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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION  
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ADVISORY COMMITTEE ON REACTOR SAFEGUARD  
(ACRS)  
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U.S. EPR SUBCOMMITTEE  
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WEDNESDAY  
APRIL 21, 2010  
+ + + + +  
ROCKVILLE, MARYLAND  
+ + + + +

The Subcommittee met at the Nuclear  
Regulatory Commission, Two White Flint North, Room  
T2B1, 11545 Rockville Pike, at 12:30 p.m., Dr. Dana  
Powers, Chairman, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

DANA A. POWERS, Chair  
HAROLD B. RAY  
MICHAEL T. RYAN  
WILLIAM J. SHACK  
JOHN D. SIEBER  
J. SAM ARMIJO

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1 NRC STAFF PRESENT:

2 DEREK WIDMAYER, Designated Federal Official

3 GETACHEW TESFAYE

4 EDWARD FULLER

5 JIM XU

6 LYNN MROWCA

7

8 ALSO PRESENT:

9 SANDRA SLOAN

10 ROBERT MARTIN

11 MICHAEL BINGHAM

12 MOHSEN KHATIB-RAHBAR

13 NISSIA SABRI-GAULTIER

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T-A-B-L-E O-F C-O-N-T-E-N-T-S

U.S. EPR DC APPLICATION FSAR, Chapter 19.....4

U.S. EPR DC SER with

Open Items for Chapter 19.....105

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

12:26 p.m.

1  
2  
3 CHAIR POWERS: Let's get into session.  
4 This is a continuation of a meeting this week of our  
5 Subcommittee on the U.S. EPR. Today we're looking at  
6 the certification aspect. And we're going to discuss  
7 Chapter 19.

8 All the rules and processes for the  
9 meeting are about the same, including the fact that we  
10 have a bridge line and that everyone that will speak  
11 will identify themselves, speak clearly and with  
12 sufficient volume to be readily heard, et cetera, et  
13 cetera.

14 And are you going to introduce this  
15 session?

16 MR. TESFAYE: Sure. Thank you.

17 Again, my name is Getachew Tesfaye. I'm  
18 the Project Manager for EPR design certification.

19 Today, we're trying to complete Phase 3  
20 Safety Evaluation Report with Open Items, presentation  
21 of Chapter 19, which is probabilistic risk assessment  
22 and severe accident evaluation.

23 Today's presentation specifically  
24 addresses severe accident portion of it that was not  
25 completed back on February 18 and 19 of this year.

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1           As I do every time I come here, for the  
2 record I will briefly summarize our Phase 3 activities  
3 that have taken place to date.

4           We have completed Phase 3 presentation of  
5 nine chapters. We presented Chapter 8 Electric Power,  
6 Chapter 2 Side Characteristics on November 3rd and  
7 Chapter 10 Steam-Power Conversion System, and Chapter  
8 12 Radiation Protection on November 19, 2009.

9           On February 18 and 19 of this year we  
10 presented Chapter 17, Quality Assurance and portions  
11 of Chapter 19 Probabilistic Risk Assessment in Severe  
12 Accident Evaluation.

13           On March 3rd of this year we presented  
14 Chapter 4 Reactor and Chapter 5 Reactor Coolant System  
15 and Connected Systems.

16           On April 6, 2010 we presented Chapter 11  
17 Radioactive Waste Management and Chapter 16 Technical  
18 Specifications.

19           In addition, on April 8, 2010 we briefed  
20 the ACRS full Committee on the seven chapters that  
21 were completed through March 2010.

22           Although we don't have a firm schedule for  
23 completion of the remaining nine chapters, our plan  
24 calls for the completion of all Phase 3 activities by  
25 early 2011.

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1 Mr. Chairman, that completes my  
2 introductory remark, unless there is any question.

3 CHAIR POWERS: Yes, I suspect we cannot  
4 complete Chapter 19 today until we get a report back  
5 from our PRA specialist.

6 MR. TESFAYE: That's true. But I'm  
7 talking about the formal presentation.

8 CHAIR POWERS: Oh, formal presentations  
9 will probably get a good start on them today.

10 Are there any other opening comments that  
11 members would care to make about this?

12 We do have Mr. Stetkar studiously plowing  
13 through the details of PRA, and he will report back to  
14 us in depth, in detail that anyone could possibly  
15 want.

16 Sandra, I guess your team is up.

17 MS. SLOAN: Okay.

18 CHAIR POWERS: Let's see, I am reminded  
19 that you're not making your presentation today on  
20 mapping all the requirements against Appendix B?

21 MS. SLOAN: I hope not. Mapping all the  
22 requirements? I'm not sure what you're referring to.

23 CHAIR POWERS: Well, I'm referring to the  
24 job that Brian suggest we assign you because you did  
25 not attend --

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1 MS. SLOAN: Oh, that job. That job.

2 CHAIR POWERS: -- our last meeting.

3 MS. SLOAN: I'll work on the homework  
4 assignment.

5 MS. SLOAN: All right. So I would say this  
6 is the unfinished business from the previous Chapter  
7 19 discussion today. The topic will be from Tier 2,  
8 Chapter 19.2 on severe accident evaluations. And  
9 consistent with the other presentations of the various  
10 chapters, our objective is to give you a summary level  
11 presentation of how this material is organized in the  
12 FSAR for design certification. Our focus, as usual,  
13 is on design features, analytical procedures,  
14 operational aspects that are unique for the U.S. EPR.

15 And our presenter today is Dr. Robert  
16 Martin. And what I would ask since we have Dr. Martin  
17 here, I'd ask him to give his background and  
18 credentials and then maybe pause before you start and  
19 like Michael Bingham give a little introduction of  
20 himself. Mike is here in a supporting role to help  
21 answer questions. So maybe the most efficient thing  
22 is Mike gives his introduction, which will save us  
23 that trouble when we get to the Q&A where he might  
24 need to pitch in.

25 So, I'll turn it over --

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1 CHAIR POWERS: And what do you dislike  
2 Mike for? You said it's trouble for him to introduce  
3 himself? She must have it in for you or something.  
4 Is it a particularly long introduction?

5 MS. SLOAN: So why don't you give your  
6 introduction?

7 DR. MARTIN: Okay. My name Robert Martin.  
8 I'm a nuclear engineer with graduate degrees from  
9 Texas A&M and Penn State.

10 Been with AREVA for 13 years. I've been  
11 primarily involved with methodology development, code  
12 development with SRAP5 code, methodology development  
13 with the realistic large-break LOCA.

14 I've had a small role with the containment  
15 analysis methodology development.

16 And, of course, my primary task for the  
17 last five years is regarding severe accident  
18 evaluations.

19 And, Mike?

20 MR. BINGHAM: My name is Michael Bingham.  
21 I'm a graduate of BYU, Brigham Young University.

22 And I spent four years working with the  
23 Navy doing some analysis, most of the time with Knolls  
24 Atomic Power Laboratory and doing some core thermal  
25 hydraulic there. So I spent four years there.

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1           And then the last four years I've been  
2 here with AREVA doing work with the severe accident  
3 group.

4           MS. SLOAN:   And before we start, I just  
5 wanted to remind everybody there are no fewer than  
6 five pages of acronyms at the end of the presentation.

7           So if you hear something, we tend to speak a lot in  
8 acronyms and abbreviations because --

9           CHAIR POWERS:  I know, you're very unusual  
10 in that respect.  Nobody does that.

11          MS. SLOAN:    But there's a five page  
12 decoder ring at the end if you need help on that.

13          CHAIR POWERS:  Okay.    What does the  
14 acronym AREVA stand for?

15          MS. SLOAN:    It has a history if you want  
16 to talk about the name.

17          DR. MARTIN:   Okay.  I will I have scripted  
18 a little bit here to keep me on track, more than  
19 anything to keep me on time.

20          CHAIR POWERS:  You have no control over  
21 that.

22          DR. MARTIN:   With regard to my boss here.

23                 Today I'm providing an overview of the  
24 content appearing in the U.S. EPR FSAR, Chapter 19,  
25 Section 2 on severe accident evaluations.

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1                   This       presentation       emphasizes       two  
2       keystones, the first being a description of the severe  
3       accident prevention and mitigation features. And then  
4       the second being AREVA's approach to the safety issue  
5       resolution regarding the former. You can see in my  
6       bullets here. I'm going to try to quickly get through  
7       -- quickly is not going to happen.

8                   But design features, we'll discuss that.  
9       And event progression which I think probably is really  
10      the more valuable element since this is probably the  
11      first you've heard about this U.S. EPR severe accident  
12      design features and event progression, at least in the  
13      formal capacity. And then, of course, the long term  
14      stabilization strategy.

15                  And then the other detail goes into how we  
16      used analytical methods to address the safety issues  
17      and how we supported that with technical basis derived  
18      from experimental programs.

19                  CHAIR POWERS: Well let me with a bit of a  
20      philosophical question. Why do we do these analyses?

21                  DR. MARTIN: Well, a lot because it's  
22      expected of us.

23                  It focuses us initially, and I'm basically  
24      going to get into that basis right here. It's, of  
25      course, the regulatory expectation. The regulatory

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1 expectation begins with the SECY-90-016, the SECY-93-  
2 087 where, as you probably know, there's laid out the  
3 expectation for safety issue resolution incorporating  
4 analytical means as well as any empirical support that  
5 we deem necessary, "we" being the collective we as an  
6 industry.

7 In the SECY-93-087 there are safety goals,  
8 as I've listed here, that have identified beginning  
9 with hydrogen mitigation and combustible gas control,  
10 core debris coolability, containment over  
11 pressurization, high-pressure melt ejection and  
12 equipment survivability.

13 This graphic was prepared in our pre-  
14 application topical submittal. Of course, by using  
15 the word "pre-application," this actually showed up to  
16 the desk of Ed Fuller and his team like in October  
17 2006 and he had about a year there to review that  
18 examining the 500 pages of content on experimental  
19 approach on our approach to analytical methods, how we  
20 recognized the particular regulatory precedents, the  
21 precedents established by our competitors, et cetera,  
22 et cetera. And then we incorporated some sample  
23 problems to kind of complete that package.

24 From that point on we have been  
25 implementing that methodology. Again, we started with

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1 the empirical basis, test programs. Again, you could  
2 took a look at that pre-application submittal to see  
3 and there's probably a couple of hundred pages of just  
4 the experimental story supporting the U.S. EPR  
5 strategy for its ex-vessel mitigation approach to a  
6 severe accident.

7 And then since that time, as I've said,  
8 we've focused on the safety issue resolution through  
9 analytical means.

10 CHAIR POWERS: Well, it appears that the  
11 entire focus of this, everything you've defined up  
12 there as safety goals and related issues, have to do  
13 with preservation of the integrity of the containment.

14 DR. MARTIN: And I would say with severe  
15 accident evaluation the emphasis is on that particular  
16 fission-product barrier. Now we in devising our  
17 analytical methods we are, as I will describe later,  
18 certainly incorporating inputs that are, say, Level 1  
19 core damage frequency-informed to, say, define what is  
20 termed more likely scenarios. Again, this is  
21 information that I have incorporated into this  
22 presentation.

23 CHAIR POWERS: And so that means that you  
24 are pretty well discounting any bypass accidents here?

25 DR. MARTIN: No, no. I mean, bypass of

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1 course, we are expected again through the regulatory  
2 verbiage in the SECY-93-087 to address bypass. Now  
3 bypass typically safety-grade isolation systems and  
4 those are discussed in more detail in other sections.

5 And I do think I get to that, at least touch on it  
6 briefly, a little bit later. But this section, 19.2,  
7 while there's a large body of information addressing  
8 analytical support in protecting the containment, the  
9 other relative areas of addressing similar accident  
10 issues including the bypass issue is incorporated by  
11 cross reference to other sections in the FSAR.

12 CHAIR POWERS: Well, a casual thumb  
13 through your presentation sees that you do not deal  
14 very extensively with issue of radionuclide behavior  
15 on this entire presentation?

16 DR. MARTIN: Right.

17 CHAIR POWERS: And I'm curious as why.  
18 Because without the radionuclides, I really wouldn't  
19 care. If you wanted to destroy your reactor, I'm  
20 perfectly willing to let you do it.

21 DR. MARTIN: Of course. The issue of  
22 radionuclides, at least with us following the Standard  
23 Review Plan and the Reg Guide 1.206, the biggest role  
24 for analysis regarding, say, radiological transport,  
25 source term evaluations really feeds into inputs for

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1 Level 3 PRA in evaluating latent fatalities, early and  
2 latent fatalities. And the expectation that I was  
3 interpreting from the primarily SECY-93-087 really  
4 limited me to the content that I have prepared in this  
5 section I can point to, and then the interface  
6 primarily with regard to what you've asked,  
7 radiological transport, followed on with I believe  
8 it'll be sections of 19.1 that touch on Level 3 to  
9 some extent. And the staff did identify particular  
10 issues with radiological transport that have been  
11 addressed through the RAI process as well.

12 The way we divvy up our work, the  
13 responsibilities of myself and my team focused on  
14 performing the calculations and the PRA team takes  
15 those results and incorporates them into the PRA  
16 related analysis supporting those kind of questions.

17 CHAIR POWERS: Well, the question I'll  
18 have for you, you don't have to answer it right now  
19 but sometime before the end of the day, is where do I  
20 go to look to see how you handled things like aerosol  
21 physics, iodine chemistry and the aqueous pool,  
22 chlorine reactions with metal surfaces; things like.

23 DR. MARTIN: Yes. And for our purposes we  
24 have, of course the MAAP code performing accident  
25 evaluations. Primarily the models do exist for

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1 fission-product transport, they exist for settling of  
2 fission-products. As you probably know with the MAAP  
3 code it is a lump-parameter code, but the models are  
4 pretty sophisticated even for a rather, say, less  
5 mechanistic type tool. Less maybe relative to say what  
6 you're more familiar with MELCOR, something like that.

7 Models do exist.

8 We have had questions along that line. I  
9 know we have an open question, I believe it's 19.3.35  
10 with regard to some discrepancies between the MAAP and  
11 MELCOR with a particular steam generator tube rupture-  
12 type situation. And so we have been sensitive or  
13 sensitized to that type of concern and in discussion  
14 with the staff.

15 CHAIR POWERS: Well, you understand my  
16 dilemma here. The only reason I care about this stuff  
17 at all is because if you don't preserve containment  
18 integrity, or even if you do, you get a certain amount  
19 of leakage of radionuclides out and in these severe  
20 accidents putting out a lot of radionuclides, I  
21 presume.

22 DR. MARTIN: Of course.

23 CHAIR POWERS: And I'm struggling to know  
24 exactly what you did.

25 Now, a certain amount of experience, a

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1 very limited amount of exposure to the MAAP code  
2 suggests an awful lot of versions of MAAP. And I'm  
3 not exactly what version you use. And I know that  
4 there are lots and lots of things that get done to it.

5 DR. MARTIN: Certainly. I'll touch on all  
6 these subjects related to how we go about performing  
7 our analytical studies. I'll try to be sensitive as I  
8 go through to radiological transport.

9 CHAIR POWERS: Good.

10 DR. MARTIN: All right. Trying to close  
11 out this slide, I guess my final point I wanted to  
12 make is that the topical report that was prepared has  
13 been incorporated extensively by reference. It  
14 provides detail, again, on the test program,  
15 analytical methods credited for demonstrating the  
16 fidelity and robustness of our design to severe  
17 accidents within the contents defined by the  
18 applicable regulation.

19 Okay. As I've already stated, our key  
20 guiding document for addressing evaluation of severe  
21 accident phenomena is the SECY-93-087 with five  
22 primary areas that are identified here. These are  
23 emphasized in the Standard Review Plan in Reg Guide  
24 1.206 as requiring a broad level of detail relating to  
25 the role of design to prevent and mitigate adverse

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1 conditions.

2 I could go into detail on these, but I  
3 would think I could probably touch on these as I go.  
4 Later I have some analyses, a limited amount of  
5 analyses and I'll probably make a reference to maybe  
6 some of the criteria I was shooting for or what I was  
7 looking at the time. So I don't think I need to read  
8 this slide.

9 CHAIR POWERS: Well, let's talk little  
10 bit about hydrogen control.

11 DR. MARTIN: Okay.

12 CHAIR POWERS: In this analysis are you  
13 relying on passive catalytic hydrogen recombiners?

14 DR. MARTIN: That's correct.

15 CHAIR POWERS: Well, what do you do about  
16 poisoning?

17 DR. MARTIN: Well, that has been a topic  
18 that we've been sensitized by the staff. We've had a  
19 RAI. I believe maybe Annmarie you offered that RAI.

20 We have addressed that RAI probably a few  
21 months ago with regard to just that line of  
22 questioning, aerosol poisoning, fires, carbon  
23 contamination. And it was several other things.

24 I wasn't the key author of that RAI,  
25 although I did have a role in reviewing it.

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1           We, I believe, made reference to a  
2 considerable number of tests that AREVA has been  
3 involved in directly, that AREVA has been involved  
4 with at least through its relationship with EDF.

5           I believe there might have been some  
6 other, maybe, OECD tests, there's a PHEBUS test that I  
7 think we mentioned several times in that response.

8           So I would say the answer to that is we  
9 had considerable amount of empirical type results to  
10 discuss this, as well as some theoretical performance  
11 information that would compliment that. But probably  
12 focus more on experimental empirical type data in that  
13 realm.

14           MS. SLOAN:     And we can make sure we  
15 identify that RAI response and make sure you get the  
16 text of that.

17           DR. MARTIN:    In fact, it was several RAIs.

18           MS. SLOAN:     Yes. We can take the action to  
19 get the particular RAI numbers and ADAMS accession  
20 numbers so you can take a look at those.

21           DR. MARTIN:    Although that was Chapter 6,  
22 I believe.

23           MS. SLOAN:     Well, we'll look it up.

24           DR. MARTIN:    But I didn't want you to go  
25 off in Chapter 19 and look because I believe it was --

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1 CHAIR POWERS: Well the difficulty I have,  
2 of course, is that in one of the tests you made  
3 oblique reference to involves an environment that is  
4 different than the environment that you're going to  
5 have when you have corium debris penetrating your  
6 vessel and coming down into your core spreading  
7 device. And yet it's in that stage where you have the  
8 potential of getting abundant hydrogen production.  
9 And we know that these PAR devices, at least the ones  
10 that I am familiar with, have platinum or palladium  
11 which is very reactive toward metals or sulfides. And  
12 certainly in ex-vessel stages of accidents we get a  
13 lot of sulfides in the atmosphere. And I don't see  
14 those in the tests that I know of that you're referred  
15 to as qualifying your PARs.

16 And we go back into the literature of  
17 PARS, we find particularly where they have been used  
18 for diesel fuels, that's one of their primary  
19 concerns, the metals and sulfides and things like that  
20 that we get in abundance during these later stages of  
21 reactor accident.

22 MS. SLOAN: I think Dr. Power, I've  
23 captured the question that I'm hearing is it will be  
24 addressed in Chapter 6. We'll follow-up and make sure  
25 that you get the RAI responses and we'll take it and

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1 make sure that when we come back for Chapter 6 we  
2 address this is that presentation.

3 MR. FULLER: This is Ed Fuller.

4 We'll also looking at this a little  
5 further for the Chapter 19 review subsequent to your  
6 comments at the last meeting, Dana. And we're working  
7 in conjunction with Annmarie right now to make sure  
8 that we do some confirmatory work as well as formulate  
9 possible additional questions.

10 CHAIR POWERS: Thank you. To we have a  
11 TBD down there. And he jumps off this slide quickly.  
12 I just started on --

13 DR. MARTIN: The main thing my wife  
14 worries about me going off on tangent and talking too  
15 much, but I don't mind talking too much.

16 Unless there's anything else, I'll move on  
17 to the next slide.

18 Now it sounds like you've done a little  
19 bit of homework here and you're cognizant of kind of  
20 the main features. Because I have not said the word  
21 passive autocatalytic recombiners, but I was going to  
22 get to it in this slide.

23 Here, I'll just try to gloss over real  
24 quick and give everyone, just reset their bearings on  
25 what we have in this plant with regard to severe

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1 accident design features. And as you see, I've in  
2 this illustration pointed out the key ones here. And  
3 I guess I'd rather go in order of, maybe, event  
4 progression.

5 Assuming a severe accident the first stage  
6 of moving into what we'll call the severe accident is  
7 when the core exist thermocouples read about 1200  
8 Fahrenheit. Upon receiving that signal, and you know  
9 that's still a parameter that we will refine, say,  
10 during a detailed design. So it's not the only thing  
11 we'll be looking at.

