

1 The design is such that if we find that
2 there are changes in this correlation and we need to
3 go to a more filter media area, the design can
4 accommodate that.

5 We're doing moisture analysis to insure
6 that what we said about dilution is true. And we're
7 doing fault tree and single failure analysis of the
8 systems to insure that such thing as global loss of
9 facility power doesn't cause us to lose all the
10 ventilation fans and other single failure type
11 problems.

12 We're doing an HVAC transient disturbance
13 analysis to make sure that we don't have small
14 perturbations in the system flow causing reverse flow
15 in other parts of the system and then causing operator
16 exposure and dose.

17 And then we're looking at the effects of
18 internal explosions.

19 All these analyses consider uncertainties.
20 For the soot loading, we take the two largest soot
21 generating fire events and lump them together. Even
22 though those events occur in separate fire areas.

23 The same for the dilution error
24 temperature analysis. We'll use the areas that
25 generate the highest temperature air flow total heat

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1 content going to the HEPA filters in order to bound
2 our dilution.

3 And as I said, we're having independent
4 empirical verification of the filtration system
5 performance by the soot loading experiments. And that
6 will be completed for the ISA.

7 CHAIRMAN POWERS: Do you verify the fact
8 that when you take a very hot gas, inject it with the
9 rest of the gases that you're going to bring into the
10 system that in fact it will mix? It won't get
11 stratified fully?

12 MR. ST. LOUIS: We've committed to look at
13 that phenomena as part of the ISA process.

14 CHAIRMAN POWERS: Good.

15 DR. LEVENSON: Is there any probability at
16 all that sometime in the first teen years or so of
17 operation you might want to change the diluent?

18 The context of my question is you're doing
19 a fire analysis based on a specific material. You
20 might want to think about whether you want to at this
21 stage take a look at other possible diluents so that
22 if you decide process wise you want to change it, you
23 haven't locked yourself in on something. It would not
24 take much effort right now to do the arithmetic.

25 MR. KIMURA: The diluent --

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1 DR. LEVENSON: The total amount of soot,
2 total quantity, that sort of thing.

3 MR. KIMURA: Yes. Where we handle mixed
4 oxide power, we have nitrogen as the main diluent in
5 the gloveboxes.

6 DR. LEVENSON: The diluent in the solvent
7 extraction.

8 MR. ASHE: Excuse me. This is Ken Ashe.

9 Right now we've got a design that we're
10 going to propose, and that's the one that we're going
11 to go forward with. If we change something that
12 significant, then obviously we'd have to go back to
13 the staff with that. But I don't believe it's our
14 intent at this point to change the diluent.

15 MR. KIMURA: All right. This slide just
16 summarizes the filtration loading experiment program.

17 As I stated, that the filter design is
18 based on previous studies that have been done. There
19 is a lot of data on burning PMMA cribs. A crib is
20 just a stack of combustible materials, like a stack of
21 firewood. And the studies were done by Gaskill and
22 Fenton, others at Lawrence Livermore in room sized
23 combustion chambers. To characterize the burning of
24 that type of soot, they burned wood, they burned other
25 materials.

1 Ballinger up at Pacific Northwest
2 characterized burning solvent on top of water. So
3 different types of diluents and stuff, and different
4 soots and combustibles generated different soots. Some
5 were long-chain agglomerates, others were relative
6 dry.

7 For PMMA Gaskill found that unless he
8 added water to the stream, it was very hard for him to
9 the HEPA filters to clog.

10 So what we're going to look at is we're
11 going to look at how soot is distributed throughout
12 the filter system. As I stated, our design basis to
13 collect -- to filter out all the embers and brands at
14 the roughing filter stage, collect most of the soot on
15 the high-efficiency stainless stain prefilter and then
16 have very little soot actually appear on the final
17 HEPA filters.

18 We're going to look at the delta p change
19 as soot is loaded up. And we're going to look at the
20 flow rate through the system, make sure we're not
21 going down to zero and clogging up our filter system.
22 And then we're going to determine the ultimate soot
23 loading capacity based on the characteristic soot that
24 we're generating.

25 This is what we anticipate to be pretty

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1 much our design for the HDE final filters. Stainless
2 steel housing, bag in, bag out ports for each of the
3 filter elements. Test ports, isolation valves so we
4 can do our testing.

5 I've mentioned a lot of historical fires
6 and other events that we used in order to evaluate our
7 filter design -- do our filter design. The key
8 lessons learned that came out, was to use
9 noncombustible materials.

10 You have to some means to protect the
11 final filter elements.

12 Dilution air is preferable over water
13 sprays to protect them excessive temperatures.

14 The duct with several bends will attenuate
15 any effects from rapid pressure excursions in order to
16 keep fires from going from one fire zone to the other.
17 There's fire isolation valves that allow us to isolate
18 system or fire wrapping to keep the duct from causing
19 secondly fires in other rooms.

20 And the building itself has multiple
21 confinement zones, so that if the primary confinement,
22 C4 area, starts to leak into C3, C3 will contain that
23 leak. And if C3 leaks, C2 will contain that leak.

24 And finally, that we keep the
25 contamination potential of the final HEPA filter

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1 element low. We don't allow material to build up.

2 The conclusion is that we think that we're
3 protecting the HEPA filters from severe environmental
4 conditions. We've accounted for various design basis
5 events scenarios, included the uncertainties in the
6 analyses that we conducted, that we have an historical
7 basis for each of the elements that make up the HEPA
8 filters, and that the combined total of all of these
9 features make the MFFF final HEPA filter design very
10 robust.

11 CHAIRMAN POWERS: Any questions of the
12 speaker.

13 Thank you.

14 We'll move to Ms. McDonald.

15 MR. JOHNSON: My name is Tim Johnson, and
16 I'm the principal reviewer for the ventilation system.

17 And what I'd like to -- if I can get this
18 thing to move here. Is to talk about our ventilation
19 system review.

20 Basically we're looking at the ability of
21 the principal structures, systems and components to
22 perform under various conditions during the required
23 confinement. And in addition, we were also looking at
24 defense-in-depth, and that's primarily redundancy of
25 system components.

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1 CHAIRMAN POWERS: In the redundancy,
2 there's lot of redundancy that we see in this system,
3 but not much diversity, it seems to me.

4 MR. JOHNSON: Well, I believe that if you
5 look at the entire confinement system, there is
6 diversity. And the diversities are in both the static
7 and dynamic barriers that are part of the design. And
8 by static barriers I'm talking about walls, gloveboxes
9 and the dynamic systems are the actual ventilation
10 systems that have active components with it.

11 In our review of the system, we basically
12 have two open items, and I'd like to talk about each
13 of those in a little bit more depth.

14 In our review of the proposed system we
15 feel that the system can function under severe
16 conditions. The question was what should be the
17 allowable removal efficiency for particulates. And in
18 our guidance we recommended that for severe conditions
19 that credit be not taken for more than 95 to 99
20 percent removal of particulates under severe
21 conditions. For example, such as a fire.

22 And what DCS is proposing is to have a
23 release fraction of 10^{-4} , which is basically a 99.99
24 percent efficiency. And we recognize that there have
25 been fires and filters that have -0 filter systems

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1 that have damaged HEPA filters. And we were very
2 concerned about the uncertainties in that. And
3 because of that we asked DCS for further justification
4 on why they felt that 10^{-4} release fraction would be
5 acceptable.

6 They provided some further information to
7 us in February and 2 weeks ago. We're still
8 considering that response, but we haven't made
9 changes. Basically the information came in too late
10 for us to make changes into the draft Safety
11 Evaluation Report. So we're still carrying that as an
12 open item while our review continues. But certainly
13 what they've proposed is more robust than what they
14 proposed originally in the Construction Authorization
15 Request. So we feel we're moving in the right
16 direction here.

17 MR. SHACK: What release fraction do they
18 have to have?

19 MR. JOHNSON: I'm sorry?

20 MR. SHACK: What release fraction do they
21 have to have?

22 MR. JOHNSON: At least 99 percent in a
23 well designed system. And what they're proposing is
24 that they retain 99 percent credit for each of the two
25 HEPA filter banks. So basically they're saying that

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1 under severe conditions both HEPA filters will survive
2 and be functioning. And by intent each HEPA filter,
3 you know, should be well over 99.9 percent efficiency
4 efficient. But, you know, with various aging effects,
5 maybe problems in installation where there's
6 additional bypass, in practice the NRC hasn't given
7 full 99.97 percent efficiency for HEPA filters. And
8 our regulatory guidance has been 99 percent.

9 The second open item is one that Sharon
10 talked about, and that's related to the soot loading.
11 And when we try to duplicate their calculations that
12 they submitted to us previously, we couldn't duplicate
13 them. And we asked for additional information on that.
14 And, again, more information was provided in February
15 and April, and, again, we're still considering that,
16 as Sharon mentioned.

17 If the soot loadings get too high, the
18 HEPA filters could fail under pressure loading, under
19 pressure drop loading.

20 CHAIRMAN POWERS: They have proposed a lot
21 of experimental studies. And discussed the
22 complexities of soot as far as of the shape. We know
23 the agglomerate -- the primary particle sizes are
24 probably right around the maximum penetrate in size,
25 but the agglomerates tend to be long-chain ugly

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1 looking things. And then they're proposing these
2 experiments to validate their models.

3 If you had thought about this issue, that
4 we know that particles that are made up of
5 agglomerates change their geometry in response to the
6 relative humidity. We have a very dry system here
7 with nitrogen as the purge as, and whatnot. The
8 experiments will be done under some other
9 circumstance. And are we likely to get data that's
10 just not applicable here, or what's your thinking on
11 this?

12 MR. JOHNSON: Well, you're right, there
13 are uncertainties in here. And that's one of the
14 reasons why the amount of credit that's given is well
15 less than -- you know, a manufacturer's 99.97 percent
16 efficient with .3 micron particles. And it's why they
17 do a leak test on installation. And, again, the
18 objective is to have no more than .05 percent bypass.
19 But I don't expect those kind of changes to
20 substantially make up a difference of two orders of
21 magnitude in the overall efficiency.

22 So I think we're still conservative. And
23 if you look at actual systems, HEPA filters are used
24 in a number of plutonium systems in DOE. And they get
25 pretty good performance out of them.

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1 CHAIRMAN POWERS: When they install them
2 correctly.

3 MR. JOHNSON: Yes, when you install them
4 correctly and you don't have fires, like we've had at
5 Rocky Flats.

6 DR. LEVENSON: Well, the fraction of the
7 gas that might be coming from an inerted facility
8 compared to room exhaust because of your mixing and
9 blending system, you probably can't get very much of
10 a change in the moisture content at the final filters.
11 It'll be whatever is your incoming controlled
12 humidity, won't it?

13 MR. JOHNSON: Well, the C4 system is your
14 glovebox system. And that is going to have mostly
15 inerted gas --

16 DR. LEVENSON: Yes. But what I'm saying is
17 that --

18 MR. JOHNSON: And that's a separate
19 system. So that'll probably stay pretty much the same.
20 But the C3 and C2 systems, they use ambient air that
21 is -- comes in from the supply.

