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NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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PUBLIC MEETING

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1 UNITED STATES OF AMERICA

2 NUCLEAR REGULATORY COMMISSION

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4 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

5 ***

6 REACTOR FUELS

7 ***

8 Public Meeting

9 ***

10 Nuclear Regulatory Commission

11 Room T2-B1

12 Two White Flint North

13 11545 Rockville Pike

14 Rockville, Maryland

15

16 Wednesday, October 18, 2000

17

18 The above-entitled proceedings commenced at 8:30

19 a.m., pursuant to notice, the HONORABLE DR. THOMAS KRESS,

20 Chairman, presiding.

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1 ACRS COMMITTEE:

2

3 DR. THOMAS KRESS

4 DR. CRONENBERG

5 DR. DANA POWERS

6 DR. ROBERT SEALE

7

8

9 APPEARANCES:

10

11 MEDHAT EL-ZEFTAWY, ACRS

12 TIM COLLINS, NRR

13 GLEN KELLY

14 BOB KENNEDY

15 CHARLIE TINKLER, Office of Research

16 JASON SCHAPEROW, Office of Research

17 ROBERT PALLA, Office of Research

18 LYNN HENDRICKS, NEI

19 GORDON THOMPSON, Institute for Resources and

20 Security Studies

21 DR. ANDREW MURPHY, Office of Research

22

23

24

25

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

2 [8:30 a.m.]

3 CHAIRMAN KRESS: Will the meeting please come to
4 order. This is a meeting of the ACRS Subcommittee on
5 Reactor Fuels. I'm Tom Kress, the acting Chairman of the
6 Subcommittee.

7 ACRS members in attendance are Dr. Dana Powers and
8 Dr. Robert Seale, and we have an ACRS fellow, Gus
9 Cronenberg.

10 The purpose of this meeting is to discuss the NRC
11 staff's efforts regarding the revised technical study on
12 spent fuel pool accident risk at decommissioning nuclear
13 power plants.

14 The subcommittee will also hear the views of the
15 Nuclear Energy Institute and the Institute for Resource and
16 Security Studies representatives on this matter.

17 The subcommittee will gather information, analyze
18 relevant issues and facts, and formulate proposed positions
19 and actions as appropriate for deliberation by the full
20 committee.

21 Dr. Med El-Zeftawy is the cognizant ACRS staff
22 engineer for this meeting.

23 The rules for participation in today's meeting
24 have been announced as part of the notice of this meeting
25 previously published in the Federal Register on October the

1 4th, 2000.

2 A transcript of this meeting is being kept and
3 will be made available as stated in the Federal Register
4 notice. Therefore, it's requested that speakers first
5 identify themselves and speak with sufficient clarity and
6 volume so that they can be readily heard.

7 We have received no additional written comments or
8 requests for time to make oral statements from members of
9 the public.

10 If you'll recall, in the last subcommittee
11 meeting, I forget when it was, on this issue, and the full
12 ACRS committee meeting, we had a number of concerns about
13 the earlier draft of this accident risks at spent fuel pools
14 and these involved things like the use of the 1.174 risk
15 acceptance criteria in view of the possibly different nature
16 of the fission product source term related to ruthenium and
17 actinides, and we had difficulty with the technical basis
18 underlying the ignition temperature.

19 We had some problems with the uncertainties
20 related to atmospheric dispersion modeling and, to some
21 extent, to offset that, we had -- we noted that a bounding
22 analysis of the seismic probably should be sharpened up a
23 little bit to get rid of some of the bounding analyses.

24 And we also noted, I think, that spent fuel pools
25 are -- there's a limited number of them for decommissioning

1 plants, anyway, and that they're only going to be there for
2 a limited amount of time, and that might not be reasonable
3 risk.
4 Well, the staff did go back and sharpen their
5 pencil and killed a few rain forest trees and has come forth
6 with a new version and that's what we're going to hear about
7 today, I understand.
8 So to proceed with the meeting, I'll turn it over
9 to Mr. Tim Collins of the NRR to start us off.
10 MR. COLLINS: Thanks. I inherited this project a
11 couple months ago. I would like to acknowledge the team
12 members. Of course, there's so many of them, I'm afraid, in
13 going through the names, I'm going to leave somebody out.
14 So I'd just like to aim at the biggest players
15 since the February report. Our efforts since February have
16 been directed at addressing the comments not only of the
17 committee, but we had some other significant comments from
18 both the industry and members of the public.
19 The big players here are Jason Schaperow, from the
20 Office of Research, has done consequence analyses and he's
21 going to be making a presentation in a little while.
22 Charlie Tinkler, from the Office of Research, has
23 done some work to address the question of ignition
24 temperature. He'll be making a presentation.
25 Bob Palla did integration of the risks using

1 Jason's input. He'll be making a presentation, as well.
2 We also had important contributions from Joe
3 Staudenmeier, who did thermal hydraulic analyses. Glen
4 Kelly did frequency assessments. Goutam Bagchi did seismic
5 analyses in conjunction with Neal LaShae, from the Office of
6 Research, and we've also had assistance from Dr. Robert
7 Kennedy in the seismic aspect.
8 Dan Barrs, from the Emergency Planning Group, has
9 worked with us on assumptions regarding emergency planning.
10 And I don't want to forget Diane Jackson, who deserted the
11 cause to become a mother early on.
12 I also want to point out right at the beginning
13 here that this study is a technical input to a rulemaking
14 process. It is not a recommendation for rulemaking in and
15 of itself. It needs to be very clear. In reading the
16 report, people have pointed out to me, in reading the draft,
17 that it looks like the staff has made a final decision with
18 regard to rulemaking and it's important to understand that
19 staff has not. This draft report is, in fact, is still in
20 review, in the concurrence process, and even when it's done,
21 it is not the rulemaking decision process.
22 That process --
23 CHAIRMAN KRESS: Some other group of people will
24 make this rule.
25 MR. COLLINS: There will be a rulemaking plan

1 developed subsequent to the completion of this report and
2 that won't even be submitted to the Commission for probably
3 three or four months. But it needs to be clear that this is
4 just one technical input to -- you know, the issue of
5 emergency planning has a lot of considerations, aside from
6 just the technical inputs. Same thing with insurance
7 considerations.
8 And I want to make sure that it's clear to
9 everyone that this is the technical input to a much bigger
10 decision-making process with regard to the rulemaking.
11 As far as my presentation goes, I just plan to
12 give kind of an overview and the details will be provided by
13 Jason, Bob and Charlie. We didn't plan to go into details
14 on the thermal hydraulics of the seismic analysis, again,
15 because I think as the other fellows make their
16 presentations, you'll see the lesser significance to the
17 decision-making of those aspects.
18 But we have the people here to answer any
19 questions in those particular areas.
20 I plan to start at the February report findings
21 and go forward from there, summarize the comments that we
22 received from the committee, from the public, and from the
23 industry, what our approach was to resolving those comments.
24 I will also give you the results, as we found
25 them, and the technical conclusions.

1 That's all I need on that slide. But we need
2 slides, right? For the members. Does everybody have slides
3 in the audience? We can put them up. Let's put them up.
4 I'm actually on the February report conclusion slide at this
5 point, slide number two.
6 CHAIRMAN KRESS: When you get to these
7 conclusions, are you going to give the basis underlying
8 them?
9 MR. COLLINS: I'll summarize the basis, yes. Back
10 in February --
11 CHAIRMAN KRESS: This is the previous.
12 MR. COLLINS: This is the draft, yes. I'm back in
13 the February timeframe. That's what started on this whole
14 revision.
15 The February report, the overall conclusion was
16 that the frequency of zirconium fire at spent fuel pools
17 would be low, but the conclusion also was that the
18 consequences of an event could be comparable to a reactor
19 accident large early release.
20 Those results, the early fatality results in that
21 report were, I would say, very much at the low end of the
22 operating reactor large early release range. They were on
23 the order of units of deaths. But the societal effects were
24 more in the mix of the operating reactors.
25 In that study, we concluded that seismic events

1 dominated. That was a result of industry commitments and
2 staff design assumptions used in the analysis, which
3 basically drove the frequency of any other events so low
4 that seismic was left.
5 That report also concluded that EP could be
6 relaxed after a year and that relaxation, however, was based
7 upon the fact that you could substitute ad hoc evacuation
8 because of the slower moving events in spent fuel pools for
9 the effect of formal off-site planning.
10 We concluded in that report that security would be
11 needed as long as fuel was maintained in the pool. It would
12 always be a target for a security threat.
13 CHAIRMAN KRESS: You didn't quantify the frequency
14 of that, but you assumed that it would be high enough that
15 this was to be the conclusion.
16 MR. COLLINS: We didn't get into quantifying any
17 security considerations, right.
18 With regard to insurance, in the February report,
19 it was a very, I think, fuzzy conclusion.
20 CHAIRMAN KRESS: How do you relate the risk of
21 whether or not you need insurance?
22 MR. COLLINS: Having insurance or not having
23 insurance doesn't affect the risk. That's a policy matter.
24 I don't know how the decision is actually reached. At what
25 point do you not have to have insurance?

1 CHAIRMAN KRESS: I was fishing for how you come to
2 this conclusion anyway. The technical issues don't seem to
3 bound that too much.
4 MR. COLLINS: Well, no. This conclusion was based
5 on the historical practice of the Commission of if a
6 zirconium fire could be precluded, you could relax
7 insurance.
8 CHAIRMAN KRESS: I see.
9 MR. COLLINS: And that calculation was done
10 assuming that you had -- at what point would air cooling be
11 sufficient to preclude reaching the ignition temperature,
12 and if you could demonstrate that, then you could relax the
13 insurance.
14 CHAIRMAN KRESS: I see.
15 MR. COLLINS: And I said it was so plant-specific
16 in this analysis because the air cooling is so dependent on
17 things like the geometry factors.
18 DR. SEALE: But it's not uncommon to have premium
19 dependent on countermeasures, if you will, and if those
20 measures are judged to be effective, then, in fact, they do
21 affect risk.
22 CHAIRMAN KRESS: You're right.
23 DR. KRESS: So it's not farfetched to put a
24 connection between insurance and risk.
25 MR. COLLINS: Actually, I think the insurance

1 industry probably uses risk more than anybody else.

2 DR. SEALE: Yes.

3 MR. COLLINS: But as far as having a requirement,

4 a regulatory requirement, it's --

5 DR. SEALE: Maybe we ought to look at that

6 connection a little closer, on general principles, maybe.

7 MR. COLLINS: You could use the 2,000 hours person

8 rem type of dollar value.

9 DR. CRONENBERG: The risk study, the February

10 report was in support of possible generic rulemaking for one

11 year, exemptions for one year. Which of the last three

12 bullets is related to one year, none or is it going to be

13 plant-specific?

14 MR. COLLINS: I'm not sure I understand the

15 question.

16 DR. CRONENBERG: In the introduction to the risk

17 study, it was in support of possible generic rulemaking for

18 decommissioned plants after one year.

19 MR. COLLINS: It was actually to try to define a

20 point at which you might change the regulations. The one

21 year wasn't the target point. That was the conclusion.

22 DR. CRONENBERG: My understanding is that it was

23 more or less the target point at which the generic

24 rulemaking was done.

25 MR. COLLINS: No. The real question when the

1 study was begun was to try to define a time at which you
2 might change the regulations and one year was the conclusion
3 that we came to. At a year, you could probably relax
4 emergency planning, from a risk perspective.
5 DR. CRONENBERG: Emergency planning only.
6 MR. COLLINS: Yes.
7 DR. CRONENBERG: Not insurance.
8 MR. COLLINS: Right. Insurance, the number
9 suggested for insurance was like five years. We thought
10 that perhaps air cooling was sufficient after five years
11 decay, but the plant-specific features were so sensitive
12 that you're likely to get a plant-specific analysis.
13 DR. CRONENBERG: And the one year was based upon
14 the ten industry commitments related to emergency planning.
15 MR. COLLINS: Yes. The industry commitments drove
16 the frequency of events down, such that the risk is
17 significantly lower.
18 CHAIRMAN KRESS: Besides security, insurance and
19 emergency response, are there other areas in which
20 relaxation might be contemplated?
21 MR. COLLINS: We haven't focused on any other
22 areas. I would think that you could use the risk study as a
23 basis for insights for any of the other -- relaxation of any
24 of the other measures, and we have focused on these areas
25 only.

1 CHAIRMAN KRESS: You may have to make a judgment
2 as to whether the relaxation affects this risk study.
3 MR. COLLINS: Yes. On the February draft -- can
4 we get the next slide? I don't mean to imply that we only
5 had six comments on the draft, from this slide. We had
6 many, many more, but these are the ones which basically
7 drove the assessments that we've done.
8 The first one was that the source term may be
9 non-conservative, came from the committee. Seismic hazard
10 estimates being too conservative was a comment we received
11 from a couple of circles, the committee mentioned it and the
12 industry believed that the hazard estimates we used were too
13 conservative.
14 Received a comment on the ignition temperature may
15 be too high. Charlie, I think, is going to talk about that.
16 He's up after I am.
17 We received a comment from the public about the
18 importance of partial drain-down events.
19 CHAIRMAN KRESS: What's the nature of that
20 comment? That the partial drain-down may be actually worse
21 than having a quick drain-down?
22 MR. COLLINS: The event which results in a partial
23 drain-down basically blocks the flow path for air cooling.
24 The flow path for air cooling, you have to go down the
25 downcomer in the pool and then the air comes up through the

1 bottom.
2 If there's water level at the bottom of the fuel assemblies,
3 then you block that air flow path and you would have a more
4 rapid heat-up.
5 CHAIRMAN KRESS: And that was considered bad
6 because you --
7 MR. COLLINS: It would shorten the --
8 CHAIRMAN KRESS: -- would shorten the --
9 MR. COLLINS: Shorten the time to release, the
10 fission product release.
11 We use the term partial drain-down. I think a
12 better term may be obstructed air flow, because you could
13 have events where -- you know, in seismic events, where you
14 could have building pieces falling into the pool. The roof
15 could fall down in the pool and block the air flow, as well.
16 Even though the water may be completely drained
17 the pool, you could still have significant blockage of the
18 air flow.
19 We also had a comment, I don't remember what the
20 source was, that the results of the February report which
21 said you could relax EP at a year could actually be
22 extrapolated back to 60 days after all the iodine had
23 decayed. It basically said that the staff indicated it was
24 okay at one year, but didn't show that it was not okay at
25 earlier times, which I think was a very reasonable comment.

1 We also, the last comment here is recommendations
2 were not risk-informed. Well, that wasn't really a comment
3 on the technical report in February. That came out in
4 subsequent meetings with the industry on the rulemaking plan
5 that went up in, I don't know, the summertime at some point,
6 I believe.
7 CHAIRMAN KRESS: What did they mean by that?
8 MR. COLLINS: Well, the relaxation EP was based
9 upon substitution of ad hoc evacuation for evacuation that
10 you would get from full EP. That doesn't have anything to
11 do with risk. You just substitute one for the other. So
12 it's deterministic as opposed to a risk-informed.
13 CHAIRMAN KRESS: Yes, that's what they had in
14 mind.
15 MR. COLLINS: The other was that in the insurance
16 recommendations, it said you had to have a zero chance of a
17 fire. Well, that's hardly risk-informed, zero chance. So I
18 listed that here as a comment which we tried to address in
19 the way we went forward with the study, even though it
20 wasn't a specific comment on the report itself.
21 DR. CRONENBERG: On the partial drain-down, again,
22 the fire exemptions for the 20-odd shut-down plants had air
23 cooling as the basis for the exemption, most all of them for
24 two years, I believe, except for Maine Yankee at about 20
25 months.

1 Is this a new criteria for the next request for
2 amendment that you have to also consider partial blockage?
3 MR. COLLINS: Well, it's a consideration. I can't
4 say it's a criteria, because the whole process hasn't been
5 gone through yet, but it's certainly going to be a
6 consideration, sure.
7 The approach to addressing these comments was we
8 asked the Office of Research to do analysis, taking into
9 account available information on potential ruthenium release
10 and release of fuel fines. Those led to the source term and
11 the consequences were recalculated.
12 We met with NEI in August, a public meeting with
13 NEI to discuss their concerns with regard to seismic
14 conservatism. After that meeting, we concluded that we
15 didn't have a basis for excluding the EPRI curve and we
16 didn't have the EPRI seismic hazard estimates or the
17 Livermore seismic hazard estimates, and we also didn't have
18 a way of choosing between them, as one being the better
19 estimate than the other.
20 So we decided that --
21 CHAIRMAN KRESS: Since they're both based on
22 expert opinion.
23 MR. COLLINS: Right. Extrapolations of data by
24 experts.
25 CHAIRMAN KRESS: It's hard to figure out how much

1 weight to give each expert, is what you're saying.

2 MR. COLLINS: That's correct.

3 CHAIRMAN KRESS: You're going to have to give full

4 weight to every one of them or have some basis for --

5 MR. COLLINS: Have experts assign weight to the

6 experts.

7 CHAIRMAN KRESS: Yes. So I guess I tend to agree

8 with your slide. I thought there had been some studies that

9 sort of discounted, to some extent, the parts of the LLNL

10 curves.

11 DR. POWERS: There was an elaborate effort

12 undertaken to bring those -- two diverse interpretations

13 into some alignment.

14 CHAIRMAN KRESS: Yes, I thought there had been,

15 too.

16 MR. COLLINS: I think that resulted in the 1993

17 revision to the Livermore curves. We used the 1993

18 revisions in our analysis.

19 CHAIRMAN KRESS: I see. But they're still a

20 decade apart.

21 MR. COLLINS: Just about, yes.

22 CHAIRMAN KRESS: Okay.

23 MR. COLLINS: So we decided we were just going to

24 present the risk results using both sets of curves and see

25 how the decision-making would be affected by that.

1 CHAIRMAN KRESS: It doesn't affect the decision.

2 DR. POWERS: I guess I don't understand. They did
3 this study and they said, okay, we can bring these curves
4 together on a consistent basis. The Livermore people say,
5 okay, we'll do that, and they change their curves. But the
6 EPRI curves didn't get changed?

7 MR. COLLINS: No.

8 DR. MURPHY: Andrew Murphy, from the Research
9 staff. No. The EPRI did not get changed.

10 CHAIRMAN KRESS: That's interesting in itself,
11 because that somehow is adding weights to the experts. You
12 added more weight to the EPRI experts if you changed the --

13 DR. POWERS: Well, I think they're the same
14 experts. There's certainly an overlap in the experts.

15 The distinction between the curves, as I
16 understand it, and I'm far from an expert in this area, is
17 the way the questions were posed and the groundrules for
18 posing the questions to the experts.

19 And the resolution between the two curves that was
20 proposed by the study that was done by the former Director
21 of Research here was to realign the way you pose the
22 questions. They discussed assigning weights to experts,
23 which is, to my mind, impossible, but now they're --

24 CHAIRMAN KRESS: Did they go back with new
25 questions to the experts?

1 DR. POWERS: I don't think so. I really honestly
2 don't know what they did.
3 DR. MURPHY: Could I offer a comment on that?
4 DR. SEALE: Give your name.
5 CHAIRMAN KRESS: Name, address, phone number,
6 e-mail.
7 DR. MURPHY: Andrew Murphy, address, upstairs.
8 I'm with the Research Office, and the, quote-unquote,
9 resolution project that Bob Budnitz was the chairman on.
10 Actually, it did not turn out to be a resolution
11 project so much as a development of guidelines on how to
12 carry out a probabilistic seismic hazard study, and those
13 guidelines were published in a great big NUREG.
14 And the conclusion or the comment that was offered
15 with respect to the EPRI and the Livermore studies was that
16 both sets fulfilled the guidelines that had been set up for
17 them.
18 We had also had the two looked at by a National
19 Academy of Science committee and, again, they had offered
20 guidelines on how to carry out an appropriate or a proper
21 probabilistic seismic hazard analysis and, again, both sets
22 of curves or processes satisfied those requirements.
23 So the Commission basically has taken the position
24 that notwithstanding the differences of them, the two are
25 equally valid and, in the past, we have made use of, in

1 effect, both of them in doing things.

2 CHAIRMAN KRESS: It seems to me like instead of
3 having five experts here and five experts here, you've got
4 ten experts. Why don't you figure out how to combine the
5 two curves, have the judgment of ten different people
6 instead of five?

7 DR. MURPHY: Because there was some differences,
8 as Dr. Powers indicated, there were some differences in the
9 procedures on how the information was collected, and it
10 wasn't simply a process of adding the two up and dividing by
11 two.

12 DR. SEALE: My recollection was that the
13 difference was primarily in the assessment for the eastern
14 part of the United States, isn't that correct? That the
15 western numbers were pretty much consistent with each other.

16 DR. MURPHY: The two studies, in effect, only did
17 the eastern and central United States. They started at 105
18 or 110 west and went east from the foothills of the Rocky
19 Mountains for both studies, and some of the differences were
20 associated with the way the information about the seismic
21 sources was collected and characterized by the two groups.

22 CHAIRMAN KRESS: I think that was very helpful.

23 DR. SEALE: Someone back here wanted to comment.

24 MR. KENNEDY: Bob Kennedy. I maybe can give you a
25 little bit of clarification, because this is an issue that

1 has really concerned me over the years.

2 When you're dealing at ten-to-the-minus-four

3 annual frequency of exceedance ground motion, both the newer

4 Livermore hazard curves and the EPRI hazard curves are quite

5 similar. Now, as you start to go to lower annual

6 frequencies of exceedance than ten-to-the-minus-four and if

7 you're trying to get to risk down around

8 ten-to-the-minus-six, we have to take the hazard curves down

9 to ten-to-the-minus-six.

10 And as you start to go lower than this

11 ten-to-the-minus-four level, the EPRI hazard curves, as the

12 ground motion goes up, the probability of exceedance starts

13 to drop off rather rapidly. With the Livermore hazard

14 curves, it drops off much slower.

15 So that as you go to lower annual frequencies,

16 these two sets of hazard curves deviate further and further

17 from each other. The basic, at least one of the major basic

18 problems in trying to resolve these differences is that in

19 the central and eastern U.S., as opposed to in California,

20 we're talking the ground motion, the earthquakes that

21 dominate the risk estimates are not that big of earthquakes.

22 They really are more in the magnitude six-and-a-half and

23 less range.

24 And the risk is coming, the ground motions are

25 coming from going multiple standard deviations above the

1 best estimate ground motion, because the frequency of
2 occurrence and -- and there's ability to have reasonable
3 understanding of what the logarithmic standard deviation is
4 from some data.
5 You fit a lognormal distribution reasonably well
6 out to about one standard deviation. We don't have data
7 beyond that. We simply don't have data. And one of the
8 major sources of problems is do you think the ground motion
9 truncates at some level. I suspect everybody thinks it
10 truncates at some level.
11 There is some level that it's just not going to
12 get above. But what is that level? Is it at one standard
13 deviation? Well, I think the data would indicate that it's
14 probably not at one standard deviation, but we simply don't
15 have data to figure out where we may or may not truncate the
16 ground motions.
17 We're talking here with Livermore hazard curves
18 with a logarithmic standard deviation of .6, typically;
19 EPRI, somewhat lower. With the Livermore hazard curves, by
20 the time we get down to ten-to-the-minus-six ground motions,
21 what's really dominating the hazard estimates and thus
22 dominating the risk is ground motions three standard
23 deviations above the best estimate.
24 With a logarithmic standard deviation of .6, the
25 ground motions that are dominating the hazard estimates are

1 like six times the best estimate. Some experts think that's
2 incredible, other experts think that's perfectly credible,
3 and there is no evidence to know whether we ought to be
4 truncating these hazard curves or not truncating the hazard
5 curves. That's a judgment call.
6 With no evidence at this stage, in my judgment, no
7 possibility of gaining the evidence within the next hundred
8 years, at the least. I mean, it's going to take a long time
9 before we have enough records that we'll really know whether
10 there is a truncation -- well, I think we all know there's a
11 truncation somewhere, but where it is.
12 And so I think you're operating -- when you start
13 talking about hazard curves at ten-to-the-minus-five,
14 ten-to-the-minus-six, ten-to-the-minus-seven, you're
15 operating in a tremendous uncertainty range and if you then
16 talk about mean risk, mean risk does try to take into
17 account uncertainty and uncertainty tends to drive the mean
18 up.
19 CHAIRMAN KRESS: Thank you.
20 MR. COLLINS: Therefore, we decided to present the
21 risks using both curves.
22 CHAIRMAN KRESS: That's interesting. How will a
23 regulatory body make use of two sets of curves?
24 MR. COLLINS: Well, I think you'll see, in the
25 end, in the results, the technical recommendations aren't

1 affected either way. Using either curve, the recommendation
2 is going to be the same. So we got lucky in that case.
3 CHAIRMAN KRESS: Had you split the fence, then you
4 would have had a problem.
5 MR. COLLINS: Split the fence?
6 CHAIRMAN KRESS: One of them on one side and one
7 on the other.
8 MR. COLLINS: No.
9 CHAIRMAN KRESS: You would have had to come down
10 on the most conservative one if that had happened to you.
11 MR. COLLINS: I think, sure, from a regulatory
12 perspective, you would have to use the more conservative.
13 Sure.
14 Getting back to how we would address different
15 comments. The comment on the fact that our February report
16 might have supported a relaxation at 60 days, we asked the
17 Office of Research to do consequence calculations at much
18 earlier times. WE did calculations all the way back to, I
19 think, 30 days.
20 CHAIRMAN KRESS: On the first bullet there, how
21 did you deal with fuel fines?
22 MR. COLLINS: Jason?
23 MR. SCHAPEROW: Would you like to hear about it
24 now or do you want to wait another hour?
25 CHAIRMAN KRESS: We can wait. This is the

1 introduction. I'll wait till we get to you.

2 MR. COLLINS: To address the comment that our

3 rulemaking plan had not been risk-informed, we did a more

4 rigorous small change in risk analysis in accordance with

5 the Reg Guide 1.174 analysis, where we calculated the risk

6 with full EP in place and we calculated the risk with EP

7 relaxed. This is the discussion that Bob is going to walk

8 through. And to try to determine whether that would, in

9 fact, be a small change in risk.

10 CHAIRMAN KRESS: That, by the way, I thought was a

11 good way to finesse the question of whether the

12 one-times-ten-to-the-minus-five was the right -- you just go

13 straight to the safety goal.

14 MR. COLLINS: Yes. Right. We went right to the

15 safety goal. The one-times-ten-to-the-minus-five was, in

16 fact, a surrogate to avoid doing the calculations all the

17 way to the end.

18 CHAIRMAN KRESS: So you just throw it out.

19 MR. COLLINS: We just throw it out. We don't

20 really use it much anymore, the ten-to-the-minus-five value.

21 We just went right to the safety goal.

22 CHAIRMAN KRESS: I thought that was a good idea.

23 MR. COLLINS: It's more direct. No more inference

24 there. It's the safety goal and there's the QHO.

25 CHAIRMAN KRESS: What that does to you is drag in

1 all the uncertainties associated with atmospheric transport
2 and consequence. But they're there anyway in the 1.174.
3 MR. COLLINS: With regard to the obstructed flow
4 cases, we looked at the different sequences that were
5 important to risk and tried to decide is it likely that you,
6 in fact, would have obstructed flow, the most important
7 cases being the seismic event and the cask drop. In those
8 cases, you don't know what the geometry is going to be when
9 you're done and there's no reason -- actually, we think it's
10 more likely than not that you're going to have obstructed
11 flow. So that turned out to be an important consideration
12 with regard to the insurance question.
13 The impact of the lower temperature criterion was
14 also examined. We did more than just look at the impact of
15 lower temperature criterion. We looked at what might be the
16 right criterion. That's what Charlie Tinkler is going to
17 talk about.
18 In the end, it turns out that it doesn't have a
19 big effect on the recommendations. The heat-up times that
20 we used in the analysis, especially at the early times, are
21 so short that having a shorter or lower temperature
22 criterion is not going to make any difference anyway.
23 CHAIRMAN KRESS: It doesn't affect the time you
24 have to do action.
25 MR. COLLINS: Right. So it turns out to be not --

1 CHAIRMAN KRESS: I was assuming it might affect
2 this time at which you can assume there's no longer any
3 risk, and that was the one I was thinking it would affect.
4 MR. COLLINS: That question is dominated by the
5 uncertainty in the geometry.
6 CHAIRMAN KRESS: The uncertainty in the geometry.
7 MR. COLLINS: You just can't constrain the problem
8 sufficiently.
9 CHAIRMAN KRESS: It just sort of finesses that
10 whole question of temperature.
11 MR. COLLINS: But we've got Charlie to make a nice
12 presentation on what the criterion might be. So use it as
13 much as you want.
14 CHAIRMAN KRESS: In case we need it for something
15 else.
16 MR. COLLINS: Well, we could skip that, if you'd
17 like.
18 CHAIRMAN KRESS: No. I want to hear it.
19 MR. COLLINS: But he did that work and it was your
20 question, so we thought we'd prepare it.
21 CHAIRMAN KRESS: I want to hear anything Charlie
22 has to say.
23 DR. CRONENBERG: On the question of flow blockage,
24 it sounds like you're coming to the conclusion that flow
25 partial blockage is really of concern and wasn't in the

1 prior exemptions.

2 What does that say for the prior exemptions?

3 MR. COLLINS: Well, recognize that the risk is low

4 even in the prior exemptions, and this question addresses

5 insurance. So it doesn't affect the risk in any way. It

6 gets back to the who's liable in the end for an accident.

7 So the liability was basically transferred to the

8 government by relaxing those insurance requirements based on

9 those exemptions.

10 Now, this raises the question of, well, maybe we

11 shouldn't be transferring that if you can't -- the criterion

12 -- I'm sorry. The criterion was that you had no chance of a

13 fire, but that presumed that you had air cooling.

14 Now, if you maintain the criterion that you have

15 to show no chance of a fire, why, you could never relax

16 insurance, because, I mean, the fact of the matter is,

17 where's your meteor insurance? So you could preclude the

18 zirconium fire. A meteor comes in and splashes in the pool

19 and could cause damage, but it's a ten-to-the-minus-tenth

20 event. You can't make it zero.

21 So the risk is not affected by those previous

22 decisions. It's a matter of the liability was transferred

23 and, well, was that the right thing to --

24 DR. CRONENBERG: The basis for the decision is

25 quite different. On one, the basis was that you didn't

1 reach ignition temperature under air cooling conditions.

2 MR. COLLINS: That's correct.

3 DR. CRONENBERG: Now you're having a different

4 basis. You're saying you don't have air cooling, you have

5 blockage.

6 MR. COLLINS: That's correct.

7 DR. CRONENBERG: So your technical basis

8 underlying that decision is different.

9 MR. COLLINS: Yes, agreed. Agreed. In the past,

10 we did not consider flow blockage, that's correct.

11 Results. Jason will walk through all the details

12 on the consequence analysis, but the result basically came

13 out when we took account, a large ruthenium release

14 fraction, we used, I believe, 75 percent for release

15 fraction for ruthenium and, I believe, a generous fuel fines

16 fraction, as well.

17 The early fatality risk increased and the

18 long-term risk increased, but not so markedly that you would

19 say it was in excess of a LERF or it didn't exceed the

20 results reported in NUREG-1150 for operating reactors.

21 So the consequences got worse, as expected, but

22 not so bad that you would change criteria based on them.

23 CHAIRMAN KRESS: I guess I'll wait till Jason gets

24 up before I ask my question.

25 DR. POWERS: It didn't exceed the bounds defined

1 in 1150?

2 MR. COLLINS: It didn't exceed the consequences

3 for events in NUREG-1150, yes, calculated results in

4 NUREG-1150.

5 DR. POWERS: Most of those severe accidents

6 resulted in less than one prompt fatality.

7 MR. COLLINS: No. One of the events, I think, had

8 400 fatalities.

9 DR. POWERS: I said most of those events resulted

10 in less than one fatality. Is that or is that not correct?

11 MR. PALLA: The higher likelihood events would

12 have the lower consequences. What we looked at was the full

13 span of events, source terms, if you will, that were

14 evaluated in the several reference plants and we contrasted

15 the worst source term, the consequences for the worst source

16 term in 1150 to the consequences from the spent fuel pool

17 accident.

18 DR. POWERS: So the average spent fuel was

19 compared to the worst of the --

20 MR. PALLA: Well, I'm not so sure that I'd say

21 what we did for spent fuel pool was average. I think what

22 we did there might be characterized as an upper bound or at

23 least a very conservative estimate.

24 DR. POWERS: I thought our intent was to get a

25 best estimate here.

1 MR. SCHAPEROW: We have a case which you might
2 call a best estimate and we have a case which you might
3 consider conservative for the large ruthenium release.
4 DR. POWERS: Well, not when I consider the large
5 ruthenium release the best estimate.
6 MR. SCHAPEROW: Potential for rubbling and --
7 DR. POWERS: I saw that comment in the report, to
8 the effect that -- I mean, it's just a comment. There's no
9 reference, there's no citation, there's no data. It says
10 rubblization of the fuel might well reduce the source term.
11 Where did that come from?
12 MR. SCHAPEROW: I think there's some evidence that
13 once the fuel exceeds a certain temperature, the number
14 cited by Sandia, I think, was about 2,500K, that it can
15 reduce the --
16 DR. POWERS: If it exceeds 2,500K, it's molten.
17 MR. SCHAPEROW: I mean, those high temperatures,
18 it can collapse a little bit on itself and form a rubble bed
19 and air won't be able to get in.
20 DR. POWERS: Clad fuel that's at 2,500 degrees K
21 is headed down by candling. Not rubblization, this is
22 candling.
23 CHAIRMAN KRESS: And, of course, this is steam
24 that that data comes from. I don't know what happens at --
25 DR. POWERS: The melting -- the phase

1 relationships between clad and fuel, most of it's been
2 developed in experiments in furnaces that have neither steam
3 nor air in it.
4 CHAIRMAN KRESS: That's right. The question is if
5 the clad is -- how much of the clad is oxidized to stop this
6 rubblization or would it --
7 DR. POWERS: Rubblization is not the issue at
8 those kinds of temperatures. How can it be an issue? It's
9 cindering together like crazy at those temperatures, I mean,
10 if it's not melting.
11 CHAIRMAN KRESS: I don't know what it's doing at
12 those temperatures in our environment of fire, to tell you
13 the truth, because I have no data.
14 DR. POWERS: Yes, it's kind of challenging there.
15 CHAIRMAN KRESS: Yes.
16 DR. POWERS: But it still begs the question of why
17 does that reduce the source term. There's no references, no
18 data, there's just -- it's just an offhand comment. I mean,
19 there must have been some reason to write it. It's not a
20 figment of your imagination. Maybe it is a figment of your
21 imagination.
22 MR. SCHAPEROW: You're right, there is no data and
23 we re-ran both cases.
24 DR. POWERS: Ultimately, this discussion came down
25 to what is the best estimate, large ruthenium release or

1 small ruthenium release.

2 MR. COLLINS: That question is very difficult.

3 The amount of data is so sparse, that I think you can make

4 arguments both ways, that a large ruthenium release is the

5 more realistic case.

6 DR. POWERS: So you're just choosing to make the

7 argument that the large ruthenium release is the bounding

8 case.

9 MR. COLLINS: I'm saying that for the purposes of

10 our decision-making, if we use a large ruthenium release,

11 very large, and if we can still make our decisions using

12 that, that's good enough for the decision-making.

13 CHAIRMAN KRESS: How did you do it with fuel

14 fines? Since we're on the subject.

15 MR. SCHAPEROW: We went back to the Chernobyl

16 accident. We found an estimate there in an NEA report, I

17 believe it was, of three and a half percent. So that's what

18 we used for our fuel fines estimate.

19 CHAIRMAN KRESS: Three and a half percent.

20 DR. POWERS: I think the three and a half percent

21 came from the prompt detonations that occurred at the very

22 beginning of the accident. I mean, I don't think I would

23 attribute them to this -- I mean, there's no explosion here,

24 right? You're not hypothesizing explosion.

25 MR. SCHAPEROW: That's correct.

1 DR. POWERS: I guess there could be one, but
2 you've not hypothesized one. There's no steam explosion
3 phenomenon here. Why would that three and a half percent be
4 a useful number?
5 MR. SCHAPEROW: I'll go and check. My
6 recollection was that was the entire fuel fines release from
7 the explosion and the fire.
8 DR. POWERS: The fact is that within the sarcophagus of the
9 Chernobyl plant is now covered with fine brown dust
10 everywhere, several inches thick, in some cases. That
11 didn't come from anything early in the accident. It's
12 coming from the decay of the fuel in air and decrepitation
13 of the fuel in the air.
14 Why wouldn't you take that number for these
15 things?
16 MR. SCHAPEROW: I'm not sure I understand what you
17 said.
18 DR. POWERS: Everywhere within the sarcophagus now,
19 everywhere, there's a fine brown dust. It's a miraculous
20 dust. I mean, it wafts up in the air with small air
21 currents. In some cases, those dust layers are inches thick
22 and it has come from the steady decrepitation of the fuel as
23 it sits there in air within the sarcophagus.
24 MR. SCHAPEROW: It hasn't gotten out.
25 DR. POWERS: Well, it gets out pretty regularly,

1 as a matter of fact. The sarcophagus is hardly leak-tight.
2 That's why they're planning to build a second sarcophagus
3 over this thing. They're getting a continuous release.
4 CHAIRMAN KRESS: Over and above the value you
5 chose, three and a half percent, what did you do with that
6 number? Did you apply it to actinides and plutonium?
7 MR. SCHAPEROW: The last two groups, the
8 lanthanides and the cerium group.
9 CHAIRMAN KRESS: You assumed the consequences of
10 those were the same as the other actinides, as the
11 actinides.
12 MR. SCHAPEROW: That's correct.
13 CHAIRMAN KRESS: Even though the concentrations of
14 actinides are probably much higher.
15 Did you have an inventory of actinides that you
16 applied the decrepitation number to?
17 MR. SCHAPEROW: Yes, the inventory in the fuel.
18 CHAIRMAN KRESS: Okay. Did you include the
19 plutonium in that?
20 MR. SCHAPEROW: Yes.
21 CHAIRMAN KRESS: When you calculated the
22 consequences, was one of them the area of essentially
23 permanent land interdiction?
24 MR. SCHAPEROW: No, we did not. It was certainly
25 included in the calculated results, but we did not assess

1 that in the part of this effort.

2 CHAIRMAN KRESS: Should that not be a concern?

3 MR. COLLINS: It would be a factor in insurance

4 considerations. But even just doing the societal dose, the

5 person rem, gives you an indication of whether you've got a

6 significant --

7 CHAIRMAN KRESS: It gives you some indication of

8 that.

9 MR. COLLINS: Right, a significant liability or

10 not.

11 DR. POWERS: I guess I don't know how it does

12 that. There's a proportionality that escapes me here.

13 You've got people here. You evacuate them, so that only the

14 residual people -- some fraction of the people just don't

15 evacuate. That's how the evacuation levels are set up.

16 So you're basically calculating the dose to those

17 residual people, aren't you?

