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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION  
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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
(ACRS)  
REACTOR FUELS SUBCOMMITTEE

+ + + + +  
MONDAY,  
APRIL 21, 2003

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ROCKVILLE, MARYLAND  
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The Subcommittee met at the Nuclear  
Regulatory Commission, Two White Flint North, Room  
T2B3, 11545 Rockville Pike, at 10:00 a.m., Dr. Dana A.  
Powers, Chairman, presiding.

COMMITTEE MEMBERS:

- |                  |          |
|------------------|----------|
| DANA A. POWERS   | Chairman |
| F . PETER FORD   | Member   |
| THOMAS S. KRESS  | Member   |
| STEPHEN L. ROSEN | Member   |
| WILLIAM J. SHACK | Member   |
| JOHN D. SIEBER   | Member   |

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ALSO PRESENT:

MILTON LEVENSON                    Member, ACNW  
MICHAEL T. RYAN                    Member, ACNW

ACRS STAFF PRESENT:

MAGGALEAN W. WESTON

OTHER NRC STAFF PRESENT:

TIM JOHNSON, SR.  
ANDREW PERSINKO  
SHARON STEELE  
CHRISTOPHER S. TRIPP  
WILLIAM TROSKOSKI  
RUSS WESCOTT

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

10:00 a.m.

CHAIRMAN POWERS: The meeting will now to order.

This is a meeting of the ACRS Subcommittee on Reactor Fuels. Those of you here for something else, should probably leave.

I'm Dana Powers, Chairman of the Subcommittee. ACRS members in attendance are Peter Ford, Thomas Kress, Steve Rosen, Jack Sieber, Bill Shack.

We also have the benefit of the presence of two members of the Advisory Committee on Nuclear Waste, Milt Levenson and Mike Ryan. Welcome, gentlemen. And we encourage you to participate fully and give the benefit of your perspective on this problem, which is undoubtedly going to be at least different.

The purpose of the meeting is to discuss the Mixed Oxide Fuel Fabrication Facility construction authorization application.

The Subcommittee will gather information, analyze those are in the issues and facts, and formulate proposed positions and actions as appropriate for the deliberation by the full

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1 Committee. In fact, we are scheduled to provide a  
2 Subcommittee report to the full Committee in May. And  
3 at the conclusion of this meeting, I will be polling  
4 the members for suggestions on input to that. I am  
5 going to be looking for fairly definitive input to  
6 that, so you might want to bear in mind as we go  
7 through these things, the points that we should be  
8 raising to the full Committee.

9 I don't believe we're going to be asked to  
10 produce anything from the full Committee. So we're  
11 going to be looking to educate the full Committee in  
12 this area. In that regard, as members have  
13 undoubtedly understood and they're looking at the  
14 written material, this is a rather different world  
15 than the reactor safety world. And there's a different  
16 set of vocabulary used here. So we're going to have  
17 to work on that.

18 I encourage everyone to re-familiarize  
19 yourself with 10 CFR 70.61 A through F, 70.64 A and B,  
20 7065, 10 CFR 50.2 to understand the definitions, the  
21 baseline design criteria, integrated safety analysis,  
22 items relied upon for safety. Because I don't intend  
23 to ask any of the speakers to go into those particular  
24 definitions except as they plan to in their  
25 presentation.

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1 I will be asking the speakers to explain  
2 to me, at least, the meanings of words like "unlikely,  
3 highly unlikely, credible and incredible," recognizing  
4 I'm a particularly credulous person.

5 Mag Weston is the cognizant ACRS staff  
6 engineer for this meeting. Mag. And she does an  
7 excellent job keeping me straight.

8 The rules for participation in today's  
9 meeting have been announced as part of a notice of  
10 this meeting, previously published in the Federal  
11 Register on April 4, 2003.

12 A transcript of the meeting is being kept,  
13 and it will be made available as stated in the Federal  
14 Register notice.

15 It is requested that speakers first  
16 identify themselves and speak with sufficient clarity  
17 and volume that they may be readily heard.

18 This is a Subcommittee meeting and I do  
19 encourage discussion and debate, and a relaxation of  
20 the formality that we might have at full Committee  
21 meetings. And so as the presentations go along, people  
22 who are not presenting, are encouraged to ask  
23 questions both from the public and any other group  
24 that wants to go on.

25 I will worry about the schedule, the

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1 speakers do not need to. The idea is to get as much  
2 information as we can in these discussions, rather  
3 than complying with a time schedule. In that regard,  
4 we are going to change some of the published  
5 scheduling here to make the presentation what we  
6 think, a little more logical.

7 We've received no written comments from  
8 the members of the public regarding today's meeting.

9 The scheduling changes that I mentioned is  
10 we're going to move Confinement Ventilation to follow  
11 Fire Protection. And we're going to switch around  
12 some of the ordering of the presentations at the  
13 beginning so that DCS will talk before the staff does  
14 on the introductory comments.

15 Do any members of the Committee have  
16 comments they want to make before we get started?  
17 Jack?

18 MR. SIEBER: A couple of questions. I  
19 would appreciate it if you would repeat the citations  
20 to Title 10 so I can write them down.

21 CHAIRMAN POWERS: I will send you a note  
22 around with those on it.

23 MR. SIEBER: All right.

24 CHAIRMAN POWERS: Because I do think it's  
25 worthwhile to reexamine those sections. Because the

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1 ones that we don't ordinarily deal with in our work  
2 with reactors. And life is different in the facility  
3 world.

4 MR. ROSEN: And I'd send them to everybody,  
5 Dana.

6 CHAIRMAN POWERS: We will do so.

7 And in particular, we'll try to understand  
8 a lot about what is meant by the words "defense-in-  
9 depth" in the context of facilities.

10 Jack, go ahead.

11 MR. SIEBER: Yes, I have another question.  
12 In the SER for this project, which is a huge work of  
13 art, there is a section that is open items.

14 CHAIRMAN POWERS: Yes.

15 MR. SIEBER: And in the open items  
16 section, there's a lot of open items in seems to me.

17 CHAIRMAN POWERS: Yes.

18 MR. SIEBER: RAIs. If speakers could  
19 mention the more important ones.

20 CHAIRMAN POWERS: Well, I suspect they  
21 would.

22 MR. SIEBER: I appreciate that also.

23 CHAIRMAN POWERS: I suspect the  
24 presentations are directed in those directions. And I  
25 know the concluding comments will discuss the

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1 inventory of open items that we had.

2 MR. SIEBER: Okay. Thank you.

3 CHAIRMAN POWERS: Are there any other  
4 comments members want to make before we get into -- if  
5 there are none, I will proceed with the meeting. And  
6 I believe Ken Ashe of Duke Cogema Stone & Webster is  
7 to start us out.

8 MR. ASHE: Good morning. My name is Ken  
9 Ashe, and I'm the license application manager for Duke  
10 Cogema Stone & Webster.

11 And I'd like to thank you for asking us to  
12 come and talk about some of the topics of interest  
13 today, specifically the topics that we'll talk about  
14 today are associated with the open items.

15 One of the first things I want to do is,  
16 is to sort of give you a little bit of a background.

17 The construction authorization request was  
18 originally submitted in February of 2001, and we got  
19 a draft Safety Evaluation Report, which you mentioned.  
20 And then we updated the construction authorization in  
21 October of 2002. And we hope to get a draft Safety  
22 Evaluation Report at the end of this month with a much  
23 shorter list of open items.

24 In the change between the first CAR and  
25 the second CAR, there was a program. And that was

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1 associated with the Department of Energy making the  
2 decision to not have a mobilization. And with that  
3 there were changes to our Construction Authorization  
4 Request that really were not that significant. There  
5 were some design changes, there were some new feed  
6 stock, etcetera. But it wasn't a real significant  
7 change. And that's why you'll see that the draft  
8 Safety Evaluation Report that we get this time came  
9 much quicker than the last one. Because the changes  
10 were really --

11 CHAIRMAN POWERS: I agree with you that  
12 the process change for most of it, it's pretty -- I  
13 mean it's virtually no change at all.

14 MR. ASHE: Right.

15 CHAIRMAN POWERS: The front end has a  
16 little bit a change. It seems to me that if I were  
17 planning to operate at this facility and suddenly I'm  
18 dealing with not one but four feeds, that's a real  
19 headache for me.

20 MR. ASHE: There were some changes  
21 associated with receiving the fuel in or the feed  
22 stock, if you will. And we did accommodate those. And  
23 there were some changes associated with the aqueous  
24 polishing. And with that, we had to take and increase  
25 some of the flow pass, if you will, by adding a lot of

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1 the same type of equipment. So there really wasn't  
2 anything that was created that provided us with a big  
3 challenge with respect with that, other than just  
4 working through the design and getting it done.

5 As you did mention, there were quite a few  
6 RAIs. There were 239 of them. We have provided a lot  
7 of correspondence back and forth. We've had several  
8 meetings with the staff to talk about those responses.  
9 There were letters of clarifications that have gone  
10 back and forth, such that we believe that we now have  
11 provided a good set of information for the staff to  
12 continue to review.

13 We understand in their draft SER there  
14 will still be some open items, some where we still owe  
15 them some information, and some where we understand  
16 that they are reviewing the information that we  
17 provided them and, hopefully, we'll get those to  
18 closure also.

19 Let's see. These things that we're going  
20 to talk about today, as you mentioned, there's two  
21 topics on chemical safety. The TPB red oil and HAN.  
22 We'll also talk on the confinement ventilation and  
23 with that we'll have a discussion on HEPA filters  
24 where we do have other than presenters, we do have a  
25 few other people in the audience to answer some of the

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1 technical questions. For HEPA filters, we do have Dr.  
2 Bergman who will be here to answer any detailed  
3 questions you have on that. And then if there's  
4 questions on our safety analysis, safety assessment,  
5 etcetera, then Gary Kaplan will also be here to answer  
6 those questions.

7 And then we will also have a presentation  
8 on fire protection.

9 And when you look at the items that we  
10 believe are still open as of the latest monthly report  
11 published by the staff, those four areas cover a good  
12 portion of those open items. So we believe that you'll  
13 get a good flavor of those things that are still  
14 outstanding.

15 CHAIRMAN POWERS: Let me ask you a couple  
16 of questions. You're giving us an overview of what  
17 you have available here. You going to have somebody  
18 that's going to be able to discuss your view of  
19 defense-in-depth, especially with respect to fire  
20 safety?

21 MR. ASHE: We'll have some discussions  
22 with respect to defense-in-depth and how our system is  
23 laid out, and how it provides for defense-in-depth.  
24 The detailed questions we will field the ones that we  
25 can, absolutely.

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1 CHAIRMAN POWERS: The issue comes up  
2 because when I look at your definition of defense-in-  
3 depth and I look at the definition of defense-in-depth  
4 that's in Appendix R Part 50 I see a different. And  
5 I want to understand that difference.

6 MR. ASHE: Okay.

7 CHAIRMAN POWERS: Because I think it has  
8 an impact on your overall safety. And whereas you do  
9 look at the single failure in your definition to  
10 defense-in-depth on fire safety, your third element  
11 idea is distinguish the fire rather than protect  
12 equipment from damage from by the fire.

13 MR. ASHE: Right.

14 CHAIRMAN POWERS: And that's the  
15 difference I want to understand.

16 MR. ASHE: Okay. Okay. Well, that was  
17 pretty much my introductory remarks. Again, thank you  
18 for the opportunity for us to be here and provide you  
19 with some information about our program.

20 CHAIRMAN POWERS: And the other question  
21 that I'll alert you to is, especially my colleague Dr.  
22 Kress will be quite interested in your categorization  
23 of items with respect to the various criteria, and in  
24 particular how you came about your consequences for  
25 some of these scenarios that you've looked into to.

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1 You going to be able to discuss that?

2 MR. ASHE: I'm trying to think with  
3 respect to the topics that were on the agenda today,  
4 do you have some examples that you were thinking of?

5 CHAIRMAN POWERS: I think it's going to be  
6 pervasive on every single one of them. But  
7 particularly in the area of fire. Issues kind of come  
8 about of how do you know what the magnitude of the  
9 release, the transport efficiency are for the  
10 materials at risk in the event of the fire?

11 MR. ASHE: We can talk some about that.  
12 We may not be prepared to answer all of your  
13 questions.

14 CHAIRMAN POWERS: That's fine. That's  
15 fine.

16 MR. ASHE: Okay.

17 CHAIRMAN POWERS: Okay. If we run into  
18 roadblocks, you can -- you can point either to the  
19 particular section in the CAR that we want, or we may  
20 chase around and find some other information.

21 MR. ASHE: Okay.

22 CHAIRMAN POWERS: The extent to which  
23 you've used the Machima database will be of interest  
24 I know to Dr. Kress.

25 MR. ASHE: Okay.

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1 CHAIRMAN POWERS: Drew? I guess I ought to  
2 be a little more formal. This is Andrew Persinko  
3 that's going to give the staff overview on this.

4 And, Drew, I'll just say that I have  
5 admired the comprehensiveness of the draft SER. We'll  
6 discuss some of the specifics as we go along, but the  
7 comprehensiveness has been impressive.

8 MR. PERSINKO: Thank you.

9 CHAIRMAN POWERS: That goes as well for  
10 the CAR as well. That's quite a comprehensive thing,  
11 too.

12 You've certainly occupied my evenings and  
13 weekends. You know, it's been delightful not to have  
14 to think about cruising out to the bars or things like  
15 that.

16 MR. PERSINKO: Sorry about that.

17 CHAIRMAN POWERS: Knowing that I have  
18 something to be occupied with.

19 MR. PERSINKO: Okay. My name is Andrew  
20 Persinko. I'm the MOX project manager at NRC.

21 We last spoke to the Subcommittee in April  
22 of last year, April 10th to be exact. Since then, we  
23 the staff, have issued the draft Safety Evaluation  
24 Report. We've received a revised Environmental report.  
25 We've received a revised Construction Authorization

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1 Request. And we've issued our draft Environmental  
2 Impact Statement, which is currently out for public  
3 comments. And our plan is to issue the revised draft  
4 Safety Evaluation Report the end of April.

5 I thought before we get into the real meat  
6 of the discussion today, very briefly it would be good  
7 to refresh the Subcommittee's memory on a few  
8 overarching items.

9 CHAIRMAN POWERS: We're old and we forget  
10 quickly.

11 MR. PERSINKO: I'm with you.

12 First of all, this is a picture overview  
13 of the mixed oxide fuel project. It's meant to show  
14 the jurisdictional and geographical boundaries, to  
15 show that should the mixed oxide fabrication facility  
16 be approved and constructed, it would be constructed  
17 at the Savannah River site along with the pit  
18 disassembly and conversion facility.

19 The pit disassembly and conversion  
20 facility will be under the auspices, jurisdictional  
21 regulation of Department of Energy. NRC would become  
22 involved with regulation of the fuel facility as well  
23 as the reactors.

24 This is a high level view of the process  
25 itself.

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1 CHAIRMAN POWERS: Drew, just to interrupt.  
2 Maybe you're going to get into it. I haven't looked  
3 ahead in your slides.

4 There are various boundaries. This is  
5 located on a government reservation. There are various  
6 boundaries that come up. I wonder if you could just  
7 walk through that various boundaries just to remind us  
8 which ones are which?

9 MR. PERSINKO: I could. I don't have a  
10 slide with me for that, but we can walk through.

11 CHAIRMAN POWERS: Just a thumbnail sketch  
12 on that.

13 MR. PERSINKO: Okay. Well, maybe we could  
14 try that right now.

15 The MOX facility itself is planned to be  
16 constructed in the F area of Savannah River site.  
17 Close proximity to the pit disassembly facility and  
18 conversion facility.

19 The applicant has chosen the control of  
20 area boundary as defined in the Part 70 regulation to  
21 be largely coincident with the Savannah River site  
22 boundary. And there are provisions within Part 70  
23 which talk about whose a member of the public and who  
24 is the worker.

25 You're familiar with the term facility

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1 worker, if you've read it. Facility worker is meant,  
2 is referring to the MOX facility worker within the  
3 restricted area right in close proximity to the  
4 facility.

5 CHAIRMAN POWERS: Those are the  
6 distinctions that I'm interested in here. Because  
7 it's important to understand the differences between  
8 facility worker and co-located worker.

9 MR. PERSINKO: The term is used by the  
10 applicant as site worker, and that is referring to the  
11 Savannah River site workers. And then it's referring  
12 to then the public, the term public is used by the  
13 applicant as people beyond the site boundary, the  
14 controlled area boundary, meaning off the Savannah  
15 River site.

16 It gets a little confusing in that the  
17 Part 70 regulation allows for persons whose ongoing  
18 duties are requiring them to be within the controlled  
19 area boundary but yet by definition they're still  
20 members of the public. Part 70 allows these people to  
21 be considered as workers if certain provisions are  
22 met, such as the training requirements that are shown  
23 in 70.61. So for the purposes of meeting the  
24 performance requirements, these people can be  
25 considered as workers if they meet certain training

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1 requirements.

2 It gets a little confusing in that Part 20  
3 also applies to the facility.

4 CHAIRMAN POWERS: Yes.

5 MR. PERSINKO: And Part 70 is a little --  
6 NRC and DOE have a difference in the term of "worker"  
7 when it comes to Part 20.

8 Part 20 -- let me see if I can remember  
9 this correctly now. You are a member of the public if  
10 your duties do not involve occupational exposure in  
11 your normal duties. So it gets slightly confusing if  
12 you're going to talk worker, are you talking worker  
13 with respect to Part 20 or worker with respect to Part  
14 70.

15 Most of the discussion today will focus  
16 with respect to the performance requirements, and  
17 there are some people on the site who NRC would  
18 consider as workers unless the training is provided,  
19 in which case for the purpose of meeting the 70.61  
20 performance requirements, they can be considered --  
21 they have the training, those people can be considered  
22 as site workers.

23 CHAIRMAN POWERS: I know that in your  
24 draft of this you made some effort to try to  
25 articulate this thing. I'd encourage you to go back

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1 and reexamine that to make sure you've made it crystal  
2 clear to the unexpert.

3 MR. PERSINKO: I think you'll see in this  
4 revision, I think we've gone from a couple of  
5 paragraphs to maybe a couple of pages.

6 CHAIRMAN POWERS: You have, and I enjoyed  
7 it. I mean, it was useful. There are still parts of it  
8 that are challenging to the nonspecialist here.

9 The other question that comes up is  
10 training that allows you to treat what I will call,  
11 perhaps incorrectly, co-located workers as radiation  
12 workers. Is that something we should look into it?  
13 Have you looked into it?

14 MR. PERSINKO: Yes. Oh, yes. It was  
15 looked into during the Part 70 rulemaking that was  
16 several years ago. And the training is described in  
17 the -- I believe it's 10 CFR Part 19.

18 CHAIRMAN POWERS: Right.

19 MR. PERSINKO: So that is the training  
20 requirements. But it's basically to inform the worker  
21 of the risks associated with the facility so that the  
22 people are aware of what goes at the facility and what  
23 to do in case of an accident. And basically so that  
24 they know and understand the risks that the facility  
25 can present.

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1 Any other questions?

2 I just wanted to present a high level  
3 overview of the process at this point. We'll be  
4 getting to some of the more specific areas when we  
5 talk later, especially with respect to chemistry.

6 The top row in this diagram represents the  
7 aqueous polishing part of the process. This part of  
8 the process is modeled after the La Hague facility in  
9 France. It consists of the three steps as shown. The  
10 impurities that are removed as such things as callium  
11 and americium.

12 The lower set of three boxes is what we  
13 call the MOX fuel fabrication process. This is modeled  
14 after the MELOX facility in Marcoule, France. And I  
15 understand a number of the Subcommittee members  
16 visited that facility since we last spoke.

17 CHAIRMAN POWERS: And they all came back  
18 starry eyed and totally impressed.

19 MR. PERSINKO: But the three major areas  
20 there are the blending of the uranium and the oxide  
21 powders, fabrication of pellets, the assemblies of  
22 rods and fuel assemblies.

23 At this stage of the facility, which is  
24 the construction that we're talking about, I would  
25 just like to point out a few things.

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1           Part 70 allows for a two step approval  
2 process. One for construction and one for possession  
3 and use, i.e., operation.

4           We are currently at the construction step  
5 only.

6           The approvals with respect to construction  
7 in Part 70 consists of staff review and approval of  
8 the design bases of the principle structures, systems  
9 and components, which we often refer today as PSSCs.  
10 It also requires that the staff approve the quality  
11 assurance program, which the staff has done separately  
12 in a separate Safety Evaluation Report already.

13           It's important to point out, I think, that  
14 the Part 70 regulation specifies that an Appendix B  
15 quality assurance program be adopted, and it is.

16           It also requires that the staff issue a  
17 decision with respect to the environment, i.e., the  
18 Environmental Impact Statement.

