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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMITTEE
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SOURCE TERM APPLICABILITY PANEL
MEETING
+ + + + +
THURSDAY
DECEMBER 13, 2001
+ + + + +
ROCKVILLE, MARYLAND
+ + + + +

The Panel met at the Nuclear
Regulatory Commission, Two White Flint North, Room
T2B1, 11545 Rockville Pike, Rockville, Maryland, at
8:35 a.m., Brent Boyack, Facilitating.

PANEL MEMBERS PRESENT:

DR. DANA POWERS, ACRS
DR. THOMAS KRESS, ACRS
BRENT BOYACK, FACILITATOR
DAVID LEAVER, EPRI
JAMES GIESEKE, CONSULTANT
BERNARD CLEMENT, CEA FRANCE
JEAN-MICHEL EVRARD, CEA FRANCE

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1 ALSO PRESENT:

2 JASON SCHAPEROW

3 MOHSEN KHATIB-RAHBAR

4 JOCELYN MITCHELL

5 PATRICK BLANPAIN

6 STEVE NESBIT

7 LARRY LOSH

8 HAROLD SCOTT

9 ED LYMAN

10 * indicates unintelligible word(s) due to
11 accent.

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

(8:35 p.m.)

1
2
3 MR. BOYACK: Good morning. Just a couple
4 of items that I wanted to check on as we begin, and
5 then we will return to our Source Term Applicability
6 work.

7 I just wanted to go ahead and reaffirm
8 that the date for the third and final meeting of the
9 panel, we agreed yesterday that that meeting would be
10 held in February, the last week, February 26th, 27th,
11 and 28th. That is Tuesday, Wednesday, and Thursday.

12 And the idea here I think for setting the
13 meeting this far ahead is so that those of you who
14 need to make arrangements that involve non-reformable
15 tickets and everything, this is a short day.

16 So I just wanted to look at Charlie and
17 Jason, and make sure that this day is all right with
18 the NRC.

19 MR. SCHAPEROW: We may have an issue with
20 it. Can we get back to you later today?

21 MR. BOYACK: Yes.

22 MR. TINKLER: Well, from what I know right
23 now, it would not be -- and not that my involvement is
24 critical, but it would be a real bad meeting for me to
25 have, because it is the start of the EUSAFE Program,

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1 and their first meeting is scheduled for that week.

2 MR. BOYACK: Just to go ahead and give you
3 an idea of where you are. If you look at the week of
4 the meeting before, you will see that there are ACRS
5 meetings; and the week of the 11th for Tom and also
6 Dana. It is a holiday the next week.

7 I can't remember if there was anybody
8 else. Then we get into February, and I was trying to
9 keep the meeting to the first part of the month, and
10 the first week was--

11 MR. CLEMENT: Well, with the NRC, Mark
12 won't be involved with that.

13 (Discussion off the record.)

14 MR. BOYACK: So a Wednesday, Thursday, and
15 Friday. I think that possibly could work, but let's
16 just check everybody's calendar. Now, the discussions
17 from the audience, you have to use the mike.

18 MR. CLEMENT: Is it a firm date for --

19 MR. TINKLER: I believe it is.

20 MR. CLEMENT: What this means is that
21 assuming now that this week that has been previously
22 scheduled is still available, it would leave within
23 the period that we initially had blocked out, two
24 weeks, the first of them beginning the week of the
25 18th of February, and there was a suggestion that we

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1 meet on Wednesday, Thursday, and Friday.

2 Is there anybody for whom that would not
3 be acceptable?

4 DR. LEAVER: My wife.

5 MR. SCHAPEROW: Shall we have the meeting
6 out in California?

7 MR. BOYACK: Okay. David, what do you see
8 there? Then there is this other possibility. While
9 David is looking at that calendar, the week of March
10 11th. What is the situation there with everybody?

11 MR. LEAVER: The week of the 11th is a
12 better week for me, and if push comes to shove, I
13 could do it then.

14 DR. KRESS: Dana, there is some suggestion
15 that we go down to Turkey Point on Wednesday and
16 Thursday of that week?

17 DR. POWERS: Yes, I think we have our
18 Turkey Point visit then.

19 MR. BOYACK: Are you talking now about the
20 week of March?

21 DR. POWERS: Yes.

22 DR. KRESS: Yes.

23 MR. BOYACK: All right. It looks like,
24 although it is difficult to David, that really leaves
25 the only available date here of -- and you suggested

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1 Wednesday, and Thursday, and Friday? Is everybody
2 else all right with that?

3 DR. POWERS: I think for us that work for
4 a hard working laboratory, we don't even get that
5 holiday.

6 DR. KRESS: I don't even know what holiday
7 it is.

8 DR. POWERS: I have no idea what it is
9 either, but I'm sure we don't get it.

10 MR. LEAVER: I'm not sure that we get it
11 either, but we might.

12 MR. BOYACK: Well, those who do work at
13 progressive laboratories do celebrate President's Day,
14 and we do celebrate it on Monday, the 18th, although
15 I can travel on Monday, the 18th. Again, it is not a
16 big thing to me. It is just a question of when you
17 would rather go.

18 If you would rather meet on the 19th,
19 20th, and 21st, that's perfectly all right with me.

20 DR. POWERS: It is mox-nix.

21 MR. BOYACK: I am the only one who has a
22 holiday, right? And you guys don't travel.

23 DR. POWERS: Oh, I am sure that they get
24 the holiday.

25 MR. SCHAPEROW: We get every holiday.

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1 DR. POWERS: And on President's Day we
2 have to travel. As an independent Federal Agency, you
3 probably shouldn't celebrate that holiday.

4 MR. TINKLER: Well, we celebrate
5 Washington's birthday.

6 DR. POWERS: Oh, that's an idea.

7 MR. LEAVER: Well, if we do the 20th,
8 21st, and 22nd, can we adjourn early enough Friday?

9 MR. BOYACK: Well, what I propose is that
10 we just go up to the middle of the week, which would
11 be the 19th to the 21st. Would that be all right with
12 everybody? February 19th through the 21st, Tuesday,
13 Wednesday, and Thursday.

14 MR. LEAVER: Yes, that's fine.

15 MR. BOYACK: Then that's okay. Now the
16 idea here is that nobody is going to cross-program,
17 and we can go ahead and make reservations and things
18 like that.

19 Now, the next thing that I would like to
20 do before we actually get working is just to ask a
21 question that would help me with the documentation.
22 If you look up on the screen here, this is one of the
23 typical tables.

24 It was the last one that we were working
25 on for the Tellurium group, and what I have done in

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1 all the tables that I have generated thus far is I
2 have just entered your initials, and it seemed to be
3 a good way because we were taking individual comments.

4 The question is the final report. There
5 are perhaps three options that occurred to me. The
6 first is that as I sit down I have tried to identify
7 what I think would be the key points. We strip any
8 reference to individuals, and it just becomes a view
9 of the panel.

10 The second one is that we leave the names
11 there and you get to clean up your own live
12 transcription of your comments, but they are
13 identifiable.

14 I guess the third approach is something
15 like they did on one of the elicitations, where they
16 become Expert One, Two, Three, Four, and Five. Does
17 anybody have any questions or comments, because I am
18 going to ask if there is a preference for how to
19 document this. Any questions?

20 MR. GLESEKE: Well, I think that as it
21 appears now there is a lot of just nonsense in there,
22 like same as X, Y, Z, or you know, those kinds of
23 comments.

24 MR. BOYACK: Sure.

25 MR. GLESEKE: I see one up there by my

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1 name, for instance. I mean, it is the same as some
2 reference. Does that mean anything?

3 MR. BOYACK: Well, my preference on a
4 claim document is to summarize the information, and
5 put it down, and let the panel review it, and comment
6 on it, and help me to correct it, and get it right.
7 But then it doesn't have specific names. David, do
8 you have any comments on this?

9 Well, the one thing that you lose there is
10 that you lose something that might look more like a
11 minority opinion, and we would have to figure out a
12 way to do that.

13 DR. POWERS: Well, you just say that the
14 majority opinion was this, and there was a view that--

15 MR. BOYACK: We could do that.

16 MR. LEAVER: I think there is some value
17 to different views, or in some cases even contrary
18 views to document that and not lose it. But I think
19 the way that Dana described it would be an okay way to
20 do it. I don't think it makes sense to have the same
21 as so and so.

22 MR. GLESEKE: And then there is a lot of
23 lines in there like this.

24 MR. LEAVER: I think it is kind of less
25 important on who said what, but to capture the

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1 fundamental information that may be of use for people
2 in the future when they are trying to figure out what
3 we did, and what they want to do.

4 DR. POWERS: Well, for instance, there is
5 a line in there that says when we looked at the JAERI
6 data, and, oh, I will get you the reference to that
7 very JAERI data, and things like that.

8 MR. LEAVER: Exactly.

9 DR. POWERS: And we can dress that up and
10 things like that. It is like progressives, and you
11 need to know what data the panel was looking at, and
12 the fact that they didn't have whatever was known in
13 five years.

14 MR. LEAVER: Exactly.

15 MR. BOYACK: All right. And again, the
16 way that this will happen is that when I send this
17 information to you, I will send it in two forms, two
18 electronic forms. One will be a PDF file, which you
19 can't work on, and one will be a Word file, Word 6 or
20 something like that.

21 And then if you choose, you can work
22 electronically on the file in color, and I will put
23 these instructions in to just send it back to me
24 marked up that way, whichever way it works for you.
25 You can mark it up and fax it back to me. I will take

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1 it any way.

2 Okay. Well, with that, before we actually
3 go back to Tellurium, are there any other comments of
4 an overview nature that you wish to offer? If not,
5 when we concluded yesterday, we had moved on to the
6 Tellurium group.

7 After we finish Tellurium, we have the
8 Barium Strontium, Cesium group, and Lanthanides to
9 complete by noon. We had gone through on Tellurium,
10 the gap release, and actually slipped in a value of a
11 half-a-percent.

12 We had some differing opinions on the
13 early vessel, and I guess those range between 15 and
14 35 percent. And I don't think -- by that time it was
15 late, and we had not really decided on how to come to
16 a view, but we just heard the comment from Dana that
17 sort of said that what we might do eventually here,
18 and the majority opinion was to state the value again,
19 and another opinion was to enter that.

20 Well, enter my password. I don't know
21 what my password is. Oh, I'm sorry. I am curious
22 about it why it came up. So I would propose that the
23 way that we handle this is since I--I don't see any
24 way to continue on in a protracted discussion, which
25 would lead us to a point where we would sort of

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1 negotiate a value here or a value there. That is my
2 opinion.

3 You may offer a different opinion, but I
4 suggest that what we do on the early in-vessel is
5 enter what we call the majority opinion about the
6 release fraction, which I think was in the area of 30
7 percent.

8 Then we would make a statement that there
9 was another opinion that the release fraction was in
10 the area of 10 to 15 percent. I don't know any other
11 way to do that.

12 MR. LEAVER: Well, there was a comment--I
13 don't know if you documented it, but I think at the
14 end of that discussion that Dana had a comment.

15 MR. BOYACK: Is that here?

16 MR. LEAVER: I thought I saw it in the
17 thing that you handed out. Maybe Dana can remember
18 what his comment was.

19 DR. POWERS: Well, my comment was that
20 even if we take the lowest value, the 15 percent
21 value, you are doing radical surgery of this, this
22 fraction, and you are really --

23 MR. SCHAPEROW: That comment is right
24 there under notes, the very last sentence.

25 MR. BOYACK: Yes, it is. Down at the

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1 bottom here, if you take a look.

2 MR. LEAVER: Yes, and I think we kind of
3 broke up right at that point.

4 MR. BOYACK: Right, that's where we are.
5 So the question is would the rest of the panel accept
6 an entry of 15 percent, and if not, we could go to the
7 majority and minority statement, because I think
8 everybody else was in the 30 percent range.

9 DR. POWERS: It seems to me that if you
10 have got a majority opinion of around 30 percent, then
11 you might as well put that in.

12 MR. BOYACK: Right.

13 DR. POWERS: I will comment that before we
14 met that the number that I had written in for that one
15 is a change as it was 15 percent, and when I did it
16 without the discussion.

17 DR. KRESS: I would be interested in how
18 you arrived at that 15 percent.

19 DR. POWERS: I think I arrived at it,
20 Tom, thinking of the release is a hundred percent from
21 the tool, and Bernard reminded us that the PHEBUS
22 result, which is a fairly oxidizing environment, but
23 not deliberately so -- it is not huge -- was a more
24 quantitative release, and that they got very much
25 higher penetration.

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1 And more troublesome than that, they get
2 higher penetration when the codes are calculated for
3 this steam generator tube. It is like the codes are
4 overpredicting what the amounts and it is an
5 aerosol/physics problem.

6 And we never thought that. We always that
7 the codes were giving us a lower bound on the
8 deposition because they don't take into account all
9 the subtleties and things like that.

10 And it just reminds us that it is a bit
11 more complicated than you think, and I don't think I
12 was taking that -- and so when I listed to you and
13 Jim, and Bernard talking, and you reminded me of the
14 FPT-1 results, I moved it back up.

15 MR. LEAVER: Let me ask a question of
16 Bernard. What was it in PHEBUS that -- you had this
17 period of between 6,000 and 6,500 seconds, of which
18 you had release occurring?

19 MR. CLEMENT: Which release?

20 MR. LEAVER: Your release occurred over a
21 period of somewhere between 6,000 and 6,5000 seconds.
22 What was going on, or what was the form of the bundle?
23 Had the bundle melted and slumped, or was it just kind
24 of sitting there with steam going by?

25 DR. POWERS: The jump in the release that

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1 you get out at the end there.

2 MR. LEAVER: At the end?

3 DR. POWERS: That is a relocation that is
4 taking place

5 MR. LEAVER: So relocation occurred at
6 around 5,500 or 6,000?

7 DR. POWERS: Yes. They had several of
8 them, but you will recall that he is giving a pretty
9 fair release all the time, and then it kind of jumps.

10 MR. CLEMENT: It jumps, and we have a
11 relocation of hot material.

12 MR. LEAVER: Do you have your integrated
13 release chart, and maybe we could take a look at it?

14 MR. CLEMENT: Too many slides. What you
15 have at the end is movement of hot materials.

16 DR. POWERS: Old time slides.

17 DR. KRESS: It's a sad day when George
18 passed away.

19 DR. POWERS: Oh, did he? I didn't notice
20 that.

21 (Discussion off the record.)

22 MR. CLEMENT: You are speaking about this?

23 MR. LEAVER: Yes.

24 MR. CLEMENT: And then it seems that the
25 * should be roughly the same for all the * inventing

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1 material lower, because it is higher because there is
2 -- this * is higher.

3 MR. LEAVER: At the end, yes.

4 MR. CLEMENT: But it is roughly the same
5 rate for all three items * and the difference in
6 slopes comes from what happens at the beginning,
7 and --

8 MR. LEAVER: There is a little bit of a
9 delay, about a 200 second delay, yes.

10 MR. CLEMENT: So, after that --

11 DR. KRESS: Actually, that is the kind of
12 results that we got at Oak Ridge when we used fuel
13 that didn't have clad on it and it was highly
14 oxidized. The ones with clad on it was the problem.

15 MR. LEAVER: Was this -- well, what kind
16 of a fuel bundle was this? Was it a typical PWR?

17 MR. CLEMENT: Yes, it was okay. 20 watts
18 coming from the R-3 reactor. So short watts coming
19 from the R-3, and --

20 MR. LEAVER: Okay. And it was fully clad?

21 MR. CLEMENT: Zircaloy full cladding and
22 the *.

23 MR. LEAVER: And it was heated how?

24 MR. CLEMENT: Heated by neutronic heating

25 --

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1 MR. LEAVER: Heating from what?

2 MR. CLEMENT: Neutronic heating from the
3 -- the UO2 is heated. But only if this is the PHEBUS,
4 but if we look at the VERCORS, we have three pellets
5 that are zircaloy -- and heated by high frequency --
6 and we have roughly the same rates for the material.

7 DR. KRESS: And that is basically what I
8 have in my model.

9 MR. CLEMENT: I mean, it is a -- * same
10 tendency, and recently they choose * .

11 MR. LEAVER: The FPT-2 has been done,
12 right?

13 MR. CLEMENT: Yes. FPT-2 has been done,
14 and it gave the results for the material.

15 DR. POWERS: And it is the same.

16 MR. CLEMENT: And they are the same.

17 DR. POWERS: Even though that one was much
18 less steam. It actually went in earlier, in 20
19 minutes of the test.

20 DR. KRESS: The only thing I would ask is
21 --

22 MR. LEAVER: And then FPT-2 was a more --

23 MR. CLEMENT: It was a period of producing
24 where it was much lower. Typically, it was .5 instead
25 of 1.5. You have things in a period of about 17 or 18

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1 minutes, and all the steam flow was consumed by
2 zircaloy oxidation, and plus nearly all the zircaloy
3 oxidized, and * . And so the Tellurium release was *
4 during this period.

5 DR. KRESS: Where did you get your fuel?

6 MR. CLEMENT: From Belgium --

7 DR. KRESS: From ER3?

8 MR. CLEMENT: ER3.

9 DR. KRESS: Yes, I wondered, because about
10 the only thing that I could reconcile the difference
11 between the Oak Ridge and that was the type of clad,
12 but that is what we used. We used Belgium ER3.

13 MR. CLEMENT: There are many sources of
14 ER3 used.

15 DR. KRESS: I was wondering.

16 MR. CLEMENT: We made a study at the
17 beginning of the safety program to be sure it was
18 okay, because many people that they *.

19 MR. LEAVER: So in terms of inert
20 materials, the only inert materials in this experiment
21 was the clad?

22 MR. CLEMENT: No, not the clad. It was
23 also *

24 MR. LEAVER: Oh, in PHEBUS you had --

25 MR. CLEMENT: Yes.

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1 MR. LEAVER: So these are the finger piece

2 --

3 MR. CLEMENT: They is a rod in the center

4 of the --

5 DR. POWERS: Oh, he just has a rod that

6 goes down and out right in the center of the package.

7 MR. LEAVER: In a BR3? I mean, it is out

8 of Westinghouse, basically a Westinghouse type report?

9 DR. POWERS: Basically, Westinghouse, yes.

10 DR. KRESS: And the VERCORS didn't have

11 any.

12 MR. CLEMENT: The VERCORS didn't have any.

13 MR. LEAVER: Yes, the VERCORS did not.

14 DR. KRESS: And it is hard to discount

15 that.

16 DR. POWERS: And it is very difficult to

17 conform.

18 DR. KRESS: Okay

19 MR. BOYACK: I think there has been a good

20 review, but we need to move on. Let me tell you how

21 I propose to handle this. What I will do is that in

22 any case where you have a difference of opinion, you

23 will see that there is a footnote here, and we will

24 refer down to the bottom, which in this case that says

25 that I recently had --

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1 But basically this is a note to the
2 majority opinion. However, one member of the panel
3 felt that lower release rate of 10 to 15 percent was
4 more applicable. So that will be explicitly called
5 out when they look at that number, rather than just
6 somewhere down in the text, okay?

7 Now, the one that we are working on now,
8 the Tellurium, we have a total of five groups left, or
9 4-1/2, and Tom drew the short straw for being the
10 first speaker on Tellurium, and then we will go
11 around, and there is four more groups and four more
12 leads. So we will just go in order.

13 And what I put in for the early release
14 was 30 percent. So, now we are going to move to the
15 next release, and it is your turn.

16 DR. POWERS: I arrived at the 30 percent
17 number by a release that was the fraction of normal
18 fuel and high vertical fuel, and so what is left that
19 didn't get released in the pool is 40 percent. And
20 that is going to get released in the same sense that
21 some of the other volatiles and from residual fuel
22 that was in the core, it will get released from that.

23 The vessel had fails, and everything that
24 goes down and does the core concrete interaction will
25 get -- and so I would be putting about a 40 percent in

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1 the -- release.

2 MR. BOYACK: All of which will be released
3 when it reaches the concrete block?

4 DR. KRESS: Yes, or in residual fuel, the
5 fuel that is left up in the vessel after the vessel
6 failed, and the fuel has been released from that, and
7 so I counted that as excess.

8 MR. BOYACK: Okay. So that the statement
9 that I need to capture is the release from the
10 residual fuel core.

11 DR. KRESS: Interaction. I know that I
12 said interaction, but --

13 MR. BOYACK: I didn't realize that I was
14 so literal on the transcription. Thank you. Okay.
15 Jim.

16 MR. GLESEKE: I'm trying to reconstruct.
17 I went through all this logic yesterday, but I can't
18 remember. I think I had --

19 MR. BOYACK: Do you need a moment to
20 reconstruct?

21 MR. GLESEKE: Yes. Let me take a few
22 minutes.

23 MR. BOYACK: Dana.

24 DR. POWERS: I'm behind Tom. I can't help
25 but relate an antidote. Dick Vogle bet me that

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1 Tellurium would not be released during a melt concrete
2 NR action because he was in love with the reaction of
3 Tellurium with metals.

4 And so I took advantage of him, because
5 when you do a melt concrete interaction after the test
6 results, you smell rotten eggs. And the reason is
7 that the gypsum out of the concrete is being reduced
8 down to sulfur, and sulfur is being vaporized as H₂S.

9 So I knew damn well that Tellurium was
10 going to come up, and so I laid a bet with him for a
11 case of Scotch, and he has never paid off.

12 MR. LEAVER: Let the record show.

13 DR. POWERS: Let the record show that he
14 has never paid off.

15 MR. BOYACK: Do you need to continue on
16 for a moment?

17 MR. GLESEKE: Yes.

18 MR. BOYACK: Okay. Bernard.

19 MR. CLEMENT: Okay. We have got in our
20 estimation a number of Tellurium in the future to be
21 released by cerium * interactions.

22 MR. BOYACK: Yes, you basically have a
23 complete release from either the fuel and residual.

24 MR. CLEMENT: Yes.

25 DR. POWERS: We will catch up with you.

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1 We are just slow, that's all. You have to remember
2 that we are colonials.

3 DR. KRESS: I didn't get the complete
4 release for two reasons. One of them was not all of
5 the fuel got real hot, because peripheral fuel was
6 pretty cold, and because a lot of the fuel was still
7 at the low burn up levels, and doesn't get released as
8 fast at the low burn up. So that is the reason that
9 I --

10 MR. CLEMENT: Okay.
11 But just what we are saying is that roughly * of
12 Tellurium, either fuel remaining in the vessel, or the
13 fuel remaining in the vessel after lower pressure, and
14 *.