18 MR. COLLINS: But if that dose is significant to

19 the land that they're coming back to and living on, had to

20 receive a significant cesium deposit, so the land is going

21 to be in trouble. Cesium is not going to --

22 CHAIRMAN KRESS: But you sort of translate that

23 back into the number of people and how they're distributed

24 to actually get a rem. I'm not sure you could do that very

25 straightforward.

1 DR. POWERS: It's a little more challenging
2 calculation than I can make on the back of the envelope
3 here.
4 CHAIRMAN KRESS: But you directly out of the MAACS
5 codes and land interdiction. It would be interesting to see
6 some of those results. It seems like that's more than just
7 insurance. That's a societal insult that ought to be part
8 of the concern, I would think.
9 MR. COLLINS: Well, that was suggested to the
10 Commission in a paper recently, that that be added to the
11 safety goals, and they said no.
12 CHAIRMAN KRESS: Well, I don't think we're exactly
13 constrained to stick strictly to the safety goals in this,
14 are we?
15 MR. COLLINS: Well, I'm constrained by time in the
16 schedules and direction. There's a lot we could study in
17 this.
18 CHAIRMAN KRESS: I could understand that
19 constraint, yes. Okay.
20 DR. CRONENBERG: How many plants do you expect
21 within the next ten or 15 years for additional requests for
22 relief from insurance and emergency planning for new
23 decommissioning plants? Are we talking ten, another ten or
24 so?
25 MR. COLLINS: I think it's probably less than

1 five. Bill?

2 MR. HUFFMAN: Yes. I'm Bill Huffman, in the

3 decommissioning section. The response is short. It's that

4 we don't see any in the near future, in the next five-year

5 timeframe. It's hard to predict how electrical deregulation

6 is going to play out, what impact that will have. But I

7 would say in the short term, we don't see any.

8 DR. CRONENBERG: The reaction is already past us.

9 MR. COLLINS: Or well in the future.

10 DR. CRONENBERG: Thank you.

11 MR. COLLINS: When we use the EPRI hazard curve,

12 it turns out that the total risk gets reduced by about a

13 factor of four. Even though the curves are about a factor

14 of ten apart, when you use the lower seismic contribution,

15 then other contributors add back in again, like the cask

16 drop event is a contribution about the same as the EPRI

17 hazard and then there's like another contribution from all

18 other events.

19 So, in fact, the net effect is a factor of four

20 when you use the EPRI hazard curve as opposed to the

21 Livermore curve.

22 My second results slide. Okay. Our results and

23 our findings when we applied the small change question to

24 the relaxation of EP, we found that the risk, in fact, would

25 be a small change, whether you had formal off-site planning

1 or you relaxed off-site planning.

2 There's still on-site emergency programs. There's

3 still an on-site program to assure off-site notification,

4 prompt off-site notification and characterization of

5 releases.

6 CHAIRMAN KRESS: Let me ask you a question. One

7 part in the report that I was scanning through and read

8 indicated that under earthquake like conditions, your

9 emergency response wouldn't be very effective, so you have

10 to change the assumptions in the MAACS code as to how you

11 deal with how good it does.

12 Is this conclusion, the 60 days, based on the fact

13 that the emergency response wasn't very effective anyway?

14 MR. COLLINS: Yes, absolutely. Absolutely. Bob

15 is going to walk through that in detail. Yes, very, very

16 dependent upon that. We had a reason for each sequence,

17 whether evacuation was going to be effective or not, and it

18 had to do with the time that you had from the uncovery of

19 the fuel and the severity of the event itself.

20 So Bob is going to go through that sequence by

21 sequence for you.

22 Another conclusion which we've already talked

23 about was the effect of the obstructed air flow. Basically,

24 it raises a significant question with regard to the

25 assumption of air cooling for insurance considerations. We

1 don't think that the air cooling assumption is a supportable
2 assumption.
3 And the temperature criterion --
4 CHAIRMAN KRESS: So how do you decide then when
5 and if you can relax those insurance requirements?
6 MR. COLLINS: That's going to be the big problem
7 for the rulemaking plan. This is real technical input, so
8 --
9 CHAIRMAN KRESS: Let them worry about it now,
10 okay.
11 MR. COLLINS: That's the next step. The technical
12 report said this is an assumption that's not valid.
13 CHAIRMAN KRESS: Okay.
14 MR. COLLINS: So somewhere, somebody's got to make
15 a decision at what point do you no longer need insurance,
16 and we can say the risks are low, how low do they have to
17 be, there's other considerations, I guess, that insurance
18 people take into account.
19 CHAIRMAN KRESS: You didn't actually come out with
20 a probability.
21 MR. COLLINS: No.
22 CHAIRMAN KRESS: Which is what they will need, if
23 they're going to go that route.
24 MR. COLLINS: Well, we can show them where the
25 risk is. We have included probabilities.

1 CHAIRMAN KRESS: Okay.

2 MR. COLLINS: But we can't drive it to zero, like
3 was implied in 93-127, that the fire chance was zero.

4 CHAIRMAN KRESS: But we will buy off on relaxing
5 the insurance if the frequency, this fire probability
6 frequency is this number. They'll be able to extract it
7 from the study.

8 MR. COLLINS: I'm sorry.

9 CHAIRMAN KRESS: If someone came up with an
10 acceptance criteria that said we will relax the insurance
11 requirements if the frequency of the fire is below this
12 magic number we pick out of the air some way, will they be
13 able to extract the time at which it's below that number out
14 of the study or will they have to do something more?

15 MR. COLLINS: I think they could probably get it
16 from the study.

17 MR. KELLY: This is Glen Kelly, with the staff.
18 The dominant contributor to risk is the seismic event and we
19 have identified the values for the nominal or the plant that
20 represents kind of the mean of all of the plants, and we've
21 also discussed those plants where they're towards the upper
22 bound.

23 We have indicated that the western plants and
24 potentially one site east of the Rocky Mountains would need
25 to do plant-specific analyses to determine whether they have

1 any potential vulnerabilities in the spent fuel pool area.
2 The actual risk associated with the seismic
3 aspects of the plant, a seismic ground motion, would be site
4 specific. We have not identified the numbers in the report
5 for each site east of the Rockies.
6 That information is available, but that was not
7 provided here, because this was a generic rulemaking thing
8 and we're showing generically how things were working.
9 CHAIRMAN KRESS: That would be a plant specific
10 determination when the time comes.
11 MR. KELLY: That's correct.
12 DR. CRONENBERG: If not accepting air cooling,
13 what are you going to do about, say, Haddam Neck or
14 something that already accepted that as the basis for the
15 insurance, relief from insurance indemnification? That's
16 not been closed for five years.
17 MR. KELLY: The issue about the insurance
18 indemnification is not that there isn't any insurance. The
19 Federal Government is providing the insurance in this
20 particular case. It may be that, in retrospect, if we had
21 had the information five years ago that we have today, that
22 we might have made a different decision, but the people
23 still in the area around there still have insurance which
24 would be provided by the Federal Government.
25 DR. CRONENBERG: So there's no going back to the

1 old request for exemptions. They're done and that's it.
2 MR. KELLY: The Commission, I suppose, if it
3 chose, could consider a backfit, but it would probably be
4 very difficult to justify.
5 MR. COLLINS: So the conclusions that are in this
6 round of the report are that the risk at the decommissioning
7 plants is very low, even with consideration of a source term
8 which includes things like a significant ruthenium release.
9 We found that a small change in risk results from
10 a relaxation of EP, even as short as 60 days after shutdown.
11 The insurance criterion would need revisited for a
12 relaxation in the future, and there's no change to the
13 security recommendation that was made in the February
14 report; that is, as long as you've got the fuel in the pool,
15 you're going to have to have some measure of security.
16 CHAIRMAN KRESS: That's because cesium, plutonium,
17 ruthenium and strontium stay in there a long time, don't
18 they?
19 MR. COLLINS: The cesium has got a 30-year
20 half-life. The other long-lived half -- there's 30 years
21 worth of fuel in that pool and it only goes -- even the
22 cesium just goes down by a factor of two every 30 years.
23 DR. CRONENBERG: It's a little hard for me to look
24 at emergency planning and insurance as drastically different
25 things. In one case, you're saying it looks like it's going

1 to be okay to reduce emergency planning for 60 -- in 60
2 days, but that you can't -- insurance may not be relaxed and
3 probably the two years for prior exemptions, the technical
4 basis of air cooling may not have been the right technical
5 basis to judge that.
6 I don't see emergency planning and insurance as
7 all that different. You're still trying to protect the
8 public from something. Emergency planning is -- it's a
9 different type of emergency planning. That's all. You're
10 not -- it's basically where all this is coming to.
11 MR. COLLINS: Well, emergency planning can have a
12 direct impact on risk. Insurance can't. Insurance is who
13 pays in the end, who is liable, but emergency planning could
14 have an effect on risk and there's a difference there.
15 The assessment on emergency planning is a change
16 in risk. Is the change in risk small if you relax emergency
17 planning? Regardless of what you do on insurance, you don't
18 change the risk. You just change the person or the entity
19 liable for damages. So they are different questions.
20 DR. CRONENBERG: So it gets down to this is what
21 the emergency plans are now and this is what the relief is
22 going to be and these are the changes in that sort of
23 planning and that's how we estimate the change in risk.
24 MR. COLLINS: I wouldn't venture to guess how the
25 Commission is going to decide on this. We made assumptions

1 as to what the changes might be and based on those potential
2 changes, we estimated what the change in risk might be, but
3 there's a lot of factors, I think, involved in emergency
4 planning which have to be considered in the actual
5 rulemaking.
6 So I wouldn't want to say that this changes are
7 going to result. All I'm saying is that it's a small change
8 in risk if you change certain things.
9 CHAIRMAN KRESS: But your basic conclusion is,
10 from this technical study, it would support only possible
11 relaxation of the emergency planning.
12 MR. COLLINS: Yes, that's right. I think that's
13 correct. I think I would characterize it, the risk change
14 shouldn't be an impediment to consideration. But other
15 factors. I mean, when emergency planning was put in place
16 years ago, it wasn't because there was a high risk that was
17 going to be offset. There were other considerations
18 involved in that decision and those same considerations are
19 likely to drive the decision down.
20 We're just providing our input for the
21 decision-makers.
22 CHAIRMAN KRESS: So Charlie is going to tell us
23 what the real ignition temperature ought to be.
24 MR. TINKLER: Charles Tinkler, from the Office of
25 Research. Basically, I'm here this morning to talk or to

1 respond to a number of comments and questions received on
2 the draft technical study, and most of the text in the final
3 report that related to this discussion is in Appendix A1-B.
4 So we'll talk about various phenomena and assorted
5 complications in determining what appropriate acceptance
6 criteria are.
7 Before I do that, since I'm here and I get an
8 opportunity, I'll give my two cents on rubbling. It's true
9 that there is not data that clearly demonstrates the effect
10 of the change in geometry on the fission product release,
11 but it's been postulated that debris beds more reluctantly
12 give up their fission products than a core geometry, which
13 is an optimal geometry for heat transfer and release of
14 fission products diffusing through the fuel.
15 But coupled with the fact that many of our
16 scenarios are very high seismic events or where you drop a
17 cask on top of this thing, it's reasonable to, I think,
18 judge that you could get some decrease in the fission
19 product release or, at a minimum, the release rate. And in
20 our calculations, we released these fission products quite
21 quickly.
22 So with respect to Chernobyl, we note that we
23 typically assume like a 75 percent release of cesium.
24 Chernobyl didn't release 75 percent of cesium. It's not the
25 same accident. They've had a long time to sit there and

1 release stuff. I mean, if they -- and I guess if they
2 continue to see decrepitation of fuel and release over very,
3 very long periods of time, I guess I'd say that in our
4 general estimation, even though we don't take credit for
5 corrective actions in the risk results, one could reasonably
6 presume that years later we'd take some corrective action.
7 It might not take years either. So those are
8 judgments, but we think that they have some validity. They
9 would push the number smaller than 100 percent release,
10 that's clear. Whether they push them much below 75 all the
11 way down to 20 or 30 or 40, that could reasonably be
12 disputed hotly until data is available.
13 CHAIRMAN KRESS: With respect to the Chernobyl
14 decrepitation, wouldn't it be reasonable to apply some sort
15 of a uranius relationship to that than presume that at the
16 high temperatures you have in the spent fuel pool compared
17 to what theirs show, you really shorten that time.
18 MR. TINKLER: Yes.
19 CHAIRMAN KRESS: It's not a long time --
20 MR. TINKLER: Yes. Yes.
21 CHAIRMAN KRESS: It would be a short time effect
22 in the pool.
23 MR. TINKLER: That's true.
24 DR. POWERS: Why would you do that, when you have
25 an elaborate data set collected by the Japanese on

1 decrepitation of urania?

2 CHAIRMAN KRESS: Yes. That's what I would turn to

3 first. I wouldn't fool with the Chernobyl.

4 DR. POWERS: Similarly, if you're going to argue

5 that rubble beds trap fission products, why wouldn't you

6 turn to the model that Ken Lee at Battelle Columbus set up

7 on fission product impaction in sand piles? I mean, this

8 dedicated avoidance of the data that's in the literature

9 that pervades this report I find remarkable.

10 CHAIRMAN KRESS: I think they suffer from the

11 problem of all of this is tied to the flow of air through

12 the rubble and that one is the hard one to come by, because

13 that's a geometry-dependent thing.

14 I would have trouble getting an air flow myself.

15 So I'd have to come down on some sort of very conservative

16 assumption on that.

17 MR. TINKLER: That's where we ended up on a number

18 of positions, frankly, because of --

19 CHAIRMAN KRESS: My conservative assumption there

20 would be that the air flow would be the best you could get

21 in this geometry and I wouldn't assume much of a

22 constriction due to the rubblization, because I don't know

23 what it does to it.

24 MR. TINKLER: Past evaluations of spent fuel pool

25 accidents have used temperature criteria of somewhere

1 between eight and 900 degrees C. They've identified the
2 temperature criteria as one for a self-sustaining oxidation
3 of the cladding. Alternatively, we've called it an auto
4 ignition temperature and ignition temperature, temperature
5 for oxidation escalation.
6 CHAIRMAN KRESS: Charlie, where did this number
7 come from?
8 MR. TINKLER: Well, historically, we thought -- I
9 think if you go back to the earlier studies of spent fuel
10 pool accidents, it was deemed to be the temperature at which
11 the oxidation -- the oxidation transient took off in air and
12 where the chemical energy was --
13 CHAIRMAN KRESS: But based on, what, CATHCART?
14 MR. TINKLER: No. They were based on the
15 correlations that were available from isothermal tests.
16 They took date from Evans and the fuels people have studied
17 --
18 CHAIRMAN KRESS: That was using virgin pure
19 zirconium.
20 MR. TINKLER: Many of those tests were fresh,
21 clean clad.
22 CHAIRMAN KRESS: Yes.
23 MR. TINKLER: Okay.
24 CHAIRMAN KRESS: Okay.
25 MR. TINKLER: But that's a complication in all

1 these estimates of where ignition occurs. The extent and
2 effect of pre-oxidation. Pre-oxidation, in this case, is
3 probably good for you. I can't prove that, but --
4 CHAIRMAN KRESS: Pre-oxidation with accompanying
5 hydrodization.
6 MR. TINKLER: That's right. There's a tradeoff of
7 hydriding, pre-oxidation. We still don't know what the
8 effect of the nitride layer under a heavy oxide layer is in
9 these kinds of environments. I concede that.
10 But in general, if you just look at the effect of
11 pre-oxidation, it slows down the chemical and energy,
12 because you've got a thicker oxide layer to go through.
13 They see that as --
14 CHAIRMAN KRESS: Unless you get this strange thing
15 called breakaway oxidation.
16 MR. TINKLER: Right. We've got breakaway
17 oxidation, we've got runaway oxidation, we've got oxidation,
18 we've got all kinds of terms for this, but, basically, we're
19 talking about the point at which the fuel is starting to
20 begin to heat rapidly.
21 In severe fuel damage tests, K heat is on the
22 order of AF to one degree K per second. That's reactor
23 decay heat. Decay heats are lower. When you get to the
24 oxidation escalation phase, we're talking about tens of
25 degrees K per second. So it's a rapid increase.

1 We acknowledge that these things are all dependent
2 on system conditions, physical configuration.
3 CHAIRMAN KRESS: In the reactor core accidents,
4 I'm used to numbers like 40 and 50 degrees K per second
5 during the rapid oxidation part. Since the air-nitrogen
6 energetics are higher, why wouldn't I expect that those kind
7 of temperature ramps in the spent fuel pool accident of like
8 40 and 50 K per second?
9 MR. TINKLER: You could.
10 CHAIRMAN KRESS: Okay.
11 MR. TINKLER: You could. Once the chemical --
12 CHAIRMAN KRESS: When you say tens, you included
13 that.
14 MR. TINKLER: Yes. When I say tens of K, I -- and
15 it could be higher. I mean, the -- I've got a couple curves
16 here that show the heat of reaction is higher in air, but
17 the reaction rate is higher, too.
18 So the total heat generation rate at the same
19 temperature for the same oxide layer, using parabolic rate
20 equations, with a factor order of magnitude higher.
21 CHAIRMAN KRESS: Yes.
22 MR. TINKLER: Okay. So there's no reason why you
23 wouldn't think that, but that can also be offset by the
24 effect of the oxidation. It can knock that order of
25 magnitude back.

1 CHAIRMAN KRESS: It could very well.

2 MR. TINKLER: Practically speaking, in the draft
3 of that study, they use these temperature criteria in two
4 ways; one, to signal the onset of significant fuel pool
5 fission product release for evaluating the time for ad hoc
6 evacuation -- ad hoc evacuation -- unevaluated -- although
7 the committee thought it was an ad hoc evaluation.

8 We also used it to determine the decay heat level
9 and corresponding time, what we called the critical decay
10 time, which an equilibrium temperature could be maintained,
11 precluding a large release, and this also attracted a fair
12 amount of attention.

13 That means, in effect, we said you could sit there
14 at 800 degrees C for a long, long time and not see any
15 fission product release. So we've reevaluated that, also.
16 But basically what we did, we tried to look at information
17 on zirconium reaction kinetics, looked at the issue of
18 hydriding and auto ignition.

19 We looked at what insights you might draw from the
20 greater body of data from severe accident fuel damage tests.
21 When we first talked to the people that do fuels testing on
22 cladding, they run these tests in an isothermal condition,
23 they say what temperature escalation, we don't get any
24 temperature escalation, but we run our tests isothermally.

25 So we try to convince them that every single

1 severe fuel damage test does indeed product temperature
2 escalation; maybe not every one, but most of them.
3 There is also the issue of the fission product
4 release data, especially the release of ruthenium at quite
5 low temperatures in oxidized fuel, preferably U-308.
6 The committee also raised a number of questions
7 about materials interactions. We tried to address that.
8 I didn't mean to exclude anybody that's run tests,
9 but these are the ones we've primarily focused on. We
10 focused heavily on the CODEX tests, because they're some of
11 the few transient air oxidation data around.
12 It's actually the CODEX data that has attracted a
13 fair amount of attention, because during the preconditioning
14 phase of the test, they reported uncontrolled temperature
15 escalation, and they say it occurred somewhere a little
16 above 900 to 950 degrees C, but they don't say how much
17 above and it's kind of hard to see from the data exactly,
18 but they generally suggested that if you wanted to control
19 your preconditioning of the cladding, stay below 900 C.
20 Now, they started out with fresh, fresh cladding.
21 But there's also evidence from CORA and QUENCH and PHEBUS.
22 Now, those are primarily steam tests, almost exclusively
23 steam tests, but we see in most of these steam tests a
24 temperature escalation occurring at around 1,200.
25 PHEBUS FBT1 saw a temperature escalation of 1,300

1 C. QUENCH reports temperature escalations between 12 to
2 1,300 C, all the way up to about 1,600 C, depending on the
3 oxidation.
4 So what we did, just to see kind of a sanity check
5 on the CODEX data, was to look at heat generation rates,
6 because we surmise that at roughly equivalent heat
7 generation rates, you could get a temperature escalation.
8 So we plotted up heat generation rates using
9 correlations.
10 CHAIRMAN KRESS: If the heat losses are
11 two-to-the-fourth, they wouldn't exactly be true.
12 MR. TINKLER: This is a first order kind of
13 comparison.
14 CHAIRMAN KRESS: That's a good way to look at it.
15 MR. TINKLER: If you look at here at 1,200 degrees
16 C on team, then you go over -- that's not very straight, but
17 -- and we conclude that's about 925, something like that,
18 925 C, and that's pretty close to the CODEX data.
19 CHAIRMAN KRESS: But if you did the
20 two-to-the-fourth thing, that could be markedly lower.
21 MR. TINKLER: It could be. It could be. We
22 looked at it for different oxide layers and it's pretty
23 consistent. You see the same sort of trend. You can also
24 see, by comparing the effect of pre-oxidation, that the
25 overall heat generation rate is substantially lower, as you

1 would expect.

2 CHAIRMAN KRESS: Where did you get the heat

3 generation rates for the oxygen?

4 MR. TINKLER: This curve was taken from the

5 correlation that ISPR developed to match the peak

6 temperature of the fuel with the CODEX AIT test.

7 This is not in your handout, but these are the

8 correlations that we used. That steam correlation, a

9 zircaloy oxygen correlation in MELCOR. We did find that the

10 examination of this by JRC, they neglected to include a

11 conversion between oxygen and zirc metal.

12 So when you look at their report, they show

13 MELCOR's curve way high. Well, that's because they forgot

14 that molecular weight ratio of zircaloy oxygen.

15 But when you go back -- like I say, when you go

16 back and look at these -- it doesn't matter which oxide

17 thickness you pick, the same differential between 1,200

18 degrees C and about 925 degrees C. But if you look at that

19 correlation at 20 microns and project it to 200 microns to

20 look at the same equivalent heat generation rate, you

21 increase that temperature escalation threshold by about 250

22 degrees C. So 925 becomes 11-something, 1,175.

23 So the effect of the pre-oxidation is fairly

24 substantial.

25 DR. POWERS: Well, to be fair, the effect of

1 pre-oxidation is substantial providing that this oxide
2 defies its Bedford pillar and the ratio and doesn't spall.
3 MR. TINKLER: Absolutely. Spalling leading to
4 runaway oxidation, breakaway oxidation, whichever term you
5 prefer, effectively removes that cladding barrier and you
6 will see a very rapid increase in the oxidation rate.
7 That was seen in some of the isothermal tests.
8 Most of those, they start out with clean, fresh cladding.
9 But they do show, point out the instability of the nitride
10 layer. They show that when you get this, you get a very
11 rapid increase in chemical energy.
12 They seem to suggest there's some sort of
13 incubation time involved here. I think it was Evans saw an
14 incubation time of about ten hours. Leistikow saw one of
15 about four hours. But we would argue that if you're looking
16 at this for a transient heat-up, if you're trying to analyze
17 the acceptability of a ten-hour delay before a significant
18 heat-up of the fuel pool, because you want to make the case
19 that there is some adequate time period, it would take some
20 ad hoc evacuation, then those times have to be considered as
21 part of the ten hours.
22 At this point, when you get to 1,800 degrees C,
23 it's starting to heat up more rapidly anyway.
24 So I guess we would argue that these conditions
25 don't really pose a challenge to a temperature threshold for

1 determining the acceptability of some relatively short
2 interval for ad hoc evacuation.
3 They do pose a real problem for sitting there for
4 long periods of time. You'd have to have data that would
5 show that this breakaway didn't occur at these kinds of
6 temperatures before you could revert to some higher
7 temperature, like 900 C.
8 The issue of hydriding has been raised. Many
9 people have experience with the easy ignition of metal
10 hydrides and potentially the auto ignition of clean metal
11 upon ballooning and burst.
12 The position we've taken on ballooning and burst
13 is that basically you're talking about small exposed surface
14 areas for clean metal. The argument on hydriding is that as
15 you approach these higher temperatures associated with
16 ballooning and burst, that the hydrogen solubility in the
17 zircaloy dramatically increases and you go into a solid
18 solution, and that the -- this is not my term -- hydride
19 reorientation occurs into the alpha zirc.
20 CHAIRMAN KRESS: That's at the 800, 900 degree
21 range?
22 MR. TINKLER: Well, they say it -- they --
23 principally, we're relying on a lot of the expertise of the
24 folks at Argonne in this area who have looked at this issue
25 and looked at the references for solubility of hydrides in

1 zirc. But they see that even at -- once you go above about
2 400 C, it starts to increase and increases pretty rapidly.
3 A factor of ten increase in solubility between
4 like -- I think it was between like 380 and 600, and it
5 exceeds the limits of hydriding allowed in cladding.
6 So if you're lucky enough to have -- I guess lucky
7 enough to have some other forms of zircaloy, beta zircaloy,
8 the solubility is even higher than that.
9 So the argument here is that you're unlikely to
10 have large amounts of hydride exposed, hydride precipitates
11 that are exposed, because normally they'd be in the boundary
12 between oxide and metal.
13 DR. POWERS: If you get a breakaway event, a
14 spallation event, that's the part that gets exposed.
15 MR. TINKLER: Absolutely.
16 DR. POWERS: And the stress is highest with the
17 hydride inclusion.
18 MR. TINKLER: That's true, but if you have the
19 breakaway event, you have enough problems just because you
20 have the breakaway and you expose relatively fresh metal.
21 So the compounding problem of hydriding for the
22 breakaway, I guess what I would argue is it doesn't make it
23 -- it makes it worse, but it's already bad because you've
24 had the breakaway. So you have to be able to show -- if you
25 want to sit there for long periods of time -- that you don't

1 have the breakaway.

2 In the draft report, we cited a temperature of 800
3 degrees C as an all purpose temperature criteria. The
4 comment was received that, well, gee, you could have
5 cladding failures below 800 C and you can get ruthenium
6 releases if you oxidize fuel.

7 So who says you could sit there forever at 800
8 degrees C and not have perhaps large ruthenium releases? So
9 we took a look at that issue, also considering the high
10 temperature release of volatiles, release of ruthenium after
11 oxidation of fuel, and this question here, under what low
12 temperature conditions might fuel oxidize leading to large
13 ruthenium releases?

14 Because it's really a -- it might be hard to
15 actually develop the sequence, because you might go to high
16 temperature pretty quickly, in which case you might not have
17 a lot of U-308.

18 We point out that in the CODEX tests, they saw no
19 evidence of U-308. They only collected U-02. So you would,
20 I guess, conclude that they wouldn't have had much ruthenium
21 release. They didn't have any anyway, because it was fresh
22 fuel. So is there some kind of sequence where you can sit
23 there for long periods of time, relatively high, but not too
24 high, where you could oxidize the fuel and produce a lot of
25 decrepitation and release of ruthenium.

1 But you could also argue, under those cases, you'd
2 have a fair amount of cladding left and that the cladding
3 would impede the release of ruthenium. It didn't just all
4 fall away. It's not just bare fuel pellets sitting there.
5 And the Parker data is bare pellets. Some of the
6 other data has cladding on it, but it's virtually all
7 completely oxidized to U-308.
8 So it may be difficult to get this combination of
9 conditions, it would in the short-term. For long decay
10 times, long radioactive decay times, after the fuel has been
11 in the pool a real long time, you're more than likely to
12 produce those kinds of conditions perhaps.
13 But basically, after looking at all these things,
14 we concluded that in order to avoid large rapid releases of
15 ruthenium for periods less than about five years, you need
16 to stay below 600 C.
17 The available evidence pushes this in the more
18 conservative direction on this one. We think that after the
19 ruthenium release -- after the ruthenium inventory has
20 decayed substantially, you can raise this number back up to
21 about 800 C, consistent with the breakaway oxidation limit.
22 CHAIRMAN KRESS: And how long does it take to
23 decay before your equilibrium temperature is 600 degrees C?
24 MR. TINKLER: Well, I guess that depends on how
25 you think air cooling is effective under various

1 configurations.

2 CHAIRMAN KRESS: I would just use

3 two-to-the-fourth, forget the air.

4 MR. TINKLER: So we ended up with a more

5 complicated set of threshold criteria for temperature

6 escalation. I don't think that led us to abandon this

7 approach. But basically, we thought that the data

8 suggested, when you're only concerned about the initial

9 transient, you could probably go to about 900 C. If you

10 have accidents where steam is important, you can probably go

11 to -- I mean, because, remember, this is the temperature at

12 which we signal a large rapid release of fission products

13 and you don't expect to see instantaneous release to 1,200

14 C, frankly.

15 But if you want to sit there forever, for a long

16 time, and you think you still have a fairly substantial

17 ruthenium inventory, you're going to have to drop this

18 temperature back, that's the general conclusion at this

19 point.

20 We do think, though, that the lack of adequate

21 data characterizing source term for these kinds of accidents

22 pushes this in these kinds of directions and that if we had

23 better data, we may be able to show that these temperatures

24 are quite conservative, frankly.

25 If you could run tests on cladding reaction

1 kinetics with hydrided pre-oxidized cladding, you might be
2 able to show relief on those temperatures. You may be able
3 to show that you don't get substantial ruthenium release
4 because the cladding barrier itself at low temperatures is
5 at least a factor in controlling those releases.
6 In general, we think that even if you use these
7 things, you've got to do a calculation, obviously, that
8 shows you're stable at these conditions. Just picking a
9 threshold by itself isn't sufficient.
10 So you should do an air view and integrated
11 calculation where you can look at all these things at the
12 same time and since I'm in the severe accident business, I
13 think you ought to use a code that's designed to do all
14 these things. We think it would have some capabilities that
15 would be attractive.
16 Now, generally speaking, that means we wouldn't
17 calculate multi-dimensional mixing in the plenum above the
18 pool for the downcomer air flow, but you can address that by
19 supplementing that calculation with some more detailed
20 thermal hydraulic calculations.
21 DR. POWERS: If you were to try to do this
22 calculation, I mean real analyses, wouldn't you have to
23 supplement your kinetic analysis with an analysis of the
24 spallation event?
25 MR. TINKLER: Yes. We have to -- well, you either

1 have to be comfortable with, in that case, substituting a
2 criteria, a temperature criteria into the calculation and
3 say that's my end point, or you have to have a better
4 understanding about spallation.
5 DR. POWERS: There was a nice paper about two or
6 three years ago in nuclear materials, in which they
7 attempted to define the structural mechanics of spallation
8 on zircaloy. Couldn't you just use that?
9 MR. TINKLER: I wouldn't want to speculate here on
10 the spot. I mean, you know, I think if we -- we're
11 relatively new to this issue, frankly. I mean, we haven't
12 spent long periods of time studying this particular issue.
13 I'm not sure that we couldn't learn some approaches out
14 there that would be adaptable.
15 DR. POWERS: They made an interesting argument in
16 that paper that they argued fairly persuasively that one had
17 to acknowledge that the underlying metal would, at these
18 kinds of temperatures, have a substantial amount of creep
19 and that would relieve the stress on the oxide, compressive
20 stress on the oxide.
21 What they couldn't do, because I think the author
22 was not aware of it, was to understand that in air, you had
23 the nitride interface.
24 It's a nice paper. It's interesting because the
25 structures are monoclinic here. So none of the

1 simplifications that you ordinarily like to make in cubic
2 systems are applicable.
3 MR. TINKLER: It's clear that stresses are
4 important to this process. If you have stress relief
5 because of a number of factors, it would work to your
6 advantage. That seems pretty clear. But we can take a look
7 at that and see if there's something to be mined out of
8 that.
9 DR. CRONENBERG: How does this kind of a summary
10 bode with the goal of going to a generic rule? I mean, now
11 you're having several criteria up here. One, you're having
12 an air cooling environment and you have a temperature of
13 900. Now you have a boil-down or steam cooling environment,
14 a different criteria. You have one for emergency planning.
15 Now you have a criteria that you're using for insurance
16 indemnification.
17 It seems to me we're going to a more complicated
18 process than what we had before.
19 MR. TINKLER: Well, in order to avoid imposing
20 excessive conservatisms across the board, we tried to break
21 this up into the issues of concern.
22 So if you wanted to do a more detailed
23 calculation, if you thought you were -- and if you want to
24 do a consistent sequence type analysis, you would want to
25 look at -- you'd want to have models for these things in the

1 calculation.

2 DR. CRONENBERG: But, before, you just had to come

3 in and show that your air cooling criteria was satisfied,

4 850 degrees, if it could show it in a decay time of two

5 years, you were granted your exemption. Now, you're having

6 to do, it seems to me, more analysis, some for emergency

7 planning, some for insurance indemnification.

8 MR. TINKLER: But the significant finding here was

9 if you wanted to --

10 DR. CRONENBERG: We're going for a goal of a

11 one-year rule.

12 MR. TINKLER: If you wanted to argue that there

13 was no release, if you want to argue there's no release, we

14 say you have to show air cooling sufficient to maintain a

15 lower temperature. But that's not the ultimate conclusion

16 that was reached.

17 I mean, ultimately, we concluded that for these

18 kinds of sequences, conditional probability of a large

19 release, one. Then the argument is that the frequency of

20 those events is sufficiently small that the overall risk is

21 acceptably small.

22 But if you want to argue now the conditional

23 probability of a large release, because of the general state

24 of data, if you want to preclude large releases for a very

25 long period of time, taking no credit for corrective action,

1 then you're faced with a lower temperature threshold.

2 CHAIRMAN KRESS: This would be a good time, I

3 think, to take a break. Be back about 17 minutes after.

4 [Recess.]

5 CHAIRMAN KRESS: I think it's 17 minutes after.

6 Can we resume? I think we're going to have the pleasure of

7 listening to Jason Schaperow now on the source terms.

8 MR. SCHAPEROW: Good morning. I'm Jason

9 Schaperow, of the Office of Nuclear Regulatory Research. My

10 presentation describes our consequence assessment for spent

11 fuel pool accidents at decommissioning reactors.

12 I'll start out with some basic points on this

13 issue. As a result of radioactive decay, after the plant is

14 shut down finally, there will be a lower inventory of

15 fission products in the pool and there will also be a lower

16 decay heat that provides the opportunity for early

17 evacuation relative to the start of the fission product

18 release.

19 Although it doesn't seem like that now, it was

20 initially thought that maybe one year would be enough for

21 most of the fission products to decay away and not get

22 serious off-site consequences, and for the further reason

23 that if the consequences were negligible, that maybe we

24 could reduce or eliminate these requirements on emergency

25 planning and insurance.

1 Therefore, we set out to perform consequence
2 calculations with MAACS to quantify this consequence
3 reduction.
4 CHAIRMAN KRESS: Now, when you do MAACS, you have
5 to have a population distribution and a meteorological wind
6 thing.
7 MR. SCHAPEROW: That's correct.
8 CHAIRMAN KRESS: Did you just use some sort of --
9 a site or some sort of generic numbers for those?
10 MR. SCHAPEROW: We started off with Surry, which,
11 as you know, is well used. Everybody analyzes Surry.
12 CHAIRMAN KRESS: It is kind of relatively high
13 population. So that's probably a good one to use.
14 MR. SCHAPEROW: I think I've heard people call
15 that maybe a generic site, kind of in the middle of the
16 range. Some are maybe in a lower population or some are in
17 a higher.
18 We also did run calculations with the uniform
19 population density and that did have some effect on the
20 results. The early fatalities can be affected if you have a
21 lot of --
22 CHAIRMAN KRESS: The trouble is what value do you
23 put on that uniform -- I mean, you could have it 600 people
24 per square mile or a thousand per square mile and it's still
25 a uniform.

1 MR. SCHAPEROW: That's true. We did perform a
2 large number of MAACS calculations, about 200, excluding
3 some of the probabilistic analyses we did. Our initial
4 calculations, as I say, focused on the reduced inventory at
5 one year and the reduced decay heat, the early versus late
6 evacuation.
7 Also, to better understand the results at one
8 year, we did perform some sensitivity calculations on the
9 release fraction of cesium.
10 We examined the effect of varying a number of
11 other parameters, including ruthenium release fractions, the
12 number of assemblies releasing fission products, fission --
13 CHAIRMAN KRESS: How do you decide how many
14 assemblies are in there and how old each are?
15 MR. SCHAPEROW: We originally started with the
16 spent fuel pool inventory of Millstone-1, which was three
17 and a half cores, and we took the number straight out of --
18 CHAIRMAN KRESS: Three and a half cores, but
19 different decay times.
20 MR. SCHAPEROW: That's correct. That's correct.
21 The inventories are according to the amount of time they're
22 in the pool. That work was done by Brookhaven in the late
23 '80s in support of Generic Safety Issue 82 resolution.
24 Most of our calculations, we assume the entire
25 three and a half cores worth of fuel. That number of

1 assemblies went up and released their fission products,
2 heated up and released their fission products.
3 We looked at fission product release fractions of
4 the other different fission product groups, such as --
5 CHAIRMAN KRESS: When you did the sensitivity to
6 ruthenium, did you also consider potential for other
7 possible volatile oxides? Where it's involatile if it's in
8 the unoxidized state, but volatile in the oxidized state,
9 such as lanthanum, for example.
10 Do you consider it might get released at a higher
11 rate than the source term? I guess I'm asking --
12 MR. SCHAPEROW: Are you referring to the --
13 CHAIRMAN KRESS: -- is ruthenium the only oxide
14 you did a sensitivity to?
15 MR. SCHAPEROW: We did sensitivities on the
16 lanthanum, but only at the three and a half percent release,
17 assuming it's a fuel fine. But, no, we didn't assume very
18 large fractions of lanthanum.
19 CHAIRMAN KRESS: Would that have made a
20 significant difference if you had a high release of
21 lanthanum, say?
22 MR. SCHAPEROW: I don't know. I'd have to look at
23 that. We also took a look at -- as suggested by the
24 committee, we looked at plume heat content, with the idea of
25 a possibly much higher plume heat content than a reactor

1 accident.

2 CHAIRMAN KRESS: We thought that would do two

3 things to you. That would send the stuff further and

4 increase the number of cancers and increase the land

5 problem, but decrease the prompt fatalities. Did that

6 happen to you?

7 MR. SCHAPEROW: We generally saw those trends.

8 I'd like to discuss that further when we get to those

9 slides.

10 This is the layout of my presentation, by the way.

11 I am going to go through what we did, each of these bullets

12 here is a slide or two, and this is essentially a sequential

13 presentation, showing where we started and at the last slide

14 or two, where we are now and then Bob will talk about how

15 they use those final calculations.

16 DR. SEALE: Check your intuition.

17 MR. SCHAPEROW: We looked at plume heat content.

18 DR. POWERS: He knows he's right. He's looking

19 forward to this.

20 MR. SCHAPEROW: We looked at heat plume content

21 and plume spreading. We also looked at decay times beyond

22 one year, as far as ten years. And, finally, we reassessed

23 the source term.

24 Now, the committee had a lot of comments on the

25 source term and we took a step back and thought about what

1 might be the best source term for this application.

2 And as I mentioned, Bob Palla is going to describe

3 how he used the results of this large number of MAACS

4 calculations to understand the risk.

5 The original objective of our consequence

6 calculations was to look at the effect of one year of decay.

7 We looked at both the inventory available for release and

8 the consequences that you'd get if you ended up with an

9 early evacuation.

