T-1143

NUCLEAR REGULATORY COMMISSION

ORIGINAL

**In the Matter of:** ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
SUBCOMMITTEE ON CLINCH RIVER BREEDER REACTOR

**DATE:** October 27, 1982 **PAGES:** 1 - 233

**AT:** Washington, D. C.

TRO4
ADD LPDR
NSIC
NTIS
CF

ALDERSON REPORTING

400 Virginia Ave., S.W. Washington, D. C. 20024

Telephone: (202) 554-2345

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
SUBCOMMITTEE ON CLINCH RIVER BREEDER REACTOR

\- - -

Nuclear Regulatory Commission
1717 H Street, N.W.
Washington, D.C.
Wednesday, October 27, 1982

The meeting of the Subcommittee on Clinch River Breeder Reactor of the Advisory Committee on Reactor Safeguards was convened at 8:30 a.m.

PRESENT FOR THE ACRS:

Max W. CARBON, Chairman
Robert AXTMANN, Member
J. Carson MARK, Member
Jeremiah J. RAY, Member

DESIGNATED FEDERAL EMPLOYEE:

P. BOEHNERT

ACRS CONSULTANTS:

W. KASTENBERG
W. Lipinski
Z. ZUDANS

ALSO PRESENT:

T. KING
G. CLARE
P. DICKSON
D. BECKER
R. STARK
B. MORRIS
P. CHECK

# PROCEEDINGS

MR. CARBON: The meeting will now come to order.

This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Clinch River Breeder Reactor, CRBR.

My name is Carbon, the subcommittee chairman. The other ACRS members present today are Robert Axtmann, Carson Mark, and Jeremiah Ray on my left. We also have in attendance ACRS consultants William Kastenberg and Zenon Zudans.

The purpose of the meeting today is to discuss CRBR plant design criteria, safeguards, and security for CRBR and design basis accidents and their associated prevention-mitigation systems.

The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act and the Government in the Sunshine Act. Paul Boehnert is the Designated Federal Employee for the meeting. The rules for participation in the meeting have been announced as part of the notice previously published in the Federal Register on Wednesday, October 6th, 1982.

A transcript of the meeting is being kept, and will be made available, as stated in the Federal

Register notice. It is requested that each person first identify himself or herself and use the microphone so that he or she can be readily heard.

We have received no written statements from members of the public, and we have received no requests for time to make oral statements from members of the public.

Before we start, I would turn to the subcommittee and ask if anyone has any comments to make or questions to raise. I would point out that our first topic is plant design criteria. We are meeting today on this topic, I believe, specifically at the request of the staff. It is a continuation of earlier discussions. You have noted and will note that I think it is four criteria that have been added to the previous list. We have been discussing those. We will be discussing in particular some questions which Dave Okrent raised the last time, and discussing whatever else we or the staff wish.

It is expected that the design criteria topic will be on the full committee meeting next week. I won't say anything, I guess, on the design basis accident rationale or plant safety and security at this time, but we will get into those as quite separate topics later in the day.

Does anyone have any comments?

MR. MARK: I have a question, which perhaps can be answered by King, Mr. King, since he is presenting the criteria. How does he propose to do that? Is he going to go through the whole 60, calling attention to them? I have a few textual questions which I could raise separately, but if he is going through the criteria one at a time, I hope he doesn't, but he might say, Criteria 1, are there any questions, Criteria 2.

MR. CARBON: Why don't you just answer when you start?

MR. KING: I do not intend to go through my criteria one by one. I intend to address the major changes in the PSAR and the site suitability report. I provided yesterday a copy of the final draft of the SER section which does go through the criteria one by one and explains all the changes from Appendix A to 10 CFR 50.

MR. MARK: Perhaps after you have gone through what you have planned, then I could have an opportunity to ask about this criteria or that one.

MR. KING: Yes. That is one of the reasons I provided the SER sections. Any questions that come up on criteria, you will at least have the words in front of you.

MR. CARBON: Are there any other questions or comments?

MR. RAY: I had a similar concern. I wondered how you were going to treat Dr. Okrent's comments.

MR. KING: I will have vu-graphs that address each of Dr. Okrent's comments.

MR. RAY: Thank you.

MR. CARBON: Let's them proceed with the meeting. I guess I call on Mr. Stark.

MR. STARK: Good morning.

Today the staff will make three presentations. Two of the presentations that will occur later, the one on accidents and sabotage, will be status reports, and they will be quite similar to the status report we made yesterday to the subcommittee on thermal hydraulics. However, as Dr. Carbon stated, the first presentation is a discussion on what we believe are mature and final design criteria.

As Dr. Carbon indicated, the design criteria were the subject of a March ACRS working group meeting. We believe we have incorporated the comments from that March meeting, as well as Dr. Okrent's July letter, and Tom King, who will be following right now, will discuss the design criteria and how they have been changed by the March ACRS meeting, and how we factored in Dr.

Okrent's comments.

So, with that, I will turn it over to Tom King.

MR. KING: My name is Tom King. I am with the NRC staff in the Clinch River Program Office.