15 DR. KRESS: But it all gets released,
16 that's for sure.

17 MR. GLESEKE: I'm coming up with about the
18 same number of 35 to 40 percent.

19 MR. BOYACK: So, see TK, the -- David.

20 MR. LEAVER: Okay. I wouldn't disagree
21 with that, but I think this is a -- well, this is
22 probably a similar kind of situation to what we had
23 for the other volatiles, which is the release really
24 is from what is left in the vessel. I don't think
25 that much Tellurium is going to go down into the

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1 container.

2 MR. BOYACK: Yes.

3 MR. LEAVER: Yes, and the way that Tom
4 expressed it was that it was very slight.

5 DR. KRESS: I think you are basically
6 right given these --

7 MR. LEAVER: Right.

8 MR. BOYACK: Okay.

9 MR. LEAVER: So we would want to footnote
10 this in the same way that we did the other volatile
11 releases, indicating that this isn't really the next
12 vessel release. It is a faster -- release.

13 DR. POWERS: There is a bunch of data from
14 Elrick and Company, and from the Brits, saying, gee,
15 you vaporized this collodium and you ran it down and
16 as soon as it sees metal it reacts, and that lent a
17 lot in the trap melt there to a very high deposition
18 of velocity for Tellurium.

19 And since that time as it moved towards
20 more sophisticated chemical models, where the gas
21 stays, and you have these control rods boiling off,
22 you end up with tin tellurides, and silver tellurides,
23 and things like that.

24 Should we note that that's why we get
25 relatively high transmission through the piping

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1 system?

2 MR. LEAVER: Well, we are getting there.

3 DR. KRESS: Well, yes, when we get late
4 releases and --

5 DR. POWERS: Yes.

6 MR. LEAVER: Well, that's where we are now
7 isn't it?

8 DR. KRESS: We --

9 MR. LEAVER: There is no transport section
10 of 1465.

11 DR. KRESS: Oh, yeah, the earlier vessel
12 has to include the fraction.

13 MR. LEAVER: And you have already done
14 that.

15 DR. KRESS: Yes, I have already done that.
16 In fact, basically I said --

17 MR. LEAVER: But maybe we need to capture
18 Dana's point just as a point of information.

19 MR. BOYACK: And that is?

20 DR. KRESS: Well, the earlier vessel
21 number is 30, and 60 percent got released, and the
22 rest of it -- and so that is what happened to the
23 other and that's where it had to go. So we are saying
24 that -- out, and that is a number that we probably
25 ought to talk about. It used to be that --

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1 MR. BOYACK: Okay. Since I was not
2 tracking the discussion at times, does somebody want
3 to give me a statement that I could enter in?

4 DR. POWERS: I think I would just note
5 that because of the fuel rod -- I mean, the control
6 rods and other metals in the system, chloromas
7 transport as Tellurides through the reactor cooling
8 system.

9 MR. CLEMENT: Not as elementary Tellurium.

10 DR. POWERS: Not as elementary Tellurium,
11 and consequently it doesn't chemically react with the
12 piping system.

13 MR. CLEMENT: I would agree that there is
14 some suspicions *

15 DR. POWERS: Yes, and that's all we know.
16 I wouldn't argue with that.

17 MR. BOYACK: Okay. So basically what
18 happens is that because of interactions with the
19 control rods, and because of chemical reactions with
20 control rod materials --

21 DR. POWERS: Because of chemical
22 interactions with vapors from the control rods, and
23 other things, and it would be tin from the clad as
24 well.

25 DR. KRESS: You see, Telluride is --

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1 DR. POWERS: It is a place in Colorado,
2 and you can ski there in the winter time, or you can
3 get doped up there anytime. I think that Telluride is
4 permanently floating about two feet off the ground.

5 MR. BOYACK: Okay. If we move on to
6 related vessel.

7 DR. KRESS: The question is why did we
8 choose the number of 50 percent?

9 DR. POWERS: Well, it is just like the
10 iodine and the season of its particular deposition.

11 DR. KRESS: Yes, but I don't think we are
12 dealing with deposition.

13 MR. LEAVER: Because it is mis-mash?

14 DR. POWERS: I don't think so.

15 MR. GLESEKE: The French experiments down
16 are less of a hold up.

17 DR. POWERS: Yes, they got real hold-ups.

18 DR. KRESS: And that might be because the
19 bulk of the aerosol --

20 DR. POWERS: It is hard to argue that they
21 didn't have it, because of the melting down fuel.

22 DR. KRESS: Well, but the aerosol
23 concentration is --

24 DR. POWERS: That is almost exactly right.
25 It is almost exactly right.

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1 DR. KRESS: -- outside the flow rate.

2 DR. POWERS: It is almost exactly right
3 for concentration in the piping system.

4 DR. KRESS: And how about delay times?

5 DR. POWERS: It is pretty well glomerated
6 up. We don't see a whole lot of evolution in the
7 aerosol. It is zipping along pretty fast, and the
8 flow rates are high.

9 DR. KRESS: And we will still stick with
10 the 50 percent.

11 MR. BOYACK: Charlie.

12 MR. TINKLER: I just want to make a
13 request here. I understand the logic as you go
14 through the tables of the different phases. But for
15 the benefit of future users of this document, it might
16 be nice if we really think that some of these releases
17 are laid in-vessel, and we put them under laid in-
18 vessel, as opposed to putting them under ex-vessel.
19 Just so that when people go through this document --

20 DR. POWERS: The problem, Charlie, is you
21 have got about 10 hours, and if we think it is
22 concentrated in the front end of it rather than spread
23 over the whole 10 hours, we put it in the ex-vessel.

24 MR. TINKLER: Well --

25 DR. POWERS: And there is a footnote that

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1 says why.

2 MR. TINKLER: Then maybe you should
3 consider some modification of the duration for the
4 laid in vessel.

5 MR. LEAVER: Or break it into two phases,
6 or something like that.

7 DR. POWERS: Well, effectively, you have
8 that.

9 MR. LEAVER: It's just that you call it
10 ex-vessel, and that is misleading.

11 DR. POWERS: Yes.

12 MR. TINKLER: I can see this now. Three
13 years down the road --

14 DR. KRESS: Nobody is going to remember
15 it.

16 MR. TINKLER: -- why in the heck did they
17 put that under -- oh, yeah, and did they do it for
18 other things, and --

19 DR. POWERS: There is a footnote on the
20 table. I mean, what do you want?

21 MR. TINKLER: I can understand.

22 MR. SCHAPEROW: Actually, this is a very
23 big departure from what is in 1150. I mean, 1150 has
24 a Tellurium release -- with more concrete interaction.
25 I don't think anybody here was on that particular

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1 panel for that issue, but I personally would like to
2 see a little more clarification in this areas, too,
3 but I am not -- I am an in-vessel, but I don't know
4 too much about that stuff.

5 DR. POWERS: All you can do is sit here
6 and create another column, and augment the amount of
7 work by 20 percent.

8 MR. TINKLER: Well, I appreciate that, but
9 I don't want to do that. To the extent -- and I want
10 to raise another issue here, too, because I know that
11 we have talked about this, and I am not proposing that
12 I know the answer to these questions, but to the
13 extent Tellurium is influenced by metals -- and I
14 know, Dana, that you have already addressed that.

15 The scaling and preservation of zircaloy
16 to fuel passes, and PHEBUS is something that you might
17 want to look at a little more carefully. We have the
18 ratio of zircaloy to fuel may be a little different in
19 some other reactors than it is in PHEBUS.

20 We have plans for zircaloy grid space, and
21 we have plans with other zircaloy. We have lots of --

22 DR. POWERS: They have zircaloy grid
23 spaces.

24 MR. TINKLER: Yes. So you re confident
25 that the zircaloy --

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1 MR. CLEMENT: For the zircaloy --

2 MR. TINKLER: So you are confident that
3 the zircaloy mass relative to the UO2 emphasis ratio
4 is good in PHEBUS?

5 MR. CLEMENT: At this time, it is * * the
6 same in the reactor right now *.

7 DR. POWERS: But when you are talk about
8 material mass, they are very good. I mean, that was
9 a focus in the design of the test, was to get the --

10 MR. TINKLER: I know, I can remember that.

11 DR. POWERS: And the relative amount is
12 about right.

13 MR. TINKLER: And I remember the concerns
14 about some of the -- and this is different, but
15 concerns that the Swiss had that they wanted more
16 upper internal steam separators, dryers, lots of steel
17 on the top of the vessel. That is not --

18 MR. CLEMENT: Speaking of volume with
19 reactors obviously.

20 MR. TINKLER: I understood that. That is
21 a difference.

22 MR. CLEMENT: Well, the * is okay.

23 MR. TINKLER: But do you -- so you think
24 the steel masses are scaled well enough, and the
25 effect of a small bundle relative to a larger core is

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1 --

2 DR. POWERS: That is more problematic.

3 MR. CLEMENT: You could argue that you are
4 getting more oxidation of metallic surfaces, and
5 perhaps PHEBUS would --

6 DR. POWERS: You would play hell trying to
7 make that argument.

8 MR. TINKLER: I am just bringing that up,
9 and this is not in any way a criticism of PHEBUS.

10 MR. CLEMENT: No, no, I understand that.

11 MR. TINKLER: I am the biggest fan of
12 PHEBUS in the world. I wish we ran three tests a year
13 instead of -- you know --

14 DR. POWERS: So do they.

15 MR. TINKLER: I would like to have more
16 high burn up tests, and air ingress tests, and
17 everything else. I am just -- the arguments about
18 unreactive metals, unoxidized metals, and the argument
19 about tellurides, that is an excellent point, and
20 would make some of my discussion moot.

21 Is the panel going to read on chemical
22 form of Tellurium?

23 MR. CLEMENT: The point also I think is
24 related to oxidation processes, because even Tom *
25 zircaloy is not * and sometimes with cladding and not

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1 being able to continue any more * and then all the
2 activity on that has not interacted with such metal.

3 I mean, it is really * processes and has
4 been * of the core that are cold than the Tellurium
5 that is left in the upper part to escape. And that is
6 really into the degradation processes, and this is
7 where it is quite not so easy to make -- to come from
8 a small bundle to * and many effects are taking place.

9 DR. POWERS: In fact, I would argue that
10 as far as getting the Tellurium in a known reactor
11 form, the large bundle is going to lead you more
12 toward that than a small bundle, because rather than
13 having a control release and then kind of tail off,
14 you are having control rods going off all the time in
15 a large bundle.

16 And so there is always kind of a constant
17 amount of silver and cadmium coming through the piping
18 system at the same time. And zircaloy reacts with
19 those things.

20 MR. TINKLER: I was just going to say that
21 originally I think we had a little too much silver,
22 the ratio of molds of silver to molds of iodine at
23 once upon a time. So we were getting an exaggeration
24 of the silver iodine to --

25 DR. POWERS: Well, that was true in zero.

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1 MR. TINKLER: But not -- okay, because it
2 was -- yes, you are right on that one. With respect
3 to the chemical form of Tellurium, could we anticipate
4 that this would decay to iodine in its --

5 DR. KRESS: It doesn't matter whether it
6 is in its chemical form or not. It will be iodine or
7 --

8 MR. TINKLER: It will be iodine in its
9 molecular form or --

10 MR. LEAVER: I was just talking with a
11 couple of more guys, and there is six isotopes in
12 Tellurium that are among the group that is considered
13 for design basis the 60 radionuclide considered for
14 design basis access.

15 And three of them -- there is one 27-M,
16 and 127 and 129-M, and 129, and those are of course
17 would not be interesting even if indicates iodine,
18 because iodine would be non-radioactive.

19 Then there is 131-M, which is interesting,
20 and 132, which is interesting. 131-M has a 25 minute
21 half-life, and as to 131, and that is the main source
22 of iodine.

23 DR. KRESS: But your question is that this
24 is going to be iodine or -- and I don't think it
25 disassociates.

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1 MR. LEAVER: We did some dose calculations
2 to get the effects of this, and it is not truly what
3 one might expect, and the 131 is a big contributor,
4 and we assumed that it was as I-2, and you are using
5 a little more I-2 than you would have otherwise.

6 DR. KRESS: I would have assumed that it
7 was iodine.

8 MR. LEAVER: You would have?

9 DR. KRESS: Or behaved like iodine.

10 MR. LEAVER: I mean, you have this clump
11 of stuff, right? A couple of micron particles of
12 something -- and the stuff decays and becomes iodine.
13 Why is it going to stay --

14 DR. KRESS: It is iodized.

15 MR. LEAVER: Why is it going to stay as an
16 iodide?

17 DR. POWERS: I think that's not how I
18 would go about attacking the problem. I would put it
19 in containment, and I know that when it decays the
20 recoil alone will rip that compound completely apart.

21 MR. LEAVER: The what?

22 DR. POWERS: The recoil will rip the
23 compound apart.

24 MR. LEAVER: The recoil?

25 DR. POWERS: The decay recoil. If I shoot

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1 an electron out this way, something has got to go this
2 way.

3 DR. KRESS: The whole thing goes out.

4 DR. POWERS: Oh, no, it would bust the
5 bond.

6 MR. CLEMENT: To compare that to your --

7 DR. POWERS: And then I would run it into
8 the iodine chemistry model, and let it do what it will
9 do what iodine does. From that point on it will do
10 what iodine does, okay?

11 Whatever state that iodine is born in, it
12 isn't going to last very long. And you have cesium
13 iodide, and I-2, it doesn't make any difference. You
14 go so quickly to a steady state that it wouldn't make
15 any difference.

16 MR. BOYACK: Could we go ahead and move
17 on.

18 MR. LEAVER: Well, these are important
19 points.

20 MR. BOYACK: That's why I waited.

21 MR. LEAVER: I thought I had reached the
22 point, and if I am wrong --

23 MR. BOYACK: I think that is acceptable.

24 MR. LEAVER: Okay.

25 MR. BOYACK: Okay. Laid-in vessel.

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1 MR. SCHAPEROW: I guess I wanted to know
2 the application of it. We are still not quite sure
3 why we would have -- coming out as a result of -- and
4 I don't know if anybody had a chance to go back and
5 look at the question.

6 All three of the experts have Tellurium,
7 have 25 percent Tellurium, from other interactions.

8 MR. LEAVER: That may be because they
9 didn't release it from the vessel.

10 MR. SCHAPEROW: Oh, okay.

11 MR. LEAVER: I mean, we may not have
12 released it all.

13 DR. KRESS: Does it --

14 DR. POWERS: Well, it is the one thing
15 that we can predict. That is the only product that I
16 am very confident of Vanessa predictions, because we
17 specifically validated that because, by god, I was
18 going to get my case of Scotch if it killed me, and
19 Dick Vogle was not going to give me the horse laugh.

20 DR. KRESS: It depends on the type of
21 concrete that you used.

22 DR. POWERS: No.

23 MR. SCHAPEROW: One of the things also
24 that I see in the beginning from where it seems the
25 message that I seem to be getting is that we insert --

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1 associated with the heat in the releases for fission
2 products, and generally it is the difference between
3 regular fuel and high burn up fuel.

4 I am not hearing much talk about, well,
5 this is so important for my burn up.

6 MR. LEAVER: I don't think that this is an
7 issue --

8 DR. POWERS: Hang on. As we move down the
9 list --

10 MR. SCHAPEROW: Maybe some of the other
11 items are more important, but at least for -- at this
12 point it doesn't seem to be.

13 MR. LEAVER: Well, it is probably worth
14 noting that what we have been discussing here for the
15 last couple of hours on zirconium is really not -- we
16 would have had this discussion whether we were here
17 for high burn up purposes or not. Is that fair to
18 say?

19 MR. KHATIB-RAHBAR: I have a comment on
20 this zirconium issue in the vessel part. The argument
21 is that in the PHEBUS you predicted a complete release
22 of Tellurium because most of the zircaloy was gone
23 either due to oxidation or relocated.

24 And the other argument that Dana was
25 giving is that Tellurium is going to be in metallic

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1 forms because of all of the control rod material. So
2 presumably that will not settle on surfaces as it
3 would otherwise, and would not react, for example, on
4 metallic constituents like tin on a surface or
5 whatever, to form things that would not be retained in
6 the vessel.

7 It would behave like cesium iodide or
8 cesium hydroxide, or what have you. If this Tellurium
9 is going to come very late, in the very late in-vessel
10 phase, you may not have a lot of control on the
11 material left inside the core.

12 Most of the stuff is probably gone by them.

13 MR. CLEMENT: You may not follow to the
14 surface.

15 MR. KHATIB-RAHBAR: Well, you have a lot
16 of surfaces inside the vessel, and there is a lot of
17 steel inserted.

18 MR. CLEMENT: Yes, and the surface is
19 oxidized.

20 MR. KHATIB-RAHBAR: I'm sorry

21 MR. CLEMENT: The surface is oxidized.

22 MR. KHATIB-RAHBAR: Well, you are assuming
23 you have lost enough steam always, but you typically
24 have steam derivatives in most of these accidents. So
25 the concern that I have is that you probably are

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1 putting too much Tellurium into the containment.

2 DR. POWERS: We have not gotten to the ex-
3 vessel late, or the late in-vessel you have.

4 MR. KHATIB-RAHBAR: But you are releasing
5 a hundred percent of it though.

6 DR. POWERS: And you only have 30 percent
7 on the viping system.

8 MR. KHATIB-RAHBAR: So 30 percent is still
9 retailed of the total.

10 DR. KRESS: Yes, but it is not going to be
11 there.

12 DR. POWERS: It's not going to be there
13 very long.

14 MR. KHATIB-RAHBAR: But the argument, the
15 way that you have it, you are going to release the
16 rest of it anyway most likely, and so you are going to
17 put most of it into the containments.

18 DR. POWERS: Eventually we are going to
19 have it pretty much in the containment. Wait until
20 Tom launches --

21 DR. KRESS: Yes, but wait until --

22 DR. POWERS: We have not gotten to that
23 part yet. But he is going after it.

24 DR. KRESS: I probably would put a .25 in
25 the -- or .02 in the halogens, or something like that.

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1 DR. POWERS: Well, the number that I wrote
2 down was .2.

3 DR. KRESS: Yes, .2.

4 DR. POWERS: Because?

5 DR. KRESS: Because the .05 is predicated
6 on the fact that there is not very much there in the
7 first place in that particular thing, and if there is
8 a lot there, it is not latched on chemically to the
9 surfaces. It is latched on to something else, like an
10 aerosol, and it is going to behave like cesium
11 hydroxide.

12 So it is about the same amount on there as
13 the cesium hydroxide, and so the .2 seems to make a
14 lot of sense.

15 MR. BOYACK: Okay. There is -- at present
16 and is not related to surface, but rather it has
17 bonded to aerosols and more readily to --

18 DR. KRESS: Released.

19 MR. BOYACK: Okay. Jim.

20 MR. GLESEKE: Twenty percent.

21 MR. BOYACK: Okay. Dana.

22 DR. POWERS: Well, once we open up the
23 piping system, and while the oxygen portion will go
24 up, we oxidize all the Telluride TEO, which is highly
25 volatile.

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1 MR. BOYACK: To what?

2 DR. POWERS: TEO.

3 MR. BOYACK: TEO?

4 DR. POWERS: Yes, and telluric acid.

5 DR. KRESS: What is the chemical formula
6 of telluric acid?

7 DR. POWERS: It depends on which one you
8 are worrying about.

9 DR. KRESS: I was going to see what it
10 would be.

11 DR. POWERS: You are just testing him.

12 MR. BOYACK: No, I don't know the formula.

13 DR. KRESS: Okay.

14 MR. BOYACK: And I don't plan on learning
15 it either.

16 DR. POWERS: Oh, come on. It is good for
17 your soul.

18 DR. KRESS: There is probably about five
19 of them or six.

20 DR. POWERS: Yeah, there is a bunch of
21 them.

22 MR. BOYACK: Okay. Bernard.

23 MR. CLEMENT: Okay. We did not study the
24 * of Tellurium. We did not consider it because of
25 uncertainty, and just because we have already put 17

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1 percent into the containment.

2 DR. KRESS: It amounts to the same thing.

3 MR. CLEMENT: But we agree with * and
4 maybe some mechanisms.

5 DR. POWERS: Well, once again, you see the
6 importance of doing the PTA work and PHEBUS.

7 MR. BOYACK: Okay. David.

8 MR. LEAVER: I would have nothing to add
9 to those comments.

10 MR. BOYACK: Okay. Jim, you realize now
11 that you are on the hook for the next lead here.

12 MR. GLESEKE: What is the next lead?

13 MR. BOYACK: On the barium strontium
14 group; and David, you will have the lead on the noble
15 metals and so on.

16 DR. POWERS: It is the noble part. It is
17 appropriate.

18 MR. BOYACK: I don't think I am going to
19 call in.

20 DR. POWERS: It only leads to dissention,
21 right?

22 MR. BOYACK: Okay. Well, how easy can it
23 be? There is only a couple of numbers. Things
24 change, right? Okay. I see, that you have moved to
25 the last of the stack.

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1 DR. POWERS: Oh, I have been demoted.

2 MR. BOYACK: No, that means that you get
3 to really just cap off the discussions and summarize
4 it and make sure that everybody else has got it right.

5 DR. POWERS: You have to understand his
6 personality. He likes to take potshots at everybody
7 that has gone before.

8 DR. KRESS: I love it.

9 MR. BOYACK: Okay. Jim. Release for
10 barium strontium for high burn up fuel.

11 MR. GLESEKE: I think I am going to have
12 to leave it real small, I think. Like zero. Zero is
13 a very small number.

14 MR. BOYACK: So in our little --

15 DR. POWERS: Say yes.

16 DR. KRESS: Negative numbers are real
17 small.

18 DR. POWERS: They are not small.

19 MR. GLESEKE: They are.

20 MR. BOYACK: Okay. Do you want me to go
21 through the whole thing, or do you want to come back
22 and take it a phase at a time?

23 MR. GLESEKE: I am thinking maybe one
24 more. That is kind of what we did with the last one.
25 I think this is going to be up from what we talked

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1 about before. I mean, from the 1465. He looks at
2 Tom's calculations, for instance, with effective burn
3 up. And where his low burn up was .02, and this may
4 be four times that much.