10 We started with the work done for Generic Safety

11 Issue 82 and we extended it by going out to one year. They

12 had done consequence analyses at 30 days and 90 days and on

13 the bottom of the page, there is a small table there showing

14 the source term that was used in that study and even some

15 later studies by Brookhaven.

16 DR. CRONENBERG: When you say one-year decay, one

17 of the cores is in there for three years, another one is in

18 there for two years, and one another one and five years.

19 MR. SCHAPEROW: Exactly, exactly.

20 DR. CRONENBERG: Is that what you did?

21 MR. SCHAPEROW: That's correct.

22 DR. CRONENBERG: When you say one-year decay,

23 that's the most recent core. The others are in the

24 calculation are two and a half years decay and four years

25 decay or whatever.

1 MR. SCHAPEROW: Yes. That's correct.

2 MR. COLLINS: Excuse me. Wasn't it that the first
3 three batches were one-year decay then each batch was a
4 subsequent cycle? So it wouldn't even be a whole core. It
5 was batches.

6 MR. SCHAPEROW: Actually, the last core was one
7 year old and then the next year was the two and a half years
8 old. The idea is that this is one year after the plant has
9 been shut down and all the fuel is now in the pool.

10 DR. CRONENBERG: For one batch and all the others
11 have the old decay.

12 MR. SCHAPEROW: That's right. Everybody -- this
13 is an accurate --

14 DR. CRONENBERG: It's not a maximum calculation.

15 MR. SCHAPEROW: No, no. This is an accurate
16 portrayal of the inventories in the pool. That was fairly
17 straightforward, I understand, originally.

18 This is a representative calculation that we did
19 with the Surry population distribution, showing results out
20 to 100 miles. That was one of the distances that we
21 calculated consequences for and it was used, I guess, in
22 some cases, to compare with reactor accident consequences at
23 those distances.

24 We also, as Bob will show you, we have results for
25 within one mile, for comparison with safety goal, and then

1 ten miles.

2 The first trend we saw in going from 30 days to a
3 year was we saw a reduction in early fatalities, about a
4 factor of two. We didn't see much change in the societal
5 dose and cancer fatalities.

6 When we reduced -- when we went to early
7 evacuation, assuming that the thing was cool enough so you
8 could get people out in a reasonable time, we got another
9 drop in early fatalities, a big drop, and, again, the
10 societal dose and cancer fatalities really didn't change.

11 We wondered about these trends, because, again, we
12 were hoping to see a bigger fall-off in consequences. So we
13 looked at cesium. If you recall, on the other slide, the
14 cesium release fraction was one and the other stuff was
15 really small. So this is kind of -- I guess, in hindsight,
16 it was an obvious target for -- this is where the
17 consequences were coming from and we went ahead and did the
18 calculation and we did see that it is cesium which dominates
19 consequences.

20 When we did the calculation without cesium, the
21 consequence measures went to very small numbers. And the
22 dominant isotope of these three is, in fact, 137, which has
23 got a long half-life.

24

25 CHAIRMAN KRESS: Not very surprising, was it?

1 MR. SCHAPEROW: Well, that's true, but we did the
2 calculation to try to demonstrate that. With regard to
3 ruthenium, again, there have been a number of tests in air
4 environments that have shown large ruthenium releases.
5 So we went ahead and did MAACS calculations with a
6 ruthenium release fraction of one. We saw very large
7 increases, particularly in the early fatalities, where we
8 had an increase of 20. That was for the uniform population.
9 And we had an increase of a factor of 100 for the Surry
10 population.
11 We looked a little harder and we confirmed that this is
12 because of the very high dose conservation factor for
13 ruthenium oxide and that's because it goes it goes in the
14 lungs and has a very long clearance time.
15 I think we've discussed these potential mitigating
16 factors. Again, these are possibilities. The ruthenium
17 half-life is a big help, because after a few years, you
18 won't have anymore ruthenium in the pool.
19 Also, I'd like to mention that there is a PHEBUS
20 test planned in a couple of years. They are going to go
21 ahead and do an integral test in an air environment. So
22 hopefully we'll learn some big insights from this one.
23 CHAIRMAN KRESS: When is test scheduled? That's
24 the next one coming up, isn't it?
25 MR. SCHAPEROW: No. I think it's the second --

1 it's the last one, isn't it?

2 DR. POWERS: The very last test.

3 CHAIRMAN KRESS: Do you think they'll actually get

4 to it?

5 MR. SCHAPEROW: There are certain pressures on

6 them to do high burn-up and other tests.

7 DR. POWERS: It's illuminating when it's the last

8 test. It's the last test because they're afraid that it

9 will do so much contamination of the facility, they may not

10 be able to do another test.

11 MR. SCHAPEROW: We are certainly looking forward

12 to that. We've been participating in PHEBUS since the start

13 and that will be important for us.

14 This slide, this table demonstrates or shows the

15 kinds of dose changes we get. The committee has seen this.

16 I presented this back in April, and we do see a big increase

17 in consequences when you add a large ruthenium release.

18 We do see some help from early evacuation.

19 DR. POWERS: When you say we see substantial help

20 from early evacuation, is that some code language for saying

21 you have a well established emergency planning?

22 MR. SCHAPEROW: I was trying to say that if the

23 pool -- I was just trying to say that the doses get smaller

24 when you can get people out of there. And I think you can,

25 if, after the while, the thing is going to start cooling

1 off. It's not going to be as hot and it will take time to
2 heat up. I know we don't have a large thermohydraulic
3 database on that, but it is going to take time.
4 DR. CRONENBERG: But that question is pretty
5 pointed.
6 MR. SCHAPEROW: I'll let Bob discuss that. He
7 gets into that a lot more. Do you want to talk about it
8 now, Bob?
9 MR. PALLA: I'll talk about it later in more
10 detail, but I don't think that the conclusion would be that
11 you need effective -- that you need a full-blown emergency
12 plan as it exists today.
13 I think the key point is if you can get people
14 out, they're not going to be there to get dosed.
15 CHAIRMAN KRESS: Is there a database on the
16 ability to evacuate people under earthquake conditions? Do
17 we have a database on that and do we know how to input that
18 into MAACS?
19 MR. PALLA: I think that FEMA may have information
20 on that, but it's not anything that we have used in our
21 study. I'll be explaining the assumptions we used in
22 seismic and the bases for that.
23 MR. SCHAPEROW: We also examined the effects of
24 the number of assemblies releasing fission products. As I
25 mentioned earlier, the original calculation was done with

1 the pool limits -- the number of assemblies that equal the
2 three and a half cores.
3 But depending on reductions in decay heat, there may be less
4 fuel involved in the heat-up.
5 CHAIRMAN KRESS: How did you make a judgment on
6 how to limit the number, amount of fuel that would be
7 involved? Because as I say, once you set off this fire, I
8 don't know if we have any propagation models or not, but it
9 looks to me like it has potential to involve the whole spent
10 fuel pool once you set it off.
11 MR. SCHAPEROW: That's true. It does have the
12 potential to involve the whole pool. The more recent
13 calculations, I guess, conclude that it could. The one core
14 was based on the work done for Generic Safety Issue 82.
15 Actually, this was done quite a while ago. I did this
16 calculations maybe almost a year ago.
17 With regard to the one core, that was the most
18 recent core. I assume that the one that was -- that's the
19 hottest one, so it most likely --
20 DR. CRONENBERG: And it had burn-up dependence and
21 all this in your inventory.
22 MR. SCHAPEROW: That's correct. And I'm going to
23 discuss that right here. Also, I ran two cases to get to
24 the importance of cesium and the consequences -- I'm sorry
25 -- ruthenium. Because of the importance of ruthenium, I ran

1 two cases without the ruthenium release and two cases with
2 the ruthenium release.
3 We saw reductions in both cases. The consequence
4 reductions were not as big in the case with the ruthenium
5 release because most of the ruthenium is in the most recent
6 core, because of the one-year half-life.
7 As I mentioned, we did present results pretty much
8 on what most of the stuff up till now -- you folks have
9 already seen. You had a number of comments. I try to
10 highlight some what I believe were some of the more
11 important ones here.
12 The fission product release fractions that we had
13 taken from the earlier study were not supported. With
14 regard to the plume-related parameters, our large early
15 release plume heat content from the NUREG-1150 study for
16 Surry was probably too small, you suggested, and, also, the
17 plume spreading model, we have better models for that now.
18 So we did set out to do a number of sensitivity
19 calculations to follow-up on these comments.
20 On the area of release fractions, we did a
21 sensitivity on a fuel fines release fraction. We brought it
22 up to one percent from the very tiny number we originally
23 had and we saw increased consequences for both cases with
24 early evacuation --
25 CHAIRMAN KRESS: And where would I find plutonium

1 in that?

2 MR. SCHAPEROW: It would be under the cerium.

3 CHAIRMAN KRESS: Under the cerium.

4 MR. SCHAPEROW: That's correct. That's cerium,

5 plutonium and neptunium, I believe, is that group. That's

6 correct. These calculations are for three and a half cores.

7 We saw increased consequences when we raised it to one

8 percent, indicating it was important. When we increased the

9 release fractions of some of the other groups, we may or may

10 not have seen changes. In the area of tellurium and barium,

11 we didn't really see a change on off-site consequences.

12 This is due to the short half-lives of the isotopes in those

13 groups.

14 In the area of strontium, we did see increased

15 consequences, again, because the half-life is significant in

16 the strontium group.

17 DR. POWERS: I thought you had indicated earlier

18 you were using three and a half percent for the fines.

19 MR. SCHAPEROW: That's the final calculations we

20 did.

21 DR. POWERS: This is just sensitivities.

22 MR. SCHAPEROW: That's correct. These were

23 earlier. Again, this is a little bit of function of the --

24 I'm kind of taking you down the path that I walked to get to

25 the end.

1 CHAIRMAN KRESS: So the conclusion I get from
2 looking at this table is that new source term considerations
3 have a big effect on both early fatalities, particularly the
4 ruthenium, and the fines have a big effect on the societal
5 dose and I would assume the land interdiction was not shown
6 in here.
7 MR. SCHAPEROW: I think that's a valid conclusion.
8 CHAIRMAN KRESS: Not much change with the cancers,
9 but enough to be worrisome.
10 MR. SCHAPEROW: That's correct. A lot of the
11 societal dose and cancer fatality results come out of the
12 doses to large numbers of people over long periods of time.
13 CHAIRMAN KRESS: Yes.
14 MR. SCHAPEROW: And there is a little play there
15 of the long-term relocation criteria that was used. I don't
16 show my results, but we did do a few sensitivities on
17 changing the long-term relocation criteria and when we cut
18 it down to two rem from four rem, I think we had about a 33
19 percent reduction in the long-term consequence.
20 So it was nearly proportional. It wasn't quite.
21 It was almost maybe half-proportional to that.
22 DR. POWERS: You've carefully labeled your results
23 here mean consequences. Can you give us an idea of what the
24 uncertainty band is around these and whether it showed a
25 sensitivity to the various things that you calculated?

1 MR. SCHAPEROW: No, I did not look at that.

2 DR. POWERS: But in your final calculations, you

3 include uncertainties for that.

4 MR. SCHAPEROW: We looked at that a little on the

5 plume. The short answer is no. We did look at that a

6 little bit on the plume spreading results, but that was

7 very, very cursory.

8 DR. POWERS: You're not afraid that in the sense,

9 as Tim said earlier, well, this is our input to the

10 decision-makers, that you're not handicapping the

11 decision-makers by not giving him a good understanding of

12 what the uncertainties are?

13 MR. PALLA: What I would say is that we have other

14 large uncertainties that, as we talked about before, the

15 seismic hazard frequencies are one area. We do, in the risk

16 assessment, look at two different source terms that we think

17 represent the reasonable bounds and when we get into those

18 discussions, I can lay out what they were.

19 But these source term -- these consequence

20 calculations were an evolution and all of what you're

21 looking at is sensitivities relative to the source term of

22 several decades ago, our earliest studies on the spent fuel

23 pool.

24 So where we ended up was with a substantially

25 different source term than this; basically, a modified

1 version of the NUREG-1465 source term is the basis for what
2 we did with the risk calculation.
3 So it's kind of hard to figure out how you would
4 weight these various cases that we've run. They're kind of
5 pretty broad range of release fractions.
6 CHAIRMAN KRESS: One reason for asking that
7 question, at least one reason I would have, if I had asked
8 the question, is that the safety goal criteria that we're
9 trying to meet was placed there with some sort of implied
10 knowledge of what the uncertainties are associated with this
11 determination for reactor core accidents, operating reactor,
12 and that's -- and a selective value, using the mean value,
13 this is a good enough value, the level of the value as it
14 represents the mean is an acceptable one.
15 Now, if the uncertainties associated with this
16 calculation are much greater, for example, than the
17 uncertainties associated with the core accidents, then one
18 might think we either can't now use a mean value like we did
19 before because of the higher uncertainties. We might ought
20 to lower the acceptance value.
21 So it brings into question whether or not the
22 safety goal, prompt fatality safety goal, as a mean, is that
23 still the right acceptance value, and then one ought to
24 factor in the uncertainties in that decision.
25 MR. SCHAPEROW: Maybe I'm missing the question,

1 but the reason I put a mean here, this is a mean of the
2 weather sampling that the code does. That's the only thing
3 we're taking an average for, it's average over the -- so if
4 one had an idea what the mean was versus the -- pardon?
5 CHAIRMAN KRESS: It's not an uncertainty
6 calculation on everything else.
7 MR. SCHAPEROW: Right, just the weather. So if
8 one had an idea what the range of the weather would be, you
9 could tack it onto here and come out with your upper and
10 lower bounds.
11 One other thing we did while we were looking at
12 the release fraction effects is we also took a look at
13 evacuation percentage. There was a question about whether
14 you could evacuate 99.5 percent or 95 percent in people, and
15 it's a factor of ten difference in the number of people
16 evacuating. And when we evacuated a factor of ten people
17 less, we got a factor of ten increase in early fatalities.
18 DR. POWERS: Certainly, that's comforting. Your
19 analysis has a certain consistency to it. We've seen
20 analyses that lack that consistency.
21 MR. SCHAPEROW: In the area of plume heat content,
22 because of the potential for a higher plume heat content for
23 a spent fuel pool accident than we normally see in a reactor
24 -- early -- large early release for the reactor accident, we
25 did perform sensitivity calculations using different plume

1 heat contents.

2 The base case was the reactor accident plume heat

3 content which we took out of 1150, which was 3.7 megawatts

4 for a plume which is a 30-minute-long plume.

5 We did a rough scoping estimate of the plume heat

6 content for a spent fuel pool accident. We assumed one core

7 oxidized completely in 30 minutes and the heat generated

8 from that was 256 megawatts.

9 We also asked Sandia to take a look at this and they did a

10 little better calculation, including heating up of the fuel,

11 how much heat the fuel would pick up along the way.

12 They came up 43 megawatts. So we did calculations

13 over that range.

14 The cases 45, 47 and 49 are for the late

15 evacuation cases and the bottom three cases are for the

16 early evacuation. We assumed a large ruthenium release in

17 all of these and, as expected, the early fatalities went way

18 down. The societal dose and cancer fatalities didn't really

19 change much, but I think this is because we looked only out

20 to 100 miles.

21 I think, as Tom suggested, if you went out to a

22 further distance, you'd probably see a bigger effect there.

23 CHAIRMAN KRESS: I think the choice of 100 miles

24 in the regulations was counted based on the implied plume

25 energy at a reactor accident, because what that is, they

1 made a lot of calculations and showed that if you go beyond
2 a 100 miles, the calculations didn't make that much of a
3 difference.
4 Now, if you redid those with a new plume energy,
5 you would say, well, maybe we ought not stop at 100, maybe
6 we ought to go on.
7 MR. SCHAPEROW: That's a possibility. On the
8 plume spreading model, the ACRS noted that we had done lots
9 of significant work in this area back in I guess around 1995
10 or thereabouts. MAACS uses a Gausian plume model, which
11 uses the plume model parameter sigma Y and sigma Z to
12 describe the spreading.
13 As part of the international effort to take
14 another look at this model and all the other models in the
15 consequence codes --
16 CHAIRMAN KRESS: These are functions of the
17 weather conditions.
18 MR. SCHAPEROW: That's right. It's a function of
19 the atmospheric stability and the distance. That's right,
20 those are the two things, the atmospheric stability and the
21 distance away from the source.
22 The experts provided updated values for these
23 parameters. They didn't actually provide point values.
24 They provided distributions, which made our job a little
25 harder. So we turned to Sandia to take a look at this.

1 They had been actually working with us for a little while
2 and they went ahead and put together an analysis based on
3 sampling from these distributions and they concluded that --
4 they performed a larger number of calculations.
5 CHAIRMAN KRESS: About 300.
6 MR. SCHAPEROW: Three hundred was what they
7 concluded was necessary for the --
8 CHAIRMAN KRESS: They did a calculation that
9 showed that you covered the whole range fairly well and got
10 the correct distribution with 300.
11 MR. SCHAPEROW: Yes.
12 CHAIRMAN KRESS: I'm used to seeing numbers like
13 10,000.
14 MR. SCHAPEROW: I'm not sure, but I think these
15 Latin hypercube sampling or some sort of a smarter sampling
16 scheme.
17 CHAIRMAN KRESS: Latin hypercube would narrow that
18 down, you're right.
19 MR. SCHAPEROW: They tried to use some sort of a
20 smarter sampling scheme to make sure they -- because it took
21 a while, even as this -- the code takes a couple minutes to
22 execute, so even this took quite a number of hours to run.
23 DR. POWERS: If you want to, in a Latin hypercube
24 -- or in a Monte Carlo calculation, not even Latin
25 hypercube, but just a straightforward Monte Carlo

1 calculation, have a 90 percent confidence that you have
2 sampled 95 percent or the range of the uncertainty
3 variables, you need to do about 200 calculations and it's
4 independent of the number of uncertain variables.
5 So a number of 300 is a pretty good analysis.
6 Now, if they did Latin hypercube and inverted the
7 distributions, the only thing -- I mean, they've done a good
8 sampling, it's enough materials. They do have narrower
9 variances than you would have if you did a straightforward
10 Monte Carlo. That's just one of the characteristics of
11 Latin hypercube is they underestimate the variances, but the
12 means are all pretty good.
13 MR. SCHAPEROW: As expected, we found a decrease
14 in the prompt fatalities and we saw an increase in the
15 cancer fatalities and population dose.
16 I would like to note, as maybe is obvious, if we
17 apply these to reactor accidents, we'd see the same trends.
18 DR. POWERS: This is where I can beat on you.
19 This belief, this fate, that you can look at prompt
20 fatalities as a surrogate for the Commission safety goals is
21 belied by this exact kind of result.
22 CHAIRMAN KRESS: So it puts that into some sort of
23 question, doesn't it?
24 DR. POWERS: It certainly does.
25 CHAIRMAN KRESS: It doesn't really put into

1 question for the reactor accidents.

2 DR. POWERS: Oh, yes, it does.

3 CHAIRMAN KRESS: Well, I don't think you can get

4 that kind of plume energies in the reactor.

5 DR. POWERS: No, no, no. Just the sigma X and the

6 sigma Y's do it.

7 CHAIRMAN KRESS: I'm sorry, I'm sorry. Yes, I

8 agree with you completely. If you had the different sigma X

9 and sigma Y. I'm sorry. You're right. You could put it

10 into question.

11 DR. POWERS: Some of the final work that we did,

12 which we did not long ago, just maybe a month or so ago, the

13 final we did was to look at the entire range of decay times

14 from 30 days out to ten years.

15 We knew we weren't going to see a huge drop at ten

16 years, because, again, we knew we had cesium around, but we

17 did see the fall-off of the effect of the ruthenium decay.

18 As part of these calculations, we take a step back

19 and reassess our source terms and we decided that we better

20 go with something a little different. We decided to use

21 NUREG-1465 for the reason that it has received a lot of peer

22 review. It's true that it is based on a steam environment,

23 at least the in-vessel phase, but it has received a

24 significant peer review.

25 It is also representative of a low pressure core

1 melt accident. We try to take into consideration some of
2 the earlier calculations we did and we did a calculation
3 with ruthenium fraction of .75 and a fuel fines release
4 fraction of .035 to try to address some of the uniqueness of
5 the spent fuel pool accident.
6 CHAIRMAN KRESS: Well, one comment on that. If I
7 would expect ruthenium oxide to be released over and above
8 the 1465, then there are a number of other oxides that I
9 would also expect to be increased to the equivalent level.
10 These would be things like lanthanum, molybdenum, probably,
11 barium oxide, also, Dana?
12 DR. POWERS: I'm harking back from memory to the
13 Lorentz experiments, because --
14 CHAIRMAN KRESS: Those are the ones I was trying
15 to go back to.
16 DR. POWERS: Because they looked at the biggest
17 spectrum of fission product releases. The one that sticks
18 out, in my mind, the molybdenum, right, but they didn't have
19 much in their fuel samples.
20 CHAIRMAN KRESS: Right, there's not much in there.
21 DR. POWERS: But they did call attention to the
22 tellurium releases.
23 CHAIRMAN KRESS: The tellurium would be one, yes.
24 DR. POWERS: That they were getting and whatnot.
25 My recollection is they actually suppressed the barium and

1 strontium releases and that they found cesium was a wash.
2 It's difficult to distinguish one to the other.
3 MR. SCHAPEROW: I think most, if not all of these
4 can be eliminated on the basis of the half-lives. The
5 tellurium one is a very -- I mean, we did the calculation at
6 .75 release fraction.
7 CHAIRMAN KRESS: You may very well be able to,
8 right.
9 MR. SCHAPEROW: And I think the barium, also. The
10 lanthanum, I think that -- I'm not sure. I'd be guessing,
11 but I think it's like 100 day half-life. It's not a huge
12 half-life.
13 CHAIRMAN KRESS: Right. I think the half-life
14 does save you on those.
15 MR. SCHAPEROW: And the ruthenium is really bad
16 because of the assumed form of ruthenium oxide in the high
17 dose conversion factor.
18 I'd like to show the results -- well, I'd like to
19 show the source terms first and see how we've evolved. We
20 started, again, with the NUREG-CR-4982 source term.
21 CHAIRMAN KRESS: The half-life might not save you
22 on these 30-day calculations, if you were to rely on them.
23 MR. SCHAPEROW: That's true. For the lanthanum,
24 that's correct.
25 DR. POWERS: Go back to your previous slide. You

1 said, gosh, let's look at 1465, it's got a tremendous peer
2 review. The peer reviewers were asked about reactor
3 accidents. They gave a hell of an endorsement for reactor
4 accidents. That doesn't help you at all for a suppression
5 pool fire. I mean, it's no endorsement at all.
6 MR. SCHAPEROW: I contend that it's a better
7 source term than the one we had. The one we had was based,
8 I believe, on the coarser M model, the same model that was
9 used for the newer ones, and this one was -- NUREG-1465 was
10 based on integrated calculations for accidents involving
11 fuel heat-up. That's true. It wasn't under oxygen
12 conditions.
13 DR. CRONENBERG: Maybe it is for the partial
14 drain-down boil-off accident, which they're saying is now --
15 CHAIRMAN KRESS: There might be a lot of steam in
16 there.
17 DR. CRONENBERG: Yes. So it depends which
18 accident you're going to use for your basis for your
19 exemption.
20 MR. SCHAPEROW: That's true. My main argument
21 here is that it's better than what we had.
22 DR. SEALE: In using 1465, you're carrying the
23 sanctioning of using time delay.
24 MR. SCHAPEROW: We only use magnitudes. We stuck
25 with the 30-minute release, that's it.

1 DR. SEALE: But it is a 30-minute release.

2 CHAIRMAN KRESS: When you say 1465, that says

3 cesium is 25 percent.

4 MR. SCHAPEROW: This is what we mean, in ex-vessel

5 and in-vessel, 75 percent iodine, 75 percent cesium. We're

6 adding the entire release from the whole accident.

7 The only pitfall here is there are some fission

8 products in the RCS.

9 CHAIRMAN KRESS: Okay.

10 MR. SCHAPEROW: The footnotes on here I've already

11 talked about, the ruthenium release fraction, we set that to

12 the same as --

13 CHAIRMAN KRESS: That was going to be my next

14 comment. The 1465 did account for some depletion of the

15 source term.

16 MR. SCHAPEROW: That's correct. And we're losing

17 some there.

18 CHAIRMAN KRESS: It my not have that depletion in

19 this accident.

20 MR. SCHAPEROW: That's correct. On the ruthenium,

21 we -- first of all, we moved from a 4982 source term to the

22 NUREG-1465 source term, and, again, we had large

23 uncertainties in the area of ruthenium and fuel fines.

24 Again, those are uncertainties.

25 As Dr. Powers pointed out, we don't know whether

1 those are the 75 percent uncertainty number or two percent.
2 We just don't know. Maybe my comment before about a best
3 estimate is not so good.
4 So we did both the calculations. The Chernobyl
5 one is, again, from that reference, we looked into that a
6 little bit and to try to get a little better basis than just
7 the one percent number we were using earlier.
8 The next two slides are just the two tables of
9 results that we produced for this whole series of cases from
10 30 days out to ten years. The top half of the table is for
11 the late evacuation and the bottom half is for the early
12 evacuation.
13 DR. POWERS: Come back to the Chernobyl. You
14 realize that if I were a skeptical person, which, of course,
15 I'm not, that I'd say, oh, oh, you're going to use 3.5
16 percent. That means that you're inherently assuming that
17 you're going to fly over this spent fuel pool and drop bags
18 and bags of sand and clay and boric acid, just like they did
19 at Chernobyl, in order to inhibit all these particular
20 releases that took place after the initial explosion.
21 Is that the intention here?
22 MR. COLLINS: I hope that we're never faced with
23 one of these.
24 MR. PALLA: That may be a good assumption, though.
25 That may be equally reasonable.

1 MR. SCHAPEROW: Maybe we'll do it in a smarter
2 way, so hopefully it will avoid so many casualties.
3 DR. POWERS: I mean, I see that as a vulnerability
4 toward this assumption, that you're inherently appealing to
5 a mitigation strategy that could have inhibited any
6 longer-term particular release after the initial explosion.
7 CHAIRMAN KRESS: Jason, on this curve, this table
8 you just showed us, the 77C, with the .736 early fatalities
9 after one year.
10 MR. SCHAPEROW: Correct.
11 CHAIRMAN KRESS: How does that relate to your
12 previous table where, after one year, with 100 percent
13 ruthenium release, you had something like 100 fatalities?
14 MR. SCHAPEROW: Which?
15 CHAIRMAN KRESS: Page 9.
16 MR. SCHAPEROW: This is the NUREG-1465 ruthenium
17 release. The next one is the --
18 CHAIRMAN KRESS: I see. Okay. I'm sorry.
19 MR. SCHAPEROW: -- 76.9, which is a little lower
20 because of the 100 percent versus 75 percent.
21 CHAIRMAN KRESS: Right. Okay.
22 MR. SCHAPEROW: The use of this tables, again,
23 you'll see this, Bob's got some graphs showing how this
24 impacts. He's multiplied these by the frequency to show the
25 risk versus time.

1 CHAIRMAN KRESS: You divide -- you also have to
2 divide this number by the population within one mile, is it,
3 to get the individual risk?
4 MR. SCHAPEROW: That's right. Actually, we would
5 take the consequences from the site boundary out one mile,
6 the first mile out from the site boundary, and we take the
7 number of fatalities and we divide that by the population.
8 Actually, the code does it itself.
9 CHAIRMAN KRESS: It does that for you.
10 MR. SCHAPEROW: It's quite a lot of output from
11 this code and there was actually a lot of discussion as to
12 what -- how the output would be used and what we needed.
13 My summary slide is basically the same as my
14 beginning slide, which is we did a lot of calculations to
15 try to examine all the different issues, as much as we
16 could, with this type of code. I think we've pretty much
17 covered enough basis to proceed with the risk work, as Bob
18 will show you.
19 DR. POWERS: I, for one, think they've done
20 awfully nice job here trying to explore the uncertainties.
21 CHAIRMAN KRESS: I think it's a good exploratory
22 study and it gives you a lot of insight as to what the
23 various effects might be. That's what I thought.
24 DR. POWERS: I think if I were going to identify a
25 defect in it, it is that they did not look to see if there

1 were substantial variations in the uncertainties in these
2 results as they went through these various changes and it
3 would be interesting to have a better understanding of the
4 overall uncertainty in these consequence calculations,
5 because --
6 CHAIRMAN KRESS: It would be helpful, if I were
7 making the decision, it would be helpful for me to know.
8 DR. POWERS: But otherwise, I think we certainly
9 have to give them credit for being very responsive to the
10 kinds of issues that the committee raised on the initial
11 study.
12 I think it's especially good that they went in and
13 looked at those expert elicitations on the dispersal
14 parameters. I think that's information that has been
15 overlooked a lot and I think that was a study that's very
16 seminal that the NRC did and deserves a lot more attention
17 than it's gotten.
18 CHAIRMAN KRESS: And I agree with you and I also
19 agree with you that one of the effects of that is to put
20 into question the dominance of the prompt fatality safety
21 goal over the other safety goals and one might ought to
22 factor that into the thinking somehow, particularly -- you
23 know, I know we have a safety goal on cancers.
24 You might want to check to see, to be sure you
25 didn't exceed that, and I think you did. But I still think

1 land interdiction ought to -- there ought to have been a
2 safety goal on that and we ought to have it in the --
3 virtually in the back of our mind, that although there's not
4 one, we ought to have one.
5 DR. POWERS: Well, I insist that we need also to
6 look at things like the injuries, as well.
7 CHAIRMAN KRESS: The injuries, as well. That's
8 right.
9 DR. POWERS: Because if we're --
10 CHAIRMAN KRESS: In fact, that may be the leading
11 problem.
12 DR. POWERS: One is reminded that whereas thyroid
13 cancer is generally recognized to be a curable cancer
14 nowadays --
15 CHAIRMAN KRESS: It costs a lot of money to do it.
16 DR. POWERS: -- it is hardly a walk in the park.
17 CHAIRMAN KRESS: And it costs a lot of heartache.
18 If you were to put money values on each of these, that might
19 be the predominant one. I don't know. You don't think so,
20 Bob?
21 DR. SEALE: Land contamination.
22 CHAIRMAN KRESS: You're probably right. It's
23 between those two, yes.
24 DR. POWERS: We'll put all our reactors out in
25 Arizona so nobody will care.

1 CHAIRMAN KRESS: Yes, so it doesn't matter.
2 DR. SEALE: We've got a new initiative on the
3 ballot this year.
4 CHAIRMAN KRESS: We'll put most of them in Tucson
5 or we'll put most of them on Phoenix, and then you wouldn't
6 care.
7 DR. POWERS: The trouble is how would you
8 calculate the ten million dollars worth of improvements that
9 radioactivity release would do Arizona.
10 CHAIRMAN KRESS: Did you factor in the effect on
11 global warming of this?
12 DR. CRONENBERG: I have a comment, Jason. It's a
13 lot of calculations, but I'm still a little confused as to
14 it looks to me like on one case, it's air oxidation, air
15 cooling environment, and you're trying to assess the release
16 of fines, and then in another case, it's you use 1465, which
17 may be for a boil-down type of accident.
18 Again, I come back to where are we going with
19 generic rulemaking and where all this fits in. What is the
20 accident you're trying to analyze, before you tell us what
21 the source term is?
22 MR. PALLA: I'm Bob Palla. I'm in the
23 Probabilistic Safety Assessment Branch.
24 CHAIRMAN KRESS: Do we have your slides? You're
25 supposed to tell us why you're qualified to --

1 DR. POWERS: I think we've seen Bob often enough
2 that we probably have a good understanding.
3 MR. PALLA: What I'm going to be doing here is
4 describing how we've taken the consequence calculations and
5 integrated that with the estimates of frequencies that were
6 the focus of the original study.
7 Basically, I, like Tim Collins, would like to use
8 the excuse that I'm new to this project and we were drafted
9 in the late stages. We basically started with the February
10 version of the technical working group report and tried to,
11 in my view, tried to better bring the information together
12 in a form that it could be used to make decisions.
13 Specifically, where I think we've made a
14 substantial change in the document is that in the original
15 report, we had information about frequencies of uncovery and
16 in the appendices, we had information about consequences,
17 and this was just the earlier consequence calculations, the
18 first part of Jason's presentation.
19 But we had not integrated that information to
20 really come up with risk in the sense of probability times
21 consequences, and we didn't have any kind of comparisons to
22 the safety goals or to comparable risks from operating
23 plants.
24 So the focus of what I'm going to be talking about
25 is how we took the information, the consequence information,

1 and married it together with the frequency information to
2 provide a characterization of risk and then to compare that
3 level of risk to the risks that exist for operating plants
4 and to compare it to safety goals.
5 And then beyond just in terms of the absolute
6 levels of risk, the real focus of what we're doing here is
7 looking at changes to the regulations for decommissioning
8 plants, primary focus on emergency preparedness relaxations,
9 possible implications for insurance, but the last thing that
10 we did and where we increased the focus of the report was on
11 the delta risks that you get when you change the emergency
12 preparedness.
13 We did this in a very scoping manner, as you'll
14 understand, and even though there was a wide range of data
15 and sensitivity studies, what we used in our study is
16 essentially the source terms that Jason just described at
17 the tail end of the presentation.
18 We used the 1465 source term as one measure and
19 then the modified -- and we called that the low ruthenium
20 source term. And then we used the same -- his other source
21 term, where the ruthenium and the fuel fines release
22 fractions had been increased, we referred to that as the
23 high ruthenium source term.
24 We did not use, in our calculations, the results
25 of the earlier sensitivity studies, from the several decade

1 old NUREG report. That's substantially lower than the
2 source terms that we used.
3 If we were to display the results for the various
4 risk measures for those other source terms, we'd probably be
5 off-scale on many of the comparisons that I'm going to be
6 showing you.
7 DR. POWERS: You did use the one that Jason showed
8 that involved things like 75 prompt fatalities and stuff
9 like that.
10 MR. PALLA: Yes. We used the 1465, we referred to
11 as the low ruthenium source term, and we used the modified
12 version and called that the high ruthenium source term.
13 The top line there is the -- I'll call it the
14 early study source term, which is substantially lower and we
15 didn't mess with that, because we basically looked to Office
16 of Research to provide us the expertise and the wisdom of
17 what is the best source term to use for these calculations.
18 CHAIRMAN KRESS: Let me ask you a question about
19 the delta. In 1.174, the philosophy is that the delta
20 change should be a small fraction of the value associated
21 with the goal. So here I would assume that if you were
22 talking about prompt fatalities, it would be
23 five-times-ten-to-the-minus-seventh is the safety goal. So
24 a delta that's small for that would be
25 five-times-ten-to-the-minus-eight.

1 MR. PALLA: For a ten percent, yes.

2 CHAIRMAN KRESS: Yes. Is that the kind of

3 thinking you were --

4 MR. PALLA: That's the kind of thinking we did.

5 There's an appendix in the report that actually focuses on

6 that, but I'm going to be laying out some of those results

7 on the table.

8 CHAIRMAN KRESS: I probably didn't get that far.

9 I tried to read this on the airplane.

10 MR. PALLA: Only if you started from the back and

11 worked your way forward would you have seen it.

12 CHAIRMAN KRESS: I started with Appendix 4, that's

13 what I read first.

14 MR. PALLA: It's 4C, I think. Okay. The first

15 step, frequencies. What we did is we took the -- I'll call

16 it the uncovery frequency in my discussion here, but really

17 the frequency was actually for an event that leads to

18 uncovery or at least a level three feet above the top of

19 fuel. But I'm referring to it as uncovery, but it really is

20 like the time that it takes to get to three feet above the

21 top of fuel.

22 But we use the frequencies for those events,

23 taking directly from the level one study. We assumed that

24 any event that went that far would result in a large

25 release, a fire. Now, you could argue is it really a fire

1 or is it in the case if you block the oxygen flow, maybe it
2 would be adiabatic type heat-up where you release a lot of
3 fission products, maybe it's not a fire in the traditional
4 way of thinking of the fire, with the oxide-rich
5 environment.
6 But we basically said if you -- you'll have a
7 frequency of getting uncovery and if you get to uncovery,
8 you get the source terms that I just described.
9 Now, we looked at what are the most appropriate
10 source terms to assign for each of the various spent fuel
11 pool accidents and in doing that, we looked at the -- we
12 considered, well, what's the expectation regarding
13 notification of off-site authorities, what's the expectation
14 of initiating and completing an evacuation in a timely
15 manner; i.e., before the release occurs.
16 And I'll describe actually on the very next
17 bullet, at the bottom here, I've described the
18 characterization that we used in estimating the risk.
19 And on the next slide I'll get to, I'll go into a
20 little bit more detail, but in seismic events, we looked
21 first at some of the NUREG-1150 analyses and the bases and
22 for how they did the assessments for two 1150 plants.
23 There's five 1150 plants, reference plants, but only two of
24 them have seismic analyses with them. That's the Surry
25 plant and the Peach Bottom plant.