12 But nonetheless, on declaration of severe  
13 accident operators are to be instructed to open  
14 primary depressurization valves which reside above the  
15 pressurizer. Of course that provides the opportunity  
16 to blow down the system with the goal, of course, to  
17 prevent a high pressure melt ejection. In doing so,  
18 and if you're in a severe accident, you expect in-  
19 vessel hydrogen production and hydrogen again escaping  
20 into the containment.

21 The primary mitigation of that hydrogen,  
22 as we've just discussed, are with passive  
23 autocatalytic recombiners. The performance of the  
24 CGCS, the combustible gas control system is enhanced  
25 by the design of the containment itself. The term now

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1 is the CONVECT system, which comes up with the  
2 containment analysis.

3 Early on we called it a hydrogen mixing  
4 system, but the system with dampers and rupture foils,  
5 rupture foils appearing above the equipment rooms,  
6 above the steam generators and then dampers that  
7 reside in the wall adjacent to the IRWST in an outer  
8 containment region. In an event in which the inner  
9 containment region pressurizes the rupture foils, and  
10 there's also these convection foils, which open on  
11 temperature --

12 CHAIR POWERS: One of the things that you  
13 have in this containment is a fair amount of  
14 compartmentalization and you're providing these relief  
15 paths so that you get mixing. What happens if the  
16 relief path doesn't open?

17 DR. MARTIN: Excuse?

18 CHAIR POWERS: Suppose your relief path  
19 doesn't open and I'm blowing this mixture of hydrogen  
20 and steam down there. And the steam condenses in the  
21 cold structures and I'm left with individual  
22 compartments that have hydrogen, presumably, that  
23 could be up way into detonable regimes.

24 DR. MARTIN: Well, we have spent a lot of  
25 effort to make that hypothetical situation highly

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1 unlikely.

2 The rupture foils themselves are designed  
3 to rupture on a relatively small differential  
4 pressures. These are passive systems. I believe the  
5 number is 50 millibar, or is it 35 millibar? Thirty-  
6 five. Nonetheless, those are passive.

7 The convective foils, these also can open  
8 on a pressure differential but to avoid this situation  
9 as you have described, the convection foils by virtue  
10 of naming these convection foils, are allowed to open  
11 on an elevated temperature. And do you know what that  
12 temperature is.

13 MR. BINGHAM: I don't recall what it is on  
14 that.

15 DR. MARTIN: Okay. Nonetheless, in our  
16 evaluation we, of course, tested these things, these  
17 components, the rupture foils, the convection foils at  
18 facilities in Germany.

19 The other side of the coin are the mixing  
20 dampers. Now the mixing dampers are fail-open on loss  
21 of power. They are attached to an I&C system such  
22 that a pressure reading, a delta pressure across the  
23 dampers of, I believe, it's either 50 or 35 millibar  
24 will open so dampers.

25 So to answer your question our response is

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1 that we've incorporated into our design mechanisms to  
2 prevent that kind of problem. We do have, of course,  
3 passive autocatalytic recombiners in the inner regions  
4 of the containment to mitigate high levels of hydrogen  
5 there as well as the PARs are outside of that region  
6 as well.

7 CHAIR POWERS: The question I come up with  
8 is you had these devices that fail on differential  
9 pressures. And you test them, and they sort of do.  
10 They're rupture foils, kind of classic design and  
11 things like that. And they do it on the design,  
12 pretty close to the design kinds of delta Ps. And  
13 then you have to show that in fact you get those delta  
14 Ps at the time you want them.

15 And so I guess I'm asking is how do we  
16 know that we get those kinds of delta Ps because my  
17 experience is with relatively but compartmentalized  
18 facilities when I blow hydrogen steam mixtures down, I  
19 get surprisingly low delta Ps in mine. My rupture  
20 foils never work.

21 I don't have your design, but mine are  
22 pretty much a failure. You do not want a higher major  
23 design in your rupture foils, whatever it is. Mine  
24 don't work.

25 DR. MARTIN: Like I say, we extensively

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1 have studied the rupture foils. And I will say that  
2 the first time we tried it, it probably wasn't  
3 optimal. You learn by that experience. WE probably  
4 have a little bit more money to iron our any design  
5 efficiencies. And I think we're rather confident in  
6 the design today. But I will say that it has evolved  
7 over, probably even in the period of the last four or  
8 five years.

9 MS. SLOAN: And I guess, Bob, I would just  
10 add that persistent functionality, we're addressing  
11 that in the context of Chapter 6.

12 CHAIR POWERS: Well, Chapter 6 is going to  
13 be fun.

14 MS. SLOAN: I think that really comes into  
15 play with the containment pressurization analysis.  
16 And, in fact, that's part of the systems described in  
17 Chapter 6. And I think we don't necessarily have the  
18 system engineers here that were involved with that  
19 testing program. But I guess what I'm hearing is we  
20 need to take that as an action and make sure that for  
21 the Chapter 6 presentation we have the right folks in  
22 the room to talk about the testing program and  
23 qualifications of the foils and dampers.

24 MR. TESFAYE: Yes. And I'd like to add,  
25 Dr. Powers, that the staff has asked significant

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1 number of questions regarding that issue in Chapter 6.

2 CHAIR POWERS: Good. Because I mean the  
3 problem is that when you test these rupture foils, you  
4 know you put pipe on one end and pipe in the other,  
5 put the foil in between. Delta p, it ruptures fine.

6 I put it in a room, put it a -- even if I  
7 put a nitrogen gas in there, yes, it fails. When I  
8 put in condensing hydrogen and steam, it doesn't fail  
9 because the steam is condensing out faster than the  
10 foil can respond. And so you just don't get the delta  
11 P that you need.

12 I mean,, the system was compartmentalized,  
13 it's that not compartmentalized. And the difficulty  
14 with all that is the steam condenses out because of  
15 boiling into a relative cool room here -- well the  
16 hydrogen that's left, you know, goes to the top of the  
17 room, up there it is and not just combustible but a  
18 detonable composition. And, you know, whatever in  
19 this world causes things to spontaneous denote will  
20 happen. And then you're struck into the question of  
21 okay, so why? And that becomes a very difficult  
22 question to ask because you're now putting dynamic  
23 loads on things that were never intended to get  
24 dynamic loads.

25 MEMBER SHACK: Are the mixing veins in the

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1 blowout panel redundant? That is, I mean since the  
2 mixing dampers are at least operator controlled?

3 DR. MARTIN: Well, there is a automatic  
4 system.

5 MEMBER SHACK: Right. But they could also  
6 be manually controlled.

7 DR. MARTIN: They also can be done  
8 manually and they're also, like I said, fail-open.  
9 And there's eight of them.

10 MEMBER SHACK: If only those worked, would  
11 you get enough convection to solve Dr. Powers'  
12 problem?

13 DR. MARTIN: We had an RAI, actually I  
14 think that came under 19, for what fracture of  
15 failures of the overall, both the dampers and the  
16 mixing foils. And I believe we got below 50 percent,  
17 possibly 25 percent of the assumed area was sufficient  
18 to get the kind of mixing that was necessary to  
19 mitigate hydrogen.

20 MEMBER SHACK: And what fraction of this  
21 area is blowout panel and mixing panel?

22 DR. MARTIN: Well, I guess I should  
23 explain a little better. The mixing dampers are  
24 actually regionally below the heavy floor that  
25 supports the RCS. And underneath that floor is the

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1 IRWST. And in the wall above the IRWST and in between  
2 the heavy floor are these eight mixing dampers.

3 And then above the steam generators, above  
4 the equipment rooms are the rupture and convection  
5 ports.

6 So anyway, just to kind of keep us moving,  
7 I will be talking about the core melt stabilization in  
8 more detail here. So I'll just move on to -- and the  
9 role of the IRWST in just a moment.

10 Okay. Here in Section 19.2.2 identify the  
11 preventive severe accident design features addressing  
12 several event precursors described in the SECY-90-016.

13 These include ATWS and mid-loop operation, station  
14 blackout, fire protection, et cetera. And kind of  
15 along the lines of what I was saying earlier with  
16 bypass issues, the detail in this section is cross  
17 referenced to other system description systems  
18 appearing in other FSAR chapters.

19 Okay. Now the next several slides I'll  
20 provide a description of the U.S. EPR's severe  
21 accident mitigation features. As we go through I will  
22 present this information within the context of an  
23 anticipated progress of a severe accident.

24 In this first slide what I'm illustrating  
25 you can focus here on the reactor pressure vessel.

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1 There in the center I've attempted to draw a molten  
2 pool. Obviously, we've already gotten to the point  
3 where we've lost cooling, we've had considerable fuel  
4 damage, we've had fuel melt, we've had relocation down  
5 into the lower part of the core region.

6 The lower core support plate is  
7 considerable larger than, say, conventional BWRs. I  
8 forget the thickness, but it's larger.

9 And then surrounding the core within the  
10 core barrel is a heavy reflector. Maybe you've heard  
11 that from other discussions on the EPR. But the  
12 consequence of this heavy material in the core is we  
13 effectively create a crucible of such which holds a  
14 pool for some period of time until what we expect is  
15 that the failure of the heavy reflector causes the  
16 relocation from the core region into the lower plenum  
17 region. And the general expectation is that that  
18 metal melt would reside above the oxide melt. That  
19 there would be some separation --

20 CHAIR POWERS: There was a brilliant paper  
21 written by a truthfully perspicacious individual  
22 pointed out that that's not true.

23 DR. MARTIN: Well, not true and a possibly  
24 are two different things. You can't prove something  
25 not true, necessarily because the exception is always

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1 possible in rare events.

2 CHAIR POWERS: I believe that we now know  
3 exactly when the metal will be will less dense than  
4 the oxide. And in most circumstances the metal phase  
5 will be the more dense. And I believe they did this  
6 in the RASPLAV and MASCA programs in Russia validating  
7 a brilliant and perspicacious analysis that preceded  
8 the experiments by several years, the author remains  
9 unnamed, of course.

10 And so what happens when the metal comes  
11 down first?

12 DR. MARTIN: Well, that's okay too.  
13 Because this design has been made to accommodate that  
14 particular uncertainty. Nonetheless, the assumptions  
15 kind of going into some of our analytical tools have  
16 incorporated this particular assumption. Again, it's  
17 not that important because, as you'll see in a moment,  
18 our treatment of the ex-vessel phase of event, it  
19 culminates that kind of uncertainty. Nonetheless, we  
20 do get relocation in a severe accident or an  
21 expectation is that'd be relocation from the core  
22 region to the lower plenum.

23 As a matter of fact, I believe in the pre-  
24 application topical report I actually do address the  
25 different possible layering effect of oxides and

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1 metals, including a metal on top of oxide on top of  
2 metal type situation.

3 But nonetheless, one way or the other, you  
4 have significant relocation to the lower plenum. We  
5 can fail the reactor pressure vessel leading to a  
6 relocation into the reactor cavity.

7 In this illustration in the reactor  
8 activity is shaded with, I'd say, a beige color. That  
9 is there to represent the sacrificial concrete.  
10 Behind that layer of sacrificial concrete is a  
11 zirconia brick. The sacrificial concrete is  
12 engineered in a manner so that in its reaction with  
13 corium it conditions the melt. As a matter of fact,  
14 it does two things.

15 It provides a period of temporary  
16 accumulation, a time period to account for the  
17 uncertainties with the end vessel progression  
18 including that which you described with, say, the  
19 effects of different laying combinations of metal and  
20 oxide. Just as much as any kind of influence from the  
21 operator or even some unforeseen type of phenomena.  
22 Nonetheless, the sacrificial concrete provides a  
23 buffering, a time buffer allowing for the reactor  
24 cavity to collect as much as of the material as  
25 possible before the system allows it to progress to a

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1 long term state.

2 MEMBER ARMIJO: Is that a special  
3 concrete, high silica content or something that makes  
4 a different --

5 DR. MARTIN: Correct. The constituents  
6 high silica improves its spreadability.

7 MEMBER ARMIJO: Flowability?

8 DR. MARTIN: Flowability. And that is one  
9 of the goals here. Obviously one of the goals, again,  
10 is to make sure it's there for a few hours assuming a  
11 large relocation. You can also imagine if you don't  
12 get a very large relocation it takes longer to oblate  
13 the concrete. So its self-adjusting in that sense.

14 The zirconia backing is provided  
15 everywhere but the bottom center. There there is a  
16 basically engineered failure spot. It like what we  
17 call a melt gate. Above it is the melt plug.

18 After the melt has obliterated through the 50  
19 centimeters or so of concrete, it will reach that  
20 aluminum gate. Aluminum doesn't put much of a fight.

21 And then once that hole opens up, the melt residing  
22 in the cavity is allowed to relocate into the  
23 transferred channel.

24 Okay. This slide covers a couple of  
25 phases.

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1           The met in this case is now relocated from  
2 the reactor cavity, has flowed into the spreading  
3 compartment. In doing so it has severed a thermal  
4 fuse, we call it a cable effectively that's tensioned  
5 with what we call a passive flooding valve. And this  
6 valve in opening completes the circuit from the IRWST  
7 to a header residing underneath the spreading  
8 compartment. That header feeds many channels spanning  
9 the floor of the spreading compartment, underneath the  
10 spreading compartment. And then the water will fill  
11 that up. The hydrostatic head is such that faster a  
12 period of time, a number of minutes, it will fill up  
13 the spreading compartment in a manner that we can cool  
14 from both the bottom and from the top. And, of  
15 course, initially there will be some steaming. The  
16 flow rate is such that it's only like a 100 kilograms  
17 a second or so. This is basically engineered with a  
18 flow limiter. So there's not a significant concern of  
19 rapid steam expansion and containment over  
20 pressurization. Over time crusts will form.

21           One of the benefits of the conditioning  
22 process in the reactor cavity is that the oxides do  
23 become lighter than the metal and it lifts the oxides  
24 up. The oxides themselves, again, they crust, they  
25 also insulate the rest of the melt. And then in

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1 insulating inhibit steaming, at least briefly. As the  
2 room fills up eventually you saturate that compartment  
3 and then there is some steady state steaming. Its  
4 around between 11 and 15 kilograms a second based on  
5 our analyses of that process.

6 CHAIR POWERS: If you could come back to  
7 the first stages of this process.

8 Ah, you wanted to get by. You know that  
9 I'm not going to --

10 DR. MARTIN: Only because I have -- you  
11 made it harder to stay to the script.

12 CHAIR POWERS: You depict an oxide melt  
13 penetrating at what in the parlance of the  
14 thermohydrologists in this world is the focal point of  
15 the heat flux on the boundary spewing into a  
16 sacrificial concrete. And so you're going to have a  
17 very hot liquid coming onto a gas-evolving solid.  
18 You're going to have a tremendous production of  
19 aerosols at that point most of which will be heavily  
20 contaminated with radionuclides in what looks like a  
21 fairly tight cavity. What happens to those?

22 DR. MARTIN: Well, I mean obviously it'll  
23 be pressure driven. There are, as you said, it is  
24 tight. And I described in the FSAR the tortuous  
25 pathways that it takes to get into the broader

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1 containment region. There is some ductwork for cooling  
2 and it would serve as a leak point. But, again, as  
3 being a tortuous path, opportunities for settling are  
4 certainly there. And again, if you failed the reactor  
5 vessel, you can plow that stuff right back inside.  
6 And then there's certainly plenty of surfaces inside  
7 there.

8 Obviously, the closer you are to the mess,  
9 you know you're going to have the biggest effect and  
10 it will be reduced, you know maybe r-squared,  
11 somewhat, as you get farther away from the mess.

12 CHAIR POWERS: It really it is crucial in  
13 this design that you be depressurized at this stage in  
14 the accident?

15 DR. MARTIN: It is crucial, absolutely.  
16 And certainly that's reflected in the SECY-93-087 that  
17 all these designs incorporate a primary  
18 depressurization system, or what do the other  
19 competitors call them? Automatic pressurization  
20 systems, and what have you. But that is obviously the  
21 primary purpose of such a feature to prevent high  
22 pressure melt ejection or even a lesser than high  
23 pressure melt ejection.

24 But MAAP does incorporate some models that  
25 provide for pressure driven transport of radionuclides

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1 that is there. And it, again, also has the models for  
2 settling out.

3 CHAIR POWERS: Have you looked at the  
4 situation of a polar failure?

5 DR. MARTIN: The what failure?

6 CHAIR POWERS: Polar failure? On the pole  
7 rather than on the lateral edge with a pressurized  
8 vessel?

9 DR. MARTIN: I think we had a question on  
10 a spallation.

11 CHAIR POWERS: That's not the one I was  
12 worried about.

13 DR. MARTIN: No. Launching. I mean, the  
14 launching is a question that I believe has to be  
15 addressed with the SECY-93-087. I'm sure I've written  
16 something in here about that issue.

17 Actually, I believe Dave Gerlits, who is  
18 listening on the phone in theory, has performed the  
19 phenomenological evaluation, specifically regarding  
20 the launching of a --

21 CHAIR POWERS: Yes. The depressure -- how  
22 depressurized do we have to be before we start doing  
23 grievous things. Of course, launching the vessel is a  
24 picturesque description, but the more troublesome  
25 thing is ripping out the penetrations.

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1 DR. MARTIN: Sure. Well, to compliment  
2 what Dave Gerlits did for the phenomenological  
3 evaluations performed with the work in 19.1 for the  
4 PRA effort, we took the results from our analysis.  
5 Now we were relatively conservative in our treatment  
6 of the depressurization process. We assumed a degree  
7 of uncertainty in timing of opening up those primary  
8 depressurization valves. In fact, the rule that will  
9 be provided to the operator would be to open them up  
10 immediately on T-core outlet. But in our assumptions  
11 in doing our analysis we delayed it by as much as a  
12 couple of hours. This was an uncertainty parameter  
13 which I'll talk about in a little bit. And then on  
14 top of that we only assume done train. In fact, we  
15 have two trains.

16 So even in a conservative analysis we  
17 showed in our results that we get to in the worst  
18 scenarios down to between 10 and 12 bar. Now looking  
19 at the results, obviously, I wanted to see us being 1  
20 or 2 bar, you know. But there was work done, I  
21 believe a Sandia, maybe colleagues of yours, that  
22 identify kind of a threshold of no concern around ten.  
23 And so I referenced that.

24 Clearly we have cases in what I would say  
25 a conservative analysis where we're just above ten.

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1 I'd prefer that we be below ten. But as we sharpen the  
2 pencil, certainly we can get down I think below ten.  
3 And as we go into the detail design, go into the  
4 accident management realm which of course we have  
5 questions on, we will sharpen the pencil in those  
6 areas and I think we will find that we don't have a  
7 problem with regard to that issue.

8 CHAIR POWERS: I am vaguely familiar your  
9 cite 400 psi, a little marginal on that. But my  
10 recollection is that was born from experiments done in  
11 specific cavity configurations and in particular for  
12 relatively open cavity configurations a la Zion,  
13 Surry, whatnot. And I don't know what the authors  
14 would have to say about tight configurations, because  
15 I don't believe they ever did experiments on what I  
16 would call a tight vessel with a small cavity.

17 So the question comes up is: Is there a  
18 threshold that they define applicable to this  
19 particular vessel and cavity configuration?

20 DR. MARTIN: Obviously, I can't answer  
21 without going back and studying that particular. One  
22 thing you can think of, it does open up a little bit.

23 There is insulation, of course, all around the  
24 reactor vessel which is sizeable. The expectation  
25 would be in a case like this that would probably rip

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1 to shreds. And it would, in theory, open up but it  
2 would also capture a lot of the mess on its way. And  
3 it would not necessarily be allowed to flow out.

4 CHAIR POWERS: And again, that's not the  
5 question I'm worried about. It's the recoil in the  
6 vessel ripping penetrations out and creating a direct  
7 leak to the outside.

8 DR. MARTIN: Yes.

9 CHAIR POWERS: And I believe the  
10 experimenters did experiments for a cavity with  
11 insulation in the vessel to cavity-wall gap and found  
12 that what happened in contrast to what was expected,  
13 which was that the insulation would be stripped of and  
14 just pushed up into the containment building, that it  
15 caught on various things and jammed up.

16 DR. MARTIN: Yes.

17 CHAIR POWERS: And though they had -- it  
18 was certainly not leak-tight, it certainly created a  
19 substantial pressure across there.

20 DR. MARTIN: Okay. Well, I'm not an  
21 expert on all of that.

22 CHAIR POWERS: Neither am I.

23 DR. MARTIN: You know, local loads or  
24 other things might also be relevant in that kind of  
25 questioning. And other areas may also be relevant to

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1 the discussion.