5 MR. LEAVER: Are you just talking about
6 just due to burn off?

7 MR. GLESEKE: Yes.

8 DR. KRESS: And you had better correct
9 that to fuel that has high burn off.

10 MR. GLESEKE: yes, maybe you need to back
11 that down some because of the percent of the amount of
12 fuel, and --

13 DR. KRESS: I know that when I make that
14 correction that it takes it down to six, .06.

15 MR. GLESEKE: Yes. I was going to say
16 .05, and .06, that's about right.

17 MR. BOYACK: So, 6 percent. Okay. So
18 let's go back to Dana then.

19 DR. POWERS: Zero is applicable.

20 MR. BOYACK: Okay. Ont he early in-
21 vessel?

22 DR. POWERS: I believe there are two
23 competing factors that are arising here. When you
24 raise the diffusion coefficient for post-strontium and
25 barium, but you increase the oxygen potential and that

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1 has the effect of decreasing the volatility of barium
2 and strontium.

3 So I don't see a bases for changing the
4 value. I see the need for experimental investigations
5 of high burn up fuel.

6 MR. BOYACK: Okay. So the first is the
7 increase in diffusion coefficient for these species,
8 and the second is the oxygen potential.

9 DR. POWERS: Yes, the oxygen potential,
10 and to depress the volatility of both strontium and
11 barium.

12 MR. BOYACK: Okay. I see no reason for
13 changing -- well, it lacks a basis really to change
14 it.

15 DR. POWERS: You don't have a bases to
16 change it.

17 MR. BOYACK: Okay. Let's see.

18 MR. CLEMENT: Applicable

19 MR. BOYACK: Sorry?

20 MR. CLEMENT: Applicable.

21 MR. BOYACK: Thank you. All right. Okay.

22 MR. CLEMENT: And barium should be treated
23 in a different way than strontium, because there is
24 experimental evidence that they are not released in
25 the same way with the same amount from the fuel.

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1 DR. KRESS: That's right.

2 MR. CLEMENT: Barium is much more volatile
3 than strontium from experiments.

4 MR. BOYACK: Which is much more volatile?

5 MR. CLEMENT: Barium.

6 MR. BOYACK: Okay.

7 DR. POWERS: Even from a chemistry thing,
8 it has to be because the barium is huge, and the
9 strontium just about fits in the vacancies of uranium
10 dioxide.

11 MR. CLEMENT: If you look at VERCORS and
12 HI/VI experiments, we derive the release of barium
13 from fuel of 50 percent of inventory, and what is true
14 from containment of 10 percent.

15 MR. BOYACK: Okay. So, this was which?

16 MR. CLEMENT: From barium, because we
17 observed important deposits above the fuel regions in
18 experiments. PHEBUS doesn't give you the same
19 reasons. PHEBUS gives you very low areas of barium,
20 and we have to take into account HI/VI and VERCORS
21 experiments, and that's why it retains high areas for
22 barium.

23 MR. LEAVER: You have to take into account
24 HI/VI?

25 MR. CLEMENT: Yes. HI/VI from that, yes,

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1 from Oak Ridge.

2 MR. LEAVER: From Oak Ridge.

3 MR. BOYACK: Well, you did get about twice
4 as much barium released in FPT-1 as you did strontium
5 didn't you?

6 MR. CLEMENT: If you want to put it as
7 negligible.

8 MR. BOYACK: Well, I have got some numbers
9 and maybe they are not right. But it is a factor of
10 two is it not?

11 MR. CLEMENT: Well, it is very small.
12 Okay. For strontium, we get 10 percent release from
13 fuel, and 2 percent through containment.

14 MR. BOYACK: FPT-1?

15 MR. CLEMENT: That is the general judgment
16 from all the available data. That is our own
17 definitions, and that is the release from fuel in the
18 --

19 MR. BOYACK: Ont he barium, was that a 10
20 percent release of barium from the fuel, and then a 10
21 percent delivery, or --

22 MR. CLEMENT: Fifty percent from the fuel.

23 MR. BOYACK: Okay. So that is what it
24 was.

25 MR. CLEMENT: And 50 from the fuel and

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1 then 10 from the containment.

2 MR. BOYACK: Thank you. I had that wrong.

3 MR. LEAVER: What are these numbers if
4 this is not correct for barium?

5 MR. CLEMENT: Yes, yes, but they are very
6 small.

7 MR. LEAVER: For FPT-1, do you have those?

8 MR. CLEMENT: They are small.

9 MR. LEAVER: This is the release from
10 containment?

11 MR. BOYACK: Tom, with what you are doing
12 for this test, what if any of the elements in the
13 middle of sentence, is it capitalized or not?

14 DR. POWERS: The names are non-
15 capitalized.

16 DR. KRESS: The names are not capitalized.

17 MR. BOYACK: Okay. Thank you. Okay.
18 David.

19 MR. LEAVER: On the barium and strontium,
20 I am just confirming with Bernard that the FPT-1
21 releases in the containment were of the order of a
22 factor of 5 to 10 less than -- and we are talking
23 about in-vessel release now, early in-vessel, and a
24 factor of 5 to 10, and less than what we have
25 currently in NUREG 1465, which is where we have 2

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1 percent.

2 For FPT-1 the releases in the containment
3 were tenths of a percent, and noting also TMI was a
4 tenth of a percent, and the SFD-14 was about one
5 percent.

6 And also noting that to the extent that
7 there is a slight increase in oxygen potential, that
8 would tend to suppress the release of barium and
9 strontium.

10 So I would say probably we are high. Our
11 2 percent number is probably high, but I certainly
12 don't see any basis for changing it other than I guess
13 we could lower it, but if we are not in the lowering
14 business, then we would leave it the same.

15 DR. POWERS: Maybe what you wanted is --
16 well, it seems like it might be a little high to me,
17 but it is not very much high.

18 MR. LEAVER: Yes. If it is high, it is
19 probably only a factor of two high.

20 DR. POWERS: Yes.

21 MR. LEAVER: So it is not a huge effect.

22 MR. CLEMENT: At that point, I believe we
23 should note that I believe that * different
24 experimental results.

25 MR. LEAVER: Between barium and strontium?

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1 MR. CLEMENT: Yes. We have got out of
2 five experiments, there was high release of barium,
3 and you take away the five experiments, and there is
4 no release of barium.

5 MR. LEAVER: Right.

6 MR. CLEMENT: And it is worthwhile to say
7 whether we have a need to understand really why.

8 MR. LEAVER: Right.

9 MR. CLEMENT: And not to say that I choose
10 one or the other.

11 MR. LEAVER: No, I think that's right. It
12 has always been in my mind that barium and strontium,
13 that there probably should have been a difference, but
14 I don't think -- you know, we are trying to decide
15 what to do with 1465, and so we could split them up
16 and make them two different numbers.

17 But I think that the .02 is probably high,
18 and so what we wouldn't want to do is leave strontium
19 the same and raise barium. We might want to reduce
20 strontium and leave barium the same.

21 But I am not sure. The difference is
22 modest enough that I am not sure that it is worth the
23 trouble of creating an extra fission product group,
24 which is what you would be doing.

25 DR. POWERS: Well, they have not stayed.

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1 When we get down into noble metals, all of the
2 problems that we will run into is the different
3 elements, because they have unique and different
4 chemistry.

5 MR. LEAVER: Right.

6 DR. POWERS: So you are averaging over
7 those things, and you have to bear that in mind. And
8 the penalty that you pay in systems level codes and
9 writing another category is a lot.

10 So you don't like to -- I mean, we went
11 from essentially noble gases, and iodine, and
12 particles, to this.

13 DR. KRESS: The question that I would have
14 is at these levels does it make any difference?

15 MR. CLEMENT: The system that would * for
16 strontium, and also --

17 DR. POWERS: Originally it was that you
18 would just take the average of them, and --

19 DR. KRESS: Well, you know, the release
20 rates are -- even if you had them differentiated, they
21 are so low that I don't think that it makes a lot of
22 difference, in terms of consequences.

23 MR. LEAVER: I think that one perspective
24 on this is that we are sort of trying to do -- I guess
25 get things as right as we can get them based on the

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1 information that we have here.

2 And I think if we were to present -- if we
3 were to present, or cut this release of strontium in
4 half, that would have a non-trivial effect on -- well,
5 with the strontium, I don't know what percent of the
6 dose is, but in the stuff that we handed out, it is
7 about 10 percent of the dose.

8 DR. KRESS: Well, the thing about
9 strontium is that it hangs around a long time, and it
10 can have environmental effects, and those are
11 overlooked in things like dose.

12 MR. LEAVER: Well, maybe -- well, i would
13 say again what I said earlier, that there certainly is
14 some evidence that we maybe overdid it a little bit on
15 strontium, and less than in barium.

16 But if we were to reduce the strontium, it
17 would have some effect, and that we are trying to get
18 it as right as we can get it, but I think that is
19 probably worth considering.

20 We seem to be changing things, and there
21 is no rule that says we can only change them in one
22 direction, or at least I haven't heard it.

23 DR. POWERS: I don't know about that one
24 either.

25 MR. LEAVER: I think it would be a

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1 significant thing if we were to break up the strontium
2 and barium, but I think that if there is a difference
3 there that we shouldn't just push them into the same
4 number if we don't think that is the right way to do
5 it.

6 And people who do dose calculations could
7 handle this without any problem. You might need a
8 little reprogramming, but it is not a big deal.

9 MR. SCHAPEROW: For the record, barium and
10 strontium, or different groups, drafted NUREG 455 in
11 '92.

12 DR. POWERS: I remember that, yes.

13 MR. SCHAPEROW: And the strontium was
14 less, and they were merged on the basis of in-close.

15 DR. POWERS: I think the argument is
16 always an ungrouping, and the argument goes that if
17 there are uncertainties, and the values are as big as
18 the differences, or commensurate with the differences,
19 then that when it comes to official product release --

20 MR. SCHAPEROW: They are separate and --

21 MR. LEAVER: Okay. Let's continue on with
22 the discussion, and first with Tom Kress on gap
23 release.

24 DR. KRESS: The same.

25 MR. BOYACK: Okay. And then we come down

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1 to the next phase --

2 DR. KRESS: My fission product release
3 model does have barium and strontium separately, and
4 the strontium gets released less than the barium, but
5 it is about half, and I link them together because
6 half is well within the uncertainties.

7 So I put them together and the analysis
8 that I get with the model tells me the same thing that
9 Jim did, that it ought to be about 6 percent. I have
10 to qualify that and say that the database that
11 underlines the barium-strontium release does not
12 really have this oxidation potential change in it,
13 because the tests will run in such a way that you
14 wouldn't get this kind of oxidation potential.

15 So to worry about just a tiny bit about
16 it, and I think that the release of strontium and
17 barium occurs later than a lot of the other materials,
18 and it is during a time when you are reducing
19 environment according to my model.

20 So I am going to go ahead and stick with
21 the 6 percent.

22 MR. BOYACK: So did you say you predict
23 the barium-strontium separately?

24 DR. KRESS: They are close enough together
25 that --

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1 MR. BOYACK: They are close enough
2 together.

3 DR. POWERS: Tom, your 6 percent is
4 released from the fuel and --

5 DR. KRESS: The 6 percent is the release
6 of aerosol that transmits all through that, and the 6
7 percent was the release.

8 DR. POWERS: So if we assume it was
9 transmitted as an aerosol, would that be consistent
10 with --

11 MR. GLESEKE: I had mine down to 3
12 percent.

13 DR. POWERS: Well, 2 percent and 3 percent
14 look an awful lot alike.

15 DR. KRESS: I have to admit that I
16 overlooked that in this particular one, and 6 percent
17 is the release from the fuel.

18 MR. GLESEKE: I had mine down to 3
19 percent.

20 DR. KRESS: So that gets me back to David,
21 and 3 percent is a lot like 2 percent. So you might
22 want to adjust that. So, 3 percent is close enough to
23 2 percent, and in fact if I separated the strontium
24 out it would be 2 percent.

25 MR. BOYACK: Okay. And so --

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1 MR. GLESEKE: And I didn't put that up
2 here either. I have it here in my calculations.

3 MR. BOYACK: Okay. So you lose your
4 identity.

5 MR. GLESEKE: Great.

6 MR. BOYACK: But that's all we are going
7 to go anyway. And then there was the debate about
8 whether or not to consider to stay combined, which at
9 the present time we will just keep them combined at
10 the two percent?

11 DR. POWERS: That's right. My argument is
12 that I will intend that Barium is always more volatile
13 than Strontium, and my uncertainty is in the absolute
14 release fraction is so high, and that the difference
15 between the two is that they just don't seem very
16 important at this point.

17 MR. BOYACK: Okay. All right. Let's see.
18 We now move to the ex-vessel phase. Jim.

19 MR. GLESEKE: I don't see anything about
20 burn up effects.

21 MR. BOYACK: Dana.

22 DR. POWERS: The release of barium and
23 strontium excess was directly proportional to the
24 amount of zirconium metal that comes ex-vessel. If it
25 has impact on that, it will adjust the number. I have

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1 no reason to think there is an impact on that, and so
2 I just stayed with what they have.

3 MR. BOYACK: Okay. Would you like to have
4 that comment in there?

5 DR. POWERS: Yes, I think it is important,
6 because they need to understand how high burn up
7 affects the core degradation process, and how much
8 metal you have coming out of this vessel.

9 MR. BOYACK: I can use it to capture three
10 word phrases, but this one went on a little longer.
11 So, if you would just --

12 DR. POWERS: Three words? Okay. Release
13 of barium and strontium ex-vessel is proportional to
14 the amount of zirconium metal becomes ex-vessel. If
15 high burn up affects the amount of ex-vessel metal, it
16 will change the release fraction in proportion.

17 DR. KRESS: High burn up fuel has been in
18 the reactor longer and has had a chance to oxidize.

19 DR. POWERS: That's right. I mean, that
20 is the potential for a severe accident. In the case
21 of a design basis accident, it is legislated that thou
22 shall not change that number very much.

23 DR. KRESS: But we are dealing in design
24 basis.

25 DR. POWERS: Okay. And I don't know how

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1 things are going to go, but what it all says to me is
2 we have got to understand how high burn up fuel
3 degrades if there is a difference. I mean, that is
4 the test.

5 I have the fundamental doubt about the
6 adequacy of the existing models to high burn up fuel.
7 I think they quantitatively lack consideration of
8 foaming potential.

9 MR. BOYACK: Okay. Very good. Bernard.

10 MR. CLEMENT: We agree with Dana that the
11 release of barium and strontium from * depends on the
12 existing amount.

13 MR. BOYACK: Okay.

14 MR. CLEMENT: I have got some values from
15 the thermal-dynamic calculations, saying that 10
16 percent of the strontium present in the core that is
17 directing * , and 2 percent of volume present in the
18 core be *. This is to be applied to our reinspections
19 to full volume, and we release 50 percent and 2
20 percent of the remaining 50 percent. So, 1 percent of
21 barium.

22 And for strontium, it is 10 percent of 90
23 percent remaining, and so 9 percent of strontium. We
24 have got some more thermal dynamic calculations, and
25 this is purely a calculation.

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1 DR. KRESS: Is that not with the Wechel
2 Code?

3 MR. CLEMENT: The Gemini Code.

4 MR. GLESEKE: And that is 10 percent of
5 the --

6 MR. CLEMENT: Ten percent of 90 percent.

7 MR. GLESEKE: Ninety percent?

8 MR. CLEMENT: Nine-zero, not 19. So, 9
9 percent.

10 MR. BOYACK: You will notice that the job
11 of the court reporter is safe. Are you going to keep
12 your day job?

13 DR. KRESS: I don't know if you have read
14 any of her transcripts.

15 DR. POWERS: I think the logic that has
16 been used in the French study and the logic that we
17 used in ours are identical. We just can't get the
18 fractions coming down, that's all. It depends
19 strictly on what you do on the in-vessel.

20 MR. CLEMENT: Yes.

21 DR. POWERS: On the ex-vessel, we agree
22 exactly on the physics ex-vessel, and we are all
23 working with the same database, and technology base
24 here. We do use different codes, radically different
25 codes. But the way that we get to our numbers is

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1 about the same.

2 MR. BOYACK: Okay. David.

3 MR. LEAVER: There may be an effective
4 burn up, but my instinct is that it is not a large
5 effect, and so I would have no basis for changing the
6 importance of that. If anything, you would think that
7 higher burn-up would tend to oxidize a bit more, and
8 so there would be a little less metal coming down and
9 it might reduce the number, but probably not a big
10 effect.

11 DR. POWERS: Well, the one thing that you
12 can't imagine is that high burn up increasing the
13 amount of metal available, and it is just very
14 difficult to see that.

15 MR. BOYACK: Right.

16 DR. POWERS: But I see the potential of
17 cutting the amount of ex-vessel Tellurium by a factor
18 of two. I mean, it certainly exists.

19 MR. BOYACK: Of course, you were will
20 remember though that the high burn up in only on a
21 portion of the core. So it is probably no a huge
22 amount. If you predicting 50 percent zinc oxidation,
23 and then you do it with what we call with a high burn
24 up core, where some portion of the core is 65 or
25 gigawatts, I would be surprised if you went from 50

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1 percent oxidation to 75.

2 DR. POWERS: I can see that.

3 MR. BOYACK: Well, that's why we need to
4 figure that out.

5 DR. POWERS: You need to run a test. It
6 won't happen if our candling models are good, and if
7 they are good for everything, then you are right. You
8 can't get up to 75 percent.

9 I can't imagine it happening if you go to
10 a foaming kind of scenario.

11 MR. LEAVER: That's a fundamental change,
12 and you don't get into the degradation process.

13 DR. POWERS: That's right. That's right.
14 And that's why you can't do this calculation. You
15 have to do it experimentally at least once, and see if
16 you need to qualitatively change the codes, and then
17 you let the codes do their thing.

18 MR. LEAVER: But I think it would tend to
19 promote oxidation as if things kind of stay up there
20 for longer.

21 DR. POWERS: Well, that's what he does.

22 MR. LEAVER: Oh, he does, yeah.

23 DR. POWERS: Actually, what happens is the
24 fuel stays up there all foamed up, and it forces the
25 steam to go where there is a code in the vessel, and

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1 it keep it there so that there are long interaction
2 times.

3 MR. BOYACK: Okay. Tom, it is your time
4 to wrap it up.

5 DR. KRESS: I have no basis to change it.

6 MR. LEAVER: That is a nice succinct way
7 of saying it.

8 MR. GLESEKE: That's a good way to wrap it
9 up, Tom.

10 MR. BOYACK: So this stayed at 10 percent.
11 Okay. Laying in vessel. Jim.

12 MR. GLESEKE: Zero.

13 MR. BOYACK: Okay. What is the phase that
14 I use here then?

15 DR. POWERS: Applicable.

16 MR. BOYACK: I need to use a little more
17 wording.

18 DR. POWERS: You guys at Los Alamos never
19 get to the point.

20 MR. BOYACK: Okay. Dana.

21 DR. POWERS: I can't see anything that
22 raises the volatility of barium and strontium in this
23 system. I see lots of potential for lowering it. It
24 is kind of hard to drop it down below zero.

25 MR. GLESEKE: My logic exactly.

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1 DR. POWERS: Sigma.

2 MR. CLEMENT: I mean, there are * on all
3 the different * processes. As you have seen then, we
4 consider elements such as barium and strontium, we see
5 from the experiments that there is rather high
6 deposits above the fuel zone.

7 So we have material available for
8 resuspension, and * many any late emission. So in
9 that case * . But maybe, for instance, some steam
10 surge, if we adjust the water on the core and things
11 like that, and we think they should be investigated.

12 MR. LEAVER: Well, a quench test is one of
13 the things --

14 MR. CLEMENT: Yes, because you release a
15 rather fraction from the fuel, and you deposit a
16 fraction in the * structure of the vessel *

17 DR. POWERS: And you get high pressure
18 steam.

19 MR. CLEMENT: And in the containment, you
20 may have mechanisms in terms of quenching that * .

21 DR. POWERS: Either a high pressure steam
22 or a high pressure hydrogen. Either one of them --

23 MR. CLEMENT: Yes.

24 DR. POWERS: -- will drive vaporization.
25 If you have a mechanism for getting that, you can get

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1 it and I think it is something to pay attention to
2 when you go experiments.

3 MR. BOYACK: Yes.

4 MR. CLEMENT: So we think we need to --

5 MR. BOYACK: Okay. So I have entered your
6 information about testing. David.

7 MR. LEAVER: I would have no change to the
8 NUREG 1465 number.

9 MR. BOYACK: Thank you.

10 DR. KRESS: I certainly agree with the
11 French position that these things are stuck on those
12 aerosols, and I know that is chemistry is going to
13 react on the surfaces, and so they could be
14 resuspended if you have ways to do it, and they could
15 be revolatilized if you have got hydrogen or steam
16 going hot enough.

17 At the moment I have no basis for
18 evaluating any of that. So I have no basis for
19 changing the number, although I think those need to be
20 investigated.

21 DR. POWERS: Hydrogen suppresses the
22 volatility.

23 DR. KRESS: Air ingression --

24 DR. POWERS: Hydrogen or steam could jack
25 it up.

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1 DR. KRESS: Yes.

2 DR. POWERS: But what most likely happen
3 is that it will just react further and bury itself
4 down in the air and oxide as barium and strontium flow
5 rate. All that work to leave the number alone. No
6 fun at all.

7 (Discussion off the record.)

8 MR. BOYACK: Okay. All right. Dana, are
9 you ready to go?

10 DR. POWERS: Okay. We are going to take
11 it as applicable here, and it is not zero, but it is
12 so small that at this stage of resolution you might as
13 well just call it zero.

14 MR. BOYACK: Dana, do you want to continue
15 on?

16 DR. POWERS: Sure. And in here we come to
17 the trouble with grouping. Within this category we
18 have ruthenium, molybdenum, and palladium.

19 DR. KRESS: And technetium.

20 DR. POWERS: And technetium. And
21 technetium by everything that I have been able to do
22 is a relatively non-volatile material. And because
23 our oxygen potential is in the fuel is going higher is
24 a relatively volatile material.

25 And you will see from the PHEBUS results

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1 that you get movement of ruthenium even though they
2 are not particularly strong in oxidizing environments.