Today I will be talking about principal design criteria for Clinch River.

Over the past several months, we have spent considerable time going through the criteria, the criteria that were developed in 1976, and that currently show up in the PSAR and the site suitability report. We think we have a complete set. We are here today to present this set and to solicit any comment or feedback you have on the comment.

I plan to summarize what we have done in terms of the approach we have taken in looking at the criteria, the major changes we have made, and to address Dr. Okrent's comments and the ACRS comments from the March 30th and 31st meeting.

(Slide.)

MR. KING: The purpose of the principal design criteria is spelled out in 10 CFR 50. Basically, it says they establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components important to safety, that is, structures, systems, and components that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

Appendix A to 10 CFR 50 provides 55 general design criteria which are written for light/water reactors, but it is acknowledged in the preface to Appendix A that they are to be used as guidelines for developing principal design criteria for other types of reactors.

(Slide.)

MR. KING: The way we accomplished or tried to accomplish what we feel the intent of the criteria is, we feel that as far as Clinch River is concerned, the intent of that criteria is to express the broad requirements which must be met to ensure that the safety of CRBR is comparable to LWR's and that core disruptive accidents are of sufficiently low likelihood that they can be excluded from the plant design basis.

In going through the criteria and looking at the changes we felt should be made, this was the basic premise we started from. We had three basic rules that followed from this. They were, in going through the criteria, we tried to, for those structures, systems, and components which are comparable to structures, systems, and components in LWR's, we made it equivalent to or more conservative than the corresponding requirements for LWR's.

For the unique aspects associated with Clinch River, we developed unique criteria, and in developing those, we tried to reflect an equivalent or more conservative safety approach than generally applied to LWR's, and we tried to look at those factors which we felt were necessary, design factors that were necessary to reduce the likelihood of core disruptive accidents such that they could be excluded from the CRBR design basis, and we have added or made changes to criteria that we feel address that point.

(Slide.)

MR. KING: Some other, more specific ground rules that we feel should be applied in going through the criteria, we used the framework of Appendix A of 10 CFR 50 as much as possible. In going through there, where there was no substantial difference between CRBR and LWR structures, systems, or components, we adopted the words from Appendix A in their entirety.

Where we felt the intent of the criteria in Appendix A applied to CRBR but we had to make some changes either due to terminology differences or CRBR systems that were a little different, we again tried to maintain the wording as much as possible from the Appendix A, and just made those changes necessary to fit the CRBR terminology. Where there were unique characteristics of the CRBR systems, we developed unique criteria.

We also went back and looked at the principal design criteria of SEFOR and FFTF, and we looked at the ANS 54.1 standard, which is currently in draft form and is being developed to address principal design criteria or design criteria for LWR's. We used those documents, and also in a general sense considered previous LMFBR experience, in terms of areas that you could look at that may prompt you to add another criteria.

MR. RAY: Mr. King, excuse me. On this list there is no indication that you considered foreign experience. Did you?

MR. KING: To the extent that we had it, yes.

MR. RAY: That phraseology arouses my curiosity. Is it limited availability to you? I mean, are they treating these things as secrets?

MR. KING: We have some general reports on experience, like for instance with Phoenix reactor, and some of the Japanese reactors. To the extent that information is presented in those, yes, we have considered it.

MR. RAY: You have not aggressively gone after
it? Is that what you meant?

MR. KING: I have not gone to try and find out what their principal design criteria are, or tried to get information specifically, specifically the types of information that would address principal design criteria.

MR. RAY: That is an interesting omission.

MR. AXTMANN: I am sorry. I don't know what SEFOR is.

MR. KING: SEFOR is a reactor that was built in Arkansas by General Electric. It stands for Southwest Experimental Fast Oxide Reactor. I believe it was a 20 megawatt oxide fuel --

MR. AXTMANN: Did it operate?

MR. KING: Yes, it operated.

MR. AXTMANN: And died?

MR. KING: I'm not sure why it was shut down. Maybe Dick Becker could answer that a little better. He was at the project.

MR. BECKER: I am Dick Becker, NRC staff, CRBR Program Office.

The SEFOR reactor was a reactor that was designed and built specifically to measure the doppler coefficient in LMFBRs. It went through the experimental program, and then it was shut down at the end of their planned experimental program, and decommissioned.

MR. AXTMANN: In what era?

MR. BECKER: It shut down in 1972.

MR. MARK: When it was decommissioned, what did they do about it? Did they just pile dirt on top of it, or take the concrete away, or what?

MR. BECKER: No, it was decommissioned to "possession only" status. They closed and sealed the containment, removed the sodium and the fuel. They cut any penetrations into the containment, sealed them, and sealed the reactor cavity with a plate across the cavity. It has intrusion alarms and water sensors, but it is essentially in a status called "possession only."

MR. MARK: Thank you.

MR. AXTMANN: What power levels or flux levels did they use?

MR. BECKER: Its design was 20 megawatts thermal power. It had a large fuel element that gave you the same temperature conditions that you would expect in an operating commercial LMFBR.

