the gap release duration and the in-vessel
8 release that ignores the heterogeneity of core
9 behavior and should never have been made to begin
10 with?

11 MR. KRESS: I wish I had said it like you
12 did, Dana. That is exactly my thought process,
13 exactly.

14 MR. POWERS: I think you are in fact
15 technically absolutely correct. There is always the
16 problem with our codes. When we did the original
17 March code, we saw the core was very uniform in
18 behavior, and the evolution since that time has been
19 make its behavior more and more heterogeneous,
20 especially for these low-pressure accidents. When you
21 stay pressurized, there is a tendency to make them
22 homogenized, but for these low-pressure accidents
23 there's a great amount of heterogeneity, both axially
24 and radially.

25 The distinction, it really comes from

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1 saying, okay, we are going to work with the large
2 break LOCA. Had they said work with a panoply of
3 accidents, then you might be more comfortable with the
4 distinction, but because they have said a large break
5 LOCA, now you can't use -- you are saying there is so
6 much overlap that summation is just not good.

7 MR. KRESS: That says it very well.

8 MR. POWERS: I don't think I disagree with
9 you on that view, and I understand where you are
10 coming from there.

11 MR. KRESS: That was a very nice
12 clarification. Thank you.

13 MR. BOYACK: Okay, basically, what I have
14 said is that total time is about the same, or 1.8
15 hours; a fraction of that occupied in-vessel release
16 is about 1.8 hours. This implies that the gap release
17 and early in-vessel release periods overlap.

18 MR. LEAVER: It implies more than that.
19 It implies that the early in-vessel release begins at
20 time zero.

21 MR. KRESS: Yes, and I didn't really mean
22 to say that.

23 MR. LEAVER: I think that's a little bit
24 too strong.

25 MR. KRESS: I really didn't mean to say

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1 that. I think the total is maybe not 1.8 hours. It
2 is more like 1.7. The fraction is like 1.7, 1.6
3 maybe.

4 MR. LEAVER: Yes.

5 MR. KRESS: You know, I'm guessing. I
6 don't have the calculations.

7 MR. LEAVER: I understand, but if we are
8 going to --

9 MR. KRESS: But you have to be consistent
10 in terms of it doesn't start at zero time. That's for
11 sure.

12 MR. LEAVER: Okay, let me ask you this
13 question, because this is another way of trying to
14 find that number: Recognizing that we have a spectrum
15 of sequences that we have to kind of bear in mind
16 here, even though low pressures may be the main one,
17 and recognizing about this distribution of burnup in
18 the core, at what time, 10 minutes, 5 minutes, 15
19 minutes, whatever, would you say it would be
20 reasonable to specify that the early in-vessel release
21 starts? I know it is not zero.

22 MR. KRESS: I know.

23 MR. LEAVER: And you don't like 30
24 minutes.

25 MR. KRESS: I think it is about a half-an-

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1 hour.

2 MR. LEAVER: You think it starts at half-
3 an-hour?

4 MR. KRESS: Well, I think --

5 MR. LEAVER: No, that would --

6 MR. KRESS: It depends on the sequence.
7 From the time the melt, the water, is starting to
8 uncover the core until the time you get this release,
9 I think is about a half-an-hour, if that helps you.

10 MR. LEAVER: It might be sooner.

11 DR. GRIFFITH: I think it is about a half-
12 an-hour. Well, it depends on the heat, of course, but
13 if the heatup rate of the top parts of the core are
14 about a half a degree centigrade percent, then I think
15 it is going to take an half-an-hour to get up to the
16 temperature where I think these high burnup fuels
17 start releasing.

18 MR. LEAVER: Start releasing, yes.

19 MR. KRESS: But if that heatup rate is a
20 little faster, it is going to take less time.

21 MR. LEAVER: Okay, but if the answer is
22 half-an-hour, that would say that -- and you believe
23 the 1.8 hours is still a reasonable number for vessel,
24 that would say that you are back to 1.3 hours for the
25 duration of the in-vessel release, but you have

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1 started out by saying you think it is longer than
2 that.

3 MR. KRESS: Well --

4 MR. LEAVER: Do you see what I am saying?
5 I mean, maybe it is in between. That's what I thought
6 you were going to say, is, instead of a half-an-hour
7 and 1.3 hours, you would like to see it maybe have the
8 in-vessel release start at, instead of 30 minutes,
9 have it start at 15 minutes or 20 minutes, and then
10 instead of 1.3, you've got like 1.5 or 1.6 hours for
11 that duration.

12 MR. BOYACK: What I propose is the
13 following: As we get to the end of the day, what I
14 will do is I will create PDF files of all this
15 information. I will work with Jason. I think what I
16 will do is I will leave somebody here to work through
17 the next meeting time, and Jason and I will go
18 upstairs and we will kick out these files and get
19 print copies, and then overnight you can spend a
20 little time reviewing and thinking about this and
21 correcting them, if you wish, and return them to me.
22 Is that okay?

23 MR. KRESS: Yes.

24 MR. BOYACK: Good.

25 MR. LEAVER: I am still --

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1 MR. KRESS: I think the problem is in the
2 1.8 that we talked about, the start of the thing until
3 the time you got through the vessel.

4 MR. LEAVER: You think it may be longer?

5 MR. KRESS: I think it's definitely
6 longer.

7 MR. LEAVER: But if that is true --

8 MR. KRESS: But that sort of relation of
9 things, and so when we are trying to fix these numbers
10 that I have here with that, it gets to be sometimes
11 the total doesn't seem to add up right, and you have
12 to face that.

13 MR. LEAVER: So one way to address your
14 comment, and Dana kind of just summarized it
15 beautifully --

16 MR. KRESS: Is extend that 1.8.

17 MR. LEAVER: -- is extend the 1.8, and
18 then you are looking at maybe, say, the same 30
19 minutes or .4 hours, whatever that is, and the instead
20 of 1.3, maybe it's 1.6 or 1.7, which makes the 1.8 go
21 to, say, 2 or 2.1.

22 MR. KRESS: Something like that probably.

23 MR. LEAVER: Yes. Okay, now I see what
24 you ar saying. That would work. I think that would
25 work.

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1 MR. BOYACK: Okay, now I may need a little
2 help on this because -- just see if there is some
3 overall agreement. What I have done right now and
4 highlighted in red is just to indicate that I have
5 left it 1.8 total hours. I haven't increased the time
6 to a larger total period.

7 MR. KRESS: In addition, you have
8 integrated bundle experience with high burnup fuel.
9 That needs to be translated into models and whole
10 core. See, integrated bundle experiments are not
11 whole cores. It needs to be translated into models
12 like VERCORS and whole core calculations made.

13 MR. BOYACK: Okay, I guess what I heard
14 was a suggestion which said that this 1.4 hours might
15 be increased.

16 MR. LEAVER: Yes, I think what Tom is
17 saying is he doesn't necessarily believe that the 1.8
18 hours for vessel failure -- and I must say that is
19 awfully fast, but we also have a spectrum of sequences
20 here, and so we are just trying to come up with
21 something that is representative, but it would, in my
22 mind, not be at all inappropriate to suggest that the
23 1.8 seems fast to us for the original 1465. So we
24 want to push that out a little bit. That gives us a
25 way to address Tom's comment of the fact that he

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1 believes that this release duration is longer, because
2 you've got the high burnup fuel on a low burnup fuel,
3 and it just takes longer for this to occur.

4 MR. POWERS: Looking at some of the Source
5 Term Code Package calculations for large break LOCAs,
6 I believe there is one in there where for the period
7 of time from core code rate to vessel failure, I
8 understand there is like zero time in the rule of
9 thumb in the Source Term Code Package calculations.
10 I mean it is a very brief time. It is only 38
11 minutes.

12 MR. LEAVER: From the time of relocation?

13 MR. KRESS: Yes, but it takes about -- I
14 don't know when they decide this accident starts. I
15 takes about sometimes half-an-hour to get to the top
16 of the core.

17 MR. POWERS: Oh, yes, it takes a long time
18 to get to the top of the core.

19 MR. KRESS: There is a blowdown on top of
20 that which takes maybe 20 minutes for some accidents.
21 It depends on the size. So I don't know when they are
22 assuming the start of this thing is. That is why I
23 worried about this 1.3 hours or 1.8 hours, because I
24 don't know when they are starting that accident.

25 MR. POWERS: I think these things are

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1 basically started at the top of the core. I'm not
2 positive of that.

3 MR. KRESS: Yes, I am not either.

4 MR. POWERS: But, traditionally, that is
5 where the --

6 MR. LEAVER: Are you talking about the
7 onset of gap release? When does that start?

8 MR. POWERS: Yes.

9 MR. LEAVER: I think that could start --

10 MR. KRESS: When is zero time?

11 MR. LEAVER: No, no, see, the way they do
12 those calculations now is -- well, no, I'm sorry.

13 MR. POWERS: There is nothing new with
14 those calculations. It has to do with the code that
15 is set up.

16 MR. LEAVER: Yes, that's right. Yes, but
17 you have a small LOCA. You could be six hours into
18 the accident before you get down to below the core
19 centerline.

20 MR. POWERS: All those things are true,
21 but this is a large break LOCA. So before you jump
22 and say, well, our time period is short, my
23 recollection is there is at least one large break
24 LOCA; I think it is an AB sequence, but I could be
25 wrong about that. It is an extraordinary short period

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1 of time.

2 There was a lot of controversy when the
3 calculation actually came out. I can't remember what
4 the resolution was. I think the resolution was we are
5 not going to worry about it because it is a low-
6 frequency accident. But it's a blitzing fast thing.

7 MR. SCHAPEROW: To interject, actually, to
8 reiterate, there is a table, Table 3, which lists the
9 duration of each of the sequences considered in the
10 in-vessel release phase. The 3-inch LOCA, which is
11 done for O'Conee, with no ESF, was 84 minutes.

12 MR. LEAVER: But there is one -- oh, okay.
13 But here's a series sequence, S3B, that is 36 minutes.
14 Those are really simple bottom head failure models,
15 though.

16 MR. POWERS: Oh, yes, the bottom head
17 failure models were very simple.

18 MR. LEAVER: I know that the models in
19 Melcorn map now are quite a bit better than what was
20 used.

21 MR. POWERS: They are still fast.

22 MR. LEAVER: I don't think they are as
23 fast as this though.

24 MR. POWERS: Well, I think that was, and
25 Jim can probably speak better than I can, but my

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1 recollection is the way we were treating the lower
2 head was really very simple. I mean, it was one step
3 better than March, which was fuel sees head; head
4 fails.

5 (Laughter.)

6 MR. BOYACK: Let me ask the question this
7 way: So far, I have heard Tom make a strong positive
8 statement for a longer period for early in-vessel. I
9 heard Dave make a, "Well, maybe that would be okay."
10 Jim, keep it where it is or change it?

11 MR. GIESEKE: I could see it creep up a
12 little. You know, these numbers are not very precise
13 in any case. You're looking at how many different
14 sequences, and you are making seat-of-the-pants
15 guesses as averages anyway, and you are not even doing
16 it a numeric average. You are doing a, well, I don't
17 know, flight-of-fancy average on these. So if it is
18 1.4, 1.5, 1.6, those are all the same numbers as far
19 as I am concerned.

20 MR. BOYACK: Okay. Dana?

21 MR. POWERS: My view is that the end-
22 points of these times are dictated by the core
23 degradation process. I'm not here as an expert in
24 core degradation process except to raise the
25 possibility that that direction is a bit different

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1 with high burnup fuel than with the fuels that we
2 thought about in the past, which, quite frankly, were
3 heavily biased toward 24 gig, 20-gigawatt-day fuel --

4 MR. LEAVER: Average.

5 MR. POWERS: -- and peaked at like 34 or
6 35.

7 MR. LEAVER: And homogeneous.

8 MR. POWERS: And relatively homogeneous
9 core.

10 So I am unwilling to move those things
11 around. I say that that is one of our needs, that we
12 really need to investigate experimentally the
13 degradation of cores with high burnup fuels, with an
14 eye to seeing if we need to introduce a qualitatively
15 different core degradation model than the one, the
16 basically candling model that we've got now.

17 MR. LEAVER: Similar comment to the one
18 you made on the .4?

19 MR. POWERS: Yes.

20 MR. LEAVER: The need for an integral
21 experiment.

22 MR. POWERS: Yes, I mean we just can't
23 ignore these things because we've had this hint. It
24 first showed up in a PBF3 experiment. It showed up
25 again in a Sandia pilot experiment. It showed up in

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1 one of the FLHT experiments. It showed up now in some
2 of the PHEBUS experiments. Some sort of fuel foaming
3 goes on. It has always been a hint.

4 When you think about fuel foaming, the
5 things that are moving us toward more fuel foaming are
6 higher-efficient product gas goods. That is what high
7 burnup fuel is.

8 If we see the kinds of foam that we saw in
9 the Sandia experiment, it provides a transitory period
10 in which core degradation is completely different than
11 the candling model, and you get a period of very high
12 core temperatures and then sudden collapses, things
13 like that, actually moving back toward more of a
14 March-type model. March may have been right all
15 along.

16 MR. BOYACK: Do our French colleagues have
17 any comment about the difference between 1.4 hours and
18 1.6 hours?

19 MR. CLEMENT: Okay, two comments. First
20 of all, the main difference is about fuel degradation
21 processes. If we have a collapse that's earlier or
22 not, I don't know exactly.

23 The other point is about the 1.3, 1.4
24 hour, about sequences. I mean, some sequences we have
25 used for our source term reassessment, but we have

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1 gotten even those that are shorter in AB sequences
2 than the 1.3 or 1.8. There is one for which we have
3 1.3 hour because there is a break in the lower head
4 failure, for instance, but with others it was much
5 longer times. So, as I said before, the order of
6 magnitude is not bad.

7 MR. LEAVER: It's not bad.

8 MR. BOYACK: Other comments? So the real
9 question here to me is whether I leave it at 1.4 or
10 whether I change it to 1.6. I just need help, like
11 three or four statements.

12 MR. CLEMENT: Yes. If we change it from
13 1.4 to 1.6, I think you probably would be aware that
14 there would be a problem, because we lower as well the
15 concentrate. We believe we lower it for this. Okay?
16 We think that using hydronic fuel goes in the other
17 direction that we raised earlier. We can get fast,
18 higher release rates. So I would not favor shortening
19 this period of in-vessel release, because this could
20 give wrong indications to people who will use it.

21 MR. SCHAPEROW: You have the wrong person
22 there (referring to what Mr. Boyack is typing).

23 MR. BOYACK: Oh, I was putting words in
24 your mouth.

25 (Laughter.)

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1 There we go; you've been cut-and-pasted.

2 Okay, if we are going to increase the
3 period, it would imply lower fission product release
4 rates; that seems to be contrary to the expectation
5 for high burnup fuel.

6 MR. POWERS: Let me say that I
7 wholeheartedly agree with the "do no harm" philosophy.
8 Don't mislead people with your changes in
9 qualitatively incorrect corrections. Do no harm is
10 the first step in making changes.

11 MR. BOYACK: All right, I will figure out
12 how to handle this. Leave as is. So I come back up
13 and so 1.4 is what I sort of hear now as the outcome.
14 All right?

15 Now at this point it seems to me there is
16 a break between these later times and these earlier
17 times, and what you want us to do is to get the
18 numbers for the earlier time as far as releases. Is
19 that correct, or should I just go on and try to deal
20 with the ex-vessel and late in-vessel durations?

21 MR. SCHAPEROW: I think we should stick
22 with in-vessel right now.

23 MR. BOYACK: Yes, okay.

24 MR. SCHAPEROW: If Dana feels differently,
25 that's fine. You guys are making much better progress

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1 without me.

2 (Laughter.)

3 MR. POWERS: Well, I think here's what I
4 will offer this time: Most people say, "ex-vessel,
5 skip it, leave it alone." But I think Bernard may
6 have some interesting comments to make about the late
7 in-vessel release that I would like to hear what he
8 has to say on that.

9 MR. BOYACK: Well, to me, other than just
10 moving along, which we are doing now, it is not too
11 much concern to me. We won't be dealing with BWR's
12 tomorrow. We'll never make it.

13 MR. POWERS: On the BWR's, let me make
14 this comment: that Ralph made a pretty important
15 point, I think, in his presentation that said that BWR
16 fuel is evolving toward looking more and more like PWR
17 fuel with like channel boxes.

18 I suspect that the channel boxes dictate
19 the timing for the degradation, and the fuel rods
20 dictate the release fractions. So I bet you the
21 timing on the BWR's looks about the same as it does
22 now, and the release fractions that we derive for the
23 PWR's begin to look a lot more like the same for
24 BWR's.

25 MR. BOYACK: So we might be able to move

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1 quickly through the BWR here, you're thinking? At
2 least we would have the information on the BWR's that
3 we could take a look at that.

4 Well, look, let's take a minute then and
5 see if Dana's statements about ex-vessel hold true.
6 We said we would start at the center of the table. So
7 Dana?

8 MR. POWERS: I think the people that
9 developed the ex-vessel releases that has dominated by
10 the period of high zirconium, I don't see that
11 changing very much with the high burnup fuels. I
12 don't see any reason to change either the timing or
13 the release fractions then.

14 MR. KRESS: Now the release fractions are
15 the fractions of the full inventory. If we are
16 getting more out in-vessel -- the release fractions
17 are the fractions of the original core inventory, and
18 if we are getting more out in-vessel, we will get less
19 out --

20 MR. POWERS: You've got to keep the sums
21 correct.

22 MR. KRESS: You've got to keep the sums
23 correct.

24 MR. POWERS: Yes.

25 MR. KRESS: I think Dana is exactly right

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1 on the zirconium. So I do see a need to change the
2 timing, change the release fractions, but not the
3 timing.

4 MR. BOYACK: Yes, just stop with timing?

5 MR. KRESS: Yes.

6 MR. SCHAPEROW: Yes, no "oxidation" after
7 "zirconium".

8 MR. BOYACK: Pardon me?

9 MR. SCHAPEROW: After the word
10 "zirconium," add oxidation.

11 MR. BOYACK: Okay, Jim?

12 MR. GIESEKE: I agree with Dana.

13 MR. BOYACK: Tom?

14 MR. KRESS: I agree now with what you
15 have.

16 MR. BOYACK: Okay. Bernard?

17 MR. CLEMENT: Yes, in our first-time
18 evaluation it was the same thing, so high zirconium
19 goes into action. So in our evaluation we had less
20 inventory in the ex-vessel. So, in fact, less
21 fission, so the duration was shorter. But I am not a
22 specialist about that.

23 Jean-Michel?

24 MR. EVRARD: If you consider relative
25 value against the produced value, I see no reason to

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1 change the numbers. No change. In fact, we have a
2 rather small value.

3 MR. BOYACK: Bernard, what I heard you say
4 is that in the French study you may have a shorter --

5 MR. CLEMENT: For the main release, not
6 for the duration of this phase as concerns
7 degradation, but to say what this should be released,
8 it would be released at the beginning of this phase.
9 That's it.

10 MR. BOYACK: Oh, okay.

11 MR. POWERS: I think the reason that the
12 ex-vessel was two hours long is they said, well, it
13 may be that you get a big plump come down and then you
14 get stuff dripping down over some period of time.
15 That's what actually caused them to extend that.
16 Otherwise, it is a huge worry, and then it dies off
17 very quickly.

18 MR. CLEMENT: Yes, that was the point,
19 yes.

20 MR. BOYACK: Dave?

21 MR. LEAVER: I would retain it.

22 MR. BOYACK: And do you guys promise that
23 from now on every one of these will be the same pace,
24 right?

25 MR. GIESEKE: Just like this.

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1 (Laughter.)

2 MR. POWERS: I thought we were going to
3 move a little faster now.

4 MR. KRESS: Now we will get to the late
5 in-vessel.

6 MR. POWERS: I thought the plan was to go
7 faster as we go through this.

8 MR. BOYACK: That's right. I'm sorry, I
9 misspoke.

10 MR. POWERS: What you need to do is say,
11 okay, no lunch break until we get through this much,
12 and see if we are smart enough to delegate pieces to
13 each one and say, "Whatever he says, I go along."

14 (Laughter.)

15 MR. KRESS: We would speed it up by a
16 factor of five.

17 MR. POWERS: Yes, right.

18 MR. BOYACK: I am using end-points because
19 that works for me. So, Tom, we are back to you. Move
20 up, yes, right there.

21 MR. LEAVER: Is this the duration of late
22 in-vessel?

23 MR. BOYACK: Yes, the duration of late in-
24 vessel.

25 MR. KRESS: I think it has probably

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1 shortened because I think there is more fission
2 product volatiles out there to create a faster heatup
3 rate wherever it is deposited. When it starts coming
4 out a little sooner and gets out a little faster -- it
5 is a qualitative statement. I don't know how to pin
6 down any difference. What have we got there, 10
7 hours? That is such a long time anyway that I suspect
8 it is not going to change it much, because the
9 difference between the quantity of fission products
10 that are plated out is probably not going to be much.
11 So I would stick with the 10 hours. If that is what
12 they calculated before, I would stick with it now.

13 MR. SCHAPEROW: The idea is that this is
14 a self-heating basically, that fission products, it
15 heats up the layer of fission products?

16 MR. KRESS: That's my view of it, yes, but
17 I don't think there is much difference in how much is
18 there and how much the heating is, and how much
19 heating is contributed by the steam and hydrogen.

20 MR. BOYACK: If somebody can help me --
21 the period is shorter because there is more fission
22 product volatilization --

23 MR. KRESS: It is shorter, but not
24 significantly shorter is the point.

25 MR. BOYACK: Jim?

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1 MR. KRESS: We have probably increased the
2 semi-volatiles component, and I don't know if they
3 have any effect on this or not, probably not.

4 MR. SCHAPEROW: The only three things that
5 we show as revitalizing are --

6 MR. KRESS: Iodine, cesium, and tellurium.

7 MR. SCHAPEROW: Iodine, cesium, and
8 tellurium.

9 MR. KRESS: Yes.

10 MR. SCHAPEROW: Tellurium is a very small
11 number.

12 MR. KRESS: Yes.

13 MR. GIESEKE: With high burnup, that may
14 change a little bit.

15 MR. KRESS: It may change.

16 MR. GIESEKE: But probably not a definable
17 amount?

18 MR. LEAVER: The magnitude would change.

19 MR. GIESEKE: Yes, the magnitude of some
20 of the other groups of fission products may change,
21 but -- is it my turn to talk?

22 MR. BOYACK: Yes, it is, it's your turn to
23 talk, and in short phrases, succinct, correct, and
24 accurate.

25 (Laughter.)

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1 MR. GIESEKE: You're saying that I usually
2 don't do that, I gather.

3 MR. POWERS: No, he's says as opposed to
4 the previous speaker.

5 (Laughter.)

6 MR. GIESEKE: I will say that, although
7 the composition of the deposits may change slightly,
8 it is not a definable change, and I don't see that we
9 need to change the duration.

10 MR. BOYACK: Dana?

11 MR. POWERS: Get ready to type. Are you
12 ready?

13 MR. LEAVER: He's going to be
14 unreasonable.

15 (Laughter.)

16 MR. POWERS: Yes, I see the late in-vessel
17 release as being composed of three constituents. One
18 is the revaporization of deposited radionuclides,
19 degradation of residual fuel within the core region,
20 and air ingress.

21 MR. BOYACK: Air ingress?

22 MR. POWERS: Air ingress. The existing
23 analyses really only addresses the first two of those.
24 We don't know what the third would contribute as far
25 as source term, and that needs to be experimentally

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1 investigated because we imagine there to be a
2 competition between the degradation process in air and
3 the fission product in air, and we don't know how that
4 competition will come out.

5 MR. KRESS: You are saying the original is
6 wrong?

7 MR. POWERS: Yes.

8 MR. LEAVER: The 10 hours?

9 MR. POWERS: The 10 hours and everything
10 about it.

11 MR. GIESEKE: the change is not the result
12 of higher burnup.

13 MR. POWERS: But I've got to do a little
14 introduction here.

15 MR. BOYACK: Just help me for one second.
16 The competition between?

17 MR. POWERS: Degradation and fission
18 product release.

19 MR. BOYACK: Okay. Thank you.

20 MR. POWERS: Okay. The duration of the
21 late in-vessel release was dictated by the
22 revaporization of fission products off, deposited
23 fission products off the reactor coolant system. I
24 think that is a best speculation, whether that is 10
25 hours or 9, because we don't understand that very

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1 well.

2 So right now, in the absence of additional
3 information, I am going to say stay with the 10 hours,
4 but clearly this is an area where we need substantial
5 further investigations. Some of that will undoubtedly
6 come from the post-test analyses of PHEBUS deposits,
7 deposits from the PHEBUS that peaked on that test.

8 I think that says what I have to say.

9 MR. BOYACK: Okay.

10 MR. POWERS: I am anxious to hear what
11 Bernard has to say because I may want to amend and
12 say, "Me, too."

13 (Laughter.)

14 MR. CLEMENT: Okay, I had some trouble
15 with this phase before, but then I made it very clear,
16 because I think we should not only consider the long-
17 term revaporization, but also other processes. In the
18 other processes, for instance, air ingress, you may
19 have, for a given period of time within these 10
20 hours, higher fission. That should be stressed
21 because consequences would be different when it comes
22 into the containment.

23 MR. BOYACK: Jean-Michel.

24 MR. EVRARD: No further statement at this
25 point.

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1 MR. BOYACK: Okay.

2 MR. LEAVER: I know of no basis for
3 changing the 10 hours, even though it is probably
4 wrong, and I think the air ingress is absolutely
5 crucial to understanding this late in-vessel. We
6 don't know much about that.

7 MR. POWERS: We need an experiment
8 because --

9 MR. LEAVER: Yes.

10 MR. POWERS: We simply cannot right now --
11 I don't see any way to analyze my way out of the
12 accident, out of the dilemma. I mean, I can do an
13 analysis and get a result, but the result is as good
14 as my analysis, and I don't know how good that is
15 until I do an experiment.

16 MR. KRESS: You get a hint from the high
17 oxidation tests on fission product release, you get a
18 hint that that is going to make a difference. It may
19 make more --

20 MR. LEAVER: It's going to be even more.

21 MR. POWERS: When I tried to use MELCOR,
22 I could get any result I wanted by just dictating how
23 fast I got sloping to the curve. Yes, I could get
24 anywhere from absolute catastrophe, a catastrophe made
25 for movies, to nothing, because it sloped together so

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1 fast, and without this prescient -- when it is in a
2 molten pool, there isn't any mass transport
3 capabilities.