3 So you have got to kind of mentally
4 integrate all those findings together for this
5 category. Based on doing that, and recognizing that
6 in the piping system that you have fundamentally
7 different processes, and you have molybdenum moving
8 along as the trioxide or the cesium molybdate.

9 And ruthenium coming out as an oxide
10 vapor, and then getting reduced down to a metallic
11 particle. So it is an aerosol physics. You have got
12 some substantial integration of the two.

13 But I would say that the preponderance of
14 information coming out now suggests that the value
15 that we have is too small in this category. That when
16 we are talking about a quarter of a percent here.

17 And based on that, I propose to raise that
18 up to about one percent.

19 MR. BOYACK: Okay. If you are ready to
20 go, I am going to take you right through them.

21 DR. POWERS: Okay. The one element that
22 we do an atrocious job in the Vanessa modeling to
23 monitor the release is ruthenium, and universally
24 under-predicted. I think we would do better for
25 molybdenum and the palladium metals and what not.

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1 But when we have looked particularly at
2 the results from Argon on the experiments, we just
3 underpredict there. Ruthenium releases by about 3
4 orders of magnitude and what not.

5 I think the people and the panel that we
6 are doing this evaluation are aware of that under-
7 prediction, and so I suspect that the number actually
8 reflects that. So I am not going to change it at this
9 point.

10 We are going to learn from the experiments
11 and other sorts that we actually get release and
12 movement of the use of materials when they are
13 deposited on the primary piping system, but they are
14 susceptible to volatilization in the oxidizing
15 environment that exists in the laid in vessel.

16 And so I am going to propose that we have
17 about a four percent revaporization of these
18 materials.

19 DR. KRESS: Four percent of what was on
20 there?

21 DR. POWERS: Yes.

22 DR. KRESS: Which was one percent?

23 DR. POWERS: No, no. It is more like 10
24 percent of releases, and I only got about 2 percent
25 through, and so I have about 8 percent of the

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1 inventory. So I am going to get half of that off.

2 MR. BOYACK: I am not sure that I got
3 enough of that.

4 DR. POWERS: I think you got enough.

5 MR. BOYACK: Okay.

6 MR. LEAVER: Just a second. I was going
7 to clarify. You are saying that the retention of this
8 group in the RCS is of the order of 80 percent,
9 aerosol deposition?

10 DR. POWERS: It is a combination of vapor
11 and aerosol, both.

12 MR. LEAVER: Some vapor condensation?

13 DR. POWERS: Yes. The palladium is moving
14 around as the trioxide and as a cesium update. The
15 ruthenium probably moves around -- it comes off as one
16 oxide, dioxide, trioxide, and even the cesium
17 luthinate.

18 And as soon as it gets the opportunity and
19 converts into a metallic particle and deposits as an
20 aerosol at that point, and it is reasonably efficient.

21 I mean, I suspect that Bernard is going to
22 show you some stuff about it from around the top of
23 the bundle and things like that. And so I think that
24 there is a lot of deposition that goes on here.

25 MR. BOYACK: Okay. And do your numbers

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1 add up? To get a one percent release to containment,
2 you would need if you had a 10 percent release of the
3 fuel, you would need 90 percent retention.

4 And if you had a 5 percent release of the
5 fuel, it would be -- well, somehow you want to end up
6 with one percent.

7 DR. POWERS: If I said one percent, I
8 should have said two percent.

9 MR. BOYACK: Would that change any of the
10 figures or just the comment?

11 DR. POWERS: Well, I should have said 2
12 percent and these fractions should be raised to 2
13 percent.

14 MR. BOYACK: Okay. Thank you. Okay.
15 Bernard.

16 MR. CLEMENT: Okay. The first one, the *.

17 MR. BOYACK: Okay.

18 MR. CLEMENT: The second one is that we
19 have a problem of grouping. There is a problem of
20 grouping here. * probably find this very volatile.

21 MR. BOYACK: And those figures were for
22 what, molybdenum?

23 MR. CLEMENT: So the figures we got from
24 experimental -- is for molybdenum, and 90 percent
25 release from * and 70 percent from containment, and

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1 the same for --

2 MR. LEAVER: And the FPT-1?

3 MR. CLEMENT: It is mainly * . And the
4 same for technetium. For rhodium, 10 percent from *
5 and 2 percent to containment.

6 MR. BOYACK: That's your severe accident?

7 MR. CLEMENT: Yes. Rhodium seems to be
8 more released than the ruthenium.

9 MR. BOYACK: What was that last --

10 MR. CLEMENT: Rhodium. And 30 percent
11 from fuel, and a total of 6 percent to containment.

12 DR. POWERS: It does not get industrial
13 use as much as some of the others.

14 MR. CLEMENT: I think --

15 DR. POWERS: It is break time.

16 MR. BOYACK: Okay. So you are again
17 showing these problems -- which is then referred to as
18 trying to deal with -- but having a significant
19 difference.

20 MR. CLEMENT: Yes, there are significant
21 differentials in * and also in the consequences for
22 each agreement.

23 DR. POWERS: The technetium not the
24 biggest problem.

25 MR. CLEMENT: No, the technetium is not

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1 the problem.

2 DR. POWERS: It is pretty high. But
3 palladium isn't very much of a problem.

4 MR. LEAVER: Not too much.

5 DR. POWERS: But ruthenium is a pole
6 buster.

7 MR. LEAVER: Yes.

8 MR. BOYACK: Okay. For the ex-vessel.

9 MR. CLEMENT: Looking for the ex-vessel
10 for what we consider exists or that * . Except that
11 our calculations indicate that we will be negligible,
12 and so for the time being there is on reason to change
13 your values.

14 MR. BOYACK: Okay. And finally the ex-
15 vessel.

16 MR. CLEMENT: Okay. There is again this
17 same problem with the reauthorization, suspension, and
18 so on. As I stated for the previous group, and I have
19 stated here, we have a lack of data and a need for
20 experiments. Just because *

21 DR. POWERS: Yes, that is absolutely
22 correct. What you are saying is that with
23 experimental we know that we can get it off, and we
24 know that we could get it on, and it would be nice to
25 know whether it comes back off again.

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1 MR. BOYACK: So you know that it is
2 created and deposited. Not created, but --

3 DR. POWERS: Released.

4 MR. BOYACK: Released. I think after we
5 get through with this, we will take a break. David.

6 MR. LEAVER: I really think that this is
7 a case where the right thing to do is to split this
8 group up, because I think the numbers are
9 substantially different for molybdenum and technetium
10 and for ruthenium. Those being -- well, I don't know
11 how important rhodium is.

12 DR. POWERS: It is about seven --

13 MR. LEAVER: Do you have data for rhodium?

14 MR. CLEMENT: No.

15 MR. LEAVER: I didn't think so. The FPT-1
16 really does show a significant higher release fraction
17 for -- and release to containment for technetium and
18 moly. So I think it is difficult to -- I think you
19 can justify using the 1465 number for earlier vessels.

20 MR. BOYACK: Okay. You are in a different
21 category than I am.

22 MR. LEAVER: I have no change on the gap.
23 Sorry. Ruthenium, I guess I don't see a basis for
24 changing the ruthenium number. If you look at FPT-1,
25 it was .005, and the 1465 number is half of that.

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1 So, I guess the factor of two is within
2 our uncertainty. I suppose that you could double it.
3 But I think I would say that the ruthenium number is
4 pretty close.

5 MR. CLEMENT: For which that is
6 containment.

7 MR. LEAVER: And that is .005. I note
8 that again for what it is worth, I tend to -- I'm
9 sorry, go ahead.

10 MR. CLEMENT: Okay. We have a high value
11 for containment because you consider it a hot leg
12 breaks, and the --

13 MR. LEAVER: Well, the hot leg breaks are
14 part of it, but certainly we need to balance that with
15 as we said before different grid locations and sizing.
16 So I think for ruthenium that I wouldn't have a
17 complete basis for changing what is in 1465.

18 But I would suggest that we recognize moly
19 and technetium, and I don't have any data for rhodium,
20 and so I am not sure where it fits, as being
21 different, and as being more volatile. And I think a
22 number like maybe 5 percent for those, and create a
23 new group.

24 MR. CLEMENT: That means that it is not
25 worthwhile because * .

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1 MR. LEAVER: Well, I don't know. You
2 don't have any data on rhodium, and so I am not sure
3 what --

4 MR. CLEMENT: * .

5 MR. LEAVER: And I don't know how
6 important rhodium is radiologically. I just don't
7 have that information with me.

8 DR. POWERS: My recollection is that it is
9 not wildly different from ruthenium.

10 MR. LEAVER: I suspect that if it was a
11 substantial release fraction, you probably would have
12 --

13 MR. CLEMENT: But I think that what is
14 most important and maybe a radiological * rhodium is
15 -- ruthenium. That means in fact what are the
16 radiological consequences in times of release of * is
17 important.

18 MR. BOYACK: You could keep rhodium with
19 you.

20 MR. CLEMENT: Yes.

21 MR. LEAVER: And also I am just going to
22 add that once could certainly debate what the right
23 release faction and containment is for technetium and
24 moly. I would be tempered somewhat in this judgment
25 again by the TMI accident, and just sort of bear that

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1 in mind.

2 And that is perhaps why I sort of arrived
3 at a number like 5 percent. It is kind of an in
4 between kind of number. It is not quite as high as
5 was observed with PHEBUS, but it is a lot higher than
6 what is in NUREG 1465 today.

7 MR. BOYACK: So your 5 percent -- is 2
8 percent?

9 MR. LEAVER: right.

10 MR. BOYACK: And that's because it was
11 splitting?

12 MR. LEAVER: Right.

13 DR. POWERS: I have integrated them
14 together and he wants them split.

15 DR. POWERS: Okay.

16 MR. BOYACK: Okay.

17 MR. LEAVER: Again, just recognizing that
18 there seems to be something fundamentally different
19 going on, which I think we understand perhaps a little
20 bit, because the release fractions are greatly
21 different.

22 MR. BOYACK: Okay. Let's see. The ex-
23 vessel. I am not sure about that. I guess I am not
24 sure why would we not see the same effects going on
25 ex-vessel for technetium and moly as we saw in the

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1 core.

2 DR. POWERS: Keep them because we have got
3 a huge amount of steel that keeps them in a metallic
4 state.

5 MR. LEAVER: In the ex-vessel?

6 DR. POWERS: Yes. And when we tend to
7 have a model, we calculated it and it was truly
8 negligible. What we left out of the database didn't
9 include cesium ruthenate, and cesium -- or the
10 corresponding sodium and potassium.

11 So when -- they did the experiments up in
12 Argon, where they delivered -- they put these into the
13 charge that we never did and --

14 MR. LEAVER: That's because you were in
15 New Mexico.

16 DR. POWERS: Yes, and they actually got
17 some release. They got releases up around -- well,
18 maybe around the one percent level, and maybe a little
19 less than that. And then we just don't calculate with
20 the codes, because we have got it all down on the
21 metal and keep it producing and release into the
22 environment.

23 And the ruthenates and -- have just
24 enough vapor pressure to give you enough release
25 protection, and I think the number on the table

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1 actually reflects that, because if you had just gone
2 on calculations, it would have been a release fraction
3 of 10 to the minus 6 or something.

4 MR. LEAVER: Well, I would say that is a
5 little more detailed explanation than what you said
6 when you dictated yours, and so I would say let's
7 leave the number the same. I have no basis for
8 changing it in light of that comment.

9 MR. BOYACK: Okay. In-vessel.

10 MR. LEAVER: No change.

11 MR. BOYACK: Okay. Tom.

12 DR. KRESS: Well, I guess I have to add
13 comments or dissenting opinions on this one. This is
14 a place where I think we have assented out of the
15 sublime in to the ridiculous, and we need a paradigm
16 shift.

17 The ability to predict things at this
18 level is just not there. You can't do it, and to put
19 the differentiation between noble metals, and cerium,
20 and lanthanides, and to try and differentiate between
21 all those things is just not a thing to do for design
22 basis accidents.

23 And those numbers up there that are
24 already there have no basis in fact. They are just
25 put up there --

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1 DR. POWERS: Are you talking about noble
2 metals?

3 DR. KRESS: Yes, all of them. Noble
4 metals, cerium, and lanthanides. What I think happens
5 is that you get some -- and especially with high burn
6 up fuel, you get the potential for some decrepitation
7 of the fuel itself because of the grain structure.

8 And even in ex-vessel core concrete
9 interactions, you get bubbles splattering off the
10 fuel, and you get the fuel itself transmitting. So
11 there is a minimum level of release that just goes
12 with the fuel itself. This doesn't have anything to
13 do with vaporization or chemistry, or anything.

14 And what you do is you just put a ground
15 floor on the release of those things, and I would put
16 it at about one percent to two percent levels, which
17 is what I think those numbers come from in the first
18 place, both ex-vessel and in-vessel.

19 And I would lump all of them, but I didn't
20 bother putting them in my model because of this. The
21 noble metals and cerium, and the lanthanides, and so
22 I think the release mechanisms are just different for
23 those, and they have to do with the way that fuel gets
24 kicked off of its -- the grains get kicked off the
25 fuel.

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1 And I would just stick them all the same,
2 both ex-vessel and in-vessel, and I would make them
3 all about 2 percent or something.

4 MR. BOYACK: Okay. So on the gap --

5 DR. KRESS: Nothing on the gap. There is
6 nothing there. I am talking about the early in-vessel
7 and the ex-vessel.

8 MR. BOYACK: So, the --

9 DR. KRESS: I would leave them all about
10 .002, and I get rid of that damn five, and do it on
11 both ex-vessel and in-vessel, and all the noble
12 metals, I would group them all together, and I would
13 also group the cerium and the lanthanides, in with
14 that.

15 MR. BOYACK: And do you see the need for
16 testing?

17 DR. KRESS: Well, always. I have never
18 argued against more testing.

19 MR. BOYACK: I guess it is hard to argue
20 against testing. So you would see then another
21 release from down here at 0.2 percent time; is that
22 what you told me?

23 DR. KRESS: Yes, something like that.

24 MR. GLESEKE: Two percent wasn't it?

25 DR. KRESS: No, no, .2.

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1 MR. BOYACK: Let's see. And where did you
2 get the .2?

3 DR. KRESS: It was just pulled out of the
4 hat, out of the air.

5 MR. BOYACK: No, what is that for?

6 DR. KRESS: For all of it. Just for ex-
7 vessel and in-vessel.

8 MR. BOYACK: For each one?

9 DR. KRESS: For each one, and I think if
10 I look at the amount of uranium that gets transmitted
11 in in-pile tests, and in the tests that we do with the
12 annealing fuel, it would be about -- it would give you
13 about that level of release just from the fuel itself.
14 There is no vaporization, and nothing. Just fuel
15 particles.

16 MR. LEAVER: But that's almost like
17 staying in the fuel. I mean, the stuff just falls
18 down.

19 DR. KRESS: No, no.

20 MR. LEAVER: Well, where does it go?

21 DR. KRESS: It is grains, and these grains
22 are very small, almost like an aerosol with
23 a --

24 MR. LEAVER: When you say very small, you
25 are talking what?

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1 DR. KRESS: Microns. Aerosols.

2 MR. LEAVER: How many -- well, aerosol-
3 sized?

4 DR. KRESS: Yes, 4 or 5, to 10.

5 MR. LEAVER: Well, with 10s, you are
6 getting big.

7 DR. KRESS: Well, I mean, it is aerosol
8 size. But you can deal with that later. So you just
9 lump it in with the aerosol. And what happens with
10 the core concrete, is that your bubbles of CO2 comes
11 up and breaks at the surface and just kicks fuel up.

12 And here is some fraction of those that
13 are real small particles compared to the aerosols, and
14 it is about the same level. I have no basis for
15 predicting how many, and so I just put a floor on it,
16 and say it is about that many.

17 DR. POWERS: Right.

18 MR. BOYACK: Laid in-vessel. Did I miss
19 something, or was that --

20 DR. KRESS: Laid in vessel and it is such
21 a small amount that it is nothing even worrying about,
22 and I just would give it at zero. But I think it jus
23 travels like an aerosol, and half of it gets re-
24 released.

25 MR. BOYACK: All right. Okay. Jim, it is

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1 your cast.

2 MR. LEAVER: Can I ask Tom a question?

3 MR. BOYACK: Okay. Go ahead.

4 MR. LEAVER: How do we account -- you are
5 looking at low percent release data from certain
6 experiments, and Tom is saying that mechanical release
7 is an aerosol from the fuel at a low percentage,
8 fractional percentages. And the French data show 90
9 percent molybdenum in the fuel.

10 DR. KRESS: That has to be a vaporization
11 process.

12 MR. GLESEKE: That's right. That's right,
13 but where does the two glide between .2 and 90, and
14 when we are looking at the data here --

15 DR. POWERS: The French are right.

16 MR. GLESEKE: What?

17 DR. POWERS: The French are right. I
18 agree with Tom. When you get down into the cerium and
19 lanthanides, I am sympathetic to the point where you
20 -- well, we can measure, and we are measuring, and we
21 are seeing differences from what we presumed with our
22 models.

23 And here is a pox on your houses, and make
24 it a constant level, and I don't think that is a bad
25 view for the cerium and lanthanides. But I think the

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1 noble metals we can do things with, and it is
2 measurable, and it looks like it is actually important
3 in discussing things like cesium, which are very
4 important.

5 MR. CLEMENT: Even for the cerium, if we
6 look at measurements, for instance, of neptunium and
7 plutonium, you can see that there is a lot of
8 difference between the reasons that neptunium is much
9 volatile than plutonium, and this is actually
10 measured.

11 So, for instance, you look at neptunium,
12 and plutonium, and uranium. Neptunium is more
13 volatile than uranium, and uranium is more volatile
14 than plutonium, which means that not only they can be
15 made from small grains *, and other mechanisms.

16 DR. KRESS: I would just trying to add on
17 the others, because the releases are low. In the case
18 of moly, I may have to retract what I said. I don't
19 like to go in the face of experimental --

20 DR. POWERS: And what we need to do is pay
21 attention to the noble metals and not -- well, is
22 because of the -- and you really want to know where
23 that ruthenium is, because ruthenium is a
24 bad --

25 DR. KRESS: And none of my data deals with

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1 air intrusion that I have.

2 DR. POWERS: And what we never suspected,
3 and I think that it is becoming more and more obvious,
4 and I think it gets worse and worse as you go to high
5 burn out, is that the ruthenium and moly would move
6 around the way we see them.

7 And I think it is simply because as you
8 burn you are driving that and you are losing the
9 ability to buffer the oxygen potential around and
10 striking that uranium.

11 And you start getting more oxidizing, and
12 these things start moving around, and it gets worse
13 and worse on you. And you get this, and there is a
14 lot of evidence in getting cesium updates so that you
15 are pulling the moly, as well as pushing it.

16 And then you say, okay, now what happens
17 if I put this stuff on the primary piping system, and
18 let air into this vessel, and watch them moving
19 around. If it was just moly, I would say, so, but
20 when I look at ruthenium toxicology, and ask guys to
21 do consequences to tell me how that relates to things
22 that I am more familiar with, they come back with a
23 scary moment data.

24 MR. BOYACK: Did you get your question
25 asked?

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1 MR. GLESEKE: Yes. Okay. Starting with
2 Tom, I will go along with the consensus there.

3 MR. BOYACK: Okay. Are you going to bring
4 clarify to vessels?

5 MR. GLESEKE: I'm afraid not. What I see
6 is a wide range of experimental results, and a lot of
7 unknowns in terms of chemistry and phenomena; from
8 aerosols, where there will be a residual aerosol, and
9 all the way down through these last groups.

10 And I can see Tom's point there, but it
11 looks to me like there is a lot of vaporization, and
12 because of the wide diversity in the experimental
13 numbers, I can't see breaking this into pieces.

14 And there is so much uncertainty in the
15 numbers that to divide them into separate groups, I
16 think you are kidding yourself no more than you do.
17 So, I would be included to lump them, at least at this
18 point in time until there is more data available, and
19 that we are dealing with a firm basis for splitting
20 them.

21 And I would go with some mid-range
22 percentages similar to Dana and Dave's numbers on
23 those, maybe 2 to 5 percent early in-vessel.

24 MR. BOYACK: Okay.

25 MR. GLESEKE: And small ex-vessel fraction

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1 of a percent here. Maybe a quarter of a percent. And
2 with a laid in-vessel, a few percent again.

3 DR. POWERS: Four is a good one, right?

4 MR. GLESEKE: Four is a good number. You
5 can define four as a few.

6 MR. BOYACK: Can somebody tell me how to
7 make something out of this mess?

8 DR. POWERS: Just take Jim's numbers.

9 MR. BOYACK: Okay. What we had talked
10 about was whether to see there was a -- and we talked
11 about majority, and the minority numbers, and there
12 was at most one or two people. And so what about
13 this? Let's see, we have got 2 percent.

14 MR. LEAVER: Can we have a little
15 discussion on this before we try --

16 MR. BOYACK: Sure.

17 MR. LEAVER: Let me just throw this out in
18 light of Jim's and Tom's comments on this. The PHEBIS
19 FPT-1, which seems to be something that people feel is
20 important, the results that we get, and it is new,
21 since 1465, and it is probably the best fission
22 product measurement experiment that we have done.

23 So we are paying attention to it. I will
24 have some other comments about that later. But there
25 is a factor of 500 difference in their release to

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1 containment for ruthenium versus these apparently more
2 volatile noble metals.

3 I just don't see how -- what bothers me a
4 little bit here is -- and maybe a lot, is the notion
5 that you are see from moly and technetium higher
6 numbers. So why not just raise the whole group.

7 But the problem with that is that if you
8 make ruthenium 4 percent or 2 percent, that really is
9 higher than what the data suggests, unless you have
10 some other reason for thinking that.

11 And how you will have a pretty significant
12 impact on dose, and not that that is not a reason to
13 do it, but I think we need to be sure that we know
14 what we are doing if we are going to do that, and I
15 just don't think that is --

16 MR. CLEMENT: Well, if it is a question of
17 the volatility of moly, the * other -- out of other
18 experiments is the first point; and the second point
19 is that it is quite logical --

20 MR. LEAVER: Right. It is logical. You
21 raise the outside potential that --

22 MR. CLEMENT: And higher volatility, and
23 I think it is clear that it is much more volatile.

24 MR. LEAVER: Especially with a little bit
25 higher oxygen potential.

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1 MR. CLEMENT: Yes, of course.