MR. AXTMANN: Temperature, but not necessarily flux?

MR. BECKER: That's right; slow power but high temperature.

MR. CARBON: Go on, Mr. King.

MR. KING: The last item is one we touched on before. We added criteria which changed existing criteria that we felt we needed to such that we wanted to reduce the likelihood of core disruptive accidents sufficiently that they can be excluded from the design basis.

MR. CARBON: Would you give an example of the last half of Number 5 there, criterion addressing those features?

MR. KING: As an example, we added a criteria on fuel rod failure propagation, Criterion 59, I believe the number is. That was added because failure propagation was one of the ways in which you could get into a core disruptive accident, an accident involving the whole core. We added a criteria requesting that either systems to detect propagation or features to prevent propagation be added to the design.

MR. CARBON: Fine. You will be discussing that one later?

MR. KING: That particular one will come up later.

MR. CARBON: Fine. Go ahead.

MR. KING: In looking at the criteria, we had to ask ourselves, how do we know they are complete?

(Slide.)

MR. KING: What we did was, we tried to categorize the criteria into basic functions in which they perform. This is the list of fuctions we came up with. We went through and attempted to make sure we had adequate criteria where there was one or multiple criteria that addressed each one of these functions, and satisfied ourselves that we had all of these areas covered in terms of CRBR systems important to safety.

I did not bring a matrix that lays out 60 criteria against each one of these, but that could be done, and we can do that.

MR. CARBON: I was writing when you said that. On what basis did you say you satisfied yourself it was complete?

MR. KING: We made this list to try to describe the basic safety functions which we wanted the criteria to address. We went through and matched up the criteria to the appropriate safety function, and looked at the systems, structures, and components. We looked at those features that we felt were necessary to prevent core disruptive accidents, and made sort of a qualitative judgment that the criteria we have address all of these functions, and we did not find any holes. Let me put it that way.

MR. ZUDANS: On this list, as it stands, you have an item, sufficient decay heat removal. I noticed in the criterion you never really mention natural circulation as a requirement. Did I miss that?

MR. KING: No. What we mention is decay heat removal. The important function, we feel, is decay heat removal.

MR. ZUDANS: Of course it is, but that's just one mechanism.

MR. KING: Natural circulation is just one of the ways in which you can remove decay heat.

MR. ZUDANS: Is it because you like to stay at the high level of resolution and not go into specifics?

MR. KING: Yes, that's a major consideration in these criteria.

MR. ZUDANS: I didn't quite like it the first time, and I don't like it now, that that is not explicitly mentioned.

MR. KING: You feel we should have a specific criteria addressing natural circulation?

MR. ZUDANS: That is my primitive way of thinking. You mention two loops and three loops, so you are very specific, but on this aspect you are not.

MR. LIPINSKI: I have a general comment. It seems like if you did not have a Clinch River design before you, and you were given the task of writing criteria, that you could still have written these criteria. But having been given Clinch River, you are specifically writing these criteria to fit Clinch River. As we go through them, I will have comments on various specific criteria, but somehow, it seems like about the only concession you might have had to make is whether it whether it was a loop or a puff type LMFBR; but you should have been able to write a general set of criteria without regard to the design, and leave it up to the designer to meet those criteria, not the other way around, that he writes the criteria to meet the design.

MR. KING: We didn't try to fit the criteria to the existing Clinch River design.

MR. LIPINSKI: I will comment on that, where you have specific words deleted and they imply something about the design, because you deleted certain words.

MR. KING: All right. We will get to those.

MR. CARBON: I do have a comment. I don't want to push it more here, but I'm sure the question will come up at the full committee meeting on how you are sure that your list is complete. Frankly, this presentation, your words, Tom, do not sound all that strong to me, and I would anticipate that in the full committee meeting, it might be well to have a little bit stronger argument or statement.

Go ahead.

MR. AXTMANN: Excuse me. I don't see any item relating to radiological safety of the operators. Is that something that was also left out in 10 CFR 50 for LWR's?

MR. KING: No, radiological protection of the operators is addressed in 10 CFR 20 and 10 CFR 100.

MR. AXTMANN: And it is not --

MR. KING: We did not try to duplicate what was covered in those portions.

MR. AXTMANN: This talks only to design. I don't think 10 CFR 20 and 100 do talk to design.

MR. KING: No, they talk to the limits that you have to meet. That is true.

MR. AXTMANN: I see. You don't see any conflict there, when you are talking about general criteria relating to safety? These are addressing the safety to the public, but you don't see a conflict about not specifically dealing with that?

MR. KING: No, I don't see any conflict.

MR. RAY: On this point, there are several places, as I remember it in reading this, where consideration of the operator is evident. Control room habitability is one of the areas. Aren't there other criteria?

MR. STARK: Criteria 17 on control room adequate radiation protection exists in the criteria right now.

MR. RAY: Is that the only one?

MR. STARK: I was just turning pages.

MR. KING: I think that's the only one that specifically mentions a dose rate.

MR. AXTMANN: I see an inconsistency there.