19           I'd also like to point out that there's a  
20 provision in 70.64 with respect to defense-in-depth.  
21 That, too, has to be applied at this stage, but it  
22 will also be applied at the operational stage as well  
23 when the PSSCs are described in more detail. At the  
24 stage the PSSCs are described primarily on a systems  
25 level. We expect, based on our discussions with the

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1 applicant, that assuming approval at this stage, that  
2 the possession and use stage these PSSCs would be  
3 described more on a component level.

4 And what I just want to point out in the  
5 last bullet is the distinction between PSSCs and  
6 IROFS. You'll see principle structure systems and  
7 components, that's associated also with the term  
8 safety analysis, which is used at the construction  
9 stage. You will hear today also the term items relied  
10 on for safety, i.e., you will hear IROFS. And that's  
11 associated with something we know as the integrated  
12 safety analysis. That part of it is respect to the  
13 possessio of use license. Sometimes we forget  
14 ourselves and use the terms interchangeably, but I  
15 want to point out that that one is for construction  
16 and one is for possession and use.

17 DR. FORD: Is there much lessons learned  
18 from the French on the slicing topic? Do you take  
19 into account their licensing process and whether we  
20 should modify it?

21 MR. PERSINKO: We did not take into  
22 account their licensing process. We are licensing it  
23 according to the NRC regulations. We discussed  
24 operational history and experience with the applicant  
25 rom the French facilities, and those are being

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1 incorporated into the design of this facility. But as  
2 far as the licensing process itself, no, we're using  
3 Part 70.

4 DR. FORD: Okay.

5 MR. PERSINKO: I just want to point the  
6 definition of design bases that we're using is the one  
7 at 50.2. I'm not going to read it, but I just want to  
8 point out what we're using.

9 In a nutshell, this is a nutshell of Part  
10 70 performance requirements. It basically is a risk-  
11 informed regulation which consists of consequences on  
12 one axis, likelihood on the other.

13 Consequences are described in the  
14 regulations to the depth you see in the left hand  
15 column. The likelihood terms are not defined in the  
16 regulation. They are described in our standard review  
17 plan, but not in the regulation itself. So they're not  
18 requirements. And during the Part 70 rulemaking  
19 process it was clear that the terms, like likelihood  
20 terms could be qualitative likelihood terms.

21 But I wanted to show that it's basically  
22 a likelihood consequence matrix with the upper right  
23 hand corner being an area that the applicant is not  
24 allowed to be in. So if there is an accident sequence  
25 which brings into one of those upper right hand boxes,

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1 the applicant must apply either at a mitigative or  
2 preventive feature to lower the likelihood or mitigate  
3 the consequences to remove themselves from the boxes.

4 I didn't want to get into a lot of detail  
5 on this, because I didn't want to turn in into a Part  
6 70 risk meeting, but --

7 CHAIRMAN POWERS: This group you can't  
8 avoid the subject of risk.

9 DR. LEVENSON: I have a question. Why are  
10 environmental releases listed only for the medium  
11 consequences, not for high and not for low?

12 CHAIRMAN POWERS: Because that's the way  
13 the regulations read.

14 MR. PERSINKO: It was per the regulation,  
15 of course. I think it was felt that the high  
16 consequences were more with respect to human  
17 exposures.

18 DR. KRESS: The picking sequences that go  
19 into likely, highly unlikely, etcetera, is that done  
20 in the ISA from expert opinion process?

21 MR. PERSINKO: It's been done even at this  
22 stage for the preliminary hazardous analysis by the  
23 applicant, which we have looked at at the applicant's  
24 offices. That's largely qualitative by the  
25 applicant's decision of where it fits.

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1           For the operational stage, possession and  
2 use stage, it also will likely be largely qualitative.  
3 It's our understanding that there will be certain  
4 systems, certain areas where the applicant will get  
5 into more detail in those areas and actually do  
6 somewhat like a PRA type analysis.

7           I would like to also mention, though, that  
8 the applicant has stated for site workers and the  
9 public, they will be applying the index method as  
10 described in the appendix to the standard review plan.  
11 But that part of it is not a PRA.

12           DR. KRESS: One other question on that  
13 then. I could see how you might define these terms  
14 like in qualitative terms, for example, as not likely  
15 to happen in the lifetime of the plant or some such  
16 frequency, qualitative frequency. Is that the way they  
17 arrive at these?

18           MR. PERSINKO: Yes.

19           DR. KRESS: Okay.

20           CHAIRMAN POWERS: The challenge that you  
21 have in nomenclature here, if I look at the  
22 regulations I see intermediate consequences. Is that  
23 what you mean by your medium consequences?

24           MR. PERSINKO: Yes. Correct.

25           CHAIRMAN POWERS: Okay. You might want to

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1 bear that in mind, that you're really talking about  
2 that.

3 What I also see in your discussions with  
4 the staff that when they say "unlikely," in some cases  
5 you've chosen what I would say a very likely  
6 probability to correspond to unlikely.

7 MR. PERSINKO: The staff has?

8 CHAIRMAN POWERS: Yes.

9 MR. PERSINKO: Perhaps you could explain?

10 CHAIRMAN POWERS: Well, there's at least  
11 one case where unlikely was taken as once a year. I'd  
12 have to dig through to point to the exact -- I mean,  
13 you were just discussing things with the staff. I  
14 mean with the applicant.

15 MR. PERSINKO: I don't know where that is  
16 off the top of my head. If you could point that out to  
17 me.

18 CHAIRMAN POWERS: It'll be a struggle.  
19 Okay.

20 So what I'm hinting at is you really have  
21 to give us some sense, some quantification of this to  
22 get some idea of what these things mean. Because aside  
23 from the contortion of language associated with not  
24 unlikely --

25 MR. PERSINKO: Let me try to add a little

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1 bit there. The applicant has chosen a qualitative  
2 definition, the regulations allow for a qualitative  
3 definition, and so does the SRP being a guidance  
4 document, of course, would allow it as well.

5 There is an appendix in the Standard  
6 Review Plan which talks about a more quantitative  
7 approach. It talks about what's known as an index  
8 method.

9 Roughly speaking a highly unlikely event  
10 is on the order of approximately ten to the minus  
11 fifth; ten to minus 4, ten minus fifth. An unlikely  
12 event is somewhere in the order, I think of ten to the  
13 minus two; ten to the minus four roughly speaking.  
14 And so that's the quantitative aspect of it that's in  
15 the Standard Review Plan.

16 CHAIRMAN POWERS: These are the same  
17 criteria that -- I mean, the bins that have been used  
18 for decades in the DOE facility regime where the top  
19 one is like one to ten to the minus two, the next  
20 one's ten to the minus two, ten to the minus four. A  
21 highly unlikely is ten to the minus four, ten to the  
22 minus six. Below ten to the minus six is deemed  
23 incredible.

24 MR. PERSINKO: Incredible. Correct.

25 CHAIRMAN POWERS: Unweighted by the

1 consequences of --

2 MR. PERSINKO: That's right.

3 This is largely, like you said, similar to  
4 like Department of Energy uses in its standard, I  
5 think it's 3009, I believe.

6 CHAIRMAN POWERS: And sometimes since I've  
7 looked at 3009 --

8 MR. PERSINKO: I mean, this isn't MOX  
9 specific. This is from the 10 CFR Part 70 regulation.

10 Just a little bit about schedule. Said I  
11 said, we issued our draft SER. Received a revised  
12 environmental report. Received a revised Construction  
13 Authorization Request. s I say, we also issued our  
14 draft EIS out for public comment. The public comment  
15 period closes in May 14th, I believe. And we intend  
16 to issue our draft SER construction this April, the  
17 end of this month, very shortly. The final EIS in  
18 August and the final SER in September.

19 CHAIRMAN POWERS: The ACRS as a matter of  
20 its own operating standards has decided not to look at  
21 Environmental Impact Statements. But let me ask you  
22 this question, would it benefit us to examine it? Or  
23 do we get everything we need to know out of the SER  
24 and the CAR?

25 MR. PERSINKO: I think there's a lot of

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1 good and interesting information in the Environmental  
2 Impact Statement. I think it's not -- of course, it  
3 has a different purpose which focused in on accident  
4 per se as more directly as this does. But I think  
5 there is a lot of good information regarding  
6 consequences since it's consequence based and not risk  
7 based -- risk-informed as a consequence document. But  
8 it has a lot of good and interesting information in  
9 it. So I think if sufficient time exists for the  
10 Subcommittee members, it's a good document to read as  
11 well.

12 CHAIRMAN POWERS: In your SER you have a  
13 set of sentences that appears sufficiently frequently  
14 that I'm surprised you didn't develop an acronym for  
15 them. You missed a real opportunity to expand the  
16 acronyms used in government here.

17 This set of sentences begin with "The  
18 applicant has determined this sequence to be 10 CFR  
19 70.61.C threshold for facility worker, but below the  
20 10 CFR 70.61.C threshold for the public and site  
21 worker. The staff has independently evaluated this  
22 sequence and agrees to its categorization."

23 DR. KRESS: It'd be a long acronym.

24 MS. WESTON: Can you give me the citation?

25 CHAIRMAN POWERS: Well, I can. It is

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1 endemic to the report. I bet it shows up a 150 times.  
2 And like I say, the opportunity for developing an  
3 acronym here was just -- I'm surprised you could  
4 resist.

5 It's 5.0-22 that I quote from.

6 What I'm interested in is can you in the  
7 course of the presentation give me a thumbnail sketch  
8 of what you meant when you said the staff has  
9 independently examined this sequence and has looked at  
10 the categorization. Does that mean that the staff  
11 took the description of the sequence and developed its  
12 own source terms for this sequence, and then compared  
13 it to the requirements in the cited section of the 10  
14 CFR?

15 MR. PERSINKO: We did some rather detailed  
16 look into that. And maybe Dave could expand on that.

17 CHAIRMAN POWERS: I'm not looking for a  
18 comprehensive discussion in this. It appears, like I  
19 say, 150 times. It is probably a lower bound estimate.  
20 But a few examples of it might be very useful. And if  
21 it can't be done here, maybe there's some other things  
22 that I should look at.

23 MR. BROWN: Well, my name is David Brown.  
24 I'm a health physicist on the licensing staff.

25 I think maybe your question is best here,

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1 looking at the subjects for the day.

2 What the staff did was look at those  
3 events which really define what principle systems,  
4 structures and components needed to be in place. There  
5 were about 40 of those types of events. And that's  
6 the level at which the staff did from conformity  
7 analysis.

8 It does require that we depend on the  
9 applicant's proposal for how much material's going to  
10 be in a certain area and what the hazard is, whether  
11 it's a fire, a spill or an over pressurization.

12 CHAIRMAN POWERS: I agree. You have to  
13 believe at the applicant when you look at the material  
14 at risk. But now when you look at the release fraction  
15 and the transport of that material, you don't have to  
16 be dependent on the staff.

17 MR. BROWN: Yes, sir.

18 CHAIRMAN POWERS: And what I'm asking for  
19 is that done independently?

20 MR. BROWN: That was done independently in  
21 the sense that we looked at the staff's handbook where  
22 we have what you referred to earlier as the Machima  
23 type release fractions and replicable fractions. That  
24 was also the reference used by the applicant.

25 CHAIRMAN POWERS: Okay. Now, if I look at

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1 the Machima database, I find for events involving  
2 plutonium in a fire, for instance, experiments with  
3 plutonium on a filter paper that's put into a fire and  
4 various things done with it. And then when I look at  
5 it applied here, I find 830 kilograms of material at  
6 risk. A hell of a piece of filter paper we're talking  
7 about here.

8 How does the staff do the extrapolation  
9 and scale what's involved here?

10 Then I look at how the material is  
11 transported and I see transport fractions cited, and  
12 whatnot. And I say, gee, you know, usually when I  
13 think about aerosols moving, I see things like  
14 turbulent deposition, gravitational settling,  
15 thermophoresis, diffusiophoresis and I don't see that  
16 here. So how does the staff independently evaluate how  
17 much material goes from the site of release to -- to  
18 site of generation to the site of release from the  
19 plant?

20 MR. BROWN: For Construction Authorization  
21 Request, the staff did not extrapolation from the  
22 experimental values published in our handbook from the  
23 studies, you know, referring to, as you say, perhaps  
24 a filter paper.

25 We did try to get some reasonable

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1 assurance that at least those experimental values are  
2 bounding. For example, if I've got 800 kilograms in  
3 a glovebox inside cans that are sealed, it's not as  
4 susceptible to release as the material on the filter  
5 paper. Nonetheless, the value was used.

6 CHAIRMAN POWERS: Yes.

7 MR. BROWN: With respect to transport  
8 fractions, the applicant largely did not credit  
9 removal mechanisms between the source of release and  
10 the SAC, except for HEPA filters. So the staff also  
11 focused on that removal mechanism.

12 CHAIRMAN POWERS: So what you're saying is  
13 that what you've done is try to assure that you're  
14 bounded?

15 MR. BROWN: Yes, that's a good summary of  
16 what we've done.

17 CHAIRMAN POWERS: Okay. That that really  
18 is what you're talking about, an independent  
19 evaluation and there's some assurance that it's  
20 bounded?

21 MR. BROWN: Right. And especially where  
22 there --

23 CHAIRMAN POWERS: There's nothing to  
24 apologize for.

25 MR. BROWN: No, no. Especially in those

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1 cases where the dose was adequately mitigated below  
2 the performance requirements we did not continue the  
3 review.

4 CHAIRMAN POWERS: Okay. Now let me ask  
5 you this question. Having struggled through this and  
6 now coming back and telling you that we got five more  
7 facilities, different in nature that you're going to  
8 do, would you like to have a better database?

9 MR. BROWN: I'm sorry?

10 CHAIRMAN POWERS: Would you like to have  
11 a better database and easier computational tools for  
12 the analysis?

13 I mean, the Machima database is  
14 interesting, because there is -- it's a huge amount of  
15 experiments and a certain discretion in which one you  
16 take as your example.

17 MR. BROWN: I think, by in large, the  
18 staff does not need additional refined data because  
19 other than for this facility, which is a plutonium  
20 facility, we're largely dealing with low enriched  
21 uranium in the fuel cycle division. And the level of  
22 refinement that you're suggesting just --

23 CHAIRMAN POWERS: Yes, but my ground rule  
24 was that you got five more of these coming down.

25 MR. BROWN: Just like this?

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1 CHAIRMAN POWERS: At least as bad as this  
2 one.

3 MR. BROWN: Oh. Yes, I would like  
4 additional data.

5 CHAIRMAN POWERS: Okay. There is a  
6 challenge in using the Machima database, it seems to  
7 me when I try to use it. And what I select is my  
8 choice of the experimental data to use there.

9 Go ahead.

10 MR. PERSINKO: That concludes my  
11 presentation.

12 Next Chris Tripp will talk about the  
13 criticality safety, I believe.

14 The Subcommittee has asked for a  
15 presentation on criticality safety to the extent that  
16 there may be some unique aspects to discuss.

17 CHAIRMAN POWERS: This is our drive toward  
18 completeness. And it's useful for us to be reminded  
19 of what's done in the area of criticality safety. And  
20 in that regard we need to understand the double  
21 contingency principle and the ANSI standard in this  
22 area.

23 MR. TRIPP: I'm Christopher Tripp. I'm  
24 the criticality reviewer for the MOX fuel fabrication  
25 facility.

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1 I can certainly talk extemporaneously  
2 about the ANSI standards or double contingency. But  
3 that wasn't really planned as part of the  
4 presentation, but I'd be more than willing to answer  
5 any questions.

6 CHAIRMAN POWERS: Well, just remind us  
7 what those things are.

8 MR. TRIPP: Well, certainly.

9 Well, double contingency is very similar  
10 to single failure criteria. You basically have to have  
11 at least two unlikely independent process upsets occur  
12 before criticality is possible.

13 And there are a variety of ANSI standards  
14 that have been developed by Subcommittee 8 that relate  
15 to this. They have to do with programmatic issues  
16 such as that's where double contingency is discussed,  
17 also code validation and so forth. There are specific  
18 criticality limits, training requirements and so  
19 forth.

20 CHAIRMAN POWERS: We recently, two or  
21 three years ago, there was a criticality event in  
22 Japan that at least created a stir in Japan. If one  
23 complies with the double contingency, would you get  
24 into that kind of criticality event? Could you still  
25 get into that kind of criticality event?

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1 MR. TRIPP: Well, of course it's not a  
2 guarantee of safety. You could have two failures occur  
3 by coincidence by just -- you know, that occur at some  
4 frequency on the order of highly unlikely, it could  
5 happen. But I think it would be much less likely.

6 I think in Japan you had a number of  
7 factors that you wouldn't have in a facility that is--  
8 this is not in accordance with double contingency.  
9 There I think you essentially had a single failure  
10 where, you know, the system was set up such that a  
11 single operator making a mistake as to the amount of--  
12 the type of material to add to the system caused a  
13 criticality.

14 CHAIRMAN POWERS: It seems to me we had a  
15 -- that we've had some recent -- again, recent is a  
16 relative term. Recent events in U.S. facilities where  
17 operators have made errors in what materials they put  
18 and leave in the vessels. Is that a violation of  
19 double contingency or is that just something that gets  
20 allowed by double contingency?

21 MR. TRIPP: Well, that would be a  
22 violation of double contingency. That would be where  
23 one of the two controls was lost.

24 CHAIRMAN POWERS: Remind me, Mag. I think  
25 we had an event -- a near miss event at General

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1 Electric. Is that true?

2 MS. WESTON: Yes.

3 MR. TRIPP: Yes. I believe in that case  
4 that it was a case of the operation not being done in  
5 compliance with the approved safety basis. So I know  
6 the inspectors are starting to develop procedures and  
7 so forth to come about that part of the process.

8 CHAIRMAN POWERS: But your essential  
9 point, I mean the salient point that you're making  
10 here is double contingency is not the guarantee that  
11 you will not have a -- compliance with double  
12 contingency does not mean that you're assured of not  
13 having a criticality event?

14 MR. TRIPP: Right. Right. It should give  
15 us reasonable assurance if, you know, other things  
16 such as reliance on engineered controls, which I think  
17 that we've seen so far is tends to be the case here  
18 more than in some of the older facilities we license.

19 CHAIRMAN POWERS: Okay.

20 MR. ROSEN: In that sense, then it's  
21 exactly like the single failure criteria?

22 CHAIRMAN POWERS: Yes. Well, it's only--

23 MR. ROSEN: No guarantee that you're going  
24 to have one failure.

25 CHAIRMAN POWERS: Yes. But I think it's

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1 more than that. I think that the operator is capable  
2 of doing things that simply are not covered by the  
3 double contingency. You can do things, especially  
4 when you employ -- use administrative controls as part  
5 of the process.

6 MR. TROSKOSKI: Just by way of background  
7 -- my name is Bill Troskoski. I'm with the NMSS staff.

8 The Tokaimura event involved mixing up, I  
9 believe it was 16 percent enriched in a system that  
10 was designed to handle only about 5 percent enriched.  
11 Most of our low level facilities only handle 5. There  
12 are a few that are involved in the downblending  
13 operations, and the possibility of mixing up the low  
14 and the high level controls has been looked at.

15 MR. TRIPP: Okay. If there is no more  
16 questions for the time being on double contingency,  
17 one thing that we were told that the ACRS was  
18 particularly interested in was discussing any unique  
19 aspects of MOX and plutonium versus uranium  
20 facilities.

21 And there are several unique aspects of  
22 that that we're prepared to talk about here. One, of  
23 course, is that plutonium chemistry and physical  
24 properties are a lot more complex than uranium in a  
25 number of ways. For one thing there are more valence

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1 states of plutonium, which means that plutonium  
2 chemistry tends to be more complex. Although that's  
3 primarily a chemical safety concern, there are some  
4 criticality impacts. Because the form and type of  
5 material has an impact on the value of effective for  
6 the system. It can be quite sensitive to that.

7 And in addition, there's a concern about  
8 efficiency of solvent extraction where if you don't  
9 have the right valance state you can concentrated  
10 plutonium in your waste streams, which would be a  
11 criticality concern because that's eventually  
12 discharged unsafe geometry.

13 In addition, there are a variety of  
14 different phases and a variety of different oxide  
15 forms. Typically they tend to have a greater amount  
16 of porosity than UO2 type oxides. And that's important  
17 because it's credited in several parts of the process,  
18 being less than theoretical.

19 And another factor is the morph complex  
20 isotopic nature. It becomes a multidimensional issue  
21 because instead of controlling just one isotopic, that  
22 of us U-235, which you do in most of our facilities,  
23 there's a number of different isotopes that have to be  
24 controlled. Particularly the plutonium 240, 241 in  
25 the incoming feed material with most of the balance

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1 being plutonium 239. Also there's a slight amount of  
2 uranium in the incoming steam. And, of course, once  
3 the oxides are blended together than the relative  
4 amounts of plutonium and uranium are a key physical  
5 perimeter that you need to control.

6 So this generally leads to having material  
7 that's almost completely plutonium 239, and we have a  
8 schematic of that on the following slide. But it  
9 leads to having lower limits typically, smaller  
10 critical masses and so forth than either low-enriched,  
11 high-enriched or spent fuel that's used for  
12 reprocessing.