2 MR. LEAVER: So there is a reason for
3 that.

4 MR. CLEMENT: And the radiological
5 consequences of moly and oxygen is not at all the same
6 as for --

7 MR. LEAVER: And you need even higher
8 oxygen potential to see the same effect --

9 MR. CLEMENT: It is a fact that
10 radiological consequences are not all the same. There
11 is other reasons for separating molybdenum from
12 ruthenium, and the radiological consequences we don't
13 care so much about moly. But for ruthenium, we care
14 very much.

15 MR. LEAVER: Right.

16 MR. GLESEKE: They do have 2 percent of
17 the containment on ruthenium

18 MR. LEAVER: Let's see. Half-a-percent is
19 what I had.

20 MR. CLEMENT: What we give as a number I
21 am just entering as a containment. It is not the
22 number from one single experiment. It is a number
23 derived from the FPT-1 experiment and other
24 experiments, and our own experiments -- and this is
25 just one piece of the feather.

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1 MR. GLESEKE: Oh, okay.

2 MR. LEAVER: I was just talking about the
3 H1/V1 number. The number that I think Bernard was
4 talking about was kind of a regulatory conglomeration.

5 MR. GLESEKE: There were more experiments
6 than one.

7 MR. LEAVER: Yes.

8 MR. GLESEKE: Well, yes, but FPT-1 to me
9 is probably more meaningful numbers for our purposes.
10 Yes, it is .005, and I am not sure whether that is a
11 basis for changing a .0025 number. It is within a
12 factor of two, and so how significant is that relative
13 to our uncertainty.

14 That is how I arrived at keeping it the
15 same, but I think the factor of 500 really to me is --
16 and in effect as Bernard points out, there is some
17 physical basis, chemical basis, for why we think the
18 moly is going to be more volatile.

19 And breaking them up does give you a more
20 adequate picture, and in this case it is probably
21 worth a significant enough effect that it is worth
22 doing.

23 MR. BOYACK: Maybe the first question that
24 we have to deal with is literally this question of
25 breaking up the groups, and I am not exactly sure how

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1 one resolves this, except to look at the users. My
2 users are the NRC, and Charlie, any comment?

3 MR. TINKLER: Yes. There is a way to
4 compromise on this, and that would be to reflect the
5 much higher volatility of some of the noble or what we
6 once called, and still may be called, transition
7 metals.

8 And then retain the other radionuclides
9 that we have separated into separate groups, and then
10 we combine those. I mean, we could reflect a
11 different release fraction for lanthanides, and then
12 combine lanthanide and plutonium, and all the cerium
13 and lanthanites, into one group.

14 I know that is another option. If we
15 think that ruthenium has a higher volatility as is
16 reflected in the vaporization phenomena, and you
17 separate that out, and then we combine all the others
18 because we think they are perhaps at least to a large
19 degree mechanically -- due to decrepitation and other
20 factors.

21 And as far as the NRC is concerned, we
22 don't have a view that thou shalt retain these
23 particular groups, and historically the original 1465
24 panel struggled over this question a little bit on
25 ruthenium versus Lanthanidium.

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1 The large difference in radiological
2 effects is clearly one of the reasons why you might
3 want to make a distinction between .2 percent and 5,
4 or 10 percent, or whatever you decide, for
5 anthranithium. I mean, there is a large difference
6 there.

7 MR. CLEMENT: I agree with you for a
8 separation of them and other groupings, but maybe we
9 have some * . For instance, if you look at the
10 VERCORS --

11 MR. LEAVER: Can we take a short break?

12 MR. BOYACK: In just one minute.

13 MR. CLEMENT: Okay. If we look at the
14 results from the tests, for instance, on neptunium,
15 and uranium, and plutonium. We have got here 6
16 percent neptunium, and 2 percent uranium, and .2
17 percent plutonium. So, exactly one decay between
18 these three elements. So we are against them because
19 they are a grouping.

20 MR. TINKLER: Yes, I understand, but in
21 this case, I would attach a little more significance
22 to some of the integral data when we are talking about
23 releases to containment, and for the less volatile
24 stuff, if it migrates a little bit to the upper part
25 of the bundle, well, that is important.

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1 And it reveals a difference, but as far as
2 my release -- to defining my release to containment,
3 I guess I am not sure that I can reflect that level of
4 discernment in the table

5 MR. BOYACK: Please come to the mike.

6 MS. MITCHELL: Jocelyn Mitchell. I wanted
7 to speak from the point of view of off-site
8 consequence calculations. We are preparing to be able
9 to put into the off-site consequences uncertainty
10 distributions, and if you see that different chemical
11 elements have a more uncertainty, or others have less
12 uncertainty, you might want to divide them.

13 Maybe they are the 50th percentile, or
14 their mean value might be the same. But if they are
15 big uncertainty differences, you might want to have
16 the ability to keep them separate so that when you get
17 to the off-site consequences that you can put in
18 different uncertainty distributions on them.

19 MR. BOYACK: I have had multiple requests
20 for a break now. Let's take 10 minutes and come back
21 at 11:00 and try to work through these.

22 (Whereupon, at 10:50 a.m., the panel
23 meeting was recessed, and resumed at 11:04 a.m.)

24 MR. BOYACK: Let's consider a little bit
25 about where we are and where we need to go before the

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1 end of the morning. We have in my view maybe until
2 12:30, and then a very short lunch -- a quick run down
3 and a quick run back, and then to go ahead and cover
4 two more areas.

5 DR. KRESS: Bring our lunch back with us?

6 MR. BOYACK: We could do that, sure.

7 (Discussion off the record.)

8 MR. BOYACK: All right. Given all of
9 that, we have had some major issues that have come up
10 since we dealt with this noble metals group, and it
11 seems clear to me that we are not going to be able to
12 deal with them in the course of this meeting, and then
13 also cover the rest of the items.

14 These primarily have to do with whether or
15 not to separate and reform the groups. And then even
16 within that, there may be some differences in the
17 values.

18 Now, I guess if we reform the groups that
19 maybe some of those differences would narrow, but I
20 don't think we can do that within this time frame that
21 we have.

22 What I would suggest is that we go on to
23 the next two, and that is that we don't firm the
24 values up right now. What we do is go on and have the
25 dialogue about the next two groups, and record that

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1 information.

2 And then between now and the next meeting,
3 try to figure out what to do with it. So that is my
4 position. Let's see. Bernard, did you end up with
5 the overhead that had our groups?

6 MR. CLEMENT: Sorry, no.

7 MR. BOYACK: IT is the one that we were
8 marking up with the changes in values.

9 MR. LEAVER: Yes, you do.

10 DR. POWERS: There you go. The third
11 group.

12 MR. CLEMENT: Oh, sorry.

13 MR. BOYACK: Maybe I ought to check and
14 see if you have --

15 DR. KRESS: Maybe he fixed the values up.

16 DR. POWERS: He corrected them. He
17 corrected them. He got them right.

18 MR. BOYACK: David, you started to make a
19 comment before? Were you just going to make a comment
20 or just put up the slide?

21 MR. LEAVER: I was just going to put the
22 slide up.

23 MR. BOYACK: Okay. Is there any
24 disagreement or other perspectives on continuing? So
25 what we have to do is -- well, just so there is no

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1 question about that value.

2 So when you get your copies, which you
3 will be provided, and I think before you leave today,
4 you will be able to get those to you. All right. So
5 that moves us on to the cerium group.

6 (Discussion off the record.)

7 MR. BOYACK: So now we are moving to the
8 cerium group. So with that in mind, I wonder,
9 Bernard, if you would be willing to provide your
10 knowledge on the cerium group.

11 MR. CLEMENT: Okay. So we start with
12 neptunium, and first of all, there is no reason for
13 changing that.

14 MR. BOYACK: Thank you. There we go.

15 MR. CLEMENT: Then neptunium for our
16 measurements, and mainly from VERCORS and also from
17 PHEBIS. We derived the value of 10 percent release
18 from cerium, and 2 percent from *.

19 Okay. For plutonium, it is one percent
20 from * and 2 percent to the containments. For cerium
21 --

22 MR. BOYACK: And what is cerium?

23 MR. CLEMENT: Cerium? CE.

24 MR. BOYACK: Thank you.

25 MR. CLEMENT: We did not have direct

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1 measurements, but * rather than with other cerium, and
2 I will speak later on on lanthanum, but from this
3 analogy, we come out with a figure of 10 percent from
4 fuel, and 2 percent from containment.

5 MR. BOYACK: That was plutonium?

6 MR. CLEMENT: That was cerium. It is the
7 measurement of lanthanum in VERCORS, and an analogy
8 between lanthanum and cerium.

9 MR. BOYACK: Anything else?

10 MR. CLEMENT: No.

11 MR. BOYACK: Okay. Then as we go along to
12 the ex-vessel.

13 MR. CLEMENT: Okay. We don't -- well, no.
14 We don't think we will have a significant release from
15 an MCCI.

16 MR. BOYACK: Okay. And the late in-
17 vessel.

18 MR. CLEMENT: The late in-vessel is the
19 same remark as for various groups. As far as we have
20 important deposits, and species whose volatilities can
21 change, depending on the oxidation degree and so on.
22 And we need more experiment on that to reduce the * on
23 these processes.

24 MR. BOYACK: Okay. Thank you. I am
25 assuming that everybody has read NUREG 1465 values?

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1 DR. KRESS: I think everyone has.

2 MR. BOYACK: Okay.

3 DR. POWERS: You had better check that
4 with the guys from LSU. They seem to do better on
5 these things. Okay, Dana.

6 MR. CLEMENT: I looked at * that maybe in
7 high burn up fuels and so I am going to * of these
8 groups.

9 MR. BOYACK: Okay. So basically --

10 MR. CLEMENT: That is not easy to quantify
11 now, but we know that the morphology of the fuel has
12 high burn up will not be the same, okay? So the
13 access from oxygen from the steam to the fuel, or from
14 the fuel to the steam, may really change, and we know
15 that the volatility of species, depending upon their
16 oxidation state -- for instance, the volatility of
17 species for plutonium is plutonium dioxide, and so it
18 has to go to dioxide and monoxide.

19 For uranium, it is thee oxides, and so it
20 is dioxide and trioxide. And then we need to have
21 more on the effect of morphology of the high burn up
22 fuel on the release of these species.

23 MR. BOYACK: Okay. Thank you. All right.
24 David.

25 MR. LEAVER: Well, the PHEBUS -- the FPT-1

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1 release of plutonium was somewhat less than 1465, the
2 1465 number for VERCORS for the cerium group, and the
3 neptunium was somewhat higher.

4 So I guess I think -- I have -- these
5 numbers are all so small that I just don't really know
6 -- I don't feel too comfortable throwing numbers
7 around because they are all so small.

8 But I think qualitatively that the
9 neptunium number from FPT-1 would make me want to
10 think that perhaps we are a little low on 1465, even
11 though the plutonium release is less than what we have
12 for 1465.

13 So I maybe would double that number just
14 to reflect that that FPT-1 data, and make it 10
15 percent. And I would have no basis for changing the
16 ex-vessel. I'm sorry, 0.1 percent.

17 And that was ex-vessel. Was there any
18 comment on any question about the vessels? I would
19 say it is applicable.

20 MR. BOYACK: Okay.

21 MR. LEAVER: Thank you.

22 DR. KRESS: The high releases of neptunium
23 and ruthenium even in the VERCORS experiments gives me
24 room for pause, because 2 percent would be a
25 significant biological effect in a design basis space.

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1 MR. LEAVER: You are talking about
2 ruthenium?

3 DR. KRESS: Yes, and I am talking about
4 neptunium also. That has a severe biological effect.
5 Cerium also does. So, I worry about those numbers.

6 I still believe that all the other things
7 ought to be capped at something like one-tenth of a
8 percent, but I am about to change my mind about
9 neptunium, and ruthenium, and cerium, and we might
10 want to separate those out as separate species,
11 because each of them have biological effects that are
12 severe, and apparently there is experimental evidence
13 to think that the releases might be in the order of
14 magnitude more than the .1 percent.

15 So I would kind of focus on those, and I
16 say that we need to understand and have more
17 experimental data to understand the PHEBUS results and
18 the VERCORS results.

19 But right now I would still say that until
20 we get that data I think I would still look for a cap
21 on all of those at .1 percent. I don't think I can
22 differentiate between .1 and .0025.

23 So I am sticking with my number, just .1
24 percent across the board right now, and with the
25 qualifier that I think we need to go back and recheck

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1 the results for neptunium, cerium, and ruthenium.
2 Those are the ones that I worry about.

3 MR. BOYACK: And that is because of the
4 health effects?

5 DR. KRESS: Yes, and I am not sure that my
6 .1 percent properly captures the results of the
7 VERCORS in places.

8 MR. BOYACK: Okay. And the next vessel?

9 DR. KRESS: The same, .1 percent.

10 MR. BOYACK: And the laid in vessel?

11 DR. KRESS: I don't have any reason to
12 worry with changing.

13 MR. BOYACK: Okay. Jim.

14 MR. GLESEKE: Well, for not necessarily
15 all the same reasons, I am going to go along with the
16 numbers that Tom has here. I would think it would be
17 important to point out that the neptunium numbers from
18 the French experience may be a big deal if they are
19 closer to right than the lower numbers. And we are
20 looking at 2 percent for the containment, and that
21 would be a significant deal. I would be inclined to
22 go with Tom's numbers on this one for the time being.

23 MR. BOYACK: Let's see. I am not sure
24 what those are.

25 MR. GLESEKE: About a tenth of a percent

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1 in the in-vessel.

2 MR. BOYACK: And for the same reason, the
3 health effects?

4 MR. GLESEKE: Yes.

5 MR. BOYACK: And the ex-vessel?

6 MR. GLESEKE: That can be a tenth of a
7 percent also for NUREG 1465.

8 MR. BOYACK: Okay. I would like to
9 introduce the clean up man for the survey group now.

10 DR. POWERS: Over the last decade there
11 has been quite a lot of work noted at the national
12 laboratory in the high country in the southwest by an
13 investigator named Oscar Krikorian, looking at the
14 vaporization of plutonium at relatively modest
15 temperatures.

16 And this has been an effort that he has
17 worked on for at least a decade, and maybe a decade-
18 and-a-half. And she has indeed found that within
19 water vapor there are vapor species for plutonium that
20 will lead to lower temperature vaporization.

21 And I think this lends credence to the
22 assessment that the French have made for plutonium
23 that is quite at odds with the thinking at the time of
24 the source to include package and the time of the
25 development of 1465.

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1 And I think we just have to say that here
2 we have two lines of investigation, totally
3 independent, that are leading to a similar result that
4 says indeed under these accident conditions you can
5 get non-trace releases of some of these elements.

6 I have conceptual difficulties with
7 estimating cerium release based on an analogy to
8 lanthanum, and I just basically wouldn't do it. I
9 think a better analogy is between cerium and
10 plutonium.

11 All together, that leads me to be very
12 supportive of the idea of an overall 2 percent in-
13 vessel release of the cerium group to the containment.

14 The results they have obtained from the
15 neptunium I find remarkable. I don't doubt them, but
16 the neptunium chemistry is an area that I just am not
17 very familiar with.

18 I did an assessment in connection with the
19 development of the Vanessa Code, and my recollection
20 is that indeed the thermal dynamic data would support
21 a higher volatility for neptunium.

22 Currently, my mental integration, biases,
23 thinks heavily toward the plutonium because I think
24 that Krikorian is giving us a much richer
25 understanding of the vapor chemistry of plutonium that

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1 would have us say, yes, this is not an irrational --
2 it is not a fluke of some particular experimental
3 thing, or that you should get some substantial
4 release.

5 So I am supportive of adopting plutonium
6 release as representative of the cerium group.

7 MR. LEAVER: Plutonium release for PHEBUS
8 or --

9 DR. POWERS: When they did their
10 assessment, PHEBUS is one point in space. They have
11 these VERCORS tests which -- and I have been able to
12 examine them only to the extent of view graphs being
13 put up on the viewing table.

14 And it would be nice to have a close
15 examination of these tests, because there are things
16 that go up and down in them that I don't quite
17 understand.

18 Again, I doubt them, and our history of
19 these out of pile tests is that there are things that
20 we don't understand about them. But you also see some
21 consistent trends.

22 And I also know that the French, when they
23 make these assessments, use heavy use of the Gemini
24 code in developing an understanding. I have spent
25 innumerable hours with some of the originators of this

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1 code name, and generally appreciate its quality that
2 they have exacted on that.

3 I state again that frequently we find
4 ourselves in completely -- in harsh debate, but I
5 think they have found something. Furthermore, it
6 seems to me that these trends that they observed and
7 their experiments to date, that it only gets
8 excesuated as we move toward high burn up fuels, where
9 there is the propensity to have somewhat more
10 oxidizing conditions in the fuel.

11 And as Bernard points out, indeed even
12 greater access of oxidizing gases to the
13 microstructure. So I am saying let's accept what you
14 have done for plutonium as representative, and flag
15 it, and say let's look further at this neptunium
16 business, because Tom tells me that neptunium is a
17 real bad actor.

18 And cerium I know has the -- is our decay
19 heat carrier for the long duration. So we need to pay
20 attention to what it is doing just as a heat source.

21 The French have taken a roughly 80 percent
22 deposition along the release path, which I think these
23 materials are transmitted primarily in the aerosol
24 form, and if we consistently looked at what we did
25 with aerosol, we basically took a 50 percent

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1 deposition.

2 And I am not going to go into that kind of
3 detail. I am just going to be supportive of the 2
4 percent to containment.

5 MR. GLESEKE: I think they have a tenth of
6 a percent of plutonium load, Dana, and not to quibble
7 over numbers.

8 MR. CLEMENT: Yes, you always take *
9 deposition, and just because when the contents just
10 above the fuel, there is not so much aerosol in which
11 they can *. So the lowest volatility of elements, the
12 highest will be the position by vapor condensation on
13 the walls.

14 If you take a highly volatile element, and
15 the condensation will find a huge population of
16 aerosols to be transported. That is the reason. That
17 is also supported by measurements of deposits in the
18 upper part above the * section and the * section, and
19 that is the idea.

20 And concerning cerium, I don't remember if
21 I have ever known why people have made the analogy
22 with *, and they were probably some reasons that I
23 don't know.

24 DR. POWERS: Well, the basis for doing it
25 is that the predominant vapor species from lanthanum

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1 sesquioxide is LAO, and the predominant vapor species
2 from cerium is CEO, and they are very similar in their
3 properties, and that's how they would do it.

4 MR. CLEMENT: In VI-5, there was a
5 measurement of 2 percent of the release of cerium, one
6 for one, and that is the only value that we have got
7 as a measurement.

8 DR. POWERS: Well, my bottom line is that
9 it is 2 percent to the containment.

10 MR. GLESEKE: Now, that's a neptunium
11 number?

12 DR. POWERS: Yes, 2 percent to the
13 containment.

14 MR. BOYACK: And the name of the
15 researcher, was that Krikorian?

16 DR. POWERS: Krikorian, yes;
17 K-R-I-K-O-R-I-A-N.

18 MR. BOYACK: I was distracted by somebody
19 speaking here. Could you give it to me one more time?

20 DR. POWERS: K-R-I-K-O-R-I-A-N. The noted
21 Lassel (phonetic).

22 MR. BOYACK: Oh, I did want to get that
23 in.

24 DR. POWERS: Yes, I figured you did.

25 MR. BOYACK: I assumed that may be what

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1 was going on when it was an unnamed lab in the
2 southwest..

3 DR. POWERS: Well, no. A famous
4 laboratory in the high country of the American
5 Southwest.

6 MR. BOYACK: And the ex-vessel.

7 DR. POWERS: The ex-vessel number here
8 again is composed of two components. One component is
9 a mechanical release due to the bubbling, the bubble
10 bursting at the surface, and then another component
11 that is a vaporization release that is directly
12 proportional to the amount of zirconium present.

13 If that amount of zirconium metal present
14 is changed radically by going to high burn up fuel,
15 you will see some change in the cerium release, but at
16 this point I am comfortable with the numbers that
17 exist.

18 MR. BOYACK: Okay.

19 DR. POWERS: And I think it is .5 percent.

20 MR. BOYACK: Oh, I'm sorry. I was just
21 looking at the other values.

22 DR. POWERS: No, .5 percent.

23 DR. KRESS: .5 percent.

24 MR. BOYACK: .5. I've got it. Thank you.

25 DR. POWERS: And for the late in-vessel

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1 release, I think any of this is a resuspension
2 release. I don't see a vaporization route here, and
3 our understanding of resuspension hinges very much on
4 physical form on the surface.

5 I think that these will be among the most
6 resuspendable of the fission products that drop on the
7 surface. But right now I think that our assessment of
8 that suspension is that it is small.

9 MR. BOYACK: Like?

10 DR. POWERS: Like zero. I would not
11 change the existing value.

12 DR. KRESS: Way to go.

13 MR. BOYACK: Way to go. Pardon me while
14 I try to find out where I am. Oh, there it is.

15 DR. POWERS: These guys up at Los Alamos,
16 they lose tape drives, and they lose -- they just
17 can't find things, you know.

18 MR. BOYACK: It is our way of keeping --

19 DR. KRESS: Look behind the xerox
20 machine..

21 DR. POWERS: The xerox machine.

22 MR. BOYACK: It is an employment thing
23 that we engender for the NRC, or not for the NRC, but
24 for the FBI and other security forces.

25 DR. POWERS: Security forces?

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1 MR. BOYACK: Yes. And I think thinking,
2 David, because you get to lead off on this.

3 MR. LEAVER: I forgot about lanthanide.
4 I guess I would see no basis for changing the numbers
5 in 1465, and that is based on that the FPT-1 data --

6 MR. BOYACK: Now, just to make sure where
7 we are, which phase are you in?

8 MR. LEAVER: Early in vessel, and there is
9 no change on the basis of the FPT-1 data, and very
10 similar results for some of the earlier tests with
11 SFD.