MR. RAY: I agree.

MR. MARK: I agree as well. It is a design matter, quite apart from the rad or rem limits, when you think about the design of making inspection and maintenance as radiation-free as possible. Just setting a limit does not do that for you. The way you lay out the pipes and so forth may very well affect that.

(Slide.)

MR. KING: This is just a vu-graph to give you an idea of the number of criteria that changed in the version that's in the PSAR and the site suitability report from the 1976 version. They started with 55 criteria in Appendix A to 10 CFR 50, omitted nine, added ten unique ones, for a total of 56, and of the 46 they used from Appendix A, 23 were modified in some way to apply to CRBR, and 23 were adopted without change.

In the version that we are proposing, starting with the 55 criteria in Appendix A, we have omitted seven. We have 12 unique ones for Clinch River, for a total of 60, and of the 48 that were used from Appendix A, we have modified 27 in some way to apply to Clinch River.

MR. CARBON: I do not understand the distinction between the two major groups. They both start out, of the 55 criteria, it says, in one case nine are omitted, and another are seven.

MR. KING: This is the version currently in the PSAR and the site suitability report, the one that was developed back in 1976. We have taken that version and we have made some changes to it, and these are the numbers that now apply to the version that we are proposing.

MR. CARBON: So in the new version you have only omitted seven instead of nine?

MR. KING: That's correct.

(Slide.)

MR. KING: What I wanted to do was run through briefly the criteria, the ones that are identical to Appendix A, just to show you which ones those are and go into the ones where we've made some changes, and then the unique ones, and the ones we omitted.

There were a total of 21 we made no change to. The numbers in parentheses are their corresponding numbers, and it is from Appendix A to 10 CFR 50. Quality standards and records we didn't change. Fire protection, sharing of systems, structures, and components, reactor inherent protection, suppression of reactor power oscillations, containment design, inspection, and testing of electrical power systems, protection of system reliability and testability, separation of protection and control systems, quality of reactor coolant boundary, capability for containment leakage rate testing, provisions for containment testing and inspection, piping systems penetrating containment, primary containment isolation, inspection of primary containment isolation, inspection of containment atmosphere cleanup system.

Testing of containment atmospheric cleanup system, control of releases of radioactive materials, prevention of criticality in fuel storage and handling, monitoring, fuel and waste storage, protection against anticipated operational occurrences.

(Slide.)

MR. RAY: Perhaps I missed it because I wasn't listening hard enough, but on plant security, is this different from 10 CFR 50, Appendix A criteria?

MR. KING: Plant security?

MR. RAY: For this plant.

MR. KING: There is no Appendix A criteria that deals with plant security.

MR. RAY: Is there any criterion that deals with plant security? Will we hear that later?

MR. KING: There is no general design criteria or principal design criteria that deals with plant security. There is Part 73 to 10 CFR 50 that deals with plant security.

MR. RAY: I see.

MR. KING: We did not put a criteria in because we felt that that section in the Code of Federal Regulations dealt with that subject.

MR. RAY: What you are saying is, that is automatically controlled?

MR. KING: That is automatically controlled.

MR. RAY: Because it is a regulation that applies to this plant?

MR. KING: That's correct.

MR. RAY: Thank you.

(Slide.)

MR. KING: Okay. There are 27 criteria that we made some change to. This is the criteria for

Appendix A. There are four that I put an asterisk next to that indicate major change. All the others are changes really that deal with terminology and making sure that we have the right words that describe the CRBR systems.

I plan to talk later specifically about the ones with the asterisks, the ones that are major changes. I did not intend to talk specifically about the ones that we felt were minor editorial or technology type changes.

(Slide.)

MR. KING: This is the second half of that list. The ones that had minor changes.

(Slide.)

MR. KING: These are the criteria that are unique to Clinch River. The last two are new from the version that was developed back in 1976. The remainder, although they are unique, they were developed back in 1976. I don't believe we have made any changes to the ones that were developed back in the previous review.

MR. AXTMANN: I have another general question. This is the first CRBR subcommittee meeting I have attended, so perhaps I am the only one in ignorance. Why is this called the CRBR criteria rather than fast reactor criteria?

MR. KING: We are writing these criteria specifically for CRBR. We are not trying to address the general LMFBR's. That is one of the ground rules. Maybe I didn't mention it earlier, but that was one of the ground rules we were going on. We are only addressing CRBR.

MR. CARBON: Would you straighten me out on something? I have some correspondence here that says there are four new items, Criteria 57 to 60, but Number 58 shows up in your first slide, your first list, anyway, as one that is identical to an earlier one.

MR. KING: Fifty-seven and 58 were added in this current version.

MR. CARBON: Why is 58 in the first chart that says CRBR criteria identical to 10 CFR 50 Appendix A?

MR. KING: Fifty-seven and 58 are included in 10 CFR 50. They are ones that were excluded in the original version, but we now believe they should be added into the original criteria. We have taken 58 verbatim and made no changes to it, and included it in the CRBR criteria. That is why it shows up in the list of no changes. That is, no changes from Appendix A.