2 All right.

3 MEMBER SHACK: Just coming back to that  
4 for a second. You have the cast iron cooling system  
5 underneath there. And as I understand it, the  
6 sacrificial material goes. And so you have the corium  
7 sitting on the cast iron and you're confident that  
8 this is going to work?

9 DR. MARTIN: That's correct. Yes. We  
10 have, I believe it's ten centimeters of the  
11 sacrificial concrete that has been engineered on that.  
12 There's been some evaluation.

13 Basically that is there to buffer to  
14 provide enough time that we can get fully developed  
15 flow into the cooling channel structure. And then, you  
16 know we certainly have analyzed it --

17 MEMBER SHACK: To limit that flow, right?  
18 I mean, that's --

19 DR. MARTIN: The flow's limited to, yes, a  
20 100 kilograms a second.

21 Now we have done tests. We've done  
22 basically single channel tests at our offices in  
23 Urlangen. Basically putting looking at flow going  
24 through the equivalent channel and then, of course,  
25 increase the heat flux to something equivalent --

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1 actually equivalent and beyond to what we would expect  
2 in this situation. So we do have a considerable  
3 amount of confidence that comes from this test  
4 program.

5 Again, it's described primarily in the  
6 pre-application topical report. I believe I do  
7 briefly mention it in this report because it  
8 established a criteria for us to measure the  
9 effectiveness of cooling. So even though there is not  
10 a explicit criteria, say in the SECY-93-087, we  
11 derived a criteria that we would then use to  
12 demonstrate the performance of the cooling structure.

13 And then, of course, we followed with conduction  
14 analysis, the WALTER code which I'll talk about in a  
15 little bit.

16 MEMBER ARMIJO: Why did you pick cast iron  
17 for that component? Anything special about it?

18 MEMBER SHACK: A nice Victorian touch, I  
19 thought.

20 DR. MARTIN: We have a lot of experience  
21 with cast iron. We all go camping and it seems to be  
22 very effective at containing my steak, or whatever I'm  
23 cooking.

24 CHAIR POWERS: But it's not so good at  
25 containing materials that have a substantial amount

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1 of unoxidized zirconium in it.

2 DR. MARTIN: And we expect a lot of  
3 oxidation of zirconium when we get to this point of  
4 the game. Certainly lots of opportunities to oxidize  
5 zirconium

6 MEMBER ARMIJO: There must have been some  
7 basis for the selection of that particular material.  
8 I just wanted to know what it was.

9 DR. MARTIN: You know, I would just  
10 speculate. I assume it's relatively easy to forge.  
11 It's a large single component.

12 CHAIR POWERS: Cheap and highly thermally  
13 conductive agent.

14 DR. MARTIN: What's that?

15 CHAIR POWERS: Cheap and highly thermally  
16 conductive.

17 DR. MARTIN: Yes.

18 MS. SLOAN: I think what I would suggest  
19 is we follow-up then to get the why question.

20 CHAIR POWERS: Yes.

21 MS. SLOAN: That's what I'm hearing; why  
22 rather than speculate.

23 CHAIR POWERS: Right.

24 MS. SLOAN: I think we just need to take  
25 that as a follow-up action.

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1 CHAIR POWERS: And then you can explain to  
2 me what happens when it gets hit with a zirconium-rich  
3 melt.

4 DR. MARTIN: Okay. Okay. And this slide  
5 illustrates the severe accident heat removal system.  
6 This system includes that phase I just talked about  
7 with the passive cooling system. Again, it's with a  
8 name like severe accident heat removal, it sounds like  
9 an active. But we fold in this passive phase of heat  
10 removal.

11 The piping illustrates here a couple of  
12 modes. One, of course, was the passive flood the  
13 orange.

14 As I said earlier, we do expect at some  
15 point the pool above the spreading area to saturate,  
16 this was steam. Steam, of course, does pressurize the  
17 containment. And we have a spray mode. Now these  
18 sprays are nonsafety-related sprays. These are sprays  
19 designed for severe accident. And as we'll get into  
20 eventually with Chapter 6, you know we do not have a  
21 spray system to address design basis analysis. But we  
22 do have a spray system to address severe accident.

23 It, of course, helps mitigate the  
24 pressure, hold the pressurization. It also helps scrub  
25 out fission products.

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1           The layout of containment is such that the  
2 spray water will drain down. Everything drains into  
3 the IRWST. And so you have a closed-loop system with  
4 regard to the cooling water.

5           Again, here's the spray line. The water  
6 will spray down. You will get some condensation in  
7 the coalescence. And everything leads right back down  
8 to here.

9           In the long term when operators have  
10 decided that it's time to address recovery,  
11 remediation, decommissioning and exactly what that  
12 time is, is yet to be determined. For the U.S. EPR it  
13 may be 24 hours, or it may be beyond that. There is a  
14 active flooding stage, in which case "active" meaning  
15 an active pump that would circulate, again, from the  
16 IRWST through the same channel where the passive flow  
17 is and then into the spreading compartment.

18           And it'll illustrate better here it will  
19 flood the spreading compartment, a chimney that  
20 resides above it, but also because there's a hole here  
21 it will flood up into the reactor pressure vessel area  
22 and recovery any remaining melt. It also provides  
23 another way to kind of capture fission products,  
24 particularly anything that remains in settled areas,  
25 as well as anything that might come out of the spray

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1 system.

2 CHAIR POWERS: Let me ask you a question  
3 about your sprays. I've talked to my friends and  
4 neighbors about the EPR. They're intensely  
5 interested, of course. Because New Mexico is so close  
6 to Maryland, no doubt, they ask me gee, the spray  
7 header in the U.S. EPR is not a safety-grade system.  
8 But the sprays in Finland EPR are. And the spray in  
9 Flammenville in France will be. How come it's not in  
10 the U.S. EPR?

11 DR. MARTIN: That stems from different  
12 definitions of safety-grade. We are more black and  
13 white in this country and the countries are --

14 MS. SLOAN: It, in part, goes to how you  
15 treat severe accident mitigation systems and how you  
16 classify those systems differently in the U.S. than we  
17 do in other regulatory environments. They're not  
18 credited to perform a safety function in the Chapter  
19 analyses, and that's essentially the criteria you  
20 would use in the U.S. to do the classification.

21 DR. MARTIN: Moving on. That kind of  
22 concludes the design description. But I expected it  
23 to be the longest section of the discussion.

24 CHAIR POWERS: We have tried to disabuse  
25 you.

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1 MS. SLOAN: I don't think I could tell.

2 DR. MARTIN: You know, I've had Ed and  
3 Annmarie cornered for a day doing this day. I have no  
4 problem going on. But Sandra and Brain, they'd take  
5 issue I spend too much time.

6 MEMBER SHACK: Which of these systems ends  
7 up in the RAP program? All of them?

8 DR. MARTIN: No. Well, the RAP list has  
9 been modified. I provided some input on RAP in my  
10 opinions. But it does not come down to my decision.

11 MS. SLOAN: We don't the answer.

12 DR. MARTIN: Right. But there are  
13 components of this that I would say it's the active  
14 components of the SAHRS fall underneath that. I would  
15 certainly recommend. Again, I don't have a say that  
16 the passive elements do not appear on this. I don't  
17 think there's precedent for that.

18 MS. SLOAN: And we'll have to follow-up  
19 and make sure you have a copy of the RAP list.

20 MEMBER SHACK: Well, it may even be in the  
21 RAP list. I just don't remember it.

22 DR. MARTIN: There's update to that.

23 MEMBER SHACK: I can't remember what the  
24 RAP list looks like off the top of my head.

25 CHAIR POWERS: Oh, Bill, come on.

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1 MEMBER SHACK: But John can.

2 CHAIR POWERS: You have some starters to  
3 maintain yours.

4 MEMBER SHACK: I'm not even going to try.

5 DR. MARTIN: Okay. In this one, I kind of  
6 as a transition slide getting to the analytical  
7 methods, I put some motherhood statements to kind of  
8 address our goals in moving forward with our  
9 analytical methods. You know. motherhood statements,  
10 sufficient technical qualities, address the goals  
11 appearing in regulatory documents with emphasis on 24  
12 hours or more likely severe accidents.

13 So, let me move on to this illustration of  
14 what we're using to perform severe accident valuation.

15 The centerpiece of our analytical tools  
16 is, as I've said, the MAAP code, MAAP Version 4.07 was  
17 effectively commissioned with models to address EPR in  
18 general, U.S. EPRs specifically. And in a case or two  
19 this expanded on the ex-vessel modeling that was  
20 necessary for EPRs, although the older versions of  
21 MAAP did have some ex-vessel capability. But we  
22 needed something to address multiple pools. We needed  
23 something to address the influence on the inside of  
24 the heavy reflector. We needed more modeling  
25 capability in the containment.

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1           We have, as you'll see in the second  
2 bullet, a model with 27 control volumes. We also keep  
3 a model with 11 control volumes now for other studies.

4           So we have our version. MAAP 4.07 is now  
5 the latest, greatest issue provided by EPRI to the  
6 MAAP users group community. So our models are  
7 available to members of EPRI.

8           Along with that we have a couple of other  
9 codes that we use to perform supplemental analysis in  
10 areas where MAAP is deficient or where we wanted to go  
11 off and do studies that related to questions that we  
12 had about severe accident phenomena.

13           These are the WALTER code, which is an in-  
14 house code. It is a one dimensional heat conduction  
15 code with phase change, a solid to liquid, liquid to  
16 solid. We used that in a couple different areas.

17           And then we had the METSPREAD code, which  
18 is an NRC-sponsored code. I believe it was developed  
19 at Argonne addressing spreading of corium. And corium  
20 mixtures with, say, concrete.

21           So those are the suite of codes that we  
22 use primarily.

23           The evaluation methodology that I was  
24 working with or working towards, I tried to model it  
25 off, basically, the Reg Guide 1.203, even though this

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1 is a Reg Guide developed for design basis safety  
2 analysis, it certainly -- I of course with my own  
3 background in design basis safety analysis I endorse  
4 its approach and wanted to emulate it to some extent.

5 Obviously, it's a little more complicated with the  
6 severe accident so it gets a unique flavor with this  
7 application.

8 So I have what I term a three-fold  
9 approach to the safety issue resolution beginning with  
10 the identification of what I termed the relevant  
11 scenarios or this is where I tried to define what more  
12 likely events, more likely scenarios, which it appears  
13 multiple times in the regulatory documents.

14 CHAIR POWERS: Now, I think this just gets  
15 you into a conundrum here. Because what we're really  
16 interested is the risk-dominant and not the frequency-  
17 dominant scenarios. And so you get locked into this  
18 CDF and it leaves you neglecting those things that  
19 have low frequency, but they're the high consequences  
20 like bypass accidents and things.

21 DR. MARTIN: Well, and in my topical  
22 report I try to address that. I try to draw a line in  
23 the sand where I say that we examined cutsets or event  
24 categories that span, I believe, 90 percent of the  
25 domain of severe accidents event precursors.

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1 CHAIR POWERS: Yes, but you're still in  
2 CDF space here.

3 DR. MARTIN: I'm still in CDF space.  
4 Again, we have expectation to define more likely  
5 scenarios. So this is how I went about it. And it is  
6 Level 1 core damage frequency-informed evaluation.

7 CHAIR POWERS: As I have characterized  
8 it's CDF-informed during normal operation events.

9 DR. MARTIN: Well, you know have to draw  
10 the line somewhere. I mean, we can take remote  
11 events, on top of remote events and remote events and  
12 you could find something that's going to cause --  
13 again, your low frequency high consequence. And  
14 that's a separate element of Chapter 19. We've  
15 certainly had questions on that.

16 When I say "more likely," I'm excluding  
17 the very low frequency type events. So that's where  
18 I'd begin all this work. So, that is a key  
19 assumption, and it's certainly open to scrutiny.

20 so I've identified a set of relevant  
21 scenarios. I'll get into that a little bit. I focus  
22 on, like I said, classes and try to capture -- maybe  
23 I'm getting ahead of myself a little bit. But since  
24 you asked, I'll go into it a little bit.

25 I tried to take this classes of events and

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1 collapse them down into kind of a manageable set. And  
2 then incorporate assumptions into this set, elements  
3 that might characterize bounding conditions of the  
4 class itself. So I've made an attempt at that.

5 I also carry along a few extra cases which  
6 I don't advertise so much, to kind of accommodate  
7 changes, the review process, whatever. Just to kind of  
8 protect myself from the uncertainty of the process of  
9 going through this type of review.

10 So I have this set. On top of that I have  
11 an uncertainty analysis. And this uncertainty  
12 analysis tries to examine all those elements that are  
13 of interest and specified in the SECY-93-087. Again,  
14 listed there, there's a same list before.

15 And then when I look at that going there  
16 are going to be holes, there's going to questions just  
17 like you have, or Ed, or Annmarie, or who. And then I  
18 start targeting the holes. And that's the last phase  
19 of it to compliment the other two.

20 So maybe -- sorry.

21 CHAIR POWERS: Maybe just to understand  
22 better, I mean one class of events that always comes  
23 promptly to mind with this particular unit as we get  
24 into the severe accident analysis and all the material  
25 that you covered earlier is suppose we have an

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1 earthquake as the initiating event, how much does that  
2 effect the progression that you outlined for us  
3 before?

4 DR. MARTIN: Well, I don't get to what  
5 causes the break or what causes the loss of a  
6 component. You know, if it's an earthquake what I  
7 would begin with is I've lost off-site power.  
8 Obviously, that's a big one as you maybe recall from  
9 our February meeting. Loss of electrical loads,  
10 station blackout is a key contributor to our PRA  
11 numbers. So that knocks out certain things. And then  
12 we have assumptions along the lines of loss of the  
13 backups, loss of anything that might lead to loss of  
14 core cooling, effectively. You know, whether it's an  
15 additional break; you know multiple failure obviously  
16 lead to a severe accident.

17 So I don't know. It may not answer your  
18 question with regard to earthquake, but I got to begin  
19 with --

20 CHAIR POWERS: Yes, it does.

21 DR. MARTIN: -- a loss of a component, not  
22 what caused the loss of the component.

23 CHAIR POWERS: But I mean in this case the  
24 initiating event has, presumably, some impact on all  
25 this structure that you've got for handling this core

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1 melt. And so it initiates the event and now the melt  
2 comes down to the lower plenum, and now what does it  
3 do when the carbon steel plate has now fallen to one  
4 side and the flow paths that you've developed have  
5 been ruptured?

6 DR. MARTIN: Well, I think, again you can  
7 apply layers of failures. And layers of failures get  
8 more and more remote as you try to find that Achilles'  
9 heel. You know, we don't assume a unique failure of  
10 the core plate, and I think that matters because we'd  
11 get relocation to the lower plenum and you wouldn't  
12 necessarily sit there on top of -- you know, I've had  
13 a pool maybe on top of the plate and --

14 CHAIR POWERS: You see, the trouble I'm  
15 having is you tell, okay, I'm going to look at things  
16 where the core damage frequency is greater than 10 to  
17 the minus 8. And I have a RCOLA coming to me on a  
18 site that I'm sure has 10 to the minus 6 earthquake  
19 core damage frequency, since every place has a 10 to  
20 the minus 6 core damage frequency due to earthquake.

21 DR. MARTIN: Right.

22 CHAIR POWERS: So, I mean it's nontrivial  
23 compared to your threshold. And I don't know how that  
24 system, and they're not two things here. The  
25 initiating event brings the damage to the melt

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1 relocation system simultaneously. And I don't know  
2 how sensitive it is to that sort of thing.

3 DR. MARTIN: Well, I mean the question  
4 certainly -- it's an obvious question whenever you're  
5 dealing with the broad uncertainty that's there with  
6 complex system. It's not a unique to U.S. EPR.  
7 Certainly not unique to advanced reactors. Not unique  
8 to nuclear power, even. So, yes, you can combine such  
9 thing, such uncertainties.

10 I think this industry does a great job by  
11 incorporating PRA. I think we get a much better look  
12 at this kind of question. As a matter of fact because  
13 we talk about it, we ask more questions.

14 So, I mean obviously I'm being a little  
15 philosophical here. But, you know, that's where we're  
16 at with those kind of questions. It becomes a bit  
17 philosophical where you draw the line.

18 CHAIR POWERS: Well, you drew the line.

19 DR. MARTIN: We take a pessimistic  
20 approach to these kind of analyses. Again, I used the  
21 PRA information to the best of my ability. I do make  
22 some assumptions. I assume for these deterministic  
23 studies that our features set -- you know, most of our  
24 features for severe accidents work, you know most  
25 important being the pumps on the SARS, you know.

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1 My goal here is to demonstrate that the  
2 concept works. And, of course, your job is to review  
3 and see if there are vulnerabilities or limitations.  
4 And at some point, you can find something that you can  
5 come up with a scenario.

6 CHAIR POWERS: Yes, but I wasn't  
7 imaginative. And I drew it within your boundaries.

8 DR. MARTIN: Well, I don't think you have  
9 to be very imaginative to get to that point. I mean,  
10 you can imagine, you know a meteorite, an asteroid --

11 CHAIR POWERS: But that would be outside  
12 of your boundary. I drew it within your boundary.

13 MS. SLOAN: I think I've captured the  
14 comment. I don't know how much further you want us to  
15 go with the discussion, Dr. Powers.

16 DR. MARTIN: Yes. Well, I would say --

17 CHAIR POWERS: Not any further. I mean,  
18 there's no point in taking it even further because we  
19 haven't got anything here.

20 DR. MARTIN: Okay. This slide's on the  
21 relevant scenarios. And I've kind went, like I said  
22 in the previous slide, I got ahead of myself a little  
23 bit in describing what we do. PRA Level 1-informed. A  
24 combination of the many scenarios classes. And the  
25 list of classes appear in actually Chapter 19 Section

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1 1.

2           And I went through an evaluation process  
3 to identify specific core and plant damage end states  
4 that emphasize the reactor pressure, reactor system  
5 pressure, reactor coolant system pressure at the onset  
6 of core damage and also where the heat was going at  
7 the time. You know, do I have, say, a natural  
8 circulation loop going out into the loops themselves  
9 or is it mostly heat contained, a pop could impact  
10 that. Those I felt were basically number one and two  
11 when it came to categorizing my relevant scenarios.  
12 Obviously, the initiating event whether it was a LOCA,  
13 whether it's a loss of heat sink were all incorporated  
14 into that decision making process.

15           And in the end I have a summary table that  
16 lists the probability of a given risk-relevant event  
17 type leading to a particular core plant damage end  
18 state.

19           Next slide provides a very high level  
20 description of these events. The LOOP TR is a loss of  
21 heat sink, a loss of off-site power event with  
22 expected the bleed valves are not open, so the RCS is  
23 high pressure at the time of core damage. In fact, I  
24 have to assume a delay that the operators do not  
25 follow the rules there of opening up the primary

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1 depressurization valves. So there is even a human  
2 element to the assumptions which, I would say,  
3 wouldn't necessarily be required in this kind of  
4 activity but it was really necessary to get us to this  
5 type of category.

6 Nonetheless, you see lists there. And  
7 you'll see LOCA, you'll see loss of off-site power,  
8 loss of heat sink without good power so that there was  
9 a pump RCP on. So I also carry a couple of others, a  
10 steam line break, I carry a large break LOCA. Again,  
11 just in case I need additional insights to these  
12 events.

13 That, gain, defines our best estimate  
14 calcs.

15 Under the cornerstone of all our  
16 evaluations hinges on uncertainty analysis.  
17 Uncertainty analysis is in the tradition of Reg Guide  
18 1.203 or the co-scaling applicability uncertainty  
19 methodology. The bottom-up, top-down type approach.

20 I went through -- we didn't do a PIRT,  
21 say, phenomenological identification and rating table  
22 process. However, this kind of activity has been done  
23 with EPR in mind. In Europe it's been done certainly  
24 for conventional PWRs. I had that information and I  
25 kind of composite together to identify

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1 phenomenological classes, as you see here in the first  
2 column, the left column in red. And I've tried to list  
3 them, more or less, in even progression order. You  
4 know, there could be an exception or two, but you'd  
5 certainly you'd understand. Thermal-hydraulic and  
6 fuel rod degradation, core melt progression in  
7 vessel, on and on.

8 The next step was to look at those classes  
9 and kind of break that down into what I viewed as much  
10 as what I could glean from literature. I do have some  
11 experience, so my judgment probably colors it  
12 somewhat. But stored energy to decay heat, obviously  
13 metal water reaction are important early on. On and  
14 on, identified several associated problems.