1 The comparisons that I show you later will --
2 where we compare spent fuel pool risks to operating reactor
3 risks, we selected the Surry and the Peach Bottom as the
4 operating plants as a point of reference, because those are
5 the only two that had the seismic part of the analysis and
6 because the spent fuel pool risks were so strongly driven by
7 seismic in order to provide the most balanced comparison, we
8 thought we needed to compare the operating risks, including
9 the seismic piece of that.
10 But in looking at the analysis for the seismic
11 analyses in NUREG-1150, the bases there, they divided
12 earthquakes into high G earthquakes of less than -- well,
13 high G was greater than .5 g, low G was less than .5. They
14 basically said in the high G earthquakes, you'd have
15 extensive off-site damage. The roads, bridges, structures,
16 electrical power, these would all be expected to be lost.
17 And their assumption was that there would be no
18 evacuation, but there would be some relocation, like 24
19 hours downstream of the event.
20 We looked also at some Commission decisions that
21 were made in the context of -- I guess the basic issue was
22 emergency planning and whether or not it needed to
23 explicitly consider seismic events in developing the
24 emergency preparedness programs.
25 And in the Commission's decision on that, which

1 had some degree of deliberation, this was for San Onofre and
2 Diablo Canyon, I think there may have been separate
3 proceedings on those plants, but the same basic issue. The
4 Commission view at that time, as stated in the decision, is
5 that emergency preparedness would have an only marginal
6 benefit in the large seismic events.
7 And then finally, we consulted with our expert,
8 Dr. Kennedy, on seismic, the level of off-site damage that
9 one would expect given the high levels of earthquakes that
10 we would need to have to fail the spent fuel pools. And
11 what's unique about spent fuel pools is that they have very
12 good -- they're very robust and if you -- if the condition
13 that we're concerned about is failing the pools, that
14 necessitates a very high ground motion and as a consequence,
15 you'd expect severe off-site damage.
16 So our realistic -- our rationale really is that
17 for the events that are giving us the concern for spent fuel
18 pools, the G values are so significant that it is a
19 reasonable expectation that radiological pre-planning would
20 have minimal impact on the ability to do an early
21 evacuation.
22 We think for the same reasons that relaxations in
23 emergency preparedness requirements would have a minimal
24 impact in these sequences.
25 So as you see on the -- for seismic, what we did

1 is we said we have basically two cases, the one column that
2 says full EP is we're going to characterize the risk
3 assuming that we have full EP. Essentially, existing
4 requirements are maintained in all aspects.
5 We said even when you do that, you're going to
6 have essentially a late evacuation. We said in the case if
7 you relaxed them, you'd also be late, for the same reasons
8 as I just said.
9 The next significant -- the next highest frequency
10 event from the level one is a cask drop event, and let me
11 just mention the frequencies, if you're not completely aware
12 about it.
13 The seismic event frequencies are
14 two-times-ten-to-the-minus-sixth if you base it on the
15 Lawrence Livermore hazard frequencies, and it's
16 two-times-ten-to-the-minus-seven if it's based on the EPRI.
17 So there's basically a full order of magnitude. That's a
18 mean value.
19 We looked at the spectrum of plants and decided
20 the mean was what we wanted to use. Actually, I think we
21 pick up 70 percent of the sites that are represented by the
22 use of the mean value.
23 So basically a decade difference if you changed
24 your seismic hazard source and then the next highest
25 sequence is a cask drop. And let me just say, a cask drop

1 is kind of characteristic of a general type of sequence that
2 you call a rapid drain-down event. Its frequency is
3 two-times-ten-to-the-minus-seven.
4 So it's equivalent to the EPRI seismic frequency
5 that we used. Boil-down is the last event there. It's just
6 slightly less than two-times-ten-to-the-minus-seven. It's
7 like 1.8-ten-to-the-minus-seven. So that's the relative
8 contribution from each of those.
9 The cask drop event is somewhat unique in that in
10 contrast to seismic events, there is no off-site damage, so
11 your infrastructure needed for emergency preparedness is
12 intact.
13 The event is unambiguous. When it occurs, there
14 shouldn't be any confusion that -- there's been a major
15 mistake here. It won't sneak up on you. So it's fair to
16 expect that the operators would recognize the damage and
17 make the notifications off-site in a timely manner.
18 Therein lies the question about the effectiveness
19 of emergency preparedness. If you have full EP, under the
20 current capabilities and planning that we do, what we said
21 in our analysis is that if there was enough time to the
22 release of fission products, if it exceeded around four to
23 five hours of delay time, then you could have an effective
24 evacuation.
25 In this case, we said for times greater than four

1 to five hours, we'll assume that it's an early evacuation
2 case, as Jason described, and when we had -- in the case
3 that we called relaxed EP, we said because you have no
4 formal off-site planning, it will -- things will have to be
5 done on an ad hoc basis. You may not have sirens, you may
6 not -- you may have to do notification via patrol cars and
7 loudspeakers, radios.
8 It would be less effective and it would take
9 longer. We believe that ten hours is a reasonable ballpark
10 estimate of the amount of time that might be ascribed to the
11 time needed to effectively complete evacuation given that
12 there really isn't any radiological pre-planning.
13 There is pre-planning for other natural disasters,
14 but we would be dropping the emergency preparedness for
15 radiological accidents.
16 So again, we assumed a late evacuation for times
17 after shutdown that resulted in releases earlier than ten
18 hours and we assumed an early evacuation for times after
19 shutdown that gave us releases after ten hours from the
20 initiating event.
21 Finally, on the boil-down sequences, we --
22 initially, on the outset, we thought, well, in boil-down
23 sequences, you got several hundred hours, so, obviously,
24 it's going to be an early evacuation, but in looking closer
25 at what really happens in the boil-down events, the

1 frequencies of events that we're quantifying are failure
2 paths and you're failing in these -- you've got hundreds of
3 hours.
4 If you've made even a halfway reasonable attempt
5 to get resources, you'd have very long times to execute
6 that. The things that get us to a boil-down event are
7 basically global failure, if you will, of the organization.
8 It's just the failure to notify or to secure in any way the
9 off-site resources necessary to maintain pool cooling.
10 So what we've done here is used the same rationale
11 to say if you have such a -- if you were ineffective in
12 several hundred hours of being able to secure off-site
13 resources to add some water to the pool, for the same
14 reasons, we think it's highly likely that you're not going
15 to make an effective notification or complete the off-site
16 actions.
17 Now, some of the contributions in these boil-down
18 sequences severe weather and it may not be a question of the
19 notification. It may be that you're unable to move the
20 resources. But for the same reason, you might not be able
21 to move the people.
22 So we basically said boil-down sequences would
23 have a late evacuation, whether it was full EP or whether it
24 was relaxed EP.
25 So what these assumptions do is essentially

1 provide the key to how we took the results from the
2 consequence calculations and linked them up with the level
3 one results.
4 DR. CRONENBERG: Excuse me. On the time, don't
5 you have to state a time greater than four to five hours?
6 That could be 20 days. What do you mean by that? You're
7 going to take some actions within a certain time period?
8 MR. PALLA: I have a slide here that kind of lays
9 out the point. What we're saying is the time to release
10 fission products increases as time after shutdown. That's
11 proportional to time after shutdown.
12 As the fission product decays, the time to heat up
13 the fuel rods and to release the fission products increases.
14 And these curves display the estimates that we've
15 generated. We did a case with air cooling and we have
16 PWR/BWR on the top plot and then we had a plot here just on
17 the bottom that shows for a PWR, the adiabatic heat-up rates
18 in the air versus the air cooling.
19 Now, interesting to note, on the adiabatic versus
20 air cool, number one, they're very close and one might think
21 that on the -- intuitively, that air cooling would be
22 superior and that things would be cooler, but in the air
23 cooled calculation, there's an oxidation term that accounts
24 for -- so there's some exothermic heat of reaction added to
25 that.

1 The adiabatic is simply an adiabatic calculation
2 without oxidation terms.
3 DR. CRONENBERG: I thought in the prior
4 exemptions, the air cooling did not include an oxidation
5 term, the ones that I looked at. There was no additional
6 heat load due to the oxidation. It was just air cooling.
7 MR. PALLA: Well, we've included it in these
8 calculations and I won't say that it's -- it will influence
9 the results. I won't say that it would change the results,
10 but it might be important.
11 Now, in getting back to the point that Tim made throughout
12 his presentation, the point being that we're unable to
13 determine the configuration that the pool may be in. If one
14 looks at the expectations for the pool failure modes in a
15 seismic event, for example, and we have Dr. Kennedy's input
16 in one of our Attachment 2 to Appendix 2-B, I believe it is,
17 he provides us some judgments about where the pool might
18 fail, based on some very limited studies that exist for a
19 couple different pools.
20 But basically, you could end up with a failure in the side
21 wall that would leave you with several feet of water. So
22 we're unable -- that's really a plant-specific failure mode
23 and one would have to look at the pool and its design and
24 the hazards for that site to determine where is the most
25 likely mode.

1 But on a generic basis, we were unable to conclude
2 things of that sort. And even a boil-down even, in and of
3 itself, will eventually reach a point, you'll boil down, you
4 will have the water level below the bottom of active fuel,
5 but still blocking the air flow path. So you'd have to heat
6 it by conduction and radiation.
7 So the key point here is adiabatic and air cooled,
8 not a lot of difference. We basically took the times off of
9 a plot like the bottom and said that -- I said four to five
10 hours for the cask drop accident and you can go to the curve
11 and look at how much time that gives you.
12 That's basically like one year, and then we said
13 it looks like about you need ten hours to give credit for ad
14 hoc EP for the cask drop accident and it looks like it's
15 somewhat over ten -- excuse me -- it's somewhat over two
16 years.
17 So let me just go to a --
18 DR. POWERS: Those calculations that you're
19 talking about on that plot, the adiabatic versus the air
20 cooled, are sufficiently straightforward. There really
21 isn't a great deal of uncertainty associated with that, if
22 you accept all your assumptions.
23 MR. PALLA: That's true.
24 CHAIRMAN KRESS: And this time is to get to 900
25 degrees C.

1 MR. PALLA: That's correct, in that calculation.
2 CHAIRMAN KRESS: We changed that to 600?
3 MR. COLLINS: We changed it to 600. See, the
4 times are so short in the early cases, that it's not going
5 to make much difference.
6 MR. PALLA: This is a plot at 60 days and it takes
7 off pretty quickly, looking at out at 600 or so. Whether
8 you use 600 or 800, your times are not substantially
9 changed. This is at 60 days. At longer times, the curves
10 will tend to be flatter, but we didn't see a tremendous
11 sensitivity to temperatures.
12 I guess this is a -- okay. This is just the
13 rationale for the modeling in each case, the slide is in
14 your package.
15 What I wanted to show here is for the cask drop
16 accident, we've got -- what we've done in the calculation is
17 essentially stick to the -- we're saying the risk is the
18 bold line, the heaviest line on the plot is the risk from
19 the cask drop accident. It is basically the results from
20 the consequence calculations times the frequency of the cask
21 drop accidents.
22 So you're going to see the axes labeled per year,
23 early fatalities. In this case, this is just representative
24 of what we're doing with cask drop accidents.
25 We're riding the late evacuation line and then

1 dropping down -- this curve here, this is the cask drop with
2 relaxed EP. So this is -- we're dropping down. We're
3 saying at about five years, you're going to have well over
4 ten hours at -- we only did the calculations at like 30
5 days, 90 days, one year, two year, five year, ten year. So
6 we're kind of making do with those data points.
7 We gave full credit for having early evacuation in the ad
8 hoc case at five years, but we stepped it down, this is just
9 a linear interpolation between the late evacuation at two
10 years and early evacuation at five years.
11 MR. COLLINS: You said at five years, you had ten
12 hours. You have 24 hours at five years.
13 MR. PALLA: You have well in excess. The reason
14 we didn't step it down earlier was because at two years, you
15 didn't quite have the ten hours. And it's unclear whether
16 you'd have ten hours in all plants. I mean, there's a lot
17 of questions, so if you're trying to make a generic
18 statement.
19 So what we did is, in essence, start to give
20 credit for it at that point and then essentially have full
21 credit for it at this point.
22 And then when you stuck with the existing
23 emergency preparedness requirements, you start this decline,
24 in effect, at the 90 day point and then at one year you're
25 getting full credit for early evacuation.

1 So you basically ride the lower part, the dotted
2 line part of the curve.
3 CHAIRMAN KRESS: The delta risk for this is --
4 MR. PALLA: The delta is effectively the
5 difference between the two curves. And after -- I guess
6 after five years, you don't see any delta, because the ad
7 hoc measures are fully effective.
8 CHAIRMAN KRESS: So you could choose a year and
9 subtract the difference between the two, the dotted line and
10 the solid line and get a delta.
11 MR. PALLA: Right.
12 CHAIRMAN KRESS: If you converted it into a risk.
13 MR. PALLA: Right. You could lift that off of
14 there. We have some plots in another appendix that just
15 present the risk increase, maximum increase.
16 CHAIRMAN KRESS: This is total early fatalities
17 and you have to divide this by the population and so on.
18 MR. PALLA: I've got another curve coming up later
19 that has that, the individual risk of early fatalities.
20 Now, this, the chart I'm going to throw up here
21 next, I think it's the next one in your package, this is
22 just one component of the risk profile. This is a
23 ten-to-the-minus-seven sequence that's swamped by the
24 seismic events or if you use the EPRI values for seismic,
25 it's equivalent.

1 These curves, taken from the report, show we've
2 included results for use of the Lawrence Livermore curve,
3 seismic hazard, and the high ruthenium source term. There's
4 the Livermore hazard curves with the lower ruthenium source
5 term.
6 I've got the EPRI hazard curves with the high
7 ruthenium and the low ruthenium source terms, so you can
8 kind of see the relative effects of each of those
9 parameters.
10 CHAIRMAN KRESS: It doesn't seem like there's much
11 difference between the relaxed and the full.
12 MR. PALLA: Exactly. That's what happens when you
13 swamp it with risks from other contributors. The deltas are
14 --
15 CHAIRMAN KRESS: That's because if you have the
16 risk from seismic, there's not much difference between the
17 relaxed and --
18 MR. PALLA: Yes. And this is a log plot, so you
19 lose that.
20 CHAIRMAN KRESS: That's another difference, yes.
21 MR. PALLA: So in our study, we have characterized
22 the value of EP or the -- I guess I'd say the risk impact
23 that you would have from an EP relaxation as being the
24 difference between the dotted and the solid curves for each
25 case.

1 Now, that goes back to the basic assumptions about
2 the effectiveness of emergency preparedness. Largely, it
3 gets back to the question of how effective is it in a
4 seismic event, and there is a sensitivity study that I'll --
5 it's described in one of the appendices for C, I believe,
6 where we maximize the credit and assume that EP was fully
7 effective, even in a large seismic event, we made the same
8 assertion. And even when you maximize it, we're still --
9 the risk increases still meet the goals.
10 Now, just a few statements about these curves, and
11 these are summarized on in your slide package there.
12 For the first one to two years, the early fatality
13 risk for the fire is low, but it's comparable to that for a
14 severe accident in an operating plant.
15 Now, I call your attention to the right-hand
16 margins of the figures, and what we've done, I alluded to it
17 before, we looked through the 1150 studies, the Peach Bottom
18 and the Surry plant, because they had the seismic
19 contribution in there, and we looked at the source terms
20 that gave us the greatest -- these are actually -- these are
21 per year. I'm sorry. These are the actual results from
22 1150 and represent the weighted results over all sequences.
23 And realize that the way that they presented these
24 results in the 1150 and really in the NUREG-4551 document is
25 where you find these details, but they presented results

1 with Livermore and they presented results with EPRI. They
2 didn't commingle them. They laid them out separately.
3 So we've laid them out here separately and in your
4 comparisons of the spent fuel pool risks with the Livermore
5 curve, they need to be compared to the operating plant risks
6 based on the Livermore, and likewise for the EPRI.
7 And on that basis --
8 CHAIRMAN KRESS: Why is that?
9 MR. PALLA: Why is that? Just to provide
10 consistent bases.
11 CHAIRMAN KRESS: What I was -- let me rephrase
12 that. Let's take the Surry with LLNL seismic. Now, this
13 number, the 9.5E-to-the-minus-five on here, that's the whole
14 risk number, isn't it, for all the sequences? All the
15 severe accident sequences.
16 MR. PALLA: Yes, with --
17 CHAIRMAN KRESS: It's not dominated by seismic,
18 because --
19 MR. PALLA: It's internal -- yes, it is. It's
20 internal events.
21 CHAIRMAN KRESS: Plus external events.
22 MR. PALLA: Plus --
23 CHAIRMAN KRESS: But you're saying it still --
24 MR. PALLA: No, just the seismic. We're adding
25 the internal events plus the seismic piece.

1 CHAIRMAN KRESS: You're just pulling out of the
2 total risk the seismic contribution here?
3 MR. COLLINS: No, it's internal risk plus the
4 seismic risk.
5 MR. PALLA: In the documents, there's a chapter on
6 internal events and there's risk values there and then
7 there's the seismic part of the report that provides it
8 broken out. These are the risk measures based on Livermore,
9 these are the risk measures based on EPRI.
10 What we're presenting in this right-hand side is
11 the internal events risk measure plus the Livermore part of
12 the seismic for that plant.
13 CHAIRMAN KRESS: And my question was if the
14 internal events far outweigh the seismic, then this is a
15 comparison that's not valid.
16 MR. PALLA: It still is total versus total,
17 because everything that we have from the spent fuel pool is
18 internally -- drain-down events, for example, boil-down
19 events.
20 CHAIRMAN KRESS: Yes, but they're dominated by
21 seismic. You have one dominated by seismic and the other
22 one not.
23 MR. PALLA: The operating plants, in fact, their
24 risk measures are dominated by seismic.
25 CHAIRMAN KRESS: In that case, it's a valid

1 comparison.

2 MR. PALLA: Initially, we started comparing just
3 the internally initiated event risk measures for operating
4 plants to these and then realized, hey, we're kind of apples
5 and oranges, to some degree, because the seismic risk is
6 what's dominating the pools.

7 Then we looked at the seismic contribution for the
8 operating plants and, lo and behold, it's orders of
9 magnitude bigger.

10 CHAIRMAN KRESS: So it is oranges and oranges.

11 MR. PALLA: Yes. Trying to make it as much so as
12 possible. So Livermore curves for spent fuel pool versus
13 Livermore results for the operating plants provide us
14 probably the least ambiguous way of characterizing those
15 differences.

16 DR. CRONENBERG: And the only difference -- you're
17 talking about early fatalities here, between the relaxed
18 emergency planning and the full emergency planning, is the
19 time. You're not taking into account the actual actions,
20 differences in actions.

21 It says, for example, in the industry commitments,
22 if you went to the generic rule, procedures in training a
23 person will be in place to ensure that site and off-site
24 resources can be brought to bear. Procedures will be in
25 place to establish communication between on-site and

1 off-site organizations during severe weather and seismic
2 events.
3 Are you telling -- how did you factor in
4 differences in actual actions for --
5 MR. PALLA: We did not look at details of
6 emergency plans and commitments on maintaining it. We took
7 more of a -- I'll characterize this as a bounding approach.
8 We're saying we're going to bound this by either saying the
9 evacuation is going to be early or it's going to be late.
10 That's as simple as it is. That's right.
11 DR. CRONENBERG: But in the generic rulemaking,
12 there will be relaxations in actual planning activities, not
13 --
14 MR. PALLA: There will be relaxations that will
15 affect the ability to actually do these things, but we're
16 assuming that --
17 DR. CRONENBERG: So we can't really accept these
18 numbers, this difference between the two curves without
19 really understanding the impact of the actions, not only
20 time.
21 MR. COLLINS: Recognize, the actions, with enough
22 time, you can always do whatever the actions are. So
23 ultimately time --
24 DR. CRONENBERG: Unless people don't know what
25 those actions should be.

1 MR. COLLINS: Well, even if they don't know,
2 depending on how much time you have, you can educate them.
3 You can tell them what they need to do.
4 Ultimately, there's two factors that we've
5 considered here. One is the time and the other is the
6 condition of the off-site structures.
7 In the seismic events, we said that the off-site
8 infrastructure is going to be severely damaged. Otherwise,
9 we couldn't have failed the pool in the first place.
10 In the case of the cask drop event, we say that
11 infrastructure is going to be well in place. You have the
12 event, everybody knows you had the event. We've maintained,
13 in both cases, that the on-site organization has to be
14 prepared to notify off-site organizations.
15 So the two factors really are things damaged that
16 you need to complete the actions and how much time do you
17 have to complete them. That's the way we looked at it. We
18 didn't get into any lower details than that.
19 DR. CRONENBERG: I understand that, but I can't
20 see how one can readily draw conclusions that this indeed is
21 the delta difference in the risk without understanding the
22 actions.
23 MR. PALLA: This is kind of an enveloping
24 assessment. If you just think of the seismic, we're
25 basically saying that there isn't any effect on the risk in

1 the seismic event from changes.

2 Now, we're not getting into the specifics of the

3 changes, what you're going to relax, what you're going to

4 retain. We're saying this is the risk and we see it not

5 changing.

6 DR. CRONENBERG: If I cannot buy that for a

7 seismic, I can't do it for cask drop.

8 MR. PALLA: Well, for cask drop, what we're saying

9 is we're simply drawing -- we're establishing a criteria of

10 timing and saying that we're making a judgment that within a

11 certain time period, certain things could be done early.

12 Effectively, enough that you could get an early evacuation

13 and we've ascribed just two different times to that. We

14 said it's four to five hours if you have full EP and we've

15 said it's on the order of ten hours if it has to be done ad

16 hoc.

17 Now, certain things have to be done to assure even

18 that, though. We're not giving away on-site EP. So there

19 still will be requirements associated with the on-site.

20 What's changing is the off-site. But these are not --

21 DR. CRONENBERG: Implicit in this, Bob, is that

22 the same actions, the same follow-through actions off-site,

23 if all you're going to look at is time, are the same for the

24 relaxed and the full.

25 MR. PALLA: The same actions have to be done.

1 It's just that more time is needed to do it, if it's to be
2 done on an ad hoc basis.
3 DR. CRONENBERG: To me, that's the emergency plan.
4 But anyway, go ahead.
5 MR. PALLA: And the effect of not having the
6 emergency plan is having to do them on an ad hoc basis and
7 so really the difference between the dotted and the solid
8 lines is really the risk difference that you see.
9 DR. CRONENBERG: But assuming the same actions.
10 It's the time difference.
11 MR. PALLA: That's correct.
12 DR. CRONENBERG: I agree with you there, then.
13 MR. PALLA: So really what you see here is that
14 for the first couple years, we're in the ballpark of the
15 operating plants at about five years, because in the case of
16 early fatalities, with the drop-off in the fission products,
17 largely a lot of the ruthenium is essentially gone at five
18 years, you're down like about two orders of magnitude lower
19 than the reactor accidents.
20 The changes to the EP is only acting on that one
21 contributor to the risk profile and it doesn't change that
22 statement at all, because it's such a minor change.
23 The use of the low ruthenium source term reduces
24 the early fatality risk by about a factor of 100 relative to
25 the high ruthenium source term within the first one to two

1 years and then it's diminished and you only see like a
2 factor of ten at about five years and beyond.
3 With the low ruthenium source term, the early
4 fatality risk for spent fuel pool accident is about an order
5 of magnitude lower than the corresponding values for the
6 reactor accident, shortly following shutdown, and about two
7 orders of magnitude lower at two years.
8 And I've got a curve in here. One could spend a
9 lot of time just going through the details of what all does
10 this mean and how much lower than are we.
11 In the case of the societal risks, these are risks that are
12 driven by the cesium, largely, slower, longer -- longer
13 half-lives, you don't see nearly the reduction as a function
14 of time.
15 CHAIRMAN KRESS: As best I recall, the difference
16 in the ruthenium high and low source terms was about two
17 orders of magnitude the number of deaths. Why don't I see a
18 two orders of magnitude change in this curve?
19 MR. PALLA: In going from a high ruthenium to a
20 low ruthenium source term?
21 CHAIRMAN KRESS: Yes. Just using the LLNL
22 seismic. Wasn't it two orders of magnitude?
23 MR. PALLA: It's one. We're talking societal.
24 CHAIRMAN KRESS: I'm sorry. That's the societal.
25 Whatever the early fatality was. Do we have one for

1 individual fatalities?

2 MR. COLLINS: Yes.

3 CHAIRMAN KRESS: I don't have --

4 DR. CRONENBERG: Figure 3, C7-3.

5 CHAIRMAN KRESS: You're right. It is about two

6 orders of magnitude. And which says that -- okay. If you

7 go from high LLNL to the EPRI low, you get two orders of

8 magnitude plus the factor of four you talked about.

9 MR. COLLINS: That's correct.

10 CHAIRMAN KRESS: Okay.

11 MR. PALLA: And in this case, you can see that if

12 you went to the low ruthenium source term, the societal risk

13 is about an order of magnitude lower than the risk for the

14 reactor accident. That doesn't change substantially with

15 time due to the decay of the fission products being much

16 longer.

17 CHAIRMAN KRESS: Are these using the atmospheric dispersion

18 numbers that were based on the --

19 MR. PALLA: Not the sensitivity study.

20 CHAIRMAN KRESS: These are the other --

21 MR. SCHAPEROW: This is what's built into the

22 MAACS code today.

23 CHAIRMAN KRESS: Okay.

24 MR. SCHAPEROW: The code hasn't been revised yet.

25 MR. PALLA: You were asking about the individual

1 early fatality risk, the comparisons to the safety goals.
2 DR. POWERS: Bob, when you're looking at these
3 consequence analyses and thinking of evacuation or
4 non-evacuation, are you -- you're envisaging a generalized
5 evacuation or is there some targeting to the evacuation to
6 follow the plume direction and things like that?
7 MR. PALLA: It would be the traditional key way
8 type of evacuation. I think the code itself might assume
9 just a radial evacuation. I don't know if you can use -- do
10 you know offhand?
11 MR. SCHAPEROW: It assumes everybody within ten
12 miles gets up and moves out, were it at four miles an hour.
13 DR. SEALE: But your delayed evacuation would be
14 key, because you'd know what the circumstances were.
15 MR. PALLA: The real life evacuation would be key.
16 The code's assumption is a simple radial evacuation in all
17 directions up to ten miles.
18 MR. SCHAPEROW: If there's a real accident, we
19 know the wind is blowing west, we'll move people out of
20 there. Not everywhere, but the code doesn't need to know
21 that, I don't think.
22 MR. PALLA: There are a couple statements about
23 them.
24 This is the individual early fatality risk within
25 the one-mile zone. This is the metric of interest for

1 comparisons to the Commission's safety goal. Got it noted
2 at the time -- five times 10 to the minus 7 is the safety
3 goal. Right hand margins, see the operating plants with
4 their margins.
5 Interestingly enough, if you will look at the
6 NUREG 1150 analyses they present comparisons to the safety
7 goal but they never rolled up the internal events and the
8 external events and combined them and then compared them to
9 the safety goals.
10 The point is you think these are closer to the
11 safety goal then you recall it's because we have combined
12 the internally initiated and the seismic piece.
13 Realize that in characterizing the operating plant
14 risks we did look at the effect of the change in the seismic
15 hazard curves that occurred subsequent to NUREG 1150 -- the
16 1150 analyses were based on I believe a 1989 version of the
17 Lawrence Livermore curves as well as the EPRI.
18 Then subsequently in '93 the Livermore curves were
19 changed. Our analysis is based on the later things, the
20 spent fuel pool analyses are based on the later, so we went
21 in and we looked at the hazard curves and made some
22 adjustments to account for the fact that -- at Peach Bottom
23 we made the adjustments there. Their hazard curve had
24 changed substantially -- the '93 Livermore versus the '89
25 Livermore.

1 DR. POWERS: Maybe you can't answer this.
2 Livermore got the study from Budnitz et al. and made a
3 change in their curves. Had EPRI gotten -- made the changes
4 in theirs to come up closer or would they get a uniformity
5 in the shift?
6 MR. PALLA: I don't know why there was no
7 corresponding change in EPRI. Any insights on that? Why
8 did we not change EPRI and change just -- okay.
9 [Pause.]
10 MR. KENNEDY: Bob Kennedy. This study that was
11 funded to improve the ability to make recommendations for
12 future seismic hazard studies, that was not the cause of
13 Livermore changing their hazard curves.
14 Livermore had already started the process of
15 changing their hazard curves so certainly some of the things
16 that I think caused Livermore to change their hazard curves
17 is some of the people who were involved in EPRI hazard
18 curves and people at EPRI and other people hired found a
19 number of problems in the '89 Livermore hazard curves and
20 those problems I think were ultimately recognized by
21 Livermore and Livermore made the modifications to correct
22 those curves.
23 Now the -- I think it's typically called the shag
24 study -- this study how to do future hazard curves -- it
25 originally was going to lay out a procedure for doing future

1 hazard curves with the hope that somebody would follow it
2 and do future hazard curves.
3 Now that somebody hasn't yet existed. There have
4 been no hazard curves actually done in accordance with the
5 full recommendations of that study but the more recent
6 Livermore hazard curves, the '93 and the EPRI hazard curves
7 which were not changes both are in reasonable agreement with
8 the recommendations of that study.
9 I think it is a mischaracterization to say
10 Livermore changed their results as a result of that study as
11 to how to come up with improved hazard curves.
12 Both Livermore and EPRI are in reasonable
13 agreements with what that effort suggested we should be
14 doing in the future and nobody has done a set of hazard
15 curves that are fully in accordance with that effort.
16 These two sets of hazard curves at least in my
17 judgment both represent some of the higher quality hazard
18 curves that we have available. We could have a better set
19 if somebody wanted to spend large amounts of money and redo
20 both of them.
21 I have no idea what that so-called better set
22 might come up with.
23 CHAIRMAN KRESS: Would it likely be in between the
24 two?
25 [Laughter.]

1 MR. KENNEDY: Probably. That would be my guess.
2 DR. POWERS: As long as you are guessing, would it
3 be more toward the upper one or --
4 [Laughter.]
5 DR. POWERS: We'll get this thing done here for no
6 cost at all.
7 MR. PALLA: You can see there that we are about
8 one to two orders of magnitude lower than the safety goal --
9 the upper curve is the highest seismic hazard, the one with
10 the highest source term. The lower curve is the EPRI
11 seismic hazard with the lowest source term and generally
12 right around in the middle is the effect -- we did not plot
13 them separately -- but if you just change even one of those
14 parameters individually you land in the middle, so this kind
15 of gives you a sense as to what might be the combined effect
16 if you have the worse case source term and the worst case
17 seismic hazard -- and you have got basically one to two
18 orders of magnitude.
19 The same is truth for the individual latent cancer
20 fatality risks as well -- one to two orders of magnitude
21 below the safety goal there.
22 In this case you are running pretty flat because,
23 as mentioned, the cesium is driving in this thing --
24 DR. POWERS: Again the conventional MACCS --
25 MR. PALLA: Conventional MACCS plume dispersion

1 model, yes.

2 DR. POWERS: So the relative positions of the two

3 might change but probably not below the safety goal?

4 MR. PALLA: Right, so we see some reduction. It

5 is about a factor of five over a five-year period that you

6 see in the early fatalities -- individual latent cancer

7 fatality risk measure is not much changed.

8 Once again, the changes, the impact of emergency

9 preparedness as modeled in terms of the risk impact doesn't

10 have much of an effect in terms of the margin, relative to

11 the margin in the safety goal it is a very small

12 contributor.

13 CHAIRMAN KRESS: Well, is this where you planned

14 on going into the 1.174?

15 MR. PALLA: Actually take a couple steps. It is

16 the next slide --

17 CHAIRMAN KRESS: The reason I am asking is is this

18 a good time to break for lunch?

19 MR. PALLA: Why don't we do that? I can pick up

20 with this.

21 CHAIRMAN KRESS: That seems like a logical break

22 point.

23 I actually envision there might be quite a bit of

24 discussion about these so this might be a good time to break

25 for lunch and let's come back at 1 o'clock, please.

1 [Whereupon, at 11:53 a.m., the hearing was
2 recessed, to reconvene at 1:00 p.m., this same day.]
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1 AFTERNOON SESSION

2 [1:00 p.m.]

3 CHAIRMAN KRESS: Can we get started again, please.
4 Okay, you're still on, Bob.

5 MR. PALLA: Okay. If anyone needed any extra
6 copies of the handouts, I've put a pile on a chair there.

7 Okay, I'm going to talk about each of the
8 principles in 1.174, Reg Guide 1.174, is impacted by
9 potential changes to EP requirements.

10 The one safety principle we don't address is that
11 the proposed changes need to comply with the regulations.
12 So, obviously, that one is not applicable, but there are
13 four other principles involving small increases in risk,
14 safety margins, defense-in-depth, and monitoring.

15 DR. SEALE: But if you ask that question, the
16 answer would be yes, wouldn't it?

17 MR. PALLA: When you're done with this. Well, if
18 you're doing a rule change, then you'll end up being
19 compliant with that.

20 DR. SEALE: Yes, okay. You understand what I'm
21 saying.

22 MR. PALLA: Okay, small increases in risk: Okay,
23 Reg Guide 1.174, Safety Principles, the proposed changes of
24 the licensing basis should result in only a small increase
25 in risk, consistent with the safety goal principles.

1 Now, it doesn't say how -- it doesn't speak in
2 terms of risk, per se; it speaks in terms of allowable
3 increases in core damage frequency for -- and that's a
4 function of core damage, the baseline core damage frequency,
5 and allowable levels of increase in the large early release
6 frequency, also, as a function of the baseline large early
7 release frequency.
8 So the concept is the risk is small and that idea
9 being that you're going to be still meeting the safety
10 goals, still meeting the goals with margin, is the way I
11 would interpret it.
12 But because it speaks in terms of LERF, and the
13 changes that we're looking at are not really changes in
14 frequency of large release; we're changing the consequences
15 that go with that.
16 What we did is take the allowable levels of
17 delta-LERF and combine them with the base -- with the levels
18 of risk at an operating plant.
19 And then we said, basically, if you're at ten to
20 minus five, we picked the ten to the minus five full
21 performance guideline and 1.174 says you could increase the
22 LERF by ten to the minus six.
23 And we essentially took ten to the minus six as a
24 multiplier, times the risk measures, the various risk
25 measures for Surrey. So we went to 1150 and the NUREG 4550

1 documents, we looked at the risk levels for internal events,
2 and external -- the seismic events.
3 We looked at the worst scenario that one could
4 have, and we basically said, if we assume as an upper limit,
5 what the Reg Guide would allow us, it would allow us a ten
6 to the minus six increase in frequency, and we will get
7 these most severe consequences as a result of that.
8 And we took the product basically and said this is
9 the most that you could justify under 1.174.
10 Actually, I was skipping ahead there. Let me just
11 kind of give -- before I plunge into that, just a couple
12 items up on the list there.
13 As we discussed previously, the comparisons that
14 we made to the various risk measures against the QHOs,
15 talking the individual early fatality risk, individual
16 latent cancer fatality risks for the reference plant, we
17 found that it met the QHOs by one or two orders of
18 magnitude, depending on assumptions.
19 And as time went on, these margins increased.
20 Now, implicit in this analysis is -- and one of the reasons
21 that you end up with the low -- the frequencies of events
22 that we talked about, is that the number of industry
23 decommissioning commitments have been made, and a number of
24 staff decommissioning assumptions are also implicit in the
25 analysis.

1 When one conforms with these assumptions and
2 commitments, the expectation is that the spent fuel facility
3 would have fuel uncovery frequencies comparable to the
4 referenced plant frequencies that we based our comparisons
5 on.
6 And so it's key that these -- what we refer to as
7 IDCs and SDAs, industry decommissioning commitments and
8 staff decommissioning assumptions, it's important that they
9 be conformed with.
10 This might be part of the rulemaking that's done,
11 that these would be required elements of a licensee having
12 the relaxations.
13 But you -- the point there that when one meets
14 these requirements, you can -- the results of our findings
15 of our study is applicable.
16 CHAIRMAN KRESS: In 1.174, you're dealing with
17 risk that's contributed by a whole host of different kinds
18 of sequences and different kinds of accidents, internal,
19 external, and the idea was that if you're going to go change
20 the regulations, or change their design basis to the
21 regulations, they're only going to allow you to do a small
22 change, a small increase in that risk, if your risk level is
23 already good enough.
24 Because you may make another change later, here.
25 We may make a change in rule here and there, and you have a

1 composite potential, an additive thing where you may be
2 slowly approaching sort of an absolutely level that you
3 don't like.
4 So we're going to make each change represent some
5 small increment of that, so that you don't really ever get
6 up there over the lifetime of the plant, based on the
7 accumulated changes.
8 The spent fuel pool seems to me like if you're
9 going to make this one change and that's it, do you have to
10 have the same small increase in risk associated with that?
11 Or could you take a chance or -- not take a
12 chance, but could you say, well, we're so well below the
13 goal that we want, we could actually allow much larger
14 increase in risk here, and then really conform to the spirit
15 of 1.174.
16 MR. PALLA: I think 1.174 also has provisions in
17 there for tracking consequences, additional amendments that
18 would --
19 CHAIRMAN KRESS: You should keep track, and then
20 do it, yes.
21 MR. PALLA: What you're suggesting is --
22 CHAIRMAN KRESS: You're going to track here or
23 you're --
24 MR. PALLA: -- left.
25 CHAIRMAN KRESS: There's only one thing you're

1 going to do one time, and that's it.

2 MR. KELLY: This is Glen Kelly from the staff. I

3 think if you go back to Bob's first and second figures where

4 he was showing the risk numbers for what we see for the

5 decommissioning facilities, and the comparisons against

6 operating plants, we'll see that, depending on which hazard

7 curves you believe, that there's not that much difference in

8 the risk between what we're seeing at a decommissioning

9 plant, and what we're seeing at an operating facility.

10 The decommissioning plant is lower, but not

11 tremendously lower. So I think from that standpoint, there

12 is reasonable basis for thinking that a small increase is

13 not unreasonable, and that larger increases would

14 potentially bring you up to a point where you don't want to

15 have the risk.

16 CHAIRMAN KRESS: Potentially, and particularly if

17 the uncertainties are much different in the two cases.

18 In any event, you can't go wrong with the small

19 increase.

20 MR. PALLA: We didn't see the small increase

21 criteria was an impediment to making the changes, at least

22 the way we characterized the risk from the changes.

23 CHAIRMAN KRESS: My comment would only apply if

24 you had a problem with the small increase not giving you --

25 if what you did resulted in actually a bigger increase than

1 what you've got.

2 MR. PALLA: I guess that if you would rationalize

3 it, it was a one time only change that maybe you can have

4 more latitude on.

5 CHAIRMAN KRESS: A one-time only change for a

6 small number of plants for a short period of time, you might

7 start throwing things like that into it.

8 MR. COLLINS: The Reg Guide 1.174 is a guideline.

9 It's not the criteria.

10 CHAIRMAN KRESS: That's right.

11 MR. PALLA: So you can say here's the guideline,

12 and you might even go beyond that guideline for other

13 considerations like you're suggesting.

14 DR. CRONENBERG: The Commission could certainly do

15 that. In your conclusions, you made those kinds of things

16 this morning for Millstone, with three and a half --

17 Millstone I with three and a half cores in the spent fuel.

18 And that's the basis for the source term, right,

19 all your calculations were for that one particular source

20 term?

21 MR. PALLA: It was for that. It was Millstone,

22 the power is scaled, and it's sited at Surrey.

23 DR. CRONENBERG: A little higher.

24 MR. PALLA: But it's either the NUREG 1465 source

25 term.

1 DR. CRONENBERG: Or Millstone --

2 MR. PALLA: Release fractions.

3 DR. CRONENBERG: The release fractions and the

4 inventory.

5 MR. PALLA: The inventory derives from the

6 Millstone power scale, and the release fractions are as

7 Jason provided from 1465 with adjustments for Ruthenium.

8 DR. CRONENBERG: Fine, okay. Now, and that's

9 representative of what we have today or in the past. Now we

10 go -- we're talking about rulemaking for the future, which

11 may have higher spent fuel burnups than Millstone.

12 You did it for the representative, you said it was

13 batched, representative, and batched according to Millstone.

14 Well, Millstone probably had things with fuel at

15 only 30 megawatt days per ton, rather than what we're now

16 going to, higher burnups.

17 And I don't know what the packing density was in

18 Millstone, but we seem to go to higher and higher packing

19 fractions in the spent fuels, and this probably is not going

20 to change until we get our long-term fuel storage.

21 So, though the future plants may be under more

22 pressure because they're operating longer, higher fuel -- is

23 your source term calculations for generic rules, are they

24 bounding everything that might come in in the future?

25 MR. PALLA: No. We did the thermal hydraulics for

1 a number of different burnups, but I think the bulk of what
2 we settled on was based on 60 megawatt days.
3 The source terms --
4 DR. CRONENBERG: I don't think --
5 MR. PALLA: What are you inventories --
6 DR. CRONENBERG: Inventories from Millstone --
7 MR. KELLY: There's a difference.
8 DR. CRONENBERG: What Jason was doing was for
9 actual inventories in the spent fuel for Millstone.
10 MR. PALLA: That' right.
11 MR. KELLY: This is Glen Kelly from the staff.
12 There's two different issues here: One of them is the
13 thermal hydraulic calculations that we did for determining
14 how much time it would take to eat up the fuel, and the
15 other one is, once you've had the zirconium fire, what kind
16 of releases you're going to get.
17 When we did the calculations for the heatup of the
18 fuel, there we did it for a variety of burnups and
19 configurations.
20 When Jason did the fission product release, it was
21 on the basis of the 1465 or out of basically a slightly
22 higher than Millstone I set of fission products.
23 DR. CRONENBERG: Still, the burnup, the
24 characteristic burnup of Millstone, and so you have -- so
25 it's a bounding calculation.