MR. CARBON: Okay, so when you have added four new items, that means compared to 1976?

MR. KING: That's correct.

MR. CARBON: Not compared to the LWR criteria.

MR. KING: That's correct. There will be some vu-graphs coming up that address the major changes from the 1976 version. Those four are on that list. Fifty-eight is one of them.

These are the criteria from Appendix A that we did not include.

(Slide.)

MR. KING: Reactor coolant makeup, Clinch River design, and the criteria have features that prevent the loss of reactor coolant, things like guard vessels and elevated piping. Therefore, we didn't see the need for a reactor coolant makeup system on Clinch River, and we did not include that criteria in Appendix A.

Emergency core cooling, inspection and testing of emergency core cooling, we did not include those because Clinch River has a captive cooling inventory. They have criteria that require this. Therefore, we did not see the need for an emergency core cooling system.

In addition, for decay heat removal, we have added some additional requirements over and above what you find in the LWR criteria to ensure decay heat removal. Containment heat removal, there were no design basis events that required a containment heat removal system. Therefore, we did not include a criteria for the inspection and testing of that system.

MR. LIPINSKI: Do LMFBR's require pressure system in containment?

MR. CARBON: Yes.

MR. LIPINSKI: Then why wouldn't Clinch River have to do something equivalent?

MR. CARBON: The leakage testing.

MR. KING: We have left the criterion for leakage testing. This is for containment.

MR. LIPINSKI: Aren't there some sodium fires postulated within containment? Not the big one, but aren't there minor fires?

MR. KING: Yes.

MR. LIPINSKI: They heat the containment, so how do you remove that heat after it's heated?

MR. KING: Conduction out through the walls of containment.

MR. LIPINSKI: How long do you wait?

MR. KING: You can wait indefinitely. Those fires do not raise the peak temperature above the design temperature or pressure.

MR. LIPINSKI: But if I have anything that heats the containment, am I not concerned about the heat removal from the containment?

MR. KING: If it heats at such that it exceeds its design temperature, yes.

MR. LIPINSKI: Well, even if I get to the limit, isn't it still important to be able to cool that containment down?

MR. KING: It's important to keep the containment below its design temperature and pressure. If you need a cooling system to do that, then that cooling system should be part of the design. If you don't need a cooling system to do that, then there is no sense of requiring that in the design. That is the thought process we went through.

MR. LIPINSKI: If I were to do a PRA and look at the time sequence of events from the time the containment was heated until it could cool by natural convection and not have access to the containment, am I vulnerable as a result of that?

MR. KING: No, there is no reason to get into containment for decay heat removal or getting into safe shutdown.

MR. LIPINSKI: All of the equipment inside is qualified to those specific conditions for an indefinite time period at high temperature?

MR. KING: For the time period demanded by the event. I wouldn't say it is indefinite. You look at what the duration of the event is, and qualify it for that period of time with some conservatism. Again, all the controls for decay heat removal and safe shutdown are in the control room. There is no monitoring that has to be done.

MR. KASTENBERG: Before you remove that, I have a question. There may be some events beyond the design basis which require decay heat removal, and there may be a system or systems to cope with that. What system would you use?

MR. KING: We are developing an appendix to our SER that will address design criteria for those systems that are used to mitigate events beyond the design basis. Maybe I didn't make it clear in the beginning. The principal design criteria address those systems, structures, and components that deal with design basis events only. We are dealing with design basis events in a separate --

MR. CARBON: Could you move your microphone up, or do you have one?

MR. KING: Is that better?

MR. ZUDANS: Is there any --

MR. KASTENBERG: You say there will be a meeting in November?

MR. STARK: The meeting in November is on core disruptive accidents. I guess that will be a piece of it. What Tom is saying is, we have an appendix to the SER that will cover beyond design basis accidents, and it will be free-standing, and it will include our assessment or criteria, and our evaluation of beyond the design basis accidents and systems, so I think that -- I'm not exactly sure. We don't have the agenda worked out for the November session, but as I recall, that was going to describe or discuss the status of our review on hypothetical core disruptive accidents, and I don't know to what extent it will include the assessment of containment heat removal systems.

I think it is just energetics right now, but I guess we could amend the agenda.

MR. KASTENBERG: At some time we ought to hear about criteria specifically, if there are systems to mitigate beyond the design basis.

MR. ZUDANS: Tom, could you as you go later on indicate where the design basis is defined in the criteria? These design criteria are only to deal with design basis events. The events themselves, at least, I can't clearly read in these criteria.

MR. KING: Design basis events are not defined in the criteria. They are defined in the PSAR.

MR. ZUDANS: There is some kind of a gap, at least in my understanding. Unless I have a set of design basis events defined, I don't see what I am applying these criteria to. In other words, I have to go to a document that is not part of this set. There is a gap in the logic that I don't understand.

MR. STARK: The second presentation today will be discussing design basis accidents.

MR. ZUDANS: Is there reference in this criteria to that set?