13 In terms of the process, the main unique  
14 step that's different than what you normally have in  
15 a traditional fuel cycle facility, traditional sort of  
16 experience that we've had in regulating facilities is  
17 this blending of oxide powders. We do have some  
18 licensed downloading operations, and they mostly  
19 consist of combing uranyl and plutonium nitrate  
20 solutions together. And in this case we have a powder  
21 blending process.

22 That's credited for criticality and it's  
23 important particularly when you have the powders to  
24 ensure the powders are dry and that they are  
25 adequately milled and homogenized and so forth so that

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1 you don't have unwanted variations in plutonium assay.  
2 So I think if it gets to the licensing stage, that's  
3 one of the key things that we would be interested in  
4 looking at and focusing on that step of the process.

5 In terms of the isotopics, I think some of  
6 you may be familiar with the reprocessing experience.  
7 What we've done here is we've contrasted the incoming  
8 feed isotopics on the left to what you would typically  
9 see for the feed material for a reprocessing plant. In  
10 this case it assumes that you have plutonium refeed in  
11 a closed fuel cycle which results in having higher  
12 proportion, higher mass plutonium isotopes. It's not  
13 necessarily indicative of French plants, but it's  
14 indicative of a typical situation.

15 And so the material being that much purer  
16 has a much higher reactivity. You may need to have  
17 lower, smaller dimensions, more bounding criticality  
18 limits and so forth.

19 And in terms of open issues, there's one  
20 main open issue in criticality, and that was  
21 identified early on as being one of the main issues  
22 that we knew would be an issue. We identified the  
23 validation, which is a part of setting the upper  
24 critical limit, the maximum  $k_{(eff)}$  as being the design  
25 basis value. And that's important because you have to

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1 know that in order to design a facility. You have to  
2 know what value of k-effective you're allowed to  
3 design up to. And so it's necessary to do it before  
4 the design is complete.

5 This really has two issues involved in  
6 that. One is the issue of benchmarking, how you  
7 benchmark the criticality codes and do you set the  
8 subcritical margins once that's done.

9 There are limited benchmark data available  
10 for a range of important perimeters, and these include  
11 the neutron energy, moderated or fuel ratio, plutonium  
12 240 content and so forth that have been identified as  
13 the main perimeters, so you have to determine the code  
14 biases, the function of.

15 There's also cases where the applicant has  
16 indicated they plan to take credit for a number of  
17 absorbers, including cadmium borated concrete and so  
18 forth. And the issue there is they're not allowed  
19 plutonium benchmarks that contain these materials.

20 In terms of setting the subcritical  
21 limits, all processes are required under 70.60.1.D to  
22 be subcritical under abnormal -- under normal and  
23 credible abnormal conditions.

24 The past licensing practice at other fuel  
25 facilities we've accepted a maximum  $k_{(eff)}$  exclusive of

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1 all bias and uncertainty is a .95 for the abnormal  
2 condition. And that's identified as a design basis  
3 value.

4 We originally considered setting a  
5 limiting value, design basis value for normal  
6 conditions which in some cases, as our two licensed  
7 high-enriched facilities is a lower value than the  
8 abnormal case. We considered setting that as a hard  
9 limit. But after a number of discussions with the  
10 applicant, it was thought that a more risk-informed  
11 approach would be to consider that a system specific  
12 basis.

13 Some systems are more sensitive to changes  
14 in  $k_{(eff)}$  with respect to perimeters of the system, such  
15 as if you have a plutonium solution system it tends to  
16 be -- small changes can have large changes in  $k_{(eff)}$ .  
17 So you may expect to have a large amount of margin in  
18 those cases.

19 There's other systems such as MOX powder  
20 system where you may have large amounts of powder and  
21 a small change in the mass is not going to effect the  
22  $k_{(eff)}$  that much. And it may argue that you don't need  
23 to have as much as margin for those cases.

24 So because that's largely system  
25 dependent, we had decided to look at that more as a

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1 limiting condition of operation type of limit to make  
2 an analogy with the reactor world and say "Okay, we're  
3 not going to call that design basis value, but we are  
4 going to say the methodology for determining that is  
5 part of the design basis." And so that remains an  
6 open issue exactly how you do that.

7 Because of the fact we had limited number  
8 of benchmarks, there are special tools required  
9 including one thing that has been used in the  
10 applicant's validation report and something that we're  
11 looking into acquiring is Oak Ridge's  
12 sensitivity/uncertainty methodology. And that's  
13 typically the way a validation has been done in the  
14 past is you tried to find experiments that are close  
15 to the systems you're trying to model in terms of they  
16 look similar, given physical terms or if they have  
17 similar neutronics. You know similar energy, neutron  
18 energy, spectrum and so forth. But that may not  
19 always be possible if you don't have a lot of  
20 benchmark data. So these more analytical techniques  
21 that have been developed in recent years to try to  
22 determine whether benchmarks that may not look like  
23 the cases that you're trying to model are in fact  
24 applicable or not.

25 DR. FORD: How rate-limiting, the fact

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1 that you say those few benchboard for validation, how  
2 limiting is that? How rate limiting to the movement  
3 forward of this licensing process? Is it years,  
4 months before you can resolve that issue?

5 MR. TRIPP: Well, we have made a lot of  
6 progress toward resolving that. The first validation  
7 that came out had a lot less benchmark data applied to  
8 it. There is more out there that has been added.

9 DR. FORD: And, again, I keep coming back  
10 to the French when we MELOX facility. Are there any  
11 informations that you can get from that facility to  
12 resolve this apparent lack of data?

13 MR. TRIPP: Well, that --

14 DR. FORD: Have either you or DCS  
15 approached them?

16 MR. TRIPP: We have not really talked to  
17 them in detail. I think you have the problem where  
18 if you go back to this graph, there's large  
19 differences between the French plants and the U.S.  
20 plant in terms of the isotopics. So the French  
21 benchmarks and validation may not be applicable.

22 DR. FORD: They are not applicable at all?

23 MR. TRIPP: Well, they're certainly not  
24 bounding because the material the French use, it would  
25 be less reactive neutronically than what we're dealing

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1 with here. It's much more purer isotopically.  
2 However, there may be other ways to deal with that in  
3 terms of conservative calculations that may be well  
4 benchmarked but may be more conservative.

5 DR. LEVENSON: Do you have access to the  
6 classified information on this?

7 MR. TRIPP: No. We haven't obtained any of  
8 that. Certainly there hasn't been any classified  
9 information in the validation that's been presented to  
10 us.

11 DR. LEVENSON: The licensee may not have  
12 access to the classified information, but I wondered  
13 if staff had access for its validating.

14 MR. TRIPP: Yes. We haven't looked to see  
15 if there's any that's applicable, and that's a  
16 suggestion that we can probably take.

17 CHAIRMAN POWERS: You're considering the  
18 investment that's been made over the last 30 years in  
19 criticality safety within the DOE framework, I would  
20 assume that there is adequate.

21 DR. LEVENSON: That's my question.

22 MR. TRIPP: We can certainly look into  
23 that.

24 In doing the validation the applicant has  
25 basically divided the plan into five different areas

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1 of applicability and found a separation determination  
2 of bias on each one. Here we can talk a little more  
3 specifically about the number of benchmarks that are  
4 available for the plutonium nitrate solutions and for  
5 finished MOX fuel there are relatively a large number  
6 of benchmarks in data out there. I think there's over  
7 a hundred experiments, I believe, of these two  
8 systems.

9 Some systems, particularly the MOX powder  
10 systems and plutonium compounds dry up to wet  
11 solutions using things like oxalates and plutonium  
12 fluorides and so forth. They're not so well  
13 benchmarked. And in those cases if there's not  
14 available benchmark data for those, there maybe need  
15 to be other things like additional margin or things  
16 applied that the -- we're not quite to that stage yet.

17 What we have done is we have reviewed a  
18 validation report that we received in January of 2003.  
19 We'd received parts of that before, but we received a  
20 more complete revision to that in January.

21 We had a meeting in -- this should say  
22 March. I apologize for the first -- different  
23 meeting. There was a meeting in March to discuss what  
24 we considered to be the big picture items in the  
25 validation. When we identified some basic concerns

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1 with the analysis they'd done, we decided to  
2 communicate early and try to come to resolution. And  
3 those are basically a comparison of the stated area of  
4 applicability to the range of perimeters covered by  
5 the benchmark data and how to deal with the lack of  
6 benchmarks in some cases. And basically what the  
7 applicant is doing now is going back and reevaluating  
8 whether they need the full range in each case or  
9 whether maybe the area of applicability may have been  
10 too broadly defined, which it looks like it may be the  
11 case in some cases. So we're waiting on the results  
12 of that.

13 In addition, we're trying to acquire the  
14 new SCALE code which will have this sensitivity and  
15 uncertainty methodology built into it to help resolve  
16 our open issues.

17 Another issue that came out of the  
18 validation recently was an issue over dual versus  
19 single perimeter control and meeting double  
20 contingency where the CAR has committed to the  
21 preference for dual perimeter control such as  
22 controlling both mass and moderation where you'd have  
23 to get a change in both perimeters in order to reach  
24 criticality. That's clearly preferable because when  
25 you realign a single perimeter, you have a lot more

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1 potential for common mode type of failures to occur.  
2 You don't know if you identified all the possible ways  
3 and that perimeter could change.

4 But in talking about the subcritical  
5 margin, there was some question about the degree to  
6 which that was being applied. So that remains an open  
7 issue that really deals with control implementation;  
8 how do you implement double contingency in the plant.  
9 But we've identified it as something that will need to  
10 be looked at, and clearly will be looked at more  
11 closely in the following stage.

12 So just to conclude, our major issue is  
13 the setting of the design basis  $k_{(eff)}$  limits which  
14 includes all of the aforementioned items. And we knew  
15 that this would be an issue early on in the review.  
16 Up until now we basically licensed two types of  
17 facilities, a low-enriched and high-enriched fuel  
18 facilities, uranium which have a lot of benchmark data  
19 available that has been historically used successfully  
20 by the applicants over a number of years. Wherever  
21 we're going outside that traditional framework in  
22 terms of composition, form and material this could be  
23 an issue. It was an issue somewhat in the ABALAS  
24 review. It could be an issue in going to greater than  
25 5 percent type fuel, and so forth.

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1           So we're in the process of reviewing the  
2 validation and trying to get the codes answered, the  
3 questions about benchmark applicability and we're  
4 essentially waiting on DCS' response to some of our  
5 questions back in March. And that's really the status.  
6 Currently we are, as with the other open items, on  
7 track for closure by September of 2003.

8           DR. FORD: I'm sorry. This is not my area,  
9 so forgive me if it sounds a simple question.

10           The SCALE-5 code, that's a neutronics  
11 code, an NRC neutronics code?

12           MR. TRIPP: Yes. It was developed by Oak  
13 Ridge under a contract and it's used by a number of  
14 applicants.

15           DR. FORD: Okay. Now, in this particular  
16 applicant also using the SCALE-5 code?

17           MR. TRIPP: Yes. Yes. When they do the  
18 validation, they would validate a specific code, a  
19 specific version of that code for use.

20           DR. FORD: And you're seeing that the main  
21 problem here is that there's few benchmark data to  
22 validate that code for these various areas of  
23 application?

24           MR. TRIPP: Right, for certain areas. Some  
25 areas are well benchmarked, other places there are

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1 holes in the data and so forth.

2 DR. FORD: Well, how big are these holes?

3 CHAIRMAN POWERS: The MOX powder, it's  
4 going to be pretty big.

5 DR. FORD: So does that not therefore put  
6 a large onus on us to try and get relevant data from  
7 the French?

8 CHAIRMAN POWERS: The trouble is, Peter,  
9 that they don't have the relevant data.

10 DR. FORD: Well, any data of any sort that  
11 might be -- it may not be precisely the right data.

12 CHAIRMAN POWERS: Your definition of  
13 precision is different here. To you the isotopics is  
14 no never mind, it's everything here.

15 DR. FORD: Okay. I'm trying to put us in  
16 a position of being in, say, 5 years time suddenly  
17 thinking oh heck, this is wrong. Is there anyway the  
18 code is wrong or the predictions from the code is  
19 wrong for the particular conditions that we have at  
20 this plant?

21 Am I fishing unnecessarily here?

22 What I'm hearing from this message is that  
23 you have other code which both the regulators and the  
24 applicant use. And there's some questions about the  
25 validation of that code for the various applications,

1 the five areas of application. Now, how comfortable  
2 or uncomfortable should we feel about that lack of  
3 benchmark data?

4 MR. KLASKY: I'm Mark Klasky from DCS.

5 I'd like to clarify a couple of things.

6 I think as Chris has pointed out in a  
7 couple of cases there are not specific experiments  
8 that precisely match the conditions that could exist.

9 DR. FORD: Right.

10 MR. KLASKY: And those conditions could be  
11 accident conditions, for example.

12 DR. FORD: Right.

13 MR. KLASKY: And the issue, and I think  
14 what has really come to the forefront in the last  
15 let's say 5 years or so, that one recognizes that the  
16 neutronic properties of systems that may not precisely  
17 have the same characteristics, but yet when one looks  
18 at neutron energy spectrum, more closely resemble than  
19 otherwise at first glance. And so in this regard  
20 certain spectral methods have been developed,  
21 certainty techniques applied to try broaden the area  
22 of applicability. But I think the important point to  
23 note is that what we're talking about is basically  
24 just enhancing or perhaps expanding upon the -- how do  
25 I want to characterize this -- the area of

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1 applicability or the margin, if you will.

2 I think what has been applied in some fuel  
3 facilities is a margin of .05. And so, obviously,  
4 when one has fewer experiments, one enhances the  
5 margin. I think that's what we're really talking about  
6 here. Putting some more quantitative assessment into  
7 further our justification of the margin that we've  
8 chosen for the facility.

9 CHAIRMAN POWERS: Peter has written to the  
10 Commission. And among the things that he recommended  
11 to the Commission was to continue those activities to  
12 expand the spectral character capabilities of the  
13 code. So he -- he was an enthusiastic supporter of  
14 that effort.

15 DR. LEVENSON: When you say it is missing  
16 data and you listed things like plutonium in solution  
17 or evaporation, etcetera, these are all steps that  
18 have been done thousands of times in our reprocessing  
19 plants because the DOE reprocessing plants, unlike the  
20 French reprocessing plants, do have this isotopic  
21 mixture. And it seemed to me that at most there is  
22 one new one, and that's the MOX mixture itself. But  
23 for almost everything else you do, there's a huge,  
24 huge database out there.

25 You know, the NRC licensed MOX fuel for

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1 both BWRs and PWRs in the mid-70s, and some assemblies  
2 in both types of reactors back then. That was largely  
3 on the basis of the government database. I guess we've  
4 lost it?

5 MR. TRIPP: Well, I would assume it's  
6 still out there, but you know how well you validate  
7 the code, like Mark Klasky said, has all to do with  
8 the amount of margin you use. I don't know how much  
9 margin was in those facilities or how they were  
10 designed --

11 DR. LEVENSON: No, no. It's the  
12 experimental data that led to their designs that I'm  
13 talking about. Not their design. You wouldn't work  
14 from their design. But there's a huge amount of data.

15 MR. TRIPP: Yes.

16 DR. LEVENSON: As our Chairman mentioned,  
17 you know a lot of people have often questioned how  
18 much money, was it all really necessary that went into  
19 the DOE criticality program. But it was huge.

20 MR. TRIPP: Yes, and there probably is  
21 data out there we haven't seen. All I can say is that  
22 it hasn't been presented to us.

23 CHAIRMAN POWERS: I'm really totally  
24 unfamiliar with the availability of those data to  
25 uncleared personnel, thought I don't imagine it's

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1 enormously protected. And it definitely covers  
2 evaporation to dryness including fluorides and things  
3 like that, because they arise naturally in our  
4 processing steps.

5 The database is geriatric relative to a  
6 lot of things, but more criticality data is fairly  
7 old. But we don't have anybody on the Committee that  
8 we can ask to go check on that very easily.

9 MR. TRIPP: Yes. Well, we haven't really  
10 taken an active role in trying to pursue that.

11 CHAIRMAN POWERS: And I can chat with the  
12 folks up at Los Alamos.

13 MR. PERSINKO: Early on in the project DOE  
14 has informed us that not having access to classified  
15 material would not be an issue. So, you know, if there  
16 is data out there that you can classify data that  
17 would be pertinent to this, I would expect the  
18 Department of Energy, who is also playing a role in  
19 this even through they're not the real applicant, to  
20 identify that data so that we could go look at it.

21 CHAIRMAN POWERS: Yes. It might be useful  
22 just to sniff around a little bit, chat with people at  
23 Los Alamos especially at TA5 and see what they think  
24 they have available. It might give an ear to give you  
25 some specificity when you talk to DOE about that.

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1 Because, I mean quite frankly what happened was we had  
2 a few criticality accidents in the complex and the  
3 decision was that ain't going to happen again.

4 Now, the database collection activities  
5 were aggressive, but we rely on the double contingency  
6 a lot, and probably more than we should.

7 Chris, go ahead.

8 MR. TRIPP: I had finished my  
9 presentation.

10 CHAIRMAN POWERS: You're done? Okay.  
11 Thank you.

12 What you're telling us, I think, is we're  
13 going to tune into this more especially in the  
14 operational -- when we go to the possession and  
15 operational licensing.

16 MR. SIEBER: Maybe I could ask a question  
17 before we leave the subject.

18 It seems to me that when you describe what  
19 the feed stock is, that there is a presumption of a  
20 certain level of various isotopes whether it's weapons  
21 grade, reactor grade and so forth. And if you go to  
22 critical or not, accidentally or otherwise, depends on  
23 precise knowledge of what the isotopic composition is.  
24 So I presume for every batch there is a set of samples  
25 that are taken and analyzed --

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1 MR. TRIPP: Yes.

2 MR. SIEBER: -- so that you know what the  
3 reactivity is for each batch, is that correct or not?

4 MR. TRIPP: Well, the approach they've  
5 taken is to define a set of bounding isotopics for the  
6 process. That the feed is supposed to stay within  
7 some specification. And they've assumed it to be 96  
8 percent plutonium 239 and 4 percent plutonium 240.

9 MR. SIEBER: Which is pretty reactive.

10 MR. TRIPP: Which is pretty reactive.

11 MR. SIEBER: Yes.

12 MR. TRIPP: And I would assume that would  
13 be sampled up front to insure that it is maintained  
14 within those boundaries.

15 MR. SIEBER: And probably more likely 80  
16 percent of 239 with the rest 240 and 241? So that's  
17 where you get the conservatism from?

18 MR. TRIPP: Well, they've told us it would  
19 be between 90 and 95 percent.

20 CHAIRMAN POWERS: Yes, it's going to be a  
21 lot more.

22 MR. KLASKY: Mark Klasky.

23 Just to answer your question, the material  
24 I think Ken mentioned at the beginning and all through  
25 expanded upon that. We have two source feeds.

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1 Certainly the material that's coming are being source  
2 feed is very well characterized and will be the 96  
3 percent. The alternate feed stock, perhaps, you know  
4 it's in essence waste that's being collected from a  
5 number of different facilities and will undoubtedly  
6 have some variability.

7 MR. SIEBER: So you're going to have to  
8 characterize the alternate feed stream?

9 MR. KLASKY: Well, that material, again,  
10 it would be conservative to assume the 96 percent.

11 MR. SIEBER: Okay.

12 MR. KLASKY: For criticality.

13 MR. SIEBER: Okay. Thank you very much.

14 MR. SIEBER: Well, thanks, Chris.

15 At this point we have adjusted the  
16 schedule. We're going to discuss a little bit about my  
17 buddy red oil here. We have two presentations on  
18 this, one from DCS and one from the NMSS staff. I  
19 intend to break for lunch between those two.

20 And, Mark Klasky, I caution you and  
21 because of various rules, that should somebody from  
22 the public show up and ask me about hearing red oil  
23 after lunch, you may get to repeat your presentation.  
24 I don't anticipate that, but I caution you that that's  
25 a possibility in making this change.

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1           At this point I'll introduce Mark Klasky.  
2 He's going to talk about one of life's little  
3 mysteries, red oil.

4           This is not, by the way, oil that comes  
5 from the former Soviet Union.

6           Mark, if you're going to wonder around  
7 loose up there, we're going to have to wire you up.  
8 And the gentleman right behind you will do that  
9 wiring.

10           MR. KLASKY: Mark Klasky. I lead the AP  
11 Safety Review for DCS.

12           I guess we're here this morning to discuss  
13 two different aspects. First, I want to present our  
14 approach to preventing TBP degradation or red oil  
15 phenomena, and we'll discuss the details of that.

16           In addition, I also want to basically  
17 address some of the issues that arose last time, I  
18 think it was last year at the ACRS meeting.