12 MR. BOYACK: S what?

13 MR. LEAVER: SFD-14.

14 MR. BOYACK: Okay. So that is applicable.
15 Ex-vessel.

16 MR. LEAVER: I would have no basis for
17 anything on NUREG 1465 on that.

18 MR. BOYACK: And in-vessel?

19 MR. LEAVER: That is a factor. That is a
20 factor.

21 MR. BOYACK: And late vessel?

22 MR. LEAVER: No basis for changing the
23 number.

24 MR. BOYACK: Okay. Tom. Is there anybody
25 who would change the gap --

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1 DR. KRESS: Hang on. I want to change
2 some things that I have done before, because I was
3 saying a cap of all of these things at .1 percent. I
4 think that is only in the early in-vessel release. I
5 would make all of those .01, or .1 percent.

6 But for the ex-vessel release, I would
7 keep those at .005, because it is a different
8 mechanism, and it is bubble bursting like Dana said,
9 and it is more like .005. So I would make all three
10 of those at .005, and the ex-vessel, and all three of
11 the early in-vessels at .001. And I would not change
12 the late-endings.

13 MR. BOYACK: I am just a little slower
14 here, because now we are going back to talking about
15 previous --

16 DR. KRESS: Yes. I had them all at .001.

17 MR. BOYACK: So, for the moment here, if
18 you could just give me this entry, and then I will go
19 back and --

20 DR. KRESS: .001 and .005., no change to
21 the NUREG 1465. I actually think that number was
22 probably based on the bubble bursting in the first
23 place.

24 DR. POWERS: It has a little bit of a
25 component in the vaporization, or the zirconium metal

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1 that is pleasant.

2 MR. BOYACK: Now, how many of these are
3 there that we need to go back to?

4 DR. KRESS: The noble metals and the
5 cerium.

6 MR. BOYACK: The noble metals and the
7 cerium. Okay. And this was now .1.

8 DR. KRESS: What are you looking at, at
9 the end-vessel?

10 MR. BOYACK: I am back at noble metals,
11 in-vessel.

12 DR. KRESS: Okay. It is .1; and ex-vessel
13 is .005, or .5.

14 MR. BOYACK: Five percent. I should have
15 been consistent on this, but I wasn't. And then we
16 were all right on the --

17 DR. KRESS: And the same thing for the
18 cerium.

19 MR. BOYACK: Okay. So, now let me get
20 this together. Now, for cerium --

21 DR. KRESS: And I have .1 percent and that
22 is okay, and down there I would use .5.

23 MR. BOYACK: Five?

24 DR. KRESS: Yes. Thank you.

25 MR. BOYACK: That is just part of the

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1 service out at Los Alamos. I am trying to keep my
2 piles straight here. One moment.

3 (Brief Pause.)

4 MR. BOYACK: This gave you a lot of time
5 to think, Jim.

6 MR. GLESEKE: And it should go pretty
7 quickly shouldn't it. Just to inform you of the
8 logic. I used Tom's total numbers here, and --

9 MR. BOYACK: That is his calculations.

10 MR. GLESEKE: His calculations of the
11 correlation of data, and I adjusted that for some loss
12 of core practice, and lo and behold we come out at
13 .002, which is amazing because that is the number that
14 is up there for the NUREG 1465. So it stays the same.

15 And I will go along with NUREG 1465 on the
16 ex-vessel, and the same for in-vessel.

17 MR. BOYACK: Okay.

18 MR. BOYACK: Zero, point, oh, two.

19 MR. POWERS: Zero, point, two percent?

20 MR. BOYACK: Zero, point, oh, two release
21 fraction.

22 MR. POWERS: Okay, all right. I'll just
23 try to be consistent. Okay. And do you want to
24 provide a basis?

25 MR. BOYACK: You're going to hear it

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1 shortly.

2 MR. POWERS: Okay.

3 MR. BOYACK: And so you can say CDC/JME up
4 there.

5 MR. POWERS: Here?

6 MR. BOYACK: Yeah.

7 MR. POWERS: CDC, CDC/JME. Okay.

8 MR. BOYACK: And for the ex vessel, I'll
9 stay with the NUREG number.

10 MR. POWERS: You say the same?

11 MR. BOYACK: Yeah, the same way.

12 MR. POWERS: I have this projector going
13 in my ear, and I just --

14 MR. BOYACK: And for the laid in vessel,
15 I don't see a lot of perturbation. I see
16 resuspension, but my understanding, resuspension is
17 fairly low level. So I'll stick with the 65 number.

18 MR. POWERS: So this was CDC?

19 MR. GIESEKE: SED.

20 MR. KRESS: The first C is SED.

21 MR. GIESEKE: It's not three initials.
22 It's a word "see."

23 MR. POWERS: As in "see saw Marjorie Daw"
24 (phonetic)?

25 MR. BOYACK: See what?

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1 MR. POWERS: CBCA, right?

2 PARTICIPANTS: No, no, no.

3 (Laughter.)

4 MR. KRESS: It's supposed to be BC.

5 MR. POWERS: "See" and then BC.

6 MR. BOYACK: Evidently, what is that when
7 you flip on I? Am I dyslexic? I've got dyslexic
8 ears, I guess. So this is CBC?

9 MR. GIESEKE: There you go. Now you're
10 okay.

11 MR. BOYACK: Hardly took anything, did it?

12 MR. KRESS: Have you heard of the
13 organization called DAM, D-A-M?

14 MR. BOYACK: Tell me.

15 MR. KRESS: That's Mothers Against
16 Dyslexic.

17 (Laughter.)

18 MR. BOYACK: Now that I see BC/JMB, what
19 am I supposed to do with this?

20 MR. POWERS: Listen.

21 (Laughter.)

22 MR. BOYACK: Oh, I'm sorry. Now I finally
23 got it.

24 (Laughter.)

25 MR. BOYACK: I am really slow, yeah.

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1 Bernard, I have been told to listen to
2 you.

3 MR. POWERS: Intently. Let me put the
4 "intently" listen.

5 MR. CLEMENT: We've got the two loops
6 because we initially thought as everybody that all of
7 this stuff had very low volatility. In fact, when we
8 performed the VERCORS HT-1 experiment, it was a burn-
9 up of 14. When they performed it up to 3,000 Kelvin,
10 we measured the significant releases of lanthanum,
11 europium.

12 MR. BOYACK: So the two groups are
13 lanthanum --

14 MR. CLEMENT: No, no. The first group,
15 you've got -- we put lanthanum, europium, and
16 praeseodyminim, Pr.

17 MR. BOYACK: Br?

18 MR. CLEMENT: Pr. It was not measured,
19 but you can do an analogy.

20 MR. GIESEKE: Yeah, yeah, not a bad
21 analogy.

22 MR. CLEMENT: Okay. So from these few
23 results, we've put ten percent release from the fuel
24 and two percent to the containment. In fact we
25 measured eight percent that we are using.

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1 For the others, zirconium, and neurodeme
2 (phonetic), there are others. Okay, but we have put
3 one percent from *, .2 percent to containment.

4 MR. BOYACK: And .2?

5 MR. CLEMENT: Point, two to containment.

6 MR. BOYACK: All right. Thank you.

7 MR. CLEMENT: Okay. I address those.
8 Okay? The same as --

9 MR. BOYACK: Okay, and laid-in vessel?

10 MR. CLEMENT: Laid-in vessel, I don't know
11 if we could have some resuspension or not for the
12 staff. That's again the point. We are in the
13 resuspension. We don't give any number, but just
14 point out that as far as we have important requisites,
15 we've got this problem of uncertainties in
16 resuspension for the latent vessel. We're saying this
17 is a point to be addressed then.

18 MR. POWERS: Right, but it has to do with
19 what we find out about the physical form of these
20 deposits, and as we learn a little more about it. In
21 some cases the deposits down in the low temperature
22 regime, they move around with a breath of air, and
23 others you can't chip them off with a hammer.

24 MR. BOYACK: All right.

25 MR. LEAVER: You certainly don't see that

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1 type of result from PHEBUS.

2 MR. CLEMENT: No.

3 MR. LEAVER: So there's something else
4 going on.

5 MR. CLEMENT: Yes. I don't know if it's
6 an effect of burn-up of temperatures, but something is
7 going on.

8 (Pause in proceedings.)

9 (Whereupon, the foregoing matter went off
10 the record at 11:49 a.m. and went back on
11 the record at 11:51 a.m.)

12 MR. BOYACK: As you know, as we dealt with
13 the last three groups, no metals, cerium group, and
14 Lanthanides, we ran into this issue where the data
15 uncertainties, this regrouping, and what I'd like to
16 do is just have your thoughts on candidate ways of
17 dealing with this, not a resolution, just options.

18 MR. KRESS: Well, first off, I would be
19 tempted to look at neptunium and cerium and lanthanum
20 separate from the other groups because of their
21 biological effectiveness, and from the fact that it
22 looks like in some cases they get released enough to
23 worry about.

24 If they didn't get released enough to
25 worry about, I wouldn't worry about them otherwise,

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1 but they seem like in some cases they get released
2 enough, and their biological effectiveness is severe
3 and can make some differences.

4 So I would be tempted to look at those as
5 separated out from the groups.

6 MR. BOYACK: Okay. So this was a case
7 where you would separate them out. What else?
8 Anything else that might occur to you or is that --
9 you can do this more than once.

10 MR. KRESS: Well, I would think all the
11 other groupings are pretty much okay because it
12 doesn't make much difference anyway, and that would be
13 my feeling.

14 MR. BOYACK: Okay. Jim, what do you
15 think? Any thoughts about how we handle this, the
16 fact that we have these --

17 MR. GIESEKE: Well, I think it's important
18 to note that at least in the case of neptunium, the
19 French data suggests that that's significantly
20 different than some of the other elements in that
21 grouping. So it warrants a special look.

22 I just supported what Tom said, I guess.

23 MR. BOYACK: Okay. Dana?

24 MR. POWERS: I guess you're asking the
25 question really of what do you do about the fact that

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1 some people say ten and other people say .1.

2 MR. BOYACK: Yeah, yeah. So what do we do
3 with the variability?

4 MR. POWERS: And I think you go with a
5 voting mechanism with careful attention in the text
6 outlining the minority opinion. I think you need to
7 end up with tables with numbers in them that people
8 can use, but I think you have to put the explanatory
9 part in there that says overall this is based on
10 incomplete information, a snapshot in time.

11 It could be that the outlier view is
12 closer to reality than the majority.

13 MR. LEAVER: Your point about ending up
14 with a table that people can use, when we started
15 this, there was some talk about writing a -- do you
16 consider this a PIRT exercise, a PIRT report, which
17 would be like a NUREG CR report similar to the ones
18 that you've done on the reactivity insertion of the
19 three that you get?

20 If we do that, then maybe we don't need a
21 table. Maybe it's a range. I don't know, but then
22 maybe it's RES' job as the issuer of 1465 to reissue
23 1465 using this information that we provide. I mean
24 that's another process here.

25 I'm not sure what the process is, but --

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1 or whether we're expected to come up with a table.

2 MR. BOYACK: Let me just comment that the
3 very first contact I had referred to this work as a
4 PIRT activity, and I carry within my mind a certain
5 definition of what that means, the processes and the
6 approach.

7 And we had a pre-meeting, came together,
8 sat down, and discussed what was really the objective
9 of the NRC activity, and that was to come up with
10 these tables, these revised tables.

11 And so you may see that I don't use the
12 word PIRT. In my correspondence I call this the
13 source term applicability panel rather than a PIRT
14 panel, and that's the reason why. I don't think it's
15 the PIRT.

16 MR. LEAVER: Yeah.

17 MR. BOYACK: I understand the point that
18 you've indicated, and so what I've done is to put down
19 as one of the options to consider whether the NRC
20 would take the results of the panel, which may not
21 have a single value, and then come up with --

22 MR. LEAVER: Well, in some cases it may;
23 in some cases it may not.

24 MR. BOYACK: Yeah.

25 MR. KRESS: Can you change that word

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1 "early" in the top line? I didn't say that or at
2 least I didn't mean it. It seems to be released to a
3 greater extent than previously filed.

4 MR. BOYACK: I can change it.

5 MR. KRESS: Yeah.

6 MR. BOYACK: Sure. Okay. Let's see. So
7 any comments about options, things we might consider?

8 MR. CLEMENT: Yes, I think that some
9 elements should be separated. So I agree with
10 neptunium, cerium, and lanthanum, and they would add
11 the volatile ones, molybdenum and technetium.

12 MR. BOYACK: Okay. So was all of that a
13 single group?

14 MR. CLEMENT: No, no, no, no, no. This
15 should be separated according to their volatility and
16 their radiological importance. I don't give the
17 separation right now of these other three important
18 factors.

19 MR. BOYACK: Let's see. The volatility was
20 the second.

21 MR. CLEMENT: Biological effects,
22 biological hazards, you know.

23 MR. BOYACK: The list of species. So let
24 me go ahead.

25 MR. CLEMENT: So neptunium, cerium,

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1 lanthanum, molybdenum, technetium at least.

2 Okay. Then the second point is I fully
3 agree with what's said that we should identify what
4 are the sources for the variability within the values.
5 This is quite very important. I think we do not have
6 time to discuss in detail all of what were always
7 sources of variability. What I would propose is when
8 you look at all what we have said, you identify the
9 most important sources of variability and maybe asking
10 panel members --

11 MR. LEAVER: To confirm that.

12 MR. CLEMENT: -- to confirm that and to
13 send in written form what are the reasons why, not for
14 all of the variables that were given, but I think that
15 you can identify after the meeting what are the main
16 sources of the main differences between the members of
17 the panel, and you could ask each member of the panel
18 to give more detail in written form about why stay
19 with that.

20 That could help to document these
21 variability.

22 MR. LEAVER: While he's typing, what are
23 we doing on getting copies of the material that you
24 presented? Is that happening? Are you going to send
25 it out next week?

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1 MR. BOYACK: They'll send that to me early
2 next week.

3 MR. LEAVER: Okay. That's going to happen
4 next week. Okay.

5 MR. BOYACK: And the one thing, I think we
6 said Power Point is what you had the material in, but
7 if you can also in addition create a PDF file. The
8 one thing I've found out is the PDF files almost
9 always work and sometimes --

10 MR. CLEMENT: Yeah, yeah, yeah.

11 MR. BOYACK: -- we have trouble with other
12 files.

13 MR. LEAVER: Is that why you do it, PDF?

14 MR. BOYACK: Absolutely.

15 MR. LEAVER: Is it a smaller file?

16 MR. BOYACK: No. It's platform
17 independent. That's why it seems to work better.
18 Since I generate on a MAC machine, that becomes
19 important.

20 MR. LEAVER: If you got after that
21 reading, something like that.

22 MR. BOYACK: Right, and those can be
23 downloaded pretty often off the Internet.

24 Okay. Is there anything else then? I
25 think that sort of captured what I wanted.

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1 Charlie, what we're going to do is in a
2 moment take a break for lunch, come back a few minutes
3 before one, and so the question I have is is there
4 anything else that you wanted us to discuss for a few
5 minutes or are we kind of covering what you wanted?

6 You'll note that we haven't done anything
7 on BWR yet, for instance.

8 MR. TINKLER: Right.

9 MR. BOYACK: And we had some discussion
10 yesterday based upon Ralph Meyer's presentation.
11 Maybe that was the first day, that the BWR fuel is
12 moving in appearance and characteristics towards a PWR
13 fuel, and there was some thought that we might be able
14 to go through the BWR --

15 MR. LEAVER: Pretty quickly.

16 MR. BOYACK: -- pretty quickly, which
17 maybe would be the first section of the final meeting

18 MR. TINKLER: Well, I mean, to the extent
19 you can talk about the BWR fuel, you know, as we went
20 into the implementation of the alternate source term,
21 revised source term, we thought again about whether or
22 not the distinctions in the source term between the
23 PWR and BWR were really worth the effort, were really
24 worth the distinction, frankly.

25 Revised system level calculations only

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1 serve to convince us that variability in sequences was
2 larger than the variability in the source term between
3 the two reactors, and that, you know, making
4 distinctions between 30 and 35 percent, which was an
5 averaging process once upon a time, just really has
6 questionable value to us, okay, and whether or not
7 it's, you know, a distinction without a difference,
8 frankly.

9 MR. BOYACK: Yeah.

10 MR. TINKLER: You know, I'm not
11 encouraging you to spend lots of time on it if you
12 want to, but you might consider whether or not it's
13 just -- considering, as we say, the preponderance of
14 evidence maybe and the uncertainty associated with all
15 of this, we just adopt the same source term for Ps and
16 B.

17 MR. LEAVER: You recognize if we do that,
18 you're talking about a 30 percent increase in iodine
19 release.

20 MR. TINKLER: I understand, but do we
21 really think that, you know, there is that much
22 difference at this point?

23 MR. LEAVER: Yeah.

24 MR. TINKLER: It's just something to
25 consider. I know that it's going to have some impact

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1 on some calculations, but do we really think there's
2 a difference within the range of uncertainties?

3 It's something you might want to debate
4 among yourselves, you might want to consider.

5 MR. BOYACK: Okay, all right. What I
6 suggest we do then now is eat lunch.

7 MR. LEAVER: That's an idea.

8 MR. BOYACK: Unless there is any real
9 objection to that particular approach.

10 MR. KRESS: Why don't we get back at
11 12:30?

12 MR. BOYACK: And?

13 MR. KRESS: You said we'd get started at
14 12:30 or did you say shortly before one?

15 MR. BOYACK: We have speakers coming in at
16 one to talk to us on this particular question.

17 (Whereupon, at 12:03 p.m., the meeting was
18 recessed for lunch, to reconvene at 1:00 p.m., the
19 same day.)

20

21

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

2 (12:57 p.m.)

3 MR. BOYACK: Let's go ahead and resume our
4 meeting.

5 We're grateful that we've been able to
6 have some individuals come and talk to us about MOX
7 fuel, and I don't know whether one of you will take
8 the lead in introducing all of that.

9 Steve Nesbit. So I'll turn the time over
10 first to Steve and have him introduce his colleagues
11 and also the course of the meeting.

12 Now, I should inform you that we have a
13 court recorder. We're going to have a transcript of
14 the meeting. There is a microphone --

15 MR. NESBIT: Whatever I say can and will
16 be used against me.

17 MR. BOYACK: -- microphone here on the
18 pulpit, and if from the audience you wish to speak, if
19 you'll use the microphone over at the side.

20 And, Steve, thank you.

21 MR. NESBIT: Thanks.

22 MR. BOYACK: And if there are handouts, I
23 can take care of getting those out.

24 MR. NESBIT: Okay, great. Okay. Thanks
25 for giving us the opportunity to come and participate

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1 in this meeting this afternoon.

2 I do have some handouts, and if you can
3 distribute those, I'd appreciate that.

4 I'm Steve Nesbit from Duke Power, and I'm
5 the mixed oxide fuel project manager for Duke Power.
6 WE also have with us today Patrick Blanpain from
7 Framtome in France. Patrick is going to give the
8 second presentation of our two.

9 Larry Losh from Framtome USA back there
10 next to Patrick, and we may be joined by Patrick
11 Rhodes from Department of Energy. I don't see him
12 here yet.

13 And we were asked to come and discuss with
14 your panel aspects of mixed oxide fuel that might bear
15 upon the applicability of the NUREG 1465 source term
16 to that fuel, and we've tried to put together a couple
17 of presentations to address those issues.

18 We certainly encourage you to ask
19 questions, and if we can't answer your questions
20 today, we'll try to get back to you at a later time.

21 The purpose of my presentation is to give
22 you a general overview and background of the program
23 that we're involved in to use mixed oxide fuel and to
24 address a few of the points that I think were raised
25 in your first meeting, which I got from reviewing the

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1 transcript there.

2 Some of this information, maybe all of it,
3 you're familiar with. I'll try not to go into
4 excruciating detail on it, but I do want to give you
5 a general overview of what we're trying to do here.

6 The Department of Energy has the
7 responsibility for managing surplus plutonium from the
8 United States Weapons Program, and in September of
9 2000 the United States and Russia signed an agreement
10 to dispose of significant portions of that plutonium,
11 34 tons of weapons grade plutonium for each country.

12 By the terms of the agreement, the
13 majority of the plutonium will be disposed of by
14 conversion to mixed oxide fuel in use in existing
15 nuclear power reactors. Pursuant to that agreement,
16 actually a little before that, DOE contracted with a
17 team of companies known as Duke Cogema Stone and
18 Webster, or DCS, to provide MOX fuel fabrication and
19 irradiation services.

20 As a general overview of the project, the
21 way it's supposed to work is this. The material, the
22 plutonium is currently in the form of pits stored at
23 Pantex in Texas, a DOE facility there. It's to be
24 transported by DOE to a facility to be developed at
25 the Savannah River site called the Pit Disassembly and

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1 Conversion Facility.

2 That facility will turn the classified
3 weapons into unclassified plutonium oxide powder,
4 which will be transferred to another facility on the
5 Savannah River site, also not yet built called the MOX
6 Fuel Fabrication Facility. That's the subject of a
7 current license proceeding in front of the Nuclear
8 Regulatory Commission. They're applying for
9 construction authorization.

10 This facility will make mixed oxide fuel.
11 It will be transported by DOE to four nuclear power
12 reactors, McGuire Units 1 and 2 and Catawba Units 1
13 and 2. There it will be used in a manner very similar
14 to existing uranium fuel and eventually it will be --
15 the eventual in-state would be a geologic repository.

16 Who's who in this team of companies? Duke
17 Cogema Stone and Webster, imaginatively named after
18 Duke Engineering and Services, Cogema, and Stone and
19 Webster. These are the three main partners.

20 Cogema, of course, is the French fuel
21 cycle company that has a lot of experience in the
22 field of plutonium and mixed oxide fuel and also
23 another partner or another subcontractor through
24 Cogema is Belgonucleaire, which is also an experienced
25 MOX fuel fabricator, and Electricity de France, which

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1 has a lot of experience using mixed oxide fuel.

2 Other subcontractors include Nuclear Fuel
3 Services, who are working in safeguards and security;
4 Duke Power, which is responsible for using the fuel;
5 and Framtome AMP, which is responsible for designing
6 the fuel.