15 And then the next step was to look at what  
16 was in the code that would reflect an influence on  
17 those phenomena. And so I broke it down even further,  
18 identified particular code inputs that which would  
19 enact some kind of influence on my simulation event  
20 progression. So, that is what the right hand column  
21 is listing there.

22 I came down to what I felt were 27 unique  
23 code inputs influencing the 19 or so or 15 or 19 or so  
24 phenomena classes.

25 Okay. So what do I do with that? Well,

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1 allow myself to be recelebrated with the expectation  
2 of SECY-93-087 looking for deterministic engineering  
3 analysis and judgment complemented by PRA. The  
4 uncertainty analysis that I have developed with a lot  
5 of help from Mike, I should say, allows for broad  
6 consideration of uncertainty. And I'm looking at 27  
7 different parameters and these influences on many  
8 phenomena.

9 I also include in the uncertainty analysis  
10 a weighting on the relevant scenarios themselves. And  
11 that, of course, is Level 1 informed. It does  
12 incorporate some engineering judgment. So it's  
13 certainly open to that kind of qualitative scrutiny.

14 And then, of course, I had to go off and  
15 do a review for what would be the uncertainty domain  
16 of those 27 parameters. And, actually I had a lot of  
17 help because Fauske and Associates has done a lot of  
18 this work. But they're not the only ones. As you  
19 know, as your friends down the hall at Sandia have  
20 done similar activity with MELCOR. And I also am  
21 familiar with work by Randy Gauntt in this area. I  
22 know he's focused a little bit on hydrogen in  
23 particular. And so I've talked to him a little bit.  
24 But, you know, I use the contacts, use the broader  
25 state of the art understanding in this field

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1 incorporated it into our methodology and have  
2 quantified, to the best of my ability, the uncertainty  
3 domain for the U.S. EPR.

4 The process itself, we apply a non-  
5 parametric approach. I'm not sure how much you've  
6 gotten into the work and the realistic large break  
7 LOCA, but it is a methodology statistical approach  
8 that what we're implying is similar to that which is  
9 applied in the large break LOCA analysis, either Monte-  
10 Carlo-like simulations with many sampled cases. These  
11 are effective experiment, numerical experiments done  
12 many times by sampling the individual parameters that  
13 have been identified for treatment within the  
14 uncertainty analysis.

15 CHAIR POWERS: The analysis that you're  
16 doing here assumes that all your parameters are  
17 independent.

18 DR. MARTIN: They're all independent,  
19 correct.

20 CHAIR POWERS: And why should I assume  
21 that?

22 DR. MARTIN: You know, you asked me that  
23 question last September when I was --

24 CHAIR POWERS: I didn't get it answered  
25 then either.

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1 DR. MARTIN: Although your example was a  
2 little bit better in September because you used the  
3 metal-water example. Because the work of Cathcart  
4 Powell identified two uncertainty parameters.  
5 Basically it's an exponential function. There's a  
6 constant on the front and then exponential  
7 uncertainty. And you pointed out that there was a  
8 correlation. And I did ignore that.

9 And I think my statement there is, it is  
10 an inherent assumption in approach.

11 CHAIR POWERS: And what it strongly  
12 effects is your bottom line there that says, okay,  
13 I've sampled 95 percent of the range. True only when  
14 they're there independent. As soon as there was  
15 correlation between them, now you no longer can say  
16 that. In fact, you've narrowed it substantially. If  
17 there's any correlation --

18 DR. MARTIN: Well, right, it gets  
19 narrowed. And part of my answer then is what it would  
20 be now. Generally by -- and it's not a hard and fast  
21 rule, but regarding the uncertainty ranges the  
22 coupling of correlation tends to broaden the overall  
23 uncertainty and move out that tolerance limit.

24 You know, I think you get a higher level  
25 of confidence the more parameters you're looking at.

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1 Particularly, we have 27, we had like 30 or in the  
2 LOCA. The more parameters you use and the more you  
3 follow that rule of thumb, I think you're okay. Again  
4 --

5 CHAIR POWERS: So I would like to have  
6 some demonstration that that rule of thumb has any --  
7 I will agree with you it seems plausible.

8 DR. MARTIN: Right.

9 CHAIR POWERS: I don't agree that I can  
10 demonstrate that in any kind of persuasive sense right  
11 now. I mean I don't argue with your argue with your  
12 plausibility. But I do argue --

13 DR. MARTIN: Right. There is an exception  
14 to every rule. It is one of those rules that you could  
15 probably find an exception to. Even in design basis  
16 space the regulations don't say 95. They say a high  
17 probability of meeting criteria.

18 So I would think and beyond design basis  
19 we probably have a little bit more liberty to stand  
20 behind that kind of -- our own definition in this  
21 particular case.

22 So, yes, you found me out. I forgot about  
23 September you brought that same question up.

24 Fifty-nine cases is the magic number with  
25 a unvarying assumption. As a matter of fact, I'm in

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1 the camp where it is always the case but that'll be  
2 something you'll probably get into more when you talk  
3 more about realistic LOCA. All I claim really in the  
4 FSAR and in our methodology is that it's a good method  
5 estimate of tolerance limits. And I try not to make a  
6 claim behind I have here.

7 But I don't believe I've used that  
8 language in FSAR, but I could be -- I was trying to be  
9 sensitive to that at the time. But I'm human.

10 Here's a list of selected uncertainty  
11 analysis parameters. I've highlighted several  
12 parameters impacting hydrogen uncertainty and core  
13 debris coolability uncertainty. As I said before, I  
14 had a lot of help there from Fauske and from the  
15 MELCOR team at Sandia in kind of picking these numbers  
16 here.

17 One thing is notable, however. Is that  
18 the 10 CFR 5044 rules regarding combustible gas say I  
19 have to look 100 percent metal water reaction with  
20 regard to hydrogen generation. The codes tried to  
21 best estimate, as well as they can with today's state  
22 of the air. As such, if you perform a best estimate  
23 analysis, you don't get a 100 percent. So I'm really  
24 not familiar what other people do, but what I chose to  
25 do was buy us parameters that I thought would have the

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1 greatest influence on the hydrogen generation.

2 So, for example, if you look at the first  
3 one, it's a water reaction multiplier. You would  
4 think best estimate would be one. A multiplier of  
5 one. You can see I used --

6 CHAIR POWERS: No you wouldn't.

7 DR. MARTIN: If someone did a best  
8 estimate model, you would hope the multiplier was one.

9 CHAIR POWERS: No, absolutely not. I  
10 mean, you're trying to compensate here for not only a  
11 zirconium reaction with steam, but also a stainless  
12 steel reaction with steam.

13 DR. MARTIN: I think it's a model that's  
14 applied to both. True.

15 CHAIR POWERS: I mean it has to be greater  
16 than one.

17 DR. MARTIN: So, again, I'm trying to get  
18 100 percent. I wasn't getting that. So you can see,  
19 1.5 is above what a best estimate model would be.  
20 Now, you know Fauske, I believe they don't use 1.5.  
21 They'll say a low value, I believe, of one. And then  
22 a high value might be 1.5 or something like that.

23 I shifted that, obviously, to get more  
24 hydrogen.

25 CHAIR POWERS: And the problem that we

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1 have with that, not so much with that one, but with  
2 many of these is that you said yes there's a range,  
3 but I don't know what that range really ought to be.  
4 And the way you sample, those are kind of fixed ranges  
5 there.

6 DR. MARTIN: They're fixed ranges, that is  
7 true. So the integrity analysis with these  
8 assumptions.

9 CHAIR POWERS: And the other problem that  
10 you have, it seems to me with this, is for instance  
11 take particularly the debris size in the lower plenum.

12 What you have is a single particle sized model until  
13 you pick the particle size there. But, in fact, we  
14 know it's a distribution of particles.

15 DR. MARTIN: Right.

16 CHAIR POWERS: And there's no reason that  
17 that behaves at all --

18 DR. MARTIN: Right.

19 CHAIR POWERS: In fact, we know absolutely  
20 that mixed debris tends to behave like the smallest  
21 debris particle in there. And so your range is in  
22 fact, even when you were in the coolable direction,  
23 where it probably should not be.

24 DR. MARTIN: Well, you know, the process  
25 to come up these numbers is not just, you know -- and

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1 particularly in the case of Fauske and Associates.  
2 They have studied these, you know, their code  
3 sensitivity to the many tests that are available in  
4 the severe accidents experimental domain. I think  
5 Fauske's like Sandia, you know has had ample access to  
6 the best that's out there. And I think we all  
7 acknowledge it. You know, they are leaders in the  
8 industries on this stuff.

9 So that's the pedigree. It comes back to  
10 that expertise and that empirical evidence of how the  
11 codes perform against that empirical evidence.

12 Granted, they themselves acknowledge that  
13 one number doesn't do it by itself for all tests.  
14 That's why they provide both the high and the low.

15 So there is a method to the madness. You  
16 know, it's logical and we're just following on by  
17 using kind of contemporary uncertainty analysis  
18 methods to get to our results. But at a proper review  
19 of this process, again, has to look from bottom up.  
20 It also has to consider it from top down.

21 The bottom up being breaking it down like  
22 this. This is the right way to do it. Breaking it  
23 down to the phenomena, looking at how the codes  
24 respond to the sensitivity in these particular  
25 parameters. And then also where those parameters come

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1 from. That comes from integral tests and how the  
2 codes respond there. And that's how you do an  
3 uncertainty analysis today. And that has been  
4 captured, I think, in the Reg Guide 1.203, which is  
5 only five years old now. But that's where we're all  
6 moving to, and it's the right approach to doing both  
7 safety analysis and, in this case, severe accident  
8 analysis.

9 And all our competitors should follow our  
10 lead.

11 CHAIR POWERS: And problems you run into  
12 are things like corium friction coefficient, and  
13 nobody knows what the corium friction coefficient it  
14 is. It's a parameter in the code to compensate for  
15 physics they don't care to model.

16 DR. MARTIN: Right.

17 CHAIR POWERS: And so the only recourse  
18 one has with that is to run against some test and vary  
19 it. And, unfortunately, there are 15 other parameters  
20 in the code. And so you don't have a unique set.

21 DR. MARTIN: Right.

22 CHAIR POWERS: And consequently corium  
23 friction coefficient has an obscure correlation with  
24 the other core. And so ipso facto is not  
25 uncorrelated.

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1 DR. MARTIN: Right. Well --

2 CHAIR POWERS: And no one knows what the  
3 appropriate range is. I mean, you take in a factor of  
4 100, it looks very impressive, you know, huge range.  
5 But in fact the real range on what that corium  
6 friction coefficient is could be much larger.

7 DR. MARTIN: Right.

8 CHAIR POWERS: Or it could be biased in  
9 the region which actually turns out to be worst in  
10 these calculation. We simply don't know and nobody  
11 can know because you can never measure the corium  
12 friction coefficient.

13 DR. MARTIN: One thing I did as kind of a  
14 sanity check. And I don't think I've incorporated it  
15 in our discussions with the NRC. Is what also kind of  
16 becoming best practices in best estimate analysis is  
17 importance analysis or sensitivity analysis that  
18 incorporates the results from this kind of analysis  
19 and effectively you can use that as data effectively  
20 to identify the importance of the parameters that are  
21 being sampled.

22 Now, it is a function of the -- well the  
23 importance of that particular -- real importance of an  
24 individual parameter, but it is also a function of the  
25 domain chosen. So you can take a very important

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1 parameter at a water reaction site, if you held it  
2 constant, you wouldn't see a sensitivity. Meaning  
3 that you could take even in the case of, say, what you  
4 just mentioned, the corium friction coefficient and  
5 its two orders of magnitude. Obviously, it's a very  
6 broad sample range. That may or may not show up in  
7 the sensitivity analysis.

8           So but it is a way that allows you to kind  
9 of close the loop with that decision making process.  
10 Now in that particular case, corium friction  
11 coefficient I don't believe come up even though it has  
12 two orders of magnitude sample range. But things that  
13 do come up are metal water reaction, the art of  
14 cladding breakout temperature and fuel melt  
15 temperature. You know, it has a big influence on both  
16 the hydrogen and core debris coolability. These  
17 things do pop out.

18           Now I will also say that severe accident  
19 analysis, and there's a lot of uncertainty as I think  
20 everyone would agree, the important elements that come  
21 out of the analysis, this particular analysis, aren't  
22 quite as dominant as, say, in LOCA where very clear  
23 break size is really important. Heat transfer, post-  
24 CHF heat transfer, these things are very dominant in  
25 the progression of a LOCA.

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1           Severe accident it's a little bit grayer  
2 and there are more things that kind of play a role.  
3 But nonetheless, you can get a lot of insight and kind  
4 of close a loop on methodology development.

5           CHAIR POWERS: I think I know what you've  
6 done, I'm not absolutely certain. I assume what  
7 you've done is when you say I've come up with these  
8 various parameters that you considered uncertain that  
9 you have subsequently looked at the correlation of  
10 those parametric values with figures of merit that you  
11 select --

12           DR. MARTIN: Correct. Exactly.

13           CHAIR POWERS: And I suspect that you've  
14 used a Pearson-type correlation model. And so you've  
15 looked at the linearity in linear correlation between  
16 results and parameters values in a system that is, if  
17 anything, that is nonlinear. And I think it would be  
18 very useful to get those results.

19           I'd like to know why you chose Pearson  
20 correlation coefficient --

21           DR. MARTIN: Spearman is also used. I  
22 wanted to use something --

23           CHAIR POWERS: Spearman is identical to  
24 Pearson.

25           DR. MARTIN: Right. And these are --

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1 CHAIR POWERS: Kendal Tau, BKR, things  
2 like that. BKR is used for when things that are not  
3 very correlated. But Kendal Tau is nice because it  
4 will reveal nonlinear correlations with the result.

5 DR. MARTIN: Yes. I focused on, again,  
6 because you can almost infer because I used large  
7 ranges and uniform distributions that what really  
8 matters most is variance -- you know the tolerance  
9 limits of the figures of merit relative to the changes  
10 being incorporated into the analysis. So I tried to  
11 quantify what those were.

12 The ranking process are just strictly  
13 that. They're ranking and they're not given in terms  
14 of, say, hydrogen concentrations. So that's why I  
15 avoided the ranking methods for some of it.

16 But anyway, it is in the NURETH-13  
17 proceedings. And we can certainly provide that if  
18 you're interested.

19 CHAIR POWERS: Well, I think it's very  
20 revealing. I find it one of the best code debugging  
21 tools that I've got. And when you see a parameter  
22 being important that you think ought not be important  
23 you --

24 DR. MARTIN: Exactly.

25 CHAIR POWERS: -- the first thing to check

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1 is your code and not to try to understand the physics  
2 behind a mysterious correlation.

3 DR. MARTIN: Exactly.

4 CHAIR POWERS: So, yes, it would be useful  
5 to see those results. And where you see either strong  
6 positive or strong negative parameters correlation and  
7 then you ask the question did I make the range too  
8 wide, not wide enough; things like that.

9 DR. MARTIN: Yes. It's a good exercise.  
10 And, again, I expect you all to make our competitors  
11 do the same thing.

12 CHAIR POWERS: I don't think people are  
13 getting very active there yet.

14 DR. MARTIN: I think so.

15 CHAIR POWERS: But I continue to worry  
16 about claims that you've samples 95 percent of the  
17 parameter range when in fact you have not looked at  
18 correlation in a realistic fashion at all, and yet  
19 it's open to because you're using Monte-Carlo instead  
20 of something really dumb like limited lat and hyper-  
21 cube sampling. You can actually take the correlation  
22 and make it one of your uncertain parameters where you  
23 think that the correlation exists, or could exist.

24 DR. MARTIN: We can incorporate  
25 correlation in this. It was a conscious decision made

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1 a long time ago that we would --

2 CHAIR POWERS: Yes, and fairly common. I  
3 mean, most people do. But you choose parameters, your  
4 parametric choices are, in some cases physical, in  
5 some cases artefacts of the code. And when you choose  
6 physical parameters, then you can choose them in such  
7 a fashion that there's a high chance that they're  
8 approximately uncorrelated. When you choose these  
9 parameters that some code analyst has chosen to hide a  
10 lot of physics in a simple parameter, they're making  
11 them uncorrelated is a -- I mean, you can just never  
12 argue that because nobody knows -- they can't be  
13 measured, nobody knows what they are. They just match  
14 a particular experiment done by some particular group  
15 on particular occasion. And you don't know what the  
16 correlations are.

17 DR. MARTIN: Yes.

18 CHAIR POWERS: And it reflects things.

19 Now I'm dying to see where we're  
20 distributing deuterium around here.

21 DR. MARTIN: Yes, this was unfortunate  
22 editing. It was not the way I shipped it out. It was  
23 not a superscript, it was a subscript.

24 But anyway, I wanted to kind of just go  
25 through our results. Of course, the FSAR discussed

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1 what we got.

2 With regard to this slide, combustible gas  
3 control system evaluation, our analysis met the  
4 following criteria. And this comes from the SECY, so  
5 I'm kind of repeating.

6 First off, that the hydrogen was well  
7 distributed in the containment and removed for the  
8 PARVs for load minimization.

9 This was evaluated by looking at, again,  
10 we had a 27 node model and then looked at how the  
11 ranges of individual compartments varied against each  
12 other. And we're looking for a relatively tight band.

13 And so, you know, they don't all lay on top of each  
14 other but there is a good trend in all the  
15 compartments.

16 This next item is, you know, you're  
17 probably most familiar with the 10 percent by volume  
18 concern. Again, the PARVs do their job and keep us  
19 well underneath the 10 percent limit.

20 CHAIR POWERS: When the PARV does its job,  
21 it is in fact burning hydrogen. And it must surely  
22 get locally quite hot on that PARV. If I have things  
23 like particulate cesium iodide following through this  
24 hot zone along with the hydrogen, do I convert the  
25 cesium iodide into iodine gas?

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1 DR. MARTIN: I can't answer that.

2 CHAIR POWERS: It seems like I would.

3 DR. MARTIN: It's certainly plausible.

4 MS. SLOAN: We can take as an action.

5 DR. MARTIN: Yes, you know, you're burning  
6 and you're in an environment where you could put an O<sub>2</sub>  
7 on probably a lot of things.

8 CHAIR POWERS: Isn't it true that Nelson  
9 did some hydrogen combustion events, experiments with  
10 -- I know nobody's suspended cesium iodide, but he  
11 distributed cesium iodide in his cell and absorbed  
12 iodine gas.

13 DR. MARTIN: I'm not familiar with the  
14 work by Nelson. But we can look it up.

15 All right. Well, that's a good question,  
16 and it kind of relates back to the early discussion  
17 about RIAs that Annmarie had provided.

18 Okay. Moving on. The next one relates to  
19 reducing hydrogen concentrations below 4 percent by 12  
20 hours.

21 CHAIR POWERS: Were you homogeneously  
22 combustible during that 12 hours?

23 DR. MARTIN: Excuse me?

24 CHAIR POWERS: You go from a maximum of 10  
25 percent down to 4 percent. That's over the course of

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1 12 hours. So you're in the combustible regime for 12  
2 hours roughly. And the probability of not getting a  
3 spark or an ignition event, I mean we know from TMI  
4 that there are spontaneous events are at least a non-  
5 zero probability over a 12 hour period. That's only  
6 true if you're not steam-inerted. You have spray  
7 system which could cause you to be de-inerted in  
8 there.

9 DR. MARTIN: Right.

10 CHAIR POWERS: So basically what I'm  
11 asking you is did your PARVs work in the sense that  
12 they perverted a global deflagration, which you tell  
13 me in your next slide in your containment, and I'm not  
14 surprised by that. Nevertheless, a global hydrogen  
15 combustion event is non-trivial. And again we know  
16 from TMI that that does damage internal equipment that  
17 we might be relying on for recovery post-accident  
18 safety measures and things like that.

19 DR. MARTIN: Could be.

20 CHAIR POWERS: And so the question I'm  
21 really posing to you is where you combustible over  
22 that entire 12 hours?

23 DR. MARTIN: And the answer is no.

24 CHAIR POWERS: No?

25 DR. MARTIN: We're not combustible.

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1 CHAIR POWERS: That means you did not  
2 activate your sprays?

3 DR. MARTIN: No, we did not activate. As  
4 a matter of fact, it's not a requirement in the U.S.  
5 but one of the reasons for the 12 hours is to  
6 demonstrate that we can accomplish these goals  
7 passively.

8 CHAIR POWERS: But then the question is  
9 what is the chance that the operators would observe  
10 your encyclical against activating the sprays over a  
11 12 period?