4 MR. LEAVER: There's no free surface.

5 MR. POWERS: As my assumptions went, my
6 results went.

7 MR. KRESS: And the calculations
8 previously done assume vapor pressures above the
9 particular temperature for species deposited. That is
10 almost surely to be wrong. There is no activity
11 coefficients for the intermixed species, no chemical
12 reactions for the surfaces.

13 MR. POWERS: That's right, and everything
14 that comes out of the PHEBUS experience says these
15 deposits are far more complicated than we thought.
16 There's some on there that they can't chip off with a
17 hammer, and there's some of them that blow off when
18 they remove parts from the system. Trust me, we never
19 thought of that diversity in the codes.

20 MR. BOYACK: All right, let's continue on
21 and finish the rest of the PWR entries before lunch.

22 (Laughter.)

23 MR. KRESS: It's time for lunch now.

24 MR. BOYACK: Let's see, okay, that's fine.

25 Okay, what I have done here is, that is

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1 the first one in the table. Isn't that noble gases?

2 So the values that are listed here at the
3 top are the NUREG 1465 values. Let's go ahead and go
4 through the phases.

5 David, would you like to --

6 MR. LEAVER: Okay, what are we estimating
7 here?

8 MR. BOYACK: Okay. We are looking at the
9 gap release. So what we are going to do is, for noble
10 gases, the gap release first; the value for NUREG 1465
11 was 5 percent, about .05. So if we go to our logic,
12 we ask, the first question is: Is the given source
13 term of .05 for a gap release of noble gases still
14 applicable? Yes or not yes, is the answer.

15 So you might think through that logic
16 yourself, each of you, as we go on. I do recognize
17 that during the course of the dialog there may be
18 points made that allow us to change our mind. That's
19 fine. We just have to go through the process. This
20 seems to work.

21 MR. KRESS: For some reason.

22 MR. BOYACK: It evokes comments.

23 MR. LEAVER: I can take a crack at this,
24 and I'm sure that I may well want to revise it when
25 the points are made.

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1 We have shortened the interval of this
2 because we recognize that things happen faster for the
3 high burnup fuel. I also think that there is some
4 data, although it is kind of running together in my
5 mind. That is why I was interested in getting those
6 slides that we talked about yesterday that you showed.

7 But it seems like the gap release is a bit
8 higher for the high burnup fuel, but the high burnup
9 fuel is only a fraction of the core. So it would not
10 be unreasonable to maybe nudge the .05 up a little
11 bit, but not too much because we've already shortened
12 the interval, and the high burnup fuel is roughly a
13 third or a fourth of the core. So maybe a 20 percent
14 increase from .05 to .06 or something like that would
15 at least qualitatively get the idea.

16 MR. BOYACK: Jean-Michel, would you have
17 any comments?

18 MR. EVRARD: Yes, as I mentioned
19 yesterday, EDF performed measurements on MOX for
20 different burnup, and this measurement shows that
21 above about 60-gigawatt-days-per-ton, you can reach a
22 value of 5 percent of noble gases in the gap now. And
23 the burn --

24 MR. LEAVER: Above 60?

25 MR. EVRARD: Yes, about. About. The

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1 other point is that there was an in-pile experiment in
2 FLASH with high burnup fuel, and I think it was 50-
3 gigawatt-days-per-ton, which showed about 5 percent,
4 but it only 50-gigawatt-days-per-ton. So the
5 explanation was that the part of the gases would have
6 released in the experiment. So I would say that maybe
7 go over a 50-gigawatt-days-per-ton, and it is possible
8 to have, I believe, not just 5 percent. But, as you
9 mentioned, the high burnup fuel is only a part of the
10 core. So there are all sorts of things to take into
11 account.

12 MR. BOYACK: I'm not sure I have yet got
13 to the point where I can summarize this. I heard you
14 say that French data for high burnup fuel indicates
15 value of about 5 percent?

16 MR. LEAVER: Is that the experimental
17 data? Is that what you said?

18 MR. BOYACK: You referred to EDF data.

19 MR. EVRARD: No, that's two parts. The
20 first part is measurement by EDF on --

21 MR. KRESS: On spent fuel.

22 MR. EVRARD: Yes. They show that you can
23 reach 5 percent at about 60-gigawatt-days-per-ton. So
24 this is the amount of fission product of noble gases
25 in the gap.

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1 MR. BOYACK: All right.

2 MR. EVRARD: And the second part is that
3 there was an in-pile experiment with fuel, high burnup
4 fuel with 50-gigawatt-days-per-ton which showed the
5 release of both of the previous values is about 5
6 percent.

7 MR. BOYACK: Higher than 5 percent gas is
8 what I heard. Again, you can certainly correct any of
9 these that I may have misinterpreted.

10 MR. EVRARD: Okay.

11 MR. SCHAPEROW: Is it prior to this 5
12 percent or at 5?

13 MR. BOYACK: That is what I am not quite
14 sure.

15 MR. EVRARD: So what is it, it was 5
16 percent?

17 MR. SCHAPEROW: At 5 percent.

18 MR. BOYACK: At 5 percent, but then I
19 thought I heard a qualification.

20 MR. LEAVER: Well, I think his opinion is
21 that that's higher, the 5 percent is higher than what
22 you would get at, say, 30 or 40. Is that what you
23 said?

24 MR. EVRARD: Yes, because if you consider
25 the measurement of EDF in the reactor, you would have

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1 less than 1 percent at 50. It would be better.

2 MR. BOYACK: Okay. All right, Bernard?

3 MR. CLEMENT: Really nothing to add to
4 what Jean-Michel said, except that people if want --
5 this is not, I mean, for just to show some kind of
6 statistical work on a LOCA experiment, and what is the
7 released during the transient up to 1200. If you need
8 more accurate data, you have to make fission using the
9 LOCA experiments. I mean, not for this Source Term
10 Panel, it's not so important, but for people like
11 Ralph Meyer or other people working in the same field,
12 you need more data. I think you have to plan LOCA
13 experiments to make fission product measurements.

14 MR. BOYACK: Dana?

15 MR. POWERS: First of all, I think you
16 ought to add that comment.

17 MR. BOYACK: Well, help me with it then.

18 MR. POWERS: Need LOCA experiments, need
19 fission product release, fission gas release.

20 MR. LEAVER: For high burnup fuel.

21 MR. POWERS: For high burnup fuel, yes.
22 Now they've got a few out-of-pile experiments, and
23 they're thinking about some in-pilot experiments.

24 Okay, let's see, I would put a plot up
25 here.

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1 MR. BOYACK: Just hold for a moment.

2 MR. KRESS: Don't mark on the screen.

3 MR. BOYACK: Oh, this one?

4 MR. POWERS: I've got to get back to my
5 microphone.

6 What I had put up here is fission gas
7 releases observed in reactivity insertion accidents in
8 Japan, and the points are I have indicated what the
9 average burnup in the fuel was in gigawatt days per
10 ton. I mean, I understand what they are doing is that
11 they are putting an energy pulse into this fuel, and
12 in some cases the fuel is coming apart, what-not.
13 They do them in a capsule so they capture all the
14 fission gas release. So you get some indication of
15 what an energy pulse does, and you see what amounts to
16 kind of a step behavior.

17 Somewhere between 42 and 50 gigawatt days
18 per ton you get a lot more fission product release,
19 and that is pretty consistent with the existence of a
20 high burnup structure, where you have created a lot of
21 fission products adjacent to the perimeter of the fuel
22 that are available for release.

23 What you would really like to see is, is
24 there a grouping of the results, not just at 50, but
25 as you approach 75 gigawatt days per ton? And we just

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1 don't have those experiments.

2 Now this leads me to believe that there
3 are more fission products available for ready release
4 when you stress the fuel in some way. Here this is a
5 pulse thermal. Does a mild thermal? Well, I think it
6 probably does.

7 So it leads me to believe that there is a
8 substantially higher fission gas release possible from
9 the high burnup fuel. Dave correctly points out,
10 well, that's only a fraction of the total fuel in the
11 core. So if I wanted to do a core averaging, I've got
12 to reduce that down.

13 So I propose to increase the noble gas
14 release associated with the gap period from the
15 existing 5 percent to 10 percent, with the
16 recognition, I think, in total agreement with Bernard,
17 that one needs to look and see if in this LOCA
18 experiments the formal transient that you get in a
19 LOCA is that sufficient to get that near surface gas
20 out.

21 MR. LEAVER: These are RIAs?

22 MR. POWERS: Yes, these are RIAs, but
23 they're putting --

24 MR. LEAVER: We notice the transient is
25 more severe than --

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1 MR. POWERS: Yes, it is a real energy
2 pulse you are putting into the fuel, far more energy
3 that you're getting in in this period between fuel
4 rupture and lightoff of the zirconium. That is not a
5 whole lot of energy. On the other hand, it is a lot
6 of time, and time and energy count here. So I don't
7 know exactly how it goes, but I want reflect that
8 things went up and then just say, measure it.

9 You can get that measurement because, when
10 you reconstitute the fuel for one of these LOCA
11 experiments, yes, you lose the gap inventory, but it
12 is really this near-surface material that you are
13 interested in, whether that adds to the inventory or
14 not.

15 MR. CLEMENT: Couldn't you then control
16 the gases?

17 MR. POWERS: Yes, well, that will give you
18 the amount that is actually in the gap. What I want
19 to know is in this .4 hour period do we get a lot more
20 out.

21 MR. CLEMENT: Yes.

22 MR. POWERS: and I raise to say, yes, I
23 think you will. I'm taking it to 10 percent. Am I
24 going to get down to brass tacks with Dave over his 6
25 percent to reflect that? No, I'm not going to argue

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1 with him. I mean, we're both doing the same thing.
2 We're trying to reflect, yes, there is more gas in a
3 more releasable form near the perimeter, and it might
4 come into the gap release, I think.

5 MR. LEAVER: I can't give you numbers, but
6 in talking to people at Westinghouse, for example,
7 that worry about these non-LOCA-type events such as
8 main steamline break, steam generator tube rupture,
9 locked pump, it is my understanding that the energy
10 deposition, the rate of energy deposition is
11 significantly less than you would see for an RIA. But
12 at the same time, certainly there is some energy
13 deposition, and without really having an experiment or
14 some good benchmark models, we don't know how much of
15 this increase that you see here, which is really
16 rather kind of a step change --

17 MR. POWERS: Yes.

18 MR. LEAVER: You don't know how much of
19 that would apply, but I would say it would be probably
20 appropriate to say that you would expect to see this
21 kind of a step change for these more mild transients.

22 MR. POWERS: Yes, I think what you have to
23 understand is a lot of this energy actually goes
24 fairly deep in the fuel in these things, and it is
25 really the surface that counts here. That is why I am

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1 a little suspect of the out-of-pile experiments, where
2 the heating is coming from the outside instead of from
3 the inside out in this phase. I think they will give
4 us an upper band on the amount of gas at least during
5 the gap phase, in addition to that that is actually in
6 the gap, the inventory.

7 MR. LEAVER: Right.

8 MR. POWERS: In-pile experiments might be
9 better here.

10 MR. BOYACK: Okay, Jim?

11 MR. GIESEKE: Listening to all the
12 comments and the discussion, my sense is that these
13 reactivity insertion experiments probably overestimate
14 the effects, but they do indicate that there might be
15 a significant effect. As you see, we are still not up
16 to the kinds of burnup levels that are of interest to
17 us, which is at least what, a third or fourth of the
18 core.

19 If you would say, well, maybe it would
20 double the rate for that one-third region that is high
21 burnup to, I don't know whether we are talking 70 or
22 thereabouts, gigawatt data per ton, you might take the
23 overall core average up maybe beyond the .6, or the 6
24 percent, up closer to the 10 percent value that Dana
25 is talking about. Somewhere in that range I would

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1 support, probably towards the upper end of that range,
2 maybe not quite as high as 10 percent, but in there.

3 MR. BOYACK: Okay, I'm basically saying
4 that you don't thing the reactivity and insertions
5 events are fully representative. Would support some
6 increase in gap release above 5 percent, but 10
7 percent is at the high end of the range that might be
8 supported, and we haven't decided where it was in
9 here.

10 MR. GIESEKE: Yes, that's good.

11 MR. LEAVER: Just so I understand, Dana,
12 on your increase from 5 to 10 percent, is that in the
13 high burnup fuel or would you say core-wide?

14 MR. POWERS: That's core-wide.

15 MR. LEAVER: So what you're really saying,
16 then, is?

17 MR. POWERS: The high burnup fuel is doing
18 a lot.

19 MR. LEAVER: Is doing more like 20, 25
20 percent?

21 MR. POWERS: Yes, yes, that's what I'm
22 saying.

23 MR. SCHAPEROW: So he is saying it is
24 dominated by that.

25 MR. LEAVER: And you think 20 or 25

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1 percent for this transient which is LOCA?

2 MR. SCHAPEROW: So you're saying like 30
3 percent of the noble gases --

4 MR. LEAVER: Would be released --

5 MR. SCHAPEROW: -- from high burnup fuel?

6 MR. LEAVER: -- from high burnup fuel?

7 MR. POWERS: Around 20, 25 percent,
8 somewhere around in there I think is a pretty good
9 guess. Because, remember, that as we go to high
10 burnup-ness, coefficients are taking place in the
11 perimeter, because the plutonium we have generated is
12 what fissioning. It has a huge a fission cross
13 section relative to uranium.

14 MR. BOYACK: Okay, Tom?

15 MR. KRESS: I must say in this case I am
16 in agreement with Dana that these experiments do
17 indicate that there is more possible releasable
18 material in the gap, and I see no reason not to think
19 it couldn't be released in the less energetic
20 experiments. So I would support the 10 percent
21 actually.

22 MR. LEAVER: What is the conversion of
23 joules per gram to calories per gram?

24 MR. POWERS: You divide by four.

25 MR. LEAVER: So that data at 200 joules

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1 per gram is of the order of 50 calories per gram?

2 MR. POWERS: Yes.

3 MR. KRESS: Pretty darn low, right?

4 MR. LEAVER: And the energy deposition
5 that Steve LaVie was talking about that's in the --

6 MR. KRESS: Two hundred eighty.

7 MR. LEAVER: So that would be out around
8 800 or so.

9 MR. POWERS: The regulation would build
10 upon trace-radiated fuel basically.

11 MR. KRESS: Yes, almost fresh fuel.

12 MR. POWERS: And what we are learning is
13 that high burnup fuel, you just have more damage in
14 the fuel; it behaves funnier.

15 What these data suggest to me is that,
16 indeed, restructuring that perimeter does interesting
17 things to you in the release of the gas. Now I hasten
18 to emphasize this is just the fission gas. I don't
19 think that there is a similar effect with respect to
20 cesium and iodine, and we will get to that number.

21 MR. BOYACK: Yes. Okay, what we've got
22 here is a range, and we had David speak initially but
23 roughly 6 percent he said he could support, 10 on the
24 other end with a couple of participants. I heard Jim
25 saying, well, I'm certainly a little bit more in the

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1 middle; I could maybe stretch to 10 percent. Our
2 French colleagues basically I think they would see
3 higher burnoff, but didn't really say, higher releases
4 but not any specific value.

5 So the question is: What do I put up here
6 for the release?

7 MR. LEAVER: Okay, that's a good question.
8 Let me say something since I was the first one and
9 some things have come up.

10 MR. BOYACK: Absolutely.

11 MR. LEAVER: I would just give an opinion;
12 that is that, to go from 5 percent to 10 percent on
13 the basis of this RIA data -- did I say that right,
14 RIA --

15 MR. BOYACK: Yes.

16 MR. LEAVER: -- just strikes me as too
17 extreme.

18 I am looking at the FLASH data which was
19 just a 5 percent release. That's fission gas;
20 krypton, was that? Jean-Michel, that was a krypton
21 measurement, right?

22 MR. EVRARD: Yes.

23 MR. LEAVER: Yes. I guess it just seems
24 to me to be too extreme. Doubling that number means
25 you really are up to 25 to 30 percent for fission gas

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1 release for the gap release from this LOCA. I just
2 don't believe it is that high.

3 MR. BOYACK: So you would certainly
4 support more data? You would be one who would say,
5 "See needs."

6 MR. LEAVER: Yes, I think certainly there
7 is a need. In all these things there is certainly a
8 need for more data pretty much. It is hard to argue
9 with that.

10 MR. BOYACK: But, specifically, the
11 relationship, the difference between the RIA approach
12 to fuel testing and the more representative France?

13 MR. LEAVER: Right, right.

14 MR. SCHAPEROW: Can you put a range in
15 there for now and go on, say 5 to 10?

16 MR. LEAVER: Yes, what's the process for
17 resolving like where there's differences?

18 MR. BOYACK: I was just going to ask that,
19 and I didn't know the answer. But, of course, the one
20 thing that somebody like myself often tries is they
21 say, oh, since Jim was on that end, would anybody
22 feel, could they live with 7.5 percent or would that
23 still be of great concern to you? If it is, then I
24 think we would just put in a range.

25 MR. GIESEKE: You're asking me if I --

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1 MR. BOYACK: I am asking all of you, 7.5
2 percent?

3 MR. GIESEKE: I did like a real quick
4 estimate. If a third of the core is at 15 and the
5 rest of the core is at 5, you get about 8. So that
6 was why I said 5 to 10, 10 being a little high. That
7 was my judgment to assume. You know, maybe the 15 for
8 that third is too high or too low. You play with that
9 number a little bit, but somewhere in that range I
10 think is where we should put it, maybe mid-range. I
11 don't know.

12 MR. BOYACK: Dana, your thoughts? I think
13 the options here are a range or a value that we sort
14 of live with, but probably lower than 10 percent.

15 MR. POWERS: Since the rationales weren't
16 included here -- I mean, there's an explanation. We
17 see a range here where you have a great deal of
18 uncertainty about this. We have some physics we
19 understand, some physics we don't understand. One guy
20 guesses kind of low at 6 percent, and that is because,
21 in no small part, I suspect, because he believes that
22 the real gap release for low burnup fuel is more like
23 1 percent. I think everybody recognizes that 5
24 percent is a little bit high. I mean, there was some
25 bounding nature, and nobody argued over it because it

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1 wasn't at the time worth arguing.

2 So, you know, that rationale is written
3 out. The rationale for 10 percent is written out.
4 The rationale for 8 percent is written out, and you're
5 selecting 8 percent, yes, I'm going to say yes because
6 in the end you want a number here, because it doesn't
7 do any good to have a range. Then everybody argues
8 about what value to use within the range.

9 MR. GIESEKE: Take the top or the bottom.

10 MR. POWERS: Yes. So I guess I'm
11 comfortable with the averaging kind of approach.

12 MR. KRESS: I don't like "075" because I
13 don't think we know that many significant figures. I
14 would prefer --

15 MR. POWERS: Jim said 8.

16 MR. KRESS: I would prefer the 8. If you
17 look at Dana's --

18 MR. BOYACK: Seven?

19 MR. KRESS: No, 8.

20 If you look at Dana's chart, there's a
21 hint of a trend versus the energetics from the
22 fifties, and if you extrapolate that back to roughly
23 100 to zero energetics, you really might say that the
24 percent of the high burnup fuel release might be like
25 Dana, like Jim said, like 15. If you use that with

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1 the one-third and recognize that the rest of the fuel,
2 the 5 represents an average of 1 to something for the
3 burnup that was in there, and do the math, you get
4 about 8. So I would support a number around like 8.

5 MR. BOYACK: Let me ask a report question.
6 There are several approaches to doing this. There
7 seems to me some value in possibly retaining some
8 identity to the comments if you wish. I'm not adverse
9 to going in and just summarizing and basically make a
10 statement that there were some who felt that the value
11 was smaller and some larger, and we ended up with this
12 medium value. It was important to have a single
13 value.

14 MR. LEAVER: how do you decide that your
15 number of .08 is the number? Is that like a majority
16 vote?

17 MR. BOYACK: Yes, and I'm still
18 struggling --

19 MR. LEAVER: I mean, you could do it that
20 way.

21 MR. BOYACK: Well, we could do that, yes.

22 MR. LEAVER: Or you could present the
23 information and let the NRC worry about how to figure
24 it out. I mean, you're in the range of 5 percent to
25 10 percent, so it's not a huge range.

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1 MR. GIESEKE: We're drawing numbers out of
2 a hat.

3 MR. POWERS: But you would end with 7 and
4 8.

5 MR. BOYACK: Well, for instance, each one
6 of you comes and you represent something, either an
7 individual consultant or a constituency in some
8 regard, which I am sensitive to. So when we were
9 doing the high burnup fuels, we had a very large
10 panel, and we just voted, and we left the span of
11 votes.

12 MR. LEAVER: You had like 20 or 25 people.

13 MR. BOYACK: Yes.

14 MR. LEAVER: It was terrible.

15 (Laughter.)

16 MR. BOYACK: As opposed to this? Oh,
17 absolutely. This is ideal, a small group.

18 Now, generally, in the past what has been
19 possible to do is to sort of reach a general idea
20 that, okay, this is okay with a smaller group. But,
21 on the other hand, I'm not sure that we've had the
22 same constituencies represented where this impacts,
23 real impacts.

24 So I'm struggling here a little bit
25 myself. Each one of these is new. It has its own

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1 circumstances and its own dynamic.

2 So I'm not quite sure which way to go.
3 Obviously, what we've got here is a situation where
4 three people over here say, yes, I could live with .8,
5 8 percent. You're saying 6. That was why I was using
6 7.5, not significant figures, but it was halfway in
7 between.

8 MR. LEAVER: But Tom is right. We don't
9 know it to 2. We probably don't even know it to 1,
10 but we're going to give it a good try.

11 (Laughter.)

12 MR. CLEMENT: Maybe you could add
13 something. There is some filtering or edging between
14 different burnups because from the few data we have,
15 we don't have precise values, but we are certain as
16 for RIA there's an acceleration of release, not at all
17 a linear process.

18 MR. BOYACK: Yes.

19 MR. CLEMENT: So that's why it's difficult
20 to have a value. Personally, I have no difficulties
21 with a range because when we really go up to the in-
22 vessel release, all the rest of the * should be
23 released during this phase. I mean that. For me,
24 putting a range is reflecting * and saying we need
25 data.

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1 MR. LEAVER: Yes, although this isn't
2 necessarily our specific problem, but the buck stops
3 at NRR, and they need to decide, to have a number
4 which the licensees use, unless they tell the
5 licensees to figure it out themselves and do the
6 calculations, but there is no licensee who is going to
7 be able to do that. It just takes too much money and
8 time, and that ain't going to happen.

9 MR. BOYACK: Is it fair to say that if we
10 had 8 percent shown as I have, that that would not be
11 of great concern to you?

12 MR. EVRARD: I think we are convinced that
13 it's higher than 5 percent, but the precise value, we
14 have no way --

15 MR. BOYACK: I guess, yes, you don't know
16 the precise value. Okay.

17 MR. GIESEKE: How about 7?

18 MR. CLEMENT: We should put 8 percent; we
19 have no problem with that.

20 MR. BOYACK: Could you live with 7 then?

21 MR. LaVIE: I will play devil's advocate
22 here. I by no means an expert, but I'm picking up
23 threads here that I want to follow up and see whether
24 or not facts are being considered.

25 Yesterday we had the discussion that the

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1 gap release phase consisted of activity that had been
2 deposited in the gap during normal operation, plus
3 some that was released from the pellet due to the
4 increased heating.

5 Now I don't know where that division lies,
6 but the stuff that has been deposited during normal
7 operations is at much lower energy deposition rates.
8 The diffusion is going to be lower.

9 So that when we look at the reactivity
10 insertion data, the reactivity insertion data includes
11 the release of the gap, but it also includes release
12 from the pellet at much higher energies.

13 Now how does this directly apply to our
14 low-pressure LOCA? I'm thinking the 5 percent or the
15 6 percent may be good, but I'm extremely uncomfortable
16 with the 10. It seems to me that we've gone way out
17 the far end. Because, as Dave has pointed out, not
18 all the fuel is at high burnup, but all the fuel is
19 not at the same radial peaking factor for the buildup
20 of the activity that is in the gap to be released. I
21 haven't heard that mentioned yet. Maybe it is a "no,
22 never mind." Maybe somebody can address that.

23 The other thing I was thinking here,
24 looking at this, is that fission gas release here, is
25 this just the gases that are of significance to

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1 radiological releases? Does this include the stable
2 gases? If it includes the stable gases, I don't think
3 we should be considering it.

4 MR. LEAVER: Do you mean like krypton 85
5 by stable gases?

6 MR. LaVIE: No, there's some that are even
7 more stable than krypton 85.

8 MR. SCHAPEROW: Actually, that's a point
9 that I had forgotten. I believe the dominant dose
10 contributor for the kryptons is a two-hour half-life,
11 krypton 89.

12 MR. LEAVER: Krypton 88.

13 MR. SCHAPEROW: Krypton 88, excuse me. So
14 that will knock this down some. I don't know --

15 MR. POWERS: Not on a percentage basis.

16 MR. SCHAPEROW: That's true.

17 MR. POWERS: It is similarly stable or
18 unstable. I mean, it is just a percentage. I can
19 look up what they actually measured. I suspect
20 they're measuring the gamma signal or something,
21 probably 85.

22 What it does not include is actually the
23 inventory in the rod because these were reconstituted
24 rods; the inventory of the gap, that was released when
25 they reformulated the rod to do the experiment.

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1 MR. KRESS: Yes, because they lost that.

2 MR. POWERS: Yes. So you're really
3 looking at what is released out of the fuel itself.
4 But that's okay. I mean, it is how you draw that
5 curve back to the kinds of energy in there and then
6 how do things change as you go from 50 to 75, all of
7 which are enormously uncertain.

8 I think that leads to agree very much with
9 what we said based on the EDF; it's higher. We don't
10 know how very much. I'm comfortable, again, with the
11 Sulinan view of, okay, we'll take the middle ground.
12 It reflects higher. It doesn't really matter because
13 whatever we don't get here, we're going to get in the
14 next one. That's how I'm going to do the early in-
15 vessel, is that I've got to get the sums correct.

16 MR. GIESEKE: You subtract that from 100,
17 95.

18 MR. BOYACK: Okay, Sulinan tries 7. Could
19 you live with the 7?

20 We're going to go on, and then there will
21 be some debate on the document. That's when comments
22 ought to be addressed. Maybe I will have to pull you
23 all together again.