22 DR. LEVENSON: But isn't the C4 system
23 diluted with the others before it gets to the final
24 filters?

25 MR. JOHNSON: Well, it's diluted by the C4

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1 streams from different fire areas.

2 DR. LEVENSON: Okay. So there's not one
3 set of final filters then?

4 MR. JOHNSON: There's one set of final
5 filters, but it takes input from various gloveboxes
6 and various fire --

7 DR. LEVENSON: No, no. What I mean is the
8 implication that I got from before was that there was
9 one set of final filters, and the dilution air came
10 from the various areas, is that incorrect?

11 MR. JOHNSON: There are final filters
12 separate for the C4 system. And separate ones for C3.

13 DR. LEVENSON: Okay. Each is -- okay.

14 MR. JOHNSON: And separate ones for C2.

15 DR. LEVENSON: Okay.

16 MR. JOHNSON: My only slide is a summary
17 slide, and it basically just restates the two open
18 items that we're carrying in the draft Safety
19 Evaluation Report, and they are the HEPA filter
20 removal efficiency credit and the soot loading. And,
21 again, both of those areas are still under review.
22 But, again, I believe we're going in the right
23 direction with both of these from the responses that
24 we've recently received from DCS.

25 Are there any other questions?

1 DR. KRESS: I'm sorry. Where did the
2 standard review plan -- 99 percent credit come from?

3 MR. JOHNSON: Well, it's based on what has
4 been used prior to that in Reg Guide 1.52 for
5 engineered safety filter systems -- safety feature
6 systems for reactors. That's the primary basis for
7 it.

8 CHAIRMAN POWERS: It's been in the DOE
9 evaluation for as long as I can remember.

10 MR. JOHNSON: Yes.

11 DR. KRESS: My basic question is where
12 does it come from?

13 CHAIRMAN POWERS: I have no idea.

14 DR. LEVENSON: It's been around a long
15 time. IT doesn't necessarily apply to systems --

16 MR. JOHNSON: We got a man with an answer
17 here. Well, Dr. Bergman can fill us in on that.

18 DR. BERGMAN: As Tim pointed out, Bergman
19 with DCS.

20 The 95 percent -- 99 percent came from Reg
21 Guide 1.52 which has been, I think, talking with Roger
22 Savadowski, he was kicking it around back amongst the
23 first drafts, he and Humphrey Gilbert.

24 The issues of what efficiency. The DOE has
25 regularly used under accident conditions credit of

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1 99.9 percent for the first stage 99.8 percent, but
2 that was based on best engineering judgments of a
3 meeting held in Albuquerque in 1971.

4 The problem with --

5 CHAIRMAN POWERS: I hasten to point out I
6 didn't attend.

7 PARTICIPANT: You weren't even born yet.

8 DR. BERGMAN: There's been a lot of work
9 done since that time. And so if one were to convene
10 the world's experts and establish what kind of credits
11 you can get for it, we attempted to do that. And DOE
12 almost came very close to issuing a DOE standard on
13 this very subject, but there was a changing of the
14 guard in headquarters and monies ran out, and
15 consequently usually when money stops, work stops.

16 But we did manage to publish a paper.
17 Myself, Mel First, Humphrey Gilbert and Wendell
18 Anderson co-authored -- and Jack Jacox, co-authored a
19 paper in which we reviewed all the available data and
20 we compiled a series of efficiencies you can use for
21 HEPA filters under various accident conditions.

22 And it's very clear if you meet the
23 conditions, the environmental conditions and assault
24 conditions for a HEPA filter, you can claim a variety
25 of efficiencies.

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1 For example, if you meet the temperature,
2 pressure, moisture conditions, you can very readily
3 claim 99.9 percent for each filter. DCS has chosen to
4 be very conservative and 99 percent. But the idea is
5 you can also find a condition where 80 percent is very
6 questionable, even 50 percent is questionable. If you
7 look at a filter that's been subjected to a tornado,
8 you just see a great big hole where there used to be
9 a HEPA filter.

10 So the idea, it's not a one cookie cutter,
11 one size fits all. It's on a case-by-case basis. And
12 this was really the bottom line of the whole consensus
13 and analysis from -- in fact, my supervisor, you know,
14 Wendell Anderson, Humphrey Gilbert, Mel First. And so
15 that was our conclusion.

16 Thank you.

17 CHAIRMAN POWERS: Okay. We arrived to the
18 point of closing comments. And I'm not sure whose
19 going first here. I know Peter Hastings is not going.
20 We're going to have to do something to Peter. He
21 carries the heavy lifting next time, right.

22 MR. JOHNSON: I'll pass that along.

23 CHAIRMAN POWERS: Yes. So Drew is going to
24 go first.

25 MR. PERSINKO: Yes. I just have a short

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1 concluding remarks here.

2 I have on the screen a bargraph of where
3 we were a year ago, what's happened in the middle and
4 where we are today in terms of numbers of open items.

5 A year ago there were approximately 57
6 open items. That was in the draft Safety Evaluation
7 Report published last April.

8 The number of items actually went up as we
9 reviewed the revised Construction Authorization
10 Request up to approximately 66.

11 Where we are today is that there are 19
12 open items. The revised draft Safety Evaluation
13 Report will show 19 open items. Of those 19 items, 14
14 of those we are -- DCS will be providing information.
15 And 5 of those are currently under review.

16 I'd also like to say of the 19 open items,
17 we talked today about 6 of them in depth. When we met
18 with you a year ago, we gave you the across the board
19 view of all the open items. Today we picked 6, what we
20 thought major ones, and discussed them with you in
21 depth today.

22 So, you can see where we were a year ago,
23 where we are today. Our plan is to continue to review
24 the information and review the information that is
25 provided by DCS, and most likely we'll be having

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1 additional meetings with the applicant.

2 CHAIRMAN POWERS: Well, it's not with the
3 applicant, but the meetings with us, that's the
4 question I want to pose here.

5 Our obligation, of course, this is
6 something the Commission has explicitly asked to
7 report on to them. But my question is in engineering
8 judgment or administrative judgment issue here, is
9 that as we resolve these and the point where you say,
10 yes, we're happy with everything, do we need to do it
11 in a Subcommittee format before we go to the full
12 committee or can we go directly to the full committee
13 given that I will do my best to educate the full
14 committee prior to you getting there?

15 MR. PERSINKO: I would think you could go
16 straight to the full committee. I think you could.

17 CHAIRMAN POWERS: I'm going to ask you
18 guys the same question.

19 MR. ASHE: This is Ken Ashe.

20 We believe that we've given you a lot of
21 information today. And if you look at our Construction
22 Authorization Request and the draft SER, you should
23 get a very good picture of where we are.

24 We also believe that as we go forward with
25 the staff working with the staff, they should be able

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1 to keep you abreast of where we stand so you can go to
2 the full committee.

3 CHAIRMAN POWERS: Right now my prejudice
4 is given that the resolution of the outstanding issues
5 does not elicit controversy. In fact, forget a
6 resolution. That everybody's happy. That we'll go
7 straight to the committee on this rather than having
8 another Subcommittee.

9 Now, of course, if -- rises in there or
10 things need a bigger discussion, we're perfectly
11 willing to have another Subcommittee meeting. But
12 that's the strategy I would like to pursue is that --
13 the plan will be success oriented in our planning and
14 will adjust it if need be.

15 MR. PERSINKO: Okay.

16 CHAIRMAN POWERS: Good. Any other
17 questions?

18 MR. PERSINKO: No. That concludes my
19 statements here.

20 CHAIRMAN POWERS: Nobody wants to ask any
21 questions?

22 MR. PERSINKO: What I do want to say is
23 staff is very interested in any comments the
24 Subcommittee would have regarding what we have been
25 doing and what we presented, especially if you have

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1 areas where you think we need to do something
2 different. Because we are planning to issue a final
3 SER in September. And we would like to -- if there's
4 any corrections we need to do, we want to do them now.

5 CHAIRMAN POWERS: Yes. Let me comment on
6 a couple of things.

7 First of all, let me comment that all of
8 your staff presentations were excellent today. Enjoyed
9 them very much.

10 On the SER, it is a very comprehensive
11 document, and that's good. It is rather well written
12 with respect to providing enough background. I don't
13 think one can read it, just pick it up and say now I
14 know everything about this facility without reading
15 any of the ancillary documents or the Construction
16 Authorization Request or something like that. But as
17 a document for reading, it is quite readable.

18 What I will comment is that about half the
19 time you come down and you tell what the applicant has
20 written. You tell me something about your analysis and
21 then you draw a conclusion. The other half of the time
22 you tell me what the applicant has done and you say we
23 looked at this and it's fine. That's not very
24 helpful.

25 The former approach where you tell me

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1 something about what you guys did more than we looked
2 at this, but give some rational for your coming to the
3 judgment that things are okay, those are great. And
4 the more you can do that, the better -- the more
5 satisfactory the document is.

6 and you're about 50/50 as far as I can
7 tell in there. And it is not a scientific proof that
8 I think people are looking for. It is some indication
9 of what a pain you went through in arriving at your
10 conclusion. It can usually be handled in a sentence
11 or two.

12 That was my view of the SER. I certainly
13 invite comments from the rest of the Committee on
14 their examination of it.

15 Jack, do you have a point to make?

16 MR. SIEBER: Well, no. I'm just prepared
17 to agree with you. I also do agree that it's a likely
18 document, very comprehensive. And it would be good on
19 a CD ROM.

20 CHAIRMAN POWERS: Yes. There's no question
21 that the staff has done a very thorough job in
22 examining this from the SER. And like I say, it is --
23 it's very good at getting the appropriate amount of
24 background, the appropriate amount of description of
25 the system. And often times it does a fine job in

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1 explaining the rationale for the conclusion you did.
2 But there are those occasions where you're pretty
3 abrupt. I forget what the exact phraseology used.
4 It's another one you could easily fabricate an
5 acronym, I think.

6 But as you go back through it. Of course,
7 there are enormous number of typographical things, as
8 you would expect from any draft and whatnot like that.
9 But quite frankly, they don't detract from the
10 document very much because it's really -- when I first
11 downloaded it I said "Oh, my God, this is going to be
12 pain." And it wasn't. I rather enjoyed reading it.
13 Thank you.

14 MR. PERSINKO: Well, let me say, the first
15 goal you set, the first example you set is our goal.
16 We wanted to be like that all the time. And it'll
17 continue to our goal so that we explain the analyses.
18 For those areas we're not, we'll take a harder look
19 at.

20 We also are trying not to repeat the CAR
21 in the application.

22 CHAIRMAN POWERS: That's right. That's
23 right.

24 MR. PERSINKO: A short summary. And if
25 you want to read more, you can read the CAR.

1 CHAIRMAN POWERS: And I think that's what
2 I'm telling you, is you've succeeded in that one. You
3 were not -- it was very evident you were trying not to
4 repeat the CAR, but to give enough background so that
5 you kind of knew what the issue was. And I think you
6 succeeded in that.