12 DR. MARTIN: Of course, we have to look at  
13 that too. And I am co-author to a paper appearing in  
14 June on the subject at ICAP. So we've done some work  
15 on that as well. And basically come to the conclusion  
16 is that while reducing the inerting to some extent  
17 does occur, it does not create a significant impact to  
18 the situation that we have a combustible problem.

19 CHAIR POWERS: That's going to be a very  
20 interesting paper. I mean, your spray is extremely  
21 effective at de-inerting you.

22 DR. MARTIN: Well, it goes to both how  
23 much hydrogen producing. It considers the performance  
24 of the PARVs. And it doesn't necessarily take 12  
25 hours to reduce down to 4 percent.

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1           As a matter of fact, you'll see in the  
2 next slide, and I'll talk about it in just a second, I  
3 just have a lot of dots right now. But we get down  
4 below one in that time period.

5           Regarding the flame acceleration, DDT that  
6 situation, you know we apply methods. I'd have to go  
7 back and review to what extent I described that in the  
8 FSAR. We followed a methodology as it states here  
9 appearing in the state of the art report on  
10 containment thermal hydraulics. Maybe you're familiar  
11 with it.

12           CHAIR POWERS: I'm going to have to  
13 truthfully admit to being absolutely confounded by the  
14 idea of DDT.

15           DR. MARTIN: What's that?

16           CHAIR POWERS: I do not understand DDT. I  
17 don't understand the experiments. I don't understand  
18 what's going on physically. And I certainly don't  
19 understand the methodology.

20           DR. MARTIN: Right. Well, and we were  
21 focus on flame acceleration, the criteria to basically  
22 show no flame acceleration. Without flame  
23 acceleration, we don't get DDT. So we tried to stay  
24 on that side of the fence that we didn't have to focus  
25 so much on those analyses.

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1           So if I have not done a good job in there  
2 describing the methodology, it is certainly in the  
3 work we've done. It's been 2½ years almost, so --

4           CHAIR POWERS: You know the problem.

5           DR. MARTIN: I'm pretty sure after 300  
6 some RAIs we've had, we've probably had something on  
7 hydrogen. But it hasn't been as big an issue as some  
8 of the other ones that we have focused on.

9           And here's one of the plots that appears  
10 in the FSAR on hydrogen. It identifies peak hydrogen  
11 concentrations during significant events. And the two  
12 I'll just focus on, under the two decided the peak  
13 hydrogen concentration in these analyses period. And  
14 you can see in the limiting case, we get about 8½  
15 percent hydrogen concentration. And then you can look  
16 the one corresponding to the initiation of sprays  
17 which follows the 12 hours. And we didn't consider  
18 that as an uncertainty parameter. Twelve hours after  
19 the declaration of a severe accident we turned on the  
20 sprays in these analysis. You can see it's all under  
21 one percent here. Here's the little light blue  
22 dashes. And the other ones are at different phases in  
23 the event. You can see gate failure, two hours before  
24 that is so called near-RV failure. So there are other  
25 ones that are in between. These kind of bookend the

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1 events that are appearing in this slide.

2 CHAIR POWERS: So you activated sprays  
3 only after a period of 12 hours?

4 DR. MARTIN: Correct.

5 CHAIR POWERS: And you've got peak  
6 concentrations akin to those at TMI. Kind of  
7 interesting. A universal constant 8.5 percent for  
8 large PWRs. And it's also worth noting that the  
9 pressure rise at TMI was only 26 psi.

10 DR. MARTIN: Right. Right.

11 CHAIR POWERS: So presumably it would be  
12 the same here.

13 DR. MARTIN: Right. And in our analyses  
14 regarding to combustion loads, our first pass at this  
15 we focused on 80 adiabatic complete combustion metric  
16 to evaluate those kind of limits. And maybe one of  
17 the open items that we have that Ed will talk about  
18 relates to the consequences of draft Reg Guide 1.203.

19 And where in December of 2008 a new expectation was  
20 provided with regard to severe accident and  
21 combustible gas loads. And we've addressed those in,  
22 actually, we've basically sharpened the pencil because  
23 it has been needed to to address the changes to -- the  
24 coming changes to the consequences --

25 CHAIR POWERS: Why don't I suggest that

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1 before we launch into MCCI, we take a 15 minute break.

2 DR. MARTIN: Fine. I ad so much momentum.

3 CHAIR POWERS: That's okay. We will do  
4 so, and then come back.

5 (Whereupon, at 2:27 p.m. off the record  
6 until 2:44.)

7 CHAIR POWERS: Let's come back into  
8 session.

9 DR. MARTIN: Okay. All right. The  
10 previous slide was on combustible gas control. In the  
11 FSAR to kind of highlight those five main areas with  
12 regard to stress and prevention. This next one  
13 relates to the core melt stabilization system. And  
14 that really encompasses from the time the corium comes  
15 into the reactor cavity until its final stabilized  
16 state in the spreading area. So there's several  
17 analyses that were addressed with regard to the CMSS  
18 evaluation. These are identified in the first bullet,  
19 the first one being examine the temporary melt  
20 retention and conditioning in the reactor activity.  
21 The next one as relates to gate failures and question  
22 whether the gate design was appropriate, whether in  
23 fact it could in some way impede the designed  
24 progression. It turns out to be a no never mind, but  
25 nonetheless, we looked at that.

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1 MEMBER ARMIJO: Before you leave that what  
2 is the difference between the melt gate and the melt  
3 plug?

4 DR. MARTIN: Good question. Often times  
5 get confused.

6 The plug is that part of the concrete, the  
7 sacrificial concrete. It is the same material as the  
8 other sacrificial concrete that resides in the pit.

9 It is separate. I should say it's a  
10 moveable piece and it resides on top of this melt  
11 gate.

12 MEMBER ARMIJO: That's the aluminum thing?

13 DR. MARTIN: An aluminum thing.

14 MEMBER ARMIJO: Okay.

15 DR. MARTIN: That the plug actually rests  
16 upon as a -- well, it's a steel frame and the rest is  
17 aluminum, aluminum cover. It is designed so that  
18 during an outage or inspection or something, it could  
19 be removed. There is a mechanism, a cart say, that  
20 provides a means for removing that.

21 MEMBER SHACK: I have pictures of a guy  
22 lifting that plug up. And it just sort --

23 MS. SLOAN: Atlas.

24 DR. MARTIN: They're pretty strong guys.  
25 They're in Finland right now. We have a program.

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1           The next study I'll briefly touch on is  
2 using the MELTSPREAD code, examining the melt-  
3 spreading process. Like I said, I'm not going to, of  
4 course, do it complete justice in the forum.  
5 Obviously, there's many really good plots and graphs  
6 and explanations that goes into some of the dynamics  
7 of it all. I'm just summarizing the results here.

8           And then the last one is the passive  
9 flooding and the long term heat removal of the spread  
10 melt.

11           Regarding the first one, the temporary  
12 melt retention and conditioning analysis. This was  
13 done exclusively with MAAP. Again, this is a version  
14 of MAAP, the incorporated models that are there to  
15 address EPR specific type issues and phenomena.

16           One of the goals was to demonstrate that  
17 the MCCI in the reactor cavity is still ongoing at the  
18 time in the lower head plus lower support plate have  
19 failed. That is the melt plug is still intact. This  
20 was a conclusion of our analyses. You can see later,  
21 and it's analyses that they got a different result  
22 with MELCOR, which is one of our open items that we'll  
23 talk about.

24           And along that lines, all of the  
25 incorporated material has been diluted in the MCCI

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1 pool, meaning that we have a well conditioned melt for  
2 spreading purposes.

3 MEMBER ARMIJO: But it's not going to be  
4 homogeneous? When you say "conditioned," what do you  
5 mean?

6 DR. MARTIN: Well homogeneous, I would say  
7 on some level, the mixing and the homogeneity of the  
8 metal and the oxide improves over time. Now again,  
9 we're adding light oxides to heavy elements of both  
10 oxides and metals. And so just the addition of the  
11 light oxides as well as the chemical reactions that  
12 are going on encourage this mixing process. This is  
13 something that has been demonstrated in test programs  
14 and it's observed empirically. So, yes, fairly well  
15 homogeneous.

16 The next analysis was done with WALTER.  
17 Again, there was some question early on whether the  
18 aluminum gate would in some way impede the progression  
19 and maybe even hold up melt in the reactor cavity. So  
20 we went off and showed that regardless of the melt  
21 composition, you know whether it's metal coming in  
22 contact which of course metal being highly conductive,  
23 thermal conduction, plows right on through the  
24 aluminum. And similarly the oxide it's a little bit  
25 slower, but even seven minutes the scale of a severe

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1 accident really isn't very long. And none of is  
2 considered the mechanical load that would otherwise be  
3 contributing to the failure. So this, at least in my  
4 mind, turned out to be a no nevermind.

5 The next one was the melt spread analysis.

6 It was a very interesting analysis in which we look  
7 at, of course, the assumptions of what goes into the  
8 core itself, you know, prior to any kind of accident.

9 So we considered it a constituents of fuel of the  
10 structure. And then, of course, we incorporate the  
11 constituents of the sacrificial concrete into a  
12 mixture. This is code input. It has the models that  
13 evaluate the viscosity of this composition and then  
14 evaluated the flow process and the multi-dimensional.

15 Well, we a two dimensional analysis. And then it  
16 examines standing weights and the subsequent dampening  
17 of sanding weight. And so those are the kind of  
18 results that occur in the EPR.

19 And then this last one, long term heat  
20 removal analysis. A couple of goals here.

21 One, we had the question earlier about the  
22 load, thermal loads on the cast iron cooling  
23 structure. I mentioned at that time that we had  
24 identified a heat flux limit through these tests that  
25 we ran in our Erlangen offices. It turns out nine

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1 kilowatts, kind of our magic number that we're  
2 shooting for. And there is some margin of that, but  
3 nonetheless that one like staying below nine, we are  
4 below any concerned with critical heat flux in those  
5 cooling channels. Although we also showed in some of  
6 those analyses that even above nine we don't really  
7 have a problem with a little bit of boiling.

8 So that was one element of that analyses.

9 And then the other side of it was, well, just look at  
10 how long it takes to finally stabilize and finally  
11 solidify and look at the temperature profiles out to  
12 30 days, which I believe the next slide looks at both  
13 the near term and the long term.

14 There is separate with the metal and  
15 oxide. We assumed -- we took kind of limiting or  
16 bounding conditions with regard to thermal loadings  
17 and corresponding oxide levels, say, 90 percent oxide  
18 and just whatever happened corresponding to the  
19 limiting cases from our MAAP analyses. So that we  
20 would maximize the thermal load onto the spreading  
21 area floor, onto the cooling structure itself. And, of  
22 course, we incorporated the expected constituents  
23 which led to a lighter oxide on top of the metal.

24 In the left hand side plot we're looking  
25 at the thermal transient over six hours. So you can

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1 see the oxide, of course, is extremely hot. It  
2 doesn't take too long for the little bit of metal  
3 that's in there to get below about 2,000 degrees  
4 Fahrenheit and quickly establish a crust. Actually,  
5 MAAP will predict crust.

6 MEMBER ARMIJO: I can't read the  
7 dimensions on those charts. Are we looking at inches  
8 or what on these?

9 DR. MARTIN: Inches, correct. Yes. We  
10 used English units in our section, which has probably  
11 caused some frustration because we have gone back and  
12 forth with units with the staff on other RIA  
13 responses. But so much of the work came from Europe  
14 we tend to work in metric where we can. But to be  
15 consistent with the other chapters in the FSAR, we  
16 stuck with English.

17 So these are inches. And you can see we're  
18 about the thickness here -- well, it's like 13, 14  
19 inches of melt within the spread compartment, which I  
20 believe is about 1800 square feet. I forgot to mention  
21 that earlier, but I believe that's right.

22 MEMBER SHACK: 1872 is what the topical  
23 says.

24 DR. MARTIN: Oh, okay. Thank you.

25 CHAIR POWERS: If you have melt spread

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1 over this area and its hot, you -- enormous flux of  
2 radionuclides into the containment?

3 DR. MARTIN: It's a high surface area, and  
4 certainly you'd expect radionuclide transport to be  
5 dependent on the surface area of that. Now, of course,  
6 there's a relatively narrow chimney that it would be  
7 funneling through.

8 You have just a matter of seconds, really,  
9 before water comes in there. Now, as you can imagine,  
10 it doesn't immediately cover the surface of the --

11 CHAIR POWERS: It would be steaming.

12 DR. MARTIN: Yes, it would be steaming for  
13 some period of time. I believe in some rough  
14 calculations, about ten minutes I think we get a  
15 significant crusting of the surface and then you can  
16 start putting in some surface a bit.

17 CHAIR POWERS: You have some confidence  
18 that your flooding won't produce --

19 DR. MARTIN: Excessive?

20 CHAIR POWERS: Well, first of all,  
21 flooding if you bring it in, it's going to produce a  
22 lot of steam.

23 DR. MARTIN: Yes.

24 CHAIR POWERS: And then it's going to blow  
25 radionuclides out. The next question is, too, why

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1 isn't there a fairly strong fuel-coolant interaction?

2 DR. MARTIN: Well, because at a 100  
3 kilograms a second you're not -- well, one, fuel-  
4 coolant interactions is also somewhat a function of  
5 more driven by the fuel. It's the breakup of the fuel  
6 and kind of the self-perpetuating nature of the  
7 breakup that leads to the rapid energy transfer to the  
8 water. But all the water converts to steam in that  
9 early phase. You get a 100 kilograms of water into  
10 the spreading room and a 100 kilograms of steam early  
11 on until you can wet that surface. But we also --

12 CHAIR POWERS: You know, it seems to me  
13 that experiments we've done in which the core melts,  
14 poured water onto melts and they got detonations. The  
15 core in alternate contact mode, steam explosions.

16 DR. MARTIN: Yes.

17 CHAIR POWERS: And my recollection of the  
18 way -- which is reasonably accurate since I use it in  
19 the class I teach, is that they bolt the concrete pad  
20 underneath the crucible where they've had the --

21 DR. MARTIN: Yes. Well, you know, I'd have  
22 to obviously confirm my statements. But I believe the  
23 reason for the flow limiter is to keep this below any  
24 sort of threshold to cause an alternate contact fuel-  
25 coolant interaction type situation.

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1 CHAIR POWERS: And usually the problem  
2 that you have on the -- on the surface, is you're also  
3 not boiling the water very fast so that you have  
4 liquid water there. And if you have any instability  
5 in the molten material surface --

6 DR. MARTIN: Yes.

7 CHAIR POWERS: -- then you get into this  
8 divine netherland of what causes steam explosions.

9 DR. MARTIN: Right.

10 CHAIR POWERS: And I'd have to admit to a  
11 certain amount of ignorance there.

12 DR. MARTIN: And, obviously, we have a  
13 high degree of uncertainty. You know, we do have  
14 tests. The silica content in the sacrificial concrete  
15 also improves the surface for watability. And also it  
16 improves the melt with regard to fuel-coolant  
17 interaction. It also improves the radionuclide  
18 transport in cases. So there's a lot of advantages,  
19 of course, to having that first phase in which the  
20 melt gets conditioned and the silica is a big part of  
21 that.

22 So moving on to the long term, that is the  
23 right hand side. We did this with the WALTER code  
24 looking at six hours to 30 days we can see that under  
25 the assumptions of now active flooding in which the

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1 SAHRs, the severe accident heat removal pumps, are in  
2 operation and underneath the cooling channel,  
3 basically a steady state heat removal within a couple  
4 of days you can see the blue line just peaks over the  
5 solidus temperature that is identified by the dotted  
6 line in that figure. But within a couple of day or so  
7 we've effectively solidified the melt within the  
8 spreading area and long term plans, of course, can  
9 then be made about eventual recovery and  
10 decommissioning.

11 High pressure melt ejection. And I'll  
12 somewhat combine the discussion in the FSAR on high  
13 pressure melt ejection and in the next slide on fuel-  
14 coolant interactions. Also cross referenced is the  
15 work that was done by our PRA team, Dave Gerlits,  
16 primarily. There they did their own phenomenological  
17 evaluations and then we supported them.

18 I believe I mentioned earlier the analysis  
19 that we did with calculating the RCS pressure at the  
20 time of failure. I mentioned about the ten or 12 bars.

21 So we complicated their --

22 MEMBER SHACK: That was the one system,  
23 right?

24 DR. MARTIN: That was just one train,  
25 correct. So I was a little conservative going in.

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1 You know, you don't have a lot of freedom to redo this  
2 things and sharpen the pencil in all these cases. But  
3 it was acceptable to go forward with those kind of  
4 results and discuss about the remoteness of high  
5 pressure melt ejection, even in this more extreme case  
6 with the assumptions with PDS activation and the use  
7 of one train.

8 Nonetheless, the high pressure melt  
9 ejection is really handled primarily in 19.1  
10 complimented by the qualitative discussion and the use  
11 of the uncertainty analysis to demonstrate the kind of  
12 results we were getting with MAAP. So it's really a  
13 two-fold response to addressing high pressure melt  
14 rejection.

15 CHAIR POWERS: The response addresses the  
16 dispersal issue and the potential for getting  
17 literally direct containment heating in the  
18 atmosphere. I'm still left with this anxiety over the  
19 recoil of the vessel, whether you get that or not and  
20 the behavior of the penetrations through the  
21 containment. Do you have anything on that?

22 DR. MARTIN: Well, again, I think in the  
23 Level 1 analysis I can't recall to what extent Dave  
24 Gerlits had talked about that, but I know it came up.

25 I would have to yield to the work done as part of the

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1 PRA and following their needs with regards to  
2 addressing all these issues, and that being among  
3 many. But I believe it's all included in the  
4 phenomonological evaluation. But it is addressed in  
5 19.1 section.

6 But you can see here, my second bullet,  
7 you know Dave and his team were following the  
8 precedent established in the staff's NUREG/CR-6338 and  
9 then some of the work done overseas. And I can't  
10 pronounce FZK, but in their document in Germany.

11 CHAIR POWERS: I think that doesn't exist  
12 anymore anyway, so --

13 DR. MARTIN: Did they change their name?

14 CHAIR POWERS: Oh, you betcha. Twice.

15 DR. MARTIN: Okay. In a similar vein, the  
16 discussion on FCI, it focuses qualitatively on the  
17 design features or the characteristics of the EP that  
18 minimize the potential contact for fuel-coolant  
19 interaction and also -- actually, I believe I  
20 incorporate by reference the discussion in the topical  
21 report where I make reference to FARO and other tests  
22 that effectively in the minds of those researchers  
23 resolved fuel-coolant interaction issue for other  
24 plant designs. And again --

25 CHAIR POWERS: Well, it may have resolved

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1 it in their mind but somehow Koreans and other people  
2 seem to persist in doing experiments in the area.

3 DR. MARTIN: The more experiments doesn't  
4 hurt, does it?

5 CHAIR POWERS: Well, you won't like these  
6 experiments. They get explosions whereas FARO seemed  
7 to be star-crossed as far as their ability to get  
8 explosions.

9 DR. MARTIN: And likewise, the Chapter  
10 19.1 phenomenological evaluations examine this using  
11 methods which precedent has already been established.  
12 Again, I'd have to defer to the PRA team on specifics  
13 of that. And again, I believe it was discussed at the  
14 February 18-19 meeting.

15 CHAIR POWERS: Your last bullet speaks of  
16 containment failures. And you'll have to forgive me,  
17 where do I look for your analysis of fragility of your  
18 containment?

19 DR. MARTIN: Again, as in 19.1?

20 CHAIR POWERS: It's in 19.1.

21 DR. MARTIN: Yes. And of course, that's  
22 much bigger than 19.2, so --

23 CHAIR POWERS: And this was an ABAQUES-  
24 type calculation?

25 DR. MARTIN: Can you speak to that Nissia.

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1 MS. SLOAN: Introduce yourself and --

2 MS. SABRI: Nissia Sabri.

3 I joined AREVA two years ago. I have been  
4 working since then with the PRA group on the U.S. EPR,  
5 mainly on Level 2.

6 My degrees are in nuclear engineering,  
7 graduate degrees from engineering schools in France  
8 and University of Florida.

9 CHAIR POWERS: Which schools in France?

10 MS. SABRI: INPD, it's in Grenoble.

11 I'm afraid I didn't actually hear the  
12 whole question.

13 CHAIR POWERS: What I did was confess to  
14 not doing all my homework. And I have not looked at  
15 the containment fragility analysis.