1 You saw there's a representative of what's around
2 today. I think that's what you're talking about.
3 CHAIRMAN KRESS: When you do the scaleups from
4 power, you just multiply the inventory by the power ratio?
5 MR. SHAPEROW: Yes. We used --
6 CHAIRMAN KRESS: So that's conservative.
7 MR. SHAPEROW: We actually assumed a 70-percent
8 increase and 70-percent power. We originally were focusing
9 on --
10 CHAIRMAN KRESS: So you brought power at 1.7 or --
11 MR. SHAPEROW: That's right.
12 CHAIRMAN KRESS: Each isotope?
13 MR. SHAPEROW: Yes, what I said earlier --
14 CHAIRMAN KRESS: So that's conservative to some
15 extent, too.
16 MR. SHAPEROW: What I said earlier about it just
17 being the Millstone inventories, Bob corrected me. We
18 actually did have a multiplier -- I think it was 1.7,
19 because we were looking at modeling a plant with higher
20 power, so we just said we'll jack that up.
21 So we actually increased --
22 CHAIRMAN KRESS: That's an easy way to do it.
23 It's conservative.
24 MR. SHAPEROW: But as Gus points out, we're not
25 bounding. I mean, some of the spent fuel pools might have

1 as many as ten cores in it. Maybe that's a maximum amount,
2 based on the highest packing.
3 I've seen those kinds of numbers. So we only have
4 three and a half.
5 CHAIRMAN KRESS: When somebody writes a rule,
6 they'll have to recognize these differences, say they have
7 to be accounted for or something in a specific plant?
8 MR. PALLA: If we were going to structure the rule
9 such that plant-specific submittals are needed, then
10 logically you'd want to look at those details.
11 My thought was that if we wrote a generic rule,
12 that we would hope that this is representative enough that
13 you could structure the rule and not require plant-specific
14 submittals, if certain conditions are met.
15 How that rule is really structured, remains to be
16 seen. Like we might limit it to 60 gigawatt day burnups,
17 and someone has higher burnups, they'd have to do some other
18 analysis.
19 Let me kind to get back to where I was started
20 there. My first bullet there is basically saying the level
21 -- the absolute level of risk is below the Commission safety
22 goals.
23 The second bullet deals with the risk increases
24 from AP, and the point is that the risk increases are small,
25 even under optimistic assumptions regarding the

1 effectiveness of emergency preparedness in seismic events.
2 Now, let me -- this is where I started speaking,
3 and out of place, actually.
4 Appendix 4D is where we looked at the Reg Guide
5 1.174 allowable increase in large early release frequency,
6 and we in effect translated a delta LERF into delta risk
7 measures, various risk measures. There is a slide that
8 follows this one in your package that I will try to explain
9 briefly what's showing on here.
10 We looked at early fatalities, population dose,
11 individual early fatality risk and individual latent cancer
12 fatality risk, the latter two of which relate to the
13 Commission's QHOs.
14 In this table, second column, I labelled it
15 Baseline. That is the risk increase due to emergency
16 preparedness relaxation as I have described earlier today.
17 This is where cask drop is the only sequence that is
18 affected by any changes.
19 In the second column or third column seismic
20 sensitivity, what we did there is said, well, as the
21 footnote says, let's assume that we'll give maximum credit
22 for the effectiveness of emergency preparedness when the
23 existing requirements are maintained and minimum
24 effectiveness when we relax it, and so what we did in effect
25 was say let's assume that we have an early evacuation for

1 the full EP case and a late evacuation for the ad hoc case.
2 Again we reverted back to the consequence results
3 for each of those situations, took those consequences times
4 the frequencies of the seismic events and computed what is
5 in the third column there.
6 That is a total risk increase when one is very
7 optimistic and says even though I know very well that
8 there's going to be extensive offsite damage if there was
9 some way that existing EP would still assure me an early
10 evacuation this is the ideal situation, so we are really
11 maximizing the benefit of EP by saying it's fully effective,
12 gives you early evacuation when you have formal full EP and
13 you get minimal effectiveness late evacuation under ad hoc,
14 and we come with the results in this third column.
15 Fourth column is the Reg Guide 1.174 increase that
16 one would get if you took the 10 to the minus 6 per year
17 increase in LERF, the product of that and the worst case
18 consequences for Surry, so these numbers here are all for
19 Surry but this column establishes in effect the allowable
20 increases.
21 In comparing the baseline values to the Reg Guide
22 allowable deltas everything here is a risk increase on a per
23 year basis. There's lot of margin, on the order of factors
24 of 10 in margin on early fatalities, population dose, right
25 on down the line.

1 The baseline assumptions where cask drop is the
2 only thing affected by EP, lots of margins, and then if you
3 shift gears and say I am going to put really bounding
4 assumptions on this and let's see on the seismic case you
5 can see you still have margins on early fatalities, on the
6 early fatality risk measure and the individual early
7 fatality risk.
8 You do see that the population dose is roughly a
9 factor of two higher, individual latent cancer fatality risk
10 generally a factor of about two higher than the Reg Guide
11 1.174 inferred values but another way of looking at this is
12 thinking back to the QHOs and what would the value of -- if
13 you took 10 percent of the QHOs and compared it to the last
14 two values, 7.3 e(-)8 and 1.8 3(-) 7, comparing those to the
15 QHOs, these are less than 10 percent the QHOs still, so even
16 though you appear to be about a factor of two higher than
17 what you might infer for Surry based on 10 to the minus 6
18 increase you are still within the 10 percent of the QHOs.
19 Your increase is like 10 percent of the QHOs.
20 Keep in mind that you are assuming early
21 evacuation in a huge seismic event that we in a level 50
22 methodology took no credit at all for it.
23 DR. SEALE: It's interesting. There's no question
24 but what the intent of the Commission is, that in some way
25 we would have to accommodate the spent fuel problem and we

1 have to do it within, I would assume, within the constraints
2 of the QHOs and the only real question is what constitutes
3 or is your judgment of what constitutes closeness good
4 enough to have merit in this discussion, you know.
5 The other things is that the Commissioners might
6 want to say something that there be -- like you said
7 earlier, a minute ago -- a fraction of the QHO but I don't
8 think they'd want to get into that business at all.
9 It seems to me you are taking the right approach.
10 That is, you are trying to set the value of this within the
11 context of the way that you are assessing the rest of the
12 system and I don't think there is much else you can do
13 except perhaps point out that the alternative is that they
14 say something about what the level is, and I don't think
15 they want to do that.
16 MR. PALLA: Yes. Well, I mean there aren't very
17 many definitive criteria that one can use to judge these
18 things. We basically have the safety goals that give you a
19 level of absolute risk and this should be less than that,
20 and the concept in Reg Guide 1.174 that says small
21 increases --
22 DR. SEALE: It does sort of put everything in a
23 nice, neat package.
24 MR. PALLA: And we're fairly bounding. I mean it
25 is hard to imagine a more bounding kind of a way to envelope

1 that situation as to way you have got early evacuation in a
2 large seismic event with full EP and late evacuation with ad
3 hoc. That pretty much maximizes the benefit there.
4 DR. SEALE: Do you see any choices or
5 alternatives?
6 DR. POWERS: What I guess is my perception is that
7 there is a lot of concern in the Commission on what they
8 call hanging on and I worry that your third column that you
9 had up there, Bob, is so bounding and what-not, and what you
10 do is you look at it and say, well, you know, we just barely
11 go over some of the acceptance criteria here and we are
12 below on most of them.
13 Other people might look at it differently, when in
14 fact your real argument is I am below the QHOs by a lot, a
15 nontrivial amount.
16 MR. PALLA: We are below it but I think here we
17 are talking to the delta here so we are really arguing both
18 of those points.
19 DR. POWERS: I think your seismic sensitivity --
20 you have got an extra measure and I am not sure but what it
21 doesn't just give a wrong impression.
22 MR. PALLA: It right. We deliberated on whether
23 or not to include that case but I mean it does provide some
24 information.
25 DR. POWERS: You have to be very knowledgeable to

1 understand what you are saying here because on first
2 examination you say, oh, well, if I really stretch these
3 things then I get into some benefit to this, when in fact
4 you have already established that it is not, and among the
5 Commissioners they worry a lot about the Staff doing all
6 kinds of machinations to hang on to various regulatory
7 things which by less contorted analyses they ought to let go
8 of.
9 If you were to ask me for a piece of advice on
10 this, I would say I would downplay the column 3 results.
11 You have said I have gone as far as I can possibly go to
12 possibly make this thing justifiable and I just don't do
13 it -- other people look at it and say you are going as far
14 as you can to find some rationale for doing this. Just a
15 comment for what it's worth. It is a political comment and
16 not a technical comment -- or maybe to just show you that I
17 understood what you did in that column.
18 MR. PALLA: The bottom conclusion is the continued
19 conformance with the industry decommissioning commitments,
20 the Staff design assumptions provides reasonable assurance
21 that risk is low and that the risk increases associated with
22 the changes to emergency preparedness would be small.
23 DR. POWERS: You have not attempted to look at, to
24 define the kinds of cases where you would have to do a
25 plant-specific analysis?

1 MR. PALLA: There could be instances where
2 plant-specific analyses are needed.
3 One such case would be for the high seismic sites
4 that -- the western sites and one eastern site that stands
5 out on the seismic hazard curve is outside of, I guess, the
6 group that we considered, so those plants would need to make
7 a plant-specific analysis.
8 It is also conceivable that plants don't fully
9 comply with the industry decommissioning commitments or the
10 Staff design assumptions and would, as a result one might
11 expect their frequencies to be higher. How much higher
12 would be really the basic question.
13 DR. POWERS: Have you tried at all to go back
14 through those commitments and see which ones are risk
15 significant and which ones are not?
16 MR. TIM COLLINS: It was discussed in the report.
17 DR. POWERS: You have to forgive me. I got the
18 report Thursday --
19 MR. TIM COLLINS: This is not an area we would
20 have expected you to read anyways because we didn't change
21 much in the frequency section but in that section there is a
22 discussion of where each of the SDAs and the IDCs impacts
23 the frequency.
24 MR. PALLA: In performing the level one analyses
25 for example certain commitments were considered instrumental

1 in the Staff's assumptions regarding certain failure rates,
2 recovery times, those kind of things.
3 They are not necessarily hard-wired but they
4 provide the groundwork -- it sets the stage for how the
5 quantification was done so we tried to have an accounting of
6 each one of those and where it plays in in the analysis.
7 DR. CRONENBERG: Don't you have to go beyond just
8 the seismic weather and the seismic region or not, like what
9 Jason said. If one came in with 10 cores tightly packed,
10 although there is absolver material in the spent fuel, it is
11 a different, it could be a different cap than this what we
12 call prototypic kind of spent fuel.
13 MR. PALLA: Well, two things about that though.
14 We use three and a half cores. We are not --
15 there is no full understanding about propagation and whether
16 fire would be limited to the most recently off-loaded cores
17 or whether it propagates three or more if you had more, so
18 the propagation question is something that we are not clear
19 on.
20 DR. CRONENBERG: Specific analysis would have to
21 demonstrate that it didn't propagate to the fifth or sixth
22 core or whatever.
23 MR. PALLA: Another point that I want to make is
24 that even though we looked at three and a half, it accounts
25 for the lion's share of ruthenium because if you consider

1 the pool is loaded with assemblies that vary in age, a third
2 of the core taken off at each outage, you have quite old
3 fuel.
4 Anything past three and a half cores has been in
5 there long enough that it has no more --
6 DR. SEALE: They're on the bottom of the deck.
7 MR. PALLA: I think we estimated 80, 85 percent or
8 so of the ruthenium is accounted for in these --
9 DR. SEALE: Are there any sites were two plants
10 are sharing the same spent fuel pool?
11 MR. PALLA: Yes, there are a number of them.
12 DR. SEALE: That's what I thought, so probably
13 they are the ones that are potentially the higher inventory,
14 that is fresh inventory sites.
15 MR. PALLA: They might not shut down at the same
16 time though.
17 DR. SEALE: Yes, but they are all on a 12 month,
18 whatever-it-is cycle and so there are two-thirds going in a
19 year or two-thirds a cycle.
20 DR. CRONENBERG: You might have Unit 1 shut down
21 five years before Unit 2 and so that is what he's saying so
22 he is sort of neglecting --
23 MR. TIM COLLINS: You wouldn't be relaxing any of
24 the requirements just because the first unit is shut down.
25 The second unit operating would have all the operating

1 reactor requirements still in place.

2 MR. PALLA: These changes if it is a multiple unit

3 site they share the same pool, we wouldn't be doing these

4 relaxations until the second unit was decommissioned. Then

5 we would be considering this.

6 MR. KELLY: This is Glenn Kelly from the Staff.

7 Also we did these assumptions for the volumes of

8 water in the pool and that based on a single pool and a

9 single reactor.

10 You would normally expect that you are going to

11 have about approximately twice the volume if you have two --

12 you are sharing pools or three times if you have got three

13 units, but these are all things that we have written down

14 specifically on our analysis where we have indicated what

15 our assumptions were about how we did it and we expect in

16 the rulemaking will be picked up and it somehow will be

17 integrated into the rulemakings to have a check against this

18 to see that somebody is not grossly different from what we

19 have assumed.

20 DR. SEALE: Well, you talk about -- that the pool

21 or let's say that if you had plants being decommissioned

22 sequentially and so on that all of the rules currently would

23 still apply until that plant went into the

24 decommissioning -- but nevertheless you want the transition

25 from a storage facility on the tail-end of an operating

1 reactor to a storage facility that accommodates the spent
2 fuel from a now decommissioned reactor to be relatively
3 seamless.
4 You want it to be smooth and you don't want to
5 suddenly have to do things with fuel that now is old and
6 brittle and everything else that's all the wrong things that
7 you don't want to have.
8 MR. KELLY: This is Glenn Kelly from the staff.
9 We don't require anybody to move any fuel, to do anything
10 differently from what they are currently doing. There is
11 nothing in there that would preclude them from following
12 their current practices that they have about moving the fuel
13 or putting it, they choose, into dry cask storage along the
14 way.
15 This is just a matter of whether not, you know,
16 we've tried to analytically determine what the risks were
17 that were associated with that operation of having the spent
18 fuel pool itself.
19 MR. PALLA: Proceed to defense in depth?
20 CHAIRMAN KRESS: Yes.
21 DR. POWERS: Even though you don't know what it
22 means.
23 MR. PALLA: This is pretty philosophical. Well,
24 this isn't as philosophical as you will make it, but, okay,
25 the bottom line conclusion is that the remaining emergency

1 preparedness requirements, which would be the onsite
2 requirements, together with a substantial amount of time
3 available for emergency response, will provide a sufficient
4 level of defense-in-depth for spent fuel pool accidents.
5 Now --
6 CHAIRMAN KRESS: The thing we'll jump on right
7 away is what does the word, sufficient mean? Continue,
8 please.
9 MR. COLLINS: Look at where you are relative to --
10 MR. PALLA: It's kind of commensurate with the
11 frequencies of these events. That's one way to think of it.
12 In the large seismic events that dominate the
13 risk, as --
14 CHAIRMAN KRESS: If I were to extrapolate that
15 philosophy to operating reactors, does it say if I can get
16 the CDF down low enough, I don't have to have a containment?
17 MR. COLLINS: If you can convince the Commission.
18 DR. SEALE: It's interesting, though, this thing
19 says that sufficient defense-in-depth is provided by the
20 requirements that remain in your emergency plan, plus the
21 additional decay time that this fuel gets as it just sits
22 there.
23 And that's all defense-in-depth that you have.
24 MR. PALLA: We're swamping out the offsite aspects
25 that we have with full EP, replacing them with ad hoc, which

1 is enabled through the additional --

2 DR. SEALE: I understand that, but what I'm saying

3 is, there are no other defense-in-depth measures that you

4 have.

5 MR. COLLINS: I think that's right; I think that's

6 correct.

7 MR. PALLA: Well, there is still defense-in-depth

8 for prevention. But in mitigation sense, yes, there's no

9 containment, so there's -- but there still are preventive

10 aspects that one, if you chose to focus on that aspect of

11 defense-in-depth, we have the IDCs, the SDAs, the systems

12 that we have.

13 DR. CRONENBERG: Pumps.

14 MR. PALLA: So there is a preventive element in

15 here, too, but what we're talking about here was just on the

16 mitigation side. You've got the onsite, and you've got now

17 more time that you could effectively replace the offsite

18 capabilities through an ad hoc capability.

19 DR. SEALE: You had to qualify the statement for

20 me.

21 MR. PALLA: Is it sufficient now?

22 Okay, in the large seismic events that have

23 dominated the frequency of uncovery, as we mentioned, the

24 current preparedness, emergency preparedness would be of

25 marginal benefit, due to the extensive collateral damage.

1 So any relaxations in EP are not expected to
2 substantially alter the outcome of the large seismic events.
3 Now, you might say that, well, you don't have
4 defense-in-depth, but you might argue also that you don't
5 have it today for the same events, so we're not changing
6 this component of the risk profile. It's basically the way
7 that it is today.
8 CHAIRMAN KRESS: Since we're only at this point,
9 talking about relaxing the emergency preparedness part of
10 the whole issue, is that a tremendous burden on the
11 licensees?
12 Do they --
13 MR. COLLINS: They will be speaking, the industry
14 will be speaking, and it would be a better question for
15 them.
16 CHAIRMAN KRESS: Okay, we'll wait for them.
17 MR. PALLA: So the number one contributor is
18 basically set aside, and then you drop down a decade in
19 terms of frequency, and in those sequences, one would expect
20 that EP could be effective because you've got your
21 infrastructure intact, and notification would be timely.
22 So we'd look at cask drops and say now what level
23 of protection do you need for those?
24 We think that -- recall that the cask drop
25 accidents that we're looking at, there's a lot of -- there

1 is a range of accidents, like heavy load drops, that could
2 drop on the wall, they could drop on the floor, they could
3 drop --
4 CHAIRMAN KRESS: Once you've put the spent fuel in
5 the pool, and you've said now we'll shut down the plant and
6 I'm decommissioning it, are there any more casks you move
7 around over there?
8 MR. PALLA: I think there are still some more.
9 CHAIRMAN KRESS: There are some sealed things you
10 move around that can drop into the pool?
11 MR. KELLY: This is Glen Kelly from the staff. In
12 the -- what's been happening recently is that the industry
13 has tended to put the building that has the spent fuel pool
14 kind of isolating that from the rest of the reactor complex.
15 And they have started dismantling the rest of the
16 complex and left the spent fuel pool, whatever building it
17 is that's housing the spent fuel pool building there.
18 At some point, usually five years after -- it can
19 happen actually while you're operating -- a utility may
20 choose to start moving its fuel into dry cask storage.
21 Currently, although the regulations allow you to
22 put fuel into dry cask storage, one year after it's been
23 removed from the reactor, we don't have any designs for the
24 casks that are licensed for anything less than five years of
25 decay.

1 So, generally --

2 CHAIRMAN KRESS: After five years, you're well

3 down on that risk curve.

4 MR. KELLY: Right, but what they might be doing is

5 that I've got fuel that's been in there five years, and I

6 also have newer fuel, and I can start moving fuel.

7 We currently have plants that are pulling fuel out

8 while they're operating.

9 CHAIRMAN KRESS: Well, okay, I see.

10 MR. KELLY: So what you can do is then at some

11 point they may choose to start pulling the fuel out of the

12 spent fuel pool, and putting it into the dry casks, and that

13 will involve moving the heavy casks.

14 DR. SEALE: You're not going to disable or

15 deactivate your cranes. Because eventually you're going to

16 need them.

17 And as long as the cranes are there, you've got to

18 consider the casks, because that's --

19 MR. KELLY: Or something very heavy that you can

20 move over there, like one plant recently moved the steam

21 generator over there that's a little heavier than the casks.

22 DR. POWERS: Bob, I'm puzzled a little bit on the

23 tack you've taken here on defense-in-depth.

24 You know, we usually think about defense-in-depth

25 in terms of prevention and mitigation. We have a little

1 different view in the area of fire.

2 But what you've done, it looks to me as if you've
3 started going through the accidents that penetrate all the
4 defense-in-depth capabilities, and say, now, what do I have
5 to mitigate these accidents that have penetrated all the
6 other defense-in-depth?

7 I think you ought not overlook the fact that we've
8 got pools, they've got water in them, that we have lots and
9 lots of ways to mitigate the consequences of a leakage and
10 whatnot.

11 That's why that accident didn't ever show up in
12 your risk -- basically, most blowoff accidents are going to
13 get caught, and people are going to put a garden hose in
14 there and they're going to recover it.

15 So there's lots of defense-in-depth that deserves,
16 I think, mention on this slide before you go in and say,
17 now, what do I have to do about these accidents that have
18 actually penetrated through all of these layers of
19 defense-in-depth? What do I have on that besides -- if I
20 don't have emergency preparedness?

21 MR. PALLA: On this slide, we stepped past that.
22 In the report, we do discuss the fact that there is
23 preventive measures there.

24 And I stepped to the very end to say that if in
25 these events that do lead to failure --

1 DR. POWERS: What you're really looking at is,
2 what, in the reactor? Is it the last line of
3 defense-in-depth, and seeing if you need that one or not in
4 this sequence; not defense-in-depth in general, because
5 there's lots of that actually still here.
6 DR. SEALE: That's what I was kind of getting at.
7 MR. PALLA: And the other spin on this is that
8 this is the defense-in-depth that is retained when you're
9 making a change in EP.
10 So that might have been some of the reason for
11 kind of not focusing much on the prevention.
12 DR. POWERS: It's not your big fish here in the
13 presentation -- but I don't want to overlook it in the
14 actual stand.
15 MR. PALLA: Okay. Getting back to the cask drops,
16 what we had done in the anslysis is assume that the cask
17 drop results in a catastrophic failure of the pool, which
18 drains it immediately.
19 This obviously is the most bounding scenario that
20 one could conceive of. If one looked at the likelihood of
21 lesser events and of the likelihood of the one that we
22 considered, it's unclear how one would partition that out.
23 But one could say that at 60 days, if you actually
24 had this hypothetical scenario, then you wouldn't, for the
25 cask drop accident, have enough time for an ad hoc offsite

1 response at 60 days.

2 But if one considers the broader set of accidents

3 in this category, it's very likely that there would be lower

4 leak rates and maybe the potential for spraying the pools.

5 That's not true?

6 MR. KELLY: No.

7 MR. PALLA: Well, in the limit, though, if we're

8 just -- if we do say, well, our best -- our representation

9 is what we want to go with, the risk, it's not a

10 defense-in-depth argument, I realize, but the risk

11 associated with this sequence and not having the EP in this

12 sequence is not that great. It's a small fraction, as we

13 showed in the other things.

14 But that's really a different argument than a

15 defense-in-depth argument.

16 That's what we are left with, essentially, a

17 judgment that defense-in-depth is reasonable, and it's

18 really commensurate with the frequency of the events that

19 we're looking at for spent fuel pools.

20 MR. COLLINS: And the frequency is so low because

21 of --

22 DR. POWERS: You can make it more, but just don't

23 let them move the cranes over fuel that's less than a year

24 old.

25 DR. SEALE: Yes.

1 MR. PALLA: There are controls, exactly,
2 administrative controls on movement. It's one of the
3 commitments that we have.
4 So this is why you're at ten to the minus seven
5 levels.
6 Safety margins: You've heard this same argument
7 before. If a facility conforms with the IDCs and the SDAs,
8 would meet the QHOs, so you're starting out with the
9 absolute level of risk being substantially below the QHOs,
10 and increasing with time.
11 There is -- I'm going to bring it up later, if you
12 have interest in it and we have time to do it; I'll discuss
13 this pool performance guideline and what we've extracted
14 from that.
15 But the essence of it is that so long as a
16 facility's uncovery frequency is less than ten to the minus
17 five per year, even with the severe source terms that were
18 considered in the consequence calculations, even when one
19 trolls through the various sensitivity studies and pulls out
20 the worst case, the worst case that I'm talking about is one
21 where there's 100 percent Ruthenium release.
22 And even for that, you link the consequences for
23 that source term with the ten to the minus five uncovery
24 frequency, and even then you continue to still meet the
25 safety goals.

1 So, the first two elements talk to the absolute
2 level of risk, and then you get to the third item that is --
3 I'm shifting gears -- talking about the risk increases.
4 As I showed in that prior table, under the
5 baseline case and even in the sensitivity study case, as
6 far-fetched as that might be perceived to be, the risk
7 increases are below the Reg Guide allowables, if you will.
8 Finally, in the case where we maximized the value
9 of EP, and said that even in a large seismic event, if we
10 said full EP would give us early evacuation and ad hoc EP
11 would give us late evacuation, even then the risk increases
12 appear to be small in like about ten percent of the QHOs.
13 So, we think we've got sufficient safety margin,
14 and, again, this is all from a risk perspective, and a lot
15 of it is relative to the change in the EP requirements.
16 But it appears that there is substantial margins
17 there, and this is, again, on the mitigation side, and
18 there's prevention and there's timing arguments, and other
19 things that one could argue as well.
20 Okay, with regard to monitoring, our expectation
21 is that certain requirements will still remain, even after
22 any relaxations or rulemaking.
23 We would expect these four subitems to be carried
24 forward under any new rules. The performance and
25 reliability monitoring of the spent fuel pool systems, the

1 heat removal, AC power, and so on, would continue to be
2 controlled under the maintenance rule.
3 There's a commitment in the staff decommission
4 assumption, actually, regarding carrying forward the
5 monitoring program for Boroflex materials, and we would
6 expect that to continue under the relaxations.
7 Heavy load activities and load paths are going to
8 be controlled by the licensee in accordance with the
9 commitments made, the Industry Design Commitment Number 1 is
10 what it's referred to.
11 So that will carry forward, and licensees should
12 continue to provide a level of onsite capabilities to assure
13 prompt notification, characterization of releases,
14 development of protective action recommendations, and
15 communications with the public.
16 The thought is that there would still be some kind
17 of periodic onsite exercises and drills. So there will --
18 this, in a way, is a monitoring function on monitor
19 performance to confirm that those capabilities are still
20 there.
21 And we think that when you roll them up, the
22 bottom line conclusion is that continued compliance with
23 maintenance rules, the IDCs, SDAs, and the remaining EP
24 requirements would provide a reasonable level of monitoring
25 for spent fuel pool safety.

1 So that's the last of the safety principles. I
2 have a slide on the pool performance guidelines, if you're
3 interested in going through that.
4 CHAIRMAN KRESS: Yes, we would.
5 MR. PALLA: Okay, the pool performance guideline
6 was conceived in the earlier version, the February version
7 of the Technical Working Group Report. A value of ten to
8 the minus five per year was recommended.
9 It's based on large early release considerations,
10 given that a spent fuel pool fire has no -- there's no
11 containment, so if you get to that situation, it's
12 effectively a release to the environment, a large early
13 release in operating reactor terms.
14 And how much worse, you know, it looks like it's
15 on par with the severe reactor accidents, bypass type
16 accidents in an operating reactor.
17 We did relook at this, the concept as well as the
18 value, ten to the minus five value, in light of the revised
19 calculations that were done to address source term issues.
20 And we think that it still is a reasonable upper
21 bound that one could use to conclude that if plants are
22 maintaining less than that, that you should still continue
23 to meet the Commission's safety goals as they are defined,
24 the individual risk of prompt fatalities within one mile,
25 and latent cancer fatalities to an individual within ten

1 miles.

2 The ten to the minus five would, in and of itself,
3 provide -- establish the frequency of the pool fires, and,
4 in fact, we're still saying uncovery equals fire, and that
5 this may, as time goes on, be less and less true, and it's
6 dependent on failure modes.

7 We've assumed all the failures go to a fire, and
8 if some are air-cooled successfully, then some partition
9 could be arguably air cooled without a fire.

10 But they would remain unlikely, even if every one
11 went to that. Now, it wouldn't be a desirable situation,
12 but it would cap the frequency of the event.

13 The risk would continue to meet the safety goals,
14 and small increases in risk, you know, would be allowable.
15 So, that's what compliance with a ten to the minus five
16 would provide you.

17 Now, let me just switch to -- I've got a table at
18 the end of the handout, and it kind of explains what we've
19 done.

20 We've looked at, for each of the source terms,
21 either the high Ruthenium early evacuation, high Ruthenium
22 late evacuation, low Ruthenium, you know, early and late,
23 and then also for the worst source term from the prior set
24 of consequence calculations.

25 What we've done is, we've lifted the individual

1 early fatality risk, and individual latent cancer fatality
2 risk results from the MACCS calculations for those
3 parameters, so that's in the second column and the seventh
4 column over.
5 That's your individual, risk to an individual of
6 either the early fatality or latent fatality. We've said as
7 an assumption, the PP -- you're at the PPG of one times ten
8 to the minus five, and just the product of that would be the
9 probability of the early fatality.
10 So, that is comparable. You could compare the
11 results in this column to the QHO. And then in the column
12 that follows, it's -- we just presented the fraction of the
13 QHO that this value has achieved, and you can see that in
14 all cases, regardless of the source term, in some cases,
15 we're close, but we're always below the QHO, and this is
16 assuming the ten to the minus five multiplier.
17 And the same is true, whether you look at the
18 individual risk of prompt fatality or the latent cancer, and
19 you can see that you're still -- your prompt fatalities are
20 still the ones that are governing, i.e., they're the closest
21 to meeting or exceeding the QHOs.
22 The latents do not -- are not the ones that are
23 driving it. So, I think this is some of the issue that you
24 had raised, Dana, about the concerns that the large
25 Ruthenium source terms might shift the balance and you might

1 be driven more, controlled more by the latent effects?

2 DR. POWERS: It's not the source term that causes

3 the problem; it's the environmental dispersal that causes

4 the problem.

5 CHAIRMAN KRESS: And I was on under the impression

6 that some of the actinides might cause that problem.

7 DR. POWERS: Yes, they might give you a more

8 active -- what is a bit frustrating about this figure, is

9 that you're giving me an estimate that is difficult to

10 characterize, but for the sake of argument, let's call it a

11 mean value.

12 But I don't have a good estimate of how close, I

13 mean, the uncertainties are in these values.

14 CHAIRMAN KRESS: Yes.

15 DR. POWERS: So when I see numbers like one

16 percent of the QHO, I don't worry about it. I mean, okay,

17 it could well be that if I looked at your 95 percentile

18 band, that you actually go over it, because we're talking

19 big uncertainties here, and so it's up there.

20 But I'm less concerned about it because I'm

21 supposed to be comparing means and means. But I'd like to

22 know how close I am. When I get these 70 percent numbers,

23 now, all of a sudden, I really wish I had the uncertainty

24 bounds here. That would make me feel a lot more

25 comfortable.

1 MR. PALLA: I guess one issue would be what
2 uncertainties would you bring into this assessment? I mean,
3 we have the source term uncertainties that one might say
4 that -- I don't know if you want to call that reasonable
5 best estimate or -- it's conservative, but there are
6 uncertainties on the source term.
7 DR. POWERS: You've got a lot of --
8 MR. PALLA: There are uncertainties on the plume
9 models, and whether -- yes.
10 And you come close, but, you know, you wouldn't
11 expect to be a one times ten to the minus five, either, if
12 you were operating in accordance with the design --
13 decommissioning commitments.
14 DR. POWERS: A lot of it is, I will admit, optics.
15 And it's only because you came close that the optics become
16 a concern.
17 And I will also admit that the calculational path
18 that gets you to these numbers, probably really isn't the
19 mean. I mean, if we went through and did a Monte Carlo
20 uncertainty assessment, which is not -- wouldn't be too
21 difficult to do with all the stuff that you guys have done
22 -- we could -- we wouldn't find numbers as high as yours on
23 these for the median value or the mean, either one.
24 I can practically guarantee it, because you've
25 kind of been biasing yourself up all the time.

1 MR. PALLA: Okay, this is --

2 DR. POWERS: Now, you will have this change, and
3 it's something we're going to have to pursue in the future
4 as we digest this information, that it may well be that in
5 reality, you're dominated -- your limiting is that the
6 latent cancer fatality, and not the prompt fatality, just
7 because of the more realistic or -- maybe they're not
8 realistic, but more expert-endorsed plume parameters could
9 change which one is the more limiting of those up there.

10 That really only matters for the higher, the
11 realistic high Ruthenium source.

12 MR. PALLA: Back to the bottom line, going to the
13 IDCs and SDAs and your frequencies should be consistent with
14 the reference plan analysis and as such would meet the PPGs
15 and plants that do not meet the IDCs and SDAs such as high
16 seismic, at the high seismic sites, or if you just had
17 something at the site that wasn't consistent with the
18 assumptions in the Staff's analysis, or consistent with the
19 commitments, the thought is that there would need to be a
20 plant specific submittal that demonstrates acceptability.

21 This is where the PPG might be used as decision
22 criterias -- is the risk low enough.

23 This last bullet really pertains to what we might
24 end up with if one proceeded and packaged up a rulemaking
25 and structured it such that you had to have plant specific

1 submittals in some instances. The one times 10 to the minus
2 5 might come into play there.
3 Otherwise, if you meet your IDCs and SDAs we would
4 expect that you would be comparable to the reference plant
5 frequencies and you would be at a lower frequency than that.
6 That is the end of what I wanted to present here.
7 DR. CRONENBERG: In the February report you gave
8 us the industry commitments, their general commitments and
9 the Staff assumptions and you have a statement in here that
10 these industry assumptions and Staff commitments will be
11 identified and implemented as appropriate in future
12 regulatory activities.
13 When we say that, there will be some communication
14 between onsite and offsite personnel and that is an industry
15 commitment. We still don't know what kind of communication
16 that is and yet you are telling us that you can show us the
17 incremental effect on risk if you meet these industry
18 commitments, and at the same time you are telling us that
19 these commitments -- we don't know what these commitments,
20 exactly what these commitments are.
21 These are philosophy commitments, not this is what
22 will be done -- you will have a telephone -- blah blah
23 blah -- you will have a VHF radio, a single sideband
24 transmitter receiver.
25 How do you estimate what the effect on the risk is

1 if you don't know what your commitments are?

2 MR. PALLA: What we have done is bounded the

3 effects and what we have not done is tied each of the

4 specific commitments to a delta risk. We haven't subdivided

5 anything that finely.

6 We have just have a bounding estimate of --

7 MR. TIM COLLINS: We have confidence that we can

8 implement these philosophies in a practical manner when we

9 need to do it.

10 I don't think you will find that the industry

11 commitments are so unachievable as to make the analysis

12 unrealistic.

13 DR. CRONENBERG: I don't see how you can

14 demonstrate your effect on risk when you don't know based

15 upon industry commitments, when you don't know what the

16 difference is before and after, when you haven't defined

17 that.

18 You are trying to give us numbers on delta risk.

19 MR. PALLA: Bounding effects, scoping type

20 numbers.

21 DR. CRONENBERG: But that got confused too because

22 your source term analysis was based on present plant

23 conditions. They weren't bounding, necessarily bounding,

24 the Millstone -- it was for a plant that may not have -- all

25 the offloads weren't at 60 megawatt days per ton, so they

1 might not have had all the inventory in there.

2 I don't know if it is bounding yet, Bob, and I

3 don't know --

4 MR. TIM COLLINS: I don't think we were trying to

5 be bounding necessarily. We did some sensitivities which

6 approach bounding but I don't think --

7 MR. PALLA: Well, we didn't argue it was bounding

8 but it's kind of representative -- I think it is pretty

9 close to it, but it's one thing to think it is close to it

10 and another thing to claim it.

11 DR. SEALE: That's right. You're not doing the

12 rule yet. You made that comment already.

13 MR. PALLA: Yes.

14 DR. SEALE: Now one of the questions is do you

15 want to add that question -- respond to that statement in

16 the rule. I am not sure you do.

17 MR. PALLA: What we have done I think provides the

18 general context, the order of magnitude sense to what is the

19 risk implications of these kind of changes, you know, on the

20 order of magnitude type -- does it compromise our ability to

21 claim that we meet the safety goals and how dramatic of an

22 increase in risk might you get.

23 I think what we have done is taking a very

24 simplified approach and I think we have bounded it and in

25 the sense that -- maybe in the sensitivity study is the best

1 example, where we have said in a seismic event with full EP
2 you will have early evacuation and with ad hoc you would
3 have late evacuation.
4 I think that is pretty bounding, so --
5 DR. CRONENBERG: So you anticipate --
6 MR. PALLA: -- but we are not hard-wired --
7 DR. CRONENBERG: -- there would be a guidance
8 document with all these sort of things spelled out.
9 MR. PALLA: Those details that you mentioned I
10 think would be -- it is our expectation that that would be
11 hashed out with the industry in rulemaking.
12 We are just providing some order of magnitude
13 sense as to where does this thing fall and does it affect
14 the margins to the safety goal, how does it affect
15 comparative operating plants.
16 MR. TIM COLLINS: There would need to be an
17 accompanying Regulatory Guide with the rulemaking, no doubt
18 about it.
19 MR. PALLA: I think we're done.
20 CHAIRMAN KRESS: Okay. In that case why don't we
21 turn to the next item. We are going to hear some views from
22 the Nuclear Energy Institute representative.
23 [Pause.]
24 MS. HENDRICKS: This is going to be sort of an
25 interesting experience. I'll look at two slides at once.