19           Next slide.

20           And it's the content of the presentation.

21           I'm going to discuss our approach to  
22 understanding tributyl phosphate, it's degradation and  
23 red oil. And there's certainly a lot of  
24 misunderstanding of the different approaches that have  
25 been attempted in the past. And I want to basically

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1 start from the perspective that what we've done here  
2 is to really go more into the details here, the  
3 fundamentals, dissect the problem into small parts and  
4 move forward, while at the same time recognizing that  
5 there's 50 years of experience, much of it largely  
6 engineering, but at the same time that experience is  
7 very important in formulating a comprehensive robust  
8 safety approach to preventing red oil events.

9 I finally want to mention that we do plan  
10 to do confirmatory testing during the integrated  
11 safety analysis to validate our approach.

12 I want to also mention that we're working  
13 in conjunction with the national laboratories and also  
14 MIT, and MIT will be involved in the confirmatory  
15 testing.

16 I want to point out the general portions  
17 of the process where we either won't have or don't  
18 have organics present.

19 DR. FORD: You're moving it too fast.  
20 There it is.

21 MR. KLASKY: In the initial part of our  
22 process we dissolve plutonium oxide into solution, and  
23 that is a nitrate solution. And that nitrate solution  
24 is then fed into a purification process where we  
25 separate plutonium from the feed stream and we send it

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1 onto the process. We precipitate it to a oxalic acid  
2 addition and finally we produce powder. And so the  
3 solvent is obviously present in the purification unit.  
4 It under normal conditions should not be present in  
5 the precipitation unit, and likewise in the solvent  
6 recovery unit we obviously expect solvent to be  
7 present in the acid recovery and oxalic mother liquor  
8 recovery, nominal organic content is very low.

9 CHAIRMAN POWERS: When you use the word  
10 solvent, you're not just talking about norprophenic  
11 hydrocarbon, you're talking about prophenic  
12 hydrocarbon with the tributyl phosphate as well.

13 MR. KLASKY: That's correct. In this  
14 process one has to use a diluent to provide the  
15 requisite density separation or phase separation, and  
16 also change the viscosities of the medium as well.  
17 So, indeed, when I speak of TBP, recognize that it's  
18 only 30 percent of the solvent itself.

19 Having gone through the nominal locations  
20 of the solvent, I think one important point to  
21 recognize is this is where the solvent is supposed to  
22 be, but you know we do have potential to move it into  
23 other process equipment. And so we have to design our  
24 facility with that in mind. And that certainly is a  
25 lessons learned through the 40 or 50 years of

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1 experience with tributyl phosphate in the diluent.

2 Okay. So now I want to talk about red  
3 oil, per se. I really want to get into its molecular  
4 form, if you will, in the next couple of slide. But  
5 first before doing so, we'll just briefly introduce  
6 it.

7 Back in Hanford about 1950, 1953 the term  
8 was first coined. And a very vague qualitative  
9 definition was attached, and it basically has  
10 accompanied red oil for 50 years. And I think that  
11 the major characteristics that have been used to  
12 describe it are, in essence, a phase inversion that is  
13 a density of 1.1 to 1.5, which in essence causes a  
14 phase inversion. The nitric acid density is,  
15 obviously, between 1.1 and 1.4 or so depending upon  
16 the normality.

17 I want to talk about the energetics of red  
18 oil. It's also used in trying to -- in a qualitative  
19 sense, describe it.

20 Experiments were conducted by Stieglitz  
21 out of Germany to characterize the energy of a TBP  
22 uranial nitrite adduct. And what they found was that  
23 basically at about 225 degrees the uranyl nitrate  
24 adduct underwent thermal decomposition. And through  
25 DTA measurements they obtained about 390 joules per

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1 gram. So, you know, it's energetic but it's not TNT.  
2 I think the important point is to really understand  
3 that it's energy content is significant, but it is not  
4 truly an explosive.

5 Red oil has been synthesized it about 5  
6 different or four different location, and it has been  
7 synthesized to a number of different methods,  
8 including reflux, reflux distil and followed by  
9 distillation. And it also produced in a closed  
10 vessel. And what nominally the means by which one  
11 produces this, for example, in reflux is to take a  
12 solution of tributyl phosphate and add nitric acid  
13 nominally in about a one to three ratio. And basically  
14 just reflux for about 48 hours, 76 hours at boiling,  
15 110 degrees or so, and depending upon what the diluent  
16 is, indeed one can produce red oil. And I think there  
17 was a number of points that I want to make.

18 Red oil is not synonymous with run away  
19 reaction. Red oil is a material that we're going to  
20 talk about in the next slide or next point.

21 Let's see, what else did I want to say?

22 MR. ROSEN: Well let me ask you a quick  
23 question.

24 MR. KLASKY: Okay.

25 MR. ROSEN: When you say 110 degrees or

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1 so, you're talking centigrade?

2 MR. KLASKY: Centigrade, yes. I'm just  
3 giving you a representative means in producing it. In  
4 closed vessel synthesis the temperatures rise. In  
5 fact, in a close vessel production of red oil has  
6 raised to pressurization of the vessel itself as well.

7 In the majority of cases where the phase  
8 inversion and energetics have really differed from  
9 that of the tributyl phosphate uranyl nitrite adduct,  
10 the diluent contained large cyclic hydrocarbons or  
11 large quantities of the diluent was a cyclic chain  
12 hydrocarbon. And that seems to be the most profound  
13 finding of the investigations where basically they  
14 tested a number of different diluents; straight chain,  
15 branched chain, and the cyclic chain diluents and  
16 really found that in the case of the cyclic chain  
17 diluent it was much more readily -- or I should say  
18 red oil is much more readily formed.

19 So in attempting to understand the  
20 molecular structure, a number of different  
21 experimental techniques have been utilized, including  
22 NMR, infrared spec, gas chromatography and elemental  
23 analysis.

24 The major results of these experimental  
25 tests have been to characterize the residence

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1 structure of the addict. And I think the most  
2 important aspect is that they've peak down to the P-31  
3 residence, a peak at about 2.4 parts per million, and  
4 that is the uranyl nitrate addict. They also found  
5 residence peaks at, I think, .5, 2.4, 4.5 and 5.4.

6 And these are peaks that really accompany  
7 -- they could be 3 -- that really hasn't been  
8 investigated all that much. That's one area that I  
9 think during our confirmatory testing that we can add  
10 some insight into precisely what is seen. These  
11 results that I'm referring to were done at Los Alamos  
12 by Pamela Gordon.

13 CHAIRMAN POWERS: Those shifts were all on  
14 addicts.

15 MR. KLASKY: Excuse me?

16 CHAIRMAN POWERS: Those shifts were all on  
17 the addicts?

18 MR. KLASKY: Yes.

19 CHAIRMAN POWERS: And do we have to have  
20 the addict to have red oil? I think not.

21 MR. KLASKY: Okay. I'll talk about that.

22 I think certainly to get the phase  
23 inversion you need the metal addict or the metal ion,  
24 I should say. You also see, if you look at the carbon  
25 and also proton, you'll see a large -- and even the

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1 phosphate -- you'll see a large percentage of the  
2 carboxylic acids, you'll see also butyl nitrate, some  
3 other degradation products. And so really I think  
4 what's seen is really a collection of different  
5 species. I mean, that's -- so red oil per se is not  
6 one species, rather it's a collection or a mixture of  
7 carboxylic acids, degradation products along with the  
8 addict.

9 So, when we speak of red oil, it's this  
10 mixture of degradation products that we're really  
11 speaking to.

12 Next slide.

13 CHAIRMAN POWERS: Well, I mean if you just  
14 think about it, anytime that you put a strong reducing  
15 agent in with an aromatic hydrocarbon, you're going to  
16 get a red product if you do it -- I mean, you get a  
17 carbene that polymerizes on you and gives you a  
18 dissociated electron that gives you the red color.  
19 Okay. And that strong reducing agent is going to give  
20 you garbage. I mean, it's going to be a mix of stuff.

21 MR. KLASKY: I think that's certainly the  
22 case when we start forming all the NOX products, we're  
23 certainly going to have oxidation products with  
24 hydrolysis occurring. I mean, we'll speak to more of  
25 that as we go through some of the degradation products

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1 that are possible in just the dyhrolysis of TBP. I  
2 think that's where we're headed next. It's on our next  
3 slide.

4 CHAIRMAN POWERS: Yes. It seems to me that  
5 you've set yourself up to get aromatic groups in this  
6 mixture when we went with tertiary butyl as the addict  
7 of the phosphate.

8 MR. KLASKY: You want to hydrolyze the  
9 TBP. I mean that's certainly the case.

10 CHAIRMAN POWERS: Yes. And it's set up to  
11 give you -- well, what you've indicated up here,  
12 butene.

13 MR. KLASKY: That's true. I think in the  
14 next slide, what I want to try to do now is to  
15 differentiate between red oil with the metal addict  
16 and tributyl phosphate.

17 DR. LEVENSON: Let me ask a question.

18 MR. KLASKY: Yes.

19 DR. LEVENSON: When you measured the  
20 energy or decomposition, do you get any from those  
21 measurements, any indication whether -- what the time  
22 constant was? Was it an instantaneous thing or over  
23 a finite period of time?

24 MR. KLASKY: Okay. I want to go into the  
25 rate laws in the next couple of slides.

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1 Mark, do you want to pull up the DTA for  
2 thorium nitrate.

3 This is a DTA and also a TGA of thorium  
4 nitrate. The DTA is up top and the TGA is just a mass  
5 loss here.

6 What you see here is, I mentioned 225 is  
7 where just in a pure TBP uranyl nitrate adduct you had  
8 thermal decomposition. And this is an experiment  
9 that's conducted with TBP and the uranyl nitrate, and  
10 nitric acid also present. And what you see is a very  
11 broad exotherm here. And what you have here in  
12 essence will show, and it's a following slide, really  
13 a phenomenon that's given by something else, and that  
14 we'll show in the next slide, in addition to the  
15 thermal decomposition of the adduct.

16 Also I mentioned at about 275 or 200 you  
17 get finally an endothermic reaction, the formation of  
18 butene is then present. It's an endothermic reaction.

19 The TBP. Perhaps this is a little  
20 clearer. You have heating followed by, in essence in  
21 the 120 degree range evaporation taking place. And  
22 then finally you have the exothermic reaction taking  
23 place. And if you go back to the other slide, you'll  
24 this is precisely where that broad exotherm appeared.

25 And so I think what you can conclude from

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1 this is that it's the attack of the nitric acid on the  
2 tributyl phosphate that's giving the predominant  
3 source of energy prior to the 225 thermal  
4 decomposition of the metal adduct. And so what you  
5 take away from this is that if we understand the  
6 decomposition of TBP, we can in essence understand how  
7 one prevents a runaway reaction. And so we can in  
8 essence remove ourselves from the metal.

9 So from this point forward we're really  
10 going to examine TBP and its degradation recognizing,  
11 of course, that the metal ion species does have  
12 potential to catalyze hydrolysis and it's something  
13 that we plan on examining during the ISA.

14 CHAIRMAN POWERS: Yes. If you come back to  
15 your previous slide, you indicate some use of thorium  
16 as a surrogate for plutonium.

17 MR. KLASKY: Yes.

18 CHAIRMAN POWERS: And, gee, it's a  
19 remarkable choice because thorium does not have the  
20 valence variability that plutonium does, whereas  
21 cerium does have that capability. Why did you pick  
22 thorium rather than cerium?

23 MR. KLASKY: I think in these experiments  
24 thorium is simply used due to the fact that it valence  
25 4 representing plutonium 4. You don't have the redox

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1 reaction that couple, and I think when the experiments  
2 are done -- you know, a testing regime they certainly  
3 don't want to use plutonium.

4 CHAIRMAN POWERS: No.

5 MR. KLASKY: So, you know, to first  
6 understand things, just to separate the metal addict  
7 from the TBP, for that purpose, it was sufficient to  
8 use plutonium -- or I'm sorry, thorium.

9 CHAIRMAN POWERS: Thorium.

10 MR. KLASKY: I think we'll get into, and  
11 I think Bill is going to talk about some of the  
12 experiments that I think -- some of the experiments  
13 that we're going to do. Is that correct?

14 So our plan, of course, is to investigate  
15 plutonium and to understand the difference between  
16 thorium and plutonium. Because I think what we're  
17 really interested in here is can it catalyze the  
18 oxidation and hydrolysis reactions. And we're  
19 certainly not learning that from using thorium.

20 CHAIRMAN POWERS: Yes. You'll never get it  
21 with thorium. Because there's no mechanism to it. If  
22 you're looking for a surrogate that does not have the  
23 experimental difficulties of plutonium, cerium has  
24 proved very good for this.

25 MR. KLASKY: Okay.

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1 CHAIRMAN POWERS: Because it does have the  
2 three four change at about the right kinds of energies  
3 and things like that.

4 DR. KRESS: Okay.

5 CHAIRMAN POWERS: No substitute for the  
6 real thing, though.

7 Go ahead, please.

8 MR. KLASKY: Okay. So recognizing that  
9 many of the salient points to be learned as to be  
10 obtained just by understanding the decomposition of  
11 tributyl phosphate, we've outlined the decomposition  
12 scheme here. And in essence what you have is phosphate  
13 underlying hydrolysis to produce the butyl alcohol and  
14 dibutyl phosphate. Dibutyl phosphate and monobutyl  
15 phosphoric acid also undergo hydrolysis, but at  
16 somewhat slower rates. So for the purposes of this  
17 discussion, we'll restrict ourselves to TBP.

18 CHAIRMAN POWERS: You're going to forgive  
19 me.

20 MR. KLASKY: Sure.

21 CHAIRMAN POWERS: My interactions with red  
22 oil have been sporadic. But I got the impression that  
23 the presence of the dibutyl phosphate was considered  
24 by some to be an essential step.

25 MR. KLASKY: I think the dibutyl phosphate

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1 by itself -- I mean, dibutyl phosphate can precipitate  
2 materials. It's less soluble. But I don't really view  
3 that as an essential step. It's only essential to the  
4 extent that it's accompanied by the butyl alcohol.

5 So having said that, I guess I view the  
6 degradation products that really matter as the butyl  
7 alcohol and butyl nitrate. And I guess that's the next  
8 step that butyl alcohol either can be oxidized or it  
9 can be nitrated. So, obviously if it's oxidized, it's  
10 producing the end products and/or the carbic cyclic  
11 acids and likewise, it's nitrated it's producing the  
12 butyl nitrate.

13 In addition, TBP can undergo paralysis at  
14 elevated temperatures, 225 or thereabouts.

15 And finally, TBP can also undergo  
16 deacclimation to produce butyl nitrate as well.

17 CHAIRMAN POWERS: Of course, what you've  
18 written down here are thermal type decompositions. Do  
19 we have to worry about the radiolytic processes? Do we  
20 have enough activity here to --

21 MR. KLASKY: Yes, we're going to talk  
22 about that in fact. That's the next slide.

23 DR. FORD: You mentioned in one of the  
24 very first presentations, you mentioned this  
25 particular process is modeled after that use at La

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1 Hague. Is that correct?

2 MR. KLASKY: That's correct.

3 DR. FORD: I'm sorry to keep coming back  
4 to this, but it seems as though you're in a time  
5 crunch here; that you're talking about doing some  
6 experiments, etcetera, to come up with the inetics and  
7 therefore onto the process control. Are there any  
8 lessons at all to be learned from the processing  
9 experience at La Hague?

10 MR. KLASKY: I think not only the  
11 experience at La Hague, but at DOE there are certainly  
12 a lot of lessons learned to be obtained. And I think  
13 we've incorporated those lessons learned into the  
14 formulation of our safety approach.

15 The experiments to be done, I think I  
16 mentioned earlier, are to be done during the  
17 integrated safety analysis. They're largely  
18 conformity analyses. They're analyses that I really  
19 don't view as largely effecting the design, rather  
20 they're to substantiate our design basis and select  
21 precise limits. You'll see in a minute the limit that  
22 I'm referring to.

23 DR. FORD: But it would have an impact on  
24 the quality control you'd be using for your process,  
25 whether it be a 6-sigma or 4-sigma, or whatever the

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1 process control matrix that you might use, the outcome  
2 from these experiments, the definers -- is that right?

3 MR. KLASKY: What's that?

4 DR. FORD: The outcome from these  
5 experiments, the kinetics, the process path, etcetera  
6 would define therefore the degree of quality control  
7 that you would have to apply at this plant?

8 MR. KLASKY: I think you're correct in the  
9 sense that one of the controls that one might obtain  
10 from this experimentation is a limit on the resonance  
11 time. That is to say, don't leave tributyl phosphate  
12 in conjunction with a nitric acid or a plutonium  
13 source for more than 3 months or 6 months or a year.  
14 And so certainly, you know, that data will be  
15 incorporated and controls will be implemented to  
16 ensure we don't exceed those limits.

17 DR. FORD: So you are talking about  
18 months, years before something can occur?

19 MR. KLASKY: I think that's the -- the  
20 evidence that we have now is that this is a phenomena  
21 that occurs, that is the build up --

22 DR. FORD: Okay.

23 MR. KLASKY: -- of sufficient degradation  
24 product. And we'll speak to the quantity of degraded  
25 organic, that's something that -- a point that I want

1 to emphasize in the synthesis of red oil. They were  
2 able to obtain red oil, but the quantity of it is very  
3 limited. This isn't something where you start with a  
4 100 milliliters of tributyl phosphate and, you know,  
5 300 milliliters of nitric acid and wind up with 100  
6 milliliters of red oil. It's very limited. There's a  
7 small fraction that is truly what one would call if  
8 red oil, if red oil hasn't a specific meaning.

9 MR. ROSEN: Take your example and give me  
10 the rest of that sentence. So how much red oil would  
11 you end up with if you left it for months? Would you  
12 end up with a milliliter, 10 milliliters, 50  
13 milliliters?

14 MR. KLASKY: It's a function of time. And  
15 I think in the next slide we're going to present the  
16 rate equation. And I think what we can tell you right  
17 now is that the rate limiting step here is hydrolysis.  
18 And you see that the rate -- this is a kinetic rate of  
19 hydrolysis of TBP is per hour. Okay. So under  
20 nominal processing machines we're operating a majority  
21 of our plant where we expect to have organics at under  
22 60 degrees. So we're talking a degradation rate of  
23 ten to the minus five or thereabouts, or less.

24 So that's the rate limiting step of our  
25 production of degradation products, it's hydrolysis.

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1 CHAIRMAN POWERS: Do I understand your  
2 slide is saying you have a thermal and a radiolytic  
3 rate?

4 MR. KLASKY: Yes.

5 CHAIRMAN POWERS: So you become non-  
6 uraniumous down in your normal operating conditions?

7 MR. KLASKY: Correct.

8 CHAIRMAN POWERS: And that's radiolytic  
9 rate is a 4 year process?

10 MR. KLASKY: Yes. Let me talk about the  
11 radiolytic component of this.

12 Basically, this radiolytic rate was  
13 derived just using the specific activity of the  
14 plutonium with the 240 content at 4 percent that we  
15 envision. Actually, there's an upper limit as well for  
16 240 content. Obviously, for just these purposes or  
17 just this purpose.

18 Also, we assumed 62 grams per liter, which  
19 is in essence in the organic phase the solubility  
20 limit. And, you know basically what one does in  
21 characterizing a radiolysis rate is to define a G  
22 value. And G value have been obtained in numerous  
23 investigation have revealed a G value of about 2. So  
24 in essence, putting that altogether you get a  
25 radiolytic decay rate of something times ten to the

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1 minus 4. I think it's eight times ten to minus 4 per  
2 hour.

3 So that's just, of course, a consequence  
4 of having alpha particles that micropart bonds just as  
5 the chemical degradation occurs, something that  
6 obviously has to be accounted for. Because, as you  
7 see, it's the -- you know, a substantial part up until  
8 60 or so -- 40 or 50 degrees. But we recognize it.  
9 The radiolysis has to be accounted for.

10 So the question, your specific question I  
11 think was well how much do we produce. And that's sort  
12 of the million dollar question. And that's of  
13 degraded organics.

14 Yes, put that slide up. I'll speak to that  
15 slide.

16 The reason we're interested in how much  
17 you can produce is butanol and butyl nitrate, as I  
18 think we showed in the previous slide, are let's say  
19 the first byproducts of tributyl phosphate, first and  
20 second phosphates. And they're oxidized at relatively  
21 low temperatures. However, you need relatively high  
22 nitric acid concentrations. It should be pointed that  
23 in most cases absence the evaporators we don't have  
24 those nitric acid concentrations present. Our  
25 extraction process, in fact, relies upon a relative

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1 low nitric acid concentration. In the extraction  
2 process, that is to remove the impurities, you want to  
3 use an acid concentration of about 4 or 5 normal  
4 nitric acid. When you strip the plutonium from the  
5 uranium, you want to go as low as possible. So in that  
6 case, we're talking about a normality of one. So the  
7 purification unit is clearly a unit that one does not  
8 normally encounter high nitric acid concentration.