MR. KING: The criteria themselves do not reference that set. The introduction to the criteria --

MR. ZUDANS: In other words, this is like a loose animal. I can walk it all over the block. It is not advertised as anything specific. I think that link has to be somehow fixed, because it would be quite different if you change your design basis.

MR. KING: I agree. I think maybe that's a good point. If you added a new event to the design basis, it could affect the criteria. I agree with that.

MR. ZUDANS: Sure. It has to be a very specifically defined thing in this set and the other set.

MR. KING: That is a good point.

MR. CARBON: Can I go back to your question or comment, Bill? I wasn't really listening to your question. There are no additional criteria beyond these. I'm not sure I caught the intent of your question.

MR. KASTENBERG: The intent is basically this. If they are going to have systems, whether they be containment systems or other, that would deal with events beyond the design basis, some criteria would have to be established for those systems. I got the feeling that the process of evolving those criteria is taking place now, and at some point we would want to hear what criteria they come up with.

MR. CARBON: Bob, back on about their second or third slide, Number 5 says, the criteria address structures, systems, and components associated only with a design basis event, and those features which reduce the likelihood of CDA's, and I don't think there are any criteria for the DBA.

MR. STARK: As I indicated earlier, we are going to have an appendix to the SER dedicated to beyond the design basis accidents. In that particular appendix, we will look at the criteria, the acceptance criteria, and also our evaluation, so I think what we are saying here is that what we are looking at today is design basis accidents and the criteria associated with the design basis accident, and what Dr. Kastenberg is saying is true. For those systems that only exist for beyond the design basis accident, they will have a criteria associated with those, and those will be the subject of the appendix to the SER.

MR. CARBON: Criteria for beyond the DBA?

MR. STARK: That's correct. We will have to use something for our acceptance review and evaluation, and Dr. Kastenberg is correct. We will have those as a part of our particular appendix in that review.

MR. CARBON: Then you are proposing next week at the full committee meeting we will only be discussing part of the criteria.

MR. STARK: We will be discussing the criteria associated with design basis accidents. That's correct. Just in the same fashion as the general design criteria only address design basis accidents for light/water reactors. There is nothing inconsistent there.

MR. CARBON: Except if I understand what you are saying, you will end up with principal design criteria for CRBR that address beyond the DBA, and you don't have those on the LWR.

MR. STARK: That is because we have made an attempt here to evaluation a beyond the design basis spectrum, and we have to develop some sort of measure or yardstick to do our evaluation to.

MR. CARBON: All I am trying to do is get consistency clear in my mind. Still on LWR's, we have no criteria for ATWS, I guess.

MR. MORRIS: This is Bill Morris, NRC staff.

You might recall that at an earlier meeting we presented to you some of the general design criteria that we were developing for events beyond the design basis. We don't call those principal design criteria. Those are special ad hoc criteria developed specifically to use in our evaluation of CDA's. Those are on the record. They were incorporated in the transcript of a previous meeting, and you may recall those.

MR. CARBON: But those are not principal design criteria.

MR. MORRIS: No, the principal design criteria for CRBR as for an LWR are those criteria that are employed to assure that you will not develop a severe accident such as a core disruptive accident. That is what they are there for. However, recognizing that such accidents may occur, the staff has decided that it should, and this follows the lead of the applicant, that we should have some provisions for accidents beyond the design basis.

So, we break things down into those two categories. The criteria that are for the beyond design basis events should not be confused with principal design criteria. We are following, as Rich said, new criteria for beyond the design basis.

May I make one clarification of something that was brought up before? What you have here in the principal design criteria is an attempt to recognize the general kind of events that could occur. It is not necessary, we contend, to know the details of the assumptions made in examining design basis accidents in Chapter 15 in order to have a complete set of general design criteria.

What we are talking about here are the general type of events, the external events such as earthquakes, but the general design criteria for LWR's do not specify what the earthquake is. Fires are postulated, but we don't specify where the fire is going to be or what its intensity is. So, that's the distinction with regard to Mr. Zudans' question. What we're doing here, and what will be done in Chapter 15 of the SER --

MR. ZUDANS: I understand your point, but of course then it could be appropriate to remove references to design basis events. You can describe the same objectives on a higher scale, which I would really like to see. You are giving criteria that relate to the product, and not your assumed behavior of the product. You say you want a certain level of risk to the public not to be exceeded, and you present criteria without reference to design basis events.

I think your reference has in mind a very specific set, and that is what bothers me.

MR. MORRIS: I think that may be the distinction. We are talking about the principal design criteria, so we must be talking about generalized postulated events.

MR. ZUDANS: Correct; but you make reference --

MR. MORRIS: We will be talking about specific criteria in the SER and the PSAR, which will be much more detailed.

MR. ZUDANS: But isn't it true that these criteria refer to the design basis events that are listed? They are written specifically to satisfy the results of design basis events that are listed in Chapter 15.

MR. MORRIS: These criteria recognize that there are going to be specific design basis events that must be mitigated, but they don't specify what those events are in detail.

MR. ZUDANS: But what is behind it is a knowledge of that set. Also behind that is, the fact that one of those items in that chapter changes the whole general criteria. And I think that is too low a level of criteria. It should be higher up.