24 MR. LEAVER: Yes, maybe the thing to do is
25 to go on and talk about the fuel releases and then

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1 maybe come back.

2 MR. BOYACK: Maybe after we go through a
3 bunch of this, because, again, we will print out this
4 information, give it to you tonight, take a look, and
5 I think it is fair game to come back and spend a
6 little time in the morning, as suggested by Jason,
7 revisiting areas of concern.

8 Okay, the next thing we have to do is eat.

9 MR. LEAVER: Good idea.

10 MR. BOYACK: Did you need 15 or 20
11 minutes?

12 (Laughter.)

13 MR. POWERS: An hour and 20 would be just
14 fine.

15 (Whereupon, the foregoing matter went off
16 the record for lunch at 12:08 p.m. and went back on the
17 record at 1:02 p.m.)

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

2 (1:02 p.m.)

3 MR. BOYACK: Now that we've got everything
4 done but the last two entries on -- I couldn't
5 remember what it was -- on the last page --

6 MR. SCHAPEROW: Okay.

7 MR. BOYACK: Okay, the panel is here.
8 We're ready to go.

9 Let's continue on now. We are in noble
10 gases. We have handled the gap release. We are now
11 going to move to early in-vessel, and the 1465 version
12 was that by this time you were up to 95 percent
13 releases in noble gases.

14 Where did I start? I ought to start with
15 somebody new. How about Jim, all right?

16 MR. GIESEKE: Ninety-five percent.

17 MR. POWERS: So we have 102 percent of
18 release, huh?

19 MR. SCHAPEROW: That's what we should do,
20 102.

21 MR. BOYACK: That's right. That's what it
22 was. So is it 100 percent released by this time?
23 See, it was 5 and 95. The total of those was one.

24 MR. KRESS: I don't know where we got 95.

25 MR. POWERS: Don't agree with 95?

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1 MR. LEAVER: Where did it come from? If
2 it came from the fact that they just made it a total
3 of 100 --

4 MR. KRESS: No, no, where did the 5
5 percent go?

6 MR. BOYACK: It was over here.

7 MR. KRESS: Oh, okay.

8 MR. BOYACK: Gap release was 5 percent.

9 MR. KRESS: Okay.

10 MR. BOYACK: The early in-vessel was 95.

11 MR. GIESEKE: So if you make that 95, then
12 you've got 102 percent. See that.

13 MR. KRESS: They just assume all the fuel
14 failed and there was no residual fuel that kept its
15 noble gases in it?

16 MR. BOYACK: So back to Jim. Are you
17 saying --

18 MR. GIESEKE: I don't know that we have
19 any data to show significant radiation.

20 MR. KRESS: It doesn't make any sense.

21 MR. BOYACK: Is the given source term
22 applicable, meaning by the end of the early in-vessel
23 phase --

24 MR. GIESEKE: Yes.

25 MR. KRESS: Yes.

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1 MR. BOYACK: Okay.

2 MR. KRESS: So we just make the math add
3 up right.

4 MR. GIESEKE: If you want to leave it 102,
5 that's okay, too. That will add a little spice to
6 somebody's life.

7 MR. BOYACK: Okay, I'll change that in a
8 moment here. Tom?

9 MR. KRESS: I'll agree.

10 MR. BOYACK: Dana?

11 MR. POWERS: You are going to force me to
12 be the outlier here, aren't you?

13 MR. KRESS: You're like me; you don't
14 really think release on that --

15 MR. POWERS: The problem is this: that we
16 see now that only a fraction of the core is going to
17 be involved at this stage in the accident. This is a
18 large -- I am much more comfortable going along with
19 the summation if we are looking at the range of
20 accidents. But when you tell me I have to look at
21 this large break LOCA specifically, then I want to
22 look at what fraction. By my back-of-the-envelope
23 digestion of what they have, when applied to the large
24 break LOCA, I come up with about 65 to 70 percent of
25 the core being involved at this stage of the accident.

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1 I am willing to concede that most of the
2 core has gone through gap release. I am not willing
3 to concede that most of the core goes through the
4 early in-vessel release. So at this point my
5 predilection would be to come along and say, okay, the
6 early in-vessel release is about 62 percent for the
7 noble gases. What it takes to get to 100, I stick the
8 remainder out into the late in-vessel release.

9 MR. BOYACK: Did you say 62 percent?

10 MR. POWERS: Yes.

11 MR. GIESEKE: Not 63 now.

12 MR. POWERS: That's right.

13 MR. BOYACK: I thought you did.

14 MR. POWERS: That's right. Now I'm exact.
15 I am just making the numbers come out. I say it is
16 about 70 percent of the core, but I have released some
17 from the gap release, and so it's about 62 percent
18 here.

19 MR. BOYACK: I hate to write this down.

20 (Laughter.)

21 MR. KRESS: Let's make it a round number,
22 70 percent.

23 MR. POWERS: What he was saying was not
24 worth hearing.

25 (Laughter.)

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1 He was just picking on me.

2 MR. KRESS: Put a little note: Kress
3 picks on Powers.

4 (Laughter.)

5 MR. LEAVER: And then follow that with
6 another note: So what's new?

7 (Laughter.)

8 MR. BOYACK: Bernard?

9 MR. CLEMENT: Okay. On the French side,
10 we considered 100 percent at the end of the early in-
11 vessel release. I said to Jean-Michel yesterday we
12 should not be below.

13 MR. POWERS: Yes, it is going to be tough
14 to get above that. It will take a very severe
15 criticality event to get it above that.

16 MR. EVRARD: No additional comments.

17 MR. BOYACK: Okay, David?

18 MR. LEAVER: I thought clearly, in my mind
19 anyway, that 100 percent is conservative, but the
20 number could be 85, 90 percent in the extreme. So I
21 think it is not unreasonable to round it up to 100.

22 MR. SCHAPEROW: Dana, I think that's what
23 was done when we did NUREG 1465. Looking at the
24 expert elicitation, each expert gave distributions and
25 they were all below 100, other than the most

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1 conservative point.

2 MR. KRESS: So you're going to take 562
3 and divide it by 6?

4 MR. BOYACK: So we have a range from 62 to
5 what now for the total released by the end of this
6 phase, from 62 to what would be 100 percent, right?

7 MR. POWERS: Well, it would be 93, up
8 there, right.

9 MR. BOYACK: Yes, I have to subtract 7
10 from 62.

11 MR. POWERS: No, 62 is the number; .62 is
12 the number to put up there properly.

13 MR. BOYACK: Oh, okay.

14 MR. POWERS: If you want to reflect most
15 of the members of the panel, you put down 3.

16 MR. BOYACK: Right.

17 MR. POWERS: Now they're wrong, but I
18 can't help that.

19 (Laughter.)

20 MR. LEAVER: But it would be the first
21 time.

22 MR. GIESEKE: That what, we're wrong?

23 MR. LEAVER: Uh-hum.

24 MR. GIESEKE: I'm not admitting to ever
25 having been wrong.

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1 MR. LEAVER: Oh, you're not admitting.
2 I'm sorry.

3 (Laughter.)

4 MR. KRESS: Dana was wrong once, I
5 remember distinctively.

6 MR. LEAVER: Really? When he said you
7 were wrong?

8 MR. KRESS: No, it was that time he
9 thought he was wrong, but later changed his mind and
10 decided he was right.

11 (Laughter.)

12 MR. POWERS: I was wrong twice that day.
13 I was wrong and then I found out I was wrong about
14 that.

15 (Laughter.)

16 MR. BOYACK: You know, the reason that
17 David Leaver did not get through the entire two days
18 of transcripts the last time is because of this, this
19 nonsense.

20 (Laughter.)

21 MR. POWERS: This is the part that helped
22 him, entertained him, right?

23 MR. KRESS: It kept him awake.

24 MR. BOYACK: There were one or two times
25 that I laughed when I read it.

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1 Okay, so, basically, unless Dana really
2 somehow --

3 MR. POWERS: Has an epiphany.

4 MR. BOYACK: Well, you have an opinion; I
5 know that.

6 MR. LEAVER: No, he said an "epiphany."

7 MR. BOYACK: An epiphany? Oh.

8 (Laughter.)

9 Well, I'm sorry, I didn't hear it so well.
10 It must be the projector.

11 Okay, well, with that in mind, I am going
12 to put the 93 percent because I will do it unless
13 somebody tells me otherwise.

14 MR. POWERS: Is this where I get to stomp
15 up and walk out of the room?

16 MR. KRESS: Yes.

17 (Laughter.)

18 MR. BOYACK: Don't give him that option.

19 MR. SCHAPEROW: I would leave it the way
20 it was --

21 MR. BOYACK: Because, eventually, the
22 reason I went to this is because now I can always see
23 the heading that goes with the information, whereas
24 otherwise it just gets cluttered. So it's simplicity
25 for one of us.

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1 Okay, ex-vessel, now we're zero and zero,
2 aren't we?

3 MR. LEAVER: Yes, we're done.

4 MR. POWERS: No, it is 31 percent out at
5 the late in-vessel.

6 MR. BOYACK: Okay, so --

7 MR. GIESEKE: And then average that,
8 divide it by 6 and get an average.

9 (Laughter.)

10 MR. BOYACK: So what I can put down here
11 -- no. So you had 62 and instead of 69 -- you had 31
12 percent.

13 MR. POWERS: That's what I said, 31
14 percent in late in-vessel release. Because, if you
15 recall, timing-wise they overlap with the ex-vessel
16 release.

17 MR. BOYACK: So this is one way, Dave, of
18 sort of dealing with this.

19 MR. LEAVER: Sure.

20 MR. BOYACK: This is the only reason Dana
21 did this, was just to illustrate a way that we could
22 have different opinions.

23 MR. POWERS: Yes, Brent asked me to do
24 this beforehand.

25 MR. LEAVER: You guys cooked this up at

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1 lunch?

2 MR. POWERS: Yes, yes.

3 MR. KRESS: Actually, truth be known, I
4 agree with Dana. I just thought it was probably a
5 "no, never mind."

6 MR. LEAVER: Oh, I think he's more right
7 than we are.

8 MR. KRESS: Yes. If we want to really
9 have a vote --

10 MR. LEAVER: But, I mean, if we're going
11 to change the .93, we would be, I guess, saying 1465
12 was wrong or too conservative.

13 MR. KRESS: Or that it didn't make any
14 difference probably.

15 MR. LEAVER: Well, it would make some
16 difference for the design basis accident.

17 MR. KRESS: I don't know. Equivalent
18 qualification or anything --

19 MR. LEAVER: Probably not much difference
20 for EQ because, if it doesn't come out early in-
21 vessel, it will come out in the later phases, all of
22 which is 12, 16 hours. The EQ is like a 100-day --

23 MR. KRESS: It might impact on meeting 10
24 CFR 100 doses at the --

25 MR. LEAVER: Yes, it would impact the

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1 design basis, doses, yes.

2 MR. KRESS: But that is governed mostly by
3 iodine, isn't it?

4 MR. LEAVER: It is, but you would see, one
5 of the things that turns out is, if your mitigation
6 systems are effective or if you do a careful job of
7 evaluating aerosol deposition, for example, about all
8 you're left with, at least for the 30-day doses,
9 control room and the LPZ, is noble gases and organic
10 iodine.

11 MR. KRESS: Well, maybe we ought to do it
12 the way we really think. I really think about 30
13 percent is late in-vessel and the rest of it is gap
14 release and early in-vessel. Dana, you said what was
15 your number?

16 MR. POWERS: I have between 65 and 70
17 percent of the core involved in this phase, this early
18 phase of the accident here.

19 MR. KRESS: It's at least 30 percent
20 roughly.

21 MR. POWERS: Roughly 30 percent. It comes
22 in, the late in-vessel release --

23 MR. KRESS: Yes, I would definitely
24 support that. It is what I believe.

25 MR. LEAVER: Interestingly, these

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1 calculations were the basis for 1465. These were in
2 NUREG CR 5747. You have mean values of noble gas
3 release for BWR's - or for PWR's of 80 percent for
4 this sequence.

5 MR. KRESS: The mean?

6 MR. LEAVER: Yes, they do a variety of
7 sequences, but you can imagine a sequence in which you
8 kind of keep the core intact as long as possible and
9 it would toast things and you can get higher --

10 MR. KRESS: Get higher releases.

11 MR. LEAVER: -- releases. So their number
12 is a little higher than what Dana is suggesting, but
13 not a lot. I mean, yours is about 7 percent full. So
14 they're saying 80 percent.

15 MR. BOYACK: Okay, I have now heard two
16 people with the Dana Powers approach. So, Jim, do you
17 want to stay where you are or do you want to respond
18 to the argument?

19 MR. GIESEKE: Well, I think it is a good
20 argument. I can back off a 100 percent. I think we
21 all agree that not all the core is going to be
22 involved to that extent at that point in time. I
23 don't now if we have any good sense of what that
24 number should be. It's a big number, but it's not 100
25 percent, maybe 80 percent.

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1 MR. LEAVER: Well, we had a calculation,
2 for what it's worth.

3 MR. GIESEKE: Yes, that 80 percent.

4 MR. LEAVER: Yes, 80 percent.

5 MR. GIESEKE: And we have this here.

6 MR. BOYACK: David, where do you end up on
7 this?

8 MR. LEAVER: I guess I would ask a
9 question of the panel or possibly the NRC. Are we --
10 and I think maybe I know the answer -- but the delta
11 approach would say we would just leave this at a total
12 of 100 percent because it can't get any worse than
13 that.

14 Then the other approach is to say, well,
15 where we don't like what 1465, the original 1465 did,
16 we're going to suggest a different number, and that's
17 kind of what we are doing here.

18 MR. KRESS: It has nothing to do with
19 burnup.

20 MR. GIESEKE: Yes, it has nothing to do
21 with burnup.

22 MR. LEAVER: It has nothing to do with
23 burnup.

24 MR. GIESEKE: It has nothing to do with
25 burnup, but the implication is that what we're doing

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1 is the result of burnup.

2 MR. LEAVER: But I haven't heard anybody
3 say that we shouldn't try to be more correct, if we
4 think there is something wrong with 1465. Up to this
5 point, I haven't heard anybody say that. So I would
6 say probably that's -- I would go along with a number
7 more like 70 or 80 percent.

8 We're kind of stepping outside of our
9 objective, I guess.

10 MR. BOYACK: I don't think we are.

11 MR. SCHAPEROW: No, I don't think so.

12 MR. LEAVER: You don't think so?

13 MR. SCHAPEROW: I think just about
14 anything we've learned in the last 10 years is game as
15 long as it is applicable.

16 MR. KRESS: We were supposed to ask, is
17 the given source term apt, and in this case we would
18 say no. Can we specify a new value? Yes. So we
19 haven't followed that chart up there.

20 MR. BOYACK: Our French colleagues
21 basically told us what they had done. You can see the
22 way this is trending, which would be that we would put
23 62 percent.

24 MR. GIESEKE: I think 62.5 percent.

25 MR. BOYACK: No, not 62.5.

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1 What I really wanted to ask was, because
2 I understand what you've done, but is there any strong
3 disagreement or facts you would like to bring to bear
4 on this change?

5 MR. CLEMENT: What we've done does not
6 make any difference from a late in-vessel release and
7 early in-vessel release. So at the end we've got the
8 100 percent.

9 MR. BOYACK: Okay, right.

10 MR. CLEMENT: That was what was
11 originally --

12 MR. BOYACK: Right, that would be in
13 agreement with 1465, yes.

14 MR. KRESS: Why not 63? Put the 63 there,
15 so it makes the other one 30.

16 MR. CLEMENT: I have a question for Dana.
17 When you say 65 to 70 percent of the core is involved,
18 but there is some release from the part of the core
19 that is not involved.

20 MR. POWERS: Yes.

21 MR. CLEMENT: So it's not right just to --

22 MR. POWERS: Yes, the two numbers are not
23 quite consistent with each other.

24 MR. CLEMENT: Yes.

25 MR. POWERS: I would say it would be 60 to

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1 70 percent, and that will make it consistent.

2 MR. CLEMENT: Yes.

3 MR. POWERS: Yes, you're right. You're
4 right.

5 MR. BOYACK: Is there something I ought to
6 be doing up here?

7 MR. POWERS: Yes, change it to 60 to 70
8 percent. Bernard's caught me on a consistency
9 problem. That will get it back to --

10 MR. BOYACK: Okay, now just I need some
11 statement regarding the ex-vessel release phase.
12 Let's see, this was now 63, and this was 30, but I'm
13 just going to put both of these on the same sheet.

14 But what was the statement about ex-vessel
15 and there being no releases there?

16 MR. KRESS: We just don't think there is
17 any down there.

18 MR. POWERS: If there is any noble gas in
19 that fuel when it's molten, dumped out on the floor,
20 and hits either water or concrete, it is gone so
21 quickly, it's indistinguishable for having released it
22 in the fuel.

23 MR. LEAVER: Yes, it probably wouldn't be
24 much.

25 MR. POWERS: No, it is not going to be

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1 much.

2 MR. SCHAPEROW: How about no remaining
3 noble gas.

4 MR. POWERS: In molten fuel that is
5 expelled from a reactor coolant system.

6 MR. LEAVER: I mean, you might have some
7 chunks of unmelted fuel.

8 MR. POWERS: Yes, you could, but not much.
9 When you blow steam or concrete, composition gases
10 through it, it spreads it out so quickly.

11 MR. EVRARD: The only problem I have, if
12 you increase the late in-vessel release, I mean, it's
13 not too long, but this will be done quite early in the
14 late in-vessel release.

15 MR. POWERS: Yes, right.

16 MR. EVRARD: The situation we have, we
17 have put the situation for revaporization. So if we
18 put the logic on here, we have to be consistent in
19 saying it will be released at the beginning of the
20 late in-vessel release.

21 MR. LEAVER: That's a good point.

22 MR. POWERS: You could probably do that
23 with a footnote or something.

24 MR. LEAVER: It's a good point.

25 MR. CLEMENT: It's the continuity of the

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1 early in-vessel, early impact. So it continues.

2 MR. POWERS: Right.

3 MR. BOYACK: Is that what I heard, that
4 basically this remaining release would occur very
5 early in this phase?

6 MR. POWERS: I would be heavily biased
7 toward the early phase. You might actually get the
8 last of the 30 percent out at the end of the late in-
9 vessel, but it would be a bunch at the beginning and
10 then kind of tail-off. So the limit of this
11 resolution, it is in the early part of it.

12 I think just the way Bernard said it is
13 correct.

14 MR. BOYACK: Is that what I wrote?

15 MR. POWERS: Yes, I think you got it.

16 MR. BOYACK: All right.

17 MR. KRESS: The late in-vessel was 10
18 hours?

19 MR. BOYACK: Yes.

20 MR. KRESS: I agree, it's not going to
21 take 10 hours.

22 MR. LEAVER: But it might for the last
23 fuel rod

24 MR. POWERS: The last fuel rod in the most
25 peripheral location up or next to a downed cooler or

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1 something like that, that one might actually release
2 it at the end of the 10 years, but by far most of it
3 is going to be up in the front end of it.

4 MR. BOYACK: Okay, Dave, do you have any
5 additional comments?

6 MR. LEAVER: the only comment I would make
7 is I would just offer this to think about: That
8 number .63 sounds like we know what it is, and of
9 course we don't.

10 (Laughter.)

11 And we have a calculation that was done as
12 part of and in support of the original 1465 that has
13 a -- well, there's several different numbers, but .8
14 is kind of, I guess, looks like the mean number. I am
15 assuming this .8 is the total of what we say, the .07.
16 Then if we made that number .73, we would have a
17 number that is, in fact, the same as what they used as
18 the basis for 1465, even though they then increased it
19 to 100 percent. We are not sure why they did that.

20 So we might be on a little bit more
21 defensible ground if we said, well, we see no reason
22 to use a number different than what was in the NUREG
23 CR 5747. You use a lower number.

24 MR. KRESS: They used MELCOR to get those
25 numbers, and it notoriously overestimates the noble

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1 gases.

2 MR. LEAVER: I don't now if that's right.
3 Did it use MELCOR for these numbers, the NUREG 5747?
4 Where do these numbers come from?

5 MR. NOURBAKHS: They are all expert
6 elicitation.

7 MR. KRESS: Not MELCOR, but CORSOR.

8 MR. LEAVER: Expert elicitation.

9 MR. KRESS: They got the original numbers,
10 though, and guided the experts out of CORSOR, and
11 CORSOR notoriously overestimates noble gases.

12 MR. BOYACK: So would you help me with
13 what comment you would like me to enter here?
14 Sometimes the conversation gets long enough that I
15 don't know quite what to write.

16 MR. SCHAPEROW: I think it is probably
17 worth noting, just in case we ever come back and
18 revisit this, that NUREG CR 5747, which was referenced
19 in 1465, is the basis for a lot of these numbers. Now
20 I am told that the numbers from 5747 were from the
21 expert elicitation. I didn't realize that.

22 But it would give you a number, total
23 noble gas release for the gap plus early in-vessel of
24 .8. So we're suggesting a number that's about 10
25 percent less than that. I guess maybe one basis would

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1 be what Tom is saying, that we believe that the expert
2 elicitation was at least in part based on CORSOR,
3 which people believe has overestimated the noble gas
4 release.

5 MR. SCHAPEROW: Yes, I think it is 83 and
6 80.

7 MR. LEAVER: Yes, I guess there were two,
8 a high zirc case and a low zirc case. TMI is about 55
9 percent, just for perspective.

10 MR. POWERS: But that's a high pressure
11 sequence.

12 MR. LEAVER: Yes, I think they had some
13 high pressure numbers in here. I'm not sure I can
14 figure out which ones are which, but, yes, that's
15 right.

16 What was the RCS, down to about 600 pounds
17 TMI?

18 MR. POWERS: It got down to the point that
19 the accumulators were starting to dump, but they were
20 still closing --

21 MR. LEAVER: Yes, so it's probably about
22 600 or 700 pounds?

23 MR. POWERS: That's 625 to 650, something
24 around in there.

25 MR. LEAVER: Yes.

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1 MR. POWERS: It was only there for a
2 little bit of time because they kept bumping the main
3 coolant pumps and things like.

4 MR. BOYACK: Any comments, Jim? Any
5 different comments? You're allowed to say, "okay" to
6 the above.

7 MR. GIESEKE: Yes, it's okay. I think
8 we're pretty consistent throughout.

9 MR. BOYACK: Essentially, what we have
10 done here is we have said, okay, we'll leave the
11 values the same, but we have noted that you could make
12 a consistency argument for NUREG 5747. Is that NUREG
13 CR?

14 MR. LEAVER: Yes, it's a CR, right.

15 MR. BOYACK: 5747, which would go to 80
16 percent through the early in-vessel phase, in which
17 case this would be 20 in the late in-vessel, but we
18 haven't changed the numbers.

19 MR. GIESEKE: It's good.

20 MR. BOYACK: Okay.

21 MR. LEAVER: The other thing we might just
22 note is in 1962 they issued TID 14844, which became
23 the basis for licensing every single operating plant
24 except those that have since gone to the alternate
25 source term, and it was 100 percent. It doesn't make

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1 it right, but that's what was done.

2 MR. BOYACK: II was going to say, where
3 did that file go?

4 MR. POWERS: I think Boyack has been doing
5 his homework. Look at this. He's got all of these
6 files all set up. He's earning his money, Jason.

7 MR. SCHAPEROW: He was on vacation last
8 week while I did this, up in Utah or something.

9 (Laughter.)

10 MR. POWERS: You know, these guys from Los
11 Alamos, they really don't have lives. They live up
12 there on the top of the mesa.

13 MR. KRESS: Nothing to do up there.

14 (Laughter.)

15 MR. BOYACK: Are they related?

16 MR. SCHAPEROW: With respect to releases
17 from the core they are, but now we've got deposition
18 coming in.

19 MR. BOYACK: If they're not related, I
20 would rather not do it because then you run out of
21 space here on the screen.

22 MR. SCHAPEROW: I was suggesting that we
23 add a line right above "halogens" for the new noble
24 gas numbers, because that is reflective more of how
25 much of the core is given up there. They're volatile

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1 fission products. This is it on the additional
2 element of the deposition. I don't know if that would
3 be of any use to the panel.

4 MR. POWERS: Well, I actually did it the
5 other way around. I said, if I'm going to get 35
6 percent of the halogens out, how much of the core must
7 have deposited, given that it is a high burning
8 sequence, and I said, well, you aren't going to
9 deposit more than about half in a large break
10 sequence. So I said, well, about 65, 70 percent,
11 something like that, and then I was corrected to 60 to
12 70 percent. I wasn't going to argue over that.

13 MR. LEAVER: Well, you're right, we've got
14 these tables, which actually are not in 1465, but are
15 in this NUREG CR 5747. It assumed a retention of not
16 quite a factor of two, I guess a transmission of .55,
17 which would be a retention of .45, and it had a
18 release of iodine of about .7. So you take .7 times
19 .55 and you get about .4. That's where the number
20 came from.

21 MR. POWERS: I mean, I just worked it the
22 other way around --

23 MR. LEAVER: Yes, sure.

24 MR. POWERS: -- to come up with how much
25 core was creating.

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1 MR. LEAVER: Right.

2 MR. POWERS: I did it in my head, so I'm
3 not quite exact with those numbers.

4 MR. BOYACK: I was actually looking for
5 the slide that had the PWR releases from NUREG 1465.
6 I just would have marked on the revised values and put
7 it up on the screen.

8 MR. LEAVER: Well, here, take this copy
9 and I'll show you where it is. The table, you mean?

10 MR. BOYACK: Well, actually, no, I'm after
11 the transparency. It's gone someplace and I don't
12 know where it is. It disappeared.

13 Okay, so with that, the reason you're on
14 the panel is you all have fantastic minds and
15 memories. So let's go on --

16 MR. POWERS: We all have CRS, as Tom Kress
17 will assure you.

18 MR. KRESS: That's right, CRS.

19 MR. BOYACK: Okay, gap release.

20 MR. KRESS: He isn't going to ask. He
21 knows better than to ask.

22 (Laughter.)

23 MR. BOYACK: Okay, what is "CRS"?

24 MR. POWERS: Can't remember stuff.

25 (Laughter.)

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1 MR. LEAVER: I've got that disease, too.