7 MR. PERSINKO: Thank you.

8 Is there any other comments, please let us
9 know.

10 DR. FORD: Yes, I've got a point to that.
11 Materials issues, I remain concerned about the
12 materials issues. I've seen too many chemical process
13 plants fail terribly, catastrophically because of the
14 assumption that, for instance in this case, 300 L-
15 series stainless steel will be all right. It's a
16 highly oxidizing environment with chloride, you will
17 undoubtedly get pitting. I wouldn't be at all
18 surprised if you get transgranular stress corrosion
19 cracking. So I really do urge someone to look at
20 that.

21 MR. PERSINKO: Let me say, we are. But
22 keep in mind, this is also a design basis information
23 at this point. And I think one of the PSSCs is a
24 corrosion control program and the details of that will
25 be established at the possession and use phase. So

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1 there will be more information at the possession and
2 use phase.

3 MR. ASHE: I want to add one thing
4 regarding the materials of construction. I think
5 within our Safety Analysis we have made a point of
6 putting the equipment with process cells and
7 consequently, the radiological consequences or
8 chemical consequences as well are below those
9 requirements of 70.61. So from a pure safety aspect,
10 I think we've accommodated the materials of
11 construction. That is not to say that we can't have
12 leaks. We have provisions to account for leaks. But
13 from a safety perspective within the AP process, I
14 think we have accounted for that --

15 DR. FORD: You not only have safety
16 issues, but public perception. And also your finances.

17 CHAIRMAN POWERS: Any other -- Steve?

18 MR. ROSEN: I just want to quickly
19 summarize a couple of technical points that were made
20 today.

21 CHAIRMAN POWERS: We'll be going around
22 later.

23 MR. ROSEN: Oh, we will.

24 CHAIRMAN POWERS: This is just -- yes.
25 We're going to -- and the plan I have is once these

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1 closing comments, we'll take a little break, then
2 we'll come back and we're going to go around and
3 discuss --

4 MR. ROSEN: Okay.

5 CHAIRMAN POWERS: You have a closing
6 comment you want to make? How much you enjoyed being
7 in front of us? What a delightful way it is to spend
8 a Monday after Easter? All those things I want to
9 hear, yes.

10 MR. ASHE: This is Ken Ashe.

11 We did enjoy ourselves today. And it was
12 wonderful to be here the day after Easter.

13 CHAIRMAN POWERS: Tell me he doesn't learn
14 quick.

15 MR. ASHE: We would like to thank you for
16 the opportunity to provide you some of the technical
17 information associated with our program. And,
18 hopefully, we did impart a confidence in our abilities
19 to go forward with this project.

20 CHAIRMAN POWERS: You've definitely
21 convinced you know more about HEPA filters than I do,
22 if that's what you're looking for.

23 MR. ASHE: Yes. Thank you.

24 And that's all.

25 CHAIRMAN POWERS: Okay. My plan is let's

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1 take a 12 minute break, Jack. And we will come back.

2 And what I want to do is just summarize
3 some technical points, but more important discuss --
4 or just as important, discuss what kinds of things we
5 want to say to the full committee in our briefing at
6 the main meeting.

7 MR. ROSEN: And some of the technical
8 points I would hope the applicant would listen to so
9 that those could be included at the main meeting.

10 CHAIRMAN POWERS: You don't think he took
11 notes while you were debating him?

12 MR. ROSEN: Well, someone should be
13 possibly -- I was hoping responsive to those points.
14 But we can talk about it.

15 CHAIRMAN POWERS: Yes. Okay. We will
16 recess for 12 minutes.

17 (Whereupon, the hearing was concluded at
18 6:47 p.m.)

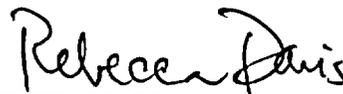
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CERTIFICATE

This is to certify that the attached proceedings
before the United States Nuclear Regulatory Commission
in the matter of:

Name of Proceeding: Advisory Committee on
Reactor Safety
Reactor Fuels Subcommittee
Docket Number: n/a
Location: Rockville, MD

were held as herein appears, and that this is the
original transcript thereof for the file of the United
States Nuclear Regulatory Commission taken by me and,
thereafter reduced to typewriting by me or under the
direction of the court reporting company, and that the
transcript is a true and accurate record of the
foregoing proceedings.



Rebecca Davis
Official Reporter
Neal R. Gross & Co., Inc.

ACRS BRIEFING

Tributyl-Phosphate (TBP) -Nitrate
(Red-Oil) Review for the Mixed Oxide Fuel
Fabrication Facility Construction
Authorization Request

William Troskosi, Sr. Chemical Eng.
NMSS/FCSS/SPIB

April 21, 2003

Introduction

- TBP - Nitrate reactions - highly exothermic chemical reactions similar to many runaway reactions found in the Chemical Process Industry (CPI).
- Regulatory Safety Concern - rapid evolution of heat and non-condensable gases can breach process equipment containing licensed material.
- Staff review - first principals as outlined by applicant and in the literature (including DOE).
- Staff considered known industry events and the CPI approach to similar runaway reactions (Process Hazard Analysis)

First Principals

Fuel - Oxygen - Heat Triangle

- TBP with limited degradation products -DBP, MBP and quantities of butanol and/or butyl nitrate.
- HNO_3 and related oxidizers - assumed to saturate the organic phase.
- Prevent TBP with limited degradation products from reaching the 137°C initiation temperature via evaporative cooling (confirmatory measurements to be performed).

Applicant's PSSCs

Safety Strategy - heat removal greater than heat generation.

- Chemical Safety System - Diluent properties (based on experiments) not susceptible to nitration or radiolysis.
- Process Safety Control Subsystem :
 - Residence time limits on organics (oxidizing agents and high radiation fields).
 - Solution temperature (organics) is within analyzed safety limits (heat transfer calculations).
- Offgas System:
 - Heat removal via evaporative cooling through venting is $1.2 \times [\text{heat generation} + \text{heat input}]$.
 - Venting to prevent over-pressurization consistent with experiments (e.g. $8 \times 10^{-3} \text{ mm}^2/\text{g}$)

Industry Events

Unexpected presence of organics and adequacy of PHA

- TNX 1953 - 80 lbs of TBP in a 78% UN concentrated aqueous solution with $T > 130^{\circ}\text{C}$ and a 50-100 psi backpressure due to partially plugged plates.
- A-Line Denitrator 1975 - 30 gal TBP with metal adducts that accumulated > 1 year; aqueous phase specific gravity change lighter than organic phase; organic transfer to evaporator, then denitrator ($\sim 225^{\circ}\text{C}$?); pyrolysis @ 150°C
- Tomsk-7 - 1,500 l concentrated nitric acid added to 500 l degraded organic solvent; organic layer @ $80-100^{\circ}\text{C}$; presence of more reactive organics

Applicant Confirmatory Experiments

- Diluent - foaming
- Impurities - metal ion affect on initiation temperature and heat generation
- Residence Time - concentration limits for heat generation
- Reaction Kinetics - for heat generation rate

Staff Review

Construction Authorization Phase - design bases of PSSCs provide reasonable assurance against consequences of potential accidents

- Applicant identified PSSCs to address red-oil event initiators and phenomena
- Staff review is considering how “highly unlikely” can be achieved; values and ranges of values for functions; and safety margins.
- Assure Defense-in-Depth
- ISA - HAZOP Analysis and What-if/Checklist to be performed.

ACRS BRIEFING

Hydroxylamine Nitrate (HAN) Review for the Mixed
Oxide Fuel Fabrication Facility Construction
Authorization Request

William Troskosi, Sr. Chemical Eng.
NMSS/FCSS/SPIB

April 21, 2003

Introduction

- HAN - Nitric Acid Solutions - susceptible to spontaneous autocatalytic reactions
- Regulatory Concern - reactions can explode if in a constrained volume, breaching process equipment containing licensed material.
- Staff Review - first principals as outlined in by Applicant and in the literature (including DOE).
- Staff considered known industry events and the CPI approach to similar runaway chemical reactions (Process Hazard Analysis)

First Principals

Fuel - Oxygen - Heat Triangle

- HAN Concentration (NH_2OH)
- HNO_3 Concentration (and related HNO_2 concentration) -HAN reacts autocatalytically with nitrous acid, which is always present in nitric acid solutions, generating more than is consumed.
- Temperature - decomposition temperature is a function several known reaction conditions (nitric acid - HAN ratio, iron concentration - a catalyst)

Applicant's PSSCs

Safety Strategy - use hydrazine to scavenge nitrous acid before N_2O_4 , the main intermediate of the autocatalytic reaction can form.

PSSCs were developed for three process vessel groups:

- HAN and hydrazine nitrate w/o NO_x addition
- HAN and no hydrazine nitrate
- HAN and hydrazine nitrate with NO_x addition

PSSCs

HAN and hydrazine nitrate w/o NOx addition and
HAN and no hydrazine nitrate

- Process Safety Control Subsystem (PSCS) - limit temperature of solutions containing HAN within safety limits.
- Chemical Safety Control (CSC) - control and maintain nitric acid, metal impurities and HAN concentrations to within safety limits

PSSCs

HAN and hydrazine nitrate with NOx addition

- CSC - control concentrations of HAN, hydrazine nitrate, and hydrazoic acid to within safety limits.
- Offgas Treatment System - provide process vessel gas exhaust path.
- PSCS - control oxidation column flow rate

Industry Events

Inadvertent concentration through heating or natural evaporation; addition of concentrated nitric acid; presence of catalysts (Fe).

- Hanford 1987 - added strong nitric acid to HAN heel
- SRS 1972 - S/U temperature over concentrated HAN and nitric acid by a factor of 10.
- SRS 1978 - makeup nitric acid added to “empty” tank heel.
- SRS 1980 - inadvertent heating for several days; leaking coil
- Hanford 1989 - HAN/hydrazine isolated for ~ 1 year
- SRS 1996 - proximity to external heat source.

DOE Approach

DOE/EH-0555 Technical Report

- Instability Index correlated nitric acid -HAN ratio, nitric acid molarity and iron molarity to temperature.
- The applicant has reviewed the approach and determined that it had limited application.
- The index did not account for affects of plutonium (Catalysis and radiolysis), impurities such as iron, and low hydroxylamine concentrations.

Applicant's Safety Strategy Approach

- Use of hydrazine to scavenge nitrous acid
- DCS still evaluating use of hydrazine as well as other means such as a direct HAN approach.

Staff Review

- Pending submittal of additional information by the applicant to support the selected approach.