MR. MORRIS: I would contend that the kind of events that are recognized here in the principal design criteria are, for example, reactivity events, sodium fires, ordinary fires, external events such as tornadoes and seismic events. Those general kinds of events are recognized here, but as I say, when you change the level of intensity of the design basis earthquake, it doesn't mean you have to go back and change a principal design criteria. That means you change the specific criteria for the components in the plant.

MR. ZUDANS: Let's take a specific example. Supposing right now there is no primary coolant pipe break that is postulated as a design basis event in the LMFBR, but there is such in an LWR. The LWR criteria takes care of that guillotine type break, don't they?

MR. MORRIS: Yes, and I agree with you that we have recognized in general here that we do not have to deal with a LOCA event as we do for a light/water reactor.

MR. ZUDANS: Why don't you? Suppose three weeks from now you change your mind for whatever reason.

MR. MORRIS: If that were the case, we would have to re-examine these criteria.

MR. ZUDANS: Well, that proves to me that the criteria are at too low a level, too precise, too much resolution. They have to be elevated to a level where the choice of events does not affect the criteria.

MR. MORRIS: However, I must point out that one of the criteria -- I cannot recall the number right now -- does address the possibility of broken pipes and leaks. It just doesn't do it in the same way as done for the LWR criteria. I would argue that the LWR criteria are possibly at too low a level in the sense that they recognize the existence of certain pieces of equipment, and they speak to equipment in addressing LOCA. In the criteria we are developing here, I think they say that you must consider the possibility of leaks in pipes and fires, so in that sense I think we are fairly general.

Although I don't want that remark to be taken as something, that there is something inadequate about the LWR criteria, you will note that some of those that are missing from our set now do correspond to specific pieces of equipment to mitigate LOCA.

MR. LIPINSKI: I would like to comment on that, because that applies to my earlier statement. The way you wrote the criteria, you had knowledge of the plant design, and your explanation goes on to say this, and as a result, you wrote the criteria with respect to a LOCA, acknowledging the design rather than writing the criteria in such a way that the design was forced to put in guard vessels and guard pipes.

MR. MORRIS: I would think what we have is a general understanding of the fact that the LMFBR systems will be operating at lower pressures.

MR. LIPINSKI: That is not the issue.

MR. MORRIS: That is taken into account in not stressing the need for mitigating a large blowdown due to a pipe break.

MR. LIPINSKI: I am not talking about that. I am talking about pumping the system dry and letting the sodium flow out. The design has acknowledged that that has happened, and there are features to prevent it, but the criteria should have dictated that these features be included, and then the design meets them. The way you wrote the criteria, you assume that equipment is available.

MR. KING: I think the criteria do not use the words fire in the vessel or piping.

MR. LIPINSKI: I would rather look at the words later.

MR. CHECK: This is Paul Check of the staff.

This is an interesting discussion. I think you two are saying something that is similar. Variations on a theme. If I understand you, it sounds like you are saying that we have acknowledged perhaps a little too much in the design, and the criteria are set at too low a level. As a matter of fact, that is acknowledging design also, but I have to say what Bill Morris has said and what Tom King has said. We have not embarked on this in an attempt to establish a new basis for doing this part of our business of licensing.

What we have tried to do is search for a basis for licensing this reactor, and we are doing it with all the tools and experience we have in buiding light/water reactors. I think what we are trying to construct here are design criteria which are close analogs, at least the set is a close analog to what the set for light/water reactors is.

I think the criticisms that you make of it can also be leveled at those for light/water reactors. After all, those criteria were developed from experience with light/water reactors. They didn't come down from a cloud. They were a distillation of a lot of experience and knowledge about what light/water reactors are, and we are doing something about that now. We certainly admit to that. We are being influenced as we converge by the design itself.

What we are trying, and we hope we will not lose, is the attainment of this objective. That is, to establish clearly a basis for licensing a plant. The basis in law for licensing this plant. Not establishing a new point of departure for licensing LMFBR's.

MR. LIPINSKI: I will go back to the subject of LOCA's. Compared to LWR's, you do not have the high pressure, but you still have the capability of taking the system inventory and pumping it all over the containment floor. There should be a very specific criteria that says you will contain the liquid from a rupture in the criterion. Then you come back and you say, we have equipment for the guard vessels and guard pipes.

MR. CARBON: I think there is something that came out from the staff in an earlier discussion that was more of a statement that this is an iterative process.

MR. CHECK: That is certainly true.

MR. CARBON: You look at the unit itself, and the design, and you go back and address the design itself. I think you can go about it any way you wish.

MR. CHECK: And we also go into -- there is the point that maybe here we have a point where reasonable men can disagree. What you are saying, Walt, makes some sense in light/water reactors. If they all of a sudden decided that meteor strikes are going to be considered, then there would be a criterion to cover them. There is some knowledge. I am trying to avoid pejorative terms, but the establishment of the set is influenced by the knowledge of what reactors are and what design events are.