2 MR. POWERS: I vulgarized it from the
3 transcript.

4 MR. BOYACK: Okay, we're on halogens, gap
5 release. Tom, it's time for you to go back to work
6 here.

7 MR. KRESS: We're on the gap release part
8 of halogens?

9 MR. BOYACK: Sure, unless you want to just
10 give me all four numbers.

11 MR. KRESS: I was going to give you all
12 four numbers.

13 MR. BOYACK: I'll just write down "TK" on
14 each one then.

15 MR. KRESS: I think the gap release is the
16 same. I think the early in-vessel release would be
17 about 70 percent, if you didn't count deposition. And
18 if you counted deposition, it is going to be about 40
19 percent. So, let's see, that gives me 75.

20 Ex-vessel, I think the late in-vessel is
21 probably -- I don't have any reason to change it. I
22 want to keep it and the remainder is excess.

23 MR. BOYACK: Okay, so that says 5, and
24 this was 75, 85; this is 15 percent.

25 MR. KRESS: Now the early in-vessel comes

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1 out to be 40.

2 MR. BOYACK: Oh, I'm sorry.

3 MR. KRESS: Yes.

4 MR. POWERS: I mean, you're revaporizing
5 it, that 30 percent that you deposited, I mean some
6 fraction of it. So you've got to make a
7 revaporization argument here.

8 MR. KRESS: Yes, but -- no, no, I think I
9 would put the full 70.

10 MR. BOYACK: Was that 50? I think it was
11 75.

12 Shall we let somebody else weigh-in on
13 this? You can do just one, if you want, Jim, but
14 otherwise if you want to look at it in total, that's
15 fine, too.

16 MR. LEAVER: Can I just ask Tom a
17 question? Is this a release from the fuel or into
18 container?

19 MR. KRESS: The 70 percent I meant to be
20 released from the fuel.

21 MR. LEAVER: Yes, that's what I thought.

22 MR. KRESS: I'm trying to figure out what
23 -- I meant that to come out of the fuel --

24 MR. LEAVER: Right.

25 MR. KRESS: -- in addition to the gap. I

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1 have no reason to believe the amount that gets
2 deposited in the RCS is any different than it was
3 before. I'm trying to figure out -- they've got a
4 late in-vessel of .1, which means they think 40
5 percent or they think only 1 percent got trapped and
6 all got released.

7 MR. POWERS: I assumed that they assumed
8 that, the way they went, they said about half of
9 whatever was released in-vessel got trapped in the
10 piping system.

11 MR. KRESS: Forever?

12 MR. LEAVER: No, no, not forever.

13 MR. POWERS: It just got trapped there,
14 and about a third of that subsequently revaporized, to
15 give them the late in-vessel release.

16 MR. KRESS: Okay, so they started out with
17 the total release of the fuel of .45?

18 MR. POWERS: No, the total release from
19 the fuel, the fuel itself, I suspect they were looking
20 at a number, if Dave is correct, it's 80 percent.

21 MR. KRESS: What's not in that total up
22 there was left on the surfaces.

23 MR. POWERS: That's right.

24 MR. KRESS: Okay. I don't have any reason
25 to change those fractions except I think that the

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1 total it gets out of the fuel is about 70, and they
2 had about half of it, do you think? So I would still
3 say it still becomes 35 because that's about half of
4 70.

5 MR. SCHAPEROW: I did make a copy of the
6 deposition that was done on 1150, if anybody's
7 interested. It's for each group on one page. I'll
8 pass it around.

9 MR. KRESS: So I didn't change anything,
10 even though I thought I was going to.

11 MR. BOYACK: So, in effect, when we came
12 down the logic diagram, you said, is the given source
13 term applicable, and you just said yes.

14 MR. KRESS: Yes.

15 MR. BOYACK: And so you told me yes.

16 MR. KRESS: I thoroughly agree we get more
17 iodine released from the higher burnup fuel. This
18 tells you you would get more released. Mentally, it
19 tells me that I get some fraction of higher release
20 from the fuel than you would have previously, because
21 you've got higher burnup fuel in there, and that tends
22 to give you more release.

23 Except I thoroughly believe that they
24 overestimated the iodine release in the 1465. So if
25 I correct the 1465 for the overestimate and then add

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1 the increment that I get from the high burnup fuel, it
2 turns out to be the same, and that's why I was
3 surprised, that I got the same thing. I thought I was
4 going to adjust it, but I'm ending up at the same
5 place that they were.

6 The reason that I think they overestimated
7 it is once again because CORSOR overestimates the
8 release.

9 MR. POWERS: I think that's where I am, I
10 guess. I think; therefore, I am, right?

11 (Laughter.)

12 MR. BOYACK: Okay, now was that just the
13 gap release phase that you just described or was
14 that --

15 MR. KRESS: No, that was the early in-
16 vessel part. It was the early in-vessel part that I
17 would say CORSOR overestimates. I correct for it and
18 then add in a correction for the high burnup; I end up
19 at the same place.

20 MR. BOYACK: Okay, and the gap release,
21 you just feel like it is the same?

22 MR. KRESS: There is a burnup correction
23 in ANS 5.4 which contains a little higher, but I think
24 the .05 is already kind of a higher estimate than it
25 should have been. So I'm going to leave it where it

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1 is. I don't have any reason to change it.

2 MR. BOYACK: Okay, Jim?

3 MR. GIESEKE: My sense was that the gap
4 release should ease up a little higher, to a little
5 higher number. I don't know how far to take it. It's
6 not a lot. It's just a nominal increase perhaps, .6.
7 No, that's a little bit -- that's not enough to worry
8 about maybe. That's within the uncertainty. Perhaps
9 we could just leave it the same.

10 I followed as much the same logic as Tom
11 on the others. I wanted to bump the releases.
12 Particularly the in-vessel release was above a good
13 1465 number, I mean NUREG 1465 number, but if the
14 sense is that those are too high, and I don't know how
15 much too high because with CORSOR it is kind of hard
16 to judge. So it gets to be maybe to the best of our
17 knowledge a wash, like Tom is calling it. I could go
18 along with that. I could accept that.

19 MR. BOYACK: So your logic was
20 basically --

21 MR. GIESEKE: Yes, basically, the same as
22 Tom's. I wanted to raise them, but if they're already
23 overestimates, then you have to make that correction
24 back down. Raise them for the effect of burnup, but
25 then back them down to the previous overestimation.

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1 MR. BOYACK: What about the logic, either
2 Tom or yourself, for ex-vessel, which has stayed the
3 same also? I guess by the time you get to the last
4 one there's no -- it's a big system, but --

5 MR. POWERS: No, that's not the case now.

6 MR. KRESS: The ex-vessel just says
7 whatever didn't get released from the fuel in-vessel
8 is going to get released ex-vessel.

9 MR. BOYACK: Oh.

10 MR. KRESS: It's the late in-vessel that's
11 questionable.

12 MR. GIESEKE: That's right.

13 MR. KRESS: Because it's a resuspension
14 revaporization thing, and all I did is say I don't
15 know how to correct it for what they did before,
16 although it very well could be different.

17 I think that is the same.

18 MR. BOYACK: Pardon me?

19 MR. KRESS: I think that one is the same.
20 I don't think that one changed. It's the late in-
21 vessel that I'm saying.

22 MR. BOYACK: Oh, that's why you're keeping
23 me straight here.

24 MR. KRESS: I have no reason to change it
25 because I don't know how to change it. It very well

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1 could be different.

2 You can zap the ex-vessel part of that.

3 You can zap the ex-vessel part of that sentence.

4 MR. BOYACK: Okay. All right, Jim,
5 anything else you want to add on either of these?

6 MR. GIESEKE: Ex-vessel, I would hold the
7 same -- oh, you're down on late in-vessel?

8 MR. BOYACK: Well, no.

9 MR. GIESEKE: I would take that as the
10 same logic as Tom; whatever was left there goes out.

11 The other one --

12 MR. BOYACK: Well, I thought that related
13 to the late in-vessel. I don't think I had logic for
14 ex-vessel, but I --

15 MR. KRESS: The ex-vessel is, whatever
16 didn't get released in-vessel will get released ex-
17 vessel. That's the logic there.

18 MR. GIESEKE: That's right.

19 MR. KRESS: The logic for the late in-
20 vessel is different.

21 MR. GIESEKE: Yes.

22 MR. BOYACK: Now is this correct?

23 MR. KRESS: No, that's wrong. It is a
24 mixture of the two.

25 MR. BOYACK: So help me get it right.

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1 MR. KRESS: What it is is I have no basis
2 to change it, although I think it could be different.

3 MR. BOYACK: Okay.

4 MR. KRESS: Yes, that's the one.

5 MR. GIESEKE: No, no, no, no, I'm not done
6 with --

7 MR. BOYACK: Ah, good.

8 MR. GIESEKE: We're just getting down --
9 the logic basically for 1465 is that roughly, what
10 we're saying, a third of what was deposited is
11 released. I think it is higher than that because I
12 believe the models that are used in that don't take
13 into account the discontinuities or the irregularities
14 in the depositions or the deposits. It would tend to
15 assume that they were more uniform across surfaces,
16 where, in fact, they are not going to be that uniform,
17 which I think will lead to higher releases, but I
18 don't know how much.

19 Again, I could take up. Instead of saying
20 a third, I could say a half, which would raise that
21 number maybe not enough to bother with, but it could
22 take it up to maybe late in-vessel to be 17 percent.
23 Pick a number.

24 MR. SCHAPEROW: And this is based on the
25 idea that they are self-heating, the fission products?

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1 Because Dana mentioned a couple of different
2 mechanisms, and it might help us in the end to see
3 which mechanisms are referred to. It's a little
4 confusing to me.

5 MR. BOYACK: So it's self-heating --

6 MR. SCHAPEROW: Self-heating of fission
7 deposits, deposited fission products.

8 MR. GIESEKE: I think that's
9 underestimated because the deposits are not uniform.

10 MR. SCHAPEROW: Oh, that's right, because
11 the deposits are not uniform.

12 MR. BOYACK: So let's see --

13 MR. GIESEKE: I think we are going to have
14 hotspots, is what I'm saying, more than calculated.

15 MR. BOYACK: Dana?

16 MR. POWERS: I believe that we can leave
17 the gap release at 5 percent because it is basically
18 a vaporization phenomena into a gas that is dominated
19 by the fill gas. Since the temperatures and timing
20 are about the same, and the fill gas is about the
21 same, it is going to be about the same.

22 MR. BOYACK: I didn't get all that.

23 MR. POWERS: Vaporization phenomenon into
24 the fill gas which didn't change.

25 MR. BOYACK: Good, thanks.

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1 MR. POWERS: I believe that the roughly 60
2 to 70 percent of the core degradation is a strong
3 function of the core degradation, and I'm not willing
4 to change that. I acknowledge that we need to
5 experimentally investigate core degradation with high
6 burnup fuel, which might be different. But at this
7 point I am not going to change and I am going to stick
8 with the roughly 50 percent deposition in the piping
9 system, so the number doesn't change.

10 I want to emphasize that, to do this
11 right, you've got to understand how high burnup fuel
12 degrades.

13 MR. BOYACK: And that's experiment?

14 MR. POWERS: Yes. You need to understand,
15 experimentally investigate it.

16 MR. KRESS: It is a tough experiment to do
17 because I think you have to take it to its burnup in
18 situ.

19 MR. POWERS: I'm not that big of a bug on
20 that. I'll take it any way --

21 MR. KRESS: You have to be very careful
22 with transporting it, moving it.

23 MR. POWERS: I think you have to --

24 MR. KRESS: I don't think you can go pick
25 up old fuel that has been sitting around 20 years that

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1 has that burnup and bring it over and do the test.

2 MR. POWERS: I think you've got some
3 challenges ahead of you in extrapolating from the test
4 to the reactor accident, but I'll take anything I can
5 get right now.

6 Okay, in the ex-vessel release we have
7 dumped the degradation of fuel that didn't get it in
8 the early in-vessel phase, and so I am going to leave
9 that alone because that is eventually how the fuel
10 goes.

11 MR. BOYACK: Does it conserve the fuel
12 degradation and early in-vessel phase? Is that what
13 you said?

14 MR. POWERS: No, it's --

15 MR. BOYACK: No change because?

16 MR. POWERS: Because that's just the
17 degradation of the fuel that was left over. It's a
18 mass balance thing.

19 MR. BOYACK: Okay.

20 MR. POWERS: Okay, the late in-vessel, I'm
21 going to go along with Jim, but I'm going to elaborate
22 on the reasons. He believes in hotspots and what-not.
23 I also think that, with respect to the halogens,
24 they're sensitive to the oxygen pressure. So if you
25 have air circulating through this piping system, we're

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1 going to jack up the releases.

2 On the iodine, I note that if we look
3 carefully at some of the recent PHEBUS results that we
4 had seen evidence of revaporization occurring after
5 they shut off the source, even though they are only
6 circulating steam at that point, so I think air will
7 have a more profound effect.

8 I had independently arrived at a number of
9 like 20 percent of the iodine inventory. I don't know
10 that that's conceptually different than Jim's 17
11 percent.

12 MR. KRESS: I would prefer to use 20.

13 MR. GIESEKE: I like 20, too. That's a
14 round number, you know.

15 MR. POWERS: And I would again say that I
16 anticipate that in the post-test analyses that are
17 going on as part of the PHEBUS program, we are very
18 likely to get some more information on whether air
19 will cause revaporization or not.

20 Better said that way than the way I said
21 it.

22 MR. BOYACK: You know, I could shift,
23 instead of putting you first, we could put Jean.
24 Okay, all right.

25 MR. CLEMENT: Before coming to numbers, I

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1 would like to say some words about how we've done this
2 same job. First of all, for the sequences that are
3 considered, there are large break LOCA, hot leg break,
4 okay? Given what we have seen on the different
5 experiments, in the case of a hot leg break, we
6 consider that we could neglect deposits of iodine in
7 the RCS. So that's the first point.

8 Then, in fact, in our numbers we have put
9 100 percent release at the break for all the phases.
10 That means we have considered that we have zero
11 release from ex-vessel. We think it is released
12 during the gap release or from a short release.

13 So I would say we do not like the
14 distinction that's spoken before, for noble gases, for
15 the part of the fuel that is 60 to 70 percent involved
16 in the degradation in the late in-vessel release, and
17 the remainder that are in the -- the remainder is in
18 the late in-vessel release, and it is 60 to 70 percent
19 involved is in the early in-vessel release. So, thus,
20 we are not to make the difference, and we should like
21 to be consistent with what was done for another
22 guesses.

23 So concerning gap releases, I think we are
24 a little bit lower than the 5 percent.

25 MR. EVRARD: That's not including --

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1 MR. CLEMENT: Not including the high
2 burnup. So for high burnup, it could be increased,
3 but lower than noble gases. Maybe you can keep the 5
4 percent. So 5 percent. Zero for ex-vessel. In-
5 vessel, okay, well, 95 percent is split between the
6 early in-vessel and early phase of late in-vessel,
7 okay, because that's a degradation.

8 MR. POWERS: The way you can get that
9 early phase of the in-vessel is actually to put it in
10 the ex-vessel because that is only a two-hour period
11 that overlaps with the late in-vessel. So if you want
12 to jam it together, if two hours is good enough for
13 you, put it actually in the ex-vessel. It's not a
14 clearing ex-vessel. Its timing is such that it's
15 overlapping.

16 MR. CLEMENT: Yes, it is overlapping.

17 MR. GIESEKE: Is that misleading, though,
18 to the reader of this document?

19 MR. POWERS: Well, he just has to
20 recognize it.

21 MR. BOYACK: Well, the reader probably
22 won't recognize it.

23 MR. GIESEKE: I think either way, whether
24 you put it in the late in-vessel and say it is early
25 or whether you put it in an ex-vessel and say where

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1 it's coming from, either way, comment has to be
2 made --

3 MR. POWERS: Either way, yes.

4 MR. GIESEKE: -- to make it clear to the
5 reader.

6 MR. POWERS: My 25 percent from the ex-
7 vessel is the same as whatever percentage he gives us
8 here, and he's right, what we did for the gap
9 releases, we put it in the late in-vessel and said it
10 was biased toward the front end. It's the same story
11 here. I put it in the ex-vessel because it all put it
12 in a two-hour period.

13 MR. CLEMENT: Yes, okay.

14 MR. POWERS: I mean, that's one way to do
15 it. But somebody has to understand that that's what
16 you are doing.

17 MR. EVRARD: Of course, it could be late
18 in-vessel.

19 MR. POWERS: It is actually a late in-
20 vessel release, but I want it on the front end of
21 that.

22 MR. EVRARD: Oh, okay.

23 MR. POWERS: So I put it in the ex-vessel
24 because those two actually overlap each other in time.
25 I mean, the way you do it is, while late in-vessel is

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1 occurring, you also have ex-vessel occurring for two
2 hours.

3 MR. CLEMENT: But late in-vessel during
4 the time period of the ex-vessel?

5 MR. POWERS: Ex-vessel, that's right.

6 MR. CLEMENT: Okay.

7 MR. POWERS: Yes.

8 MR. BOYACK: Do I need to just put a
9 qualifying statement down here under late in-vessel
10 then for you? Because what I basically heard you say
11 is that this is --

12 MR. POWERS: Subsequently, in my late in-
13 vessel release, that's really the revaporization off
14 the piping system, and it does occur over a 10-hour
15 period, and involves interactions and all kinds of
16 things. It is just a way of getting the timing
17 approximately correct on this.

18 MR. BOYACK: All right, we're early in-
19 vessel on your comments, and I am a little confused,
20 but --

21 MR. CLEMENT: In our approach we have
22 about 5 percent for the gap, and now we have 95
23 percent to share in between early in-vessel and the
24 early phase of the late in-vessel. Okay, so this work
25 we have not done during our reassessments because we

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1 have merged these two. So I don't know.

2 MR. BOYACK: Now let me get this right.

3 MR. CLEMENT: So maybe I don't want to
4 give a definitive number. Maybe it could be 17, the
5 early in-vessel, and 25 in the early phase of the late
6 ex-vessel, or something like that.

7 MR. GIESEKE: This late in-vessel source,
8 however, is not previously-deposited material. That's
9 zero.

10 MR. CLEMENT: Well, no, a negligible
11 amount of deposited material.

12 MR. GIESEKE: Yes. So his late in-vessel
13 that the others of us are attributing to
14 revaporization from surfaces, he is saying is zero
15 because he is taking no account of deposit of the
16 early in-vessel material. So when you fill in early
17 in-vessel up there, you have to note that it is so
18 much released from the fuel with zero deposition or
19 zero retention during that phase.

20 MR. BOYACK: Okay, I just need a little
21 wording in this. So I start out saying 95 percent
22 remaining for these phases, and there's three phases.
23 It's divided between -- and then I heard talk about
24 two phases, but there's three remaining. So I got
25 confused.

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1 MR. CLEMENT: So with ex-vessel, zero,
2 because consider that everything is released from
3 fuel.

4 MR. BOYACK: Oh, okay.

5 MR. CLEMENT: Okay, so you put ex-vessel
6 as zero.

7 MR. BOYACK: Got it.

8 MR. CLEMENT: Then the 95 percent, you
9 have to share in between the early in-vessel and the
10 last phase, the beginning of the last phase.

11 MR. BOYACK: Okay, so now I've got it.
12 That was confusing to me for a moment.

13 MR. CLEMENT: But we do not make this
14 distinction because for us it was rather artificial
15 because it is a continuous process.

16 MR. LEAVER: Sure.

17 MR. CLEMENT: So it is just to enter
18 within your tables. It is difficult to enter our
19 numbers within your tables because --

20 MR. BOYACK: Right.

21 MR. CLEMENT: -- of the distinctions, some
22 are the same, different phases.

23 MR. SCHAPEROW: You don't feel that there
24 will be deposition of iodine inside the reactor
25 coolant system?

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1 MR. CLEMENT: If we consider a hot leg
2 break, all that we see as experimental evidence is, I
3 mean, vapor for iodine with maybe a few depositions.
4 As we want to be getting the same difficult term,
5 "reasonably", we could have been one or two persons,
6 but it doesn't matter, the one or two persons.

7 MR. EVRARD: I think the main part of the
8 deposit will accumulate *.

9 MR. LEAVER: It depends on the sequence.

10 MR. CLEMENT: Yes, but the most important
11 deposits occur where the vapor is condensing, while it
12 is still vapor and there is not any suction --

13 MR. LEAVER: But it won't be vapor up in
14 the upper --

15 MR. CLEMENT: As I said before, we have
16 made the hypothesis in order to able to consider a hot
17 leg break and iodine emitted as a vapor into the
18 containers. That's why we do not consider any
19 depositions.

20 MR. LEAVER: Because you wanted iodine
21 emitted as a vapor into containers?

22 MR. CLEMENT: Yes.

23 MR. LEAVER: I'm not sure how that could
24 happen though.

25 MR. CLEMENT: Again, it depends on what

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1 use you are making of the source term evaluations.

2 MR. LEAVER: Yes, okay.

3 MR. CLEMENT: For our own purposes, we
4 thought we had to go up to this degree of
5 conservatism, but, again, it depends on what you want
6 to do with your source term assessment.

7 MR. POWERS: That's absolutely true.

8 MR. LEAVER: Yes, that's true.

9 MR. BOYACK: Go ahead, Jean.

10 MR. EVRARD: Generally speaking, we take
11 values which are a lot of the release fraction itself
12 in VERCORS experience to make up for it.

13 MR. BOYACK: For this entry, shall I just
14 put a slash and your name, too, if that's all right?

15 MR. GIESEKE: The best you can do there is
16 that 95 minus "X" and down in the late in-vessel put
17 "X."

18 MR. SCHAPEROW: You are suggesting that
19 the original value, that 50 percent deposition -- see
20 the set of tables there in front of you?

21 MR. CLEMENT: It's zero.

22 MR. SCHAPEROW: Instead of 50 percent
23 where there is iodine, it has a mean value suggesting
24 maybe closer to zero deposition.

25 MR. LEAVER: I think he is saying that

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1 they --

2 MR. CLEMENT: No.

3 MR. LEAVER: I don't think he said that.

4 MR. SCHAPEROW: Then you said, even if we
5 were more realistic, we would still get only a few
6 percent deposition?

7 MR. CLEMENT: I mean, it depends on the
8 sequences you are considering. If you are considering
9 not only hot leg breaks, you will get deposition.

10 MR. SCHAPEROW: Okay, and we have got a
11 whole bunch of different sequences.

12 MR. LEAVER: Clearly, a large break,
13 double-guillotine break at the hot leg nozzle --

14 MR. POWERS: You aren't going to get quat.

15 MR. LEAVER: -- you aren't going to get
16 much deposition.

17 But I personally think that some kind of
18 risk-informed approach to this is the right thing to
19 do. So I would not think that you should just
20 consider that particular type of sequence.

21 MR. BOYACK: Okay, we are on to you, Dave.

22 MR. LEAVER: Okay. I think the 5 percent,
23 based on the discussion we had on noble gases, I could
24 argue the 5 percent is high, but then we have the
25 effect of the additional burnup. So I would say leave

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1 it the same. I wouldn't have any basis for changing
2 it.

3 The iodine will tend to condense as it
4 moves away from the core, and so there would be some
5 deposition even of what comes from the gap. So it
6 seems to me it would be, potentially could be
7 significantly less than the noble gas, but I think
8 that is okay to leave it at 5 percent.

9 I think in the 35 percent, there are some
10 competing effects here of Tom's point about the CORSOR
11 tending to overestimate all released, but then we have
12 some portion of the core in high burnup. So I would
13 say, in my mind, those two tend to balance one
14 another. I wouldn't have a basis for changing that
15 number.

16 I think on the ex-vessel, it is hard for
17 me to imagine that you are going to get 25 percent of
18 the iodine down there, but I would tend to think you
19 would get more, a higher release from the late in-
20 vessel, for one thing, because of the ingress of air,
21 but I don't think it matters too much on the ex-
22 vessel. So I guess I would leave that the same.
23 Presumably, these plants are smart enough to figure
24 out how to get water in there and at least scrub some
25 of that.

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1 But I would increase the late in-vessel.
2 I think the 20 percent number would be a reasonable
3 estimate. So the total would be a little higher than
4 the total within the original 1465.

5 MR. BOYACK: So under the context of what
6 was being done in the United States, is this what I
7 heard: Everything else just stays the same?

8 MR. GIESEKE: I think we need to address
9 the French position, though, because I don't know what
10 Dave's position was on that, since it got lost in the
11 numbers, but are you assuming, then, 50 percent
12 deposition --

13 MR. LEAVER: Yes, I'm looking at what --

14 MR. GIESEKE: In-vessel and then as --

15 MR. LEAVER: From these expert
16 elicitations and what they used. If they extracted
17 that and assembled it in NUREG CR 5747, which is the
18 basis for 1465, and we have all these arguments about:
19 Where is the break and how big is it, and hot leg
20 versus cold leg, and all that sort of thing. But we
21 really are, I think, trying to get something that is
22 representative of the spectrum of sequences. So I
23 think the .5 is not unreasonable.

24 So I guess to make a long story short,
25 yes, .5 of the release fraction from the fuel, which

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1 would is estimated to be about 70 percent, which we
2 think may be an overestimate for 1465, but there may
3 be some increase of that due to the effects of the
4 high burnup fuel, and I would say that those things
5 balance.

6 But now as I look at this, I am wondering
7 how in the heck can you get 25 percent of the iodine
8 down on the floor of the container? How can that
9 happen?

10 MR. POWERS: What you are really looking
11 at is the degradation of fuel late in the accident
12 sequence.

13 MR. LEAVER: Where is that fuel?

14 MR. POWERS: In the core.

15 MR. LEAVER: So it's not ex-vessel then?

16 MR. POWERS: It is not really ex-vessel,
17 but you want it to occur for a fairly short period of
18 time.

19 MR. LEAVER: It is really late -- so you
20 demand that you put it in the two-hour --

21 MR. POWERS: What you say is that it
22 melts, falls down, and the release occurs ex-vessel.

23 MR. LEAVER: So you're just putting it
24 down there because you want to release it sooner?

25 MR. POWERS: Yes.

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1 MR. LEAVER: Yes, okay.