ACRS BRIEFING

Nuclear Criticality Safety Review for the MOX Fuel
Fabrication Facility Construction Authorization Request

Christopher S. Tripp, Senior Nuclear Process Engineer (Criticality)
NMSS/FCSS/SPIB

April 21, 2003

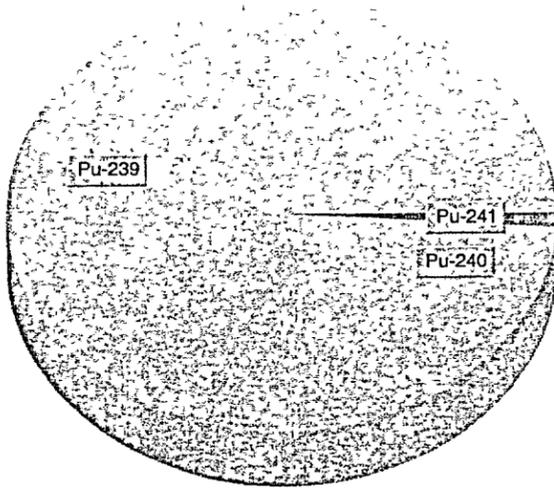
MFFF vs. Licensed Part 70 Facilities

- Pu characteristics vs. U:
 - ▶ Complex chemical and physical properties
 - ▶ Isotopics:
 - $^{240}\text{Pu}/\text{Pu}$
 - $^{241}\text{Pu}/\text{Pu}$
 - $^{235}\text{U}/\text{U}$
 - $\text{Pu}/(\text{U}+\text{Pu})$
 - ▶ Generally smaller critical mass/limits than LEU, HEU, SNF
- Dry “Downblending”:
 - ▶ Oxide powders downblended in large geometry tanks.
 - ▶ Downstream processes credit isotopics.
 - ▶ Homogenization important for criticality safety.

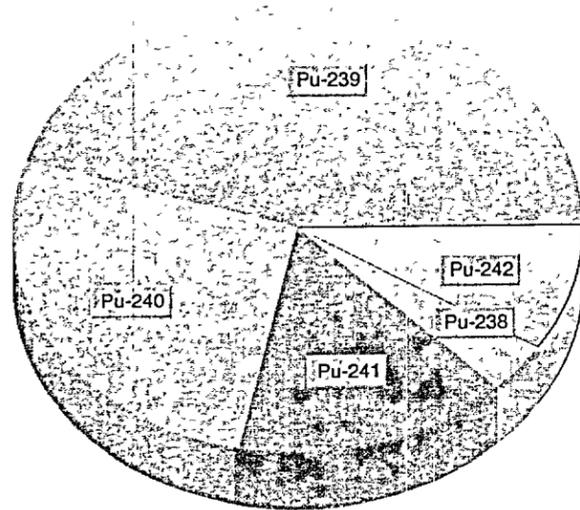
Comparison of Pu Isotopes

Comparison is for Highest Impurity MFFF Feed vs. Typical SNF (w/ Pu Recycle)

Weapons-Grade Pu



Reprocessed Pu



Current NCS Issues

- Code validation:
 - ▶ Few critical benchmarks for:
 - Limited Pu/MOX benchmarks across range of important parameters.
 - Few Pu/MOX benchmarks with required absorbers.

- Subcritical Margin/Code Validation:
 - ▶ ABNORMAL: $k_{\text{eff}} + \text{bias} + \text{uncertainty} \leq 0.95$ Design Basis
 - ▶ NORMAL: Normal margin $\Rightarrow k_{\text{eff}}$ sensitivity Non-Design Basis
 - System-dependent/variable
 - Parameters or k_{eff}
 - ▶ Few benchmarks for code validation \Rightarrow special tools required

Code Validation

- 5 different Areas of Applicability (AOAs):
 - ▶ Pu nitrate solutions
 - ▶ MOX pellets, rods, and assemblies
 - ▶ PuO₂ powder
 - ▶ MOX powder
 - ▶ Pu compound solutions

- Received VR January 2003.
 - ▶ Meeting January 2003: parametric range required by AOAs to be reevaluated.
 - ▶ NRC will acquire new version of SCALE code May, 2003 => resolve open questions on benchmark applicability.
 - ▶ Dual vs. Single-parameter control.

Conclusions

- One main open issues remaining for NCS => setting design basis k-effective limits.
 - ▶ Validation across all AOAs.
 - ▶ Normal case subcritical margin.
 - ▶ Adherence to dual-parameter approach.

- Identified early as main technical challenge for NCS.
- Staff reviewing validation reports => design basis k_{eff} limits.
- SCALE-5 code being pursued to answer benchmark questions.
- DCS reevaluating. On schedule for closure by September 2003.

ACRS BRIEFING

Confinement Ventilation Review of the Mixed Oxide
Fuel Fabrication Facility Construction Authorization
Request

Tim Johnson, Sr. Mechanical Eng.
NMSS/FCSS/SPIB

April 21, 2003

Ventilation and Confinement Systems

■ Design Basis Objectives

- ▶ Principal structures, systems, and components (PSSCs) of confinement systems must perform safety functions under conditions requiring confinement
- ▶ Systems must exhibit defense-in-depth

Proposed Confinement System

- Confinement and ventilation systems are important in minimizing release and dispersal of radioactive material.

- Release of radioactive materials minimized by:
 - ▶ Static Barriers (e.g., gloveboxes, process cells)
 - ▶ Dynamic Barriers (Ventilation systems)

HEPA Filter Removal Efficiency

- DCS is proposing to use a 10^{-4} release fraction in its accident analyses
- Because of past experiences where fire damage has occurred in filtration systems, and due to uncertainties in fire analyses, NRC staff asked for further justification of proposed removal efficiency
- DCS provided further justification on February 18, 2003, and April 10, 2003. Staff is considering April response to questions.

Soot Loading Analysis

- NRC staff unable to verify HEPA filter Soot Loading calculation under fire accident conditions;
- If HEPA filters can rupture under excessive loading conditions;
- DCS provided further justification on February 18, 2003, and April 10, 2003. Staff is considering April response to questions.

Open Items

- How much credit should be given for HEPA filter particulate removal efficiency?
- Under fire conditions, will HEPA filters undergo excessive soot loading conditions?

ACRS BRIEFING

Confinement Ventilation Review of the Mixed Oxide
Fuel Fabrication Facility Construction Authorization
Request

Tim Johnson, Sr. Mechanical Eng.
NMSS/FCSS/SPIB

April 21, 2003

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ACRS BRIEFING

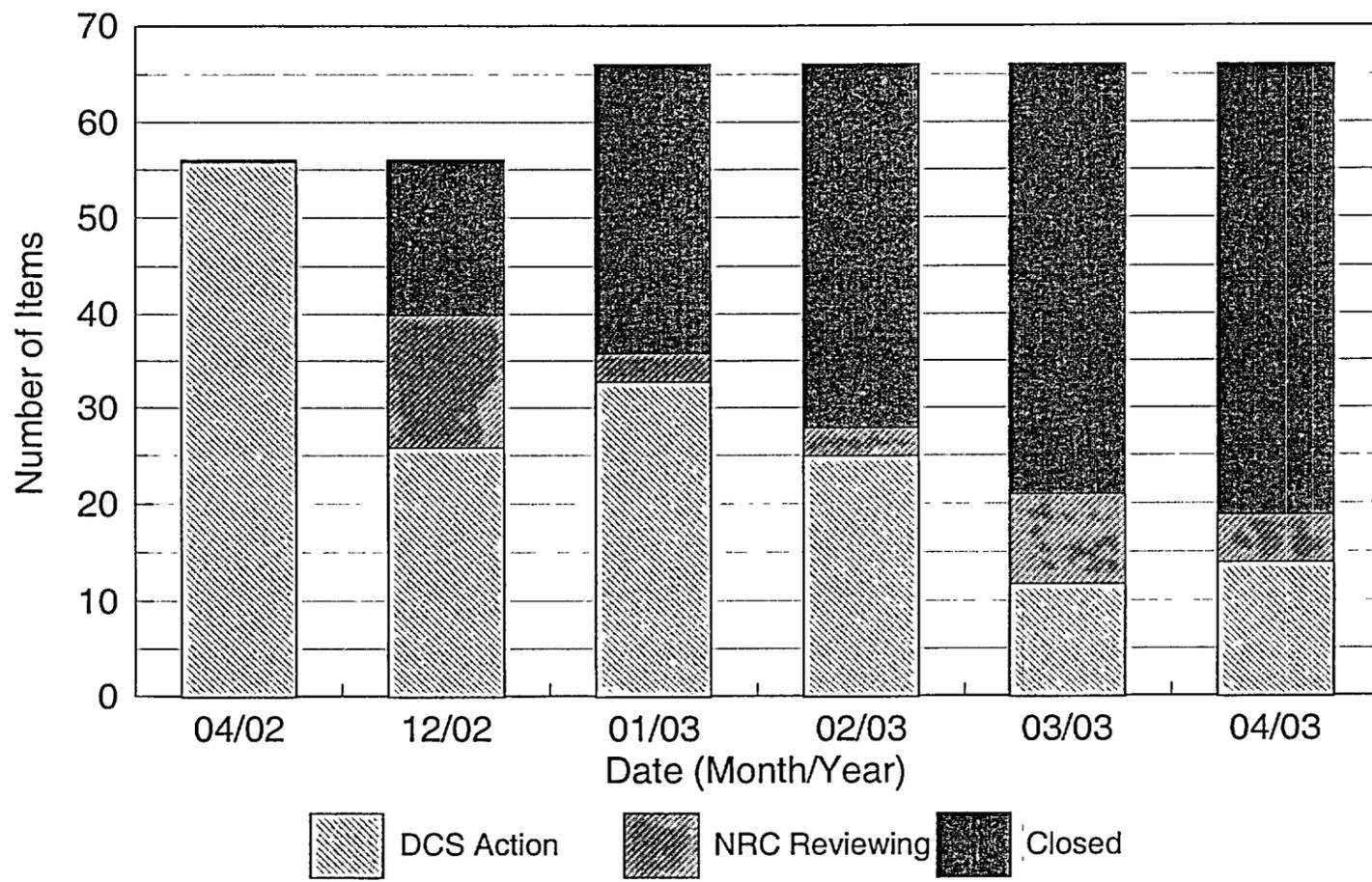
Review of the Mixed Oxide Fuel Fabrication Facility
Construction Authorization Request

Closing Remarks

Andrew Persinko, Sr. Project Manager
NMSS/FCSS/SPIB

Closing Remarks

DSER Open Items



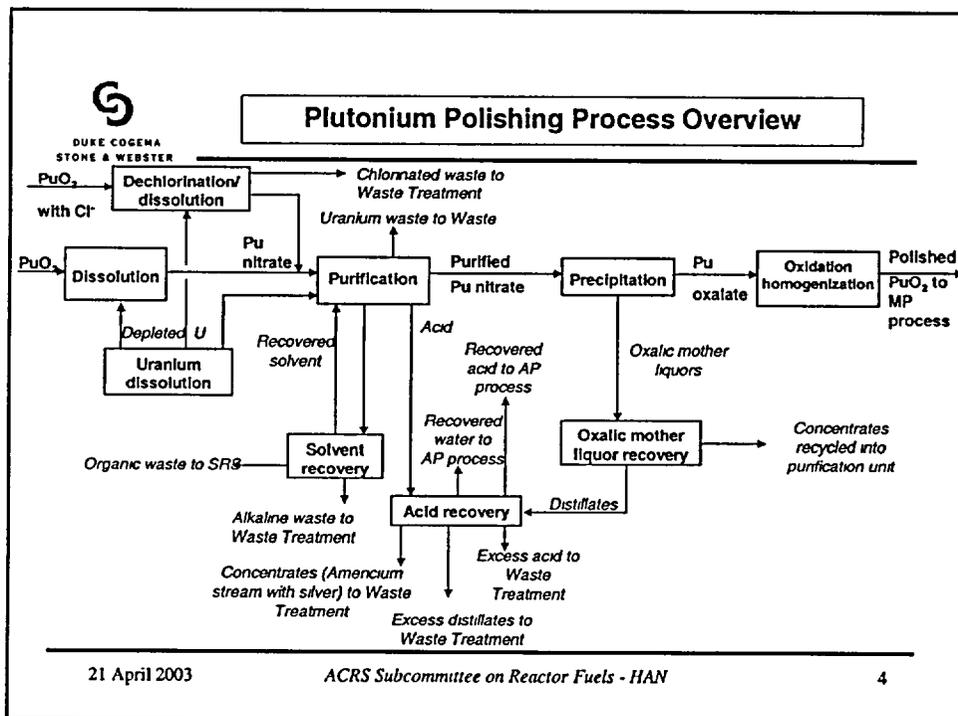
MOX Fuel Fabrication Facility (MFFF) Hydroxylamine Nitrate (HAN)