1 I guess I would like to start by saying I
2 appreciate the invitation by the ACRS to share industry's
3 perspectives of this issue.
4 I think you get into a lot of philosophy, policy
5 type questions which of course everybody has a lot of
6 opinions on.
7 CHAIRMAN KRESS: We certainly appreciate your
8 willingness to come in and share these views.
9 MS. HENDRICKS: Thank you.
10 I would also like to say that I really appreciated
11 hearing the Staff's presentations. They have obviously done
12 an awful lot of work. I have to state upfront that I have
13 not had the ability -- or the opportunity, maybe not the
14 ability either, to review the Staff's report at all.
15 I am very interested to see it and I am sure we
16 will have some opportunity to put in some comments.
17 I don't know that that is going to be issued
18 specifically as another draft for comment but certainly as
19 it goes to the Commission there will be an opportunity to
20 give some views on that.
21 I think since I am going to try to stick more to
22 philosophy and some of the policy implications of this
23 initiative to risk inform decommissioning regulations I am
24 going to start by reviewing the Commission's, what I
25 interpret as the Commission's directives on risk informing

1 decommissioning regulations contained in their 12-21-00 SRM.
2 They talk there about an integrated, risk-informed
3 rulemaking specifically addressing EP financial protection
4 security backfit and operator training. They directed the
5 Staff in that SRM to consider all realistic scenarios.
6 I would like to note at this point that later
7 Commission decisions on reduction of applicability of
8 operating plants will be needed in many other areas and so
9 that the risk study in my view should be viewed as a tool to
10 look across the board and not just explicitly at a couple of
11 requirements, and certainly I would like to not see an
12 over-emphasis on EP.
13 Some of those later decisions that we have
14 indicated could benefit from risk insights, and again risk
15 insights should be useful whether the rule is risk based or
16 not, so I would maintain that it may be a different sort of
17 approach for something like financial protection versus
18 maintenance rule, but risk insights nonetheless should be
19 valuable in both cases.
20 DR. POWERS: What do you mean by the M maintenance
21 rule?
22 MS. HENDRICKS: That's strictly a typo.
23 [Laughter.]
24 DR. POWERS: I am sitting here --
25 MS. HENDRICKS: I even though about --

1 DR. POWERS: I mean what acronym is an M?
2 [Laughter.]
3 DR. SEALE: I little M.
4 MS. HENDRICKS: Right. Maintenance rule with a
5 little M because actually we don't think that the
6 maintenance rule should apply.
7 We think the system is so simple that the type of
8 specific commitments --
9 DR. POWERS: The empty maintenance rule is what
10 you meant.
11 What you raise is an interesting view. What you
12 saw today was the Staff moving expeditiously to develop a
13 technical basis to support a particular decision, and they
14 made a variety of justifiable technical shortcuts in doing
15 that, but that is to support a particular decision, I think,
16 in regard to this.
17 There is not reason to think that those technical
18 shortcuts would be similarly suitable in looking at all
19 these other decisions including your "empty" maintenance
20 rule decision here.
21 Are you saying that you would like to see the
22 Staff re-examine this technical body of work and get it in
23 better shape so that it could be something that we would
24 have on the shelf and be able to go back to as we confronted
25 each one of these things?

1 MS. HENDRICKS: Right.

2 DR. POWERS: I think that is very consistent with
3 the kind of view that the ACRS expressed in their first
4 letter on this subject.

5 Tom, she's good people, and we can let her come
6 again.

7 [Laughter.]

8 MS. HENDRICKS: Well, we're not done yet.

9 DR. POWERS: You wanted to quit while you're
10 ahead.

11 MS. HENDRICKS: We've put something in here to
12 make everybody mad up there.

13 So, in my view, then, looking from the broader
14 perspective of looking at a lot of rules, the scope then is,
15 to state it broadly, is to use risk insights to adapt
16 deterministic rules for operating plants to decommissioning
17 plants.

18 And I think that it's important to realize that's
19 what this rulemaking is about, taking operating plant
20 requirements and doing something with them for the
21 decommissioning plant configuration.

22 One of the challenges in doing that -- and I think
23 the staff has wrestled mightily, and I think also
24 effectively with these, is the challenge to adapt the
25 risk-informing measures to different types of consequences,

1 lower probability, and a different type of system. In other
2 words, it's passive, robust, and you for the most part have
3 slowly evolving sequences.
4 DR. POWERS: When you say different types of
5 consequences, are you speaking of things like Mr. Seale's
6 land contamination and Dr. Kress's latent injuries?
7 MS. HENDRICKS: Yes.
8 DR. POWERS: She knows that. Do you want to join
9 the Committee?
10 [Laughter.]
11 MS. HENDRICKS: Not yet, not yet. The objective,
12 then, given that --
13 CHAIRMAN KRESS: On that list underneath your
14 second bullet, I would have added a bullet, fewer plants,
15 shorter times associated, things that are in people's minds
16 about risk, but never seem to get explicitly factored in
17 very much.
18 MS. HENDRICKS: Absolutely. That's a great one.
19 Maybe we are going to get along. I like that.
20 So the objective, then, if that is the scope, I
21 think is to best inform the Commission to make judgment
22 calls, and we've talked about that. That's come up many
23 times today, but I think that in the end, they are going to
24 be fundamental decision on fundamental issues, EP, financial
25 protection.

1 There is no magic formula. We don't have
2 risk-based approaches to begin with for virtually any of the
3 requirements.
4 So, in my view, the way to do that is to provide
5 the Commission with an apples-to-apples type comparison to
6 the maximum extent possible with the risk profile presented
7 by operating plants, because, in essence, we're taking
8 requirements that were slapped onto operating plants and
9 we're trying to determine if, and to what extent those
10 requirements should be reduced for decommissioning plants.
11 And the second issue then becomes -- and, again, a
12 lot of discussion on this with the last presenter -- is to
13 examine defense-in-depth in context, that you have a simple
14 passive system where most sequences again have all been --
15 I'd even add your point again that fewer plants and a
16 shorter risk period.
17 CHAIRMAN KRESS: We made that point when we talked
18 about risk-informing NMSS activities, where the risk may be
19 lower, the systems a lot less complex, and you're not
20 dealing with thousands of sequences; you're dealing with a
21 few.
22 That under those circumstances, it seems like you
23 ought to alter your thinking of how and what the depth of
24 the defense-in-depth ought to be.
25 MS. HENDRICKS: Exactly.

1 CHAIRMAN KRESS: And that's what you have in mind?
2 MS. HENDRICKS: Exactly, defense-in-depth
3 commensurate with the -- well, I won't say risk, because I
4 think risk is an absolute term.
5 So that, I think, leads you to the issue of risk
6 treatment. I think it's imperative when you're looking at
7 something like this, because it is an apples-to-apples
8 comparison with operating plants, it's really nothing else.
9 And in that sense, I think it has to stand in a
10 absolute risk sense as well. We've got to be a little
11 careful about getting too distracted in specific
12 applications like EP. I think we need to remember that
13 ultimately the Commission is going to need this tool of an
14 absolute risk that is an apples-to-apples comparison.
15 It's really important that it be some sort of a
16 best estimate.
17 CHAIRMAN KRESS: I hate to ask you this, but what
18 do you mean by best estimate risk treatment?
19 MS. HENDRICKS: Well, we've heard a lot of
20 examples, and I think it's very much human nature to say,
21 well, there's uncertainty, so we'll be conservative.
22 Everywhere there's uncertainty, we'll be conservative.
23 And when you end up compounding those
24 conservatisms, you end up with a skewed answer of the risk,
25 and I think you, by skewing the overall risk, you lose

1 opportunities to make -- I'll get to that more at the end --
2 to do actual, practical risk-informing.
3 Once you determined that the overall risk is so
4 great, for example, that you can't reduce your operating
5 plant requirements, you've really missed an opportunity to
6 apply the more practical risk reduction measures.
7 Because in the end, in a regulatory sense, when
8 the staff sits down and tries to implement these
9 commitments, there's going to have to be something given to
10 justify the increase.
11 I mean, you can't just shut down and have EP and
12 financial protection that was devised for a full range of
13 operating events, and now you've got EP and financial
14 protection, even if it's slightly different EP for this
15 single pool, much reduced set of sequences, and you're going
16 to add all these expensive requirements onto the system at
17 the same time, like seismic screening.
18 One of the commitments was to add new
19 instrumentation to the pool. You cannot justify those costs
20 in a regulatory basis, you cannot justify costly
21 improvements if you're going to retain the operating plant
22 requirements.
23 It's sort of --
24 DR. SEALE: One of the comments in the discussion
25 we've been having lately on what constitutes an adequate

1 PRA, one of the comments, of course, is that in many cases,
2 the PRA should not be comprehensive, but rather when you're
3 looking at the difference between two alternatives, to focus
4 on the details of those differences.
5 And this, it seems to me, is a good example where
6 you want to be very selective in the sense that you look at
7 the problem.
8 MS. HENDRICKS: And if you're not careful --
9 DR. SEALE: And not invent a bunch of other things
10 to throw into the soup.
11 MS. HENDRICKS: If you overstate the risk, you'll
12 obscure the differences, and you won't even be looking at
13 them.
14 And also I think if you don't do a best estimate,
15 I mean, you're going to end up taking Agency resources and
16 industry resources and focusing them on this event, and if
17 it's a good estimate of the risk, that's appropriate, but if
18 you greatly overstated the risk, you've taken industry and
19 Commission resources away from focusing on other areas that
20 might actually have been more risk significant, or may have
21 offered more opportunity to take steps to actually reduce
22 risk.
23 I mean, the thing that concerns me about this is
24 we're often left in this scenario where we are dominated by
25 a large seismic risk for which there is not mitigation

1 possible.

2 CHAIRMAN KRESS: You can't do anything.

3 MS. HENDRICKS: You can't do anything about it.

4 CHAIRMAN KRESS: With respect to this compounding

5 of conservatisms on uncertainties that you don't know, we've

6 often been faced with two ways that's been handled.

7 One way is, you look at what you know about the

8 parameter and you pick out a value you think represents the

9 mean value, just as a guess, and you plug that into your

10 PRA.

11 Another way is to look at the possible ranges and

12 put some sort of distribution on it, and do a propagation of

13 that error through and get a distribution of uncertainty.

14 Do you have a choice for which of those you prefer

15 in something like this?

16 MS. HENDRICKS: I guess I'm not enough of an

17 expert at looking at PRAs to appreciate the difference. I

18 mean, I may be drawn to say, look at the means, and you'll

19 end up with the best estimate, which really is what you're

20 going for.

21 But I guess I don't -- I'm not well versed enough

22 in the application of those concepts to really give a

23 definitive answer.

24 It's a good thing Dana left, because the next

25 bullet may not agree so well with you guys. I guess I have

1 some concerns about some of these phenomena that to me
2 appear to be somewhat novel, the Ruthenium, and some of the
3 things that can generate large amounts of fuel fires being
4 used as the basis for this risk study, if they haven't been
5 validated, as some of the other severe accident concerns
6 have, more thoroughly, and then vetted through the Agency
7 prior to their adoption and prior to their application in a
8 regulatory sense.
9 Second point: More efforts, I think, should be
10 devoted to the probability side of the risk equation, and
11 here, I'll say a little more next about the seismic risk.
12 But also, I'll observe that if the probability is
13 acceptably low, eventually there will be some diminishing
14 returns on efforts to further refine the consequences,
15 however, I don't think that means that you don't need to do
16 best estimate on the consequences.
17 I mean, that's a particular area of concern where
18 you may end up getting into new areas and saying, well, we
19 don't know, so we'll assume 75 percent Ruthenium release. I
20 mean, we've seen over and over today, what a tremendous
21 impact that has on the risk profile for the whole --
22 CHAIRMAN KRESS: It makes a huge difference.
23 MS. HENDRICKS: Yes, a huge difference, orders of
24 magnitude.
25 CHAIRMAN KRESS: But I think Dana might argue that

1 that's more close to the best estimate in the sense of what
2 we know about it, than not having it.
3 MS. HENDRICKS: Right.
4 Turning to the seismic risk, again, just stated
5 empirically, I think the fact that these huge seismic events
6 that end up being background risk factors, for operating
7 plants, dominate the risk profile for decommissioning
8 plants.
9 I think that should be cause for pause and
10 additional efforts to put the seismic risk in perspective.
11 Some approach to that would be to treat it in a manner that
12 is comparable to operating plants, but then also to look at
13 the final conclusion, that if the whole risk is being driven
14 by the seismic, then should there be more effort to qualify
15 that in terms of risk informing and the Commission's policy?
16 CHAIRMAN KRESS: I think you're absolutely right
17 on those two bullets; that there is a difference in the
18 seismic contribution, and that what I think we were asking
19 for is can we look at the uncertainties somehow and quantify
20 them, and show that your uncertainties on the one end are a
21 lot different than on the other, and deal with that some
22 way.
23 But I don't know how to deal with this issue,
24 other than that, because I think Mr. Kennedy told us that
25 with the spent fuel pool, you're operating down at the end

1 of the curve as a very low frequency, and that just
2 uncertainties are probably huge. We have no data for it. I
3 think I'm quoting you correctly.
4 MR. KENNEDY: This is Bob Kennedy again. I mean,
5 we're operating -- I've been in the vast majority of the
6 seismic PRAs on the operating plants, and for core damage,
7 it's controlled by things typically that are weaker than the
8 spent fuel pool, so the annual frequencies of core damage
9 tend to be higher than the annual frequencies we're talking
10 about here.
11 For consequences, the operating plant has a
12 containment, and we've been saying the spent fuel pool is
13 robust, but the containment is more robust than the spent
14 fuel pool.
15 So, I mean --
16 CHAIRMAN KRESS: So it's not exactly.
17 MR. KENNEDY: So it's not exactly. We are dealing
18 with something robust here in the spent fuel pool, but
19 consequences, as long as you have that containment, the
20 containment helps, and it's more robust than the spent fuel.
21 CHAIRMAN KRESS: Thank you, that helps, yes. So
22 that in a sense, these two are directly comparable?
23 MR. KENNEDY: The calculations are being done
24 identically.
25 CHAIRMAN KRESS: Okay, thank you.

1 MS. HENDRICKS: This one is bound to stir some
2 controversy. I do think that with the seismic risk there is
3 some opportunity to disposition the risk deterministically.
4 I thought that was the route we were on when we engaged with
5 the Staff, developed the seismic checklist, and the concept
6 there is to screen out -- you can screen out not having
7 vulnerabilities to seismic at two to three times the SSE,
8 which is thought to give you quite a large margin.
9 Most PRAs screen out at the SSE by using the
10 seismic experts. I was corrected. I understand that a lot
11 of the IPEEEs did and that some of the newer PRAs don't in
12 fact do this. They do in fact treat the seismic risk in
13 more of a probabilistic fashion.
14 In response to your question or your statement you
15 really don't know how to put or treat the seismic risk, I
16 thought it was interesting to look at NUREG 1150, their
17 discussion of external events in the beginning of the report
18 and what they essentially decided to do for seismic, which
19 was, first of all, they are sort of -- even though it was a
20 long time ago they are where we are today -- then they
21 acknowledge that the Livermore approach does tend to permit
22 rare but large events to contribute significantly to risk.
23 They did acknowledge that the EPRI and Livermore
24 approaches are both fundamentally sound, same conclusion we
25 heard from Dr. Kennedy.

1 However, the action that they took I thought was
2 interesting in terms of a perspective and that was they
3 stated that they were going to avoid including offsite
4 consequences in risk from findings because of the lack of
5 the ability to put those findings in context.
6 The context that they were referring to is, the
7 recommendation was that if you are going to look at those
8 consequences in risk from very large, which include these
9 very large seismic events that you ought to then in fact put
10 it in the context of the overall losses that would be
11 experienced with the event -- in other words, the
12 non-nuclear property losses, life losses, that sort of
13 thing.
14 They had reference to one reference that said that
15 the nuclear losses from the seismic event would be
16 relatively small compared to the overall losses, and I think
17 this is a good point to emphasize because we all agree these
18 are very large events but no matter how often you say it I
19 think you need a little more to put that into context.
20 I mean these are events that are going to have
21 tremendous impact on the whole region.
22 CHAIRMAN KRESS: You are saying this size of an
23 earthquake is going to kill a lot more people than the 70,
24 80 or 90 we talked about?
25 MS. HENDRICKS: That was the implication.

1 CHAIRMAN KRESS: I might agree except it sort of
2 leaves out the land interdiction and the injuries issue but
3 I think they are comparable.
4 You could always recover from an earthquake
5 eventually. You put a lot of cesium out there --
6 MS. HENDRICKS: High cost though.
7 CHAIRMAN KRESS: -- and it is expensive, yes.
8 MS. HENDRICKS: You may have an opportunity to
9 look at re-use of the land different ways.
10 DR. POWERS: There is a question I have on this.
11 It may not relate to this talk so much as the previous talks
12 on this -- evacuation in the face of a large earthquake.
13 I have in mind Browns Ferry. As a plant it
14 happens to be on my mind. If I had a large earthquake at
15 that site it might do grievous things to the towns that are
16 nearby. The population in the vicinity of the plant --
17 there's no major infrastructure to destroy. The roads may
18 be impassable but not very impassable. You can go around
19 any damage to them.
20 CHAIRMAN KRESS: With four wheel drive.
21 DR. POWERS: And most of them have that -- so, you
22 know, I am thinking, gee, might not be so difficult to
23 evacuate that affected population even in the face of a
24 fairly large earthquake.
25 CHAIRMAN KRESS: That's probably true.

1 MS. HENDRICKS: You still have to give
2 notification some way and electricity is out and how would
3 you notify people that they should be more concerned and run
4 in this direction when everything around them was --
5 DR. POWERS: But, see, I don't actually buy off on
6 this run in one direction or the other sort of arguments
7 because I know the wind changes and it changes fairly
8 frequently at most of these sites and at Browns Ferry in
9 particular it changes really frequently so the idea of a
10 keyhole evacuation is probably a bad idea. You want a
11 uniform evacuation at that site.
12 MS. HENDRICKS: But they still need to know to run
13 away from the plant instead of towards it.
14 CHAIRMAN KRESS: That's true.
15 DR. POWERS: And as far as notification, I mean
16 you can quite literally go tell them.
17 CHAIRMAN KRESS: Like they did in Chernobyl.
18 DR. POWERS: Chernobyl had an advantage in that
19 the population was under a fair amount of control and in
20 fact there they delayed evacuation because they were afraid
21 of evacuating through -- into the plume direction -- as you
22 well know as a noted expert.
23 I am wondering and maybe we want to not discount
24 the efficacy of evacuation in a large earthquake just
25 because we envision major cities having big problems but the

1 fact is that we have deliberately located these plants --
2 CHAIRMAN KRESS: Away from them.
3 DR. POWERS: -- away from major cities and away
4 from big things that get destroyed, so that they may come
5 through the earthquake in a fairly swimming fashion.
6 My own experience in rural areas around a 7
7 earthquake is that after a little bit of shaking you hardly
8 even know anything happened.
9 CHAIRMAN KRESS: What do you think about the last
10 bullet in the second slide?
11 DR. POWERS: I guess I just would echo exactly
12 what you say, that you have to be very careful in making
13 comparisons of reactor accidents to any other kind of
14 accident because of this peculiarity of the consequences.
15 Again I harken back to a comparison of Pripyat to
16 cities in the south that seem to annually get evacuated in
17 response to train wrecks. They go back, whereas Pripyat we
18 don't go back.
19 MS. HENDRICKS: Again, we covered this. The
20 defense-in-depth considerations should not necessarily begin
21 and end with EP considerations and may involve more
22 fundamental differences in the operating plant versus the
23 spent fuel pool, such as the robustness of the structure,
24 simplicity of operation, slow evolution, and then the last
25 bullet on that slide is just another point of comparison,

1 that you have hundreds, literally hundreds, of internal
2 sequences in an operating plant.
3 CHAIRMAN KRESS: That is a valid point.
4 DR. POWERS: Especially the complexity. If you
5 look at the history of the evolution and thought about
6 defense-in-depth the complexity of sequences played such an
7 important role in how it has evolved.
8 Now you are talking out things that leak or don't
9 leak. There are not too many ways to cause a loss of
10 coolant. It boils off, leaks out, and that's it. I mean
11 Martians don't cause water to change into gas or something
12 like that.
13 MS. HENDRICKS: Getting to the conclusions again
14 in sort of the regulatory space and I guess this conclusion
15 is, the first one is certainly opinion on my part that
16 bounding estimates of seismic risk should not be used to
17 justify retention of operating plant requirements that were
18 in fact intended for a much broader scope of initiating
19 events.
20 Second conclusion, overly conservative treatment
21 of seismic risks can lead to the conclusion that operating
22 plants' requirements should in fact be retained across the
23 board. That has other ramifications in regulatory space.
24 CHAIRMAN KRESS: Have you considered what you
25 heard on this risk study to be overly conservative or

1 bounding?

2 It has some conservative aspects to it, that's for

3 sure.

4 MS. HENDRICKS: Yes.

5 CHAIRMAN KRESS: I don't know what overly

6 conservative in this context would mean.

7 MS. HENDRICKS: Yes, and again I am at a bit of a

8 disadvantage not having the benefit of seeing the study

9 where you can kind of go through and best estimate is a

10 little like -- I guess the adage is pornography, where you

11 know it when you see it but you can't necessarily define it.

12 CHAIRMAN KRESS: Right.

13 DR. POWERS: I think that's inherently challenging

14 because there was not an effort to keep track of the

15 uncertainties and the compounding effect of -- you know,

16 they take a little bound here and a little bound there and

17 pretty soon it starts to add up to real money.

18 In our previous letter on this subject we really

19 asked for an uncertainty analysis and I don't think it was

20 essential for this particular decision. I mean I think they

21 got to that particular decision, but if you are looking at

22 this as that bedrock of phenomenological analyses that can

23 underpin a variety of decisions with respect to

24 decommissioning, you know, you really kind of miss having

25 that because you would like to know lots of things and you

1 harken back to the instrumentation issues and are these
2 things really essential.
3 Maybe with a good, strong phenomenological
4 understanding you could understand what is essential and
5 what is not essential, as an example, but there are probably
6 others in your list. Defense-in-depth itself probably be
7 attacked more rigorously if you have a good, strong
8 phenomenological understanding.
9 CHAIRMAN KRESS: I have noticed in the past that
10 as we develop better phenomenological understandings in the
11 whole area of risk that we often change our views as to what
12 is conservative, what is not, what is important, and what is
13 not. You just get to know more.
14 DR. POWERS: You have this additional problem of
15 what is conservative in the context of this particular
16 decision could well not be conservative in the context of
17 another decision.
18 DR. SEALE: But I think it is a lot more fruitful
19 to take a look at the context of decommissioning and focus
20 on the places where you know the real unique risk, that is
21 the risk that the Commission is concerned with addressing in
22 its regulation, namely the spent fuel, focus on that and
23 what it means to the overall process of decommissioning and
24 then looking at that then you get a feel which you can then
25 wean into, as necessary, into the rest of the problem.

1 So it strikes me that this is a much more fruitful
2 way to look at those risks, hazards, whatever in the
3 specifics of spent fuel pools rather than trying to look at
4 the whole thing at once. It is hard to get your hands
5 around it then, and this is what the Commission is
6 interested in and legally they are required to be concerned
7 with.
8 DR. CRONENBERG: Tom asked a question a little bit
9 about what is the impact on cost for the full -- the
10 emergency plan for operating plants and then a reduced
11 emergency plan for the spent fuel. After one year, what --
12 can you address that? -- what is the impact on cost if we go
13 one route versus the other.
14 MS. HENDRICKS: The cost deltas are a little --
15 they have to be qualified a little bit.
16 I got an estimate from one plant, a single unit
17 plant, that if you got rid of EP and financial protection
18 you would save about $2 million a year, and obviously if it
19 goes out one year it is not a big deal but if it goes on and
20 on and on that is a lot of money.
21 DR. CRONENBERG: What about just on the emergency
22 planning, if you got relief after one year, just that part
23 of the approach to this generic rule?
24 MS. HENDRICKS: I think the estimate there, and I
25 think we would need to revisit it in terms of how much

1 relief you got, but it all comes down to staffing and if you
2 can't shrink staffing I know it came out to it seems like it
3 was a couple hundred thousand dollars a month to have extra
4 staff to support extra staffing for full EP --
5 DR. CRONENBERG: For just the emergency planning?
6 MS. HENDRICKS: It may have involved other
7 things -- security -- I mean before you can actually
8 process, shrink your programs down.
9 DR. CRONENBERG: Decay time buys you a lot. Do
10 you know the cost difference between an exemption for
11 emergency planning if you kept it in place and got relief
12 after one year or got relief after three years, because
13 decay time just buys you a lot from a regulatory perspective
14 on safety --
15 MS. HENDRICKS: Right. Again, it was my
16 recollection that it was, the financial protection for a
17 single unit plant is a big deal.
18 Ironically it is not as big a deal in cost
19 differential for a multi-unit plant because some of the cost
20 is site-specific and some of it isn't.
21 DR. CRONENBERG: Yes, but they are looking at now
22 financial protection, indemnity -- you start talking about
23 five years or longer because of different assumptions --
24 MS. HENDRICKS: Right.
25 DR. CRONENBERG: -- and new ways of looking at

1 spent fuels than what was in the past.

2 MS. HENDRICKS: Right.

3 DR. CRONENBERG: I would really like to restrict

4 it right now to I am trying to understand where is the big

5 payoff here with all the work that is being done on relief

6 from emergency planning.

7 MS. HENDRICKS: The quote about the single-unit

8 plant was two million a year, and I think the preponderance

9 of that was financial protection. So let's say 500,000 plus

10 was EP, and that might be a good back of the envelope sort

11 of calculation.

12 DR. CRONENBERG: So it's not a terrific amount

13 when there's more expensive -- probably be relicensed,

14 they're going to go for renewal. We already have 20 some

15 exemptions, and they're not going to be looked at again.

16 Maybe we're going to get maybe five.

17 MS. HENDRICKS: Right. It's more than -- I mean,

18 literally staff cost is one way to look at it, but then if

19 you're due for another drill, do you do a full-blown drill

20 with the public, you know, involving FEMA and the states?

21 And beyond that, an important point that some

22 plants brought up is that it's also a public communication

23 issue. I mean, what are you telling them the risk of this

24 thing is?

25 You shut the plant down, and if, in fact, the

1 spent fuel pool was actually just as risky as the plant, why
2 weren't they told that?
3 You beg some questions.
4 DR. CRONENBERG: But another part of that point is
5 that people might feel comfortable that -- I think most
6 people can understand decay, okay, and what time buys you.
7 What's the imperative to go to the one year
8 exemption versus out a little further in time?
9 CHAIRMAN KRESS: For two years.
10 DR. CRONENBERG: Two years or three years?
11 MS. HENDRICKS: Are we talking about --
12 DR. CRONENBERG: For emergency planning.
13 CHAIRMAN KRESS: For just emergency planning.
14 MS. HENDRICKS: For just emergency planning? I
15 think there is some cost, as we discussed, that's not
16 insignificant. Another way to put cost in perspective for
17 decommissioning plants is, when you shut down, that's all
18 you've got.
19 And time is money, and the more you can restrict
20 and get on with decommissioning, the better off you are.
21 You don't have funds coming in from selling power any more.
22 You've got a fund and you're trying to get a job done, and
23 you have, you know, to a certain extent, limited funds.
24 I think you have the provision to go back for
25 reasonable contingencies, but I think there is also an onus

1 to make sure the funds are spent --

2 DR. SEALE: The only guy that's generating cash is

3 your junk man.

4 DR. CRONENBERG: I understand, but there's -- the

5 staff was separating out indemnity from emergency planning,

6 and in your introductory slides, you sort of -- was that

7 deliberate? You sort of lumped emergency planning,

8 security, indemnity, all in one.

9 Is that what you would like the Commission to go

10 on a generic rule, and all-in-one that encompasses the whole

11 thing?

12 MS. HENDRICKS: To a certain extent, that's their

13 intent, but I think lumping them together also serves to

14 direct the effort towards what I think is the best way to

15 go, a best estimate, try to put it in absolute risk terms,

16 because the Commission is going to have to make these

17 fundamental decisions about EP, no-EP, financial protection,

18 no-financial protection.

19 And the best tool you can give them is a best

20 estimate of the risk so that they can look at the magnitude

21 of decrease from the operating plant, because, again, you're

22 taking those operating plant requirements and you're

23 thinking about when and how to reduce their applicability.

24 DR. CRONENBERG: So NEI is coming in, they want

25 some generic rule with it all, and the staff is coming with

1 this segmented approach. And so there's a big disconnect?
2 Do I have that right?
3 MS. HENDRICKS: Yes. The genesis was a little
4 different. I mean, the staff had ongoing, several
5 rulemakings, and the Commission's directive in the SRM I
6 mentioned said to integrate them, risk-inform them, combine
7 them. Those were just the ones that were probably the most
8 difficult from the exemption-issuing standpoint.
9 But then there were several other things that you
10 also need exemptions from, such as the one we mentioned. We
11 did actually come back and encourage the staff that as long
12 as you're doing a rulemaking, get a risk basis and do them
13 all.
14 Well, that's easy for us to say. You know, they
15 are judgment calls. Fitness for duty, yes or no? Staff
16 says yes, here's the basis, put it out in the proposed rule.
17 You know, we think that there could be some
18 efficiencies and some logic for the public, and some -- just
19 to do it all at once. It would make sense to us, but the
20 staff counters with we really would need to go back and
21 revisit the bases as they are for all those rules, and, in
22 fact, there isn't that opportunity with the current
23 resources. I think that might be a fair way to state that.
24 CHAIRMAN KRESS: I finally found a bullet I don't
25 like. I would have added a bullet below that one that

1 relevant observed phenomena should not be ignored in
2 consequences.
3 MS. HENDRICKS: Right.
4 MR. NELSON: May I add a comment? I'm Alan
5 Nelson.
6 In the cost estimates, if we all -- in the way the
7 rules are written now, the typical site would be developing
8 exemption and their packaging at about five to two years
9 prior to the actual shutdown.
10 And what are they really doing? They're
11 transitioning an operating company into one that's
12 decommissioning. And the way that was done, we watched
13 Oyster Creek do this for quite awhile, but fortunately, they
14 were purchased and went into operate.
15 But they had set up their programs so that they
16 could go into a decommissioning mode shortly after shutdown.
17 And that was by developing these packages for
18 exemption. Typically, they would have had anywhere from
19 five, six, 800 employees as an operating company. Today,
20 that's turned over to a dock that is now transitioning into
21 a decommissioning company for dismantling the reactor and
22 the facility at large.
23 So what are they doing? They are maintaining this
24 operating organization while they're transitioning, and
25 that's the basis of the cost.

1 So that's where they're hung up. You have
2 operator, operator requal training, RP, et cetera, plus
3 you're maintaining these facilities such as the technical
4 support center, the operations facility, as well as, if you
5 need to, do offsite exercises.
6 So that, in total, is the bulkier cost, plus
7 maintaining equipment that may never be needed in a case of
8 an emergency itself. So it's really people- and
9 process-related, because you're really moving into a
10 non-operator phase.
11 MR. BAGCHI: Dr. Kress, I would like to point out
12 something. This is Goutam Bagchi of the staff.
13 On the NEI Slide Number 4, the top slide, it talks
14 about screening checklist at two to three times the SSE. I
15 want to point out that that was in the draft report, and we
16 have gone back and taken it off and proposed in the new
17 report, that they screen that .5g SSE, .5g peak ground
18 acceleration, or 1.2g spectral acceleration value.
19 And I'd like to make sure that the main Committee
20 doesn't read this and think that we are still on our overly
21 conservative kick.
22 MS. HENDRICKS: I guess I'm having a hard time
23 understanding that statement, Goutam, because it was my
24 understanding that for the Eastern United States plants,
25 they would normally be at .15 -- their SSE would be between

1 .15 and .25g, and so, in fact, if you do go to .5, you are
2 at two to three times the SSE. So I don't understand the
3 change.
4 MR. BAGCHI: We are at two times the SSE, but
5 really, that proposal, three times the SSE was my proposal
6 initially in the draft report.
7 That has been taken out, and in reality, it is
8 anywhere from two to three times the SSE; that's correct.
9 So it's not to point out that it is an erroneous statement,
10 that's not my intent. My intent is to make it very clear
11 that the screening is at 1.2g peak spectral acceleration.
12 MS. HENDRICKS: I think we're in violent
13 agreement, again.
14 The top conclusion there, I think I stated it
15 before, but I think it bears restatement. This gets to be
16 sort of really in the philosophy area, but that if you do,
17 in fact, determine on a risk basis that you do need to
18 retain operating plant requirements, I think you lose the
19 opportunity to apply some of the practical risk insights. I
20 think there is a direct tradeoff there.
21 And that gets back to the analogy that if you're
22 operating with EP and financial protection and other
23 requirements intended to address the risk of an operating
24 plant with its full spectrum of events and different
25 complexity, when you shut down, it's going to be very

1 difficult in the context of a rulemaking, to justify any
2 additional requirements, even in the practical sense, the
3 type of commitments that we had talked about.
4 Even if they are not extremely costly, it's going
5 to be difficult to justify that, because you don't have them
6 when you're operating, and that's essentially what we're
7 looking at.
8 CHAIRMAN KRESS: Thank you very much.
9 MS. HENDRICKS: Thank you.
10 CHAIRMAN KRESS: The next item on the agenda is
11 that we are going to hear from a representative from the
12 Institute for Resource and Security Studies, Mr. Gordon
13 Thompson.
14 DR. THOMPSON: Are we ready?
15 CHAIRMAN KRESS: Yes, you may proceed.
16 DR. THOMPSON: Good afternoon.
17 I would like to thank the subcommittee for
18 inviting me to come today. I am going to make a brief
19 presentation. I have asked for 10 minutes. That will cover
20 it if I am not interrupted, but if I am interrupted --
21 CHAIRMAN KRESS: Don't count on my --
22 [Laughter.]
23 DR. THOMPSON: I'm happy to go as long as you
24 want. I don't have any written papers. I am anticipating
25 making a more detailed presentation at the next meeting of

1 the full committee and on that occasion I will have backup
2 paper material.
3 I am not speaking to the regulatory issues that
4 have been focused on today. My presentation here is a more
5 general one about the fuel pool hazard issue.
6 I am bringing it to the ACRS, initially to this
7 subcommittee, because this is a body that brings the broader
8 scientific community close to the heart of the Nuclear
9 Regulatory Commission.
10 Now there is a context for the fuel pool fire
11 issue.
12 Firstly, the hazard has arisen over two decades or
13 more as pool densities have risen. It was recognized
14 early-on. Sandia produced a report in 1979 that I think was
15 quite credible for its time that recognized the issue.
16 The hazard exists at both operating and
17 decommissioning plants. The hazard could be almost entirely
18 removed by adopting a combination of low storage density in
19 pools and dry storage.
20 I think citizens could have reasonably expected
21 that before the NRC permitted the high density pool storage
22 it would have sought to acquire a thorough understanding of
23 the hazard. This was not done. As I mentioned, Sandia
24 reported in the issue in 1979. That was never properly
25 followed up. The work to date is incomplete.

1 CHAIRMAN KRESS: I'm sorry, could I interrupt you?
2 DR. THOMPSON: Certainly.
3 CHAIRMAN KRESS: You mentioned that this could be
4 ameliorated by the use of dry storage.
5 Could you expand on that just a little?
6 DR. THOMPSON: I think I said the hazard could be
7 almost entirely removed by combining low density storage in
8 pools and dry storage. The hazard I am speaking of is the
9 oxidation reaction pursuant to a dry-out of a pool.
10 By definition, that can't occur in dry storage.
11 Other hazard scenarios can be developed for dry storage.
12 The probabilities of those as far as you can estimate them
13 appear to be substantially less than for pool storage.
14 CHAIRMAN KRESS: Dry storage is much more robust?
15 DR. THOMPSON: Much more robust.
16 Low density pool storage, which was the way pools
17 were initially set up in the early years, can be configured
18 so that there is no oxidation reaction in the event of a
19 dryout provided the configuration is retained.
20 The residual hazard in that case that if the
21 configuration is interrupted, perhaps by dropping a cask,
22 even at low density you could have a oxidation reaction, but
23 that would be a smaller quantity of fuel and the overall
24 probability would be much less.
25 I will summarize this by saying that the oxidation

1 hazard issue could be almost entirely removed.

2 Should I go on?

3 CHAIRMAN KRESS: Yes, thank you.

4 DR. CRONENBERG: Excuse me. For the low density

5 still you need some time. You can't have this like 60 days.

6 They are not that low -- low density -- that if you had

7 offloaded your last core, what sort of decay time are you

8 talking about before you --

9 DR. THOMPSON: Well --

10 DR. CRONENBERG: -- oxidation.

11 DR. THOMPSON: -- you can configure a low density

12 open frame rack so that you can offload a full core into it

13 and immediately dry out.

14 Now what that spacing is of that rack I don't know

15 at this moment, but you could certainly configure it.

16 DR. CRONENBERG: Within the designs that were the

17 original designs you would still need a period of decay

18 before you could have air cooling that you wouldn't get

19 temperatures up to --

20 DR. THOMPSON: I have never seen that computed but

21 certainly a year decay, the old open frame racks, would --

22 DR. CRONENBERG: -- would be possible.

23 DR. THOMPSON: -- be safe in the event of dryout.

24 There would be some point in time less than a year

25 at which they could suffer oxidation --

1 DR. CRONENBERG: I just wanted to clarify that.

2 DR. THOMPSON: Right, but in principle you could,
3 as I said, go to low enough density for a full core
4 discharge.

5 If the commitment were made to make pools
6 inherently safe by adopting some low density then there
7 would have to be some decision made about what cooling time
8 within the first year you wanted to set.

9 That analysis, if it exists, I have not seen.

10 Since the analysis to date is incomplete, what
11 should be done?

12 I would propose that there be a moratorium on any
13 regulatory action that could increase the hazard of
14 oxidation reaction in pools and during this moratorium
15 period there be a fairly rapid effort to acquire a thorough
16 understanding of the issue and I think the basis for that
17 does exist.

18 The scientific capability undoubtedly exists in
19 the National Labs and elsewhere. The modeling work that has
20 been done in recent years I think has filled in a lot of the
21 gaps and I think with a serious effort in a couple years,
22 maybe less, you could get what I would regard as a thorough
23 understanding of this hazard.

24 How would I recommend that this be done?

25 I would start on the consequence end. We know

1 enough now that we recognize that ignition or run-away
2 reactions could occur in part or indeed all of a pool in the
3 event of dryout over a range of conditions, so let's start
4 on the consequence end.
5 What I would like to see above all is a set of
6 maps showing the estimated contours of land contamination
7 over time with sensitivity to weather conditions and source
8 term assumptions, and in source term assumptions I include
9 timing, plume, heat and so forth.
10 MACCS and other codes are capable of doing this.
11 These maps we could then compare with real data that we have
12 from Chernobyl, contour lines of cesium and strontium
13 contamination, and we could see what we are dealing with.
14 Land interdiction is a secondary parameter. I
15 support the committee's discussion of that but that is a
16 secondary parameter contingent on assumptions about the
17 radiation level at which you relocate populations.
18 Where we should really start here is the contours
19 of land contamination. That could be done in a matter of
20 weeks and after all these years it is way overdue that we
21 haven't done that.
22 You then provide this to the public and
23 decision-makers and let them chew on it a little bit in
24 their minds. When the Staff comes and says --
25 CHAIRMAN KRESS: You would do this for each

1 specific plant?

2 DR. THOMPSON: I think you would start doing it

3 generically but perhaps for a few selected sites, real

4 sites.

5 CHAIRMAN KRESS: The way the codes like MACCS work

6 is they don't really get those contours. They probability

7 smear them out.

8 DR. THOMPSON: But they can be tweaked to give you

9 the contours.

10 CHAIRMAN KRESS: If you had a better atmospheric

11 transport and a better description of the site

12 characteristics and there are code that can do it -- they

13 are not as easy to use as MACCS but it can be done.

14 DR. THOMPSON: Even MACCS I think could be tweaked

15 to do it.

16 CHAIRMAN KRESS: I would be surprised if it could

17 do it very well with MACCS but there are codes, even NRC has

18 some codes that can do that.

19 DR. THOMPSON: And you of course always recognize

20 that such a code is not to represent the sort of reality

21 that you have in the Chernobyl data --

22 CHAIRMAN KRESS: Oh, yes.

23 DR. THOMPSON: -- because you can't pick up the

24 changing wind directions and stability and so forth.