2 MR. POWERS: It's timing. It's to get the
3 timing.

4 MR. LEAVER: Yes.

5 MR. POWERS: It is not iodine left in the
6 melt that transcends all of this.

7 MR. LEAVER: Right.

8 MR. SCHAPEROW: You need to identify that.

9 MR. BOYACK: Yes.

10 MR. LEAVER: I think if you do do an
11 overhaul of 1465, probably the thing to do is put that
12 25 percent out in the late in-vessel and say that some
13 of it gets released sooner. Because the idea that you
14 get that much iodine down on the concrete is --

15 MR. SCHAPEROW: That is why I wanted to
16 keep the noble gas on the same page there. I think we
17 did it the other way for noble gases. For noble
18 gases, we specifically said that there will be noble
19 gas release late in-vessel. But in this case we are
20 putting it in the ex-vessel column.

21 MR. POWERS: We probably ought to go back
22 and switch that around just to get the timing correct.

23 MR. GIESEKE: Well, we put a comment in
24 the previous one that said it occurs early in the
25 late --

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1 MR. LEAVER: Yes, we did.

2 MR. GIESEKE: -- in-vessel.

3 MR. LEAVER: And it's the same thing.

4 MR. SCHAPEROW: That feels better to me,
5 just from the point of view of where is the material.

6 MR. LEAVER: In the interest of not
7 misleading people that use this, maybe we should say
8 we think that ex-vessel iodine really isn't ex-vessel;
9 it's early in the late vessel, or late in-vessel.
10 Sorry. Early in the late in-vessel.

11 MR. GIESEKE: I was doing the same thing.
12 I was getting all those words mixed up.

13 MR. LEAVER: Mixed up.

14 MR. BOYACK: I would be very happy if
15 somebody would give me some words. We're on the
16 halogens, right? Ex-vessel, and you want to qualify
17 this. This is showing up as 25 percent right here,
18 but you want to qualify this because it really isn't
19 halogens on the floor?

20 MR. SCHAPEROW: Go up the previous
21 numbers. You had the noble gases. It's the same
22 release we put in the last column.

23 MR. BOYACK: So that's this statement here
24 for continuity of the early in-vessel release, the
25 late in-vessel release would occur in -- so you want

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1 to do something consistently or what?

2 MR. POWERS: Yes.

3 MR. GIESEKE: We are talking about the
4 same mechanism basically, that the material comes
5 down, but it is an in-vessel sort of release, release
6 in-vessel or from in-vessel materials after the
7 failure of the vessel. It may occur ex-vessel if they
8 fall through, and they probably do. Unfortunately,
9 some will be in the vessel as well as outside the
10 vessel.

11 MR. BOYACK: This is an area where I am
12 having trouble by trying to do the actual physical
13 work and then to keep track of the arguments. I have
14 lost it on this one. I just don't know where to go.

15 MR. SCHAPEROW: Well, the fuel that is
16 releasing the fission products is situated inside of
17 the reactor vessel.

18 MR. BOYACK: Yes, what I am really looking
19 for is for you to tell me what to do on the document,
20 or someone tell me.

21 MR. POWERS: You have to remember that,
22 unlike gap release and early in-vessel release, ex-
23 vessel release and late in-vessel release, the way
24 they are used, they overlap in time.

25 MR. BOYACK: Okay.

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1 MR. POWERS: Okay? What we would like to
2 do is to bias these releases that are occurring from
3 residual fuel early in that 10-hour period.

4 MR. BOYACK: Yes.

5 MR. POWERS: One way to do it is to put it
6 in the ex-vessel, which is only two hours.

7 MR. BOYACK: Okay.

8 MR. POWERS: It looks to me like that's
9 what people were doing when they came up with the
10 original thing, because even at TMI, a fully
11 pressurized accident, you really only have about 10
12 percent of the cesium left in the fuel melted; we're
13 down to zip with the iodine.

14 So I think we are putting it in the ex-
15 vessel to get it forward to the time. Because if you
16 put it over the entire late in-vessel, then you are
17 putting it up over a long period of time, and there is
18 a tendency for it to remain and be even more of a
19 containment for a long period of time.

20 So, to be realistic, I think they put it
21 in the ex-vessel. That suggests that we do the same
22 thing here for the noble gases. It is not so terribly
23 important where you stick the noble gases, except if
24 you don't want to do -- you don't want to mislead
25 people about the timing on it. So you move that .3

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1 over to the ex-vessel, even though it is occurring in
2 the vessel; it is not in the melt concrete
3 interactions or anything like that.

4 MR. NOURBAKHS: You could say that this
5 should not be exposed to the air for overlaying water.

6 MR. POWERS: That's right. That's right,
7 yes. It doesn't have any--

8 MR. NOURBAKHS: Somehow that
9 clarification should be made in a footnote.

10 MR. KRESS: Yes, that's a good point.

11 MR. SCHAPEROW: Looking back at the
12 original expert elicitation, there are no curves for
13 iodine and cesium for core/concrete interactions.
14 There's no curves for releases. I think there might
15 be a statement upfront. Wait a minute.

16 MR. POWERS: When we did the first
17 experiments on melt/concrete interactions, we actually
18 put cesium-iodine into the melt. We poured it on the
19 concrete, and said, oh, well, we'll just monitor how
20 fast it comes out.

21 MR. KRESS: And then you couldn't?

22 MR. POWERS: Well, it came out faster than
23 the sampling time. The very first sample was on at
24 the time the melt hit the concrete. The second sample
25 came on 10 seconds later after it hit. The first one

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1 had cesium and iodine in it; the second one had
2 nothing. It blew it out --

3 MR. KRESS: That's interesting.

4 MR. POWERS: It just doesn't stay in the
5 melt when you sparge it through with gases.

6 MR. SCHAPEROW: It is hard to tell where
7 they got the originals numbers. They are not in Load
8 50. Maybe Hossein knows. Where did the iodine and
9 the cesium release fractions in 1465 come from?

10 MR. BOYACK: Hossein, if you're going to
11 answer that, come to the mike.

12 MR. SCHAPEROW: Here's the expert
13 elicitation, and it doesn't show any iodine-cesium
14 numbers. Maybe you can recall?

15 MR. NOURBAKHS: That's exactly the same.
16 Whatever retained melt, when it comes go core
17 construction, everything been released. So that is
18 basically whatever comes from these numbers, they are
19 not for iodine and cesium, but it means that they are
20 100 percent.

21 MR. SCHAPEROW: Okay, thank you.

22 MR. BOYACK: Okay, two questions. The
23 first of them is: Do any of these release fraction
24 values for halogen change or are they still okay? The
25 way that we had them down was the only one that we

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1 changed was the 0.2 on the late in-vessel.

2 Now there is talk about a footnote or
3 another explanation. So what I am asking is, is that
4 something we just enter as comments by one of the
5 people or do you want it just down below the table
6 here as a separate footnote.

7 MR. POWERS: I would put it down here at
8 the bottom of the table. In the footnote I would say
9 is that cesium and iodine releases ex-vessel are not
10 mitigated by an overlying water pool.

11 MR. KRESS: That's a little cryptic.
12 Somebody will say, why not? The answer to why not is
13 because it doesn't go through any water.

14 MR. POWERS: Okay, and the reason is that
15 the release is actually occurring in the vessel and
16 going transit to the ex-vessel. So it never sees the
17 water.

18 MR. KRESS: Yes.

19 MR. SCHAPEROW: I have a request that we
20 fix the noble gas table to be the same as this table
21 as far as which phase --

22 MR. KRESS: I think that would help. I
23 think it was just a little confusing to me otherwise.

24 MR. SCHAPEROW: Thank you, right.

25 MR. KRESS: Thank you.

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1 MR. BOYACK: Now is this one okay now?
2 David, I guess we didn't give you a chance to get
3 through anything.

4 So let me go back and try to correct --
5 first, I'm going to get rid of that one. Okay, noble
6 gases. Now you're talking about changing numbers or
7 just text? You're talking about putting some of this
8 over here?

9 MR. SCHAPEROW: Did we?

10 MR. BOYACK: No.

11 MR. SCHAPEROW: Oh, we never did. Oh, my
12 goodness. I thought you had one where you had a late
13 in-vessel release for noble gases.

14 MR. BOYACK: No.

15 MR. SCHAPEROW: Oh, we never did?

16 MR. BOYACK: No. Oh, wait a minute. Wait
17 a minute. Wait a minute. Sorry. Let me fast
18 forward.

19 MR. LEAVER: What was that first one?

20 MR. BOYACK: I was just taking them one
21 phase at a time. This is the gap release comment.
22 Then you go down to the next one, here's the early in-
23 vessel information.

24 MR. LEAVER: Oh, okay.

25 MR. GIESEKE: It's misleading because your

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1 heading up --

2 MR. BOYACK: Well, I was just changing the
3 red numbers as we went along.

4 MR. GIESEKE: Well, if you know what
5 you're doing, then that's fine.

6 MR. BOYACK: Hey, listen, I am perfectly
7 competent and I know what I'm doing.

8 MR. GIESEKE: I know you are. That's
9 because you're from Los Alamos, right?

10 MR. BOYACK: Okay, now --

11 MR. KRESS: The idea was to put the 30
12 into the ex-vessel.

13 MR. BOYACK: Is that right?

14 MR. KRESS: I think.

15 MR. POWERS: I think certainly Bernard's
16 comment that they're biased forward in time, and I
17 believe that as well. That rescues us out of this
18 problem.

19 MR. KRESS: Yes, you need a footnote.

20 MR. SCHAPEROW: It's really a mess with a
21 table. Yes, that's the ex-vessel and late in-vessel
22 table there. The table covers both. That covers both
23 the last two phases.

24 MR. BOYACK: Well, it doesn't right now.

25 MR. POWERS: Yes, it does.

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1 MR. SCHAPEROW: Yes, see, there is an ex-
2 vessel --

3 MR. BOYACK: It's got the numbers; it
4 doesn't have the justification.

5 MR. SCHAPEROW: It doesn't? Oh.

6 MR. BOYACK: The justification is right
7 here.

8 MR. SCHAPEROW: That's early in-vessel.
9 You've only got three tables.

10 MR. BOYACK: By golly, I do, don't I?

11 MR. POWERS: Jason is on top of this.

12 MR. BOYACK: Because there's the other.
13 All right. I am so tricky with my file here, I
14 tricked myself. Okay, I'm with you. Now what do I do
15 with the number?

16 MR. KRESS: Put 30 in the next estimate.
17 Then write a footnote.

18 MR. BOYACK: Which is that the noble gas
19 releases?

20 MR. POWERS: Aren't mitigated by an
21 overlying water pool because they can't be.

22 (Laughter.)

23 MR. LEAVER: Because it's not possible.

24 MR. POWERS: Actually, when I did the
25 analysis for the ACRR reactor, the safety analysis,

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1 the release there is predominantly a krypton release.
2 There is such a huge pool of water and it's so deep
3 that it goes into the solution deep and then actually
4 it stays in the solution and releases very, very
5 slowly. So much water and such a small amount of
6 krypton gas --

7 MR. LEAVER: There's a small amount of
8 solubility.

9 MR. POWERS: It's a small solubility, but
10 it is a huge volume of water. It actually goes into
11 solution, and the net result of it is that you can't
12 go in and recover from the accident. This slow
13 release of dissolved krypton keeps the radiation load
14 high enough that people can't go in and turn off pumps
15 or anything like that. It's actually a pain in the
16 ass. If it would just go through the water pool and
17 come out, then it's clean in the atmosphere and you
18 could come in. So if you have enough water, you can
19 mitigate krypton release, but it's a lot of water.

20 MR. KRESS: The note that you want here is
21 the release is actually occurring in-vessel, but after
22 the time when the bottom head fails. So it is counted
23 as an ex-vessel release.

24 MR. POWERS: Yes, it's actually occurring
25 in-vessel.

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1 MR. KRESS: Yes.

2 MR. GIESEKE: There you go.

3 MR. SCHAPEROW: That would be a nice
4 comment to add on the other table, too.

5 MR. BOYACK: Okay, where is this --

6 MR. KRESS: In-vessel.

7 MR. BOYACK: So?

8 MR. KRESS: So it's counted as an ex-
9 vessel release.

10 MR. BOYACK: All right.

11 MR. SCHAPEROW: Could you copy that for
12 the other one, too, the other table?

13 MR. BOYACK: You were asking if I would
14 get tired on a day like today.

15 MR. LEAVER: You're starting to?

16 MR. BOYACK: The eyes are starting to feel
17 it. Absolutely.

18 Now it is the halogen releases?

19 MR. KRESS: Yes.

20 MR. GIESEKE: It is in-vessel and during
21 transit.

22 MR. BOYACK: Yes.

23 MR. GIESEKE: This is your last sentence.

24 MR. BOYACK: So this last sentence,
25 discard it?

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1 MR. POWERS: You want to keep that.

2 MR. GIESEKE: I think you want to keep
3 that instead of the first one, but just add the last
4 one. What is it? "Therefore, it's after the time
5 that the bottom head failed, and so it's counted as an
6 ex-vessel release."

7 MR. KRESS: Yes, you want to get rid of
8 that middle sentence. They are if they are released
9 ex-vessel.

10 MR. GIESEKE: You're right, they are.
11 Well, they're not.

12 MR. KRESS: That's confusing.

13 MR. BOYACK: Okay, I guess now let's see,
14 this is halogen. So these numbers are okay then. The
15 only thing that changes is this late in-vessel?

16 MR. SCHAPEROW: Did you want to add a
17 comment also on Bernard's statement that no deposition
18 due to consideration of an AB sequence or deposition
19 is sequence-dependent?

20 MR. BOYACK: Where do I do that?

21 MR. SCHAPEROW: Right now all there is is
22 a statement saying 95 percent released to containment.
23 I wondered if you wanted to qualify at least that.

24 MR. BOYACK: This is right?

25 MR. SCHAPEROW: Yes, right there, maybe at

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1 the end. Are you going to qualify that?

2 MR. LEAVER: Explain why they are assuming
3 that.

4 MR. SCHAPEROW: Yes, just to say that
5 deposition is sequence-dependent. Is that okay to say
6 that?

7 MR. LEAVER: They wanted to wanted to wait
8 for a release --

9 MR. SCHAPEROW: Oh, okay, worse case or a
10 conservative --

11 MR. CLEMENT: Reasonably --

12 MR. LEAVER: Extremely unlikely.

13 MR. CLEMENT: But, I mean, reasonably it
14 could be different from one to another. When you want
15 to be sure that your emergency plans outside of the
16 plant will be okay, you need some conservatism in
17 writing. Okay?

18 MR. BOYACK: Conservative approach to
19 assure --

20 MR. SCHAPEROW: Well, it's conservative
21 because they chose an AB sequence. They chose a hot
22 leg break, a large hot leg break.

23 MR. POWERS: A large break, hot leg break
24 was assumed.

25 MR. BOYACK: And there's no deposition in

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1 such an event.

2 MR. SCHAPEROW: Yes.

3 MR. BOYACK: Oh, I like that.

4 MR. SCHAPEROW: I don't want to put words
5 in your mouth. Right now we've got -- I'm just seeing
6 if one more thing might help the explanation.
7 Somebody looking at it later might now know why does
8 it say 95 percent.

9 MR. KRESS: We will forget.

10 MR. SCHAPEROW: And other experts say --

11 MR. POWERS: Reminds me of a panic-
12 stricken phone call I got from an NRC staff member,
13 who's not present, so I can talk behind his back.
14 They had one of the Commissioners, who is no longer a
15 Commissioner, so I can talk about him, had been in
16 Europe and they were talking about the source term
17 there. They were, of course, talking about the source
18 term to the environment. RES had come in and talked
19 about the source term, and of course they were talking
20 about the source term to the containment. The
21 Commissioner says, "Oh, my God, RES has gone off the
22 deep end. They have this huge source term.

23 MR. LEAVER: It's a hundred times greater
24 than what --

25 MR. POWERS: Oh, thousands of times

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1 bigger. This was in Sweden. They were talking about
2 1 percent release, and it made all kinds of
3 accusations of irresponsibility on the part of the NRC
4 staff, and they wanted me to conduct and write a
5 report for this guy on the different source terms used
6 around the world for these things. There was this
7 massive phone-calling going on just to straighten out
8 one element of confusion, but it couldn't be
9 straightened out with this guy by the RES staff. He
10 was convinced that they were irresponsible,
11 duplicitous, overly conservative individuals, and it
12 was simply a matter of nomenclature.

13 (Laughter.)

14 MR. SCHAPEROW: Do you want to take a
15 break now? I can go ahead and print those out.

16 MR. BOYACK: I was actually going to try
17 to go to 3:00.

18 MR. GIESEKE: Rest your eyes, Brent.
19 Don't kill yourself.

20 MR. LEAVER: Yes, let's take a break.

21 MR. GIESEKE: If you want to take a break
22 for a while and rest and we'll take another break, and
23 we'll work a little later.

24 MR. BOYACK: How about 10 minutes then?

25 MR. GIESEKE: No, we'll work later, if

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1 necessary.

2 (Whereupon, the foregoing matter went off
3 the record at 2:33 p.m. and went back on the record at
4 2:45 p.m.)

5 MR. BOYACK: The next fission product on
6 the list is alkaline metals.

7 MR. GIESEKE: Dana said he wants to be
8 first on all of these.

9 (Laughter.)

10 MR. BOYACK: This may be right, but I have
11 sort of forgotten where we were last time.

12 MR. GIESEKE: I think I was first last
13 time.

14 MR. BOYACK: So why don't we -- I've
15 allowed our French colleagues to not go first unless
16 they have a desire to do so. Would you like to weigh-
17 in and offer your opinion on alkaline metals?

18 MR. CLEMENT: Okay. So for gap release,
19 I think we should have the same values as for iodine.
20 There is no reason to have differences.

21 Then go to the other points. For cesium
22 we consider that there will be some deposits, okay?
23 So we consider --

24 MR. BOYACK: Now are we down in the early
25 in-vessel area here or is it just that I'm still

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1 continuing on with -- no, gap release you said.

2 MR. CLEMENT: Gap release, that's okay.

3 MR. BOYACK: Okay.

4 MR. CLEMENT: Then we have the same --
5 okay, how to express it? We consider that we will
6 have 65 percent release both in the early in-vessel
7 and in the early phase of the ex-vessel, as I said
8 before.

9 MR. BOYACK: Total?

10 MR. CLEMENT: Total.

11 MR. KRESS: No deposits?

12 MR. CLEMENT: Yes, deposits. That's at
13 the break, through the containment. We consider, in
14 fact, an overall release from the fuel of 95 percent.

15 MR. KRESS: Okay.

16 MR. CLEMENT: And overall, that is not --

17 MR. BOYACK: Did I get that right?

18 MR. CLEMENT: Okay. So I will summarize.

19 So phase 1 --

20 MR. BOYACK: Yes?

21 MR. CLEMENT: -- that was gap release, 5
22 percent.

23 MR. BOYACK: Yes.

24 MR. CLEMENT: Okay? Then for the phase 2
25 and 4, okay, that is early in-vessel --

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1 MR. BOYACK: Okay, so the --

2 MR. CLEMENT: That is early in-vessel and
3 early phase of late in-vessel, okay? You have a 90
4 percent release from fuel, that there are some
5 deposits. You consider some deposits, and there is 65
6 percent release at the break.

7 MR. BOYACK: Okay.

8 MR. CLEMENT: We did not consider an ex-
9 vessel release. In fact, there is some cesium left in
10 the fuel because we only release 95 percent from the
11 fuel. So we consider that there is some cesium left
12 in the fuel, but not all will be released, so we did
13 not consider it.

14 MR. BOYACK: Okay, so --

15 MR. CLEMENT: Then I am considering our
16 figure from the two in-vessel phases, except the gap
17 releases. This should be shared in the same way then
18 for other volatiles.

19 MR. BOYACK: So did I read this right,
20 that you retained about 30 percent of the cesium in
21 the fuel or --

22 MR. CLEMENT: No.

23 MR. BOYACK: Then I've got my numbers
24 wrong somehow.

25 MR. CLEMENT: Ninety-five release from the

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1 fuel, including gap release.

2 MR. BOYACK: So, okay, this figure is 95.

3 Pardon me.

4 MR. LEAVER: Ninety.

5 MR. CLEMENT: Ninety.

6 MR. BOYACK: I'm sorry, I misunderstood.

7 MR. CLEMENT: Okay. >From this 90, 65
8 percent goes to the containment from this 90.

9 MR. BOYACK: That will be 90 percent,
10 60 --

11 MR. CLEMENT: Five

12 MR. BOYACK: Sixty-five percent is
13 released to containment.

14 MR. CLEMENT: Yes.

15 MR. SCHAPEROW: Twenty-five is deposited.
16 Is that okay? After "deposit," did you write in
17 "RCS"?

18 MR. BOYACK: And this represents both of
19 you?

20 MR. CLEMENT: It is, in fact, what is in
21 our own estimates.

22 MR. BOYACK: Okay, we'll stay over on the
23 other side of the table, David, if it's all right with
24 you and ask for your comments. David Leaver?

25 MR. LEAVER: Well, the cesium, at least if

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1 you believe the tendency in the expert elicitations
2 from 1150, you had maybe a 10 to 15 percent less of a
3 release from the fuel for cesium. I'm not sure that's
4 right, but I had in my mind that the iodine and cesium
5 releases would tend to be about the same. So I guess
6 if one accepts these expert elicitations, and there's
7 also information in here that suggests that there's
8 slightly greater retention of the cesium in the RCS,
9 that tends to justify the -- that is the basis for the
10 25 percent versus 30 percent number. Is it 25
11 percent?

12 MR. POWERS: Twenty-five percent early in-
13 vessel release.

14 MR. LEAVER: It is a difference of 40
15 percent versus 25 percent?

16 MR. POWERS: Thirty-five versus 25.

17 MR. LEAVER: Thirty-five versus 25?

18 MR. POWERS: Yes.

19 MR. LEAVER: Yes, for the PWR, right.
20 Okay.

21 I guess it would seem to me the logic that
22 we apply to the iodine release in terms of the effect
23 of burnup would tend to be the same here, which is
24 maybe for the higher burnup fuel, you might see
25 slightly higher releases, but at least for the iodine,

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1 and I would think the same logic would apply with the
2 -- they may have been overestimated, the cesium may
3 have been overestimated in the first place. So that
4 would suggest that the .05 and the .25 not change.

5 I've always struggled a little bit with
6 the idea that the cesium would be that much less than
7 the iodine, say .35 versus .25. I'll just check one
8 thing.

9 MR. BOYACK: While he is doing that, which
10 one is the real problematic group? Because I wanted
11 to start it out with Dave on that one.

12 MR. LEAVER: Oh, you mean the contentious
13 group?

14 MR. BOYACK: Yes, of these fission
15 products.

16 MR. LEAVER: Barium, certainly barium,
17 strontium and ruthenium might be. Interestingly, at
18 TMI, I know -- I was just trying to recreate --

19 MR. CLEMENT: Sorry, but for barium,
20 strontium, and ruthenium, we would have some
21 differentials because we don't have the same
22 classification that you have for release in groups.

23 MR. BOYACK: Actually, what happened was
24 I was trying to be funny and it wasn't.

25 (Laughter.)

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1 That's because people think it may be
2 true.

3 MR. LEAVER: At TMI both iodine and
4 cesium, release fraction was 55 percent from the fuel.
5 In the PBF, the one I have here, which is 1/4, the
6 cesium release was twice as much, almost as twice as
7 much as the iodine release. So I, for one, have never
8 been comfortable particularly with the cesium being
9 less than the iodine, but the iodine is pretty high.
10 So I don't know if it would make sense to increase the
11 cesium up to the iodine. So I guess I would be, at
12 least at this point, satisfied to leave it the same.

13 MR. BOYACK: Okay, and on the early in-
14 vessel now, of course, what our French colleagues have
15 done is sort of combined these phases. But, by
16 necessity, I think we have to separate them.

17 So early in-vessel?

18 MR. KRESS: That is the one he just said
19 was the same.

20 MR. LEAVER: Yes, the gap in early in-
21 vessel.

22 MR. BOYACK: Oh, it was early. See,
23 you've gone ahead of me, and I hadn't realized it.

24 MR. LEAVER: I was just kind of treating
25 a few together.

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1 MR. BOYACK: So you're saying hold it at
2 25 percent?

3 MR. LEAVER: Yes, although I would
4 certainly be willing to enter into the discussion. I
5 would like to understand better why it makes sense for
6 the cesium to be less than the iodine, given the fact
7 that probably among the two best integral experiments
8 we have, TMI and one of the PBF's, had it just the
9 opposite.

10 I would also say it is hard to imagine 35
11 percent of the cesium being in the debris that comes
12 out of the vessel. So that same logic that we used on
13 the iodine would tend to apply here. Well, that's
14 another story, but whatever it is, there's not going
15 to be very much cesium left in what's on the floor.
16 And if anything, cesium would tend to be more volatile
17 than iodine. So I would think that the late in-vessel
18 would make sense. Since we increased that for iodine,
19 we would expect to get the same kind of increase for
20 cesium.

21 MR. BOYACK: Okay, so can you help me a
22 little bit with what these values might be? So for
23 the early in-vessel, it clearly is less than what we
24 were seeing for iodine, but what would you suggest a
25 value of?

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1 MR. LEAVER: Well, let me ask a question
2 before I do that. Why is this number less than the
3 iodine number?

4 MR. POWERS: Because we can identify a lot
5 of vapor pressure cesium compounds that form in the
6 system, and especially if you have boric acid.

7 MR. LEAVER: Cesium borate, you mean?

8 MR. POWERS: Forms cesium borate and
9 things like that with relatively low vapor pressures.
10 So they found that both, there was the potential of
11 retaining more of the fuel as cesium uranate, and the
12 potential for depositing more in the reactor coolant
13 system as things like cesium borate or zircanate,
14 things like that. Though people were aware of
15 experimental evidence on cesium release, I think most
16 people conceded iodine tends on the whole to be
17 released more than the cesium.

18 MR. LEAVER: Even though two pretty
19 good --

20 MR. POWERS: Yes, they also knew what the
21 uncertainties in those numbers were.

22 MR. LEAVER: Yes, yes, but it is
23 interesting that both of them fly in the face of that.

24 MR. POWERS: Yes. What we also know is
25 finding all the iodine, the mass balances on these

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1 experiments on iodine is not very good. At least on
2 the PBF experiments it was never very good. Finding
3 all the iodine is a chore. So I think they just
4 underestimated it.

5 MR. LEAVER: So the denominator may be
6 wrong for the iodine.

7 MR. POWERS: Yes. And let's see, I did
8 think, based on TMI, that there would be some
9 retention and the fuel in ex-vessel. Most of that 35
10 percent is, in fact, the 25 percent of the residual
11 fuel that didn't melt during the in-vessel phase
12 melting out late.