9 Of course, you know, for safety analysis  
10 purposes, we assume the worst. We assume, okay, what  
11 would happen if you did have this high concentration?  
12 Now, the reason we assume it is simply it's  
13 conservative to assume it and we don't have to  
14 implement controls such so that we, you know, have to  
15 assume something else. If one can accommodate a more  
16 conservative approach, one does so. And that's what  
17 we're doing here.

18 So the important point is that the energy  
19 that is liberated is substantial. And so  
20 consequentially what we want to do is to assure  
21 ourselves that we don't built up a quantity of these  
22 byproducts of TBP that can produce energy and heat,  
23 and gas as well. And these are much more easily  
24 oxidized in tributyl phosphate.

25 I think I mentioned before that the

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1 hydrolysis of TBP is the rate limiting step. So it  
2 really is important to ensure that these products that  
3 are oxidized more quickly don't build up. And that's,  
4 in fact, what we want to do. And also a lessons  
5 learned that the Tomsk event, which we'll speak to  
6 later, is certainly a case where it is believed that  
7 substantial quantities of these degradation products  
8 did build up over time and consequently what you had  
9 was in essence these products raised the temperature  
10 to the point that the hydrolysis of TBP did become  
11 significant, and then you basically involved the  
12 majority of your organic in the overall reaction  
13 scheme.

14 So this is a real key in providing for  
15 safety.

16 To answer your question how much degraded  
17 organic can one build up, one has to know a number of  
18 rate constants. Rate constants that receive the most  
19 attention, and rightly so, has been the hydrolysis  
20 rate constant. Less information is really known about  
21 the oxidation of the degradation products, or I think  
22 what's not shown here as well is the nitration rate  
23 constant as well. So it's a goal of our experimental  
24 program during the integrated safety analysis to begin  
25 getting back to first principles here to determine the

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1 rate constants, such that we can predict the  
2 concentration of these degradation products at any  
3 point in the process, at any time, at any temperature  
4 and any normality. So then we'll really truly have a  
5 firm handle on the rate constants and the quantities  
6 of degraded organic that can build up in the process.  
7 But to date, not all these rate constants are known.

8 Go ahead.

9 CHAIRMAN POWERS: I'm surprised that you  
10 don't have terms of higher order in here. That is,  
11 you have a rate constant for this hydrolysis rate  
12 constant, but why don't you have a term with a square  
13 of the TBP concentration?

14 MR. KLASKY: The hydrolysis rate constant  
15 has been shown to be pseudo-first order in TBP. We're  
16 talking -- here we're only talking about the organic  
17 phase. And the reason we're talking about the organic  
18 phase, is that the solubility of TBP in the aqueous  
19 phase is exceedingly low, about --

20 CHAIRMAN POWERS: I understand that.

21 MR. KLASKY: But I think the only -- the  
22 only answer that I can give you with respect to the  
23 order of the reaction is simply the experimental  
24 evidence suggests that the rate is pseudo-first order  
25 in TBP. I don't know if that answers your question.

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1 CHAIRMAN POWERS: Well, I mean it could  
2 well be that the data accrued enough you can't see the  
3 higher order term, but you clearly have it. Because  
4 your aromatic ties and things. There's got to be some  
5 point at which you've got this hydroxide clipped off  
6 the tertiary butyl alcohol to create something which  
7 is either ionic or a radical hermitage.

8 MR. KLASKY: Mark, do you want to --

9 MR. VIAL: Mark Vial, DCS.

10 I didn't quite understand the equation.  
11 Why would you be looking for an order two in your TBO  
12 concentration while it may only -- the mechanism of  
13 the hydrolysis or de-alcoholization is more likely to  
14 be an SN2 type mechanism. So you wouldn't involve a  
15 power 2 in your concentration.

16 CHAIRMAN POWERS: The hydrolysis is  
17 clearly -- you would expect to be first order.

18 MR. VIAL: Correct.

19 CHAIRMAN POWERS: But it's the subsequent  
20 formation of a -- something -- you got to have  
21 something that becomes red in this system. Nothing up  
22 there is going to be red, okay. And the only thing  
23 that's going to be red is something with an aromatic  
24 diluent.

25 MR. VIAL: Correct. But in your case and

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1 you are talking about the rate -- so you are talking  
2 about a situation where you have an aromatic diluent.  
3 In our case and unlike BNFL, for instance, we have  
4 just a branched alkane. We don't have any impurity of  
5 aromatic group, such as nasty group of the chaz  
6 benzene unless, unlike -- which is used by BNFL. So  
7 what you say is with your byproduct from the  
8 decomposition of these diluents, not necessarily on  
9 the solvent itself now, but on the diluent. And in  
10 our case it doesn't apply. It doesn't apply.

11 CHAIRMAN POWERS: What you're saying is  
12 red is a coincidence?

13 MR. KLASKY: No. I think what we're saying  
14 is that the -- I think we mentioned earlier the  
15 properties of the diluent are very important and when  
16 you get down to the early work that was done in  
17 Hanford, I mean this was part of the learning  
18 experience. Early on in the project, you know,  
19 different diluents were tried. And it eventually  
20 turned out that they were using -- I think the diluent  
21 at the time was a shell based spray which had a very  
22 high naphthalene content. And subsequently when they  
23 went exploring, you know, different diluents, that  
24 they clearly saw the presence of the diluent as a  
25 major factor.

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1           And as Mark mentioned, the branched chain  
2           and the straight chain alkane really has been found to  
3           be rather robust in that regard to nitric acid, or  
4           basically is not attacked by the nitric acid and is  
5           also rather resilient to radiation fields.

6           The diluent does play a large role. And  
7           the red color I think is more attached to the diluent  
8           than anything else. So clearly it's an important  
9           factor, and I think we'll mention that in our safety  
10          strategy as a major control that we want to evoke in  
11          justifying our safety basis here.

12          DR. LEVENSON: Are you really saying that,  
13          as Dana pointed out, the bulk of the degradation  
14          products do not have red color, but in a way they're  
15          the source of the energetics, if there is going to be  
16          any from exothermic reaction that the red color is a  
17          second ordered thing and probably can't contribute  
18          much to any energy issue? Is that really --

19          MR. KLASKY: Well, I guess two things.  
20          That's largely correct. But the diluent, again, as  
21          they found out early on, certainly can produce  
22          energetic byproducts. And so --

23          DR. LEVENSON: But they're necessarily  
24          red?

25          MR. KLASKY: No, it depends what diluent

1 one uses. That the naphthalene group happened to be  
2 such that, you know, one got a red color. And when  
3 they formed in a limited number of experiments or one  
4 experiment where they formed a phase inversion with  
5 dodecane, they got a yellow color. So it largely is  
6 a property of the diluent. I think I'd leave it at  
7 that.

8 MR. VIAL: I think the color is not the  
9 issue. The color just reveals that you have aromatic  
10 cycle with certain number of double bonds. And here  
11 the only source of double bond would be the formation  
12 of butene at truly high temperature. So it would be  
13 really in the end of a decomposition, it would already  
14 have started to run away.

15 DR. FORD: Will we be talking at anytime  
16 about the materials of the construction for this  
17 polishing plant?

18 MR. KLASKY: I don't think that's the  
19 intent.

20 DR. FORD: It won't be talked about at all  
21 today?

22 MR. KLASKY: No, I don't think so.

23 DR. FORD: Okay.

24 CHAIRMAN POWERS: I was a restriction I  
25 put on the meeting that there would be no discussion

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1 of corrosion.

2 MR. SIEBER: And that's why it's a one day  
3 meeting.

4 CHAIRMAN POWERS: That's right.

5 MR. KLASKY: So, we talked about the  
6 energy generation.

7 CHAIRMAN POWERS: See, we're discussing  
8 important stuff, chemistry here.

9 MR. KLASKY: We talked about energy  
10 generation, and obviously we have material that is  
11 capable of being oxidized in liberating energy. But  
12 equally as important is the mass and heat transfer  
13 afforded to the system. And so really to understand  
14 the system, one has to, in essence, perform a heat  
15 balance and just if you want to prevent a runaway  
16 action, just ensure that your heat transfer is  
17 sufficient. It's that simple.

18 CHAIRMAN POWERS: Guaranteed to work.  
19 Sometimes a little challenging, but guaranteed to  
20 work.

21 MR. KLASKY: I think there's one aspect  
22 that I want to mention, it's an important aspect and  
23 it sort of -- it's followed red oil for a number of  
24 years, and that is the idea that one can, you know,  
25 just simply operate below a certain temperature. And

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1 we're clearly not saying that.

2           What we're clearly saying here is at every  
3 temperature that either under normal or abnormal  
4 accident conditions that we may encounter, we have to  
5 ensure that this heat balance is maintained. And I  
6 think that is fundamentally our safety strategy here,  
7 to focus on that energy balance and assure that we  
8 have the requisite heat transfer afforded to the  
9 system sufficient to overcome the energy generated.  
10 And obviously we have to do both.

11           So we talked about the somewhat more  
12 fundamental or theoretical aspects of TBP and red oil,  
13 but obviously we have 50 years of operational  
14 experience, that is collectively. And, you know, it's  
15 important to understand what was tried and to really  
16 learn from that history. And so we have done that by  
17 analyzing the experiments, or the experiments, the  
18 accidents and really understanding why is it that this  
19 event occurred. And I think we start back in the early  
20 '50s, I think there were two aspects that really come  
21 out of those accident, and those are as follows.

22           They didn't at first recognize the overall  
23 importance of the diluent. They saw degradation in  
24 subsequent experiments of the diluents occur at much  
25 lower temperatures where TBP was basically inert; that

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1 is some of the diluents were reactive at 110 degrees.  
2 And clearly that's a problem. If one can encounter  
3 temperatures in excess of 110 and your diluent is  
4 being attacked by nitric acid or nitrous acid, that's  
5 a problem. And so a large experimental effort was  
6 undertaken by Hanford back in the early mid-'50s to  
7 really resolve this issue of the diluent. And I think  
8 to date that aspect of the problem has largely been  
9 tackled.

10 The other aspect of the '53 events was  
11 that they didn't have redundant equipment. That was,  
12 you know, they had the nominal equipment. Their  
13 mission was to produce a product, and consequently  
14 that idea of single failure criteria just simply was  
15 not implemented in the facility at that time.

16 It's about 25 years later, they found out  
17 that, well, you know, tributyl phosphate itself if you  
18 heat it high enough or hot enough, you can loosen the  
19 bonds, hence the name paralysis. And although they  
20 had adequate venting and they did their best to  
21 restrict the quantity of TBP into evaporators, they  
22 also found that one could get phase inversion, one  
23 could concentrate TBP in evaporators, the diluent is  
24 more volatile than TBP and consequently one is left  
25 with TBP, and if left on its own, if you heat, you're

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1 going to break the bonds and you're going to produce  
2 butene. And so they learned, basically, that you  
3 really have to provide that heat transfer mechanism to  
4 ensure that one does not heat to the point of  
5 producing butene. Because once you get to the butene,  
6 you're producing flammables, and that obviously can be  
7 a problem.

8 The final accident or last accident  
9 occurred in '93, and that is obviously much published,  
10 the Tomsk event. And I think there are a number of  
11 lessons with Tomsk. But I think the most important  
12 one that stands out is that, you know, again it's a  
13 heat balance. They felt that they were operating at  
14 relatively low temperatures, 60/70 degrees, and  
15 attached to this red oil phenomena was this 135  
16 number. And they felt, well, you know, we're under 135  
17 and consequently it shouldn't be a problem. But they  
18 learned that these degradation products are much more  
19 energetic and if left to build up, they can provide  
20 that initiation energy to raise the bulk temperature  
21 of the organic to the point where hydrolysis becomes  
22 significant and consequently, you know, involve the  
23 bulk quantity organic and you run away.

24 MR. ROSEN: Which is to say, I think, that  
25 they didn't pay attention to the rate steps. You said

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1 if left for long enough, which implies a time, a rate.

2 MR. KLASKY: Correct.

3 MR. ROSEN: And they didn't know anything  
4 about the rate. Well, they assumed the rates were low  
5 enough at those low temperatures that they wouldn't  
6 have to worry in essentially infinite time, which  
7 turned out to be the wrong answer.

8 MR. KLASKY: Correct. I think that there's  
9 also something, if you look at the rate equations,  
10 you'll see -- Mark, if you want to put the rate  
11 equations back.

12 You'll see the second equation, there's a  
13 loss, or actually there are two lost terms.  
14 Evaporation, that's the exponent and there's a  $k_4$   
15 which is in essence an oxidation rate.

16 So theoretically if you're at a low  
17 temperature, you minimize those two terms. And so --  
18 but of course  $k_1$  hydrolysis also goes down. But  
19 remember we also have radiolysis.

20 Now our facility is fortunate in the  
21 respect that we're dealing just solely with the  
22 plutonium, we don't have fission products present. So  
23 our radiation fields are somewhat restricted from what  
24 one encounters in a fuel processing facility. But the  
25 point is that at low temperature you still have to be

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1 concerned with radiolysis. And, you know, if you  
2 allow the tributyl phosphate or if you use the wrong  
3 diluent -- it's unclear what they used at Tomsk  
4 actually, it could have been a cyclic change diluent.  
5 The information just isn't there. But you can build  
6 up degraded organic.

7 And so I guess what we're saying is, yes,  
8 it's very important to understand from the  
9 fundamentals what the phenomena is, what the rate laws  
10 are, what the mechanisms are. If you truly want to  
11 understand something to prevent it, in my way of  
12 thinking is a prerequisite.

13 CHAIRMAN POWERS: I mean if you look at  
14 your rate equation, you in fact to get to a steady  
15 state.

16 MR. KLASKY: Well, it's --

17 CHAIRMAN POWERS: I don't know what it is.

18 MR. KLASKY: Right. That's -- you may get  
19 to a steady state.

20 CHAIRMAN POWERS: I said if you wait long  
21 enough, you'll get to a steady state.

22 MR. KLASKY: Right. And, hopefully, it's  
23 not all degraded organics.

24 In any event, so our approach is to  
25 characterize these degradation products, their rates

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1 and their energetics and develop --

2 CHAIRMAN POWERS: Well, I mean it's  
3 because of that, in your unsteady stateness of your  
4 rate equation, somehow I just cannot believe there's  
5 not a higher order terms in here someplace.

6 MR. KLASKY: Okay. Sort of pull back a  
7 little now and talk about what is our safety strategy  
8 here, what are we implementing into the facility to  
9 assure that we don't have runaway reactions. I think  
10 we've spoken to most of these, but I want to go over  
11 them.

12 We identified the diluent as it being a  
13 branched chain hydrocarbon or I think more correctly,  
14 excluding cyclic diluents from the process as a  
15 principle SSC.

16 In addition, we talk about the  
17 confirmatory testing to assure that our diluent does  
18 not create foam such that it could, in essence,  
19 insolate the material and cause subsequent temperature  
20 and pressurized by clogging the vents, for example.  
21 And that, obviously, will raise the temperatures.

22 CHAIRMAN POWERS: Have you going to put an  
23 anti-foaming agent into your --

24 MR. KLASKY: We haven't planned on that  
25 yet.

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1 CHAIRMAN POWERS: Right. You haven't  
2 gotten there. Because that's just going to complicate  
3 things.

4 MR. KLASKY: Yes. We have to make sure  
5 that, you know, we don't have surfactants and whatnot  
6 as well. And I think, again, this is something that  
7 we're going to investigate during the ISA.

8 We have identified venting both from two  
9 different perspectives. One, that the venting has to  
10 be sufficient to allow for evaporative cooling. We  
11 clearly need to be able to vent the water, the soluble  
12 and the organic to allow for the cooling. That's  
13 providing the predominant cooling mechanism, although  
14 conductive heat transfer out the sides in our tanks  
15 because of criticality constraints, that also might be  
16 significant because of the surface area-to-volume  
17 ratio.

18 Also our vent also can accommodate  
19 pressurization.

20 Finally -- or I shouldn't say finally.  
21 Two more.

22 The steam temperature on our evaporators  
23 we're restricting to 135 degrees. And that is not to  
24 say that our solution temperature is raised to 135  
25 degrees, rather it's our steam temperature and the

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1 temperature of the solution will just be the boiling  
2 point of our low boiler, in which case it's water and  
3 nitric acid.

4 DR. FORD: But you said just now that at  
5 Tomsk there was an accident with temperatures below  
6 135.

7 MR. KLASKY: Correct.

8 DR. FORD: So in other words you don't  
9 know all the other interactions between the other  
10 process variables that would lower that limiting  
11 temperature, or do you?

12 MR. KLASKY: We're going to get at that in  
13 the next control, limiting the exposure time to  
14 prevent the degradation products. If we --

15 DR. FORD: And you know that's what  
16 happened at Tomsk? They did not limit the exposure  
17 temperature time?

18 MR. KLASKY: Well, we suspect that they  
19 had given that the evidence that we have is that they  
20 initiated the runaway reaction at temperatures 60 to  
21 70 degrees. We suspect that the energetics of both  
22 butyl and butyl nitrate support that hypothesis.

23 I think during the ISA we also are going  
24 to do testing on the heat transfer mechanism as well.  
25 So I think we'll be able to provide a much more

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1 definitive answer into what possibly occurred at  
2 Tomsk.

3 Of course, you know, it will never be  
4 known 100 percent, just because the precise details of  
5 the starting conditions aren't known 100 percent.

6 CHAIRMAN POWERS: And they blew up the  
7 experimental labs.

8 MR. KLASKY: So I think we can just  
9 create, you know, just apply a scientific method and  
10 look at steps and try to deduce what the mechanism was  
11 and confirm that, both due to the experimental data  
12 that we take and the models that we develop.

13 DR. FORD: You're rightfully pointing out  
14 that there's some unknowns and that you're going to do  
15 experiments to resolve that. Does that data  
16 collection and understanding development, does that  
17 become a rate limiting step to this whole project?

18 MR. KLASKY: I don't think so. Our plan  
19 for tributyl phosphate, I don't envision as a rate  
20 limiting step. It's something that we feel we can do  
21 over the course of the ISA.

22 CHAIRMAN POWERS: My interpretation,  
23 they're required to be state-of-the-art. And the 135  
24 limit is the state-of-the-art right now.

25 DR. LEVENSON: Is this an atmospheric

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1 event? Have you evaporated atmospheric pressure?

2 MR. KLASKY: One of them is actually sub-  
3 atmospheric, the other is basically atmospheric, yes.

4 MR. ROSEN: You see, I'm having the same  
5 trouble that Dr. Ford is having.

6 MR. KLASKY: Okay.

7 MR. ROSEN: And that is all of this makes  
8 eminent good sense to me, and the determination of  
9 these rate constants is clearly necessary. And yet it  
10 seems to be necessary before one could be at the stage  
11 you're at. I mean, it seems like you should arrive at  
12 more of these fundamental understandings to me, before  
13 you could get to the laying out a set of components on  
14 a flow diagram.

15 MR. KLASKY: I think what we've tried to  
16 illustrate is that what these rates constants are  
17 really doing is they're just restricting operations so  
18 one could view the final product of these experiments  
19 as, in essence, tech specs. So I really don't think  
20 that the ultimately that the facility design is  
21 changed by the results of the experiment. Rather what  
22 may change is perhaps how you operate the facility.

23 DR. LEVENSON: Isn't the only potential  
24 impact on design the size of the solvent recirculation  
25 and cleanup system?

1 MR. KLASKY: Or just the exposure time. I  
2 didn't mention, but as part of the --

3 DR. LEVENSON: Well, the exposure time is  
4 really controlled by how frequently --

5 MR. KLASKY: Yes.

6 DR. LEVENSON: I mean, it isn't exposure  
7 time in the process equipment. It's integrated  
8 exposure time over many passes?

9 MR. KLASKY: Yes, exactly.

10 DR. LEVENSON: So that the limiting step  
11 really isn't exposure time. It's the length of time  
12 between solvent cleanings.

13 MR. KLASKY: Or we're not even taking  
14 credit for the solvent cleaning. I'd characterize --  
15 for safety, that is. I'd characterize exposure time  
16 as just, you know, T equals zero, you introduce  
17 tributyl phosphate. And, you know, T equals -- I  
18 don't know, one year as the time that the tributyl  
19 phosphate has been in your process. So what might  
20 change is we might conclude that every 8 months we  
21 remove all solvent and we just send it to SRS. Yes.

22 CHAIRMAN POWERS: Help them out.

23 MR. KLASKY: But I think the important  
24 aspect of this is, again, it's not facility design  
25 that's going to change. It's going to be how we

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1 operate, how long we allow the solvent to remain in  
2 process.

3 We currently have a process where we draw  
4 off a percentage of solvent each time, and we add  
5 fresh solvent. And, in essence, you know that's a  
6 decay rate in essence. So --

7 DR. LEVENSON: Well, I don't know whether  
8 overall -- you know, it may be an easy answer, to say  
9 we're just not going to take credit for solvent  
10 cleaning. But that means you're going to significantly  
11 increase the rate of solvent disposal and generate a  
12 big waste disposal problem that maybe doesn't have to  
13 be there.