16 MS. SABRI: Okay.

17 CHAIR POWERS: And I asked where it was,  
18 and then I was told, fairly I had not my homework and  
19 I knew I hadn't. And that I asked if that fragility  
20 analysis was done with something like ABAQUS?

21 MS. SABRI: Well, to answer your first  
22 question, the containment fragility is addressed in  
23 the FSAR. There is specific section where we have the  
24 fragility curve that we have generated using Monte-  
25 Carlo methods based on deterministic inputs from the

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1 structural group that was done using ANSYS.

2 I will not be able to give you all the  
3 details, but the thermalistic structure analysis I  
4 believe it will be covered when that chapter will have  
5 the ACRS meeting. However, I can just give you on how  
6 the composite fragility curve derived. It was  
7 basically the containment was divided into six  
8 sublocations and we had as input, the median pressure  
9 of failure as well as the uncertainties that depend on  
10 the methodology and the material. They have been  
11 given to us and evaluated by the structural team. And  
12 then using that, we did a composite fragility, as I  
13 said earlier, using Monte-Carlo methods. And the  
14 composite reflected actually the weakness location in  
15 the containment, and that was the base of the dome in  
16 the containment.

17 CHAIR POWERS: The base of the dome?

18 MS. SABRI: Yes.

19 CHAIR POWERS: What we see fairly  
20 routinely in experiments with containment models is  
21 hat failures seem to occur always at details in the  
22 construction that are below the resolution of models.  
23 And it is common for equipment hatches and things like  
24 that to be those locations.

25 And the question is have you done a fine

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1 enough gridding to identify the most susceptible  
2 locations for failures and is there a sufficient  
3 margin between the pressures we anticipate and the  
4 failure pressures at those localized areas?

5 MS. SABRI: Well, we have actually a  
6 margin between the design basis pressure and ultimate  
7 pressure, factor of about 2.9 almost --

8 CHAIR POWERS: You saying 2.9?

9 MS. SABRI: Yes. And for the completeness  
10 of the study at this stage it focused on fragility  
11 concerning rupture of the containment. It did not  
12 cover equipment actually penetrations that are, for  
13 example, personnel hatch. A discovered hatch,  
14 however, a closed hatch basically. A discovered hatch,  
15 the hatch was one of the locations that was explicitly  
16 modeled. However, it's when the hatch was closed and  
17 there is --

18 CHAIR POWERS: That's fair. I don't  
19 object to that.

20 The other question is we routinely  
21 critique these is that they use core properties. Did  
22 you use core properties or did you have temperature  
23 dependent properties?

24 MS. SABRI: We did initially have  
25 different fragility curves depending on temperature,

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1 and that was on cold temperature transients as well as  
2 third type of accident. I believe it's in the process  
3 of a revision of the containment fragilities for any  
4 other temperature than just the design basis  
5 temperature.

6 CHAIR POWERS: Okay.

7 MS. SABRI: So the current fragility curve  
8 in FSAR is only represented for one temperature.

9 DR. MARTIN: Okay. Thanks, Nissia.

10 The next subject is equipment  
11 survivability. In this section we identify, of  
12 course, several systems, structures, components for  
13 which equipment survivability evaluation is necessary.

14 We incorporated our uncertainty analysis to identify  
15 key figures of merit, pressure, temperature, humidity,  
16 radiation. We also looked at certain specific areas  
17 for survivability questions. For example, thermal  
18 loadings on the PDS valves. Let's see, I had another  
19 example in mind.

20 Oh, loadings in the reactor cavity for  
21 which we make a statement about a 20-bar limit and we  
22 have analysis accompanying that.

23 We can also add in, you know through the  
24 PRA process, we had several questions with regard to  
25 thee bar survivability. That certainly falls in the

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1 same vein.

2 This particular plot is one of a couple  
3 that take the results from the uncertainty analysis  
4 and look at different events and create an envelope, in  
5 this case pressure and temperature, that we might  
6 expect during a severe accident event. And these are  
7 kind of bounding results.

8 Now we will incorporate these results. We  
9 will certainly refine these results with best estimate  
10 type analyses as well and come up with a complete  
11 equipment survivability plan so that we can move into  
12 procurement element. This is a detail design task,  
13 but it's a considerable amount of effort that goes  
14 into the detail design effort to identify the  
15 specifications and components and particular  
16 instrumentation. Much of the severe accident response  
17 in the EPR is passive because of the ex-vessel  
18 approach. But one of the most important things  
19 becomes the monitoring element and the  
20 instrumentation. And so there's an emphasis there  
21 when it comes to survivability questions. And as a  
22 matter of fact, we're kind of working in that area  
23 right now back in Lynchburg.

24 Okay. This slide kind of follows up the  
25 three-fold strategy that I mentioned early on. Of

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1 course, I've talked about the estimate calcs and the  
2 uncertainty analyses extensively and then how they are  
3 reflected in the results and presented in the FSAR.

4 Complimenting those are, again, analyses  
5 that we did in the beginning to determine the fidelity  
6 of the model. I've talked about the WALTER and the  
7 METSPREAD analyses, some of those survivability  
8 calculations are incorporated here. But I wanted to  
9 incorporate this slide to kind of reflect and kind of  
10 close the loop on the methodology approach to the  
11 calculation metrics. This of course can be added on  
12 to or probably has been added on through RAI process,  
13 primarily. And even going beyond as we look at the  
14 next subject, accident management.

15 Again, we'll have a considerably more  
16 deterministic studies to compliment an uncertainty  
17 analysis base approach, a similar approach.

18 This slide, of course, moves away from the  
19 severe accident studies focused primarily on  
20 containment integrity. Moves into the severe accident  
21 management guideline development space. Obviously,  
22 the utility is expected to have all its emergency  
23 plans in place prior to getting an operation license.

24 And we as AREVA provide a lot of the kind of leg work  
25 through a methodology we call Operating Strategies for

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1 Severe Accidents. Of course, the whole point is that  
2 severe accident management extends to the defense-in-  
3 depth philosophy to plant operating staff by extending  
4 operating procedures beyond the plant design basis.

5 What I've provided staff so far, or at  
6 least initially through FSAR, is a summary of this  
7 approach where we describe some severe accident  
8 challenges, some candidate entrance/exit criteria,  
9 some preliminary response strategies, some end  
10 products.

11 Through the RAI process if we got a more  
12 detailed question, and we've provided an extensive  
13 response. So that we've gotten a follow-up question.

14 Well again, that'll go more into it. And then we'll  
15 expect to have even more information along this line.

16 But it's like emergency operating procedures. It's  
17 part of detailed engineering. And what we have today  
18 are methodologies. We've done some analyses.  
19 Certainly it's farther along at OL-3 in Finland, so we  
20 have insight from their experience and certainly we're  
21 drawing on that to the best of our ability. You know,  
22 there are some design differences and we have to  
23 address that as well.

24 So it's a work in progress today. We have  
25 methodology and an ongoing dialogue with the NRC staff

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1 with regard to what we term OSSA, Operating Strategies  
2 for Severe Accident.

3 Section 19.6 address severe accident  
4 mitigation design alternative or the analysis for  
5 SAMDA. It's an evaluation of plant design  
6 alternatives that could significantly reduce a  
7 radiological risk from core damage.

8 What was prepared for the FSAR applied  
9 existing precedent in SAMDA analyses incorporating the  
10 work by NEI and also NUREG/BR-0184 reports. We also  
11 expanded the analyses methodology in those reports to  
12 incorporate our own, U.S. EPR-specific hardware and  
13 actions and procedures.

14 In that original analysis we identified  
15 the maximum benefit of 51,000. We've gotten some  
16 feedback. And you see the last bullet, because I'm  
17 jumping a little bit, a rev to that last year. And I  
18 believe the maximum jumped up to like 71,000. But  
19 don't quote me exactly on that.

20 So nonetheless, the evaluation completed  
21 that additional plant modifications are not cost  
22 beneficial.

23 And if you like, we could talk about the--  
24 maybe we'll save that.

25 CHAIR POWERS: Any other questions you'd

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1 like to pose to the speaker?

2 MEMBER ARMIJO: Yes, I got a question. On  
3 your page 70, and I got to confess I'm not familiar  
4 with your system design. So the drawing shows the  
5 spreading compartment. Slide seven zero.

6 DR. MARTIN: Okay. All right.

7 MEMBER ARMIJO: Yes. And the same cooling  
8 line that cools that cooling plate also provides a  
9 flooding of the melt in this spreading compartment, is  
10 that correct?

11 DR. MARTIN: Let's see.

12 MEMBER ARMIJO: That line goes --

13 DR. MARTIN: You were looking here?

14 MEMBER ARMIJO: Yes.

15 DR. MARTIN: This is the passive line.

16 MEMBER ARMIJO: Right.

17 DR. MARTIN: And maybe, Mike, you can help  
18 me with this a little bit. Because you've got the most  
19 experience I think with the FSAR.

20 MR. BINGHAM: Yes. When the thermal  
21 actuator opens the valve in the spreading room, it  
22 opens one of these little valves to the right there.

23 MEMBER ARMIJO: Right.

24 MR. BINGHAM: Yes. So the water flows  
25 through the passive outflow reducer, that circle

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1 there, and flows passively along the orange path  
2 through the clean channels and then up on top of the  
3 melt.

4 MEMBER ARMIJO: Right.

5 MR. BINGHAM: That's just the passive  
6 portion. So then during the active --

7 MEMBER ARMIJO: Now that same cooling line  
8 cools the plate, this cooling plate?

9 MR. BINGHAM: The cooling channels?

10 MEMBER ARMIJO: Yes.

11 MR. BINGHAM: Yes. That's right.

12 MEMBER ARMIJO: Now if in the event if you  
13 had a blockage of that line for whatever reason, do  
14 you have another way of flooding the melt in the  
15 spreading compartment? Is there another way that you  
16 get water in there?

17 MR. BINGHAM: There are two lines. This  
18 only shows one, but there are two lines.

19 MEMBER ARMIJO: There's two lines?

20 MR. BINGHAM: That's right.

21 DR. MARTIN: Fifty kilograms is right,  
22 isn't it?

23 MR. BINGHAM: Right. I think so.

24 DR. MARTIN: More or less.

25 MEMBER ARMIJO: But they're just --

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1 MR. BINGHAM: Passive.

2 MEMBER ARMIJO: -- passive. So it's just  
3 the head water is moving back and forth?

4 MR. BINGHAM: That's right. That's right.

5 CHAIR POWERS: Any other questions?

6 Well, thanks very much.

7 MS. SLOAN: Mr. Chairman, before we go,  
8 Hanh was nice enough to share with me one of your  
9 questions was what components of the SAHRS are in the  
10 RAP list and Hanh has had the RAI number, it's RAI 268  
11 question 17.4-22.

12 CHAIR POWERS: So there. Now you know.

13 MR. TESFAYE: Good afternoon. Let me just  
14 get started here.

15 Prosanta Chowdhury is the Chapter PM.  
16 Since he has to leave early, I'm taking over as  
17 Chapter PM.

18 This portion is the staff's presentation  
19 of SER open items. You're familiar with Ed Fuller who  
20 got his Ph.D. in the last century, the middle of last  
21 century.

22 MR. FULLER: A few years before Dana got  
23 his.

24 CHAIR POWERS: The day before yesterday we  
25 had a speaker introduce himself by saying that he'd

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1 worked in six different decades.

2 MR. FULLER: That's all?

3 MR. TESFAYE: And I think with that, I'll  
4 let Ed get started with page 77. That's where we  
5 stopped back in February. And then Jim Xu will have a  
6 portion of this presentation also. Ed Fuller who got  
7 his Ph.D. in the last century, the middle of last  
8 century.

9 MR. FULLER: Okay. I am not going to go  
10 through our entire review. I'm just going to focus on  
11 open items. That's not to say that if you have any  
12 questions of us about items that we don't discuss, we  
13 wouldn't be prepared to answer them.

14 CHAIR POWERS: Yes. I think it's fair to  
15 say that we're going to be back on this stuff.

16 MR. FULLER: Yes. We're jumping right to  
17 severe accident mitigation features. We won't be  
18 discussing the prevention features because we had no  
19 open items there.

20 Besides, you know, Bob really gave an  
21 excellent presentation to give a really perspective on  
22 the breadth of their application for Chapter 19  
23 Section 2. So it's okay for me to skip, I think.

24 Let's start off with hydrogen generation  
25 and control systems related to severe accident

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1 mitigation.

2 We reviewed the combustible gas control  
3 system and the hydrogen monitoring system descriptions  
4 and various analyses. Asked quite a few RAI questions  
5 and got some extremely detailed responses. I think I  
6 told you last time that we designed some of our  
7 questions to get as much information on the docket as  
8 possible. And a couple of RAI responses related to  
9 the hydrogen control to hundreds of pages because they  
10 gave us all kinds of graphs that came out of MAAP  
11 calculations. I was impressed, but obviously didn't  
12 look at them all. But we did look at key things.

13 And we thought, at least in terms of the  
14 overall conclusions, that their analyses were  
15 reasonable. Of course, we did ask for additional  
16 information pertaining not only to the PARs, but also  
17 to the way the gases would mix in this normally "two-  
18 region containment," which opens up to a one-region  
19 containment when these dampers open and so on and so  
20 forth.

21 So we asked some questions related to  
22 potential for flame acceleration to DDT conditions.  
23 And we got some responses that we thought were  
24 reasonable.

25 In particular, Question 19-235 the

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1 response to that did show large margins to potential  
2 flame acceleration or detonation in the various  
3 regions as they were modeled by AREVA.

4 We did perform some confirmatory  
5 calculations, and actually we're still doing this. We  
6 did calculations for the representative accident  
7 scenarios, not just the "relevant ones" that Bob  
8 talked about, but representative of certain scenarios  
9 that may not have necessarily been the big ticket CDF  
10 items.

11 And we did confirm that as far as, at  
12 least when their model was working as designed,  
13 efficiently recombined the hydrogen and the oxygen as  
14 we determined that as long as this system works as  
15 designed, there would be little potential for forming  
16 pockets of high hydrogen concentrations. And  
17 therefore, we wouldn't expect a large deflagration  
18 during any of those scenarios.

19 We are, though, looking at conditions  
20 where the efficiency of the FSARs is reduced, sort of  
21 step-wise downward, to see what the impacts would be.

22 And we're doing this work with our contractor ERI and  
23 working in conjunction with the Containment Branch.  
24 So that we're going to make sure that we get  
25 comprehensive set of responses that satisfies our

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1 needs for both Chapter 6 and 19 out of this.

2 Okay. Let's go to the next slide.

3 We probably spend more time on systems  
4 related debris coolability than to any other ones in  
5 all of our reviews of design certifications for severe  
6 accident evaluation. This one's no exception. So  
7 we've asked a lot of questions. We still have some  
8 open items here which I'll get into in a second.

9 CHAIR POWERS: Let me ask you question.

10 MR. FULLER: The next four or five --

11 CHAIR POWERS: Let me ask you question.

12 MR. FULLER: Yes.

13 CHAIR POWERS: Did you do an analysis in  
14 which you just assumed that all of this stuff doesn't  
15 work? The melt comes down, close out, there's no  
16 water at all and look at the containment pressure  
17 there versus the containment pressure when it does  
18 work?

19 MR. FULLER: Yes. We actually asked AREVA  
20 to provide us with that kind of an analysis. And they  
21 did provide it.

22 CHAIR POWERS: And did they get into  
23 trouble with that kind --

24 MR. FULLER: Well, the short answer is  
25 yes. If for some reason the melt plug/gate never

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1 works and the debris gets trapped in the cavity, then  
2 you get significant basemat penetration within 24  
3 hours.

4 If the severe accident heat removal system  
5 doesn't work and you get core debris into the  
6 spreading room and no water comes in, likewise the  
7 calculation is that you will have a significant core  
8 debris concrete interaction leading to significant  
9 ablation.

10 So, yes, we did do those. In those I'm not  
11 sure if -- yes, we got down to the plate. Definitely  
12 got down to the plate.

13 CHAIR POWERS: Yes. But you didn't  
14 overpressurize containment?

15 MR. FULLER: Well, eventually you did,  
16 yes. I don't remember the details.

17 CHAIR POWERS: No.

18 MR. FULLER: And hold on, I think I want  
19 to ask Mohsen Khatib-Rahbar to talk about what our  
20 melt core calculations might have shown here too.

21 MR. KHATIB-RAHBAR: We did the calculation  
22 where we assumed the cooling on the spreading area  
23 would not occur, and this would result in MCCI. We  
24 do, of course, get significant penetration of the  
25 concrete but it does not pressurize the containment as

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1 failure condition. The pressure still remains low in  
2 the containment.

3 MEMBER SHACK: Is that with the spray  
4 working or that's without the spray?

5 MR. KHATIB-RAHBAR: Without spray. Dry,  
6 totally dry.

7 MEMBER SHACK: Totally dry?

8 MR. FULLER: Okay. The next three slides  
9 I'm going to skip because Bob did a much better job  
10 than I could do explaining how the core melt  
11 stabilization system work, as well as the severe  
12 accident heat removal system. So unless you want to  
13 revisit any aspect of that, we'll just skip those and  
14 go to Slide 81.

15 I want to focus on one of our open items  
16 here. And we're in the cavity or the pit here. Just  
17 after vessel breach the debris would have to, as you  
18 know, penetrate the sacrificial material and then fail  
19 the melt plug and go through the gate. And AREVA's  
20 calculations using MAAP indicated that by the time  
21 this happens you've gotten essentially all of the core  
22 debris out of the vessel. And it's mixed itself quite  
23 nicely with concrete, core concrete interaction  
24 reaction products and then flows down the channel into  
25 the spreading room.

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1           We find that, you know we had some  
2 questions about the refractory material behind the  
3 sacrificial material both in the walls and on the  
4 floor. And noting that these bricks have a low  
5 thermal conductivity and mechanical strength greater  
6 than concrete, but we're not sure about what happens  
7 when its attacked because it's brittle and subject to  
8 failure by thermal shock. So we asked the applicant  
9 to demonstrate that its integrity could be maintained  
10 during severe accident conditions. And we were  
11 referred and they provided us with some priority  
12 reports that we looked at. And by in large, we're  
13 getting pretty comfortable with their argument but  
14 there are some questions that still remain. And  
15 because of that, this RAI 19-332 remains an open item.

16           I would guess that we have to really talk  
17 about these in detail, we would have to arrange a  
18 closed meeting.

19           MEMBER ARMIJO: My question would be on  
20 the bricks. Are they bonded to the concrete as those  
21 failure of those bonds could result in the bricks,  
22 basically? Not providing any protection.

23           MR. FULLER: I don't know the answer. Is  
24 that a priority set of piece of information?

25           DR. MARTIN: I'll just comment. Again,

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1 this is Bob Martin.

2 It's part of your question, I believe, 19-  
3 332. And we're addressing that --

4 MEMBER ARMIJO: There is an RAI on that?

5 DR. MARTIN: Yes. This is referred to as  
6 19-332. This was issued after the SE draft was given  
7 to us. We got a handful -- actually we continue to get  
8 a few questions here. This 332 said 349 was received  
9 by the late January time frame, I believe.

10 MR. FULLER: Yes.

11 DR. MARTIN: And we've started the work  
12 activity to address that. And that element of your  
13 question is --

14 MEMBER ARMIJO: Well, you know the other  
15 part of my question is there's all kinds of  
16 formulations of zirconia: The density, there can be  
17 additives to stabilize the zirconia, yttrium for  
18 example. So I just wondered does the staff have that  
19 level of detail information?

20 MR. FULLER: Well, I think in the response  
21 to question 312 we might because that was a very  
22 detailed response. And again, there's a lot of  
23 priority information in there, which I'm sure you  
24 folks could get privately.

25 MEMBER ARMIJO: I'd like to get that.

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1 CHAIR POWERS: I mean, it's kind of  
2 surprising not to use stabilizer zirconium, because  
3 it's not that much more expensive than unstabilized.

4 MEMBER ARMIJO: It may be, he just says  
5 zirconium, and I don't know if it --

6 CHAIR POWERS: Yes. Stabilized zirconium  
7 is dirt cheap.

8 MEMBER ARMIJO: Yes.

9 CHAIR POWERS: I mean, none of them are  
10 dirt cheap, but they're not that much different.

11 MR. FULLER: They're testing programs too.  
12 I'm sorry in respond.

13 CHAIR POWERS: The interesting question  
14 that comes up is how you choose the sacrificial  
15 material. Because if it's the highest silica  
16 materials, that creates a acidic melt which corrodes  
17 zirconia pretty badly. And if you choose a more  
18 calcium-rich material, that's a basic melt and it goes  
19 after zirconia very quickly.