13 MR. LEAVER: The same as for --

14 MR. POWERS: As for the iodine.

15 MR. LEAVER: -- as for iodine, right.
16 Yes, that I understand.

17 Okay, so the point you're making is cesium
18 we know it is wrong to assume that it is all
19 hydroxide. Maybe even none of it is hydroxide. It's
20 these other forms which tend to have reduced vapor
21 pressures, and that can explain -- it is not as
22 volatile as it would be if it were hydroxide.

23 MR. POWERS: Yes, I think that people
24 didn't know exactly. All they knew is they could
25 identify all these things when they had more vapor.

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1 We had done some calculations explicitly with various
2 forms of cesium borate and showed that we could just
3 drop the vapor pressure down to zip, depending which
4 of the borates formed, and bend it on the boric
5 acid/the cesium ratio that you had.

6 MR. LEAVER: It is very stable stuff?

7 MR. POWERS: What happens is just the
8 cesium activity drops off so low that there's no vapor
9 pressure, is what happens. We find these polyborates
10 that have one cesium atom in every 100 boron atoms.
11 There's no activity.

12 So it is largely based on just
13 identification rather than explicit calculation.
14 Whether it is really true or not, of course, not bad.
15 Not bad.

16 MR. LEAVER: Well, if you want a number,
17 I guess I will do the number of 25 percent and maybe
18 listen to what everybody says and be allowed to
19 reconsider that at the end perhaps.

20 MR. BOYACK: But that was a good question
21 because it did solicit the information.

22 MR. LEAVER: Well, I think Dana has a very
23 good point about the cesium compounds. I think 10
24 years ago everybody said it's hydroxide, and I think
25 we know now that that's not that simple. That would

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1 explain why people think the number is less, although
2 I tend to believe the experimental results than what
3 people calculate on these things, but, of course,
4 there is uncertainty in experiments, too. These
5 measurements are hard to make.

6 MR. BOYACK: Okay, so let's move on to the
7 ex-vessel phase.

8 MR. LEAVER: For me you mean?

9 MR. BOYACK: Yes.

10 MR. LEAVER: I don't believe the 35
11 percent, but I guess what it is is it's a way of
12 saying that this release from what's left in the fuel
13 that is in the vessel goes out sooner, the same as for
14 iodine. So I think that structure you had with the
15 footnote would apply, and the reason it is 35 percent
16 instead of 25 is because I guess you've got an
17 additional amount of cesium left up in there, which if
18 you heat that fuel, if that fuel continues to heat up
19 long enough, it's all going to go.

20 MR. SCHAPEROW: You are on halogens,
21 right?

22 MR. LEAVER: Yes, you call it halogens,
23 right.

24 MR. SCHAPEROW: I think you included that
25 in the ex-vessel column, though, for halogens.

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1 MR. BOYACK: Pardon me? Oh, okay, yes.

2 MR. SCHAPEROW: The actual number.

3 MR. BOYACK: I see. Okay, so were we
4 leaving this at 35 percent then on the ex-vessel?

5 MR. LEAVER: Well, it's the footnoted ex-
6 vessel, which is that it is really released early in
7 the late in-vessel phase.

8 MR. BOYACK: Okay, and that leaves us late
9 in-vessel. So maybe this comment that I entered in is
10 no longer valid because it was prior to your
11 discussion with Dana.

12 MR. LEAVER: What does that say?

13 MR. BOYACK: It says nothing because I
14 don't think it made sense. I had gone down quickly
15 and made some others.

16 So let me just ask you, what about the
17 late in-vessel phase, your thoughts?

18 MR. LEAVER: I guess I would leave it the
19 same.

20 MR. BOYACK: So what this is saying, 60,
21 65, 75, this is saying what, 25 percent is retained,
22 the cesium is retained, 30, 65, 75, right?

23 MR. SCHAPEROW: In the RCS.

24 MR. BOYACK: Uh-huh.

25 MR. LEAVER: A third of it.

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1 MR. BOYACK: Yes. So you're okay with
2 using --

3 MR. LEAVER: Yes, I think that is kind of
4 consistent with, if we believe the cesium really is
5 somewhat less volatile form, then that is probably not
6 a bad number.

7 MR. SCHAPEROW: There was also a
8 chemisorption model that we put in our codes over the
9 last few years, some Sandia experiments where this
10 chemisorbed on the interior surfaces of the RCS. Dana
11 can probably help me with that.

12 MR. POWERS: For a long time they have
13 modeled cesium in terms of a condensation and an
14 irreversible chemisorption.

15 MR. LEAVER: As a hydroxide?

16 MR. POWERS: They don't call it a species
17 because what they observed in the experiments was that
18 they would find these tightly-bound cesium species on
19 the surface associated with the tramp elements, like
20 phosphorous-added steel, alumina that came from God
21 knows where, probably the water supply, and things
22 like that. Of course, it was forming the cesium
23 luminates and cesium phosphates and things like that.
24 It was forming these mixed oxides through a relatively
25 non-volatile.

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1 So they set up -- so from back in the days
2 of trapped milk, they set up an irreversible
3 chemisorption term in the deposition models, as well
4 as a more physical absorption due to cesium hydroxide.

5 As you go on in time in the analysis, what
6 happens is the physically-absorbed material vaporizes
7 and some fraction of it deposits irreversibly. So you
8 get a slow conversion into this irreversible kind of
9 thing.

10 Similarly, in TMI we found cesium bound to
11 the lead screws as cesium silicate, which is the
12 silicate impurity in the lead screw steel. So it
13 slowly converts itself into a --

14 MR. LEAVER: It's very reactive stuff.

15 MR. POWERS: It's very reactive stuff.

16 MR. BOYACK: Okay, Dana, how about you
17 begin with gap release for alkaline metals?

18 MR. POWERS: I'm going to be enormously
19 controversial here and just say I want to leave the
20 numbers alone. My reasons closely parallel Dave's
21 thinking on this.

22 The one I have question about is whether
23 we are overestimating the vaporization release, but I
24 am attentive to Jim's comment that we probably tend,
25 we could naturally tend to disperse the material so we

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1 have a low heat source, don't get these hotspots,
2 which will perhaps counterweigh the tendency to form
3 less volatile species.

4 So the net effect is that understanding
5 the revaporization of cesium is a critical need. We
6 need experiments in that area. I'm not prepared to
7 argue for substantial changes to the numbers. I think
8 revaporization becomes much less likely as you get air
9 intrusion because you tend to form iron oxides and
10 chromium oxides that will form cesium chromates and
11 cesium ferrates, which will be even more type of
12 binding material.

13 So the upshot is I can't find a basis to
14 change the numbers.

15 MR. BOYACK: Okay, but you did have a
16 statement of need, did you not?

17 MR. POWERS: Right.

18 MR. BOYACK: And that was?

19 MR. POWERS: We need experiments on
20 revaporization of cesium.

21 MR. SCHAPEROW: In the last in-vessel and
22 the early in-vessel or just late in-vessel?

23 MR. POWERS: It is really the late in-
24 vessel.

25 MR. CLEMENT: I think Dana is right

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1 because we have some similar experiments and complex
2 reactions of cesium with sulfates, not only with
3 chemisorption, but even when only deposited by vapor
4 or condensation, then it reacts with the sulfates and
5 forms different species, many bundled, some being able
6 sometimes to revaporize at rather low temperatures.
7 So it is a very complex pattern.

8 MR. BOYACK: Okay, Jim?

9 MR. GIESEKE: I am torn between going
10 through some hand-waving with leaving everything the
11 same. Because I went through a logic system and I
12 don't come up with anything that's very different from
13 what is there, thinking about all the things.

14 MR. BOYACK: But sometimes just the
15 comments to the rest of the panel are useful.

16 MR. GIESEKE: Well, I was going to say, as
17 far as release from fuel, I don't know, that could
18 range pretty widely, 30 to 100 percent, maybe half
19 that retained, or thereabouts, in transit. A few
20 percent, 5 percent gap release, if you want to put
21 that, that's okay. Maybe 30 to up close to 100
22 percent or 90 percent release with continuation. So
23 I would guess like 30 percent for the early in-vessel,
24 but that -- what's the number that's there? It is not
25 that much different.

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1 MR. POWERS: Twenty-five.

2 MR. GIESEKE: Yes.

3 MR. BOYACK: So you are saying, if you --

4 MR. GIESEKE: I went through some numbers
5 and I came up with these, but they are not that
6 different. So it is hardly worth quibbling about.

7 MR. BOYACK: All right. So if you're
8 going through this the first time, you may have put 30
9 percent.

10 MR. GIESEKE: Yes.

11 MR. BOYACK: Given sort of the fact of the
12 uncertainty, you can live with the 25 percent?

13 MR. GIESEKE: Yes.

14 MR. BOYACK: Okay. Like I say, any of
15 these, later on you will be able to strike or modify
16 any of these statements.

17 MR. GIESEKE: What's this one attaining?

18 MR. POWERS: Thirty-five percent.

19 MR. GIESEKE: Thirty-five. I guess a
20 little lower.

21 MR. BOYACK: So I had this one wrong.

22 MR. GIESEKE: Yes, retain the 25.

23 MR. BOYACK: Actually, I --

24 MR. GIESEKE: The 35 I mean.

25 MR. BOYACK: Yes, yes.

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1 MR. GIESEKE: Actually, those should be
2 about the same also, for the same reasons that Dana
3 mentioned, the two conflicting reasons.

4 MR. BOYACK: I didn't really enter that in
5 this table. I might be able to just enter it one
6 place, those two conflicting reasons. One of them was
7 air ingress, was it?

8 MR. GIESEKE: Air ingress and hotspots.

9 MR. BOYACK: Okay.

10 MR. POWERS: Well, I would call it
11 compound formation and hotspots.

12 MR. GIESEKE: Yes.

13 MR. POWERS: Because it's complex
14 structures and things like that that we are seeing.
15 I mean, this has been known for a long time: that
16 cesium just loves to react with stuff. Unfortunately,
17 those reactions are things that we don't have in the
18 thermo-chemical databases.

19 MR. BOYACK: And that gets that.

20 MR. SCHAPEROW: The second one is not air
21 ingress. It's --

22 MR. BOYACK: Hotspots.

23 MR. SCHAPEROW: Hotspots

24 MR. POWERS: Hotspots caused by localized
25 deposition. What happens, like you say, you've got a

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1 little discontinuity of the pipe; you get these
2 recirculating structures, and all of the products go
3 right back there, whereas the code tends to steer
4 those out over the whole pipe.

5 MR. GIESEKE: These are the same.

6 MR. BOYACK: If I read this right, this
7 brings us to -- drum roll --

8 MR. POWERS: You're going to be difficult,
9 I can tell. You're not going to be difficult?

10 MR. KRESS: Not very difficult, a little
11 difficult.

12 .05 is okay, for the same reasons that we
13 have said. I am going to be a little contrary on the
14 in-vessel. I'm going to go with Jim's 30. I think
15 it's actually a real number, partly because of what
16 Dave said. When I looked at the separate effects
17 test, release rates for cesium, they are not that far
18 below the iodine, as shown. So when I make a
19 correction for that, I get it releasing something like
20 60 percent as opposed to 70 percent for iodine. But
21 about half of that gets retained in the vessel. So
22 that makes it 30 percent for me, and I'm going to go
23 with it. I actually believe that's a good number.

24 I would keep the 35 for ex-vessel, and for
25 the same reason everybody else is.

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1 MR. LEAVER: This is not a burnup effect
2 that you're talking about though?

3 MR. KRESS: No, there's a slight burnup
4 effect.

5 MR. LEAVER: Slight?

6 MR. KRESS: There's not a lot.

7 MR. LEAVER: But if there was no burnup
8 effect, you would still tend to --

9 MR. KRESS: I would still raise it, and I
10 wouldn't go all the way to 30 if it wasn't for the
11 burnup effect.

12 I thoroughly believe that cesium is
13 retained much better than the one-third that we are
14 using, but I think for a design basis source term,
15 it's better to take care of the uncertainty by letting
16 it get out. So I'm going to stick with the .1,
17 although I think it is less than that.

18 MR. BOYACK: This is the revaporization?

19 MR. SCHAPEROW: Yes.

20 MR. BOYACK: There's this comment that I
21 have entered for cesium, retained better --

22 MR. KRESS: I'm saying that 30 percent got
23 retained and then 10 percent of that got released in
24 my numbers. I'm saying I really believe that less
25 than 10 percent got released; more of it got retained.

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1 But I think it is better -- I am uncertain about that,
2 and I think it is better to deal with that uncertainty
3 by going ahead and releasing it in the late in-vessel.
4 So I'm saying I'm going to stick with the 10 percent
5 because I think it is a better design basis number to
6 use, although I thoroughly believe more of it will be,
7 when it gets locked onto those surfaces, it stays
8 there, is what I believe.

9 MR. BOYACK: Okay. Now we face this
10 challenge between sort of the French approach and the
11 U.S. approach, but this will go mainly to the U.S.
12 usage, so I will probably continue to divide these.

13 So the only issue, if I heard it right,
14 was -- these are okay.

15 MR. LEAVER: There is not that much
16 difference between necessarily what the French are
17 saying and what we're saying.

18 MR. POWERS: The difference is between 60
19 and 65 percent release into containment, and then we
20 have 10 percent later on.

21 MR. LEAVER: Yes.

22 MR. POWERS: Okay. So we are 5 percent
23 below them at start and 5 percent above them at the
24 end, and there is not a whole lot of difference there.

25 MR. LEAVER: I feel like they are kind of

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1 validating a little what we're -- okay, it is all kind
2 of hand-waving, but not too bad.

3 MR. BOYACK: My comment was breaking it up
4 into tables, but, yes, that notwithstanding, I
5 understand.

6 MR. LEAVER: Yes.

7 MR. KRESS: I wonder if my very
8 unconvincing arguments convinced anybody to go with
9 the 30 percent instead of 45?

10 MR. BOYACK: So, basically, we have a
11 couple of people that have got to 30 percent.

12 MR. KRESS: Yes, Jim was wanting to go
13 there, but he didn't quite do it.

14 MR. GIESEKE: I gave up.

15 MR. BOYACK: Is there --

16 MR. KRESS: I think it is inconsistent
17 with the iodine mainly.

18 MR. SCHAPEROW: I think we have a larger
19 alkaline metal ex-vessel release than for iodine,
20 unless we change that.

21 MR. BOYACK: We could always change that.

22 MR. POWERS: If you take Tom's 30 percent
23 there, I'll bet you you're going to take the extra 5
24 percent out of the ex-vessel release.

25 MR. KRESS: It adds up.

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1 MR. SCHAPEROW: What was the iodine table,
2 Brent?

3 MR. POWERS: I mean the sums are the same.
4 The iodine table has 35 and 25 and this one has 25 and
5 35.

6 MR. SCHAPEROW: Noble gases.

7 MR. BOYACK: That's what we want, isn't
8 it?

9 MR. SCHAPEROW: Iodine, halogens.

10 MR. BOYACK: Halogens? Oh, well, let me
11 get the right one then. All right, there we go.

12 MR. SCHAPEROW: 05, .35, .25, .10.

13 MR. POWERS: Are we going to normalize?

14 MR. KRESS: If you look at that, the 35 is
15 half of 70. The add the 5 for the gap, and it makes
16 it 75. So that leaves you 25 ex-vessel. It is the
17 same thing here. My 30 is half of 60. Sixty and five
18 is 65; that leaves 35 in ex-vessel.

19 MR. GIESEKE: But there's a difference.
20 The French are saying a total of 90 percent release.

21 MR. KRESS: I think it all gets eventually
22 released.

23 MR. BOYACK: I haven't heard anybody say
24 change that to 30. With enough numbers, then I'm
25 going to do it, but I just wanted to know whether

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1 anybody has a strong opinion.

2 MR. KRESS: You're not getting much of a
3 hue and cry for 30 percent, are you?

4 MR. BOYACK: Well, no, and I shouldn't be
5 the final arbiter of this.

6 MR. POWERS: are you going to take the
7 extra 5 percent out of the ex-vessel hide?

8 MR. KRESS: No, it still adds up.

9 MR. LEAVER: It adds up to more than
10 iodine if you don't take it out. Your total release
11 would be greater, wouldn't it?

12 MR. KRESS: Yes, my release of the cesium
13 from the fuel is 60 percent. That is what I
14 calculated using my release model with the high burnup
15 correction. Okay. If that 60 percent gets 30 percent
16 or half of it gets deposited, I don't even need to
17 worry about what gets deposited. The 30 I have is
18 half of the 60. The rest of it gets deposited.

19 MR. LEAVER: Okay. So you've got 30.

20 MR. KRESS: So I have 60 plus 5 over here.

21 MR. LEAVER: Right, right, 65.

22 MR. KRESS: Sixty-five.

23 MR. LEAVER: Plus 35.

24 MR. KRESS: Plus 35. That's all of it.

25 MR. LEAVER: So you have no release for

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1 late in-vessel?

2 MR. KRESS: Yes, the part that gets
3 deposited, 30 percent. Thirty percent got deposited;
4 10 percent of that got re-released. So it adds up.

5 MR. POWERS: Okay, so you just want early
6 in-vessel to go up to 30 percent?

7 MR. KRESS: No.

8 MR. LEAVER: Yes, he does.

9 MR. KRESS: Yes, yes, that's the only
10 thing I want, is the early in-vessel to go up to 30
11 percent, right, and my numbers still add up.

12 Now this is where it doesn't add up, I
13 don't think, unless they are assuming 60 percent
14 release, but --

15 MR. POWERS: There's more deposition.

16 MR. KRESS: There's a lot of deposit.

17 MR. POWERS: There's more deposition.
18 There's a combination. There is more retained in the
19 fuel. I mean, at the time they were heavily biased by
20 the 10 percent number for the melt in the bottom at
21 TMI, plus in the analysis for cesium-iodine all I had
22 was a physical process. They knew for the cesium,
23 without the iodine, that they had an irreversible
24 chemical deposition. Okay, that is what leads to that
25 number there.

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1 MR. KRESS: What leads to the extra
2 deposition? I don't know what leads to the extra
3 deposition of cesium compared to iodine. You would
4 have thought they deposited about the same.

5 MR. POWERS: No, what they were saying was
6 the cesium, at the time they were saying cesium-iodine
7 deposits largely by condensation mechanisms. Cesium
8 hydroxide deposits both by condensation and chemical
9 reaction with the surface.

10 MR. KRESS: Yes, but the amount that goes
11 there is condensation.

12 MR. LEAVER: It's what stays there.

13 MR. POWERS: No. No, because --

14 MR. KRESS: Condensation is a two-way
15 street?

16 MR. POWERS: Well, the partial pressure at
17 the interface, the chemical reaction is very, very
18 low.

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

20 MR. POWERS: Whereas the partial pressure
21 when you have condensation is actually quite high.

22 MR. LEAVER: You could have no
23 condensation; if you have the chemisorption, you're
24 going to have deposition.

25 MR. POWERS: Deposition, yes, and that is

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1 what the code did for you, was it gave you deposition
2 from the leading edge, whereas condensation only
3 occurred way down the pipe. That's how it came about.
4 Now whether they got their sums right and things like
5 that, that is open to argument.

6 MR. KRESS: So I might be tempted to
7 say --

8 MR. POWERS: I wouldn't have to say
9 anything.

10 MR. KRESS: Yes, I think I will leave it
11 at that.

12 MR. POWERS: Thirty, between 25 and 30
13 just doesn't get me too excited.

14 MR. LEAVER: Me, either. You couldn't
15 argue that he is wrong with 30. That's for sure.

16 MR. POWERS: No. No, I've got no argument
17 for him, but I simply have no argument that the 25 is
18 wrong either.

19 MR. LEAVER: Right.

20 MR. POWERS: So, I mean, if he was going
21 to froth at the mouth and blubber and bawl and things
22 like that, I would give in to him. Since he's not
23 going to do that, I am going to make him sweat it out.

24 (Laughter.)

25 MR. GIESEKE: One reason to raise the

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1 number would be to be closer with the French guidance.

2 MR. POWERS: That would get you right on
3 top of the French guidance.

4 MR. GIESEKE: Well, no, they're saying 70
5 percent penetration, 30 percent deposition, roughly.
6 We're saying 50 percent deposition, 50 percent
7 penetration. But this would move us up a little
8 closer to them, which is the only consideration, is a
9 consideration for raising it to 30 rather than the 25,
10 looking at everything together, regardless of what I
11 compute, doing a people averaging exercise.

12 MR. POWERS: Show us what we have done so
13 far. Can you just flip through these now. Start from
14 the top.

15 MR. LEAVER: It would be nice to have a
16 transparency that you could mark up. I have forgotten
17 already what we did on the duration.

18 MR. BOYACK: I'll tell you what --

19 MR. GIESEKE: I have, too. I don't even
20 remember the duration.

21 MR. BOYACK: Is it possible to get a
22 transparency made of this?

23 MR. SCHAPEROW: Sure.

24 MR. BOYACK: And then we can just mark on
25 the changes and keep it up there.

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1 MR. SCHAPEROW: Yes, I think we need that.
2 I really do.

3 (Whereupon, the foregoing matter went off
4 the record at 3:31 p.m. and went back on the record at
5 3:40 p.m.)

6 MR. BOYACK: The first thing I want to do,
7 as I mentioned to you, Jason, during the break we took
8 the time to look at the calendar and to schedule,
9 assuming that there is no conflict with NRC schedules,
10 the third and final meeting of the panel.

11 MR. SCHAPEROW: That's just fine with me.

12 MR. BOYACK: Okay. So, for the record, if
13 you would consider that we will be holding the third
14 and final panel meeting on February 26th, 27th, 28th.
15 That's a Tuesday through Thursday. For your travel
16 arrangements, if you would sort of hold to the idea
17 that we would finish maybe two o'clock in the
18 afternoon generally is about the time that we finish.
19 We will need a little afternoon time. Occasionally,
20 we get done early, but generally that is the approach.

21 Now, given that, why don't I flash these
22 up and let you --

23 MR. SCHAPEROW: I'll mark them. Okay, go
24 ahead and put the other thing up and I'll mark them.

25 MR. BOYACK: So we start out with noble

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1 gases. Okay, let me come down here. Okay. The next
2 one is 0.63.

3 MR. POWERS: Brent, if people would like
4 to get coffee, the coffee place will close in the next
5 few minutes.

6 MR. BOYACK: Is there somebody that would
7 like to have coffee? Then Dana could take them down
8 or one of the badged people could. Anybody that wants
9 coffee?

10 Okay, it will take us a moment.

11 MR. SCHAPEROW: Are we going into the
12 timing also?

13 MR. BOYACK: Yes, I can do that.

14 MR. SCHAPEROW: We'll do the whole thing
15 here, see how we're making out.

16 MR. BOYACK: Let me get down to the bottom
17 here and see. Okay.

18 The first one is 0.4, then 1.4, and the
19 last two are staying the same.

20 Then we go to halogens. The only thing we
21 changed on halogens was the late in-vessel, which went
22 to 0.2.

23 Let's see, now we're down to alkali
24 metals. I believe this is the one. Okay. So alkali
25 metals, we left those all the same, didn't we?

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1 MR. SCHAPEROW: That's what we were
2 discussing, actually these two numbers, the early in-
3 vessel and ex-vessel.

4 MR. BOYACK: Okay. So now is this an
5 ongoing discussion?

6 MR. KRESS: I think we're going to leave
7 it.

8 MR. SCHAPEROW: We leave it?

9 MR. KRESS: I couldn't convince anybody.

10 MR. BOYACK: So that moves us on to the
11 tellurium group, right?

12 MR. SCHAPEROW: Just for clarification, I
13 guess I'm kind of wondering why so much of an alkali
14 metal release ex-vessel. I think that kind of does
15 tie into the --

16 MR. LEAVER: It's not ex-vessel.

17 MR. KRESS: It's the same comment as the
18 halogens do.

19 MR. SCHAPEROW: But it comes out later
20 though. The idea is that cesium comes out a little
21 bit later than iodine.

22 MR. KRESS: But not much.

23 MR. SCHAPEROW: But not much, all right.
24 All right.

25 MR. BOYACK: Okay. So the next one on the

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1 list would be the tellurium.

2 MR. SCHAPEROW: Would it be all right if
3 I put like an asterisk on these two, saying they're
4 released early in the late in-vessel period, or I
5 don't know?

6 MR. BOYACK: Well, if you want --

7 MR. SCHAPEROW: Well, let's see how the
8 next one comes out, I guess. All right.

9 MR. BOYACK: Now, Tom, I want you to start
10 thinking because you are going to be first.

11 MR. KRESS: I'm ready to start, except I
12 want Dana here, because I don't, for the life of me,
13 know where they got those tellurium numbers. I would
14 have them almost exactly the same as the iodine and
15 even a little higher or close to the iodine.

16 MR. SCHAPEROW: There is also a comment in
17 the final points that talks about tellurium release
18 being reduced somewhat in response to comments. Shall
19 I get those? Those are up there in my office.

20 MR. BOYACK: You notice we're in a mini-
21 break here now while we wait for Dana to come back.

22 (Whereupon, the foregoing matter went off
23 the record at 3:47 p.m. and went back on the record at
24 3:55 p.m.)

25 MR. BOYACK: Tom Kress said that he just

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1 found it impossible to go ahead and launch on the
2 tellurium until Dana got back.

3 MR. KRESS: Tellurium.

4 MR. GIESEKE: The big "T" group.

5 MR. KRESS: If one looks at the volatility
6 of tellurium, it is even higher than that of iodine.
7 It's close to it. If it were not for the fact that
8 some people think, and the evidence is there, that it
9 gets held up by the clad, it would get released just
10 about like the iodine would.

11 Is it a fact that the clad or somewhere it
12 gets tied up, either in the fuel or in the clad, until
13 about 90 or 95 percent of the clad gets oxidized, and
14 then it gets released as a burst, almost
15 quantitatively.

16 So the question comes down to, how much of
17 the clad will get fully or 95 percent oxidized in a
18 given transient, so that that fraction of the
19 tellurium gets released from that fraction they've got
20 tied up, say, if it got tied in the clad?

21 I think the .05, which is 5 percent, is
22 ridiculous. I think more than 5 percent of the core
23 gets fully oxidized in most of the accidents. So I
24 would raise that number to something, but I'm not sure
25 what yet.