14 MR. KLASKY: I think with respect to the  
15 crediting or noncrediting, we have a neutralization  
16 process. And that naturalization process removed  
17 primarily the tributyl phosphoric acid and monobutyl  
18 phosphoric acid along with those degradation products  
19 that are soluble in the aqueous stream.

20 There are certain degradation products  
21 that are soluble in the organic stream. And so, you  
22 know, in the end given the rate constants of  
23 hydrolysis and the oxidation, what we believe to be  
24 order of magnitude estimates of the oxidation products  
25 we don't suspect that this is going to be a problem.

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1 But having said that, you know, we're going to  
2 quantify this and demonstrate this. We need some basis  
3 for our estimate of degradation time, and that's what  
4 we're going to obtain here. And the fundamental  
5 changes to the facility, I just don't foresee and  
6 instead we're talking about resonance time. I think  
7 that's in the end what we're getting at. We're not  
8 talking about modification of equipment, per se.

9 MR. ROSEN: That's a very unsatisfactory  
10 answer to me, in the sense that by analogy to the  
11 reactor systems, which we know a lot more about, the  
12 idea that the designers would say "Well, leave this to  
13 the operators, we'll take care of it with tech specs.  
14 Sure, we have some fundamental issues in design, but  
15 we'll take care of it with tech specs and leave it to  
16 the operators to figure out."

17 It has always been anathema to me and to  
18 operators, too. And now you're saying the same thing  
19 about this facility, and that's what it's very  
20 unsatisfactory.

21 MR. KLASKY: I think what we're saying is  
22 that clearly from operational history, 40 years of  
23 operational history, we clearly know that people  
24 operated the plants without these rate constants. I  
25 mean, to a varying degree of safety. And what we're

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1 seeking to do now is to quantify that safety, how long  
2 one can go in this environment prior to exceeding some  
3 limit of degradation products.

4 DR. FORD: Yes, but it's too small like a  
5 mountain underneath the ocean floor. You don't know  
6 how much leeway you have. We might have just grazed  
7 an accident and you didn't know about it.

8 MR. KLASKY: I'm not disagreeing with  
9 that. That's true. I think what we're doing is  
10 trying to quantify -- to come up to some conclusion  
11 that after 6 months of sitting in a tank if that's  
12 the, you know, unexpected event that were to occur,  
13 that we have sufficient margin. But really  
14 fundamentally the process will not change. It's just  
15 we'll know what our limit is. And I guess I can't  
16 foresee any fundamental change if we were to know that  
17 data today. We'd simply be able to state a number.  
18 Don't allow it to remain in a nitric acid environment  
19 for 3 months or 6 months, but fundamentally if we  
20 obtain that information a year from now, we're still  
21 going to have the same number.

22 MR. ROSEN: What if it's 3 days?

23 MR. KLASKY: Well, I think we know that  
24 based on the hydrolysis rate constants, that it's not  
25 3 days. You can obtain -- if you want your most

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1 conservative answer, just take the hydrolysis rate of  
2 TBO and just assume that nothing's lost. And, in  
3 essence, you'll arrive very quickly at the conclusion  
4 that it's not 3 days.

5 We're talking a rate of hydrolysis that's  
6 nominally ten to the minus 5 per hour.

7 MR. ROSEN: At 60 degrees?

8 MR. KLASKY: At 60 degrees. And I think  
9 we've indicated that in the process equipment that we  
10 expect to TBP to be present, 60 degrees is a hard  
11 limit for a number of different reasons. In other  
12 process equipment, we're at somewhat higher  
13 temperatures to 135. But one recognizes that oxidation  
14 rates at those temperatures are much faster than  
15 hydrolysis rates, or can be.

16 MR. ROSEN: Well, let me postulate  
17 something for you.

18 MR. KLASKY: Okay.

19 MR. ROSEN: At 60 degrees you have these  
20 times, long enough to give you some comfort. But in  
21 abnormal conditions, how long do you have? Well, how  
22 abnormal? Well, let's say you lose temperature  
23 control and the rate constants are really 3 hours, not  
24 3 days, not 3 months, not 3 years.

25 I just don't know enough to be able to

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1 postulate in a bounding way or to state in a bounding  
2 way that you can't get into trouble, and that's why I  
3 so much applaud your evaluations of these rate  
4 constants. But I think we've got the cart a little bit  
5 before the horse here, and I think that's where Dr.  
6 Ford started this discussion.

7 MR. KLASKY: I think what we've done with  
8 respect to your hypothesis that we, in essence, lose  
9 control of temperature, clearly we recognize  
10 temperature to be a major driver, and so consequently  
11 we have IROFS or will have IROFS to preclude that,  
12 we'll have redundant controls to ensure that  
13 temperature doesn't exceed specified limits. But on  
14 the other hand, I think, Mark, if you go up to the  
15 oxidation slide, the table, you'll see that the  
16 oxidation rates are very dependent on acidity. And  
17 so, you know, what we're again trying to do is we're  
18 not trying to argue that we're controlling the  
19 normality. We're trying to take the fewest --  
20 implement the fewest controls with respect to assuring  
21 the -- how would I say this?

22 We're basically conservatively taking the  
23 worse case and all the other variables that were not  
24 controlling. So we're not attempting to make  
25 arguments with respect to well we'll never have a

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1 problem with butyl nitrates since we don't expect the  
2 normality to go above 8. Rather, we're assuming it's  
3 above 8.

4 And so, you know, I think those features,  
5 we call them additional protective features, are  
6 implemented throughout the design. That's, I guess,  
7 all I can say.

8 DR. FORD: That's 10 molar nitric acid?

9 MR. KLASKY: This is in the aqueous phase.  
10 With a case of butyl nitrate, butyl nitrate only  
11 resides in the organic phase. So with TBP of a  
12 distribution coefficient of about 3, so in essence the  
13 highest normality that you get in the organic phase is  
14 about 5. So just take these numbers and divide by 3,  
15 and that's roughly what you have in the organic phase.

16 CHAIRMAN POWERS: This is concentrated  
17 chemistry.

18 DR. FORD: I'd love to see what the  
19 materials of the construction are. I just love it.

20 MR. ROSEN: That's why we don't have that  
21 discussion today.

22 DR. FORD: That's right.

23 MR. KLASKY: Any questions?

24 CHAIRMAN POWERS: Any questions?

25 This is fine. I encourage on this. I like

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1 the fact that you're not relying just on the  
2 temperature criterion, because that's always been a  
3 dissatisfactory thing. And it is true that every  
4 radial event that I can think of involved old  
5 material, and whatnot.

6 Members have any other questions to pose  
7 to the speakers?

8 Our intention is to come back to this  
9 issue right lunch, and we will come back right after  
10 at 1:30.

11 (Whereupon, the Subcommittee was adjourned  
12 at 12:25 p.m., to reconvene this same day at 1:31  
13 p.m.)

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

1:31 p.m.

1  
2  
3 CHAIRMAN POWERS: Let's continue our  
4 discussion of red oil, which may or may not be red and  
5 may not be oil.

6 So, Bill, your show.

7 MR. TROSKOSKI: Okay. I'll have to  
8 confess, I've never seen red oil in my life. I know  
9 it's going to shock somebody.

10 CHAIRMAN POWERS: Maybe we ought to ask,  
11 what your qualifications for being here?

12 MR. TROSKOSKI: Well, I am a chemical  
13 engineer.

14 CHAIRMAN POWERS: And you did some work at  
15 Savannah River?

16 MR. TROSKOSKI: And I worked at Savannah  
17 River building the reactor department.

18 CHAIRMAN POWERS: Well, that puts you in  
19 good stead with the rest of us, so go ahead.

20 MR. TROSKOSKI: All right.

21 MR. ROSEN: Especially the chemical  
22 engineering part.

23 MR. TROSKOSKI: Okay. My name is Bill  
24 Troskoski. I am a chem safety reviewer in the fuel  
25 cycle safety division. I would like to discuss the

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1 staff's review of the tributyl phosphate nitrate  
2 runaway reactions that can occur at fuel cycle  
3 processing facilities. It is also known as red oil,  
4 though as we know, it's not necessarily red. And in  
5 many respects it's similar to other chemical runaway  
6 reaction phenomena that is well known in the chemical  
7 process industry.

8           These are highly exothermic reactions that  
9 involve large amounts of thermal energy and  
10 noncondensable gases. If the reaction rate is not  
11 properly controlled or adequate venting applied,  
12 process components could be ruptured releasing license  
13 material, possibly injuring any operations and  
14 personnel nearby.

15           The staff has reviewed the applicant's  
16 approach based on first principle, as well as the  
17 literature and passed operating events including those  
18 from DOE and Russian facilities. The staff also notes  
19 that the French facility is using a very similar  
20 process to that proposed by DCS for the aqueous  
21 polishing system, have had no red oil events that we  
22 know of.

23           In conducting our review the staff is  
24 aware of the chemical process industry's response and  
25 approach to dealing with runaway reactions through the

1 Process Hazard Analysis methodology, a process a very  
2 similar to the ISA that the applicant has yet to  
3 perform.

4 CHAIRMAN POWERS: You know, that's an  
5 insight that really hadn't dawned on me, but the  
6 Process Hazard Analysis is much like the ISA, isn't  
7 it?

8 MR. TROSKOSKI: Very much so. And what the  
9 applicant is proposing to do here is a very rigorous  
10 and in my view the way to go, they're going to do a  
11 HAZOP supplemented with a What-if/Checklist. And the  
12 What-if/Checklist, of course, you can get valuable  
13 insights from other operating events to highlight,  
14 make sure you look at certain key points regardless of  
15 the disciplined -- the approach that you take in  
16 looking at step-by-step for each component.

17 The first principles. By way of  
18 illustration, a runaway reaction can be evaluated in  
19 the classical fire triangle terms. You conserve fuel,  
20 oxygen and heat presence that you need for this  
21 reaction to occur.

22 For red oil, the fuel is a tributyl  
23 phosphate and associated degradation products; dibutyl  
24 phosphate, monobutyl phosphate, the butanols and/or  
25 butyl nitrate, maybe even butene as well as any metal

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1 adducts that may be present.

2 Each constituent has its own reaction  
3 initiation temperature. Consequently, it's important  
4 then to have a known starting point to understand how  
5 much heat can be liberated and to what rate.

6 The applicant has committed to identifying  
7 and limiting the initiation temperature and possible  
8 energy generation through the conduct of confirmatory  
9 experiments and implementation of appropriate process  
10 controls.

11 Nitric acid is an expected constituent of  
12 the process, often in high concentrations. For  
13 analysis purposes, the applicant has assumed that the  
14 organic phase is saturated with nitric acid, which is  
15 a conservative bounding assumption.

16 With the first two legs of the reaction  
17 triangle in place, we come to the third bullet, the  
18 reactions initiation temperature, which has been  
19 determined generally accepted to be about 137 degrees  
20 C.

21 For the reaction to take place the  
22 applicant has pointed out that the tributyl phosphate  
23 and associated degradation products must reach this  
24 temperature. The applicant is proposing to ensure  
25 adequate evaporative cooling to prevent this from

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1 occurring. This approach provides a certain level of  
2 independence from the external heat sources such as  
3 the evaporator steam supply system.

4 The applicant's overall strategy is to  
5 ensure that heat removal rate is greater than the heat  
6 generation rate. To be successful, one must know the  
7 reaction constituents, understand the reaction rates  
8 and the initial conditions.

9 The first PSSC that the applicant has  
10 chosen is the Chemical Safety System. The diluent is  
11 to be selected based on properties that limits its  
12 vulnerability to get degradation through both chemical  
13 and radiation exposures prevalent in the process.  
14 Diluent properties related to foaming are also  
15 considered to limit the possible events on the gas  
16 treatment systems venting function, which is vital for  
17 evaporative cooling.

18 The second PSSC is the Process Safety  
19 Control Subsystem. There are two main features:

20 First, the residence time limits on  
21 organics in process vessels containing oxidizing  
22 agents and potentially exposed to high temperatures  
23 and in radiation fields.

24 The second is to ensure that the  
25 temperature of the solutions containing the organic is

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1 restricted to temperatures within safety limits to  
2 control the energy generation rate. Again, this is  
3 classical heat balance.

4 The third PSSC is the Offgas Treatment  
5 System. Again, there are two major functions.

6 First, it provides an exhaust path for the  
7 aqueous evaporative cooling. As the applicant has  
8 indicated, the design basis value will be determined  
9 through experiments.

10 Secondly, for closed systems, venting is  
11 provided to provide adequate heat removal. The vent  
12 size will accommodate enough mass transfer to prevent  
13 initiation of the runaway reaction. However, it may  
14 not be large enough to fully relieve the energy and  
15 pressure generated by a full scale runaway reaction.  
16 So the applicant is taking a purely preventative  
17 approach for a limited number of components, mainly  
18 their evaporators.

19 DR. FORD: Excuse me.

20 MR. TROSKOSKI: Yes, sir.

21 DR. FORD: The safety structure is really  
22 the balance between the heat removal rate and the heat  
23 generation rate.

24 MR. TROSKOSKI: Correct.

25 DR. FORD: Which means, I suppose, that as

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1 I understand from the previous speaker, it's going to  
2 take a long, long time to create the various tentacles  
3 involved in this exothermic reaction.

4 MR. TROSKOSKI: It may, we have to look at  
5 that.

6 DR. FORD: And then, presumably, the  
7 accident is going to take off at a fairly rapid rate?

8 MR. TROSKOSKI: Oh, yes, I would expect a  
9 reaction once initiated to go very rapidly.

10 DR. FORD: So what will the system  
11 monitoring process be to tell you when you're about to  
12 start to go onto this rapid --

13 MR. TROSKOSKI: I don't think you can do  
14 that. I don't think you can really tell when it's  
15 going to go off on you. That's why you need a margin.  
16 And safety factors are to keep you from it.

17 DR. FORD: So you've got no way of  
18 monitoring the system?

19 MR. TROSKOSKI: What way?

20 DR. FORD: I have no idea what the  
21 monitoring would be, but I mean --

22 MR. TROSKOSKI: What you're doing is  
23 you're going to limit the constituents. You're going  
24 to limit the temperature and you're going to make sure  
25 that the material that you have, say, in your

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1 evaporator, that you're pulling off enough through  
2 evaporative cooling that you'll never reach the self  
3 heating portion, which is where the reaction take off.  
4 And what the applicant has proposed do was give us a  
5 safety factor of about 1.2 times the energy input plus  
6 the energy generation, being able to pull that off  
7 through evaporative cooling.

8 DR. FORD: So the monitoring is the  
9 temperature? You're going to monitor the temperature  
10 continuously.

11 MR. TROSKOSKI: You're going to be  
12 monitoring a lot of stuff.

13 DR. FORD: Well, that was my question.  
14 What are the things you're going to be monitoring?

15 MR. TROSKOSKI: For one thing, yes, you're  
16 going to be monitoring temperature. But, remember, you  
17 also have to know where you're starting at, and where  
18 you're starting at means what are the constituents in  
19 the degraded products that you have built up. So  
20 that's just another interrelated link in this whole.

21 You've got to define the diluent so it  
22 doesn't take part in this. You have to define what the  
23 effect of the radiolysis was going to be, what the  
24 effect of the other degraded products and metal  
25 adducts that may be present. And you define that,

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1 then you know what your starting point is.

2 Then as this stuff is being evaporated  
3 off, you've got a steam supply, an external heat  
4 source to it. You're pulling off water, nitric acid  
5 that's evaporating there. And the rate that you're  
6 pulling it off has to have a significant margin so  
7 that you never reach the self-initiation temperature.

8 DR. FORD: As far as the NRC is concerned-  
9 -

10 MR. TROSKOSKI: Yes. Now that --

11 DR. FORD: The NRC will be satisfying  
12 themselves that there's enough system controlling --  
13 monitoring temperature, whatever you're going to  
14 monitor.

15 MR. TROSKOSKI: We will be getting to that  
16 in a minute.

17 DR. FORD: Okay.

18 MR. TROSKOSKI: But, yes, there is a lot  
19 of staff discussion on what the margins are going to  
20 be, where they're at, how you're going to ensure that  
21 the reaction is going to be highly unlikely, defense-  
22 in-depth.

23 DR. FORD: Okay.

24 MR. TROSKOSKI: All that's to be  
25 considered.

1 MR. ROSEN: You know, so far what you've  
2 told us is sort of a -- you talk about bulk parameter  
3 monitoring and --

4 MR. TROSKOSKI: Yes.

5 DR. FORD: -- bulk parameter strategies.  
6 And yet this system is comprised of pumps and pipes,  
7 and valves. What can you say about, to give us  
8 assurance, that local conditions can't vary so much  
9 that you can get into trouble locally even though the  
10 bulk conditions are okay?

11 MR. TROSKOSKI: A very good question.

12 Right now I cannot give you the assurance  
13 on a component-by-component basis, because that step  
14 won't be done until you do your ISA Process Hazard  
15 Analysis. That's where you get into the nitty gritty  
16 on a component-by-component and how the components  
17 relate to each other upstream and downstream. That's  
18 a systematic approach where you ask what happens if  
19 this variable goes outside of certain limits. And  
20 that's part of the final design approach, the ISA  
21 approach that the application is still to do.

22 MR. ROSEN: Vents and drains, and places  
23 like that where you could --

24 MR. TROSKOSKI: External heat sources,  
25 anything you can think of, yes.

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1 MR. ROSEN: Were you could conditions  
2 locally which could get you in trouble?

3 MR. TROSKOSKI: Oh, yes.

4 MR. ROSEN: Even though on a broad thing,  
5 the goes-into minus the goes-out-ofs is okay.

6 MR. TROSKOSKI: Yes. What you have to do  
7 is you have to protect all of your assumptions, all  
8 the initial conditions in your heat transfer  
9 calculations from --

10 MR. ROSEN: So from a chemical engineering  
11 standpoint, you're going to draw one big black box  
12 around this and make sure the arrows are going in the  
13 right direction, and you're okay? Then you're going  
14 to draw increasingly smaller boxes around --

15 MR. TROSKOSKI: And see how they  
16 interconnect.

17 MR. ROSEN: -- each component and see how  
18 they interconnect and do the same kind of mass and  
19 heat balances around each component?

20 MR. TROSKOSKI: Absolutely. Absolutely.

21 MR. SIEBER: I think that's also contained  
22 in the staff's comments, which are in the SER, the  
23 fact that actually have to do that component-by-  
24 component. That's the way I read the SER.

25 MR. TROSKOSKI: And actually from a

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1 chemical processing point for any system, that's what  
2 should be done if you have to do a Process Hazard  
3 Analysis if you're dealing with highly hazardous  
4 materials or a process. And in the chemical process  
5 industry, that is the practice that they do. So  
6 there's nothing new or unusual about this, this is a  
7 tried and proven methodology.

8 MR. PERSINKO: As I said in the opening  
9 remarks, for construction we're worried about the  
10 design basis of the principle structure systems and  
11 components. And at this stage the applicant has chosen  
12 to define the PSSCs mostly on the system's basis.

13 MR. TROSKOSKI: So we still have to get  
14 down into it. And we get the second bite of the apple  
15 at the licensing phase.

16 Okay. I've already discussed briefly the  
17 vent size. It's going to be sized to accommodate the  
18 mass transfer to prevent the initiation of the runaway  
19 reaction.

20 Let me see, next one I'd like to go to is  
21 Industry Events.

22 Now, there have been a number of red oil  
23 events in the nuclear industry. Three of the known  
24 events are just shown for reference. The Hanford was  
25 very similar to the Savannah River one in 1953.

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1 A review of those events really surfaced  
2 two strong themes. One was the unexpected presence of  
3 tributyl phosphate and/or the degraded products, which  
4 often accumulated over an extended period of time. And  
5 the second one is either a lack of or an inadequate  
6 Process Hazard Evaluation.

7 While the applicant's proposed safety  
8 strategy and PSSCs appeared to address the various  
9 known initiation conditions, they have still to  
10 perform their ISA, which will be needed to support the  
11 licensing phase of the process.

12 The staff does note that DOE has  
13 previously reviewed the red oil events and has  
14 developed a number of recommendations that we have  
15 found in published accounts and various documents.

16 DOE has also established a fine safety  
17 record at various facilities involved in plutonium  
18 separation and processing. We know the applicant is  
19 aware of the DOE actions and many of the applicant's  
20 proposed safety features envelope the DOE's  
21 recommendations, but not all of them. The applicant  
22 has determined that some do not apply to their process  
23 which they developed from the French. And  
24 specifically, DCS is not limiting the evaporator steam  
25 temperature to 120 degrees, but is proposing about 133

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1 or 135 degrees. While the question of margin can be  
2 raised regarding the 137 degree accepted initiation  
3 temperature, again as long as they are able maintain  
4 heat removal rate and keep it greater than the heat  
5 generation rate with the safety margin that they're  
6 committing to, the tributyl phosphate and associated  
7 degradation products cannot reach the initiation  
8 temperature.