7 Some key milestones. I mentioned that
8 there's a construction authorization request before
9 the Commission. That was submitted in 2001 for the
10 MOX fuel fabrication facility. The goal was to start
11 MOX fuel fabrication facility construction 2002 or
12 2003; receive a license to possess and use nuclear
13 material at the facility in 2004; begin a lead
14 assembly irradiation program in one of our reactors in
15 2004; complete the MOX fuel fabrication facility
16 construction and start-up and testing and start making
17 mixed oxide fuel in the 2006 and 2007 time frame, and
18 ultimately start to use the fuel at McGuire and
19 Catawba 2007 to 2008.

20 Moving on to some facts about what MOX
21 fuel is and isn't, MOX fuel is, as you're probably
22 aware, a blend of about five percent plutonium oxide
23 with about 95 percent uranium oxide, depleted uranium
24 oxide in our case, and I will point out that like
25 conventional low enriched uranium fuel, MOX fuel

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1 pellets are primarily uranium.

2 Fission power from MOX fuel comes from
3 Plutonium 239 primarily rather than Uranium 235.
4 Other than the fuel pellet material, a MOX fuel
5 assembly is essentially the same as a uranium fuel
6 assembly.

7 MR. POWERS: When you say "a blend," you
8 don't mean a blend on the atomic scale, do you?

9 MR. NESBIT: I think you're asking about
10 a question that pertains to the microstructure of the
11 pellet itself.

12 MR. POWERS: Yes.

13 MR. NESBIT: Mr. Blanpain is going to
14 address those issues.

15 Using mixed oxide fuel in light water
16 reactors, typically this is being done on an
17 industrial scale in Europe today. There's 35 reactors
18 using mixed oxide fuel.

19 You typically load a mixture of mixed
20 oxide fuel assemblies and conventional uranium fuel
21 assemblies in a core.

22 If you look at the EDF program, they have
23 30 percent MOX fuel assemblies in the core. The
24 European experience base actually goes up to 38
25 percent in German reactors. Our plans for the fuel is

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1 to use approximately 40 percent MOX fuel assemblies
2 and the remainder conventional uranium fuel
3 assemblies.

4 We designed the MOX fuel assembly in terms
5 of plutonium concentration to have essentially the
6 same reactivity as the uranium fuel.

7 MR. BOYACK: Does the plan to burn this
8 how many tons, 34 tons of plutonium in these four
9 plants and no others?

10 MR. NESBIT: The current plan is that. In
11 fact, there's currently 25 tons of plutonium allocated
12 for MOX fuel. Those 25 tons would be used in those
13 four plants.

14 What kind of plutonium is in the MOX fuel?
15 Well, in the European programs, the plutonium comes
16 from recycled or reprocessed commercial nuclear fuel.
17 As a result of that, the isotopic mix is approximately
18 60 percent Plutonium 239, more than 20 percent
19 Plutonium 240.

20 The material that we're going to be using
21 is weapons grade plutonium. It will have 93, 94
22 percent Plutonium 239, and the remainder Plutonium
23 240. Obviously the material we're using, the weapons
24 grade material was produced in a special manner
25 optimizing or maximizing the amount of Plutonium 239

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1 in the mix.

2 I've got some analytical comparisons I'm
3 going to show between different mox fuel types and
4 uranium fuel that shed a little bit of light on
5 differences and similarities between the fuel.

6 This first slide is a nuclear slide, and
7 I'm a nuclear engineer. So I actually understand
8 this. What you have got on the Y axis is K infinity
9 or a measure of the reactivity of the fuel assembly as
10 a function of burn-up on the X axis, and of course, as
11 the fuel is burned, the reactivity or the energy
12 content decreases.

13 The purple or blue line here is a nominal
14 low enriched uranium fuel assembly. The red line is
15 a reactor grade MOX fuel assembly, and as you can see,
16 compared to the uranium fuel assembly, the reactivity
17 in the reactor grade MOX assembly drops off much
18 slower.

19 The third line is the weapons grade MOX
20 fuel assembly, and as you can see, the nuclear
21 behavior is between the other two, the reactor grade
22 MOX and the low enriched uranium fuel. So the
23 behavior is bounded by the other two.

24 Total plutonium content shows a similar
25 story. Again, these assemblies have a similar

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1 reactivity at burn-up of 20 gigawatt days per ton.
2 This is the amount of plutonium in a fuel assembly as
3 a function of burn-up. The uranium fuel assembly
4 starts with none and builds up to around one percent
5 as the fuel assemblies burn.

6 Reactor grade starts with more because the
7 plutonium is not as high grade as the weapons grade
8 plutonium, and it decreases with burn-up. The weapons
9 grade decreases with burn-up.

10 Two points. Weapons grade is between
11 reactor grade MOX and low enriched uranium fuel, and
12 second, as you burn it up in terms of content of the
13 fuel material, the weapons grade becomes increasingly
14 close to low enriched uranium fuel.

15 The fuel that we're going to use in our
16 program is shown here, and it's a proven design in the
17 United States. It's the Mark BW Framtome design that
18 has been used for years, and in fact, for years in the
19 McGuire and Catawba reactors.

20 The difference, of course, is the fuel
21 pellet material will be five percent weapons grade
22 plutonium in the form of MOX fuel. There is advanced
23 alloy M5 cladding for the fuel. I think you all are
24 probably familiar with that; intermediate flow mixing
25 grids to make it compatible with the co-resident

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1 uranium fuel, and another difference here between
2 uranium and MOX fuel, We've got radial plutonium
3 concentration zones within an assembly. I've got a
4 picture here that's going to show that a little
5 better.

6 Most pressurized water reactor fuel
7 assemblies have all the pins are the same enrichment
8 uranium. That's not uniformly true. There actually
9 is some uranium fuel that I'm aware of that's zoned in
10 two zones.

11 With MOX fuel, MOX fuel has a much lower
12 thermal neutron flux than uranium fuel, and therefore,
13 when you put a MOX fuel assembly next to a uranium
14 fuel assembly, the edge pins in the MOX fuel assembly
15 see a high neutron flux leakage from the adjacent
16 uranium fuel assembly.

17 So we zone the fuel assembly. We put low
18 concentration plutonium in the corners and on the
19 edges and next to the control rod guide tubes, and
20 that way that keeps the power profile across the
21 assembly flat.

22 Talk briefly about the reactors that are
23 going to use the mixed oxide fuel in the United States
24 program. McGuire Units 1 and 2 were started up in
25 1981 and 1984. They're located near Cornelius, North

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1 Carolina, which is north of Charlotte.

2 Catawba Units 1 and 2, located near
3 Clover, South Carolina, which is southwest of
4 Charlotte, and Catawba units started up in 1985 and
5 1986. All four units are operated by Duke Power.

6 All four units share the same designed
7 primary system and core, for the Westinghouse
8 pressurized water reactors; core power level of 3411
9 megawatts thermal and 193 fuel assemblies in the core.

10 And all four reactors employ an ice
11 condense containment system.

12 I want to talk briefly about our planned
13 fuel management with mixed oxide fuel. We're
14 currently on 18 month cycles at these reactors. Our
15 intent is to stay on 18 month cycles so that we'll
16 keep the same cycle length.

17 We usually have batches around 80 or 84
18 feed. In other words, we load 80 or 84 fresh fuel
19 assemblies for each reload, and we anticipate that
20 we'll keep about the same feed batch size.

21 For the MOX fuel, we are going to impose
22 a 50 gigawatt day per ton burn-up limit on the fuel.
23 Now, our uranium fuel is licensed to either 60 or 62
24 gigawatt days per ton burn-up, but we're putting this
25 limit on there for the MOX fuel to make the burn-up

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1 that we're going to use consistent with the burn-up
2 that's been achieved in European reactors.

3 And Patrick Blanpain is going to talk a
4 little bit more about that in a minute, too.

5 We're going to discharge the mixed oxide
6 fuel assemblies after two cycles. Most of the low
7 enriched uranium fuel will run for three cycles. What
8 we expect, based on our preliminary core designs is
9 that the typical mox fuel assembly burn-up will be
10 about 40 gigawatt days per ton.

11 The maximum fuel assembly burn-up will be
12 in the area of 45 gigawatt days per ton in order to
13 keep the rod burn-up under the 50 gigawatt day per ton
14 limit.

15 MR. POWERS: How do those limits compare
16 to the limits the French have on their MOX?

17 MR. NESBIT: The French, interestingly
18 enough, don't have specific burn-up limits for their
19 fuel. They have fuel management licensed by their
20 regulatory authority. It's a little different.

21 The French typically see burn-ups in the
22 range of 36 to 40 for their MOX fuel assemblies.
23 However, other countries in Europe which use mixed
24 oxide fuel typically see burn-ups in the 40 to 50
25 range.

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1 Patrick is going to have a slide that
2 shows that, but the Germans and the Belgians for years
3 have been using mixed oxide fuel to burn-ups in the 45
4 gigawatt day per ton range.

5 I should add that that's also on a
6 production basis, and that there's lead assembly
7 programs in various countries that are taking the fuel
8 burn-up well above 50 gigawatt days per ton.

9 Here's typical uranium fuel management
10 that we use in our cores. The shaded assemblies, this
11 is a quarter core slice. The shaded assemblies are
12 the feed assemblies. These are all uranium
13 assemblies. We use a low leakage pattern, one or
14 twice burned fuel on the exterior. This increases
15 neutron economy, and it also minimizes the fluence
16 (phonetic) at the reactor vessel walls. It's a
17 typical checker board pattern with concentration feed
18 assemblies in the so-called "ring of fire" here.

19 This is a busier slide here that tries to
20 illustrate our MOX fuel core management as we envision
21 it today, but the point that I'll make is that in
22 terms of patterns of feed assemblies, it's almost the
23 same as the uranium patterns. Again, the checker
24 board feeds in the middle.

25 In this case, the feed LEU are shaded

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1 light green. The feed MOX are shaded dark red. The
2 once burned MOX are shaded light red. Again, checker
3 board in the middle, the "ring of fire," the once or
4 twice burned fuel on the exterior.

5 Shift gears a little bit here. One of the
6 issues that I think was discussed at your first
7 meeting I would like to talk about briefly:
8 radionuclide inventories or, I guess, the starting
9 point for your source term work. Framtome
10 specifically has done some work on the applicability
11 of the scale code system for mixed oxide fuel and they
12 benchmark scale, 4.4 against MOX and LEU fuel rod
13 measurements.

14 And what they've seen is that when you
15 compare agreement between the code prediction and the
16 measurement or the C over M, if you will, calculated
17 over measured, that the results are comparable for MOX
18 and LEU fuel. For most isotopes you're within plus or
19 minus ten percent.

20 I should mention when I say scale that
21 includes the code origin that some people might be
22 more familiar with the code system by that name.

23 Oak Ridge has done a lot of work with
24 scale. In fact, they're the people who developed the
25 code and maintain it. They are participants in the

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1 ARIANE Program, which has recently been completed in
2 Belgium, managed by Belgonucleaire actually all over
3 Europe.

4 And there has been benchmarks there to LEU
5 and mixed oxide fuel rods. They benchmarked other LEU
6 and MOX fuel rods, and again, they've come to the same
7 results that Framtome has, that the results are
8 generally comparable in terms of accuracy between MOX
9 and LEU fuel.

10 So when you exercise the codes against two
11 fuel types what happens, what you find out is
12 generally MOX fuel has slightly fewer fission products
13 than uranium fuel, and it has more actinides than
14 uranium fuel, and that's due to the fact that you've
15 got the initial presence of some plutonium there. So
16 you are already starting higher up on the atomic
17 number scale.

18 Framtome did force some comparisons of
19 radionuclide inventories using scale. I forgot to
20 capitalize it. Sorry. And they compared a couple or
21 three different fuel assembly types actually, low
22 enriched uranium, weapons grade MOX, and reactor grade
23 MOX at a 45 gigawatt day per ton burn-up point with no
24 decay time.

25 So this is right at 45 gigawatt days per

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1 ton, no shutdown time. What kind of fission products
2 do you see?

3 And I just pulled some samples out here.
4 These are some radioisotopes that are important to
5 dose calculations, certainly not all, but I just want
6 to show the general pattern.

7 Again, the same radioisotopes are there.
8 They're in different concentrations depending on what
9 fuel type you've got. What I've done is I've
10 normalized everything to the low enriched uranium
11 value here. So you start here with weapons grade MOX,
12 Krypton 87, about 68 percent of the activity;
13 Ruthenium 106, 74 percent higher activity; Iodine 131;
14 Xenon 133, about the same; Xenon 135, about 60 percent
15 higher in MOX; Cesium 137 about the same; Cerium 144,
16 about 17 percent lower.

17 Integrated over all of the fission
18 products, you're about 98 percent of the low enriched
19 uranium fuel at that point, at that snapshot point.

20 Reactor grade MOX is very similar to
21 weapons grade MOX.

22 Actinide activities, as I mentioned,
23 weapons grade MOX and the reactor grade MOX are
24 significantly higher than the low enriched uranium
25 because you just start out with more plutonium there,

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1 two to three times higher for these type of isotopes.

2 Another issue that may bear on your work
3 is decay heat. There's two real contributors to decay
4 heat in fuel. One is fission product decay, and that
5 is higher enriched, low enriched uranium fuel.
6 There's actinide decay or the heavy elements. That's
7 higher in mixed oxide fuel.

8 As a result, when you look at a total
9 decay heat comparison between the two fuel types,
10 short-term decay heat is lower than mixed oxide fuel.
11 It's dominated by the fission products, and that
12 difference is what makes the difference there.

13 Long-term decay heat is higher in mixed
14 oxide fuel. After many of the fission products have
15 had a chance to decay off, then the actinide
16 contribution is more important, and the MOX fuel has
17 a higher decay heat. I guess the point that I would
18 leave you with here is that MOX fuel has lower decay
19 heat during the time frame of the kind of accidents
20 that I think you're considering for the purpose of
21 your work on source terms, and I have got a plot here
22 that shows that a little more quantitatively.

23 This is a comparison, again, a ratio of
24 MOX to LEU decay heat. Total decay heat for two fuel
25 assemblies irradiated to 43 gigawatt days per ton.

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1 One is weapons grade MOX. The other is low enriched
2 uranium fuel.

3 So in the vicinity of 80 days or a little
4 longer, you cross over the 1.0 point. So before --
5 excuse me -- hours, 80 hours. Before 80 hours, the
6 delay heat from the MOX fuel is lower. Afterwards it
7 would be higher.

8 I've tried to give you a brief overview,
9 and Patrick Blanpain is going to give you a much more
10 detailed and technical overview of the MOX fuel pellet
11 and the characteristics there.

12 I will leave you with this. As a part of
13 our program we have been working developing reports,
14 submitting them to the NRC. I'll call your attention
15 to several that you may be interested in. The
16 COPERNIC topical report from Framtome covers a
17 COPERNIC code which is used to predict fuel mechanical
18 behavior. And the MOX part of that was submitted to
19 the NRC in August of 2000.

20 D.C. Hess has developed a fuel
21 qualification plan, which describes the work that
22 we're doing in order to qualify in mixed oxide fuel
23 for use in United States reactors.

24 Revision 2 was provided to the NRC for
25 information in April 2001, and I would add that it has

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1 a lot of information that we're covering today in
2 there.

3 Duke Power submitted a topical report on
4 nuclear analysis methods for MOX and uranium fuel in
5 August of 2001, and that's before the NRC for review
6 right now.

7 There's a Web site that the DCS Company
8 runs that has information on DCS and also has links to
9 other Web sites that are out there that have plutonium
10 MOX fuel information.

11 So that's about it for me. If anybody has
12 any questions they want to ask now, you're welcome to,
13 or if not, I'll turn it over to Patrick.

14 MR. BOYACK: Any questions?

15 (No response.)

16 MR. BOYACK: Okay. Why don't we proceed
17 with Patrick's presentation then?

18 MR. BLANPAIN: Good afternoon, ladies and
19 gentlemen. The purpose of my talk is a general
20 overview on the MOX fuel fabrication, on the MOX fuel
21 experience in Europe, and on the MOX fuel behavior in
22 the reactor.

23 First is the introduction to the stages of
24 MOX fuel use in Europe.

25 The first commission in 1972 in Germany,

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1 and in 1987 in France, fuel recycling is a form of MOX
2 fuel, has reached an additional maturity.

3 The production capacity used by Framtome
4 ANP was 180 ton per year heavy metal with the MIMAS
5 process. The two French Cogema plants in Kederash
6 (phonetic) and Machood (phonetic), and the Belgian at
7 Desser (phonetic) operated by Gelgonucleaire.

8 More than 1,700 fuel assemblies have been
9 delivered by Framtome in Bay of Fragema to 20 French,
10 two Belgian, and three German pressurized reactors.
11 A little more than 1,000 fuel assemblies have been
12 delivered by Framtome NP GMBH, formerly Siemens to 11
13 German and three Swiss PNBWRs.

14 Now, a few words about the MOX pellet
15 fabrication. Through the MIMAS process, which means
16 the micronization massive plants where you're starting
17 with UO2 powder and Pu2 powder. First, we are
18 performing a primary blend with Pu2 powder and Pu2
19 powder at a ratio that's about 20 to 30 percent of *
20 stock in UO2.

21 That primary blend is micronized with a
22 ball grinding (phonetic) to micronic size.

23 MR. POWERS: What kind of balls are you
24 micronizing?

25 MR. BLANPAIN: Please?

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1 MR. POWERS: What kind of balls are used
2 for the micronizing?

3 MR. POWERS: I think it's uranium balls.

4 So that primary blend -- also with the
5 primary blend we can recycle the scraps, and that is
6 one of the interests of this process. We can reuse
7 all of the scraps of the fabrication in the primary
8 blend.

9 So the primary blend is then mixed with
10 fresh U2 powder to constitute the secondary blend,
11 which is mechanically mixed, and then the process is
12 famous for U2 fuel pressing, centering, and different
13 dried grinding compared to U2 where we use wet
14 grinding control, and then the MOX pellets.

15 And the results is that * structure.
16 That's the fresh MOX pellets as fabricated. It is
17 micrographed after chemical etching to reveal the
18 grain boundaries. That scale is ten microns.

19 So we can hear what age of plutonium, the
20 plutonium * uranium. So you can see here are some
21 quite white, large grains that's plutonium rich
22 particles. So with plutonium enriched zone here, we
23 can see the gray, some pure uranium particles or
24 grains.

25 So it's easy to see something here that

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1 need to be more easy. And you saw the micrograph
2 after special attract or review, the plutonium
3 sustained edge chemical attack, and we can see the
4 plutonium oxide in white.

5 So that what is called plutonium enriched
6 particles, but what is important is that the plutonium
7 compound in those particles is the content of the
8 primary blend between 20 and 30 percent of Pu2.

9 You can see also that we have plutonium in
10 the U2 matrix also, and here on the right you have a
11 careful analysis of the plutonium distribution into
12 pellets. On the Y axis there is the total, percentage
13 of total plutonium in the pellets, and on the X axis
14 the particle size in micron from zero to 100 microns.

15 And this was mixed by EPNE (phonetic). So
16 we can see from that graph we have two curves because
17 two -- the * obtained with a U2, AOC U2 border or ADU
18 U2 border. There is small differences in that zone.

19 But we can say that 50 percent of the
20 total plutonium is included in particles larger than
21 eight microns. That means also that 50 percent of the
22 plutonium is included in very small particle size,
23 smaller than eight microns in this region.

24 And also it's about 25 percent of the
25 total plutonium is included in particles larger than

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1 30 microns, to give you those large particles, size 20
2 to 30 microns.

3 So that fuel is not so intelligent in
4 radiation use, but most of the plutonium is spread in
5 very small particles. And the plutonium content of
6 those particles is the content of the primary blend.
7 So it's charged through EPMA, and these are the
8 plutonium through the pellets. It will glow if
9 there's a plutonium content to plutonium rich
10 particles. That's the size of the particles, about 60
11 microns here. It's a large one.

12 So if we have zero plutonium here in the
13 U2 grain and then the particles with present content
14 of about 25 percent, which was the plutonium content
15 of the primary blend.

16 Then out of the particle there's another
17 small particle, back to the U2 metric, and then the
18 next one.

19 MR. SCOTT: You mentioned on the --

20 THE REPORTER: Could you use the
21 microphone?

22 MR. BOYACK: You can go over here.

23 MR. SCOTT: The question had to do with
24 the dimension on the bottom of the graph. Was that
25 your just arbitrary scale? It was over 100.

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1 MR. BLANPAIN: Here? Sorry. That scale,
2 it's micron.

3 MR. SCOTT: Micron.

4 MR. BLANPAIN: So it's the size of the
5 particles between -- it's roughly 40 microns.

6 So as I said, this is the MOX use in
7 Europe. So we're using MOX U in light water reactors
8 up to 1,300 megawatts electric and are using different
9 * designs. For example, for the PWRs from 14 by 14 to
10 18 by 18 array.

11 They're using in Europe different
12 neutronic design in fuel management. They're using a
13 total * content up to seven percent, enriched
14 assembly, and given to U5 enrichment to more than four
15 percent. That would be in Germany, for example.

16 Different core loading schemes are used,
17 one third annual or one fourth annual.

18 As mentioned before by Steve Nesbit,
19 recycle rate is usually 30 percent of MOX fuel
20 assemblies in the core, but 50 percent of MOX
21 assemblies in the core is licensed in Germany, but in
22 fact, with maximum use it's 38 percent.

23 We are using different U2 matrix,
24 depleted, due to natural U2, natural U2 that's
25 formally in Germany, but not used among it for the

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1 most.

2 The discharge assembly burn-up are usually
3 around 45 * and up to 54 gigawatt day * assembly was
4 reached for individual elements.

5 In France the MOX fuel can operate in
6 neutral load model without any restrictions, and so
7 the conclusion of that is no rods, no MOX rod ever
8 failed for a mox specific reasons. I mean for reasons
9 linking to the fuel itself or to the plutonium content
10 of the fuel.

11 That table shows in more details the MOX
12 used in Europe. Here is reactor type, B or PWRs, and
13 different countries, Germany, France, Belgium and
14 Switzerland.

15 The initial year of loading from 1996.
16 The total number of assemblies delivered at the end of
17 2000 and the max assembly burn-up at shields and the
18 time. This year delivered fuel assemblies reached 80
19 and 58 * in the German * water reactor. The rough
20 burn-up in the assembly was 63.

21 In France the discharge burn-up is usually
22 around 37, 40, but it is on assemblies which * 58
23 gigawatt days per *. Also in Switzerland.