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1 Even more ridiculous is the 25 percent ex-
2 vessel because, if it didn't come out in-vessel, when
3 it gets down there in the ex-vessel, it's going to
4 come out during the zirc oxidation part of that. So
5 I don't know where they got the 25 from.

6 I'm not too happy with the late in-vessel
7 either because I think there are some questions of
8 residual fuel that, when you get to the higher
9 oxidation, it might very well come out there.

10 So those are my comments. I don't know
11 exactly how to change the numbers, and I don't know
12 where they got those numbers from. Any discussion
13 about that?

14 MR. BOYACK: Hossein, do you have any
15 background or comments you wish to make about the
16 tellurium?

17 MR. NOURBAKHS: In the draft document,
18 based on again 5747, it was 15 percent. There was a
19 comment, from what I see here, from the British -- I
20 don't remember who -- that made the comments that this
21 is too high. So they made it -- I mean, the NRC
22 decided to lower that down.

23 MR. KRESS: I think what they are talking
24 about is, what fraction of the plant gets oxidized to
25 95 percent? That fraction is going to release that

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1 fraction in tellurium. I think it ought to be more
2 like 15 percent or even 20 percent. I don't know
3 where they get the 5. Then what about the 25 percent?

4 MR. LEAVER: So it was a British comment,
5 but you don't know the substance of that comment?

6 MR. NOURBAKHSB: I know the comment; I
7 have a copy of the comment, at least the part that I
8 highlighted for NRC.

9 MR. KRESS: How did they come up with 25
10 percent for the ex-vessel? I don't recall at all
11 that.

12 MR. NOURBAKHSB: It doesn't say that
13 point. It says it is high because of the diffusion by
14 cladding.

15 MR. LEAVER: They were talking about the
16 in-vessel.

17 MR. NOURBAKHSB: In-vessel.

18 MR. LEAVER: Yes.

19 MR. NOURBAKHSB: In the final report it
20 came down from 15 to 5.

21 MR. SCHAPEROW: And for the in-vessel
22 release, one of the experts had a very low release of
23 tellurium. It was expert B. He's got this curve
24 here. He doesn't get --

25 MR. NOURBAKHSB: Yes, but if you look at

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1 the onset of these, the tellurium is much higher --

2 MR. SCHAPEROW: Then in the ex-vessel the
3 experts all suggested that tellurium would be released
4 ex-vessel. That is one of the five curves we got from
5 the expert elicitation. That is the first one.

6 MR. KRESS: Then what's that 25 percent up
7 there for?

8 MR. SCHAPEROW: It should be the mean
9 value from this curve.

10 MR. POWERS: Twenty-five percent of the
11 core has slumped down into the ex-vessel, and it
12 releases 100 percent of its inventory.

13 MR. KRESS: But there is only 25 percent
14 of the core.

15 MR. LEAVER: No, there's got to be more
16 because --

17 MR. POWERS: There's got to be more.

18 MR. LEAVER: I think it is more like 35 or
19 40 percent because the cesium release ex-vessel was 35
20 percent, unless these guys meant by that, that that's
21 what was released from late in-vessel. I don't know.

22 MR. POWERS: One thing, I mean, what you
23 know is a lot gets released, but tellurium has this
24 propensity to react with any metal it sees along the
25 flow pathway.

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1 MR. LEAVER: I would offer --

2 MR. KRESS: So maybe that 5 percent, the
3 difference is what gets plated out in-vessel? It gets
4 latched onto things in-vessel, do you think?

5 MR. POWERS: I don't know. I know that
6 they were really, at the time, these crazy guys at Oak
7 Ridge were saying that you had to oxidize clad up to
8 these fairly high numbers --

9 MR. KRESS: Ninety-five percent is what
10 they said.

11 MR. POWERS: -- to get any kind of
12 release. At the time there was a bias to argue that
13 the codes were overpredicting the amount of clad that
14 was oxidized.

15 MR. KRESS: So you put those things
16 together --

17 MR. POWERS: They may have suppressed the
18 release fraction and then they may have tied up a lot
19 of it in the primary piping system, was their
20 thinking.

21 MR. KRESS: All those things lower than
22 one number.

23 MR. POWERS: Yes.

24 MR. BOYACK: In your testing it in France,
25 have there been any insights into tellurium behavior?

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1 MR. CLEMENT: Yes. We cite here that
2 clearly the tellurium reaches very higher release
3 fraction. That's true that the release stops at a
4 given place. We are close to 90, 95 percent. But I
5 am not so sure that we should apply this amount of
6 oxidized cladding to calculate the amount of tellurium
7 because when the zircaloy is not oxidized, what
8 happens when you are speaking of that melt, there are
9 some interactions. It slows down. It could be, I
10 mean, oxidized after *, and so on. This doesn't mean
11 that if you have some zircaloy, unoxidized uranium,
12 that's getting oxidation one way, * tellurium.

13 I know that during the oxidation the
14 tellurium or something *, and so on.

15 For instance, in PHEBUS we had reported
16 metal interactions that probably the counts, at least
17 our counts, underestimate, and this didn't appear
18 until nearly 100 percent tellurium release, very high,
19 or 85 percent.

20 So I think that, from our point of view,
21 we should stick to very high release fraction from the
22 fuel for tellurium.

23 MR. BOYACK: Right now they are only
24 showing about 1 in 30 percent release.

25 MR. KRESS: Well, I don't know how much is

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1 retained in the primary system. You can't tell from
2 those numbers.

3 MR. BOYACK: Even if it was just these two
4 figures, you're saying some fraction of that may be
5 redeposited or --

6 MR. KRESS: Redeposited in the primary
7 system.

8 MR. BOYACK: But even at that, that's the
9 maximum. You could have that none of it reacted or
10 redeposited.

11 MR. POWERS: Some of those numbers reflect
12 some material being deposited in the primary piping
13 system and being fairly irreversibly retained.

14 MR. BOYACK: So, basically, what I hear is
15 you're not comfortable -- I presume this is all --
16 you are not comfortable with the current value of the
17 NUREG 1465 numbers. So I guess at this point the
18 thing would be to do to try to ask ourselves what
19 might be the appropriate values and the physics to go
20 along with that. And you're telling me, I guess, that
21 it's not clear what the physics are.

22 MR. POWERS: The empirical observation is
23 that as long as you keep that fuel so that the fuel
24 environment itself is substantially reduced, there is
25 clad around to suck up the steam, that you don't seem

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1 to get a lot of tellurium release.

2 MR. BOYACK: Okay.

3 MR. POWERS: Now where that tellurium is
4 I don't think has been conclusively demonstrated. We
5 have certainly had the Oak Ridge experiments in which
6 they certainly found the tellurium somewhere around
7 the clad. I think a gamma standard or something, but
8 you found it.

9 When we did the Sandia in-pile
10 experiments, it is a very tricky measurement to do
11 because you very quickly get blinded by the cesium
12 signal, but we deliberately took the scan of the fuel
13 right after the test in a window where we could see
14 tellurium, and we had melted the clad and it had
15 drained off the fuel, and the tellurium was right in
16 the fuel. It was not in that clad. The molten clad
17 pool down at the bottom was tellurium-free.

18 MR. KRESS: So the clad may just be
19 preventing the oxygen from getting into the fuel.

20 MR. POWERS: The fuel. I mean that was
21 the conclusion, but it still didn't tell you where the
22 tellurium was. It had to be something, because if it
23 is just tellurium, that sucker would be a vapor.

24 MR. KRESS: Oh, yes, at those
25 temperatures, it just --

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1 MR. POWERS: So we knew it had to be
2 something, and I have always assumed, well, it must be
3 reacting with the metal inclusions because they form
4 incredibly stable tellurides, but I don't know that
5 for a fact.

6 So then why does it un-react when it
7 becomes oxidized? Well, it will do that. I mean,
8 that is just the truth of those things.

9 So now we have the PHEBUS results in which
10 they say they've got tellurium all over the place.
11 They're hip-deep in tellurium in there.

12 MR. CLEMENT: We can give you more precise
13 figures from our work on the PHEBUS tests; for the
14 VERCORS 4, VERCORS 5, and VERCORS 6 tests, that's 100
15 percent, more than 98 percent, and 97 percent release
16 of tellurium.

17 MR. KRESS: That's pretty close to the
18 lot.

19 MR. POWERS: When we run the Victoria Code
20 on these things, we tend to see the tellurium tied up
21 and it's things like silver tellurides, stuff like
22 that, like it's pre-reactive. In other words, it is
23 already a telluride, so that when it sees the piping
24 system, it doesn't want to turn into iron telluride or
25 nickel telluride or something like that.

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1 Just knowing the environment that Brian
2 Bausher was operating in, he had just been doing
3 experiments on tellurium reaction with nickel
4 planchettes, and of course nickel sucks up tellurium
5 like a sponge. I mean, it really goes after
6 tellurium. So he may have, when he made his comment,
7 been thinking of the nickel in the piping system.

8 But, I mean, I think for the PHEBUS it's
9 pretty clear. They are running it up out of the fuel
10 along several meters of 700 degrees Centigrade, in
11 canal. I mean, that's a serious nickel.

12 MR. CLEMENT: But it's oxidized.

13 MR. POWERS: Well, the surface is
14 oxidized.

15 MR. CLEMENT: The surface is oxidized.
16 That's why there is no --

17 MR. POWERS: Well, even oxidized in canal
18 sucks tellurium, and then it goes up through the steam
19 generator tubes and out into the containment. So, I
20 mean, it looks to me like understanding that we have
21 very few actual tellurium measurements from in-pile
22 tests, because it's a tricky measurement to make.

23 MR. KRESS: In fact, that's one of the few
24 I know of. I don't know what they did in PBM.

25 MR. POWERS: PBM had a heck of a time with

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1 it.

2 MR. GIESEKE: That's really dramatic
3 there, Dana.

4 MR. CLEMENT: Well, there is uncertainty
5 for the VERCORS, if I look at the PHEBUS, if I compare
6 * that is retaining the fuel through other *. So we
7 are 17 percent of tellurium retained in the fuel as
8 compared to 16 percent for cesium and 13 percent for
9 iodine.

10 MR. LEAVER: You said 17 percent?

11 MR. CLEMENT: Seventeen percent.

12 MR. LEAVER: One seven?

13 MR. CLEMENT: Yes, one seven, as compared
14 to 16 for cesium and 13 for iodine. So it is really
15 comparable and it corresponds to re-entering the lower
16 part of the bundle that was not so hot. Then if you
17 look at the retention in the hot zone that made the in
18 canal, 700 meters long, it was 3 percent of the
19 inventory.

20 MR. KRESS: Three percent?

21 MR. CLEMENT: Yes.

22 MR. KRESS: Okay.

23 MR. CLEMENT: Okay. So that is our
24 results.

25 MR. KRESS: Those results argue for a lot

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1 different numbers than we've got up there.

2 MR. BOYACK: David, why don't you talk to
3 these numbers. Then we can put that up after he has
4 shown that, and then maybe we can talk about it.

5 MR. LEAVER: This is just for the release
6 of FPT-1 and FPT-1-14, which of course are radiated
7 fuel, and FPT-0 is not radiated.

8 MR. CLEMENT: You are with respect to your
9 first column --

10 MR. LEAVER: Tellurium release fraction.

11 MR. CLEMENT: Okay.

12 MR. LEAVER: It is 79 percent, 53 percent,
13 21 percent.

14 MR. CLEMENT: Seventeen percent.

15 MR. LEAVER: Seventy?

16 MR. CLEMENT: No, 17.

17 MR. LEAVER: Seven zero or 17?

18 MR. KRESS: It's the released.

19 MR. LEAVER: Released fractions?

20 MR. KRESS: This is the amount released.

21 MR. LEAVER: That's to the fuel?

22 MR. CLEMENT: It is .83.

23 MR. LEAVER: Oh, it's .83?

24 MR. CLEMENT: Yes, .83.

25 MR. LEAVER: All right, well, I had

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1 something that said 53, but all right.

2 So it sort of correlated with the percent
3 zirc oxidized, although we are getting a very high
4 release with a little over half of the zirc oxidized.
5 But even more significant I think is the time and
6 temperature. It does seem to be strongly correlated
7 to that.

8 I don't know -- the NRC, it was research
9 that ultimately decided what to put in NUREG 1465, and
10 they got, of course, the work that Hossein did and
11 then they got input from other people, and that is
12 where these comments from Brian Bausher came in.

13 But I suspect that TMI had something to do
14 with where they ended up because that is a heck of an
15 experiment. Even though we can argue that the
16 accident wasn't typical, it's an accident on a reactor
17 and that's what they got.

18 I think the time and temperature are
19 significant. If you hold the fuel and the melt and
20 the debris and you let it sit there and cook, then
21 that would suggest that at some point it's going to
22 go. Now how much of this sort of phenomena we want to
23 push into that 1.4 hours, well, I guess that's the
24 question.

25 MR. BOYACK: Okay, I wonder if we could go

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1 ahead and see the French data one more time.

2 MR. CLEMENT: So that is PHEBUS FPT-1.
3 Here this foam is what is retained in the fuel. So it
4 is tellurium, 17 percent; cesium, 16 percent, iodine,
5 13 percent. So very similar.

6 Then we have what is deposited in the zone
7 just above the fuel. So we have only 5 percent for
8 iodine. That is not condensed in that zone. For
9 cesium and tellurium, roughly 26 percent. That is
10 because the vapors are condensing in that zone.

11 Then we have aerosol, and we are convinced
12 that that our rates are rather small. So that's the
13 overall value.

14 Now when you get kinetics --

15 MR. LEAVER: Can I take a look at it?

16 MR. CLEMENT: Yes, sorry.

17 MR. LEAVER: If I can just hold it?

18 MR. CLEMENT: So this is cesium released.
19 This one is tellurium. Okay? What you can see here,
20 this is the trapping value of zircaloy foam, non-
21 oxidized zircaloy. Both go in the same direction.
22 That's the degradation process *. This is why we are
23 concerned.

24 So why don't we have sufficient regulation
25 level? We think the release of tellurium would be

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1 similar to that of other tellurides.

2 MR. BOYACK: So you're showing about 85
3 percent? I'm not sure which one --

4 MR. SCHAPEROW: One of the things to think
5 about, I think, is after about an hour or so, they
6 have some separation. We are talking, as Dave said,
7 about a 1.4-hour heatup time. So even around 14,000,
8 15,000 seconds, one's a bit below the other, but it's
9 not a huge difference.

10 MR. BOYACK: All right.

11 MR. LEAVER: This is released from the
12 bundle?

13 MR. CLEMENT: This is released from the
14 bundle, yes.

15 MR. BOYACK: So then you have to decide
16 what was deposited, but the release is 85 percent,
17 roughly.

18 MR. LEAVER: Bernard, how would you
19 explain, in light of this and the intuition and
20 insight that this gives you, how would you explain
21 what happened at TMI with tellurium? Have you thought
22 about that?

23 MR. CLEMENT: No.

24 MR. LEAVER: No?

25 MR. BOYACK: So what did they do to do the

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1 TMI measurements? They took some --

2 MR. LEAVER: Well, they did a lot of
3 things. I mean, they measured what was in the
4 containment. They took the entire what was left of
5 the core out and did a lot of examination of what was
6 left. I mean, perhaps Dana could speak to the
7 measurements they actually made, but their guys spent
8 10 or 15 years of their life doing those measurements.
9 It was very, very carefully done, and there are a lot
10 of papers written on it.

11 So I think maybe there is some uncertainty
12 on the 2 percent measurement for TMI, but certainly
13 not -- I would be surprised if it was too large of an
14 uncertainty.

15 MR. SCHAPEROW: That's 2 percent of the
16 entire fuel --

17 MR. LEAVER: Of the core inventory.

18 MR. SCHAPEROW: Released from the fuel?

19 MR. LEAVER: Probably that's okay for us
20 to assume, that it was released from the fuel. I'm
21 actually not sure if they say that's released to
22 containment or released from fuel, but it doesn't
23 really matter. If it is 2 percent for the fuel, then
24 it is 1 percent to containment; if it is 4 percent to
25 the fuel, then it is 2 percent to the containment.

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1 But the idea is that they were looking at 2 percent.

2 And then SFD test, which admittedly was a
3 lower zirc oxidation, but, nonetheless, they saw the
4 same kind of thing from SFT-1-4.

5 MR. BOYACK: To this point in the
6 tellurium discussion, what we have really done is we
7 have gone back and reviewed the information. So
8 having done that, now I would like to come back and go
9 around the table and see what people have to say by
10 phase. We have the four phases, and sometimes I get
11 lost because I don't track when you change from phase
12 to phase, but if you would tell me your thoughts for
13 the four phases, we'll go around the table. Tom?

14 MR. KRESS: My thoughts are that --

15 MR. BOYACK: Starting with gap release.

16 MR. KRESS: Gap release, I don't care;
17 it's zero.

18 MR. SCHAPEROW: You might save yourself
19 some time and see if anybody thinks there is a
20 significant gap release for tellurium.

21 MR. BOYACK: Well, I have to enter it
22 anyway. Okay. Early in-vessel?

23 MR. KRESS: I'm inclined to put a lot of
24 weight on the PHEBUS results and say that the
25 tellurium releases in-vessel are very high. I don't

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1 know how high yet, but this is significant because
2 tellurium decays to iodine. It is a pretty serious
3 isotope. If we have to deal with it in design basis
4 space, we ought to know where it is coming out. There
5 is a lot of it there, and I am inclined to say we had
6 better think about those PHEBUS experiments and put a
7 lot of weight on them.

8 MR. BOYACK: Is there a need here
9 underlying this? It seems to me this is one --

10 MR. KRESS: There is a need to explain the
11 difference between what PHEBUS gives and what you get
12 in these little separate effects tests, where you heat
13 up fuel in a furnace, and all of the tellurium gets
14 trapped in the fuel and doesn't get released until you
15 oxidize 95 percent of the clad. Why do you get that
16 in these experiments and why does PHEBUS get
17 quantitative release summarily? What's the
18 difference?

19 MR. CLEMENT: At VERCORS we got a lot.

20 MR. KRESS: Oh, you got it in VERCORS.

21 MR. CLEMENT: Yes.

22 MR. KRESS: So there is an inconsistency
23 between VERCORS and, say, the ORNL tests, and I don't
24 know why the difference, but TMI I don't think that
25 was a very good experiment. I don't think TMI was a

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1 very good experiment.

2 MR. SCHAPEROW: ORNL tests, he said
3 various ORNL.

4 MR. BOYACK: Okay.

5 MR. KRESS: So, primarily, the conception
6 that you don't get tellurium release until you get 95
7 percent of the clad comes out of the ORNL tests. Here
8 we've got two sets of tests, one of them in-pile and
9 one of them separate, that contradicts that. We need
10 to know why, but that sure puts a big question mark on
11 the ORNL tests.

12 MR. POWERS: I mean, I think ORNL and SFD
13 tests.

14 MR. KRESS: Oh, the SFD tests also did
15 that.

16 MR. POWERS: Those guys -- you guys at
17 ORNL started focusing on it because they weren't
18 seeing the release in the SFD.

19 MR. KRESS: Why if something is that
20 volatile, why didn't you see it? That's right.

21 MR. SCHAPEROW: SFD, Severe Fuel Damage.

22 MR. POWERS: Somehow in our in-pile tests
23 that we did we didn't get the tellurium out. It was
24 still in the fuel.

25 MR. LEAVER: The SFD tests?

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1 MR. POWERS: No, the ones that were done
2 in Sandia. There were some specialized tests done to
3 look at the highly-reducing conditions, and they did
4 a couple of tests. Tellurium did not move.

5 MR. KRESS: There's a need to reconcile
6 these contradictory results, but in the meantime if we
7 have to specific a source term for design basis, I am
8 one of these people that falls down on the
9 conservative side and says, let's use the PHEBUS
10 results, because that gives you more problem in what
11 you have to do.

12 MR. POWERS: Well, I tend to look at it a
13 little this way: that we were really floundering
14 around with the SFD tests. I mean, they were
15 basically core degradation tests, and they monitored
16 fission products. We really didn't know what we were
17 doing, whereas PHEBUS tests were dedicated, directed
18 from inception to look at fission product release and
19 transport, and they had lots of help in ensuring that
20 they did well-designed test.

21 MR. KRESS: And, similarly, the Oak Ridge
22 test --

23 MR. POWERS: Is that how you describe it,
24 "lots of help"?

25 (Laughter.)

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1 MR. KRESS: Similarly, the Oak Ridge test
2 had trouble finding tellurium because there wasn't
3 much of it in that fuel going in and they didn't re-
4 irradiate. So they really had problems with their
5 tellurium analysis.

6 MR. POWERS: Well, that's another thing to
7 bear in mind, is that the tellurium, the radioactive
8 tellurium you are seeing in the PHEBUS test is short-
9 life stuff. If it has been generated, it perhaps has
10 not had the opportunity to go around and find
11 something to tie itself up with.

12 MR. KRESS: And that is another possible
13 explanation for the difference. The question is, what
14 would a reactor do? Maybe that short-life stuff --

15 MR. POWERS: I mean, what I'm going to
16 argue is that, as we move to high burnup fuel, we take
17 the tin out of the clad. As we consume the metallic
18 alloys that can react with things by inherent
19 oxidation, that we're losing --

20 MR. KRESS: You're moving towards more
21 tellurium.

22 MR. POWERS: So we are going to move much
23 more toward the PHEBUS result.

24 MR. BOYACK: So, basically, what I said
25 for Tom for the early in-vessel release of tellurium,

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1 which decays to iodine, those PHEBUS tests were
2 designed and directed to fission product management.
3 There is justification for basing source term
4 applicability on the PHEBUS results.

5 MR. KRESS: That's pretty much what I
6 think.

7 MR. BOYACK: Okay. So if you were basing
8 it on, for this early in-vessel phase, what do you use
9 for the --

10 MR. KRESS: I would be tempted to make it
11 just like the iodine phase that we had, except I would
12 have to rethink a little bit about retention in the
13 primary system, but I would also be guided over the
14 PHEBUS tests, that if your primary system is oxidized,
15 maybe the tellurium doesn't have that reading. So I
16 would be tempted to make a lot like the iodine.

17 MR. POWERS: You know, there is another
18 thing about the Severe Fuel Damage tests. When they
19 blew the control rods, that material slumped promptly.
20 Control rod material is highly reactive toward
21 tellurium. If that sucked it out and it fell out of
22 the hot zone very quickly, you would not get --

23 MR. KRESS: It sequesters it.

24 MR. POWERS: -- it sequesters; you
25 wouldn't get any release; whereas, in PHEBUS it tends

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1 to hang up.

2 MR. KRESS: That's interesting.

3 MR. POWERS: I think what you are going to
4 see, I mean all of the analyses that I have seen on
5 the primary piping system always show the tellurium
6 tied up, silver-Indian tellurides and things like
7 that, I mean you see lots of tellurides, like it's
8 already reacted from that --

9 MR. LEAVER: Not just tin telluride, but
10 there's --

11 MR. POWERS: In fact, I can't recall ever
12 seeing any tin telluride. It's always Indian
13 telluride or silver telluride, but I can't remember
14 the calculations that well. There may be tin
15 telluride, but I just don't remember.

16 MR. LEAVER: Well, that's what I remember,
17 but there's a lot of Indian in the PWR's.

18 MR. KRESS: Yes, but they tend to go
19 first, and I'm not sure if they're still around -- I
20 don't know; it depends on how you calculate the core
21 melt progression, but those things tend to go first
22 and get dispersed. Maybe they are still there; maybe
23 they aren't by the time the tellurium --

24 MR. POWERS: Well, they tend to be all
25 over the place because you've got control rods going

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1 off sequentially in time.

2 MR. LEAVER: There's just a lot of mass of
3 Indian, a lot of moles --

4 MR. KRESS: Oh, yes.

5 MR. LEAVER: -- relative to the moles of
6 tellurium.

7 MR. KRESS: Yes, a lot there.

8 MR. LEAVER: So, yes, some of it could go
9 off. It is hard to imagine that there wouldn't be
10 some of it around.

11 MR. POWERS: It depends on two things.
12 You have this -- the control rods are going off as a
13 function of time, and then if you model it to slump
14 down out of a hot zone very quickly and quench on the
15 lower support plane, you don't have very much. If you
16 spray it, interact a little bit with the clad, hang it
17 up in things, then you've got silver all the time.

18 MR. LEAVER: But, of course, things aren't
19 homogeneous.

20 MR. POWERS: The answer is probably, yes,
21 it does all those things.

22 MR. BOYACK: Okay, we've got you through
23 two of the phases now, but these are hard phases. Do
24 you want me to stick with and just take the first
25 couple of phases and go around the table, and then

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1 come back?

2 MR. KRESS: Yes, let me think about the
3 other things.

4 MR. BOYACK: Okay, Jim, let's start with
5 the gap release for tellurium. Your thoughts?

6 MR. GIESEKE: I'm go with Tom on that.
7 He's saying -- what is it, zero? It's zero.

8 MR. BOYACK: Yes. You've heard the dialog
9 on the early in-vessel releases. What are your --

10 MR. GIESEKE: It's really confusing is
11 what it is

12 (Laughter.)

13 MR. BOYACK: Really confusing.

14 MR. GIESEKE: I'm inclined to think that
15 there should be a lot of release, but I don't know
16 what's going to happen to it. It wants to get tied
17 up, and whether that happens in-vessel or in transit
18 is not clear.

19 I was wondering if we know the computed
20 retention was in the RCS for tellurium.

21 MR. LEAVER: Yes, I've got it here.

22 MR. GIESEKE: Do you have those?

23 MR. LEAVER: Yes. This is the
24 transmission, not the retention.

25 MR. GIESEKE: Oh, okay, what was that?

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1 MR. LEAVER: These are the numbers under
2 the tellurium column for the different environment
3 conditions.

4 MR. NOURBAKSH: They are the 1150
5 elicitation.

6 MR. LEAVER: Yes, those are the 1150
7 elicitations.

8 MR. NOURBAKSH: Those are quite high. If
9 you look at chad melt-type calculation, you are
10 getting -- you can bond it like 50 percent.

11 MR. GIESEKE: So the retention is similar
12 to the iodine, cesium --

13 MR. NOURBAKSH: No, the total release
14 would be like 50.

15 MR. GIESEKE: You mean the retention
16 fraction, the retained fraction?

17 MR. BOYACK: If you are going to talk,
18 stand by the mike.

19 Jim, if you were forced to give a value,
20 would you -- pardon me, encouraged to give a value --
21 do you have a sense of what release fraction you would
22 use for the early in-vessel phase?