9 The applicant has already indicated that  
10 they will be performing a number of conformity  
11 measurements to verify or determine the key safety  
12 characteristics of several process variables. These  
13 experiments, generally identified by the four bullets  
14 I've got up there, will define the heat generation  
15 rate and the heat removal capabilities. I've already  
16 conducted a number of experiments relating to venting  
17 size and I believe still have some to go.

18 The staff is determining whether the  
19 design basis of the proposed PSSCs provides reasonable  
20 assurance against the consequence of potential  
21 accidents. While the applicant's proposed approach  
22 does not exactly match the current published DOE  
23 approach, the applicant has provided a rational basis  
24 for their specific process to be supported by  
25 laboratory experiments and the safe operating history

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1 of a very similar process in France. The issue  
2 remains open to any resolution of the applicant's  
3 approach to achieving highly unlikely, identifying  
4 values and ranges of values for certain safety  
5 functions as the degraded product concentration limits  
6 and related safety margins.

7 The staff is reviewing additional  
8 clarifications of the design approach recently  
9 provided by the applicant. The staff review will also  
10 consider whether the proposed approach can support the  
11 defense-in-depth requirements of 70.64, which will be  
12 finalized in the ISA process.

13 The staff also acknowledges that  
14 additional changes to the PSSCs and the design values  
15 may occur at the ISA stage. This possibility is  
16 expected and it's recognized in the Standard Review  
17 Plan.

18 That would conclude the formal part of my  
19 presentation. If there are any questions, I don't  
20 understand why you were holding back this long --

21 CHAIRMAN POWERS: Let me just interject.  
22 This is Bill's first meeting in front of the ACRS.  
23 He's learning quick, isn't he?

24 DR. FORD: I know we have joked about  
25 materials and we are entering the construction

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1 authorization phase, my interactions with the chemical  
2 process industry, materials are kind of an Achilles'  
3 heel, the theory of materials. Has anyone in this  
4 process looked at the integrity of the proposed  
5 structural materials?

6 MR. TROSKOSKI: Process --

7 DR. FORD: Ten molars salt and placing  
8 acid with chloride is not a nice environment.

9 MR. TROSKOSKI: I recognize that. Before  
10 this I had another job, I was an inspector for the  
11 fuel cycle group, so I've got to go to all of our fuel  
12 cycle facilities, including some that handle hydrogen  
13 fluoride and a few other really nasty chemicals. And  
14 I can appreciate where you're coming from on this.

15 The short answer is from a regulatory  
16 point of view, we have not yet. The licensee is --  
17 their mechanical integrity program is to ensure, I  
18 think, gross integrity. They're not that concerned  
19 with small leaks. They're assuming that they're going  
20 to occur and they're going to deal with it as part of  
21 normal operating conditions, very similar to what  
22 other facilities do.

23 DR. FORD: Well, I'm thinking more in case  
24 -- in one of your things here you say the rapid  
25 evolution of heat and non-condensable gases can breach

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1 the process equipment. So I'm looking at an accident  
2 situation.

3 MR. TROSKOSKI: Sure. That would be where  
4 you would have a pressurized vessel. And, again, I  
5 believe the two main evaporators of concern here, they  
6 are going to be atmospheric.

7 MR. MURRAY: If I could just interject a  
8 little bit. I'm Alex Murray, Bill and I work together  
9 on the chem safety issues.

10 In the case of materials of construction,  
11 the applicant has stated, just in a descriptive  
12 manner, that they will compatible materials such as  
13 300 L-grade stainless steels. They do have material  
14 surveillance programs which they have identified as  
15 PSSCs. These will include the monitoring both on a  
16 longer term point of view, such as with corrosion 2 in  
17 testing, and also as part of a periodic inspection  
18 program. So they will have that in place.

19 DR. FORD: And is there experience in  
20 Europe or anywhere else of L-grade stainless steel in  
21 these environment?

22 MR. MURRAY: 300 L-grade stainless steel  
23 is typically used for these types of evaporators.  
24 There can be some pitting phenomena which has been  
25 observed, but generally if it is an L-grade and if

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1 there's appropriate heat treatments are done after  
2 welding to avoid hazardous and so on, it's generally  
3 acceptable.

4 DR. LEVENSON: They generally been used  
5 for solvent extraction type things since the first  
6 solvent extraction plant was built in 1945.

7 CHAIRMAN POWERS: '44. There's been quite  
8 a lot of work with this, which basically a glorified  
9 PUREX process. Yes.

10 MR. ROSEN: Notwithstanding all that, is  
11 there typically an in-service inspection like program  
12 to check the key components in service?

13 MR. MURRAY: That is what they are  
14 planning, and they have it identified as a principle  
15 structure system and component.

16 CHAIRMAN POWERS: Okay.

17 MR. SIEBER: It seems to me that since  
18 most of this operates at very low pressures, that you  
19 don't have the hazards of ruptures, but you might have  
20 the hazards of pitting, cracks, small leaks and so  
21 forth which are within the realm of an operator being  
22 able to handle.

23 MR. TROSKOSKI: Right. And that's what the  
24 applicant has indicate they expect.

25 DR. FORD: Well, I'm thinking in terms of

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1 -- if you had some intergranular attack, not cracking,  
2 attack.

3 MR. TROSKOSKI: Okay.

4 DR. FORD: And then you had an exposure,  
5 the line, would it still be all right.

6 MR. SIEBER: I think that it wouldn't make  
7 any difference if you have an explosion in the line  
8 and the line could be -- have perfect structural  
9 integrity and still rupture.

10 MR. TROSKOSKI: Once you've got the event.

11 MR. SIEBER: Once the event occurs, you  
12 know, settles that sort of. You aren't trying to  
13 contain the explosion, is that not true? You're not  
14 trying to prevent it?

15 MR. TROSKOSKI: No, what we're trying to--  
16 the applicant it taking a preventive approach, they're  
17 not taking a mitigative approach. So they're not  
18 designing pressure vessels for an explosion. They have  
19 not proposed that to us at all. Although, i they  
20 would like to, we'd certainly listen to them.

21 DR. LEVENSON: The evaporators which are  
22 maybe the most questionable things are not pressurized  
23 vessels. They're atmospheric. So any reasonable rate  
24 of increase pressure can't overpressurize --

25 MR. TROSKOSKI: Right. And --

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1 DR. LEVENSON: It might splash some liquid  
2 out, but with very limited consequences.

3 MR. TROSKOSKI: And, again, pressure also  
4 plays a part in the reaction rate, too. So that's why  
5 you've got to be very careful to prevent -- to protect  
6 the venting so that you don't have a back pressure  
7 should a reaction occur.

8 MR. SIEBER: All right. I have an  
9 additional question, which probably will reveal that  
10 I don't fully understand the temperature phenomenon.  
11 But I got the feeling that if you let this solvent sit  
12 long enough with enough nitric acid in it, that that  
13 temperature or the rapid exothermic reaction is really  
14 not fixed, that it could be lower than that. And you  
15 can get that reaction with a temperature less than  
16 130.

17 MR. TROSKOSKI: Well, the initiation  
18 temperature was the function of a number of things.  
19 Your constituents.

20 MR. SIEBER: Right.

21 MR. TROSKOSKI: Pressure, concentrations.  
22 I mean, that's all classical reaction kinetics.

23 MR. SIEBER: That's right. So when you  
24 set a hard and fast number and say I'm not going to  
25 let this get any hotter than this amount --

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1 MR. TROSKOSKI: That's based on a number  
2 of assumptions further down the line that you have to  
3 protect for that to be valid.

4 MR. SIEBER: Yes. Well, maybe it would be  
5 good if you told us what are the things are you  
6 controlling to make that number valid?

7 MR. TROSKOSKI: Okay.

8 MR. SIEBER: And how are they doing it?

9 MR. TROSKOSKI: Sure. That was one of the  
10 slides I think Mark had up earlier.

11 You're controlling the diluent, and that's  
12 important for two different things. One, so it doesn't  
13 impact the venting capability, and two so it doesn't  
14 add degraded products to the process.

15 Second, they're going to be controlling  
16 the resonance time of the tributyl phosphate, and what  
17 they're doing there is in effect controlling the  
18 concentration of the reaction products and  
19 constituents that you have built up over a period of  
20 time to within that assumed in the bounding heat  
21 analysis calculations.

22 Once you define that, how much mass you've  
23 got, what the constituents are, what your temperature  
24 is, then you pretty much have it enveloped where you  
25 start off and where it can end up.

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1 MR. SIEBER: Okay. That's the box you  
2 have to build?

3 MR. TROSKOSKI: That the box. And around  
4 that box what they're doing is they're going to say,  
5 ultimately I'm going to be able to remove 20 percent  
6 easy, more heat than I could possibly generate either  
7 through the reaction or through the external sources.

8 MR. ROSEN: And what you said earlier is  
9 that sort of rational is going to be applied globally  
10 and then locally?

11 MR. TROSKOSKI: Yes. Well, you have to  
12 component-by-component. That's the only way you can  
13 do a valid HAZOP. You can't do one HAZOP for the  
14 entire aqueous polishing system. You have to do by  
15 logical component-by-component. And that methodology  
16 is well known and practiced very widely throughout the  
17 chemical process industry. There are many books on  
18 it. There are companies that make their bread and  
19 butter giving training courses on it.

20 You can read it in a lot of the OSHA  
21 related process safety management literature.

22 Now, do you still feel uncomfortable about  
23 something.

24 MR. ROSEN: No.

25 MR. TROSKOSKI: Oh, okay. I'm not sure

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1 whether I was --

2 MR. ROSEN: I'll let you know.

3 MR. TROSKOSKI: Don't be shy.

4 CHAIRMAN POWERS: It's a real problem with  
5 this committee, shyness, so I'm glad that you  
6 encourage them.

7 MR. TROSKOSKI: Yes.

8 DR. KRESS: We've been given some  
9 indications of the possible chemical reactions to  
10 produce heat. We're going to balance this heat with  
11 the rate of evaporation. What sort of equation are  
12 they using to determine the rate of evaporation?

13 MR. TROSKOSKI: They have not provided  
14 that to us yet.

15 DR. KRESS: Oh. They just said that will  
16 be the -- okay.

17 MR. TROSKOSKI: Yes.

18 CHAIRMAN POWERS: Any other questions?

19 DR. LEVENSON: Just an order of magnitude,  
20 what's the heat capacity, for instance, of the  
21 evaporator when it's full of liquid compared to the  
22 amount of energy we're talking about here?

23 MR. TROSKOSKI: Well, Mark, can you help  
24 me out on that one, since your evaporator?

25 MR. KLASKY: Well, the solubility, I think

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1 we mentioned earlier. Solubility of the aqueous  
2 solution in the organic, get about 2 molar or 2½  
3 molar. So ultimately that for a given fixed quantity  
4 of organic, that's your cooling capacity. In addition  
5 you have nitric acid, which is also going to  
6 participate in the evaporative process.

7 DR. LEVENSON: I'm not asking about the  
8 evaporative process. I want to know the heat capacity  
9 of the total system evaporator plus its load of liquid  
10 if you have an incident.

11 MR. SIEBER: You may have enough heat sink  
12 to take a significant part of that.

13 CHAIRMAN POWERS: Milt, that presumes you  
14 can rapid heat transfer to the bulk of the apparatus,  
15 and it's just not going to happen.

16 DR. LEVENSON: Well, it's going to  
17 transfer to the liquid. It's in the liquid. It's  
18 going to be instantaneous transfer to the liquid.

19 CHAIRMAN POWERS: But the steel is not  
20 going to observe an instant --

21 DR. LEVENSON: The liquid is probably the  
22 bulk of it.

23 CHAIRMAN POWERS: Well, then it's just a  
24 liquid heat capacity, it's not the whole apparatus.

25 MR. KLASKY: I think one thing that will

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1 clarify, I think what we're really talking about in  
2 the way of heat transfer is really at the evaporative  
3 point it's providing the real removal -- the  
4 conductivity or the thermal conduction under certain  
5 situations if you're talking about --

6 DR. LEVENSON: Yes, I understand that. I  
7 just -- to get a feel for the significance of it, to  
8 get some kind of feel for how fast the temperature  
9 might spike or something, I need to know the heat  
10 capacity of all of the liquid in there versus the --

11 MR. TROSKOSKI: You're asking how  
12 sensitive the system is.

13 DR. LEVENSON: Yes.

14 MR. KLASKY: I think we gave you an energy  
15 content. You get about 400 joules per gram of tributyl  
16 phosphate. And we have an evaporator that's about 50  
17 liters. And we'll assume tributyl phosphate,  
18 equivalent of water capacity. Does that help in terms  
19 of characterize the thermal mass that we have?

20 DR. LEVENSON: Well, the answer that  
21 you've given is that you haven't considered this  
22 issue.

23 MR. KLASKY: I think what we've considered  
24 is that evaporative cooling in the heat transfer, not  
25 the conduction.

1 DR. LEVENSON: Yes, yes, I know. But if  
2 you tell me that the energy you release is going to  
3 spike the bulk temperature up 20 degrees, then your  
4 evaporator rate goes way up also.

5 MR. KLASKY: Correct.

6 DR. LEVENSON: But if you haven't done  
7 that analysis, then you just haven't taken the --

8 MR. KLASKY: I think we have spoken to the  
9 means by which we were going to provide heat transfer,  
10 not having done a formal count.

11 CHAIRMAN POWERS: Any other questions.

12 We've got to get on to not Han Solo, HAN  
13 nitric acid, right?

14 MR. KLASKY: HAN nitric acid. Yes.

15 CHAIRMAN POWERS: Mark, you start us on  
16 this? And this one's not so mysterious, this one's  
17 easy, right?

18 MR. KLASKY: Yes. Hydroxylamine nitrate  
19 reacting with nitric acid.

20 Okay. Briefly we'll outline our approach  
21 to safety and then get into some of the reactions that  
22 are possible in a system that is comprised of  
23 hydroxylamine, plutonium and nitric acid. And finally  
24 we'll speak on the hydrazine that also accompanies the  
25 hydroxylamine, and finally discuss our safety

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1 strategy.

2 I think our approach is precisely the same  
3 as that we described for red oil. Again, we're  
4 focusing on really understanding the fundamental  
5 chemical reactions that are taking place, their  
6 kinetic rates and the thermodynamic that accompanies  
7 those kinetics or chemical reactions.

8 Again, we've incorporated the pertinent or  
9 salient features of the DOE lessons learned. And,  
10 again, we envision testing to be performed during the  
11 integrated safety analysis or next phase of our safety  
12 analysis.

13 CHAIRMAN POWERS: Well, you're going to  
14 have done an heroic amount of work by the time you're  
15 done doing that, an exhaustive review of the  
16 literature of hydroxylamine nitrate. You have given  
17 any thought to putting it together, publishing it and  
18 get some peer review on it.

19 MR. KLASKY: I think that's precisely with  
20 respect to both red oil and hydroxylamine nitrate, I  
21 think we have, you know, a number of papers in all  
22 this work, so review papers and also the experimental  
23 results and the models that we build to, you know, in  
24 essence explain more data into something that is then  
25 used to, in essence, predict the behavior of the

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1 material in our system. So, yes, we certainly do.

2 I want to put some things into perspective  
3 here where hydroxylamine nitrate is used. It's used  
4 precisely in one part of the process, that is the  
5 purification unit. And to insure that it does not, in  
6 essence, move into other areas we have sampling that  
7 we perform to insure, for example, that it doesn't  
8 move into the oxalic precipitation unit and also down  
9 into the acid recovery unit as well. So we're very  
10 much aware of restricting the location of  
11 hydroxylamine, and this is something that we've  
12 committed to in terms of providing for safety, to  
13 really limit its propagation through the system. And  
14 I want to go into more detail in terms of precisely  
15 where with even the purification unit that we have  
16 hydroxylamine. It's a very simplified flow sheet, if  
17 you will, on hydroxylamine nitrate.

18 I think that's missing from the figure,  
19 I'll just point out that plutonium nitrate in the  
20 valent state 4 enters the extraction column. The  
21 first box. I've lost my pointer.

22 At that point what we're doing is removing  
23 the plutonium from all the actinides, so the uranium  
24 will accompany the plutonium in the extraction  
25 columns.

1           Then we have a scrub, a moving left to  
2 right, following the plutonium itself. We scrub the  
3 organic solution further removing any impurities it  
4 might have either through entrainment or just their  
5 distribution into the organic phase, we remove those  
6 impurities with a nitric acid scrub.

7           And finally we talk about where we  
8 actually introduce hydroxylamine nitrate in the  
9 hydrazine. That's the plutonium stripping column.  
10 And there what we're doing is we're using  
11 hydroxylamine nitrate to reduce the balance state of  
12 the plutonium and move the plutonium from the organic  
13 phase into the aqueous phase.

14           The uranium is subsequently moved  
15 downstream and we treat the -- we actually remove  
16 uranium in a separate unit. We have diluent wash.  
17 What that does, is we have entrained material or  
18 tributyl phosphate that's soluble in the organic phase  
19 and we can preferentially put the TBP into the organic  
20 phase and so further reduce the propagation of  
21 tributyl phosphate into the accompanying units.

22           CHAIRMAN POWERS: Before you do the strip,  
23 that's a bounded vessel?

24           MR. KLASKY: During pulse columns --  
25 actually we have a plus column and we have a mixer

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1 settler. The answer is yes.

2 CHAIRMAN POWERS: Do you get accumulation  
3 of ammonium nitrate in the vent?

4 MR. KLASKY: Not to my knowledge. Maybe  
5 when we move into the reactions that characterize the  
6 system we can talk about it. But I don't know of any  
7 accumulation of ammonium nitrate.

8 CHAIRMAN POWERS: It's always been a  
9 concern.

10 MR. KLASKY: Okay. I just want to point  
11 one more thing out. This is a once through system;  
12 that is the hydroxylamine that we use moves through  
13 the plutonium stripping, diluent wash and then we  
14 destroy it in the oxidation column. So we're not  
15 talking about continual degradation of HAN or anything  
16 of the sort. It's a once through system and in the  
17 oxidation column, that's where we change back the  
18 plutonium from 3 to 4 to facilitate its precipitation  
19 in the subsequent unit.

20 Now I want to talk about some properties  
21 of hydroxylamine. And the first point is that it's  
22 only soluble in the aqueous phase. And, as I  
23 described, it's used to extract the plutonium or  
24 separate plutonium from uranium. It's a very good  
25 reducer in that capacity. So, then on the other hand,

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1 we have the possibility of reactions with both nitric  
2 acid and itrous acid, and we describe some of the  
3 kinetics associated with those reactions.

4 There are two possible -- depending upon  
5 the ratio of plutonium to hydroxylamine nitrate, so in  
6 fact you see the reduction of plutonium and the  
7 accompanying acidification of the medium as well.

8 CHAIRMAN POWERS: The reduction by adding  
9 the nitrate to the ammonium -- to the hydroxylamine or  
10 other way around.

11 MR. KLASKY: The reagents here are  
12 hydroxylamine nitrate, which is formed in the reagent  
13 building and then it's sampled, brought in. We  
14 introduce it in two streams into the process, one into  
15 the pulse column one in the subsequent mixer/settler  
16 that is our plutonium barrier. So we form  
17 hydroxylamine nitrate in our reagent building and that  
18 is basically -- we purchase hydroxylamine nitrate, we  
19 actually dilute it to the required specifications in  
20 the process.

21 Now we get to the real meat of the issue  
22 here, why we're here. Hydroxylamine nitrate and the  
23 possible other catalytic reaction. The previous slide  
24 was really just basic plutonium reduction, which has  
25 been done for 50 years. I mean, that's precisely how

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1 this material that we are receiving was produced, by  
2 reduction. Not necessarily with hydroxylamine or  
3 other older techniques. We've chosen hydroxylamine to  
4 reduce the waste, because as I pointed out, we destroy  
5 it in the oxidation column whereas some of the other  
6 reducers that were used basically have lead to an  
7 accumulation of liquid waste. The ferrous sulfamate,  
8 for example.

9 So anyway, these are the two reactions  
10 that we have to concern ourselves with. The first of  
11 the possible autocatalytic reaction, that is we're  
12 producing three moles of nitrous acid each nitrate,  
13 and we have a scavenging reaction. HAN actually  
14 scavenges nitrous acid as well. So, again, this is a  
15 balancing act between production of nitrous acid and  
16 consumption of nitrous acid.

17 So, in order to understand this balance  
18 between these two reactions, we could develop a  
19 equation. And what we have here basically a reaction  
20 scheme that is -- or a mechanism that has been  
21 investigation for probably the last 40 years. Most of  
22 the work actually has been done, part of BNFL's work.  
23 What they basically determined is that the mechanism  
24 proceeds through the production of dinitrogen  
25 tetroxide. And under most conditions the equilibrium

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1 lies to the left. And the key to understanding this is  
2 to understand the rate at which dinitrogen tetroxide  
3 is produced.