20 So choosing the right sacrificial material  
21 is kind of an interesting problem.

22 MR. TESFAYE: I will take an action to  
23 provide you these RAI responses.

24 MEMBER ARMIJO: Yes. Thank you.

25 MR. FULLER: Okay. Let's go to slide 82.

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1 Continuing on, another question that we  
2 had regarding behavior in the pit is because, as I  
3 said before MAAP calculations indicated that all of  
4 the core debris was out of the vessel by the time the  
5 plug failed, whereas in our confirmatory MELCOR  
6 calculations that wasn't the case. And that there may  
7 be quite a bit left when it fails. And this has some  
8 implications on possible energetic molten fuel-coolant  
9 interactions. Because if you think about it, if the  
10 core melt goes into the spreading room and whatever  
11 the inventory was at that point, and then water comes  
12 in on top, floods back up the channel and perhaps into  
13 the cavity, if at that point a substantial portion of  
14 the core debris that was still in the vessel comes  
15 out, you're opening yourself to the possibility of an  
16 ex-vessel steam explosion.

17 And so we've asked them to evaluate this.

18 And this follow-up RAI 349 question, 19-332 it's one  
19 that they're still evaluating as well. So this is an  
20 open item at this juncture.

21 CHAIR POWERS: Did you look at the delta  
22 contact mode explosion potential?

23 MR. FULLER: We didn't look at them, per  
24 se. We were asking them to evaluate the potential.

25 CHAIR POWERS: Yes. It just seems to me

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1 that they have a potential of alternate contact mode.  
2 Now the consequences of that I'm uncertain of. I mean,  
3 it's in the lower cavity, who cares. You can blow  
4 things up like crazy and it just doesn't make any  
5 difference because there's nothing to damage there.  
6 But this is interesting that we don't seem to have --  
7 you know, we have elaborate detail in some aspects and  
8 then here's this explosive potential demonstrated by  
9 experiment that putting water on top of melts they  
10 will explode even when the water won't wet the melt  
11 because you're above the Liedenfrost temperature. And  
12 that gets no never mind and it's kind of curious.

13 MR. FULLER: Right. So this is something  
14 we need to get a better handle on before we can close  
15 this particular item.

16 Okay.

17 CHAIR POWERS: The reason to pay attention  
18 to ex-vessel steam explosions as far as I see it is  
19 it's a way to mechanically commutate the melt and you  
20 get otherwise relatively nonvolatile fission products  
21 launched into the atmosphere and available to leak  
22 from the containment, even if the containment has not  
23 grossly failed. And that changes the mix of fission  
24 products you're dealing on the great out of doors and  
25 a different consequence analysis then you might

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1 otherwise expect.

2 MR. FULLER: Slide 83. Continuing on in  
3 debris coolability space, there is a set of questions  
4 that are basically trying to get at what some of the  
5 differences are between the MAAP calculations that  
6 AREVA did for this application and our MELCOR  
7 confirmatory assessment calculations. I don't list  
8 the details here, but if you look at these questions  
9 you can get a feeling for what they might be. I also  
10 list in the SER with open items.

11 There's some questions that I list here  
12 that are related directly to debris coolability. And  
13 there were one or two other questions related to the  
14 hydrogen control as well in that set.

15 Assuming that we resolve these, we believe  
16 that if the core melt stabilization system works as  
17 they designed it, they'd probably with pretty good  
18 reliably be able to arrest the core concrete attack.  
19 And in conjunction with a severe accident heat removal  
20 system design they could avoid basemat melt-through  
21 and keep the pressure from failing in the containment,  
22 and temperature relatively cool as well.

23 CHAIR POWERS: Have you looked at what  
24 happens in an earthquake-induced accident for this  
25 system?

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1 MR. FULLER: No. I think you've made an  
2 interesting point before when you talk about how an  
3 earthquake can probably degrade certain structures in  
4 some way which might alter the course of an accident  
5 progression. But I haven't the foggiest idea how that  
6 would work out.

7 CHAIR POWERS: Yes. I mean, I don't know.  
8 Certainly can't do the integration in my head, so --

9 MR. FULLER: No, we haven't looked at  
10 that. The way we look at earthquake-initiating  
11 events, they are basically contributors to losses of  
12 systems and loss of off-site power is obviously high  
13 up on the list.

14 Back in one of my former jobs when I was a  
15 consultant doing a project for EPRI, we looked at  
16 steam generator tube integrity risk assessment. And we  
17 did a project on the Diablo Canyon plant. Obviously,  
18 that one is probably the most studied plant in the  
19 country with respect to seismic events.

20 It turned out that the major contributor  
21 to risk was from earthquake-induced station blackout  
22 type of events leading to a possible induced steam  
23 generator tube ruptures is the tubes are damaged. Now  
24 it wasn't even close. It was more than twice the  
25 internal events of power. Of course, that's the

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1 extreme.

2 But I think if you look at various plants  
3 carefully you would find that seismic initiators are  
4 quite important.

5 Okay. Let's go to the next one.

6 We talked about high pressure melt  
7 ejection a little while ago. And, of course, the EPR  
8 design has the primary depressurization system which  
9 with a very high reliability, would lower the RCS  
10 pressure if you started off an accident with transient  
11 in high pressure. And not only that, we discussed the  
12 cavity with its tight confined vessel above it and the  
13 tortuous paths, which happen to lead, actually, to  
14 steam generator compartments and pump rooms, and the  
15 like.

16 When I looked at some of their MAAP  
17 analyses, I saw that after depressurization their RCS  
18 pressure wasn't all the way down. It was in the order  
19 of a little less than 200 psi. And that would mean  
20 given the tortuous paths is very little core debris  
21 would make it into the upper containment. However,  
22 there would be significant relocation into these other  
23 compartments. And this is consistent with the set of  
24 experiments that were done at Karlsruhe. And I think  
25 I brought these up last time.

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1           And what concern is that we believe that  
2           in developing their accident management technical  
3           basis, which would turn into SAMG eventually, that  
4           they need to take the presence of core debris in these  
5           rooms into account and whatever that core debris might  
6           do to fail certain monitoring systems or other things  
7           that are usually expected to be there during the  
8           severe accident.

9           We realize that AREVA's really taking a  
10          close look at this kind of thing from the equipment  
11          survivability point of view, and they do talk about  
12          this in their OSSA documentation. But this is one of  
13          these follow-up accident management items that we just  
14          recently asked them to consider.

15          Next.

16          Containment bypass. Well, there are two  
17          classical ways to look at it in these PWRs. One is  
18          from steam generator tube ruptures. The other one is  
19          from interfacing system LOCAs. And they've gone out  
20          of their way to beef up the piping systems so that  
21          they can withstand as much pressure as the primary  
22          pipes can.

23          So looking it over we don't believe we  
24          need to worry too much about severe accident  
25          consequences from an ISLOCA. The probabilities seem

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1 to be very, very low. However, the possibility of  
2 induced steam generator tube rupture in high pressure  
3 scenarios is still something that we're concerned  
4 about. And we believe that it is important to have  
5 the depressurization valves open in a timely fashion.

6 We asked them a question, question 19-240  
7 in RAI 133 asking them questions about this. And they  
8 gave in their answer some information that indicated  
9 that the time between when the core exit temperature  
10 reaching 1200 Fahrenheit and when induced steam  
11 generator tube rupture might occur if you hadn't  
12 depressurized after that, might be expected to be  
13 between 18 to 20 minutes assuming a hot leg nozzle  
14 wouldn't fail it first. And that was a function of the  
15 degree of core tube damage.

16 We also asked them to do this for  
17 scenarios where the secondary side was depressurized,  
18 because that's when you get in trouble.

19 So that gives us a good feeling for what  
20 we're looking at. But we believe that they need to  
21 make sure that this kind of information is factored  
22 into their OSSA, their severe accident management  
23 technical basis. And so another question we've asked  
24 in that latest set is to give us more information on  
25 this on how they're going to address it in OSSa and

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1 how their Human Reliability Assessment would be  
2 utilized in this regard.

3 Okay. Now we have a little break because  
4 Jim is going to be discussing the containment  
5 performance.

6 MR. XU: You want me to introduce myself?

7 MR. TESFAYE: Yes, go ahead and introduce  
8 yourself.

9 MR. XU: My name is Jim Xu. Senior  
10 Structural Engineer from Structural Engineering  
11 Branch, NRO.

12 I have been with NRO for three years and  
13 I've been primarily responsible for review of COLAs  
14 related to structures, circulating structures, the  
15 components.

16 And prior to joining NRC, I worked at  
17 Brookhaven National Lab for 20 years. I primarily  
18 worked on the NRC and the DOE projects to address  
19 seismic and nuclear safety issues.

20 And then I have a Ph.D. in structural  
21 engineering. I think I should be qualified to answer  
22 all your questions that you have.

23 CHAIR POWERS: Okay. How does the cross  
24 nodalization system behave in an earthquake?

25 MR. XU: I could answer that question --

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1 but then I'll answer whatever question you may have.

2 Okay. On the containment performance  
3 capability, what we're focused here is on the  
4 structural aspects. And the staff's review focused on  
5 two issues.

6 The first issue has to do with Regulation  
7 50.44, you know that series is related for pressure  
8 build up in the containment due to 100 percent fuel-  
9 coolant interaction for the hydrogen burning, what is  
10 the structural class. And according to 50.44(c)(5)  
11 and Reg Guide 1.7 the applicant needed to perform  
12 analyses assuming 100 percent fuel-coolant interaction  
13 and develop the pressure and the temperature time is  
14 free from containment and to perform a structural  
15 analyses of containment that determine that the demand  
16 on the containment and compare that with the ASME  
17 Service Level C limit to ensure that whatever demand  
18 due to the water-metal reaction will be below the ASME  
19 Service Level C stress and strength limit.

20 MEMBER SHACK: How does that Level C limit  
21 compare with the ultimate limit that I get from a  
22 fragility analyses?

23 MR. XU: There are two different  
24 attributes. The Service Level C elements are a very  
25 conservative limit because these are design limit.

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1 MEMBER SHACK: But it's like twice the  
2 design limit, right? Something like that, roughly?

3 MR. XU: Yes, it's --

4 MEMBER SHACK: That's the number I keep in  
5 my head.

6 MR. XU: It may be even bigger. It may be  
7 even bigger, yes. Because, for example, for the liner  
8 strength the ASME Service Level C limit is .3 percent.

9 And if you go over the fragility and test that, it  
10 will show the liner can stretch to, you know, 2  
11 percent or higher. So the Service Level C limit is a  
12 very conservative capacity.

13 So we have open area on this issue. And we  
14 didn't receive AREVA's response to our RAIs, but that  
15 was received after we prepared an SER on these slides.

16 So, as a matter of fact, next week we're going down  
17 to AREVA's site to perform all the analyses related to  
18 this RAI. So we'll probably examine more in details.

19 And basically on their RAI response, and  
20 the response basically formulated to answer our RAI  
21 questions and it basically said that they analyses.  
22 They have, you know, checked with ASME Service Level C  
23 limit, and they demonstrated that the demand is below  
24 the limits. But we have to verify that. And to see if  
25 the containment analysis did perform adequately. That

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1 will be done next week. That's my first slide.

2 On my second slide this one deal with the  
3 containment deterministic performance goal, which is  
4 the staff goal approved by the Commission through SRM  
5 through SECY-93-087.

6 This goal is very similar to the previous  
7 slides, except the loading is different. Because the  
8 previous slide deal with the hydrogen load, which  
9 probably has a lower frequency then what would be in  
10 here.

11 And according to SECY-93-087 there are  
12 three aspects -- or two aspects they need to address.

13 For the more likely internal challenges, I mean this  
14 is a very fuzzy kind of term. And we do have Reg  
15 Guide which the pre-decisional form has been  
16 development, I think end of the last year. I don't  
17 know the status of that right now. It's Reg. Guide  
18 1.216. So I don't know the status, if it has  
19 officially been issued yet. But that guide provide,  
20 you know detail guidance how --

21 MR. FULLER: We're going to be looking at  
22 that shortly.

23 MR. XU: That will be good, yes.

24 And for more likely internal challenges, I  
25 mean when we review the -- and we found out that they

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1 had not drafted this issue. So we had to issue an RAI  
2 and this is the same situation, actually in the same  
3 set of RAI response, they responded after we prepared  
4 an SER. So it's not reflected in here.

5 But the issue has three parts. One is the  
6 group of the more likely accident events. And the  
7 applicant regarding the second accident need to  
8 demonstrate for the pressure temperature generated  
9 from those events but containment structures will be  
10 below -- that the event will be below Service Level C  
11 limits. Okay. For initial 24 hours after the core  
12 melt. And then the applicant need to demonstrate  
13 after 24 hours the containment would continue to  
14 provide a barrier against uncontrolled release of  
15 fission product.

16 And, you know I looked at the response and  
17 they did have addressed all the issues, you know we  
18 asked for. And they have demonstrated that the  
19 demands due to the internal challenges are formed  
20 below the Service Level C limit and that they also  
21 show the up to 24 hours the pressure and the  
22 temperature do not increase again. So it's basically  
23 from decay half of melt.

24 So, but again, we will review in detail  
25 next week their containment analysis and to see if

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1 they have found that was always in details. So want  
2 to see the containment analyses.

3 So these are the structural issues we have  
4 asked for the containment structural performance.

5 And if you have any question on the  
6 seismic, you know, I'd be glad to answer it.

7 CHAIR POWERS: Okay.

8 MR. XU: In fact, I also want question  
9 because it continue to come up on whether the severe  
10 accident analyses has considered the seismic as an  
11 initiating events. And the answer is that the severe  
12 accident space and the seismic space do not intersect.

13 But that mean as their feeling was extremely low  
14 probably events.

15 Even if you include that low sequences in  
16 the seismic PRA, the old seismic core damage purpose  
17 it will not change much. The seismic core damage  
18 frequency are critical in the range of ten to the  
19 minus 4 and ten to the minus six. Okay. What didn't  
20 here is lower than ten to the minus eight core damage  
21 sequences. So, you know, whether you include them or  
22 not, it will not impact seismic.

23 CHAIR POWERS: I guess I just don't  
24 understand the argument there. It seems to me we have  
25 a low internal event frequencies at this plant.

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1 MR. XU: Yes. Right.

2 CHAIR POWERS: Consequently, the seismic  
3 initiator, which is roughly ten to the minus six --

4 MR. XU: Yes.

5 CHAIR POWERS: Argue with me plus or minus  
6 a factor of ten and it didn't make any different. And  
7 so it becomes kind of frequency-dominant initiator  
8 here.

9 MR. XU: That's right. Yes.

10 CHAIR POWERS: And so you ask well what  
11 does that do with all of this accident phenomena that  
12 I've looked at? I mean, here I have a structure, it  
13 has a connection of fairly weak nature between that  
14 and the containment foundation. Those things seem to  
15 be ripe for the discontinuity of motions renouncing  
16 one of the dominant consequences of earthquake event.  
17 I mean, to me it's a fairly obvious question. What  
18 happens to this core stabilization system --

19 MEMBER SHACK: If you're going to mitigate  
20 a severe accident, why not pick the most likely severe  
21 accident --

22 CHAIR POWERS: That you're going to have.

23 MEMBER SHACK: -- that you're going to  
24 have.

25 MR. XU: The frequency is low. In the

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1 seismic PRA you have a screening criteria. So it  
2 would not have any contribution -- the situation would  
3 not have any contribution on core --

4 MEMBER SHACK: Yes. But I think the  
5 argument is here, you know a mitigating system to  
6 mitigate internal event core damage, which has a  
7 frequency of ten to the minus seven and your guess is  
8 that seismic are going to be larger than that by some  
9 number, ten to the minus six.

10 MR. XU: I think the impact would be not  
11 on the core damage frequency side, it would be on the  
12 LRF. And for that, I mean I haven't seen any seismic  
13 for PRA perform for our --

14 MR. FULLER: Well right now all they're  
15 doing is seismic margins analysis.

16 MEMBER SHACK: Well, you know, Dana looks  
17 at the structure, I look at the SAHR system and wonder  
18 if it's seismic qualified. I mean, that would be my  
19 sort of question about it. I'm less worried about the  
20 structure, but the SAHR system certainly ought to hang  
21 together and work.

22 MR. XU: But the containment typically has  
23 a very high seismic -- typically has more than 1g  
24 HCLF.

25 MEMBER SHACK: That's the containment?

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1 MR. XU: Yes.

2 MEMBER ARMIJO: What about the piping, you  
3 know the water line that goes into the spreading  
4 compartment, those kind of components.

5 MEMBER SHACK: The pump?

6 MEMBER ARMIJO: Yes.

7 MEMBER SHACK: The pipe, the valves?

8 MR. XU: Well, the only part I know that  
9 is not seismic for design is the containment spraying,  
10 but I don't know other components --

11 MEMBER SHACK: Well, they're non-safety.

12 MR. XU: They're non-safety. If they're  
13 non-safety, then they're not seismic qualified. So we  
14 cannot credit that in seismic events, which would  
15 assume them to fail during seismic.

16 MEMBER SHACK: Well then it does come back  
17 to it just seems strange to have a mitigating system  
18 that doesn't work on my most likely initiator of a  
19 severe accident.

20 MEMBER ARMIJO: Yes.

21 MR. XU: But at least they cannot credit  
22 the containment spray for seismic event.

23 MR. FULLER: Shall we go to the accident  
24 management now?

25 Yes, I was leading up to this with a

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1 couple of slides before.

2 AREVA's has got this operating strategies  
3 for severe accidents project which actually looks  
4 really good to me. They're still in the stage of  
5 putting together all of the details of it. And I do  
6 know when they do get it together, they would like it  
7 to do is to provide mitigation strategies to cover all  
8 events leading to core melt, I guess including  
9 seismic, and to stop or reduce the release of fission  
10 products to the environment.

11 And they, of course, tie this just like  
12 the existing severe accident management strategies for  
13 existing plants, they tie it to the emergency  
14 operating procedures that would presumably prevent  
15 core damage.

16 And they've actually got a -- I wish they  
17 would put up this OSSA figure showing the transition  
18 between the operating --

19 CHAIR POWERS: I think they did at one  
20 time, didn't they?

21 MR. FULLER: It's got three regimes in it.

22 CHAIR POWERS: Yes.

23 MR. FULLER: It's in there OSSA  
24 documentation.

25 CHAIR POWERS: I think in one of their

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1 presentations they showed that transition, the various  
2 regimes.

3 MR. FULLER: But it gives you a good  
4 feeling for what they're up to.

5 The way I see it, it boils down to being a  
6 passive approach for the first 12 hours relying on the  
7 combustible gas control system and the other hydrogen  
8 flow control system to work, and the core melt  
9 stabilization system and severe accident heat removal  
10 system.

11 So, and then after 12 hours they would  
12 utilize those non-safety related, shall we say,  
13 sprays. Because they are an important part of  
14 maintaining a long term approach to a safe stable  
15 state.

16 CHAIR POWERS: And it seems to me that  
17 because we're working in severe accident space at this  
18 point that there is no reluctance to grant them that  
19 their spray system is likely to be functional. And  
20 barring something that --

21 MR. FULLER: You would certainly hope that  
22 it's going to be functional, and you certainly hope  
23 they're use it, yes.

24 CHAIR POWERS: Barring something that  
25 makes failure of those system unequivocally follows

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1 directly from the accident phenomena.

2 MR. FULLER: Right. Right.

3 CHAIR POWERS: And of course one of those  
4 things, I mean you've mentioned debris dispersal into  
5 the sections and things like that, that raises a  
6 question about that that we need to explore a little  
7 bit. But otherwise, I mean the fact that the spray  
8 system is not declared a safety system relates more to  
9 the Chapter 15 analyses and not to the Chapter 19  
10 analyses. And in Chapter 19 we're perfectly willing to  
11 give you condition credit on that system. I mean, it  
12 seems to me that's the way I look at things.

13 So I took my shot and you rebuffed it  
14 nicely.

15 MEMBER RAY: Maybe we should discuss it  
16 another time, Dana, if we're being consistent here.  
17 Because I'm declined to agree with what Bill said,  
18 which is the most likely cause of this catastrophe  
19 is==

20 CHAIR POWERS: Yes, absolutely. If you're  
21 initiated by the seismic event and that guarantees  
22 that you failed, despite independent event and became  
23 multiplied probabilities and we're stopped. Okay.  
24 Fair enough.