23 MR. GIESEKE: Well, I'm inclined to think
24 it might be similar to the iodine.

25 MR. BOYACK: Okay, Dana?

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1 MR. POWERS: Tellurium is one of the first
2 ones where I think we started seeing really
3 profound --

4 MR. BOYACK: Just a minute.

5 MR. GIESEKE: Okay, fraction released from
6 the pool goes into containment. Those are fairly
7 high, aren't they? There's not too much --

8 MR. BOYACK: Okay, thanks, Dana.

9 MR. POWERS: Tellurium is the element
10 where I think we start seeing profound burnup effects
11 potentially intruding, and especially as you move
12 toward 75-gigawatt-day fuel, I think that you will
13 have lost your oxygen potential buffering capacity.
14 In that light, I would think that I would need to
15 include some tellurium release in the gap release. I
16 don't think it is large, but I will argue for
17 something on the order of 1 percent. You could talk
18 me into a half a percent without much trouble.

19 But I want to emphasize that this is an
20 area where I think we need experimental measurements
21 of fission product release during design basis
22 accidents.

23 MR. BOYACK: So the need is -- part of the
24 problem is I'm typing while you're talking, so I
25 missed it. What was the latter part on need?

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1 MR. POWERS: We need experiments with high
2 burnup fuel under LOCA conditions and measuring
3 fission product release, both gap release, which you
4 only get kind of in the experiment, but you'll get
5 something, and --

6 MR. KRESS: Is that PHEBUS LOCA?

7 MR. POWERS: Well, I mean, they may be
8 able to do them in the single-rod experiments. I
9 don't see how if they don't re-irradiate. You have to
10 be careful of re-irradiation because then you're
11 getting short-life stuff that hasn't had a chance to
12 move around. So you may get an upper bound there, but
13 you have to be careful, and I think we ought to be
14 measuring that. I mean, why guess?

15 PHEBUS LOCA experiments are ones that
16 haven't been done yet. They're proposed.

17 MR. BOYACK: Okay, so you're talking about
18 a gap release of half to 1 percent and the need for
19 experiments. Okay.

20 Is that what you have in the gap release
21 phase and your other earlier comments --

22 MR. POWERS: I'm ready to move on to early
23 in-vessel release.

24 MR. BOYACK: Okay.

25 MR. POWERS: I just can't ignore the

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1 PHEBUS results. So my tendency is to say, gee, I
2 believe I'll just take the average of the iodine and
3 cesium or that fraction that gets released from the
4 fuel in-vessel and transported through the reactor
5 coolant system.

6 MR. BOYACK: Take the average of iodine
7 and cesium that is released, transported, and used
8 for -- is that what --

9 MR. POWERS: Yes, yes, and say it is going
10 to be right in between those two someplace. I swallow
11 the PHEBUS results, and I mean I've watched those
12 tests from their inception. It's kind of hard for me
13 to neglect them. They were well-designed. They
14 seemed to yield a pretty incontrovertible result.

15 MR. BOYACK: What is that, roughly 30
16 percent now?

17 MR. POWERS: Yes. See, this is Tom's 30
18 percent that he has been arguing for all along. We're
19 going to give it to him here. I'll just put it in a
20 different box, Tom. We were going to get there.

21 (Laughter.)

22 MR. KRESS: I don't mind as long as we get
23 it up there somehow.

24 MR. BOYACK: You mean any place you get 30
25 percent?

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1 MR. KRESS: Yes.

2 (Laughter.)

3 MR. GIESEKE: Any 30 percent will do.

4 MR. KRESS: If you could do that on my
5 IRA, I would appreciate it.

6 (Laughter.)

7 MR. BOYACK: We talked about reconciling
8 the differences, but is there any need for additional
9 experimental programs that are not already planned?

10 MR. POWERS: Again, I think that we should
11 be doing experiments with high burnup fuel under both
12 severe accident and low conditions.

13 MR. BOYACK: All right, Bernard? We're
14 sort of dealing with the first two phases here, gap
15 release --

16 MR. CLEMENT: Okay. So for the gap
17 release, we don't think about what *. We did not
18 consider any gap release, but I understand the
19 arguments that maybe there could be some, but I don't
20 know.

21 MR. BOYACK: Okay.

22 MR. CLEMENT: Concerning the other phases
23 of in-vessel release, so without distinction between
24 phases, as for other volatiles, okay, we arrive with
25 the same figure of overall release; that is, for the

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1 containment, 70 percent fuel deposition and 70 percent
2 for the containment. They should be separated in the
3 same way.

4 MR. BOYACK: Same way. Would you remind
5 me what the breakdown of the 75 percent was?

6 MR. CLEMENT: Seventy. We did not make
7 any breakdown.

8 MR. SCHAPEROW: The same as cesium is what
9 he said.

10 MR. CLEMENT: Yes. We personally did not
11 make any breakdown.

12 MR. BOYACK: No, I wasn't talking about
13 the breakdown between the phases, but I was referring
14 to what was deposited and what was containment.

15 MR. CLEMENT: Okay. It should be clear:
16 100 percent release from fuel, and 70 release to
17 containment.

18 MR. BOYACK: Okay.

19 MR. CLEMENT: We say 100 instead of 95
20 because of the 5 percent we did not consider as
21 released during the gap will be released anyway.

22 MR. BOYACK: So 100 percent is released
23 from the fuel, and released to the containment was --
24 was that the 75 percent?

25 MR. CLEMENT: Seventy percent.

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1 MR. BOYACK: Seventy percent; I thought I
2 heard you say that. Okay.

3 Anything else?

4 MR. CLEMENT: No.

5 MR. BOYACK: Okay, Dave?

6 MR. LEAVER: I think that the FPT-1 data
7 is new since 1465 and is significant. I would just
8 observe that from the integral release curve that it
9 tends to be on the order of maybe two-thirds to three-
10 quarters of the cesium release right until the very
11 end, when they both kind of jump up to 85 percent or
12 so on that curve.

13 So I think, in my view, that the tellurium
14 number should come up. This is primarily, I guess, a
15 relooking at 1465-type observation as opposed to
16 effect of higher burnup. I think I would make these
17 comments irrespective of the higher burnup, and I
18 think the FPT data is the main reason to make this
19 some kind of increase.

20 But if you observe, first of all, that the
21 tellurium release is on the order of two-thirds to
22 three-quarters of the cesium on that integral release
23 curve, and the second thing is while TMI and SFD are
24 old, I don't think we should just ignore them
25 completely.

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1 Oh, I guess another observation would be
2 the fact that the FPT was at temperature for maybe
3 twice as long as what we're saying our in-vessel
4 release duration is, roughly, or 1.7 or 1.8 times. So
5 at least acknowledging that TMI and SFD results and
6 the fact that we're looking at this early in-vessel
7 release as a significantly shorter period than the
8 FTP-1, but balance that with the fact that the release
9 rate seems to be higher than what came out of 1465,
10 perhaps something a little bit less than the cesium,
11 I would say a number maybe like for tellurium released
12 from the fuel, maybe 20 to 25 percent with some amount
13 of retention.

14 I don't see a basis for deviating too much
15 from the factor of two, which tends to be kind of a
16 mish-mash-type number, considering a lot of different
17 sequences conditions, which would lead me a number for
18 tellurium of, say, into the containment of somewhere
19 in the neighborhood of 10 to 15 percent.

20 MR. GIESEKE: Just as a point of
21 information, the computed values for transmission of
22 tellurium were roughly 80 percent, for better or
23 worse.

24 MR. LEAVER: Oh, they were?

25 MR. GIESEKE: Yes.

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1 MR. LEAVER: These are transmission is 15
2 to 20, maybe 30 percent, according to this. This is
3 from the expert -- do you mean this table?

4 MR. GIESEKE: No, his computations. The
5 computations.

6 MR. LEAVER: Which computations?

7 MR. NOURBAKSH: The table you are looking
8 at are NUREG 1150, the mean values. They have looked
9 at the result of Source Term Code Package, but they
10 tend to look at them like upper bound. When they
11 quantified the distributions, it came lower.

12 MR. LEAVER: So, like all these numbers,
13 there's a range, and, yes, these are median and means,
14 but I guess a factor of two. I'm not smart enough, I
15 guess, to say that this number should be different
16 than a factor of two.

17 So, with a release from the fuel of 20 to
18 25 percent, based on the FPT result, but acknowledging
19 that we are looking at duration on the order of 1 to
20 1.5 hours, and remembering the fact that there was
21 this event called TMI and the SFD tests, I guess I
22 would come in at 20 to 25 percent, with a factor of
23 two reduction, giving me 10 to 15 percent.

24 MR. BOYACK: Okay, Dave, on the gap
25 release, I think all your comments with respect to

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1 early in-vessel and then subsequent to that --

2 MR. LEAVER: Yes, I would have no basis to
3 change the gap release, though we might make it
4 something other than zero. We could make it some
5 really small number, but I don't think -- I wouldn't
6 adjust it to a number like 1 percent or something, if
7 we want to make it something other than zero. That
8 would at least qualitatively acknowledge that maybe we
9 think something would come out during the gap. I
10 think it is hard to defend zero for the gap release;
11 that's for sure.

12 MR. BOYACK: Okay. Now let's walk through
13 a couple of these and see if we can't wrap these two.

14 The first of them is the gap release,
15 which is somewhere between zero and 1.

16 MR. GIESEKE: I said a half is somewhere
17 between zero and 1.

18 MR. BOYACK: I guess that's right.

19 MR. KRESS: Probabilities are between 0
20 and 1.

21 (Laughter.)

22 MR. BOYACK: Some of us are getting near
23 the end of the day, I can tell.

24 (Laughter.)

25 Okay, the question, I think, is basically:

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1 Do we want a non-zero value? Originally, we started
2 out over here, and then there was some discussion
3 about the possibility of perhaps having a non-zero
4 value, and Dana would live with a half percent and
5 David would live with a half percent. The question
6 is, anybody else --

7 MR. GIESEKE: I'll live with a half
8 percent.

9 MR. KRESS: Five percent is all right with
10 me.

11 MR. BOYACK: Okay.

12 MR. POWERS: I think you need another zero
13 in there.

14 (Laughter.)

15 MR. BOYACK: Okay, I'm sorry. Now we come
16 to the early in-vessel, and there is a span here, if
17 I've recorded right, between 25 and 35 percent, 20 to
18 35 percent.

19 MR. SCHAPEROW: Actually, Dave had about
20 10 percent.

21 MR. LEAVER: No, not 20.

22 MR. BOYACK: Oh, I guess what happened is,
23 when I heard you, I interpreted you to be telling me
24 something down here.

25 MR. LEAVER: Okay.

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1 MR. BOYACK: So this is wrong.

2 MR. LEAVER: No, my thought was early in-
3 vessel.

4 MR. BOYACK: So it is 10 to 15 percent,
5 right?

6 MR. LEAVER: Right.

7 MR. BOYACK: You've got to watch the typer
8 all the time.

9 (Laughter.)

10 Okay. So now what I would like to do is
11 try to figure out how to deal with this. Actually, we
12 had three of the panel members were up in the area of
13 30 to 35, and I guess the French don't break it down.
14 Okay. But you get 100 percent release from fuel and
15 eventually delivery to the containment of 70 percent,
16 which is, again --

17 MR. CLEMENT: Not so far from the total.

18 MR. BOYACK: Okay. This thing is starting
19 to get warm evidently because, if you can see, I am
20 losing some of the lines here (referring to
21 equipment).

22 So we have Dave who is down at a much
23 lower value.

24 MR. GIESEKE: I would like to propose a
25 higher value. I would like to look at Tom's

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1 calculation for this sort of burnup. He gets 100
2 percent release predicted. If you take the
3 computation of 80 percent of transmission, then you
4 are looking at 80 percent to the containment as an
5 upper bound. I think that is probably an
6 overestimate, but I think that is consistent with what
7 the French are finding in their experiments. I think
8 it is a little high, but I would like to see the
9 number higher.

10 MR. BOYACK: Higher than 35?

11 MR. POWERS: Understand that you're
12 working in this phase with only 60 to 70 percent of
13 the core melting down. So if you take --

14 MR. GIESEKE: Okay, you can take that
15 times 60 percent, if you want.

16 MR. POWERS: So if you take 70 percent of
17 the core and 80 percent transmission, that would give
18 you a 56 percent release.

19 MR. GIESEKE: Yes.

20 MR. KRESS: So perhaps we can play with
21 that.

22 MR. POWERS: That's what he means by -- he
23 says 20 percent of that being plated out.

24 MR. GIESEKE: Yes.

25 MR. POWERS: You're going to be pasted by the

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1 transcriber.

2 MR. GIESEKE: I'm just saying I think to
3 go down to 10-15 percent is lower than what I would
4 say. My 60 percent Dana is saying is probably on the
5 high end. So I think it is closer to maybe a half;
6 40, 50 percent would be a better number than the low
7 end, especially since it is supported by the
8 experimental results from the French.

9 MR. BOYACK: So is that number different
10 than what you've got here?

11 MR. GIESEKE: It needs to be modified for
12 some fraction of the core, for the fraction of the
13 core involved, say 70 percent of the core involved in
14 this in that time period.

15 MR. BOYACK: Yes, what I'm asking, Jim, is
16 I'm having a hard time tracking whether this number is
17 the same as you offered initially or changed.

18 MR. GIESEKE: I didn't give you a number
19 initially.

20 MR. BOYACK: Well, sure you did. See,
21 it's right here.

22 (Laughter.)

23 MR. GIESEKE: That was from the fuel.

24 MR. BOYACK: Oh, this is a release
25 fraction from the fuel, right?

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1 MR. GIESEKE: Right. But it could be
2 higher than that even, if you want to use Tom's
3 calculation. He calculates 100 percent, but being a
4 little skeptical, I'm giving 90 percent or something
5 like that. So you take .9 times .7 times .8 and what
6 do you get? Fifty percent. Now that still may be
7 high. You know, it seems like a big number to me, but
8 it tends to be more supported by the French data is
9 all I'm saying. There is some logic behind those
10 numbers.

11 I'll start talking down from that number
12 now, if you want.

13 MR. BOYACK: And I'm putting 50, is that
14 right? See, I'm not quite sure whether I'm missing
15 something.

16 MR. GIESEKE: Yes, take out "from the
17 fuel" and just say 50 percent.

18 MR. KRESS: That's the number that goes in
19 the box.

20 MR. BOYACK: Yes, that's the number I was
21 after. Okay, so now we're between 10 and 50 percent.
22 You heard some of the dialog. Does any of this change
23 your mind or are you still back where you were?

24 MR. LEAVER: No, I guess not. I think if
25 we believe cesium to be 25 percent in-vessel, and if

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1 we think we're talking about a release duration on the
2 order of 1.4 hours, and then the reason, at least one
3 of the reasons for that release duration is we are
4 saying this is a recovered accident. That is what we
5 say in design basis space, and that is the reason why
6 we don't consider the ex-vessel and the late in-vessel
7 release.

8 So with that release duration and the fact
9 that we felt that the right number for cesium was 25
10 percent, and if you look at the French data, the
11 tellurium is lagging the cesium release such that you
12 get roughly three-quarters or so of the cesium
13 release, although at the end, as I said, it catches
14 up, but that's out of like 6500 seconds or so, I don't
15 see how we can justify a larger number for tellurium
16 unless you believe tellurium isn't retained in the
17 RCS.

18 If you look at the French results, it
19 shows about the same retention. Now I'm not
20 personally -- I don't feel like I am smart enough to
21 say that the retention would be different.

22 MR. GIESEKE: The French shows -- what did
23 they say -- 70 percent?

24 MR. LEAVER: Well, I was just looking
25 at --

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1 MR. GIESEKE: It's a 30 percent retention.

2 MR. LEAVER: Yes, I was just looking at
3 the -- if you look at the cesium, this is for FPT-1,
4 the cesium line and the tellurium line, the percent in
5 the upper plenum and the percent deposit in the hot
6 leg, and what-not, look roughly the same.

7 So I would say, even if you were to say
8 three-quarters of our cesium number, we would be close
9 to 15 percent. I mean, maybe it is a little more.
10 Also, I just don't feel that we should totally throw
11 out what happened with TMI and SFD. I think we want
12 to consider a range of conditions and sequence types
13 and that sort of thing. So that is kind of what we
14 are doing, and those two data points, in my mind, tend
15 to kind of make me want to tamp the number down a
16 little bit or at least accept the kind of logic that
17 I just went through that would give us a number of, if
18 not 15 percent, then between 15 and 20.

19 MR. BOYACK: Okay, I don't know where to
20 go with this one, but are there any other comments?
21 As you heard the dialog back and forth, is there
22 anything that changes anybody's mind?

23 (No response.)

24 Okay, so this is a case where we get a
25 large range.

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1 MR. POWERS: It's a large range, but
2 understand, even if we took the bottom of that range
3 and made some radical change in the way we look at the
4 source term, I mean even if you were to take Dave's
5 number which is at the bottom of the range at 10 to 15
6 percent, it is three times what you've got now, but,
7 more importantly, it is a big difference in the way of
8 looking at things.

9 MR. SCHAPEROW: A big difference in what?

10 MR. POWERS: How you look at things.

11 MR. LEAVER: In terms of tellurium.

12 MR. POWERS: That's right, in terms of
13 tellurium.

14 MR. LEAVER: Are acknowledging, I think,
15 that there is that difference. Yes, that's right.

16 MR. POWERS: We've got some really good
17 data points now.

18 MR. LEAVER: There is some significant
19 data that we didn't have a couple of years ago.

20 MR. POWERS: A guy can come along and make
21 an argument and say, okay, you've got a core that's
22 like a third high burnup fuel and two-thirds lower
23 burnup fuel, and if you said, well, lower burnup fuel
24 behaves just like TMI, releases squat, and higher
25 burnup fuel behaves a whole lot like PHEBUS and

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1 releases a bunch, you come up with these kinds of
2 numbers, I think.

3 MR. LEAVER: Wait a minute. Are you
4 saying that the FPT-1 was high burnup fuel?

5 MR. POWERS: Well, it was not, but it was
6 up around -- I think FPT-1 was 20 --

7 MR. CLEMENT: Twenty-four.

8 MR. POWERS: Twenty-four?

9 MR. CLEMENT: Twenty-four.

10 MR. POWERS: Gigawatt-days per ton.

11 MR. LEAVER: Twenty-four.

12 MR. POWERS: Whereas, TMI is 8.

13 MR. LEAVER: oh, core average was 8?

14 MR. POWERS: Yes.

15 MR. KRESS: That is why TMI shouldn't be
16 extrapolated to these kinds of numbers. The burnup is
17 just too low.

18 MR. LEAVER: Well, yes, I don't think we
19 are extrapolating it. I am just saying I can't bring
20 myself just to completely ignore it. So it tends to
21 want to at least impact a little bit on my thinking.

22 But I agree with what you said, Dana. I
23 think that we are acknowledging a different way of
24 looking at tellurium than we did five years ago when
25 we did 1465, or eight or nine years ago when we did

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1 the thinking for 1465.

2 MR. SCHAPEROW: Twelve years ago.

3 (Laughter.)

4 MR. POWERS: It was a long time ago. As
5 I said, for the NUREG 1150 elicitations, I said, for
6 tellurium I'm totally uncertain, drew a diagonal
7 line --

8 MR. KRESS: Just straight across.

9 MR. POWERS: I'm totally uncertain. Today
10 I think I would end up drawing maybe not a diagonal
11 line, but it would still be a vast uncertainty
12 associated with this.

13 MR. SCHAPEROW: I see your diagonal line
14 right there. There it is.

15 MR. POWERS: Yes, that's me.

16 (Laughter.)

17 MR. SCHAPEROW: Somebody thought it was
18 very low. This is a very low fraction.

19 MR. POWERS: Well, you have to understand
20 at the time that they weren't seeing anything in the
21 SFD tests. So they asked Oak Ridge to take a look
22 particularly at it, and Oak Ridge couldn't find it.
23 Then they came up with this clad thing. They wrote a
24 paper on it. I mean it's in Nuclear Technology or
25 something like that.

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1 At the same time we were going in an era
2 from a period in the March code where we said every
3 bit of the clad gets oxidized during the in-vessel
4 core degradation to saying, no, wait, lots of this
5 escapes oxidation in the core and comes ex-vessel. So
6 those combinations of things led at least one guy to
7 say, oh, it's very low release inside.

8 But, understand, what you don't get
9 inside, you bring it ex-vessel and my melt concrete
10 gets it for you. I mean, if there is one fission
11 product that I think we know well experimentally on
12 melt concrete interaction and calculate well on melt
13 concrete interaction, that is tellurium.

14 MR. KRESS: That is why I never understood
15 that 25 percent.

16 MR. POWERS: Well, I think that is 25 --
17 well, I don't know why. I guess I don't understand it
18 either.

19 MR. BOYACK: Let me ask a question at the
20 extremes of the values. What is the user impact of a
21 number now that goes into the source term for high
22 burnup fuel of 15, even though it is reflecting
23 knowledge not on high burnup fuel, but just on
24 tellurium? What is the impact on the 15 percent value
25 and what is the impact on a 50 percent value? Is

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1 there any significant real-large impact on the end-
2 user?

3 MR. SCHAPEROW: Well, as Tom pointed out,
4 one of the tellurium isotopes decays to Iodine-132.
5 Generally, right not it is pretty small.

6 MR. LEAVER: What's the half-life of
7 I-132? The half-life of Iodine-132, like about 90
8 minutes?

9 MR. SCHAPEROW: If you multiply that --

10 MR. POWERS: No, it's a few hours.

11 MR. LEAVER: A few hours? Five, six
12 hours?

13 MR. POWERS: I think it is longer than
14 that, but I can't remember exactly.

15 MR. BOYACK: The reason I am asking is if
16 relatively insensitive to one end or the other, then
17 maybe you can just pick one of the values and say,
18 okay, it's not a matter that is really highly
19 sensitive on the impact, but if it has large impact,
20 then there is large uncertainty.

21 MR. GIESEKE: Let me reconsider my number.
22 I think I overestimated because I didn't consider the
23 distribution of high burnup in the fuel.

24 MR. BOYACK: Yes.

25 MR. GIESEKE: If I go through that

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1 estimation of the fractions of the fuel for high
2 burnup compared with lower burnup, I can get my
3 estimated number from the 50 down to 30 percent.

4 MR. KRESS: So he is right online with me.
5 in saying it is about the same as the iodine.

6 MR. GIESEKE: Yes, I forgot about that
7 when I made my first calculation. Of course, that
8 puts it to be not consistent with the French line, or
9 less consistent.

10 MR. POWERS: Well, we will get back up to
11 the French when we do the other two sections. We will
12 catch up with them.

13 (Laughter.)

14 We're just slow; that's all.

15 (Laughter.)

16 MR. KRESS: What's the half-life of it?

17 MR. POWERS: 2.3 hours. But, effectively,
18 Iodine-132 has an 88 half-life.

19 MR. LEAVER: Well, Tellurium-132 has a 78-
20 hour half-life.

21 MR. POWERS: Seventy-eight? All right.

22 MR. LEAVER: That defines the half-life
23 for iodine.

24 MR. POWERS: Tellurium-132 in an accident
25 acts like it has a 78-hour half-life.

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1 MR. BOYACK: I am not sure we know the
2 answer to the question you are asking, which is --

3 MR. KRESS: I thought I would just try
4 that question.

5 MR. LEAVER: It is too bad we didn't come
6 to this at two o'clock because I probably could have
7 made a couple of phone calls and had a couple of quick
8 calculations done where we could probably tell you
9 pretty darn good what the impact that would be. It is
10 not trivial.

11 MR. BOYACK: Well, I don't even know it's
12 a problem for us.

13 MR. LEAVER: The 50 percent number I think
14 I could be a potential disaster.

15 MR. BOYACK: Well, the 50 percent just
16 went away to 30.

17 MR. SCHAPEROW: Imagine that.

18 MR. LEAVER: A factor of three. If we
19 went from 5 percent to 15 percent --

20 MR. BOYACK: See, this isn't my call. So
21 the question is: How do we deal with this?

22 MR. SCHAPEROW: I think we should sleep on
23 it because it's five o'clock.

24 MR. BOYACK: Well, yes.

25 (Laughter.)

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1 MR. POWERS: Yes, I don't mind sleeping on
2 it, and I emphasize what I said earlier, that even if
3 we take Dave's number and put it in there, you're
4 telegraphing then that you really need to do some
5 serious study in this area because you just made a
6 huge change in this thing. It calls attention to it.
7 Maybe we need to sleep on it and just go on and do the
8 others so that we catch up with the French, you know.
9 Those guys are always ahead of us.

10 MR. LEAVER: They were ahead of us when
11 they built standardized plants.

12 MR. POWERS: Yes, that's the thing. Ever
13 since they went to standardized plants, they've been
14 ahead of us.

15 (Laughter.)

16 MR. KRESS: Now we are trying to --

17 MR. POWERS: Well, we gave up. We just
18 imported them and had them make the MOX fuel for us.

19 (Laughter.)

20 We will never catch up on MOX. We should
21 buy theirs; it's easier.

22 MR. KRESS: We should have listened to
23 them, shouldn't we?

24 MR. POWERS: We would, but they were
25 speaking French all the time.

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1 MR. KRESS: Yes.

2 (Laughter.)

3 MR. LEAVER: And then they dropped the
4 "s," and that really confused us.

5 MR. POWERS: Yes. They said, "l'reactors"
6 and "reactors" and we thought they said "la reactor,"
7 and thought they were only building one, you know.

8 (Laughter.)

9 MR. KRESS: But they kind of screwed up on
10 the liquid metal. We'll forgive them for that, right?

11 MR. POWERS: Well, they built one, as
12 opposed to us.

13 (Laughter.)

14 It is just our arguments that had holes in
15 it.

16 (Laughter.)

17 MR. SCHAPEROW: If you can go upstairs for
18 like five minutes, we can get this stuff printed out,
19 I think. I can plug you into a printer up there, if
20 you would like.

21 MR. POWERS: Hey, that would be kind of
22 neat.

23 MR. SCHAPEROW: We'll be back in about
24 five or ten minutes, hopefully, with the recording of
25 today here.

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1 (Whereupon, the foregoing matter went off
2 the record at 5:09 p.m. to reconvene the following
3 day, Thursday, December 13, 2001.)
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