**ACRS Subcommittee on Reactor Fuels Meeting
21 April 2003**

Content of the Presentation

- Approach to Safety
- Use of HAN within the AP Process
- Properties of HAN
 - Back Extraction of Pu (IV) from Organic Phase
 - Reaction with nitric acid
 - Reaction with nitrous acid
 - Re-oxidation of Plutonium
- Use of Hydrazine
- DCS Safety Strategy

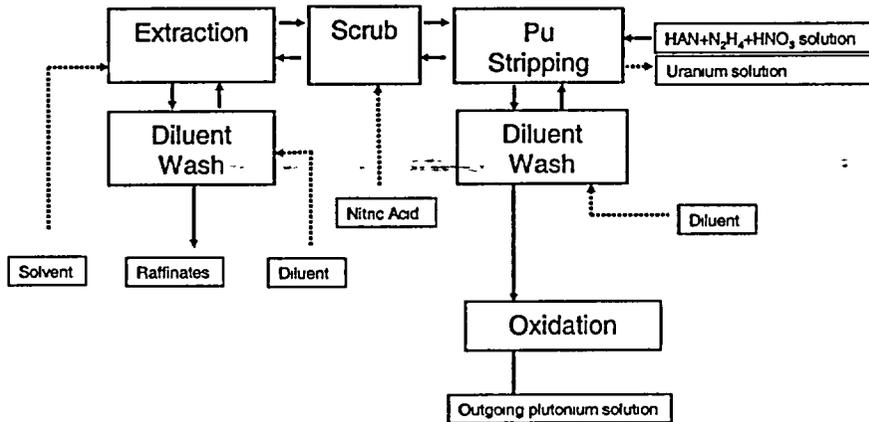
1. Development of a *fundamental understanding of the system* through:
 - an exhaustive review of the literature
 - a detailed investigation of the chemistry and physical phenomena of the system with the support of experts from national laboratories and universities
2. Incorporation of lessons learned from previous events
3. Confirmatory testing during the ISA to validate our analysis





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Simplified Purification Process



21 April 2003

ACRS Subcommittee on Reactor Fuels - HAN

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Properties of Hydroxylamine (HAN)

- Soluble only in aqueous phase
- Extraction - Reduction of Plutonium [Pu(IV) → Pu(III)]
- Reactions with nitric acid and nitrous acid

21 April 2003

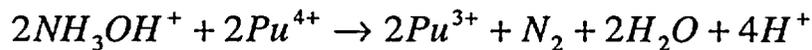
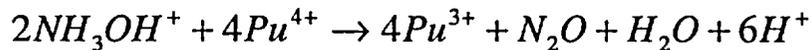
ACRS Subcommittee on Reactor Fuels - HAN

6



Extraction - Reduction of Plutonium

- Reduction of Pu(IV) to Pu(III) by HAN
- Two Reactions are possible:



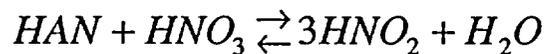
- Preferred Reaction depends on the ratio R

$$R = \frac{[\text{Pu(IV)}]_0}{[\text{NH}_3\text{OH}^+]_0} \quad \bullet \quad R > 1: \text{reaction 1}$$
$$\bullet \quad R < 1: \text{reaction 2}$$

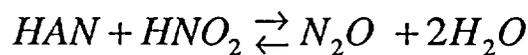


Competitive Reactions involving HAN

- Reaction of HAN with Nitric Acid



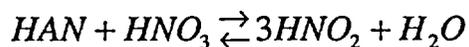
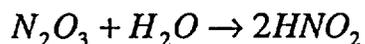
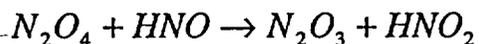
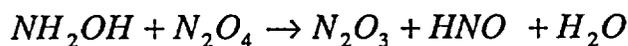
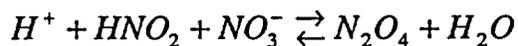
- Reaction of HAN with Nitrous Acid



Reaction of HAN with Nitric Acid



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ACRS Subcommittee on Reactor Fuels - HAN

9

Kinetics of Decomposition of HAN



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The rate law of decomposition of HAN by Nitric and Nitrous Acids can be derived by applying the steady state approximation to N_2O_4 , HNO and N_2O_3 :

$$\frac{d[HNO_2]}{dt} = [HNO_2][NH_3OH^+] \left(\frac{k_1[H^+][NO_3^-]}{k_{-1} + 2[NH_3OH^+]} - k_3 \right)$$

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ACRS Subcommittee on Reactor Fuels - HAN

10



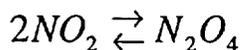
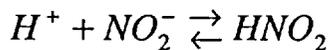
Energetics of HAN Decomposition

- HAN autocatalytic oxidation is *exothermic*.



Plutonium Re-oxidation Mechanism

- The Re-Oxidation of Pu(III) has two main side effects
 - Re- produces Pu(IV) and therefore consumes HAN
 - Consumes Hydrazine
 - Autocatalyzes the production of Nitrous Acid



Use of Hydrazine

- Hydrazine scavenges nitrous acid which impedes the production of N_2O_4
- This scavenging consequently impedes
 - Plutonium re-oxidation
 - The auto-catalytic HAN/nitric acid reaction

Hydrazine is a more effective Nitrous Scavenging Agent than Hydroxylamine

Substrate	0.05 M [H ⁺]	0.5 M [H ⁺]	1.3 M [H ⁺]
HAN	0.15	2.1	9.6
Hydrazine	31	390	1820

Note: Rate constant are in $M^{-1} s^{-1}$

Reactivity of Nitrous Acid Scavengers @ 25°C:



DCS Safety Strategy

- Hydrazine is an effective nitrous scavenging agent that will be utilized to demonstrate that the autocatalytic decomposition of HAN is precluded.
- PSSCs identified in CAR:
 - Chemical Safety Controls (e.g concentration of HAN, hydrazine)
 - Process Safety Controls (Temperature)
- Confirmatory testing will be performed during the ISA to further substantiate the minimum hydrazine necessary to preclude the autocatalytic HAN reaction.



MOX Fuel Fabrication Facility (MFFF) HEPA Filter Design Features to Mitigate Fire Effects

**ACRS Subcommittee on Reactor Fuels Meeting
21 April 2003**



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Purpose

- Present key MFFF design features that will protect HEPA filters from damage from severe environmental conditions during accident scenarios such as fire



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HEPA Filter Basics

- Particulate removal systems
- Testing ensures efficiency in service
- HEPA filter efficiency is the same across all stages
- Over 50 years of performance history
- MFFF HEPA filter design based on principles rooted in history
- Additional analyses being performed for the ISA will demonstrate that the final HEPA filters are protected

21 April 2003

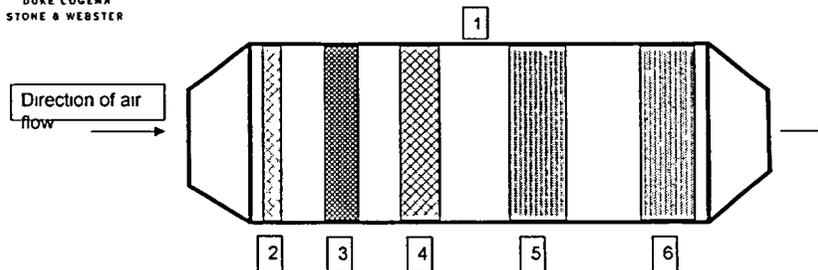
ACRS Meeting MFFF HEPA Filter Design Features

3



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MFFF HEPA Filter Unit Schematic



- 1 All stainless steel filter housing (per ASME N 509)
- 2 Structurally strong roughing filter, all stainless steel with reinforced stainless steel wire mesh filter media (embers)
- 3 Structurally strong high efficiency prefilter, all stainless steel with reinforced stainless steel wire/glass fiber mesh media (soot)
- 4 Noncombustible prefilter (optional)
- 5 Nuclear grade HEPA filters (1st Stage)
- 6 Nuclear grade HEPA filters (2nd Stage)

21 April 2003

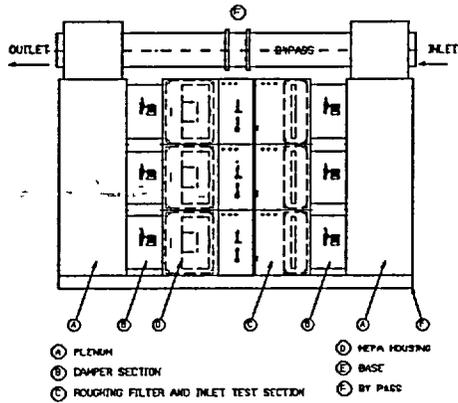
ACRS Meeting MFFF HEPA Filter Design Features

4



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INTERMEDIATE HEPA FILTER BOX



21 April 2003

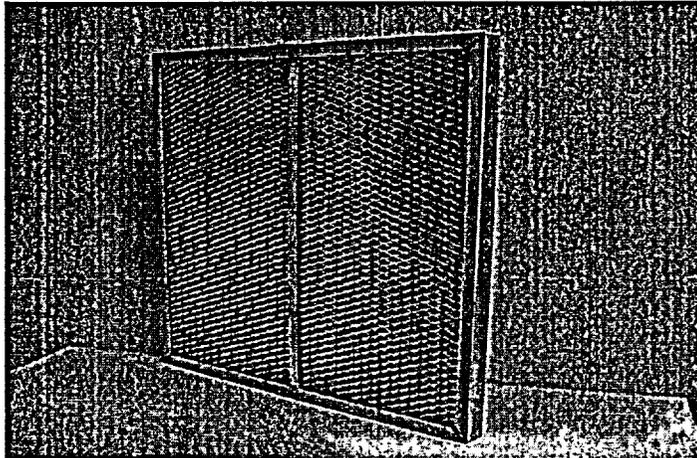
ACRS Subcommittee on Reactor Fuels - HEPA Filters