25 MR. FULLER: Okay. Let's go to the next

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1 slide. So what we wanted to do is we know that AREVA  
2 really wants to do this right. They told us that, and  
3 they're giving us information that it suggests to us  
4 that the ultimate goal would be reached. But that's  
5 only half of the battle. The other half is to make  
6 sure that the COL applicants get this information in a  
7 timely way and start using it to put together their  
8 emergency operating guidelines, EOPs, SMAGs, training  
9 in the use of these. So we've asked them to provide a  
10 means to assure that.

11 So we requested them to identify a COL  
12 action item that would basically have the COL  
13 applicant provide us some documentation of the severe  
14 accident management technical basis, which of course  
15 they would get from AREVA. So that was our first  
16 question.

17 So we asked the follow-up question,  
18 Question 19-243. So I'll go to the next slide, slide  
19 91.

20 And we asked them to elaborate. So what  
21 they did is they did send at that point the detailed.

22 So if you look at the response to this question, and  
23 go into the file, you get a nice long attachment which  
24 is their first crack at the OSA technical basis  
25 documentation. And in addition, in the RAI response

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1 they provided these words for a COL information item  
2 that are recorded in this sub bullet. So that they're  
3 saying that the COL applicants would reference -- will  
4 develop and implement the guidelines prior to fuel  
5 loading using the OSSA. And basically we want this to  
6 appear in the version of the FSAR, Chapter 19. And so  
7 that they say they'll put it there, and we're waiting  
8 for the next revision to make sure it's there.

9           Since I wrote this slide we have completed  
10 our first crack through the OSSA review. We've  
11 participated with our regulatory cohorts in Europe  
12 because they are either going to get their versions of  
13 OSSA or already have. And we actually had a meeting  
14 with them about three weeks ago in which we went over  
15 what we got from AREVA and what IRSN got from EDF,  
16 which they got from AREVA. And what the British hope  
17 to get and what the Finns hope to get.

18           And so we put our heads together and got a  
19 much better understanding of the breadth of what OSSA  
20 is going to be. And so we discussed some of these  
21 detail questions that would arise out of our review  
22 with them and got some additional ideas. We prepared  
23 a set of follow-up questions which, they've been sent  
24 now, right?

25           MR. TESHAYE: I think everything that's in

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1 my inbox has been sent.

2 MR. FULLER: So we have received this  
3 package of about 15 or 20 questions.

4 MEMBER SHACK: Man with a clean inbox. I'm  
5 impressed.

6 MR. FULLER: That's as of this morning.

7 CHAIR POWERS: You do not want to get on  
8 his distribution list, that's all I can say.

9 MR. FULLER: Okay. Let's go to the next  
10 slide.

11 So our approach is that we'd review  
12 accident management plans at the COL stage and audit  
13 each COL applicant to ensure that they would have the  
14 commitments in place and intend to meet them. And  
15 provide a means of systematically assessing, enhancing  
16 and maintaining their accident management capabilities  
17 consistent with our guidance and our agreement between  
18 the nuclear industry and the NRC that's in NEI 91-04.

19 And COL applicants should develop their  
20 plans based on the final as-go plant. You know,  
21 obviously we cannot give them a COL until -- we would  
22 give them a COL before they had their final procedures  
23 in place and training in place, obviously. But we  
24 want to make sure that they bought into the path  
25 towards making the correct ones.

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1 CHAIR POWERS: Yes. It's like our stage 3.

2 MR. FULLER: Okay. Finally, I have a  
3 couple of slides on severe accident mitigation design  
4 alternatives.

5 You know, the main reason for this in  
6 design certification space is to satisfy the NEPA  
7 requirement arising from the Limerick action way back  
8 when. And so they have to do this, our regulations  
9 require that the design certification application has  
10 to produce an Environmental Report, which is no and no  
11 less than the SAMDA evaluation. The Environmental  
12 Report is the SAMDA evaluation, okay? And AREVA did  
13 that. And ANP-10290 Rev 1 is their latest versions of  
14 that.

15 We saw the original versions, had  
16 questions, they responded to the questions and on that  
17 basis revised that report.

18 Basically in the report they conclude that  
19 because they really have gone out of their way to put  
20 these radical by current plant standards severe  
21 accident mitigation features in their plant, that  
22 there isn't much else they can do. They couldn't find  
23 anything that was cost beneficial.

24 Nevertheless, we just for the record we  
25 gave them some comments and asked them to comment

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1 pertaining to some of the assumptions made in the cost  
2 benefit assessment they did. For example, they  
3 question point estimate core damage frequencies and  
4 not mean values. And we asked them to do mean values.  
5 They did.

6 And then we did identify some shortcomings  
7 in that initial response. Asked them some follow-up  
8 questions. And to make a long story short they  
9 basically addressed all of those subsequently.

10 And so we have no more open items on the  
11 SAMDA.

12 So let's go to the last one, our  
13 conclusion.

14 MR. TESHAYE: Previously?

15 MR. FULLER: Page 94.

16 MR. TESHAYE: Ninety-four.

17 MR. FULLER: Sorry.

18 So in summary we find that they meet our  
19 requirement. RAI questions have been resolved and  
20 there aren't any open items associated with SAMDA or  
21 the Environmental Report.

22 We did have more conservative estimations  
23 of what the maximum benefit would be than they did.  
24 But, still, nothing comes close to being cost  
25 beneficial. So even those that do come relatively

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1 close, we don't feel they need to include in their  
2 design. And we didn't ourselves uncover any  
3 additional design alternatives that they should have  
4 considered.

5 With that --

6 CHAIR POWERS: Look --

7 MR. FULLER: Pardon me?

8 CHAIR POWERS: Did you consider the  
9 alternative between using PAR and using spark igniters

10 MR. FULLER: No. They've already got PARs  
11 in their design. You have to do this as basically a  
12 delta to the design you're reviewing.

13 CHAIR POWERS: So there's really no  
14 benefit, so it didn't matter what they cost?

15 MR. FULLER: Yes. Now if they had meter  
16 in there, now we're talking a different story.

17 CHAIR POWERS: Yes. So it's really that  
18 if you can't define a benefit, unless you find  
19 something about the PARs just makes them not work and  
20 either from the get-go, all right, some portion of the  
21 accident --

22 MR. FULLER: Yes.

23 CHAIR POWERS: -- there's no benefit to be  
24 gained.

25 MR. FULLER: Now I imagine, I don't know

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1 what their thought process was, but I imagine back  
2 when they were first considering what they were going  
3 to put into this design, they probably evaluated PARs  
4 and igniters both.

5 CHAIR POWERS: PARs have the wonderful  
6 feature that you don't have to have power to them.  
7 And furthermore, they work at even relatively modest  
8 levels of hydrogen, typically between one and two  
9 percent hydrogen you get recombination --

10 MR. FULLER: So we know what we you would  
11 have chosen.

12 CHAIR POWERS: No. I myself don't know. I  
13 mean, I'm very attracted to PARs, but I do know that  
14 the down side is that they poison, and they poison  
15 unless one's careful, during normal operating  
16 procedure. Paint something, the organic gets on them  
17 and they coat and things like that. And in a previous  
18 life, like you I had a previous life, I look a  
19 degradation of catalyst surfaces as a function of  
20 environmental considerations. And yes, I mean  
21 catalysts are wonderful things but you can  
22 irreversible or reversibly poison them.

23 MEMBER SHACK: Yes. I remember you raised  
24 this issue I think 15 years ago when Mike Snodderly  
25 was doing some initial analysis. It comes up every

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1 time somebody mentions it now.

2 I'd like the staff to come up with a  
3 definitive --

4 CHAIR POWERS: In other words, shut up.

5 MEMBER SHACK: It's one of those perennial  
6 issues that come up.

7 CHAIR POWERS: Boiling of pants off you,  
8 huh?

9 MEMBER SHACK: Well, no. I just added to  
10 my little list of responses. Remember you put  
11 together one time --

12 CHAIR POWERS: Yes.

13 MR. TESFAYE: I think that's all we have.  
14 If you don't have anymore questions of the staff.

15 CHAIR POWERS: Very good. Do we have any  
16 questions that people would like to pose to the  
17 speakers?

18 And here's our situation. My feeling is  
19 that we're still struggling a little bit, not with  
20 getting through Chapter 19. We have PRA expert out  
21 exploring the details, plowing into the details,  
22 plunging into the details and then we'll be interested  
23 to hear what he has to come back with.

24 In this particular area I know -- it's a  
25 lot of a situation of no good deed goes unpunished

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1 here. That indeed, the applicant has struggled  
2 heroically to come up with a way to accommodate severe  
3 accidents in a way well beyond what any existing plant  
4 does. And they have done quite a lot here. And, of  
5 course, to assure that they're not too content we  
6 raise a lot of questions on these.

7 My own feeling is that out of this  
8 questioning we've identified a couple of areas where  
9 there is some crucial behavior that we need to assure.

10 That is we need to understand how the system  
11 depressurizes, that it depressurizes, how far it  
12 depressurizes and what to my mind the consequences of  
13 that is, is really do we rattle the vessel around  
14 enough to cause penetrations to the vessel so we get a  
15 prompt leak out of there. And we need to assure  
16 ourselves the PARs will function as designed. And  
17 apparently we will hear about that when we go into  
18 Chapter 6. And I'm perfectly willing to wait for  
19 doing that. Because I think we understand well how  
20 the PARs interface with this severe accident analyses.

21 I myself see a credible analysis of the  
22 progress of accidents. We did not go into a lot of  
23 the details of the core degradation process, and as Ed  
24 has pointed out there are questions in that area on  
25 the extent of core degradation at the time of vessel

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1 failure which is an area of discrepancy between the  
2 MAAP code and the rest of the world that MAAP tends to  
3 melt down cores very completely and quickly, and  
4 probably is an element of conservatism in there. For  
5 anything we've learned that's what conservative in one  
6 aspect of an accident may not be conservative in  
7 another aspect. So there could be differences there.

8 And apparently that's one of the questions to be  
9 resolved. And I think there is a pathway to resolve  
10 that. I don't have any troubles letting that move  
11 forward.

12 See, the question of how a seismic  
13 initiator effects this system I think is an open  
14 question.

15 MEMBER SHACK: When are we going to hear  
16 about the seismic margins analysis? I mean, I'm not  
17 really saying this should be a Class 1 seismic  
18 analysis --

19 CHAIR POWERS: No, no.

20 MEMBER SHACK: But that you got to have a  
21 seismic margin of 1.67.

22 CHAIR POWERS: You think so?

23 MR. XU: We discuss about that on the  
24 last-- we discussed that last time.

25 MEMBER SHACK: We did that already? Did

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1 we do that system-by-system? Okay. I missed it.

2 MR. XU: There's a 19.1 --

3 CHAIR POWERS: Well, it remains unclear to  
4 me how this system is effected by it.

5 And the other area that, you know. we need  
6 incorporate progression and if they get their melt  
7 densities wrong and things like that, but I think we  
8 understand that that's not going to make a qualitative  
9 change in things. It may change the quantitative  
10 nature of things and whatnot. You know, the system  
11 seems to be robust to those criticisms.

12 I come away not very confident in an  
13 understanding of what the radionuclides behavior is in  
14 these accidents. Now a lot of that will get clarified  
15 when we go into the Chapter 15 analysis because I  
16 assume there are similarities in the modeling and we  
17 can think about doing it in connection with Chapter  
18 15.

19 Those are kind of my gross -- I mean, I  
20 got lots of detailed things. But those are the things  
21 that I see as making a qualitative -- you know, how we  
22 access this thing qualitatively. Which is really what  
23 we're doing here. I mean, we're in accident space and  
24 we're not asking them for 95 percentile things and  
25 whatnot. Yes, it's to get a feel for things.

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1 Qualitative is pretty good here in this area, but it's  
2 the radionuclide I don't come away with a good  
3 qualitative feel on how that is handled.

4 Bill?

5 MEMBER SHACK: If I'm assured the SAHR has  
6 a 1.67 seismic margin --

7 CHAIR POWERS: That's not a threat, Bill,  
8 or is that a --

9 MEMBER SHACK: Add that to my flaw  
10 distribution.

11 CHAIR POWERS: Mike?

12 MEMBER RYAN: I am good. Thank you.

13 CHAIR POWERS: Sam, you've asked for some  
14 specific things.

15 MEMBER ARMIJO: Yes. Mainly because I  
16 haven't done my homework, I'm sort of a guest member  
17 of this Subcommittee.

18 CHAIR POWERS: An honored member of the  
19 Committee.

20 MEMBER ARMIJO: Thank you very much.

21 But anyway, first of all, I think the  
22 systems that AREVA has designed really go into a space  
23 where we've never been and addressed accidents in a  
24 way that no existing plant does. But we're all  
25 engineers and whatever you put in, we all want to make

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1 sure they work.

2 And in the case of the SAHRs and the core  
3 melts, the stabilization system to me the most  
4 important thing is to make sure that the cooling water  
5 lines that cool that core plate and ultimately flood  
6 the spreading room actually don't get blocks. Of  
7 course, in Bill's seismic event or somehow work in  
8 some degraded way so they don't put in as much water.

9 Yes, you have two lines but what if each of them is  
10 not working quite. So I don't have a feeling for the  
11 margin in the system.

12 Obviously, if everything works like it's  
13 supposed to we shouldn't even be wasting time. But  
14 that's an area where I'd like to learn some more. I'd  
15 like to learn a little bit more about the ceramic  
16 materials, the zirconia. I think I asked a question on  
17 that.

18 That's all I have.

19 MR. WIDMAYER: There's an RAI that we'll  
20 get to.

21 MEMBER ARMIJO: Right. Right. And I asked  
22 the question a little bit more about cast iron is  
23 something that I learned about as a young metallurgist  
24 many, many years ago. And I thought it had just --

25 MEMBER SHACK: It had just come out.

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1 MEMBER ARMIJO: And there's brittle cast  
2 iron and there's -- cast iron. I don't know if this is  
3 welded. So any document that describes that system a  
4 little bit more.

5 MEMBER SHACK: It's a big hunk of cast  
6 iron.

7 MEMBER ARMIJO: It must be.

8 MEMBER SHACK: Because that's a big room.

9 MEMBER ARMIJO: So I'd just like to get a  
10 copy of that.

11 CHAIR POWERS: Well, just understand that  
12 it has some advantages over the bronze you're used to.

13 MEMBER ARMIJO: So anyway, the request is  
14 any other information, a topical report or something  
15 like that, a technical report on these materials would  
16 be of interest to me.

17 MR. TESFAYE: We will look into that.

18 MEMBER ARMIJO: Thank you.

19 CHAIR POWERS: Harold?

20 MEMBER RAY: You've captured everything.

21 CHAIR POWERS: Okay.

22 John?

23 MEMBER SIEBER: I guess the only thing  
24 that sort of struck me quantitatively as opposed to  
25 quantitatively is the idea that somehow or other in

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1 the whole core assembly the way it is operating I  
2 still have to decide whether there is a potential for  
3 a steam explosion or not. And I have to do some more  
4 research, but maybe somebody can assure me at the full  
5 Committee meeting that they have looked at all the  
6 various aspects that would cause me, and they tell me  
7 that it can't happen.

8 CHAIR POWERS: If they can do that, we  
9 will be praying to them shortly afterwards. The  
10 disability of steam explosive is vanishingly small.

11 MEMBER SIEBER: Yes, but it just seems to  
12 me the potential is there.

13 CHAIR POWERS: Yes.

14 MEMBER SIEBER: Okay.

15 CHAIR POWERS: You bring up a good point,  
16 though, John. The ACRS at it's last meeting has  
17 indicated they're giving substantial discretion in the  
18 future to the subcommittees to decide when they bring  
19 things forward tot he full Committee. And I intend to  
20 take liberal use of that discretion. Because  
21 especially and quite frankly in connection with this  
22 plant we're not getting a lot of issues that require  
23 the wisdom and judgment of the full Committee as a  
24 whole. And so I am moving in the direction of the  
25 amount of time that we spend in front of the full

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1 Committee. And my preference, my personal preference  
2 is to come before the full Committee when we say we  
3 have moved from this stage to the next and focus on  
4 why we think we can move to the next. But I am going  
5 to leave that discretion open to input both from the  
6 staff, the applicant and the members of the Committee  
7 that is if there are points at which you think it  
8 would be useful short of that milestone to bring  
9 things forward to the full Committee.

10 And one of the candidates is that when you  
11 have -- I think we're going to need another meeting on  
12 Chapter 19 just to tie all the bows and get the inputs  
13 from our experts and things like that, and round out  
14 some of the issues here.

15 One of the possibilities is Chapter 19  
16 might be one to take forward to the full Committee,  
17 and so I toss that out. And I'm certainly open to  
18 suggestions from everybody on that regard.

19 But otherwise, my intention with this  
20 reactor is to until we run into what I would call  
21 significant issues in the process -- there always  
22 could be issues and things like that, but the way it's  
23 organized now it really didn't come to us until things  
24 are going to be pretty well resolved and there's not  
25 much to tell the full Committee. The exception, of

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1 course, is this Chapter. Another Chapter that might be  
2 a candidate would be 15 just because its figured so  
3 prominently in the regulatory process. I toss that  
4 out.

5 MEMBER SHACK: Yes.

6 (Member Shack gesturing ten.)

7 CHAIR POWERS: Of course, unavoidable  
8 there. But that keeps getting pushed back farther and  
9 farther in time.

10 Any other comments people want to make?

11 Well, it's been a very enjoyable session.  
12 I think you very much for your presentation. It was a  
13 heroic job. And one of these days you'll get the met  
14 density properly set.

15 MEMBER SHACK: He gives us a 95/95 and we  
16 still complain about it.

17 CHAIR POWERS: Yes, because he didn't take  
18 into account correlations. And he keeps using that  
19 ridiculous Pearson linear correlation instead of a  
20 decent one like a Kendal Tau.

21 MS. MROWCA: Dr. Powers?

22 CHAIR POWERS: Yes, sir.

23 MS. MROWCA: This is Lynn Mrowca and I  
24 have a question for you what you said before about  
25 meeting again Chapter 19. I guess it would help us

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1 maybe to understand if there are specific issues that  
2 you want to talk about. And for our schedule, I was  
3 wondering if you're talking about, and right now we  
4 move on to Phase 4 which is where we take our safety  
5 evaluation with open items and close them. So are you  
6 talking about sometime in that time frame?

7 CHAIR POWERS: You ask me to remember  
8 calendars -- no, I think we just need to find a time  
9 that we can meet to go over again. I mean, we did not  
10 finish the PRA itself. I think I have raised some  
11 questions about the severe accident analysis,  
12 especially radionuclide behavior, the seismic issue  
13 remains open to us. And I think we just need to round  
14 those out.

15 And quite frankly, it's a question of  
16 scheduling. I know that's a problem because right now  
17 the members are covering way too many systems all at  
18 once. So finding the time is a chore. And so that's  
19 why you get the big bucks.

20 MS. SLOAN: Dr. Powers, I guess I had a  
21 similar question. Is the meeting you're talking about  
22 on Chapter 19 a meeting in addition to like the Phase  
23 5 type --

24 CHAIR POWERS: Yes. It's much like this  
25 meeting, except we will give you a list of questions

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1 that we're trying to address. And if you come back to  
2 us and say we would prefer to address this in  
3 connection with another chapter, I think that's okay.

4 Quite frankly, I mean to all concerns,  
5 staff and applicant both, this is going smoothly  
6 enough that I don't have trouble moving things among  
7 chapters. I'm not encountering a difficulty with that  
8 myself, and I'm not hearing from any of the members of  
9 the Subcommittee have difficulties shifting from one  
10 chapter to the other. If you'll put up with our  
11 seemingly foolish questions because we've gotten  
12 confused from chapter-to-chapter, you know. And if  
13 you do find that frustrating, you know let me know and  
14 we'll make a more rigid structure for those.

15 Yes, I'm willing to work very collegially  
16 on this process right now. Because I see excellent  
17 intentions on the parts of both. I mean I truthfully  
18 believe the staff is tried to do a heroic job on this.

19 I know the applicant is trying very hard to do a  
20 technically responsible job here. So I'm willing to  
21 work you guys very collegially, in both parties, on  
22 scheduling and what we cover and things like that.  
23 And if you think we're not being specific enough in  
24 what we're asking you to present -- you'd be surprised  
25 how thick my skin is and my ability to tell you that's

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1 why you get the big bucks, too.

2 Okay. Any other comments that people  
3 would like to make?

4 Well thank you very much.

5 Again, congratulation to all. I think  
6 you're gone well beyond what's required of you.

7 (Whereupon, at 4:43 p.m. the Subcommittee  
8 meeting was adjourned.)

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