25 CHAIRMAN KRESS: You have to have some specific

1 pattern of wind to do this.

2 DR. THOMPSON: But it does give you a picture of
3 what you are dealing with and I think the public and the
4 decision-makers deserve that picture, so when the Staff says
5 we are happy if this event occurs with a probability of no
6 more than 10 to the minus 5 per year, then you say okay,
7 maybe there's 100 pools all remaining, 100 pools in the
8 country. Ten to the minus 5 times 100 pools gives you a
9 probability of this event of about 1 percent a decade and
10 does the public really want to have an event like this,
11 maybe with a contaminated area an order of magnitude greater
12 than we can go and look at at Chernobyl, with a probability
13 of 1 percent per decade. Maybe they do and maybe they
14 don't.

15 Give them the information and let them decide.

16 Second of all, the work that has been done on fuel
17 heatup and the development of oxidation reactions should be
18 done much more comprehensively with the sort of rigor that
19 was attempted in NUREG 1150 rather than the bits and pieces
20 that we have seen to date.

21 That should show the onset and development of the
22 oxidation reaction as a function of various pool
23 configurations including the potential for flow blockage and
24 for drainage states.

25 There has been this unfortunate assumption for

1 many years that total instantaneous drainage is worst case
2 and it simply isn't true.
3 In many practical accident conditions the drainage
4 could be partial. The level could fall, rise, or remain
5 static for long periods. Bear in mind that water makeup is
6 likely in many instances as people attempt to recover from
7 the accident or perhaps some makeup capability has been left
8 operating unattended, and so you cannot assume that any
9 particular water level is going to operate and total
10 instantaneous drainage is not the worst case because there
11 are configurations with low levels of water that give you
12 higher temperatures in the mid-regions of the fuel
13 assemblies.
14 The reaction then is a steam-zirc reaction, then
15 an air-zirc reaction, but you might also transition. You
16 might have a declining water level and transition from
17 steam-zirc to air-zirc reaction.
18 CHAIRMAN KRESS: Air-zirc --
19 DR. CRONENBERG: Excuse me, the air-zirc reactions
20 take off at a higher temperature than the air-zirc
21 reactions --
22 DR. THOMPSON: Right, they do.
23 DR. CRONENBERG: -- so you would initiate the
24 air-zirc reaction. I assume you are talking that both air
25 and steam are available in this accident. You initiate the

1 air oxidation first.

2 DR. THOMPSON: Well, let's hypothesize an intact

3 pool, no makeup, water declines through evaporation, so a

4 steady decline.

5 You could potentially enter a state where you have

6 steam as the level declines. Somewhere mid-high to the

7 assemblies you get a steam-zirc reaction initiates.

8 DR. CRONENBERG: Steam-zirc?

9 DR. THOMPSON: Because during the gas reaching the

10 mid-range of the assemblies is steam from the --

11 DR. CRONENBERG: Then you are at very high

12 temperatures here you are talking about.

13 DR. THOMPSON: And that is possible because you

14 have prevented convective flow down the sides of the pool

15 and along the base and up. Your only heat loss mechanisms

16 in that configuration are one, conduction, two, longitudinal

17 radiation in a very confined space, and three, the forced

18 convection of steam from the foot of the assembly.

19 DR. CRONENBERG: You can get cooling that way too.

20 DR. THOMPSON: Those are the three cooling

21 mechanisms and this has never been properly analyzed either

22 with the rigor that has been given so far to the air cooling

23 situation, but I am convinced to the extent I have looked at

24 this that you will find there are configurations where the

25 mid high temperature is sufficient to ignite steam-zirc

1 reactions.

2 if that is true, then you could have a period of

3 steam-zirc reaction, water level declines. Air then gains

4 access from beneath and you then get into an air-zirc

5 reaction.

6 You might go the other way if you have a dry pool

7 and somebody starts spraying it or adding makeup. You might

8 get into steam-zirc reaction after having an air-zirc

9 reaction initially.

10 I think all of that needs to be addressed.

11 You need to include effects of fuel burnup and

12 there is a tendency in the industry to move to high burnups,

13 burnups in the 50,000 megawatt day range are quite common

14 these days. Fuel behaves differently in that range. The

15 cladding properties start to be different. If that trend

16 continues we might be in to the 60s and higher.

17 Thirdly, there needs to be development of analysis

18 of scenarios could cause dryout. Initially this should be

19 done in a technical qualitative way, I believe, rather than

20 initially attacking it in a probabilistic way.

21 An example in this area that concerns me is the

22 precipitation of a pool accident by a preceding reactor

23 accident, a reactor accident involving degraded core and

24 containment failure bypass inhibits access to the pool and

25 thereby prevents the continuance or restoration of cooling,

1 leading to pool dryout, and I believe that requires very
2 careful analysis.
3 Finally, last of all, I think you would do the
4 probabilistic analysis which in any case would have a site
5 specific quality to it.
6 The preceding three areas I think are mostly
7 generic. Thank you.
8 CHAIRMAN KRESS: Thank you very much. That gives
9 us some thoughts to chew on. Are there any questions?
10 DR. POWERS: I guess he proposed a question in my
11 mind that I have a hard time thinking about right now.
12 Maybe I'm not thinking very well right now.
13 But we put water into these pools and it's
14 oxygen-saturated. We now take that water up in temperature,
15 and so the steam has a partial pressure of oxygen in it.
16 CHAIRMAN KRESS: It will have.
17 DR. POWERS: At roughly ten to the minus fourth.
18 I'm just taking the solubility of water, of oxygen and
19 water.
20 To my knowledge, we've never really looked at
21 oxygen-saturated water interacting with Zircalloy clad on
22 whether it is more like steam oxidizing the clad or because
23 you have the nitrogen there, do you get this nitrogen
24 interface that leads to breakaway?
25 CHAIRMAN KRESS: I'm trying to recall the

1 experiments that have been done to develop the reaction
2 rates. I think you're right that those were pretty clean
3 steam.
4 DR. POWERS: In every case except Baker-Just.
5 CHAIRMAN KRESS: Yes, Baker-Just had --
6 DR. POWERS: Had sloppy water.
7 CHAIRMAN KRESS: Sloppy water.
8 DR. POWERS: That's an intriguing thing. When you
9 talk about situations where you have partial draindown, you
10 know, I think we do understand what the consequences on
11 Ruthenium release are if we've got at the clad. Because the
12 partial pressure of oxygen in steam in those circumstances
13 is a world compared to pure steam by itself.
14 CHAIRMAN KRESS: Yes.
15 DR. POWERS: But the clad itself is a more
16 complicated analysis. I'm not sure what it's like. I don't
17 know how to do your middle ground calculations right now.
18 I have to think about that.
19 DR. THOMPSON: Okay.
20 DR. CRONENBERG: You brought up some interesting
21 points, and I don't agree with a number of them, but what
22 about if the Agency was not considering following such an
23 aggressive time for emergency planning relief over one year
24 decay, something more than one year, say two or three years
25 before they consider it?

1 Does that alleviate some of your concerns?

2 DR. THOMPSON: For accidents of the type we're
3 discussing, emergency planning is a relatively secondary
4 consideration. The main concern that I have is long-term
5 contamination of land and all the things that flow from
6 that. And emergency planning does bear on that to a small
7 degree, but it's not a major factor.

8 DR. POWERS: What I find interesting is that a
9 speaker from NEI got up and said do a good phenomenological
10 analysis. This speaker stood up and said do a good high
11 quality phenomenological analysis and the ACRS did a good,
12 high quality phenomenological analysis.

13 There's consensus on one point.

14 [Laughter.]

15 DR. THOMPSON: I hope it's done.

16 DR. POWERS: I agree with you. I think that there
17 -- without criticizing the thrust for a particular area of
18 decision, to say that in this general area, I think that
19 there are areas of phenomenology that I'm not comfortable
20 with that I understand real well to do an analysis that I
21 have a great deal of confidence in.

22 And one of the areas that I continue to worry
23 about a lot is what happens when you get geometry shifting
24 around and you get contacts between different kinds of
25 metals in these systems as you go through degradation and

1 things like that.

2 There was some of that alluded to in the original

3 report, and we suggested that you really ought to look at

4 things like intermetallic reactions and stuff like that,

5 because they become funky at high temperatures.

6 So there is a lot of room for improvement.

7 CHAIRMAN KRESS: I share this concern about the

8 land interdiction. That was quite obvious in some of my

9 comments. But I think that that's the one part of this

10 study on the decommissioning that has not in my mind been

11 sufficiently closed.

12 Other than that, I think the quality of the

13 phenomenological study and the other things they did were,

14 on the whole, sufficient to make this particular decision

15 with respect to decommissioning.

16 But I share your view that it's not just the

17 decommissioning issue. These -- we have operating plants

18 with crews there all the time, they're contributing to the

19 risk profile of the plant during operation.

20 You have things like shutdown risk where you can

21 get hour-related accidents, you can get regression accidents

22 to regular severe accidents of the core. At later stages,

23 you could have -- so I think this question, the questions we

24 have raised with respect to this decommissioning issue,

25 don't go away, even though they may have enough of a good

1 analysis to make this decision.

2 So, you know, I hope they don't go away and forget

3 about these things, and say, well, we're through with it

4 because we can now make this decision. I think there are

5 other decisions that may need to be made that are based on

6 risk-informed concepts that need maybe a better

7 phenomenological understanding of these things. So that's

8 -- you know, I agree that we need to do a better

9 phenomenological -- have a better phenomenological

10 understanding of several of these things.

11 DR. THOMPSON: Can I say that there is an

12 international dimension to that, as well. This is not just

13 a United States problem.

14 The most extreme case I know in terms of the

15 potential consequences is the La Havre facility in France

16 which is a reprocessing center, and they're planning to

17 extend their pool capacity to 18,000 tons in high density

18 water storage.

19 I don't believe that the French authorities have

20 anything approaching an adequate understanding of what the

21 hazard is.

22 And if the NRC would do a proper job on the pool

23 hazard, then interested people could take that to the French

24 and show them what they're doing.

25 CHAIRMAN KRESS: They probably wouldn't listen to

1 us.

2 [Laughter.]

3 DR. POWERS: Well, in fairness, I'm not familiar

4 with the situation at La Havre, but I think Mr. Shaperow, in

5 his presentation, provided the fact that the French are

6 sponsoring a planned test to look at air on fuel rods.

7 And they have already, as part of the PHEBUS

8 program, conducted a study that was actually run out of the

9 Joint Research Center as part of the PHEBUS program, to do

10 some tests.

11 CHAIRMAN KRESS: I think that's great. We ought

12 to take full advantage of our participation in those

13 programs to get that information.

14 Would the staff like to make any other comments?

15 You're welcome to sort of close it down.

16 MR. COLLINS: This is Tim Collins from the staff.

17 I only want to remind everyone of the statement that I made

18 at the beginning. This is technical input; this is a

19 technical study that is an input to the development of a

20 rulemaking.

21 It should not be construed as the staff's

22 recommendation for rulemaking; it's just an input to one

23 that's got some other very important considerations.

24 And I wanted to make sure that everybody goes away

25 with that message.

1 CHAIRMAN KRESS: Thank you. Before we leave, I
2 guess we need to make some decisions on what to do with the
3 full Committee meeting.
4 Can we discuss that, what our thoughts are on
5 that? I think an expanded version of your introductions
6 would be good, perhaps 30 minutes worth, where you pull in
7 some of Jason's stuff and maybe some of Bob's stuff, and we
8 want to hear an abbreviated version of Jason, maybe 30
9 minutes worth of Jason's stuff.
10 DR. POWERS: It's very important to get Jason's
11 slide where he has the list of all of those phenomenological
12 areas.
13 CHAIRMAN KRESS: Yes.
14 DR. POWERS: That list, I think, is the one that
15 most directly addresses the phenomenological conditions that
16 came up.
17 CHAIRMAN KRESS: And we'd also like maybe 45
18 minutes worth of Bob Palla's integration into the risk part
19 of it. And NEI, I thought some of your comments were very
20 valuable, and a half an hour would be for that.
21 And I --
22 DR. POWERS: Especially when she agrees with you,
23 right?
24 CHAIRMAN KRESS: Yes.
25 [Laughter.]

1 CHAIRMAN KRESS: Everything except your last
2 slide. And, Mr. Thompson, I think we can give you about a
3 half hour, about a half hour on the full Committee.
4 We certainly appreciate what we've heard, and
5 there were some pretty good discussions, and a pretty good
6 piece of work. So, thanks to everybody, and with that, the
7 I'll close this Subcommittee meeting.
8 [Whereupon, at 3:22 p.m., the meeting was
9 adjourned.]
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REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

NAME OF PROCEEDING: ACRS - REACTOR FUELS PUBLIC MEETING

PLACE OF PROCEEDING: ROCKVILLE, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Jon Hundley /BR

Jon Hundley
Official Reporter
Ann Riley & Associates, Ltd.

NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: Risk Analysis Results and Conclusions

DATE: October 18, 2000

PRESENTER: Robert L. Palla

TITLE/ORG: Sr. Reactor Engineer
Probabilistic Safety Assessment Branch
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

TELEPHONE: 415-1095

Risk Characterization

- Risk for each accident estimated based on frequency of fuel uncovery and SFP consequence estimates
- Fuel uncovery assumed to result in SFP fire (large release)
- Consequences assigned based on either early or late evacuation cases, depending on factors affecting EP
  - effectiveness of offsite notification
  - fission product release times relative to evacuation times
- Evacuation modeled as follows:

Event	Full EP	Relaxed EP
Seismic	Late	Late
Cask Drop	Early (for t > 4-5 h)	Early (for t > 10 h)
Boildown	Late	Late

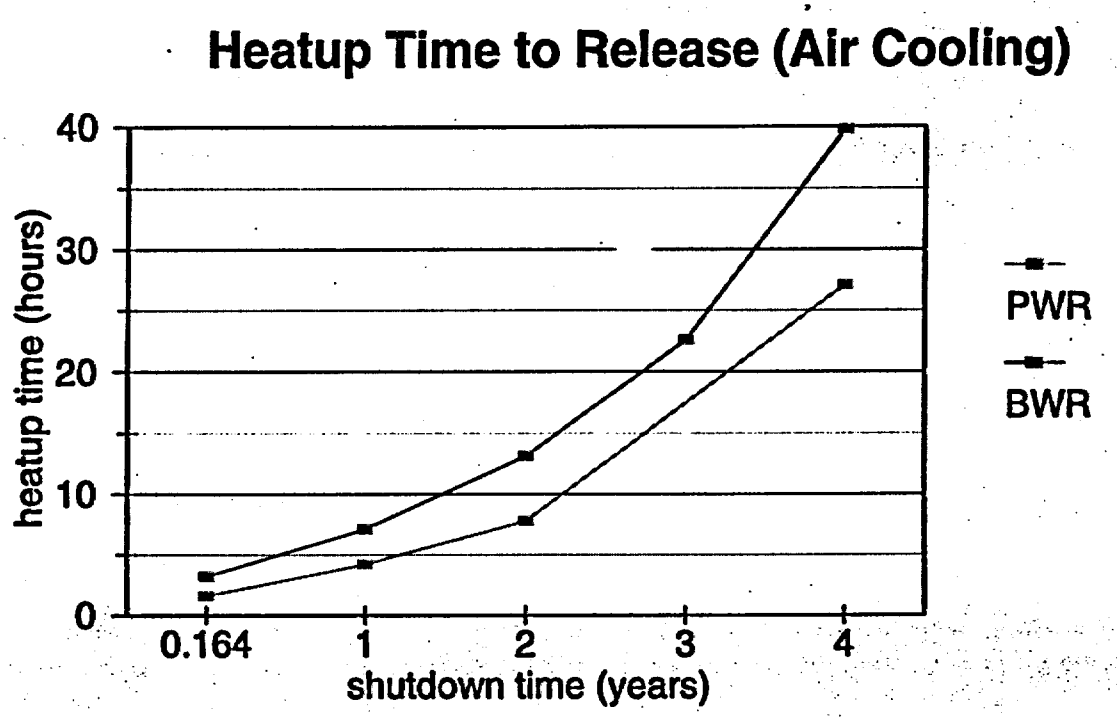

Figure 2.1 Heatup time from 30 °C to 900 °C

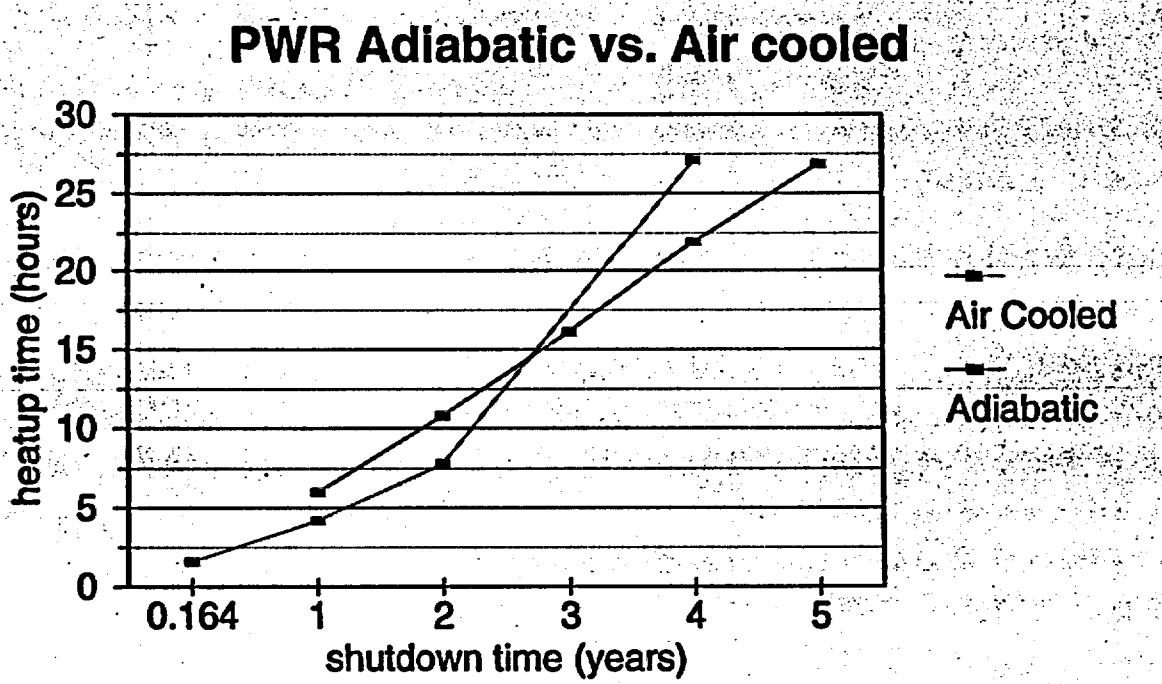

Figure 2.2 PWR heatup times for air cooling and adiabatic heatup.

Rationale for Evacuation Modeling

- Seismic
  - for ground motion corresponding to SFP failure, there would be extensive collateral damage within the emergency planning zone (electric power, structures, roads, bridges)
  - radiological pre-planning would have marginal impact because of impairment by offsite damage

- Cask Drop
  - unambiguous indication of event; intact infrastructure for emergency response
  - Full EP: evacuation credited when > 4-5 hours delay time (1 year after shutdown and beyond)
  - Relaxed EP: evacuation credited when > 10 hours delay time (5 years after shutdown and beyond)

- Boildown
  - failure paths involve failure to acquire offsite resources to provide SFP makeup
  - failure to contact offsite authorities or implement effective response also expected for the same reasons

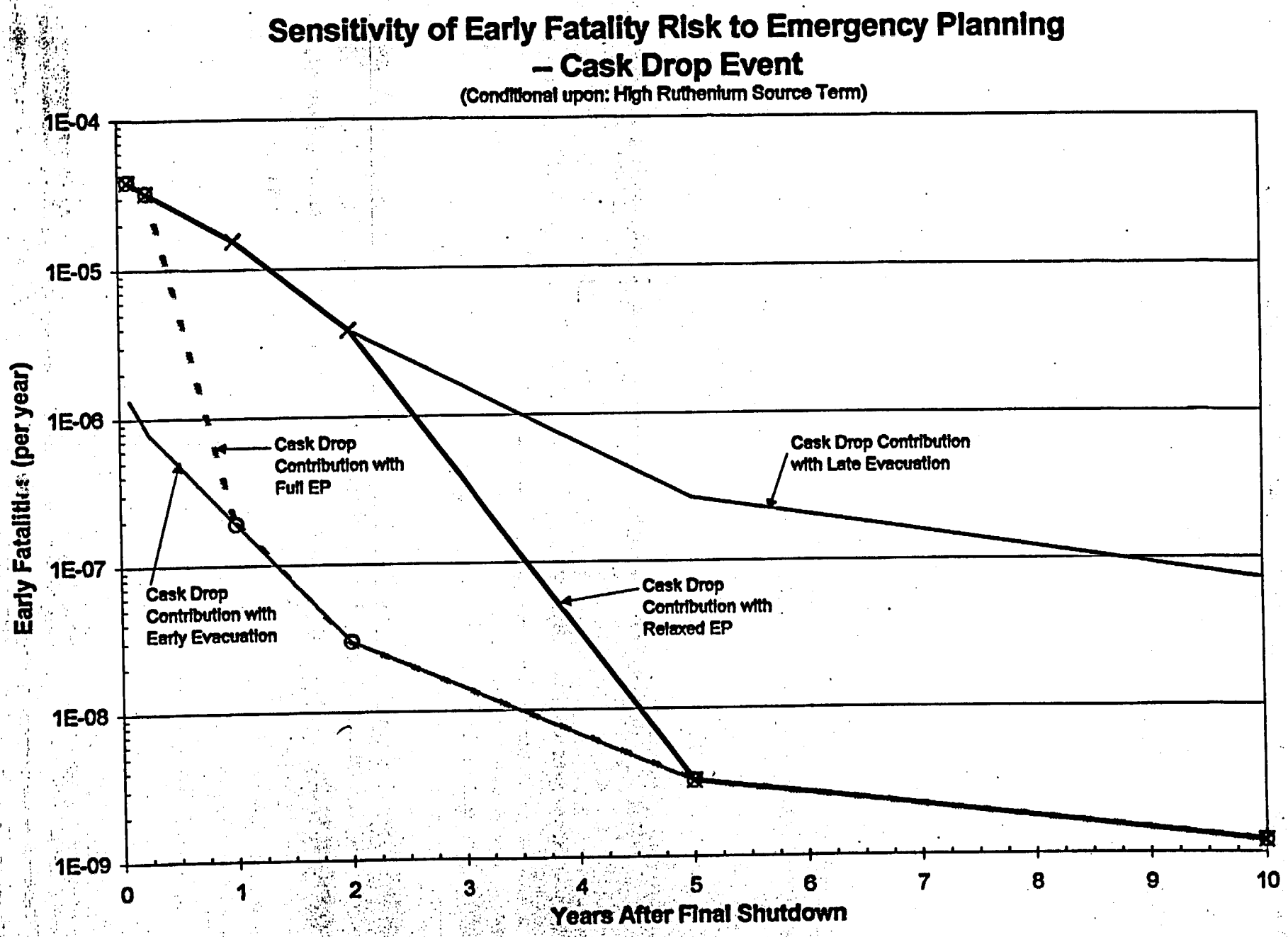
Sensitivity of Early Fatality Risk to Emergency Planning
-- Cask Drop Event
(Conditional upon: High Ruthenium Source Term)
Early Fatalities (per year)
1E-04
1E-05
1E-06
1E-07
1E-08
1E-09
0
1
2
3
4
5
6
7
8
9
10
Years After Final Shutdown
Cask Drop Contribution with Full EP
Cask Drop Contribution with Early Evacuation
Cask Drop Contribution with Relaxed EP
Cask Drop Contribution with Late Evacuation

Figure 3.7-5

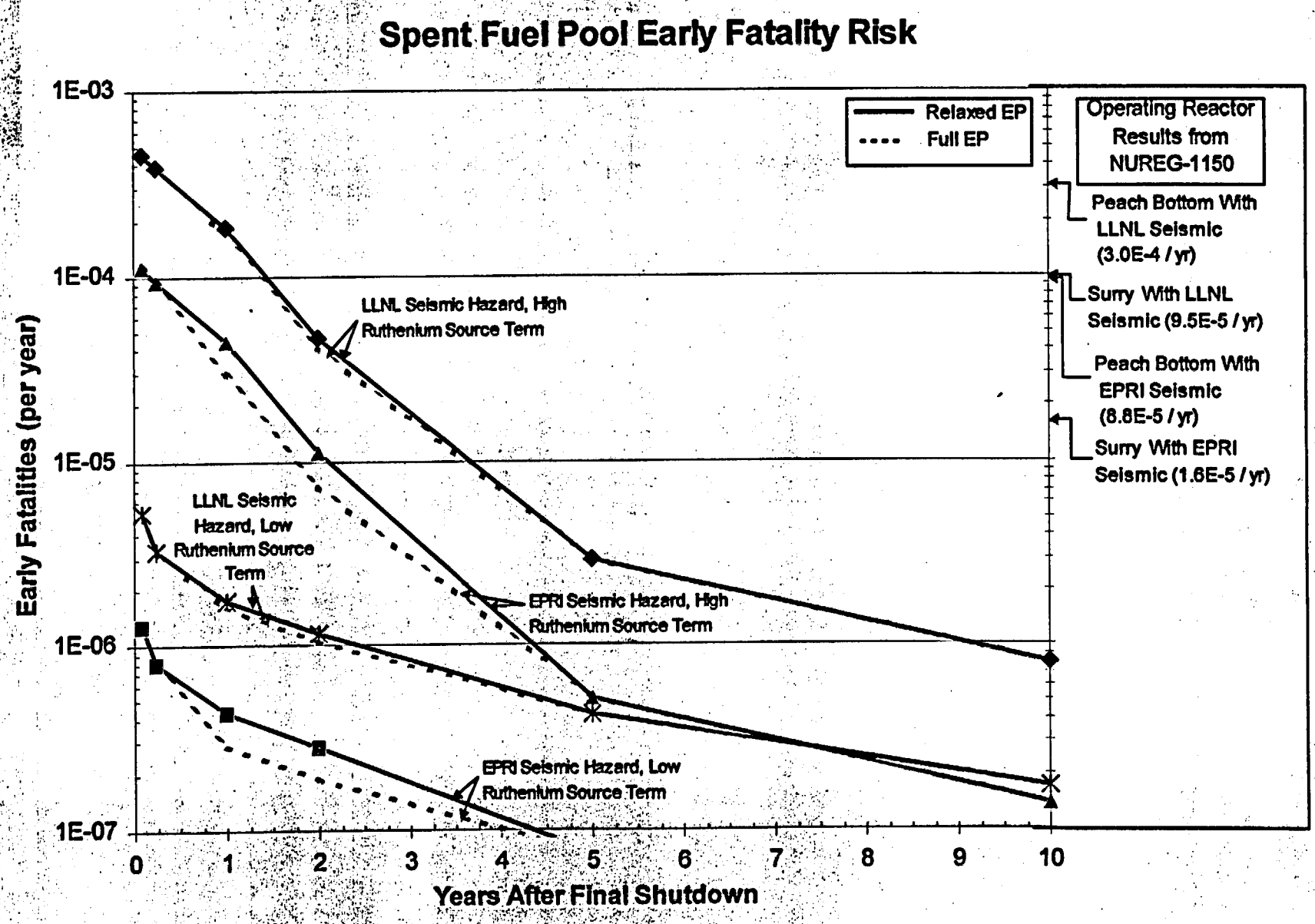
Spent Fuel Pool Early Fatality Risk
Early Fatalities (per year)
1E-03
1E-04
1E-05
1E-06
1E-07
0
1
2
3
4
5
6
7
8
9
10
Years After Final Shutdown
Relaxed EP
Full EP
Operating Reactor Results from NUREG-1150
Peach Bottom With LLNL Seismic (3.0E-4 / yr)
Surry With LLNL Seismic (9.5E-5 / yr)
Peach Bottom With EPRI Seismic (8.8E-5 / yr)
Surry With EPRI Seismic (1.6E-5 / yr)
LLNL Seismic Hazard, High Ruthenium Source Term
LLNL Seismic Hazard, Low Ruthenium Source Term
EPRI Seismic Hazard, High Ruthenium Source Term
EPRI Seismic Hazard, Low Ruthenium Source Term

Figure 3.7-3

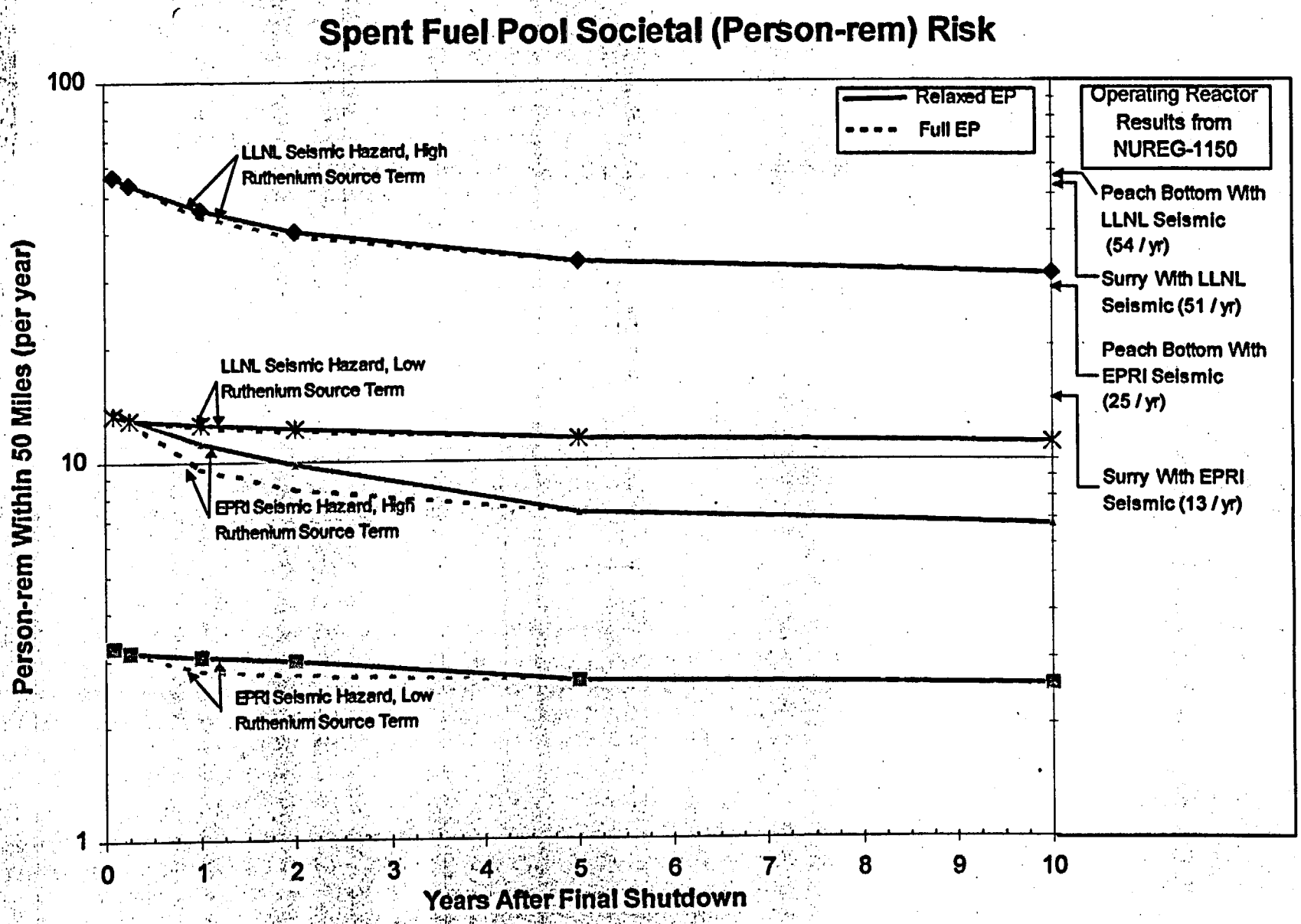
Spent Fuel Pool Societal (Person-rem) Risk
Person-rem Within 50 Miles (per year)
100
10
1
0
1
2
3
4
5
6
7
8
9
10
Years After Final Shutdown
Relaxed EP
Full EP
Operating Reactor Results from NUREG-1150
LLNL Seismic Hazard, High Ruthenium Source Term
LLNL Seismic Hazard, Low Ruthenium Source Term
EPRI Seismic Hazard, High Ruthenium Source Term
EPRI Seismic Hazard, Low Ruthenium Source Term
Peach Bottom With LLNL Seismic (54 / yr)
Surry With LLNL Seismic (51 / yr)
Peach Bottom With EPRI Seismic (25 / yr)
Surry With EPRI Seismic (13 / yr)

Figure 3.7-4

Risk Conclusions

- For the first 1 to 2 years, the early fatality risk for a SFP fire is low, but comparable to that for a severe accident in an operating reactor. At 5 years following shutdown, the early fatality risk for SFP accidents is approximately two orders of magnitude lower than for a reactor accident

- Societal risk for a SFP fire is also comparable to that for a severe accident in an operating reactor, but does not exhibit a substantial reduction with time due to the slower decay of fission products and the interdiction modeling assumptions that drive long term doses

- Changes to EP requirements affect only the cask drop accident, and do not substantially impact either the total risk or the margin between SFP risk and operating reactor risk due to the low frequency of cask drop accidents

Risk Conclusions (continued)

- Use of the low ruthenium source term reduces early fatality risk by about a factor of 100 (relative to the high ruthenium source term) within the first 1 to 2 years, and by about a factor of 10 at 5 years and beyond

- With the low ruthenium source term, the early fatality risk for SFP accidents is about an order of magnitude lower than the corresponding values for a reactor accident shortly following shutdown, and about two orders of magnitude lower at 2 years following shutdown

- With the low ruthenium source term, the societal risk for SFP accidents is also about an order of magnitude lower than the corresponding values for a reactor accident shortly following shutdown, but does not exhibit a substantial reduction with time due to the slower decay of fission products and the interdiction modeling assumptions

- The above observations are valid regardless of whether seismic event frequencies are based on the LLNL or the EPRI seismic hazard study.