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Stainless Steel Mesh Roughing Filter Element



Roughing Filter (Full-Size Prototype)

21 April 2003

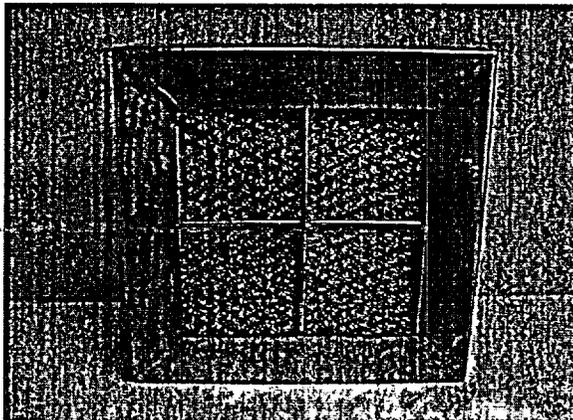
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Stainless Steel/Glass Fiber Mesh Prefilter



Stainless Steel / Glass Fiber Prefilter
(Half-Size Prototype)

21 April 2003

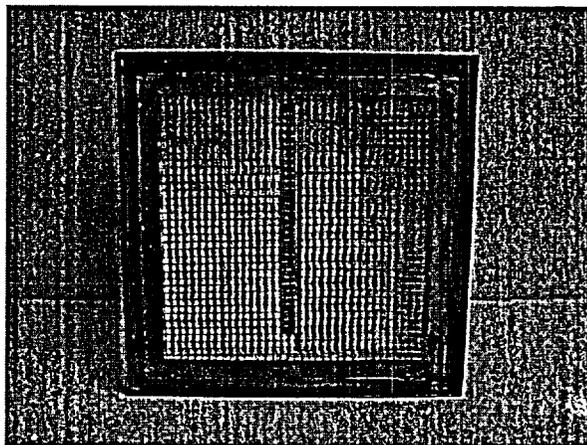
ACRS Subcommittee on Reactor Fuels - HEPA Filters

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HEPA Filter Element



HEPA Filter (Half-Size Prototype)

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8



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Testing ensures efficiency in service

- Manufacturer tests designs for efficiency, pressure drop, rough handling, pressure, moisture, heated air, pinhole leaks, and spot flame resistance
- All filters are tested for efficiency before shipment
- The MFFF performs insitu efficiency tests at installation, replacement and periodic intervals
- These tests ensure that installed HEPA filters work
 - Efficiency of > 99.9% for 0.2 μm at rated flow
 - Structurally withstand pressure drop > 10 inches H_2O
 - Withstand 700°F for 5 minutes

21 April 2003

ACRS Subcommittee on Reactor Fuels - HEPA Filters

9



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HEPA filter efficiency is the same across all stages

- Tests and analyses indicate that filters in series do not lose efficiency: the second stage is just as efficient as the first stage
- Two HEPA filters in series have a combined efficiency of at least 99.9999% for most penetrating particles

21 April 2003

ACRS Subcommittee on Reactor Fuels - HEPA Filters

10



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Over 50 years of performance history

- HEPA filter performance in nuclear service has been studied for more than 50 years
- Scientific studies, lessons learned, expert review panels, industrial/government standards organizations have all identified factors that impact HEPA filter performance
- These factors fall within 3 categories
 - Short Term Physical Effects (Leaking, Clogging, Bursting)
 - Embers, Smoke/Soot, High Temperature, Moisture/Water, Airflow
 - Long Term Degradation Effects (Aging)
 - Chemicals, Moisture/Water, Radiation
 - Other Factors
 - Manufacturing Defects, Installation Errors, Inspection Errors

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ACRS Subcommittee on Reactor Fuels - HEPA Filters

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MFFF HEPA filter design based on principles rooted in history

- Embers – mitigated by high strength roughing filter
- Soot – mitigated by high strength high efficiency prefilter
- High temperature – mitigated by noncombustible materials, high temperature materials and dilution air flow
- High moisture – mitigated by dilution air flow
- Entrained water – prevented by design features (i.e., no sprinklers, high strength high efficiency prefilter), dilution air flow

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ACRS Subcommittee on Reactor Fuels - HEPA Filters

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MFFF HEPA filter design based on principles rooted in history (continued)

- High ΔP – prevented by combustible loading controls, fire detection/suppression features, high strength prefilter elements with DID monitoring for timely switchover to spare filter units
- Aging – mitigated by periodic inspection, testing and replacement
 - Chemical Exposure – also mitigated by process design features
 - Radiation Exposure – also prevented by facility design features
 - Moisture Exposure – also mitigated by facility design features

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ACRS Subcommittee on Reactor Fuels - HEPA Filters

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Summary of Analyses

- Fire hazard analysis
- Fire severity modeling
- Soot loading analysis
- Dilution temperature analysis
- Moisture analysis
- Fault tree analysis
- Single failure analysis
- HVAC transient and disturbance analyses
- Internal explosion analysis

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ACRS Subcommittee on Reactor Fuels - HEPA Filters

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Analyses Consider Uncertainties

- Factors that could affect HEPA filter performance are well known and have been quantified
- The systems and safety analysis use conservative values to bound these impacts
 - two largest fire events for both smoke
 - temperature challenges
- Independent empirical verification of filtration system performance by filter soot loading experiments is planned for the ISA



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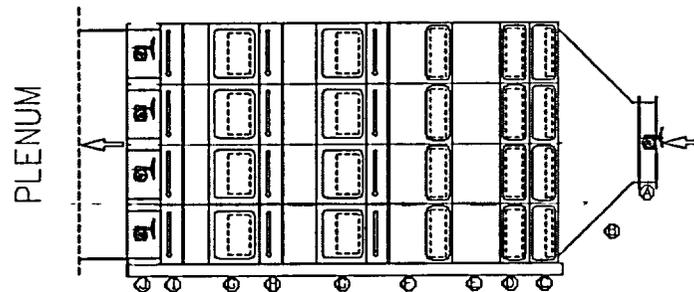
MFFF Filtration System Soot Loading Experiments

- Filter design is based on previous empirical studies
- No specific data characterizes behavior of MFFF soot
- Filtration system soot loading experiments will determine behavior of soot in MFFF filtration system:
 - Distribution of soot through the filtration system
 - ΔP across each filter of the filtration system as a function of soot load
 - Change in flow rate as a function of soot load
 - Ultimate soot loading capacity of the filtration system



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FINAL HEPA FILTER HOUSING



- | | |
|------------------------------|----------------------------|
| ① ISOLATION DAMPER | ⑥ INLET TEST SECTION |
| ② TRANSITION | ⑦ HEPA FILTER SECTION |
| ③ ROUGHING FILTER | ⑧ COMBINATION TEST SECTION |
| ④ HIGH EFFICIENCY PRE FILTER | ⑨ OUTLET TEST SECTION |
| ⑤ PLENUM SECTION | ⑩ DAMPER SECTION |

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Application of Lessons Learned from Historical Fires

- HVAC systems and filter elements are constructed of noncombustible materials
- HEPA filters have special features to protect the final HEPA filter elements
- Dilution air, not water sprays, protect the HEPA filters from excessive temperatures
- Ventilation duct attenuates rapid pressure excursions
- Fire isolation valves/fire wrapping provided for beyond design basis events
- MFFF process building designs provide multiple confinement layers
- Low potential contamination of final HEPA filters

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Conclusions

- The MFFF design prevents the final HEPA filters from exposure to severe environmental conditions
- The design basis event scenarios under which the filter design is being evaluated include and account for uncertainties in postulated events
- The design has a historical basis for each of the elements that make up the “HEPA Filter”
- These features make the MFFF Final HEPA filters robust

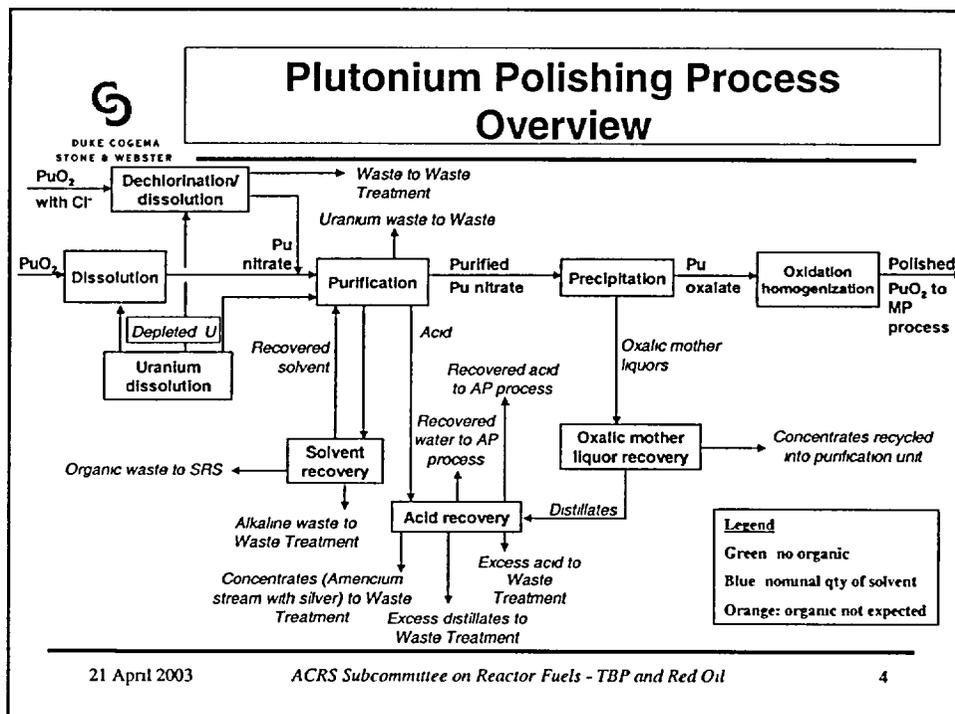
MOX Fuel Fabrication Facility (MFFF) TBP Degradation and Red Oil Phenomena

**ACRS Subcommittee on Reactor Fuels Meeting
21 April 2003**

Content of the Presentation

- DCS Approach to Safety
- Operations with TBP Degradation Hazard
- Characteristics of Red Oil
- TBP Degradation
- Lessons Learned From Previous Events
- DCS Safety Strategy/Principal SSCs

1. Development of a *fundamental understanding of the system* through:
 - an exhaustive review of the literature
 - a detailed investigation of the chemistry and physical phenomena of the system with the support of experts from national laboratories and universities
2. Incorporation of lessons learned from previous events
3. Confirmatory testing during the ISA to validate our analysis





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Characteristics of Red Oil

- Characteristics of Red Oil:
 - ✓ Organic-based material which can be formed by metal, nitric acid, and TBP and a hydrocarbon diluent.
 - ✓ Dense material (1.1 to 1.5 g/cm³)
 - ✓ Energetic material (with different thermal decomposition temperature than the metal adduct)
- Red Oil has been synthesized by:
 - Gordon et al. (Los Alamos National Laboratory)
 - Stieglitz et al. (Kernforschungszentrum Karlsruhe)
 - Wagner et al. (Hanford)
 - Wilbourn et al. (General Atomic)