24 And that is the actual situation of
25 discharge burn-up with the burn-up experience for the

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1 Fragema deliveries in Belgium, Germany, and France.
2 In blue we have France. You can see that average
3 discharge burn-up is around 37, 38 with lead
4 assemblies at higher burn-up here. That corresponds
5 to a rough burn-up of about 60 gigawatt days per ton
6 metal.

7 In Germany and Belgium the numbers are
8 quite higher, in green and yellow here. We show burn-
9 up around 43, 45.

10 That was our experience, and now some more
11 about the design and on the performance of the MOX
12 fuel. First, the mechanical design of the fuel
13 assembly structure is identical for uranium and MOX
14 fuel assemblies.

15 MR. POWERS: That suggests to me that you
16 anticipate the swelling of the fuel to be the same.

17 MR. BLANPAIN: I will show you some
18 examples.

19 I submit the design of the fuel assembly
20 first. Okay? So FOU to fuel meter variable
21 prediction of the thermal critical behavior of the
22 fuel rods. So we are making a design of the MOX fuel
23 with adequate description of the MOX specific
24 properties.

25 The design models and codes are

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1 continuously clarified by comparison with
2 measurements, and that is continuing with high burn-
3 up, and for the design code, we have for the moment
4 the same level of * as for uranium fuel.

5 In France, the current 17 by 17 fuel rod
6 design accommodate high efficient * of the MOX fuel by
7 an increase of the plenum volume and the lower area of
8 initial pressure, and that was * mainly to accommodate
9 high efficient gasoleaks (phonetic) due to the load
10 follow effect.

11 In Germany, they don't do that because
12 they have a larger plenum than the 13 by 13 designs.
13 They have two plenums.

14 So some examples of the physical
15 properties of the MOX fuel we use in all codes. The
16 thermal properties, a more important one, and the
17 specific heat of the MOX fuel compared to U2 fuel.
18 You can see U2 in the red and the MOX fuel in black
19 and blue. It's going from an open literature and
20 showing it the same tendency.

21 The larger difference between MOX and U2
22 is the thermal conductivity. The thermal conductivity
23 of the MOX fuel is a little bit lower than the U2
24 fuel. It depends, of course, on the plutonium content
25 in the pellets.

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1 Here we have the thermal conductivity of
2 temperature. The dashed line is U2 and the lower
3 using for the MOX fuel in blue. There is about a
4 difference of five percent for the six percent of
5 plutonium in the penthouse (phonetic).

6 MR. POWERS: There is something that I
7 don't quite understand when you show heat capacity as
8 a function of temperature. For a heterogeneous
9 material, surely as you get up in the upper range of
10 that temperature you have plutonium dissolving into
11 the lattice.

12 MR. BLANPAIN: Yeah.

13 MR. POWERS: And that becomes a time
14 dependent phenomena, and there must surely be some
15 sort of heat of solution that's reflected in your
16 measurements, you know.

17 MR. BLANPAIN: Yes, we have a * of
18 plutonium in the metric has a very, very high
19 temperature above lattice, 1,800 degrees. No, there's
20 no asset to that, but it was measured, I know, because
21 we have performed measurement at very high
22 temperature.

23 Finally, to the thermal expansion of fuel
24 U2, fuel U2 and mixture of * U2 with the same BA load
25 of course.

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1 Again, the fuel -- the thermal
2 conductivity and the fuel temperature. That's just
3 the reason of the experiment.

4 The final experiment is MOX and U2 rod
5 flex with a central thermocouple evaluated in the same
6 condition in the same reactor, and on the Y axis we
7 have the central comparator as a function of the
8 power. In blue we have the MOX fuel and in red the U2
9 fuel.

10 You can see that small difference, and
11 typically we have a difference of 50 degrees at 200
12 watt per centimeter, cell * temperature at beginning
13 of life.

14 Also reasons for experiment about the fuel
15 central departure, but at high level, that's a watt *,
16 50 gigawatt days per ton. It also is a rod pre-
17 irradiated in a commercial reactor and then
18 refabricated with central thermocouple and irradiated
19 in the Alden reactor.

20 Here we have the comparison. Then we have
21 the central temperature, assumption of power. The
22 experimental points are in blue here. and the * are
23 the calculations made by design code. That's the
24 percentage here and the two bounds, the upper and
25 lower limits.

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1 And that is the prediction at high burn-
2 up, and what is interesting to note is that the fuel
3 * degradation with burn-up in MOX fuel is the same as
4 for U2 fuel. It was demonstrated in the Alden
5 experiments.

6 For fission gasoline, I'm going later on
7 the resource, but that is the comparison of the
8 prediction and the measurement with COPERNIC on 56
9 commercial fuel rods irradiated to four radiation
10 cycles, typically burn-up to 50, 53. I'm show a quite
11 good prediction of the codes.

12 Now I will show you some regions from
13 partial examination of irradiated fuel. We have a
14 quite large experience feedback through surveillance
15 and analytical programs. We have about 100 commercial
16 fuel rods, to a rod burn-up of 60.

17 We have performed a lot of power ramp
18 testing and also instrumented * irradiation which have
19 been launched through a national or international
20 program to assess the particular interaction, fission
21 gas release, fuel central temperature, *
22 specification, and so on.

23 Those experiments were published in the
24 open literature.

25 But as the main reasons of those programs.

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1 So the MOX fuel has the same behavior as U2 fuel
2 concerning the fuel rod growth, the cladding variance
3 of the formation. That means the fuel swelling in
4 normal irradiation conditions. So the irradiation of
5 the fuel density is the same.

6 The cladding water wide corrosion, there
7 is no MOX effect on the cladding and no mutual
8 spectrum effect on the corrosion. As already
9 mentioned, the pellet solid swelling is the same. It
10 is quite normal because it is a cell fission
11 (phonetic) product in the same amount of fission
12 product in the U2 metrics.

13 Also with no difference concerning the
14 zirconium oxide internal layer. That's zirconium
15 oxide internal layer gross with burn-up after the
16 contact of the pellet and the cladding, and then
17 stabilized with thickness of around ten, 12 microns as
18 in high burn-up U2 fuel.

19 Roughly the fission product and activity
20 release of failed rod, of failed MOX rod is the same
21 as for U2 MOX rod. So we can see some differences in
22 the ratio of some isotopes. So that allows us to know
23 if it is a linked MOX assembly or U2 assembly, but the
24 activity release is the same.

25 And those results were published in the

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1 literature.

2 So we're seeing the somewhat high
3 efficient gasolines than U2 fuel at high burn-up.
4 That means about 40 gigawatt days per meter, leading
5 to a higher fuel rod internal pressure at the end of
6 life. I will explain that later.

7 The MOX fuel shows a better cladding
8 behavior due to the high creep property of the pellet.
9 So it is interesting for us in France because the MOX
10 fuel is automating (phonetic) versus the plant
11 maneuverability. So there is no limitation for the *
12 operation.

13 And also there is no AW release in normal
14 pressurized water reactor irradiation conditions. As
15 you know, the MOX fuel produce more radium than U2
16 fuel. This is another magnitude of difference mainly
17 due to the decay of the Curium 242.

18 Helium release was observed in non-precise
19 fuel rod, and it's also observed in boiling water
20 reactor fuel rods, but in the case of pressurized fuel
21 rod, there is no helium release because helium *
22 pressure is higher outside than inside the pellet.

23 So fission gas release data. After
24 fission gas release, at the induction of rod burn-up
25 for commercial fuel rods irradiated in EDF reactors in

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1 France. The MOX data are in red. They're compared to
2 some U2 data, whereas it is also because it's due to
3 quite high enrichment. That's in higher power than
4 the standard U2.

5 And you can see that fission of radiator
6 (phonetic) of the MOX is generally higher than for
7 U2, and mainly at high level, above 42 gigawatt days
8 per ton here.

9 What's interesting, that at high burn-up
10 this is three cycle fuel rods, annual cycles, and four
11 cycle fuel rods. There's no fission rate enhancement
12 due to the burn-up alone. It's, of course, normal
13 because the power during the four cycles is
14 decreasing.

15 We had obtained very recently new fission
16 release data after five irradiation cycles. They are
17 here.

18 And loss MOX rod while irradiated, power
19 level similar to the U2 fuel rods. So we can see that
20 they are in the U2 range.

21 Other data provides by our German
22 colleagues. Here we have the fractional fission * as
23 a fraction of the rod power during the second
24 irradiation cycle because it's the high powered cycle,
25 and there have been the open triangles, U2, and here

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1 the MOX fuel. There's data above 100 for * and
2 showing roughly the same * at relatively low burn-up.

3 At somewhat high efficient gasoline we
4 have observed in the ADS plant, is explained first
5 mainly by the neutronic properties of the MOX fuel
6 leading to the higher linear heat rate at medium and
7 high burn-up. That's the first factor.

8 I know so the MOX fuel presents a
9 different paired radial power density distribution
10 leading to the higher fuel temperature at high burn-
11 up, and that's higher power, high burn-up. It's
12 explained by the K infinity showed by Steve Nesbit
13 during his presentation.

14 So due to the physical properties, due to
15 the relatively lower thermal conductivity already
16 mentioned, what is important is the typical threshold
17 for fission gas release is the same for MOX fuel and
18 for U2 fuel that was demonstrated in different
19 experiments. These are Framatome Halden reactor
20 projects, and that tendency remains the same at high
21 burn-up.

22 Another factor we could explain high
23 efficiency gasoline is the oxide microstructure. It's
24 the presence of plutonium rich particles of 230
25 percent of Pu2 during the * process can change and

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1 make an inefficient gasoline.

2 And due to the local high burn-up zone,
3 which leads to the formation of dense pore
4 populations. I didn't go into more details about
5 that.

6 So as a result of EPMA measurements in MOX
7 fuel, mainly in the plutonium enriched particles,
8 that's a nine concentration, as I mentioned, for the
9 burn-up as a function of the average paired burn-up of
10 50, we have a local burn-up of 102, 150 gigawatt day
11 per ton of metal in the plutonium enriched particles.

12 And what is interesting also to note, it's
13 no big difference, is that it's normal between the
14 periphery with radius and the center of the pellet.
15 That's the nine. It's the difference increased
16 slightly with burn-up. It's due to the fluid
17 depression in the pellet of high burn-up.

18 Here we have a typical radial cut of a MOX
19 pellet at high burn-up. It is 50, showing the typical
20 cracked bottom as U2 fuel, but what we can see here,
21 the black spots enhanced due to the chemical etching,
22 but it is plutonium rich agglomerates.

23 And on magnification of that
24 microstructure, it shows it on the large plutonium
25 agglomerates, 20 microns. That's why it's a big one,

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1 but periphery, we have the formation in the plutonium
2 rich zones if porosities of brittles (phonetic). It's
3 like a *. At big radius, it goes out at center where
4 the temperature is higher. We have * coalescence, and
5 so we have the presence of larger pebbles, and that's
6 pretty centralized. Sometimes we have a big
7 coalescence of the purpose leading to the whole
8 surrounded by smaller porosities and metallic
9 precipitates.

10 And here we have an X-ray map of plutonium
11 and xenon in the set time of agglomerates. Here we
12 have plutonium mapping. You can see in white plutonium
13 rich zone with porosities in black. And to the right
14 side is xenon mapping. We cannot see anymore xenon in
15 the plutonium rich particle, mainly due to the cutting
16 and polishing of the pellet. So the gas escape the
17 porosities.

18 But it is interesting that we have a lot
19 of xenon around, such as in red, higher with xenon,
20 higher across red around the agglomerate, of course,
21 is due to the fission in the U2 around agglomerates.

22 Actually now also we have plutonium also
23 in -- this is quite a solid solution in the pellet,
24 but also we have xenon around due to the fission
25 spike, the * and recourse, but our high burn-up with

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1 quite a lot of xenon in the U2 matrix.

2 We have homogenization of the fuel with
3 the burn-up.

4 Also the result of EPMA analysis, but
5 through the pellets, both the pellet's periphery and
6 the pellet's center, in green here is the calculated
7 prediction of xenon, and the red spot, the measured
8 xenon. We can see a quite large expression, of
9 course, is due to the porosities because we cannot see
10 xenon porosities, but EPMA cannot see xenon in pulse
11 and bubbles, and also we have cracks in the fuel *.
12 So about half of the gas escape in the detection.
13 It's the same for U2, but particularly for the MOX
14 fuel.

15 But what is interesting, that that fuel
16 rod release -- I don't remember -- but five to six
17 percent of gas, and we have the depression of xenon in
18 the center of pellet exactly as can be seen on the U2
19 fuel. So it is the same fission gasoline mechanics.

20 Going back to the helium in the fuel, the
21 graphs show a helium balance in commercial figure of
22 MOX fuel rods, and yet here, the helium volume t the
23 permit (phonetic), and the open square here is initial
24 volumes with uncertainty on the as fabricated fuel
25 rods.

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1 And the blue squares are the final volume
2 of helium which is lower than the initial volume.
3 That means that a part of the helium was absorbed by
4 the fuel. It's well known we have exactly the same
5 reasons for U2 fuel.

6 And also after power ramping. So we have
7 an example here. The initial volume of the rod before
8 ramp testing and in green the final volume after
9 testing. So we have no helium release doing standard
10 less two power ramps.

11 And the last results about fission gas
12 release obtained for weapon grade MOX fuel. This is
13 the data from Oak Ridge, the Oak Ridge National
14 Laboratory. And those data are compared to commercial
15 data coming from Germany. It's the same data I
16 presented before.

17 The fractional release is a function of
18 average pour (phonetic) during the second irradiation
19 cycle. So we have German data, and here the data from
20 the short rods irradiated by Oak Ridge at Aidelle
21 (phonetic) with weapon grade fuel, and a quite large
22 amount of gallium, around the one ppm.

23 And here after 20 gigawatt days per ton
24 metal and sufficient gasoline resource, and after 30
25 gigawatt days per ton metal. So we have a very good

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1 correspondence with other fission data. So we can say
2 that there's no gallium effect on the fission
3 gasolines.

4 And as a conclusion of my talk and our
5 major and long-term development. So for economical
6 reasons, MOX fuel will perform as efficiently as U2
7 fuel, with the gas burn-up and * of flexibility
8 because the burn-up, the key balance to uranium fuel
9 assemblies as applied in Germany, Switzerland, and
10 Belgium. It's the maximum assembly discharge burn-up
11 around 50 gigawatt days per ton of metal.

12 In France that U2 and MOX parity will be
13 achieved near 2004 because today the maximum burn-up
14 arrived is 52, and it's due to a MOX -- 52 is the name
15 of the project.

16 The licensing process is underway. It's
17 a quite constant process because it concerns the 20
18 MOX license plans in France, and the rod burn-up will
19 be 60 in that fuel management.

20 So that we are thinking about the future,
21 that disparity must be studied on a long-term basis,
22 and the objective of EDF is to further increase the U2
23 fuel assembly discharge burn-up.

24 The next step is six days of degraded
25 pattern meter (phonetic) assembly by 2010, and

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1 research and development to prepare the future MOX
2 product is still ongoing.

3 Thank you for your attention

4 MR. BOYACK: Thank you.

5 Any questions or comments?

6 MR. POWERS: I thought it was a very nice
7 presentation, the introduction.

8 MR. BOYACK: Yes, it was.

9 There was a third presentation, and then
10 we can open it up.

11 MR. POWERS: I have to leave.

12 MR. BOYACK: You have to leave? Okay.

13 Any other questions or comments here?

14 MR. NESBIT: That's it for us.

15 MR. BOYACK: That is? Okay. Very good.
16 I just wanted to make sure I had that right. Okay.

17 Then you've escaped us without a lot of
18 questions. Again, the presentation was very nice and
19 very much appreciated.

20 MR. NESBIT: Thank you.

21 MR. BOYACK: Would you come up to the
22 microphone if you have a question? Would you come up
23 to the microphone?

24 MR. SCHAPEROW: Brent, would you like to
25 pass around the sign-up sheet again? I think there

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1 are a few more people that weren't here earlier.

2 MR. BOYACK: That would be good because I
3 didn't pass it around at all.

4 MR. SCHAPEROW: Well, I think the very
5 first day when we started the meeting you did.

6 MR. BOYACK: Yeah, okay.

7 MR. SCHAPEROW: If you could say your
8 name.

9 MR. LYMAN: Yeah, I'm Ed Lyman from the
10 Nuclear Control Institute.

11 I have questions actually for Steve
12 Nesbit, but they pertain to the presentation we just
13 saw.

14 I just want to establish for the record
15 now we saw the pellet homogeneity distribution of the
16 MIMAS fuel that's used in France, and I just want to
17 compare that to the specification which DCS has issued
18 in the dual qualification plan, and it looks to me
19 like those are not the same, and that the DCS
20 specification is less strict as far as concerning the
21 size distribution of the agglomerate.

22 So it just --

23 MR. NESBIT: Well, the purpose of our
24 presentation here wasn't to get into a detailed
25 comparison of fuel specifications and information that

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1 you may have gleaned or inferred from this
2 presentation, and I'm not going to stand up here and
3 try to respond to that question.

4 Do you have any other questions?

5 MR. LYMAN: But it's important because if
6 you're going to argue that the French data is
7 pertinent to this discussion, you want to know if the
8 parameters are the same for the two types of fuels.

9 MR. NESBIT: The specification that we're
10 using for weapons grade MOX fuel is fundamentally the
11 same as the specifications being used in Europe today
12 for reactor grade MOX fuel.

13 MR. LYMAN: But that -- well, I have the
14 specification here. It says it's 95 percent of the
15 plutonium enriched particles shall have an effective
16 diameter of less than 100 microns, and the mean of the
17 plutonium enriched particle distribution shall be less
18 than 50.

19 Now, if you look at the distribution that
20 was just shown, it shows a much smaller number, a much
21 smaller fraction as an agglomerate size of 100
22 microns. So it's --

23 MR. NESBIT: Well, but that's actual
24 results of manufacturing process versus the
25 specification. The specification provides upper

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1 limits for acceptable parameters. It doesn't provide
2 "you shall not be below this."

3 MR. LYMAN: Well, considering that
4 Westinghouse recommended back in '94 that improvements
5 be made for the U.S. MOX program, in fact, limits on
6 plutonium agglomerates should -- the average should be
7 limited to ten to 15 microns. Why don't you start
8 with the specification that's at least as good as what
9 the French are achieving and try to improve it?

10 MR. NESBIT: We're using the same
11 specification.

12 Anymore questions?

13 MR. LYMAN: Okay. The other question I
14 have is you keep maintaining that the maximum fuel
15 assembly burn-up is typical of European experience,
16 but from the graph that was shown, just by eyeballing
17 this it looks like no more than about ten percent of
18 the fuel assemblies that have been burned have burn-
19 ups greater than about 40 gigawatt days per ton.

20 And so it just looks to me like a maximum
21 burn-up of 45 is outside of the envelope of the bulk
22 of the experience.

23 MR. NESBIT: It's clearly within the
24 experience as shown by that graph, and I would further
25 add that if you were to look at uranium oxide fuel

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1 burn-ups in the United States, you'd see a similar
2 shape. b ut that doesn't mean we can't and don't take
3 uranium fuel to burn-ups of 45 or 50 or 55 gigawatt
4 days per ton.

5 MR. LYMAN: Well, but there are issues
6 associated with high burn-up MOX fuel performance that
7 may be more critical than high burn-up LEU fuel
8 performance, and so I think it's even more critical
9 that the experience be supported for the --

10 MR. NESBIT: Your opinion is noted.

11 MR. LYMAN: Okay.

12 MR. BOYACK: Okay. Thank you.

13 Let's see. If there were no other
14 comments or questions, first off, I want to thank our
15 guests for bringing in the MOX material. It was very,
16 very much appreciated.

17 What will happen, for your information, is
18 we will be meeting, if I can find the slide, we will
19 be meeting in the third and final panel meeting here
20 at the NRC February 19th to 21st, and that will be the
21 meeting that focuses on the MOX source term
22 applicability, February 19 to 21.

23 And I have you, Steve, I have you on the
24 distribution list. So you'll receive the E-mails that
25 have to do with that, but I wanted to make sure you

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1 were aware of when we meet again.

2 MR. NESBIT: Do you anticipate a desire
3 for any more participation from our team at that
4 meeting or is that yes/no or is that to be determined
5 later?

6 MR. BOYACK: Maybe I don't have the answer
7 because I basically facilitate and rather than deal
8 with the technical aspects of the meeting, but,
9 Charlie, do you have any insights as to an answer to
10 that question?

11 MR. TINKLER: Well, since that's the
12 meeting at which we will be discussing release
13 fractions, to the extent anyone has an interest in
14 hearing those deliberations I would encourage you to
15 attend, you know, if it's --

16 MR. BOYACK: And we --

17 MR. TINKLER: You know, if you think
18 you're going to have an interest in that, I would
19 encourage anyone to attend.

20 MR. NESBIT: Well, I'm sure we will. I
21 just wondered if --

22 MR. TINKLER: No. Right now I guess I
23 don't see a need for presentations as part of that.
24 Okay? All that will be panel deliberations.

25 MR. BOYACK: But we also welcome and

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1 accept the comments coming from the --

2 MR. TINKLER: Oh, sure, sure.

3 MR. BOYACK: -- the participants, too.

4 Okay. Well, very good. I think we have
5 concluded the business that I had arranged for
6 ourselves. What I will be doing is momentarily going
7 upstairs adjacent to make copies as we did yesterday
8 of the materials that we generate through the course
9 of our discussions today, and certainly if you want to
10 stay here for a few moments.

11 The other alternative is I'm going to be
12 providing these as PDF files in any case to people,
13 but we will go upstairs and make quick copies if you
14 want to stay here for a few moments, and we'll be
15 back. It takes us about 15 minutes to get them out of
16 my computer through the copying machine and back down
17 here to you.

18 PARTICIPANT: If we're leaving do we need
19 escorts or do we need to wait for you?

20 MR. BOYACK: Okay. The question was
21 whether we need escorts, and anybody that's not an NRC
22 person needs escorts.

23 MR. SCHAPEROW: It says on your badge
24 whether you do or not.

25 MR. BOYACK: With that, I will adjourn the

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1 meeting.

2 Thank you very much.

3 (Whereupon, at 2:16 p.m., the meeting in
4 the above-entitled matter was adjourned.)

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