Comparisons to the Safety Goals

- Both the Individual Early Fatality Risk and the Individual Latent Cancer Fatality Risk for a SFP accident are about one to two orders of magnitude lower than the Commission's Safety Goal, depending on assumptions regarding the SFP accident source term and seismic hazard
  - At upper end (LLNL seismic hazard estimates and high ruthenium source term) the risks are somewhat lower than the corresponding risks for reactor accidents, and about a decade lower than the Safety Goal
  - At lower end (EPRI seismic hazard estimates and low ruthenium source term) the risks are lower than those for reactor accidents, and about 2 decades lower than the Safety Goal

- The Individual Early Fatality Risk for a SFP accident decreases with time, and is about a factor of 5 lower at 5 years following shutdown (relative to the value at 30 days)

- The Individual Latent Cancer Fatality Risk is not substantially reduced with time due to the slower decay of fission products and the interdiction modeling assumptions that drive long term doses

- Changes to EP requirements, as modeled, do not substantially impact the margin between SFP risk and the Safety Goals due to the low frequency of events for which EP would be effective

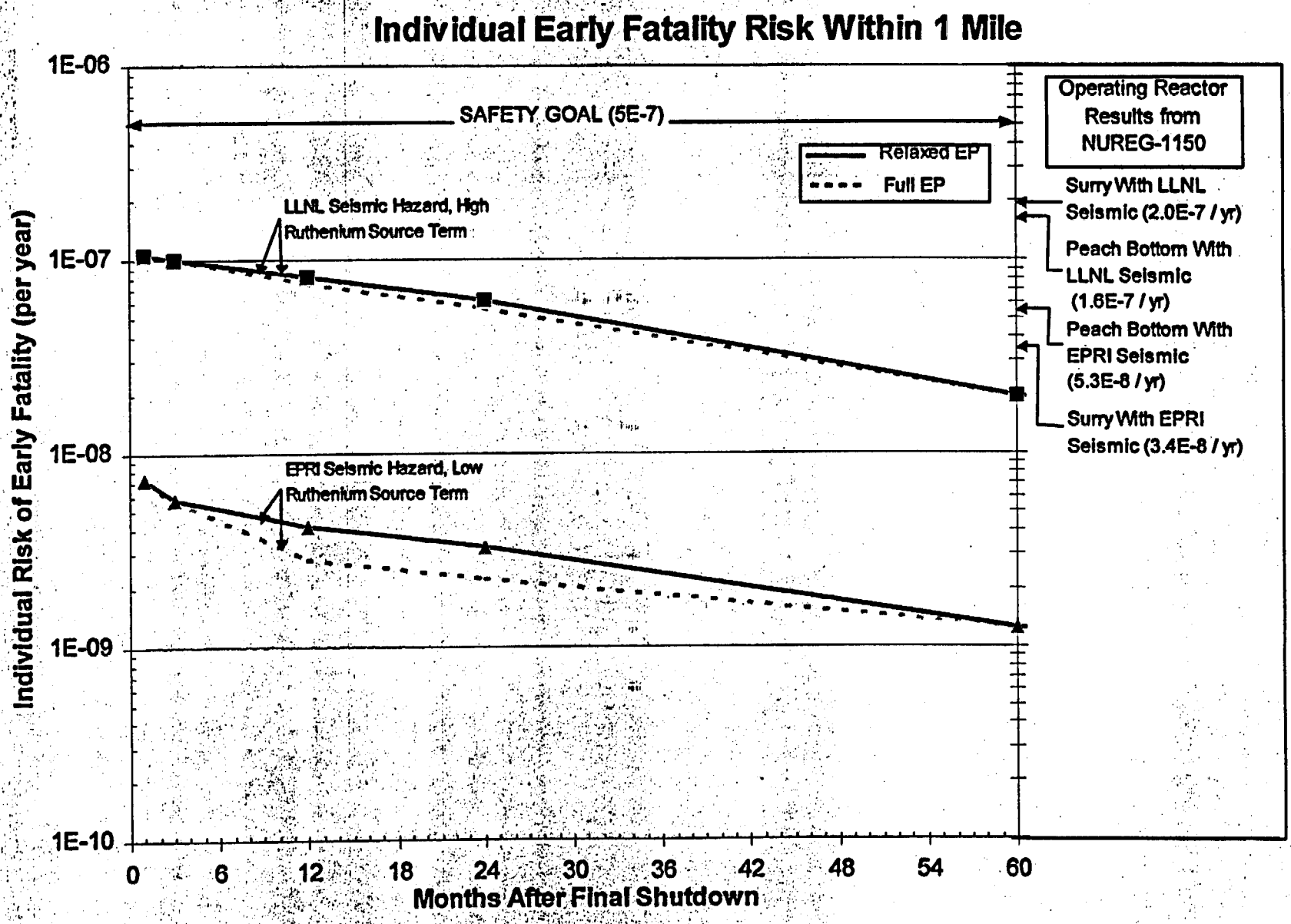
Individual Early Fatality Risk Within 1 Mile
1E-06
1E-07
1E-08
1E-09
1E-10
Individual Risk of Early Fatality (per year)
SAFETY GOAL (5E-7)
Relaxed EP
Full EP
LLNL Seismic Hazard, High Ruthenium Source Term
EPRI Seismic Hazard, Low Ruthenium Source Term
Operating Reactor Results from NUREG-1150
Surry With LLNL Seismic (2.0E-7 / yr)
Peach Bottom With LLNL Seismic (1.6E-7 / yr)
Peach Bottom With EPRI Seismic (5.3E-8 / yr)
Surry With EPRI Seismic (3.4E-8 / yr)
0
6
12
18
24
30
36
42
48
54
60
Months After Final Shutdown

Figure 3.7-7

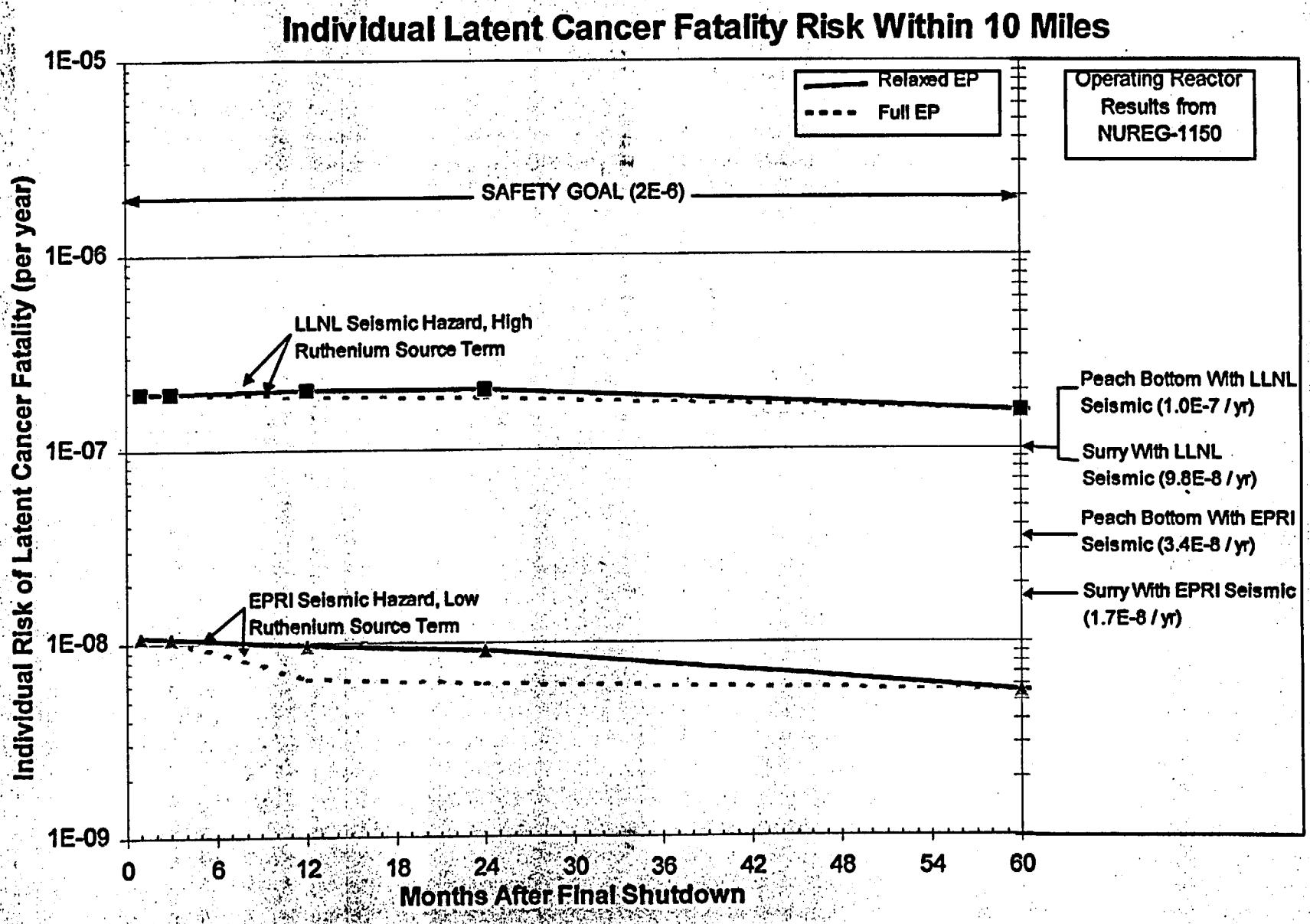
Individual Latent Cancer Fatality Risk Within 10 Miles
Relaxed EP
Full EP
Operating Reactor Results from NUREG-1150
SAFETY GOAL (2E-6)
LLNL Seismic Hazard, High Ruthenium Source Term
EPRI Seismic Hazard, Low Ruthenium Source Term
Peach Bottom With LLNL Seismic (1.0E-7 / yr)
Surry With LLNL Seismic (9.8E-8 / yr)
Peach Bottom With EPRI Seismic (3.4E-8 / yr)
Surry With EPRI Seismic (1.7E-8 / yr)
Individual Risk of Latent Cancer Fatality (per year)
1E-05
1E-06
1E-07
1E-08
1E-09
0
6
12
18
24
30
36
42
48
54
60
Months After Final Shutdown

Figure 3.7-8

Comparison to RG 1.174 Principles
1. Small Increases in Risk

- A SFP facility that conforms with IDCs and SDAs would meet the QHOs by one to two orders of magnitude shortly after shutdown, and with greater margins at later times
- Risk increases associated with EP relaxations are small, even under optimistic assumptions regarding the value of EP in seismic events, and the QHOs continue to be met with margin
- Continued conformance with IDCs and SDAs provides reasonable assurance that the SFP risk and risk increases associated with regulatory changes would remain small

Table 4 - Comparison of Risk Increase with RG 1.174 Guideline (at one year)

Risk Measure	Risk Increase Due to EP Relaxation (per year)		RG 1.174 Guideline Risk Increase (per year)
	Baseline [1]	Seismic Sensitivity [2]	
Early Fatalities	1.5×10^{-5}	1.6×10^{-4}	2.5×10^{-4}
Population Dose	1.6	17.6	11
Individual Early Fatality Risk	6.6×10^{-9}	7.3×10^{-8}	8.7×10^{-8}
Individual Latent Cancer Fatality Risk	1.6×10^{-8}	1.8×10^{-7}	6.9×10^{-8}

1 - Assumes no effective evacuation in seismic events, regardless of pre-planning
2 - Assumes maximum effectiveness of emergency planning (i.e., early evacuation) when EP requirements are maintained, and minimum effectiveness (i.e., late evacuation) when EP requirements are relaxed

Comparison to RG 1.174 Principles
2. Defense-in-Depth

- Remaining EP requirements, together with the substantial amount of time available for emergency response will provide a sufficient level of defense-in-depth for SFP accidents

- In the large seismic events that dominate SFP risk, current EP would be of marginal value due to extensive collateral damage offsite. Accordingly, relaxations in EP requirements are not expected to substantially alter the outcome from such a large seismic event

- In those sequences in which current EP would be effective, such as cask drop accidents, a comparable level of protection should continue to be provided though remaining requirements for on-site EP and the capability to implement offsite protective actions on an ad hoc basis.

Comparison to RG 1.174 Principles
3. Safety Margins

- A SFP facility that conforms with IDCs and SDAs would meet the QHOs by one to two orders of magnitude shortly after shutdown, and with greater margins at later times

- A SFP facility maintained at or below the recommended PPG would continue to meet the QHOs for even the most severe source term.

- The estimated risk increases associated with the EP relaxations are well below the values developed from the RG 1.174 LERF criteria (by about a factor of 10)

- Even under optimistic assumptions regarding the value of EP in seismic events, the change in risk associated with EP relaxations is relatively small
  - increases in early fatalities and individual early fatality risk remain below the maximum allowable for each risk measure
  - population dose and individual latent cancer fatality risk are about a factor of two higher than the allowable value inferred from RG 1.174, however, the increase in individual latent cancer risk represents less than 10 percent of the QHO

Comparison to RG 1.174 Principles
4. Monitoring Program

- The following monitoring should continue following decommissioning in order to assure SFP risk remains low:
  - Performance and reliability monitoring of the SFP systems, heat removal, AC power and inventory should be carried out similar to the provisions of the maintenance rule (10 CFR 50.65)
  - The current monitoring programs identified in licensee's responses to Generic Letter 96-04 with respect to monitoring of the Boraflex absorber material should be maintained by decommissioning plants until all fuel is removed from the SFP (SDA #7)
  - Heavy load activities and load paths should be monitored and controlled by the licensee (IDC # 1)
  - Licensees should continue to provide a level of onsite capabilities to assure prompt notification of offsite authorities, characterization of potential releases, development of protective action recommendations and communication with the public. These capabilities should be monitored by holding periodic onsite exercises and drills
- Continued compliance with the maintenance rule, the IDCs, and the SDAs, together with remaining requirements related to onsite EP provides a reasonable level of monitoring of SFP safety

Pool Performance Guideline (PPG)

- PPG provides threshold for controlling risk from decommissioning plant SFP
- PPG of 1E-5/y proposed in February 2000 report was reassessed in view of SFP source term issues
- Based on further evaluation, PPG of 1E-5/y is appropriate – by maintaining fuel uncovery frequency less than PPG:
  - zirconium fires remain unlikely
  - risk will continue to meet Commission's Safety Goals
  - small increases in risk may be permitted
- Plants that conform with Industry Decommissioning Commitments (IDCs) and Staff Decommissioning Assumptions (SDAs) will have SFP accident frequencies consistent with reference plant analysis and meet PPG (with exception of high seismic sites)
- Plants that do not meet IDCs and SDAs (including high seismic sites) would need to demonstrate compliance with PPG on plant-specific basis

Comparison of Spent Fuel Pool Accident Risk One Year After Shutdown with Quantitative Health Objectives (QHOs)

Case	QHO for Individual Risk of Prompt Fatality					QHO for Societal Risk of Latent Cancer Fatality				
	Ind. Early Fatality Risk (per event)	PPG (events per year)	Prob of Early Fatality (per year)	QHO (per year)	% of QHO	Ind. Latent C. Fatality Risk (per event)	PPG (events per year)	Prob of Latent C. Fatality (per year)	QHO (per year)	% of QHO
Low Ruthenium Source Term, Early Evacuation	5.44E-4	1E-5	5.44E-9	5E-7	1	9.09E-4	1E-5	9.09E-9	2E-6	<1
Low Ruthenium Source Term, Late Evacuation	7.13E-3	1E-5	7.13E-8	5E-7	14	1.68E-2	1E-5	1.68E-7	2E-6	8
High Ruthenium Source Term, Early Evacuation	1.50E-3	1E-5	1.50E-8	5E-7	3	4.33E-3	1E-5	4.33E-8	2E-6	2
High Ruthenium Source Term, Late Evacuation	3.46E-2	1E-5	3.46E-7	5E-7	69	8.49E-2	1E-5	8.49E-7	2E-6	42
Worst Source Term in App. 4A, Late Evacuation	3.66E-2	1E-5	3.66E-7	5E-7	73	5.16E-2	1E-5	5.16E-7	2E-6	26

Consequence Assessment for Spent Fuel Pool Accidents

Presentation to the Advisory Committee on Reactor Safeguards

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October 18, 2000

Overview

As a result of radioactive decay:

- **lower inventory available for release from spent fuel.**
- **lower decay heat, providing time for early evacuation.**

It was initially thought that at one year after final shutdown the radiological consequences from a spent fuel pool accident might be negligible.

If consequences were negligible, requirements for emergency planning and insurance could be eliminated.

Therefore, performed offsite radiological consequence calculations with MACCS to quantify the consequences.

Overview (cont.)

Issues examined

- **reduced inventory (at 1 year)**
- **early vs. late evacuation (at 1 year)**
- **importance of cesium**
- **importance of ruthenium**
- **number of assemblies releasing fission products**
- **fission product release fractions**
- **plume heat content**
- **plume spreading**
- **decay times beyond 1 year**
- **reassessment of source term**

Results of large number of MACCS calculations were used to understand decommissioning risk in staff's generic study.

Consequence Assessment

Original objective: evaluate effect of one year of decay on offsite consequences

- **reduced inventory available for release**
- **reduced decay heat (i.e., early vs. late evacuation)**

Summary of approach

Update of spent fuel pool accident study in NUREG/CR-4982 (GSI-82)

Used the MACCS consequence code with fission product inventories for 30 days, 90 days, and 1 year after final shutdown

Source Term	Release Fractions								
	noble gases	iodine	cesium	tellurium	strontium	barium	ruthenium	lanthanum	cerium
NUREG/CR-4982	1	1	1	.02	.002	.002	$2x10^{-5}$	$1x10^{-6}$	$1x10^{-6}$

Representative Results

Decay Time Prior to Accident	Mean Consequences for Surry Population Density (0-100 miles)		
	Early Fatalities	Societal Dose (rem)	Cancer Fatalities
30 days	1.75	4.77×10^6	2,460
1 year	1.01	4.54×10^6	2,320
1 year[a]	.0048	4.18×10^6	1,990

[a]Based on early evacuation.

Conclusions

Effect of reduced inventory

- **Early fatalities reduced by about a factor of 2 from 30 days to 1 year.**
- **Cancer fatalities and societal dose unaffected.**

Effect of reduced decay heat (early evacuation)

- **Early fatalities reduced by up to a factor of 100.**
- **Cancer fatalities and societal dose unaffected.**

Effect of Cesium

As a follow-up, evaluated the impact of cesium to better understand why consequence reduction from a year of decay not greater.

Cesium release fraction: 1.0
Cesium half-lives: Cs-134, 2 years; Cs-136, 13 days; Cs-137, 30 years

Decay Time Prior to Accident	Mean Consequences for Surry Population Density (0-100 miles)		
	Early Fatalities	Societal Dose (rem)	Cancer Fatalities
1 year	1.01	4.54×10^6	2,320
1 year (without cesium)	0.00	1.46×10^5	42

Effect of Ruthenium

Small-scale Canadian tests with an air environment showed significant ruthenium release following cladding oxidation.

MACCS calculations show that release of all ruthenium increases early fatalities by a factor of 20 to 100, because the assumed form (oxide) has a large dose per Ci inhaled due to its long clearance time from the lung.

Mitigating factors for ruthenium releases in spent fuel pool accidents

- **rubbling of the fuel limits air ingression**
- **1 year half-life of ruthenium**

PHEBUS test planned to examine effect of air ingression on a larger scale in an integral facility

Effect of Ruthenium (cont.)

Decay Time Prior to Accident	Mean Consequences for Surry Population Density (0-100 miles)		
	Early Fatalities	Societal Dose (rem)	Cancer Fatalities
1 year	1.01	4.54×10^6	2,320
1 year (100% ruthenium release)	95.3	9.53×10^6	9,150
1 year (100% ruthenium release)[a]	.13	6.75×10^6	6,300

[a]Based on early evacuation.

Conclusion: Ruthenium release can increases consequences, but can be offset by early evacuation.

Effect of Number of Fuel Assemblies Releasing Fission Products

- **Original calculations assumed entire spent fuel pool inventory of Millstone 1 was involved in heatup and release (3.5 cores).**

- **Depending on reductions in decay heat from radioactive decay, less fuel may be involved in heatup.**

- **Performed MACCS calculations for two cases: (a) entire spent fuel pool inventory (3.5 cores) and (b) inventory in final core offload.**

Effect of Number of Fuel Assemblies Releasing Fission Products (cont.)

Ruthenium Release Fraction	# of cores	Mean Consequences for Surry Population Density (0-100 miles)		
		Early Fatalities	Societal Dose (rem)	Cancer Fatalities
$2x10^{-5}$	3.5	1.01	$4.54x10^{6}$	2,320
$2x10^{-5}$	1	.014	$3.23x10^{6}$	1,530
1	3.5	95.3	$9.53x10^{6}$	9,150
1	1	50.5	$7.25x10^{6}$	7,360

Number of cores reduced for cases with and without large ruthenium release

Smaller consequence reduction for case with large ruthenium release because most ruthenium is in final core offload due to its one year half-life

Other Issues

Results with and without large ruthenium releases presented to ACRS in April 2000.

ACRS comments

Fission product release fractions from spent fuel pool accident study in NUREG/CR-4982 not supported

Plume-related parameters

- **Plume heat content**
- **Plume spreading**

Sensitivity calculations were performed to follow-up on ACRS comments.

Effect of Release Fractions

Case	Release Fraction							Mean Consequences (0-100 miles)		
	I,Cs	Ru	Te	Ba	Sr	Ce	La	Early Fatalities	Societal Dose (rem)	Cancer Fatalities
1	1	$2x10^{-5}$	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	1.01	$4.54x10^{6}$	2,320
45	1	1	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	92.2	$9.50x10^{6}$	9,150
45a	1	1	.02	.01	.01	.01	.01	103	$1.33x10^{7}$	11,700
45b	.75	.75	.02	.01	.01	.01	.01	54.9	$1.17x10^{7}$	10,300
46[a]	1	1	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	1.32	$6.84x10^{6}$	6,430
46a[a]	1	1	.02	.01	.01	.01	.01	1.54	$8.89x10^{6}$	8,160
46b[a]	.75	.75	.02	.01	.01	.01	.01	.543	$7.94x10^{6}$	6,880
46c[a]	.75	.75	.75	.01	.01	.01	.01	.544	$7.94x10^{6}$	6,880
46d[a]	.75	.75	.75	.75	.01	.01	.01	.544	$7.94x10^{6}$	6,880
46e[a]	.75	.75	.75	.75	.75	.01	.01	.644	$1.01x10^{7}$	8,350

[a]Based on early evacuation.

Effect of Release Fractions (cont.)

Results

Increased fuel fines release fraction: increased consequences for cases with early and late evacuation.

Increased tellurium and barium release fractions: no change in consequences due to short half-lives.

Increased strontium release fraction: increased consequences.

Also evaluated the effect of evacuation percentage (99.5% vs. 95%).

Main difference involved early evacuation; factor-of-ten increase in early fatalities.

Effect of Plume Heat Content

Potential for plume heat content to be higher than that of a reactor accident —> staff performed sensitivity calculations using different plume heat contents

Base Case: plume heat content from NUREG-1150 (3.7 MW)

Staff estimated plume heat content to be about 256 MW for complete oxidation of one core in 30 minutes

SNL performed a more detailed estimate of plume heat content (about 43 MW)

Effect of Plume Heat Content (cont.)

Case	Release Fraction							Plume Heat Content (MW)	Mean Consequences (within 100 miles)		
	I,Cs	Ru	Te	Ba	Sr	Ce	La		Early Fatalities	Societal Dose (rem)	Cancer Fatalities
1	1	$2x10^{-5}$	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	3.7	1.01	$4.54x10^{6}$	2,320
45	1	1	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	3.7	92.2	$9.50x10^{6}$	9,150
47	1	1	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	83.0	57.3	$9.24x10^{6}$	9,280
49	1	1	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	256.0	18.3	$8.24x10^{6}$	8,380
46[a]	1	1	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	3.7	1.32	$6.84x10^{6}$	6,430
48[a]	1	1	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	83.0	.00509	$7.28x10^{6}$	7,060
50[a]	1	1	.02	.002	.002	$1x10^{-6}$	$1x10^{-6}$	256.0	.00357	$6.96x10^{6}$	6,650

[a]Based on early evacuation.

Increasing plume heat content mainly affects early fatalities.

Effect of Plume Spreading

MACCS uses a Gaussian plume model with the amount of spreading determined by the model parameters σ_y and σ_z.

As part of international cooperative effort on consequence assessment codes, experts provided updated values for σ_y and σ_z.

Experts provided distributions for σ_y and σ_z, instead of point estimates.

SNL performed MACCS calculations using values for σ_y and σ_z selected by sampling from the distributions; a total of 300 MACCS calculations were run.

Results: Factor of 1.1 to 15 decrease in prompt fatalities. Up to a 60% increase in cancer fatalities and population dose. (Expect similar effects for reactor accidents.)

Decay Times Beyond One Year

Performed calculations at longer decay times (out to 10 years) with and without early evacuation.

As part of these calculations, reassessed the source terms used.

In these calculations, used release fractions from NUREG-1465 (both in-vessel and ex-vessel releases) instead of NUREG/CR-4982.

NUREG-1465 has received significant peer review and is representative of a low pressure core-melt accident

Performed consequence calculations for two cases

- **NUREG-1465**
- **NUREG-1465, with the ruthenium and fuel fines release fractions changed to .75 and .035, respectively**

Source Terms

Source Term	Release Fractions								
	noble gases	iodine	cesium	tellurium	strontium	barium	ruthenium	lanthanum	cerium
NUREG/CR-4982	1	1	1	.02	.002	.002	$2x10^{-5}$	$1x10^{-6}$	$1x10^{-6}$
NUREG-1465	1	.75	.75	.31	.12	.12	.005	.0052	.0055
NUREG-1465 (mod)	1	.75	.75	.31	.12	.12	.75[a]	.035[b]	.035[b]

[a]Ruthenium release fraction is that of a volatile fission product.
[b]Fuel fines release fraction is that of the Chernobyl accident (*Chernobyl Ten Years On, Radiological and Health Impact, An Appraisal by the NEA Committee on Radiation Protection and Public Health*, November 1995).

Results for Decay Times Beyond One Year (NUREG-1465)

Case	Decay Time	Mean Consequences (0-100 miles)		
		Early Fatalities	Societal Dose (rem)	Cancer Fatalities
77a	30 days	2.21	7.15×10^6	4540
77b	90 days	1.37	6.99×10^6	4420
77c	1 year	.736	6.81×10^6	4190
77d	2 years	.481	6.65×10^6	4020
77e	5 years	.192	6.47×10^6	3800
77f	10 years	.0778	6.26×10^6	3620
78a[a]	30 days	.0720	5.69×10^6	3240
78b[a]	90 days	.0461	5.58×10^6	3150
78c[a]	1 year	.0301	5.48×10^6	3020
78d[a]	2 years	.0208	5.40×10^6	2930
78e[a]	5 years	.00882	5.33×10^6	2820
78f[a]	10 years	.00400	5.24×10^6	2730

[a]Based on early evacuation.

Results for Decay Times Beyond One Year (NUREG-1465 modified)

Case	Decay Time	Mean Consequences (0-100 miles)		
		Early Fatalities	Societal Dose (rem)	Cancer Fatalities
79a	30 days	192	2.62×10^7	21100
79b	90 days	162	2.49×10^7	20000
79c	1 year	76.9	2.15×10^7	17400
79d	2 years	19.2	1.90×10^7	15400
79e	5 years	1.34	1.66×10^7	12600
79f	10 years	.360	1.53×10^7	11400
80a[a]	30 days	6.65	1.60×10^7	15400
80b[a]	90 days	3.95	1.52×10^7	14300
80c[a]	1 year	.951	1.34×10^7	11500
80d[a]	2 years	.149	1.20×10^7	9480
80e[a]	5 years	.0162	1.07×10^7	7620
80f[a]	10 years	.00601	1.00×10^7	6490

[a]Based on early evacuation.

Summary

Issues examined

- **reduced inventory (at 1 year)**
- **early vs. late evacuation (at 1 year)**
- **importance of cesium**
- **importance of ruthenium**
- **number of assemblies releasing fission products**
- **fission product release fractions**
- **plume heat content**
- **plume spreading**
- **decay times beyond 1 year**
- **reassessment of source term**

Results of large number of MACCS calculations were used to understand decommissioning risk in staff's generic study.

Presentation to the ACRS Reactor Fuels Subcommittee

Subcommittee Meeting

October 18, 2000

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Air Ingression and Temperature Criteria For Analysis of Spent Fuel Pool Accidents

- Past evaluations of spent fuel pool accidents have used temperature criteria of 800–900 °C, identified as a temperature criterion for self-sustaining reaction of Zr cladding in air (autoignition/ignition).

- More appropriately, temperature criterion may be thought of as threshold for temperature escalation leading to significant fuel damage.

  - Criterion dependent on system conditions, physical configuration, heat generation and losses.

Air Ingression and Temperature Criteria For Analysis of Spent Fuel Pool Accidents (continued)

- Practically, the temperature criteria was used in draft generic study:

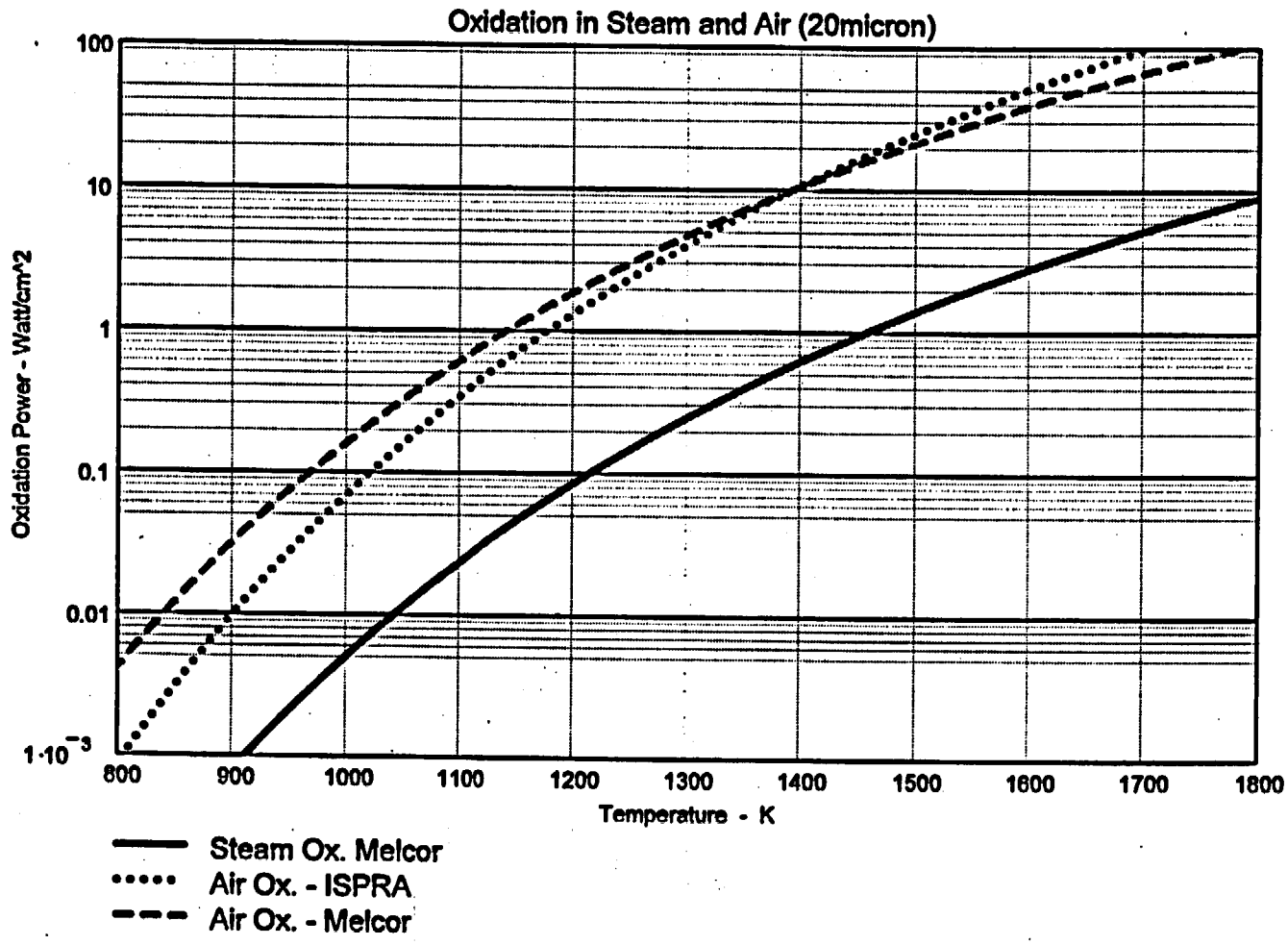
  1) Signal onset of significant fuel pool release for evaluating time for ad hoc evaluation.

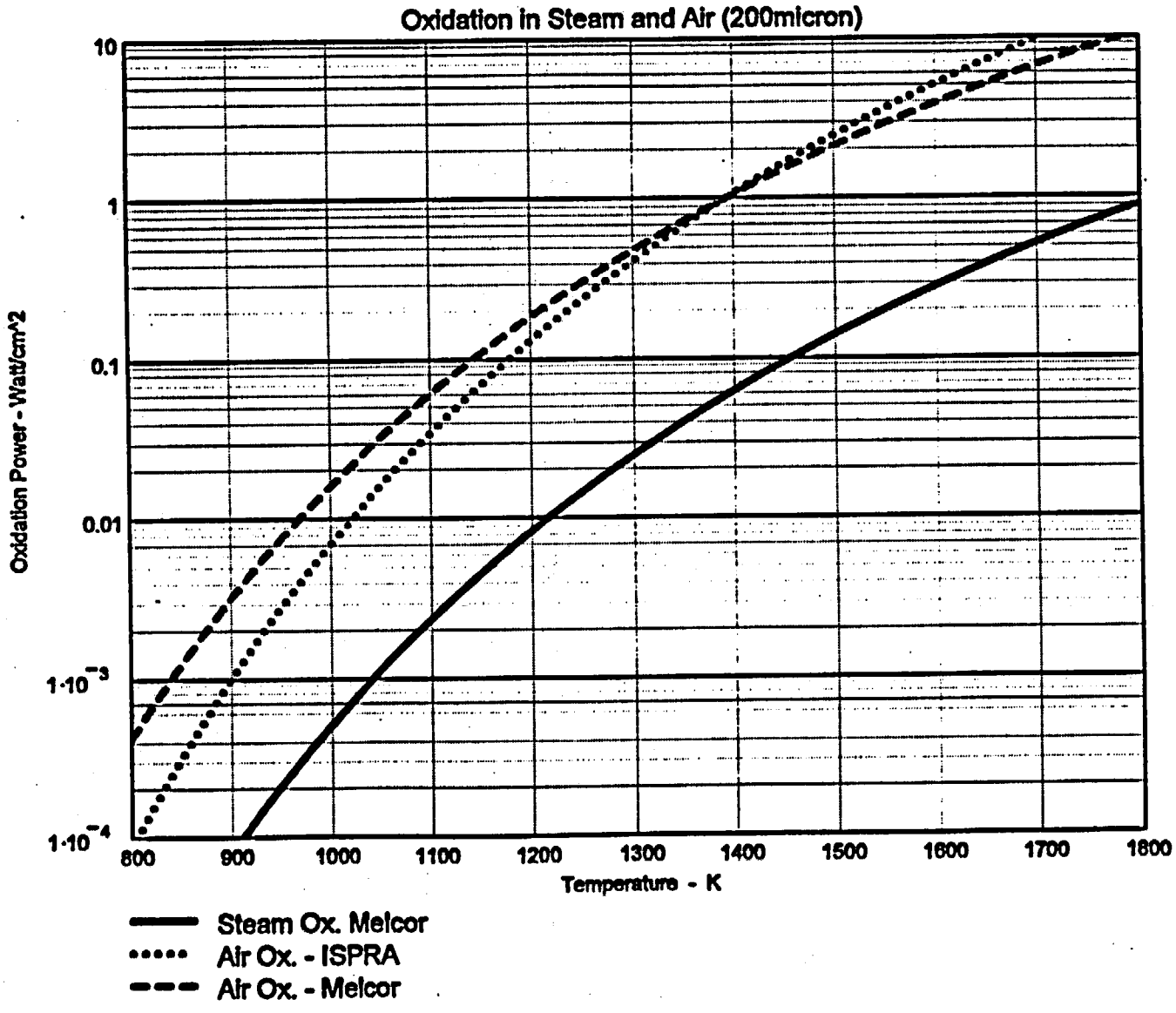
  2) For determination of decay heat level and corresponding time ("critical decay time") at which equilibrium temperature could be maintained, <u>precluding large release</u> (~ 5 years).

- NRC has reevaluated appropriateness of temperature criteria considering:
  - Zr reaction kinetics
  - Hydriding/autoignition
  - Fuel damage testing
  - Fission product release data (ruthenium)
  - Materials interactions

Zr Oxidation Kinetics

- Review of steam and air oxidation data
  - CORA, QUENCH, PHEBUS, and CODEX data on temperature escalation.
  - Determination of temperatures for equivalent heat generation between air and steam.
- Temperature of 1200 °C, representative of temperature escalation in steam core damage tests corresponds to an equivalent heat generation in air at ~ 925 °C using ISPRA's best fit to CODEX data.
- Above approach produces a threshold for temperature escalation quite close to CODEX observation.


Oxidation in Steam and Air (20micron)
Oxidation Power - Watt/cm^2
100
10
1
0.1
0.01
1·10^-3
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
Temperature - K
Steam Ox. Melcor
Air Ox. - ISPRA
Air Ox. - Melcor


Oxidation in Steam and Air (200micron)
Oxidation Power - Watt/cm^2
10
1
0.1
0.01
1·10^-3
1·10^-4
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
Temperature - K
Steam Ox. Melcor
Air Ox. - ISPRA
Air Ox. - Melcor

Zr Oxidation Kinetics (continued)

- Autoignition of clean metal or hydride.
  - Normally oxidized but exposed on ballooning/burst small surface area.
  - Hydrides dissolution prior to reaching conditions for ignition.
- Breakaway oxidation.
  - Reported in isothermal tests (Leistikow, Evans).
  - Instability of nitride layer.
  - Deviation from parabolic rate kinetics.
  - Incubation time of 4–10 hours at 800 °C.
    - Not limiting for transient heatup but would be limiting for long-term equilibrium criterion.

Temperature Criteria and Fission Product Releases

- Fission product releases
  - Initial release of fission products upon cladding failure.
  - High-temperature release of volatiles
  - Release of Ru after oxidation of fuel. (Under what low temperature conditions might fuel oxidize leading to large ruthenium releases?)
  - To avoid rapid releases of Ru, in draindown scenarios temp should be maintained less than 600 °C

Summary

	Adequacy of 10 hrs for Evacuation	Precluding Large Release Fuel <5yrs	Precluding Large Release Fuel >5yrs
Dominant Air Environment	900 °C	600 °C	800 °C
Dominant Steam Environment	1200 °C	N/A	N/A

- Use of temperature criteria must be supported by analysis of all significant heat generation and loss mechanisms.
- Determination of an acceptable long term condition requires confirmation of equilibrium temperature condition.
- Integrated modeling of thermal hydraulics, cladding reactions and fuel heatup and fission product release would provide consistent consideration of conditions for sequence specific analysis. Would provide means for more realistic estimates.

Spent Fuel Pool Accident Risk Study

Timothy E. Collins
Deputy Director, DSSA

ACRS Fuels Subcommittee Meeting
October 18, 2000

Presentation Outline

- February report findings
- Summary of significant comments
- Approach to comment resolution
- Results of re-analysis
- Conclusions

February Report Conclusions

- Frequency of zirconium fire is low
- Consequences comparable to reactor accident large early release
- Seismic events dominate
- EP relaxation after one year is supportable
- Security needed as long as fuel in pool
- Insurance relaxation is more plant specific

Comments On February Draft

- Source term may be non conservative
- Seismic hazard estimates too conservative
- Zr ignition temperature may be too high
- Partial draindown needs more attention
- Results support EP relaxation at 60 days
- Recommendations not risk-informed

Approach To Comment Resolution

- Ruthenium and fuel fines added to source term for consequence analyses
- Risks assessed using EPRI and LLNL estimates
- Consequences calculated at earlier times

Approach To Comment Resolution (con't)

- "Small change" analysis per RG 1.174
- Evaluated sequences for likelihood of flow blockage
- Impact of lower temperature criterion examined

Results

- Consequences with ruthenium and fuel fines still comparable to reactor large early release
- Risk is low but in ball park of operating reactors for first years
- Use of EPRI hazard estimate reduces total risk by about a factor of 4

Results (con't)

- EP relaxation after 60 days is "small change" consistent with guidelines
- Obstructed air flow potential precludes generic decay time when "significant release is no longer possible"
- Temperature criterion effect not important due to already short times in first years

Conclusions

- Risk at decommissioning plants is low even in consideration of ruthenium source term
- Relaxation of EP after 60 days is consistent with "small change" in risk guidelines
- New criterion needed if insurance relaxation is to be considered
- Security required as long as fuel is in pool

Risk Informing Decommissioning Regulations

ACRS Subcommittee on Reactor Fuels

October 18, 2000

by

Lynnette Hendricks, NEI

NEI

Commission Directives 12/21/99 SRM

- Integrated, risk informed rulemaking addressing EP, FP, Security, Backfit and Operator Training
- Consider all realistic scenarios
- (Later Commission decisions on applicability of m maintenance rule, fitness for duty, station blackout, fire protection, etc. to D&D plants will benefit from risk insights)

NEI

Scope

- Use risk insights to adapt deterministic rules for operating plants to decommissioning plants
- Commission principles on risk informing must be adapted to address
  - Different type of consequences
  - Lower probability
  - Different type of system, e.g., passive, robust, slowly evolving sequences

NEI

Objective

- Best Inform Commission to make judgement calls (no magic formula)
  - Provide "apples to apples" type comparison to risk profile presented by operating plants
  - Examine defense in depth in context of simple, passive system where most sequences evolve over very long time frames

NEI

Risk treatment

- Best estimates should be used
- Consequences should not be based on phenomena that have not been validated through NRC's severe accident program
- More efforts should be devoted to probability side of risk equation.
- If probability of spent fuel fire is acceptably low there are diminishing returns on efforts to refine consequences

NEI

Seismic risk in spent fuel pool risk study

- Huge seismic events that are background risk factors for operating plants, dominate risk profile for decommissioning plants
- Seismic risk should be treated in the same manner for decommissioning plants as for operating plants

NEI

Treatment of seismic risk

- Disposition deterministically
  - Screen out using checklist, at 2-3SSE provides large margin
  - Most PRAs screen out at SSE by using seismic experts to establish seismic margins

NEI

Commission Policy on Treatment of Seismic Risk

- NUREG 1150:
  - Use of LLNL: rare but large events contribute significantly to risk
  - EPRI and LLNL approaches are fundamentally sound
  - Avoided including offsite consequences and risk from seismic in findings without context
  - Recommend context: reactor induced accident losses be compared to overall losses (report observes nuclear losses likely to be very small)

NEI

Defense in Depth Considerations for spent fuel pool

- Draft risk report observes defense in depth provided by:
  - Robustness of Pool Structure
  - Simplicity of operation
  - Slow evolution of all but 2 sequences
- By comparison operating PRA's have 100's of sequences for internal events

NEI

Conclusions

- Bounding estimate of seismic risk should not be used to justify retention of operating plant requirements intended for a much broader scope of initiating events
- Overly conservative treatment of seismic risk leads to conclusion that operating plant requirements should be retained

NEI

Conclusions (cont.)

- Opportunities to apply practical risk insights are lost if operating plant requirements are retained
- Speculative phenomena should not be used to determine consequences

NEI