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Techniques Used to Investigate Red Oil

- Red Oil synthesized by:
 - Reflux
 - Reflux/distillation
 - Closed pressurized vessel
- Formation of "Red Oil" found when diluent contained large quantities of naphthalene
- Characterized by:
 - Nuclear Magnetic Resonance (¹H, ¹³C, ³¹P)
 - Infra-red spectroscopy
 - Gas Chromatography – Mass Spectroscopy
 - Elemental / Combustion analysis
- Main Results
 - ³¹P NMR: δ for UO₂(NO₃).2TBP @ 2.4ppm
 - Carbon (35-55%wt) and Nitrogen (1.5-5.0%wt) contents
 - Presence of Carboxylic Acid and Nitro/Nitrate/Nitrite group



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Results of Analysis of Red Oil

Differential Thermal Analysis (DTA)

- Broad exothermic between 130°C-250°C due to:
 - ✓ Nitric acid reaction with TBP
 - ✓ Partial pyrolysis of TBP
 - ✓ Incipient calcination of $\text{Th}(\text{NO}_3)_4 \cdot 2\text{TBP}$
 - // Thorium is used as a surrogate for plutonium
- Endothermic δ @ 300°C
 - ✓ TBP pyrolysis - Butene



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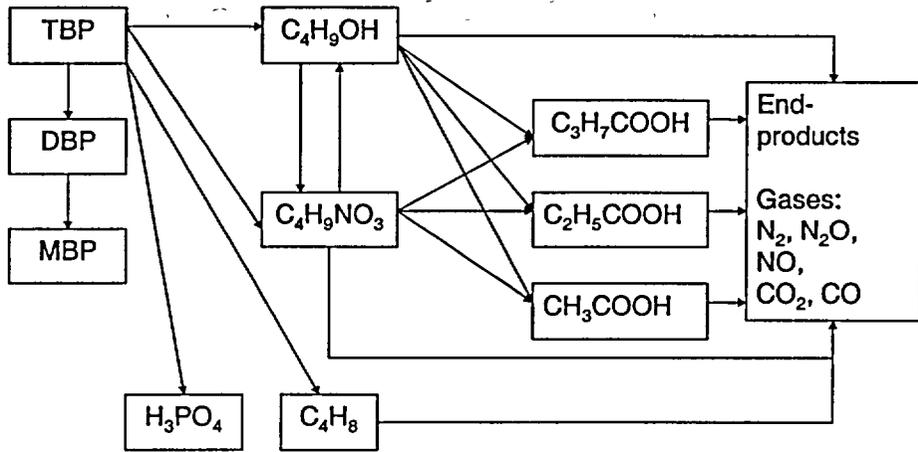
Influence of the Solvent

- The initiation temperature of the exothermic decomposition of the metal nitrate-TBP complex previously presented is altered by the oxidation of TBP products in nitric acid medium.
- Therefore, to understand this alteration of thermal decomposition of the metal nitrate-TBP complex, it is necessary to understand the phenomenon associated with TBP degradation in a nitric acid medium.



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TBP Degradation



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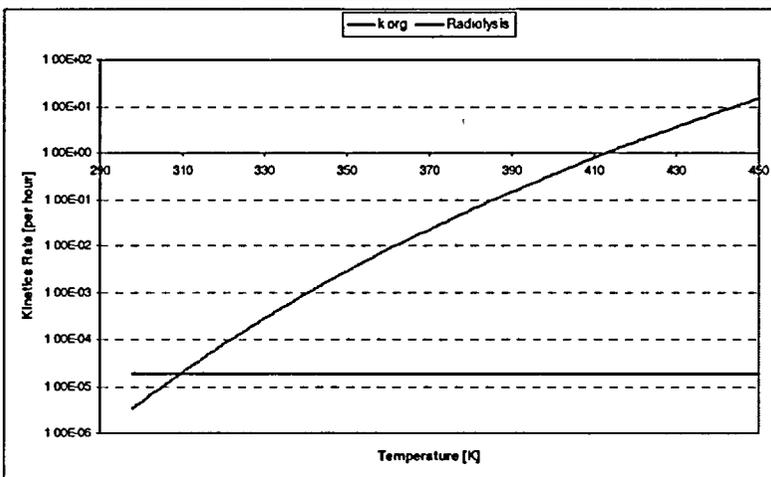
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Hydrolysis and Radiolysis Effects



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Influence of Temperature and Acidity on the Energy Production from Degraded Products

TBP Degradation Product	[HNO ₃] (M)	Oxidation Onset Temp. (°C)	Exotherm Peak Temp (°C)	Measured Exotherm (cal/g) Organic
Butanol	15.8	35	52	102
	12.0	37	58	254
	10.0	60	68	254
	8.0	55	74	190
	6.0	75	86	34
Butyl Nitrate	15.8	52	78	176
	12.0	74	92	41
	10.0	85	94	6
	8.0	No Exotherm	No Exotherm	0

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Limiting Quantity of Degradation Products

$$\frac{dM_{TBP}(t)}{dt} = -k_1 M_{TBP}(t) - k_2 M_{TBP}(t)$$

$$\frac{dM_{DO}(t)}{dt} = k_1 M_{TBP}(t) + k_2 M_{TBP}(t) - M_{DO}(t) \exp(-k_3 t) - k_4 M_{DO}(t)$$

- M_{TBP} = mass of TBP as a function of time
- M_{DO} = mass of degraded organics as a function of time
- k_1 = hydrolysis rate constant
- k_2 = radiolysis rate constant
- k_3 = evaporation rate constant
- k_4 = oxidation rate for butyl nitrate

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Mass & Heat Transfer

Production terms

- Limit heating sources (<60° C except evaporator units; evaporators limited to steam temperature of 135° C)
- Heat from exothermic reactions

Removal terms

- Evaporation of water and other materials
- Heat transfer by conduction or convection to an aqueous phase
- Heat transfer to the vessel walls
- Heat transfer from endothermic reactions



Lessons Learned

- 1953: Early events (SRS, Hanford) identified the importance of the properties of the diluent in determining safety and the necessity for redundant safety controls
- 1975: Savannah River event identified the importance in limiting flammable gaseous products produced during TBP degradation reactions
- 1993: Tomsk events identified the importance of long term degradation of solvent buildup and heat transfer mechanism



MFFF Principal SSCs

- Diluent: branched chain hydrocarbon
- Venting: provide cooling mechanism to provide heat transfer and limit pressurization
- Steam temperature: limited at 135°C
- Limit exposure time to prevent degradation of chemical species and subsequent buildup of degraded organics



Conclusions

- A fundamental understanding of the chemistry and physical mechanisms related to TBP degradation has been obtained
- Lessons learned from previous accidents have been utilized in formulating a safety strategy
- Principal SSCs and corresponding design bases have been identified
- Confirmatory testing has been identified

MIXED OXIDE FUEL FABRICATION FACILITY



ACRS PRESENTATION

April 21, 2003

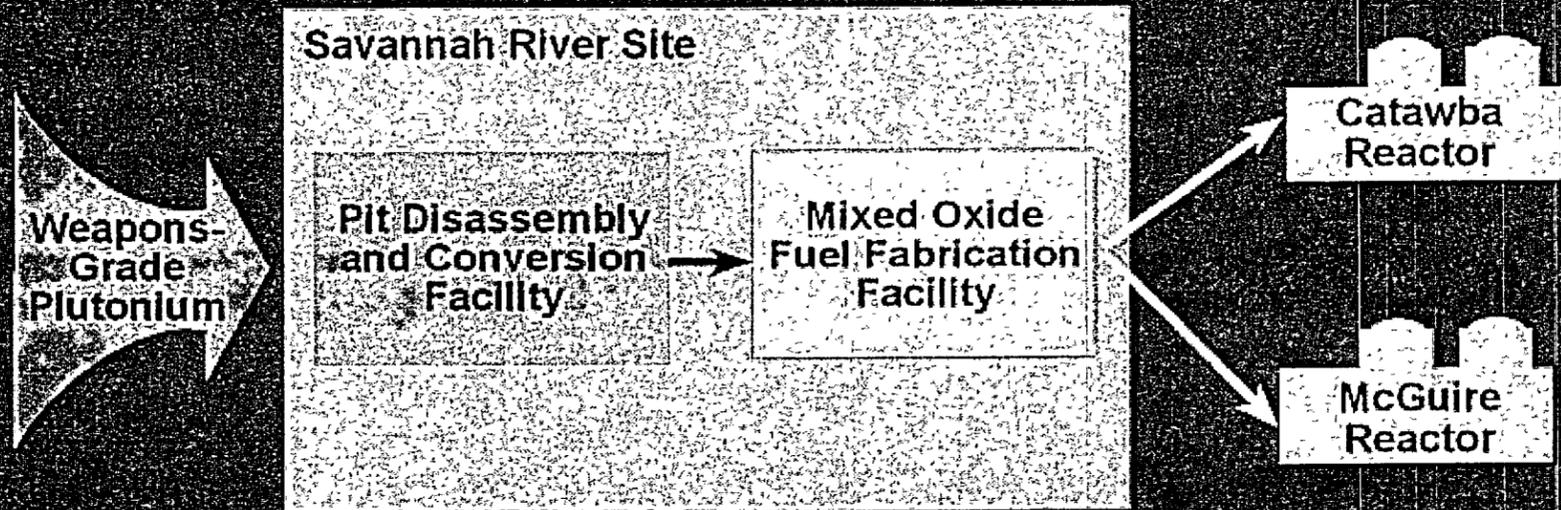
ACRS BRIEFING

Review of the Mixed Oxide Fuel Fabrication Facility
Construction Authorization Request