4 Dinitrogen tetroxide reacts with HAN to  
5 produce dinitrogen trioxide and that also can react,  
6 actually water, to produce nitrous acid or the  
7 dinitrogen tetroxide can react with the nitroxyl to  
8 produce dinitrogen trioxide. The stoich geometry is  
9 basically given by the last reaction, which is a  
10 repeat of the previous slide just summing components,  
11 balancing.

12 MR. VIAL: Just something to add. We're  
13 going to show you some constant, kinetic constant  
14 layer that are referring to the first -- the two first  
15 reaction. Index 1 is going to be in reference to the  
16 first reaction and the second one, index 2, will refer  
17 to the second reaction, which has a two limiting step  
18 in the mechanism.

19 MR. KLASKY: The third and fourth  
20 reactions are very fast. You can -- that governs the  
21 behavior of this system. We spoke about these  
22 scavenging properties of the hydroxylamine. Here  
23 we're using hydroxylamine ion, which is just the  
24 ionized HAN. And as Mark referred to, we have  
25 reaction constants  $k_1$ , which is the rate at which

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1 dinitrogen tetroxide is produced. K-1, which is the  
2 back reaction. K-2 which is the reaction between HAN  
3 or hydroxylamine ion and the dinitrogen tetroxide.  
4 And k-3, which is the scavenging late constant.

5 CHAIRMAN POWERS: I don't understand why  
6 you put a stay state approximation on the HNO and  
7 N<sub>2</sub>O<sub>3</sub>. I can understand why you take the rate of  
8 change of the concentrations of the HNO and the N<sub>2</sub>O<sub>3</sub>  
9 is zero. I don't understand why you can set the rate  
10 of change in the concentration in the N<sub>2</sub>O<sub>4</sub> to zero.

11 MR. KLASKY: We are not doing that. Are  
12 you referring to the third reaction, the dinitrogen  
13 tetroxide with the nitroxyl?

14 CHAIRMAN POWERS: I'm referring to you're  
15 deriving it by applying the steady state approximation  
16 to the species. Now, to me that means that you're  
17 saving the rate of change of that concentrations to  
18 zero in order to drive this whole overall rate  
19 constant. Because you're arguing that thy are low  
20 concentration intermediates in the reactions.

21 MR. KLASKY: Yes.

22 CHAIRMAN POWERS: And that's perfectly  
23 understandable for the HNO and the N<sub>2</sub>O<sub>3</sub>. I'm not sure  
24 I understand why it's justified for the N<sub>2</sub>O<sub>4</sub>.

25 MR. KLASKY: Reaction 1 we're not taking

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1 the steady state. We're deriving the rate law for the  
2 first reaction. We're taking the steady state --  
3 we're making the steady state approximation for  
4 reactions 2 and 3, as you indicated.

5 CHAIRMAN POWERS: Why do you list  $N_2O_4$  in  
6 your slide as being part of the steady state here?

7 MR. VIAL: Well, actually we use a steady  
8 state approximation for reaction 2 as well.

9 CHAIRMAN POWERS: Put your next slide.

10 MR. VIAL: Yes. This one.

11 CHAIRMAN POWERS: See, you say we take the  
12 steady state approximation 2,  $N_2O_4$ , HNO and  $N_2O_3$ . And  
13 the last two I can understand why you do that. It's  
14 not clear to me why you make that approximation on  
15  $N_2O_4$ . Now you're saying you misprinted on the slide?

16 MR. VIAL: No, no, no. It's --

17 MR. KLASKY: I think he's referring to the  
18 third -- it's the third reaction. It shouldn't be the  
19 second reaction where that approximation is made.

20 CHAIRMAN POWERS: I will bet that in fact  
21 when you went through -- that you still set the  $N_2O_4$ ,  
22 the time rate of change of the  $N_2O_4$  concentration to  
23 zero. But I don't know.

24 MR. KLASKY: No. My recollection is that  
25 the reaction two HAN and  $N_2O_4$  is not -- we do not make

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1 that approximation. But we can get back to you on  
2 that.

3 CHAIRMAN POWERS: I'm just reading what  
4 you said on your slide.

5 MR. KLASKY: Right. And I think it's taken  
6 out of context.  $N_2O_4$  reaction with the nitroxyl is  
7 where we made that approximation. And that's the only  
8 place where we made it with respect to  $N_2O_4$ .

9 CHAIRMAN POWERS: You had to do something  
10 with the  $N_2O_3$  as well.

11 MR. KLASKY: The  $N_2O_3$  is definitely a fast  
12 reaction, either between --

13 MR. VIAL: But I think  $N_2O_4$  refer to this  
14 reaction.

15 MR. KLASKY: Yes. We'll check that.

16 CHAIRMAN POWERS: I mean, I'm just reading  
17 what your words are.

18 MR. KLASKY: So the question is why are we  
19 interested in this reaction. Well, I think as we have  
20 shown in the previous slide, it's autocatalytic and  
21 also it's releasing a substantial amount of energy  
22 accompanying the autocatalytic reaction. So it's  
23 important to prevent this runaway reaction in our  
24 process. So, consequently, what we're going to do is  
25 to try to understand our system and understand those

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1 rate constants to predict stability. But before we do  
2 that, we introduce one more detail, and that is we're  
3 reducing plutonium to valent state III. There's always  
4 potential under certain regimes for plutonium to  
5 reoxidize. And in so doing, the re-oxidation of  
6 plutonium basically proceeds much in the same manner  
7 as the mechanism by which we produce autocatalytically  
8 nitrous acid, that is we go through a dinitrogen  
9 tetroxide mechanism. So another aspect of this  
10 problem is to prevent re-oxidation of plutonium,  
11 because it's another source for producing nitrous  
12 acid.

13 CHAIRMAN POWERS: Is it true that only the  
14 dimmers has reacted toward the trivalent?

15 MR. KLASKY: I don't know the answer to  
16 that question.

17 MR. VIAL: I don't know --

18 CHAIRMAN POWERS: Well, I mean that's the  
19 way you've written it. You've written it as though --

20 MR. KLASKY: But I -- you know --

21 CHAIRMAN POWERS: The monomer is  
22 nonreactive and --

23 MR. VIAL: Yes.

24 CHAIRMAN POWERS: And assuredly the --

25 MR. VIAL: If you combine and it's through

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1 the  $N_2O_4$ , yes.

2 MR. KLASKY: I mean, this is one  
3 postulated reaction mechanism.

4 MR. TRIPP: The fact is in the literature  
5 you're going to see that some people like this  
6 equation instead of considering dinitrogen tetroxide.  
7 They're going to consider the nitrous acid. But it's  
8 not the reactive species that's going to react. The  
9 reactive species in -- is  $N_2O_4$  because you have the  
10 equilibrium where you have -- this equilibrium is  
11 really to the right. So the species you have in  
12 solution is mainly  $N_2O_4$ . And what you're going to have  
13 is, you're going to have this exchange of electron.  
14 You're going to have your two nitrogen is your 4  
15 oxygen and -- and you're going to have a kind of --  
16 where you going to reduce -- where you're going to  
17 oxidize your plutonium by transferring an electron and  
18 thus removing one molecule of  $NO_2$  out of your  $N_2O_4$ .  
19 That's why you are producing these two species.

20 CHAIRMAN POWERS: Going to take an inner  
21 sphere transfer?

22 MR. VIAL: Well, I think what you're going  
23 to have is you won't have a 1, 2, 1. What you're  
24 going to have is you're going to have your plutonium  
25 and you might have 2 and 2 and 4 on each side in a

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1 kind of assembly like this where you're going to --  
2 and you're going to have the exchange. That's what's  
3 going to justify the formation of -- because you're  
4 going to have one that's going to catch more electron  
5 than the other one. This one is more stable species.  
6 And you're going to have your negative charge because  
7 of -- in your system you won't have a strictly one to  
8 one ratio of plutonium over  $N_2O_4$ . So depending on the  
9 arrangement of the molecule between themselves, you're  
10 going to produce these -- well, one ionic species and  
11 the other one, which is just  $NO_2$ . That's going to  
12 going recombine very quick with another  $NO_2$ . Because  
13 they are really close together. You have a really fast  
14 reaction of -- not dimerization, but formation of  $N_2O_4$   
15 that this will happen. And that's why over all you're  
16 going to start -- what you have to consider is not one  
17 cycle, it's two cycle and every -- well, actually,  
18 three cycle every -- three cycles which you're going  
19 producing -- you're going to produce 1.5 molecule of  
20 nitrous acid. That's why this reaction is also  
21 autocatalytic. Because it's going to produce more  
22 nitrous component that you use.

23 You follow me? No, maybe not.

24 CHAIRMAN POWERS: Yes. It just seems to me  
25 that I would have run an inner sphere reaction on it.

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1 Because then I don't have to substitute in on the  
2 plutonium, which will give you flow step in the  
3 process that you haven't built here. I mean an inner  
4 sphere reaction seems to me -- okay.

5 I mean, I -- I just don't know this  
6 chemistry, so I can't tell you what the kinetics is.  
7 But I wouldn't have guessed that it was only --

8 MR. VIAL: Well, the other component to  
9 take into account is the media. And depending on the  
10 acidity of the association coefficient -- and it's  
11 going to also drive the prediction of your NO two  
12 minus.

13 MR. KLASKY: Okay. I think that's the  
14 important thing. Remember this reduction reaction is  
15 we're really maintaining low acidity. And, Mark, we  
16 have a backup slide. Let me go to the written law for  
17 plutonium reduction.

18 And the reason is that we have a  
19 dependency to develop a written law for plutonium  
20 reduction which is dependent on -- or inversely  
21 proportional to the fourth power of acidity. So we  
22 basically want to operate, you know, as low as  
23 possible but we have other constraints as well on the  
24 process.

25 CHAIRMAN POWERS: Are we going to discuss

1 plutonium hydroxide precipitation in this?

2 MR. KLASKY: We weren't planning to today.  
3 You're talking polymerization as well. Polymerization  
4 is something that we can talk about.

5 CHAIRMAN POWERS: Go ahead.

6 MR. KLASKY: Okay. So basically with  
7 respect to the control of hydroxylamine nitrate, the  
8 DOE has developed an empirical relationship, an  
9 instability index.

10 And, Mark, you throw back the weight law  
11 you can see that the weight law -- no. Throw the  
12 nitrous acid back.

13 Basically you have a competition. You  
14 want to insure that the  $k_3$  term is larger than the  
15 first term. And in so doing then, you have a decaying  
16 solution of nitrous acid.

17 So the bottom line is that, you know, if  
18 you want a strong nitrous acid scavenging agent. If  
19 you can -- now and to a certain extent if your  
20 concentration of hydroxylamine nitrate is large  
21 enough, hydroxylamine nitrate can hold the plutonium  
22 or, in this case, prevent the autocatalytic reaction  
23 in so doing. But when you do this, you have to be  
24 very careful in terms of temperature. Nitric acid  
25 constraints. Because those constants,  $k_1$ ,  $k_{-1}$

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1 and k2 and k3 are very dependent on temperature and  
2 also nitric acid concentration, also ionic strength  
3 of--

4 CHAIRMAN POWERS: I hope the k3 -- I mean,  
5 k1 and k2 are not concentration.

6 MR. KLASKY: Of nitric acid?

7 CHAIRMAN POWERS: Yes.

8 MR. KLASKY: Well, k1 is the production of  
9 dinitrogen tetroxide and it actually is very dependent  
10 on nitric acid concentration.

11 CHAIRMAN POWERS: IF they were rate  
12 constants, they better not be dependent on  
13 concentrations or we're going to rework this whole  
14 thing.

15 MR. VIAL: Exactly. And that's why you  
16 have the term -- and not the minus. That's where you  
17 have HNO<sub>3</sub>. Okay. One is mainly dependent on the  
18 temperature.

19 MR. KLASKY: Okay. I stand corrected.

20 Let's see. So k3 is the scavenging  
21 properties of the hydroxylamine nitrate. And the  
22 instability index that DOE had developed is built on  
23 control of both temperature, concentration nitric acid  
24 and the hydroxylamine concentration.

25 MR. VIAL: Want to show it?

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1 MR. KLASKY: No, that's okay.

2 But I think what we've recognized in that  
3 we use hydrogen in our process to basically hold the  
4 plutonium to make sure that we don't have re-  
5 oxidization of the plutonium. And we can also use  
6 hydrazine to demonstrate that the production of  
7 dinitrogen tetroxide is basically -- we're interfering  
8 with the mechanism. That is, we're scavenging the  
9 nitrous acid. So in so doing we basically prevent the  
10 autocatalytic reaction from occurring.

11 So the next slide depicts relative  
12 reaction rates for hydrazine to show you just how  
13 effective hydrazine is scavenging nitrous acid from  
14 the system. And this is precisely what we want to  
15 utilize to insure that we don't have an autocatalytic  
16 reaction, that is by ensuring that we have a  
17 concentration of hydrazine present that is sufficient  
18 to balance the production that is going through the  
19 production of dinitrogen tetroxide, we can assure that  
20 we don't enter an autocatalytic regime.

21 So the equation that we presented the rate  
22 law, obviously, would be modified to add an additional  
23 term, and that is the scavenging of nitrous acid via  
24 hydrazine.

25 And this is, in effect, what we've

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1 describe in the Construction Authorization Request.  
2 We've identified the fact that hydrazine has this  
3 property of being a very effective nitrous acid  
4 scavenging agent and so this is an open item with the  
5 NRC, but we intend to demonstrate a de minimis  
6 quantity of hydrazine is effective in precluding the  
7 autocatalytic reaction. And currently we've identified  
8 concentration of HAN and hydrazine along with constant  
9 safety control as providing for a stable boundary.

10 CHAIRMAN POWERS: You used the work "de  
11 minimis."

12 MR. KLASKY: Yes.

13 CHAIRMAN POWERS: Which has long ago been  
14 forbidden from this room by act of Congress. Some  
15 people know the story, so I won't go into it.

16 I assume you were just being colloquial in  
17 your use of de minimis?

18 MR. KLASKY: Yes, yes, yes.

19 MR. ROSEN: It means "a little bit of."

20 MR. KLASKY: I think, you know, the  
21 relative rates -- I guess if you start of with the --  
22 you know, understanding that you can demonstrate and  
23 DOE has established an instability index. And we've  
24 pointed out, and Bill, I think you'll go into the  
25 rational for why we're not using it. And I can -- I

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1 don't want to step on Bill's toes, but we can go into  
2 that if you want.

3 CHAIRMAN POWERS: No. I mean just the  
4 language you used, what you're talking about is that  
5 you're going to use a low concentration of hydrazine  
6 in the solution.

7 MR. KLASKY: Correct.

8 CHAIRMAN POWERS: So that you're going to  
9 bring those rates so they're roughly equal or what is  
10 it?

11 MR. KLASKY: No. I think we're going to be  
12 just order of magnitude estimate. You know, we said  
13 we were going to do testing, and this is certainly one  
14 of the areas in which we're going to do testing.

15 There have been two studies to my  
16 knowledge that have attempted to quantify this de  
17 minimis concentration, if you will. And they found  
18 about five times to the minus four of molar or normal  
19 to be sufficient.

20 We're starting with .14. So that just puts  
21 things in perspective. That's why I say die minimis.  
22 I just meant it with respect to what we're adding.

23 CHAIRMAN POWERS: In my world those are  
24 highly concentrated solutions.

25 MR. KLASKY: Yes. So, I think we're

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1 certainly operating this plant with a pretty  
2 sufficient, or I should say a sufficient margin. But  
3 this is something that we're going to validate in the  
4 ISA.

5 CHAIRMAN POWERS: Okay.

6 DR. FORD: Could I follow up on Mr.  
7 Rosen's question later on about controlled by  
8 monitoring either globally or locally?

9 What this is sensitivity of this control  
10 to where you do the monitoring?

11 MR. KLASKY: Right now what we do is we  
12 monitor -- or I should say we sample to ensure that  
13 the quantity of hydrazone that we have is, you know,  
14 the requisite amount going into the process. And I  
15 think I've described the fact that it's a once through  
16 system so that, you know, each step through once it  
17 hits the oxidation column it's destroyed. If isn't  
18 destroyed right there, before it goes into the next  
19 process unit -- or I should say process operation, we  
20 sample, we ensure that it's gone. That is, hydrazine  
21 is removed and also hydroxylamine as well.

22 So, the sampling is coming in and going  
23 out. That's where we're implementing these controls.

24 I think that's it.

25 DR. RYAN: Mr. Chairman. I think this is

1 our last chemistry presentation. And before we leave,  
2 I've been --

3 CHAIRMAN POWERS: Don't count on it.

4 DR. RYAN: On the agenda, anyway.

5 CHAIRMAN POWERS: We have at least one  
6 more.

7 DR. RYAN: Okay. That's great.

8 The thought strikes me have you tried to  
9 optimize any of these processes with regard to your  
10 waste generation? It looks like you're going to  
11 generate lots of mixed waste, and I'm not sure if it's  
12 mixed TRU or mixed SNM, or mixed spent fuel, or all  
13 three. But in your process analysis, particularly  
14 your hazard analysis, looking at waste generation  
15 might not be a bad thing. You might end up producing  
16 less troublesome waste if you took a look at that end  
17 point in order to help you figure out your chemistry.

18 Have you done that sort of thing yet?

19 MR. KLASKY: I think the adoption of  
20 hydrazine and hydrogen is precisely done for that  
21 reason.

22 DR. RYAN: What reason is that? What is  
23 the -- it's to minimize quantity or --

24 MR. KLASKY: To minimize quantity of  
25 waste, yes.

1 DR. RYAN: Okay.

2 MR. KLASKY: Before, as I pointed out, the  
3 ferrous sulfamate used to be used and there were a lot  
4 of material issues that were introduced when one uses  
5 the ferrous sulfamate. And in addition, in the end you  
6 were left with, you know, certainly waste. And if you  
7 go to Hanford or Savannah River early, you wind up  
8 with waste. And in this process, you know, sort of  
9 the whole benefit of this is that you minimize that or  
10 you eliminate that from your outgoing stream. You  
11 don't have that.

12 So, I think that's a large part of the  
13 reason for selection hydroxylamine.

14 DR. RYAN: Thanks.

15 You know, I guess I would extend that from  
16 this particular chemical to your entire process.  
17 Analysis to think carefully about what waste you might  
18 be generating, what metals you could be leeching  
19 because you might end up with either characteristic  
20 mixed waste or true mixed waste that you can't, you  
21 know, have an outlet for. That's something certainly  
22 to think about.

23 DR. LEVENSON: How far do you go in your  
24 waste treatment, or did you ask that? What's your end  
25 point for your waste?

1 MR. KLASKY: Oh. Let's see, Mark, you  
2 want the first slide up on the process.

3 DR. LEVENSON: I saw one arrow that said  
4 your organic waste goes to SRS.

5 MR. KLASKY: Okay.

6 DR. LEVENSON: You didn't say anything  
7 about any of the aqueous wastes.

8 MR. KLASKY: All of our wastes go into a  
9 waste treatment unit. I think you'll see it's a waste  
10 treatment -- we have a unit --

11 DR. LEVENSON: What does waste treatment  
12 consist of? What's your end product? Do you go all  
13 the way to glass. Do you ship the liquid somewhere?

14 MR. KLASKY: The liquids are shipped to  
15 Savannah River for treatment.

16 DR. LEVENSON: So the ultimate disposal is  
17 Savannah River's problem?

18 MR. KLASKY: Correct. Well, let me just  
19 point out what we do in waste treatment. We're  
20 combining a number of waste streams. And before we  
21 combine a couple of the waste streams, we have a  
22 process that -- we destroy any azides that might have  
23 formed. So that's our main focus of the waste unit.  
24 And the subsequent volume reduction and whatnot is  
25 done, to my knowledge, at Savannah River.

1 DR. RYAN: There's another dimension that  
2 you've got to take into account, and that is to the  
3 best you can predict what end points the wastes are  
4 going to have, what they're going to look like both in  
5 terms of chemical and constituents and radiological  
6 constituents.

7 Please be careful that you have an outlet  
8 for those wastes, because you might find that you want  
9 to modify your treatment in order to make the waste  
10 acceptable for disposal somewhere, whether it's WIPP  
11 or somewhere else. You need to think about it. But  
12 don't think about it in terms of chemical process.  
13 That's certainly one way to think about it. Think  
14 about it in terms of making an acceptable waste for  
15 disposal.

16 MR. KLASKY: Right. I think we have --  
17 maybe Ken, you can speak to this. The WAC.

18 MR. ASHE: Right. Ken Ashe.

19 That's correct. We do have with Savannah  
20 River site Waste Acceptance Criteria, and we are  
21 actively looking at the waste that we product and make  
22 sure that they can receive it before we send it.

23 DR. RYAN: Okay. So that fits into the  
24 treatment and disposal scheme?

25 MR. ASHE: That's correct.