Introduction

Andrew Persinko, Sr. Project Manager
NMSS/FCSS/SPIB

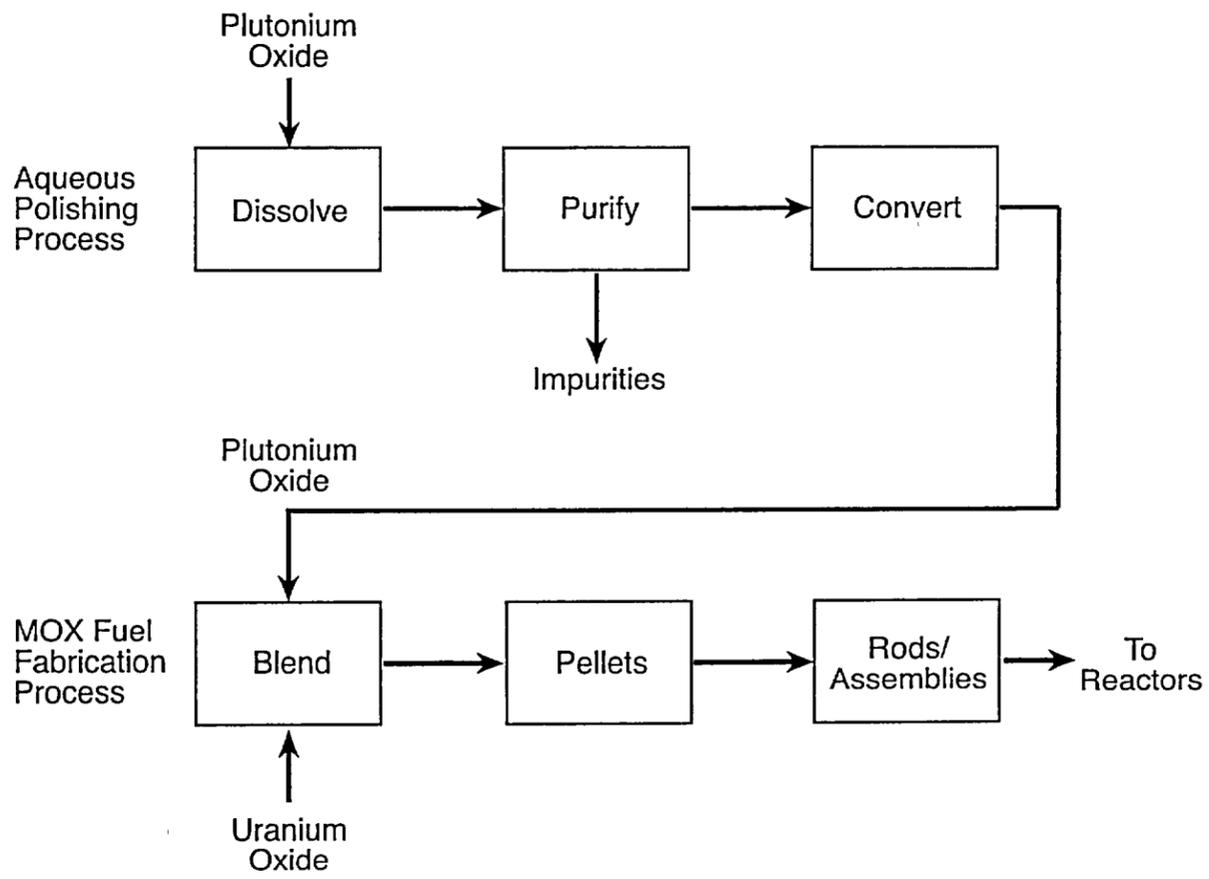
NRC Role in Regulating Mixed Oxide Fuel



Yellow = NRC regulated

Blue = DOE regulated

Mixed Oxide Fuel Fabrication Facility Process



Mixed Oxide Fuel Fabrication Facility

Licensing

- 2-step approval:
 - ▶ Construction
 - ▶ Operation/possession of special nuclear material
- Approvals to start construction plutonium facility
 - ▶ Design bases of principal structures, systems, and components (PSSCs)
 - ▶ Quality assurance program
 - ▶ Environmental impact statement
- Principal structures, systems, and components /
Items relied on for safety

Construction

Design Bases

► 10 CFR 50.2 Definition:

“Design Bases means that information which identifies the specific functions to be performed by a structure, system, or component of a facility and the specific values or ranges of values chosen for controlling parameters as reference bounds for design...”

10 CFR 70.61 Performance Requirements

	Highly Unlikely	Unlikely	Not unlikely
High Consequence Publ Dose > 25 rem Worker Dose > 100 rem	Acceptable	Not Acceptable	Not Acceptable
Medium Consequence Publ Dose 5 - 25 rem Worker Dose 25 -100 rem Env releases > 5000 Tbl 2	Acceptable	Acceptable	Not Acceptable
Low Consequence Publ Dose < 5 rem Worker Dose < 25 rem	Acceptable	Acceptable	Acceptable

Schedule

Major Milestones

- Issued draft Safety Evaluation Report (SER) for construction 4/30/02
- Received revised Environmental Report 7/11/02
- Received revised Construction Authorization Request 10/31/02

Schedule

Major Milestones

- Issued draft Environmental Impact Statement (EIS) for public comment 2/28/03
- Issue revised draft SER for construction 4/03
- Issue final EIS 8/03
- Issue final SER and construction licensing decision 9/03

ACRS BRIEFING

Fire Protection Review of the Mixed Oxide Fuel
Fabrication Facility Construction Authorization Request

Sharon Steele, Fire Protection Engineer
NMSS/FCSS/SPIB

April 21, 2003

Fire Protection Issues

Status of open issues identified in the April 2002 draft Safety Evaluation Report (SER)

- Closed:
 - ▶ Glovebox window material
 - ▶ Facility wide system
- Open:
 - ▶ Fire Barriers
 - ▶ Soot loading analysis

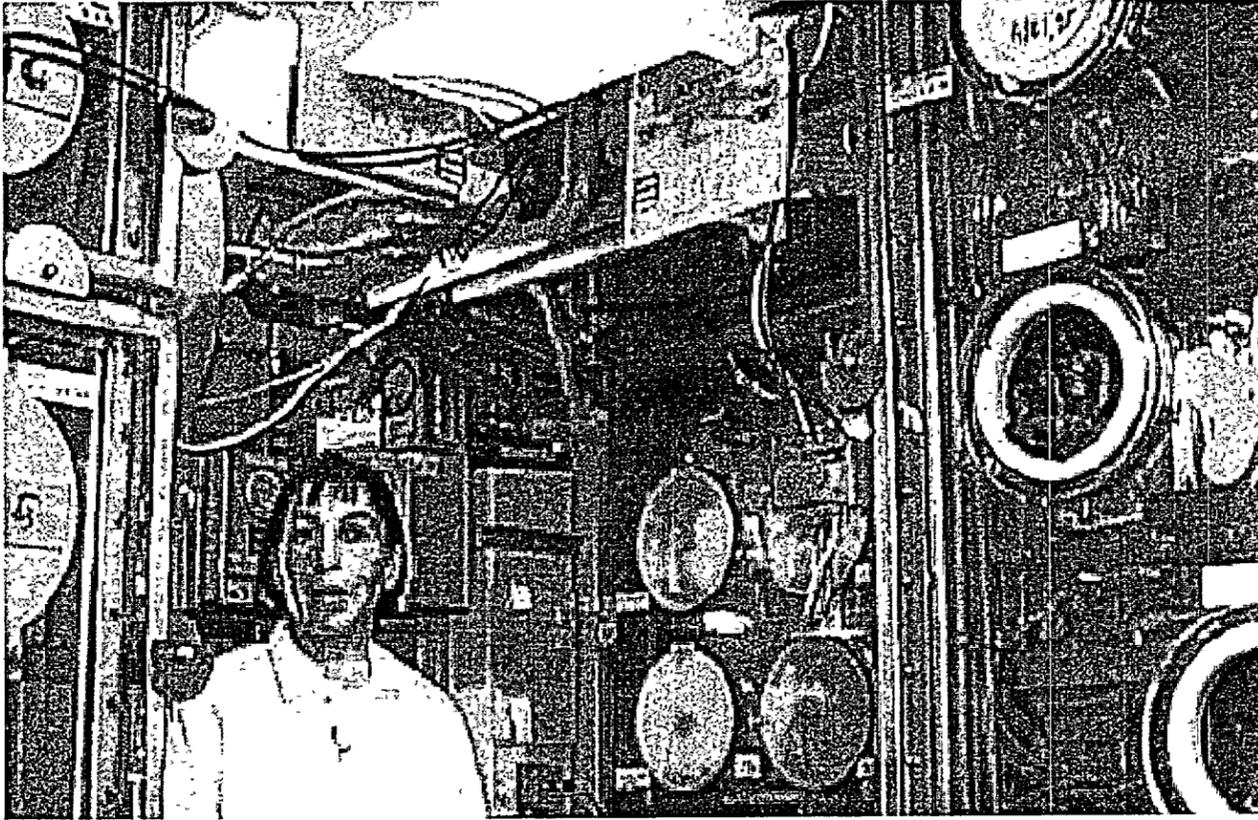
Closed: Design basis criteria for glovebox window

- National Fire Protection Association -NFPA 801, “Standards for Fire Protection for Facilities Handling Radioactive Material”
 - ▶ *“The glovebox and window shall be of non-combustible construction”*
- Polycarbonate glovebox windows - to reduce seismic vulnerability and overall risk.

MOX Polycarbonate Report:

- ▶ superior seismic inertia and deflection properties compared to glass
- ▶ superior fire properties compared to other plastics

Typical Glovebox Installation



Closed: Design basis criteria for glovebox window

- NRC requested the design basis criteria (to assure stated mechanical, fire and seismic properties were bounding)
- Additional fire protection features:
 - ▶ automatic detection and suppression (PSSC)
 - ▶ manual CO₂ glovebox injection
 - ▶ inert atmospheres
 - ▶ combustible loading controls (PSSC)

*PSSC - Principal
Structures,
Systems and
Components*

Closed: Design basis criteria for glovebox window

- Fire Hazard Analysis will account for polycarbonate
- Integrated Safety Analysis will evaluate:
 - ▶ Whether range of properties are bounding for expected use/conditions
 - ▶ Normal operating conditions such as material creep
- NRC considers polycarbonate to be a candidate material

Closed: Propagation of Hot Gas through Facility Wide Systems

- Pneumatic pipe automatic transfer system carries material throughout the facility
 - ▶ Convenience cans, sample vials
 - ▶ Between gloveboxes (across process atmospheres)

- Hot gases from a fire could be transported across fire area boundaries

Closed: Propagation of Hot Gas through Facility Wide Systems

- Double wall piping
- Combustible loading control -PSSC
- Integrated Safety Analysis will evaluate:
 - ▶ Impact of hot gas transport in the pneumatic transfer tubes
 - ▶ Isolation valves as IROFS where needed
- High confidence that design is acceptable

Open: Fire barriers

- Insufficient margin of safety
- Fire barriers are rated a minimum of two hours per ASTM E-119 standard time-temperature curve
- Equal Area Hypothesis method - relates fire severity to fire barrier rating
- Fire modeling - demonstrated that the duration of fires was less than barrier rating (with slow growth fire assumptions)

Open: Fire barriers

- Construction authorization:
 - ▶ Applicant will evaluate fire scenarios where temperatures could exceed the ASTM E-119 curve (using rapid growth fire assumptions)
 - ▶ Fire barriers could withstand thermal shock due to rapid fire development

- Integrated Safety Analysis:
 - ▶ fire barrier performance under credible fire conditions (including flashover)
 - ▶ account for potential barrier failure

Open: Soot loading analysis

- Process room and glovebox exhaust systems remain operational during a fire
- Protection of final HEPA filters provided by air stream dilution, spark arrester and pre-filter
- Insufficient justification that the final HEPA filters could perform their safety function under fire/soot conditions:
 - No soot analysis for the glovebox exhaust system
 - Process room exhaust appeared to have inadequate capacity to remove the expected soot loading.

Open: Soot loading analysis

- Revision of final filtration analysis
- Applicant provided additional information - February and April (not incorporated in the revised draft SER)
- Soot loading will be experimentally verified

Conclusion

- Technical meetings on open items
- Additional information to address open issues before the final SER