MR. LIPINSKI: Let me take --

MR. CARBON: I think maybe we had better move on.

MR. LIPINSKI: I've got another example.

(Slide.)

MR. KING: What I want to talk about next are the major changes from the 1976 version. There are eight of these I am going to talk about.

The first one is the principal design criteria number 8, reactor design. We have added a requirement to that criteria that requires the design to provide means to prevent fuel management errors. We use the words from ANS 50.1, which has that same requirement and that same specification, that same criteria.

The rationale was that fuel management errors are not a design basis event at Clinch River as they are in LWR's. Therefore, we felt if they are not going to be included as a design basis event, then features should be required to prevent them. That is why we have added that additional statement.

MR. LIPINSKI: I am puzzled by that, because why are they not part of the design basis event? They are certainly probable. They are not completely impossible. I have no disagreement with what you have said here, but I am surprised that it says, since such errors are not included in the CRBR design basis event spectrum. I wasn't aware that they weren't. The question is, why weren't they?

MR. KING: They weren't because there are things to prevent them, discriminator posts and --

MR. LIPINSKI: Yes. Well, the probabilities are very small, but some of these devices can fail. They are not totally infallible, and the question is, what happens if. Is it a disaster, or is it something minor? Here again, you are taking an assumption that the design has included these features to prevent it as opposed to requiring this in the criteria and then making sure that the design comes up with features to live up to the criteria.

MR. KING: We are requiring those things in the criteria, and we are looking at them to see if they are adequate. You are saying maybe we had it backwards because the features were there before we stuck the words in the criteria.

MR. LIPINSKI: That's correct. You looked at the features and didn't have it in the criteria, and now you've modified the criteria to be sure the features are included.

MR. KING: This is a case where we have looked at design basis events and decided we needed to write some additional words in the criteria to be compatible with the design basis events.

MR. ZUDANS: I would like to add one comment. Whatever you said is correct, and I also think what I said is correct. There is too strong an emphasis on principal design criteria being subservient to design basis events. Read number 24 that you have there. I can't help but feel uncomfortable that there is a God-sent set of design basis events to which this set of criteria is subservient. I don't like that reference and I think that's what's wrong with it, not that the criteria are wrong.

MR. CHECK: Well, you certainly know, Mr. Zudans, that it is every bit as difficult to establish a set of design basis events as it is to establish --

MR. ZUDANS: That seems to be the primary thing. This is subservient to that. That is what is wrong, in my opinion. Maybe the wording is wrong, not the content.

MR. CHECK: They are linked.

MR. ZUDANS: They are not linked.

MR. CHECK: They are linked.

MR. ZUDANS: They are not linked. They are totally dependent, according to this. Read number 24.

MR. CHECK: I have never thought --

MR. ZUDANS: Well, read number 24.

MR. CHECK: Oh, I understand the dependence, yes. One is dependent on the other.

MR. ZUDANS: Not so. The one is primary and the criteria is secondary. All you do is make sure this design copes with design basis events. That means there is a God-sent set made by humans that these criteria now are out of the set, and I think it should be the other way around, not that they would change in content.

Design basis events are determined by design. The design either can have a limit or may not have. It is a design. Okay? The principal design criteria should only reflect what the design must have, not to endanger the public health and safety. That is all you are concerned with.

A natural phenomena is very easy because those events will exist. You can define seismic events and extreme phenomena. That is fine. That has nothing to do with the design. There is a set that the design is capable of experiencing, and that set is very design-specific, and the way the design criteria are written now, they seem to be subservient to that set.

MR. CHECK: That is history. The reactors were here first, and the design events followed. That goes back further than I do, so I am not sure. But the codification of design events certainly began before design criteria.

MR. CARBON: Zenons, if I understand correctly, for example you are saying in number 24 you would delete the last comment and provide reactivity control systems, period.

MR. ZUDANS: That is correct.

MR. CARBON: Let's leave that for your consideration at present.

MR. ZUDANS: But there are many places where that shows up.

MR. LIPINSKI: I have no trouble with this criteria requiring the two independent reactivity control systems, but in looking at the rest of the criteria I cannot figure out what activates there.

I can have a PPS system that comes out with a common signal that activates two independent reactivity control systems, but I cannot interpret your criteria as saying anything upstream of this is duplicated.

MR. KING: Maybe the words need to be cleared up, but certainly the intent of that is to have entirely independent systems.

MR. LIPINSKI: I know what your intent was. I read this, but I cannot come out with that interpretation.

MR. CARBON: Does number 24 say that?

MR. LIPINSKI: That is the mechanism. If I go back and look at the criteria for electronics, I cannot get --

MR. CARBON: The system does not have any criteria for electronics?

MR. LIPINSKI: As I say, I have no trouble with 24, but when I go back and look at the other criteria I cannot match it up for getting duplication.

MR. CARBON: Yes, because you are saying systems does not include electronics, by your definition?

MR. LIPINSKI: There are other criteria that do cover this, but when I read them I cannot get the words that say I have to have that duplicated to match up with number 24.

MR. KING: I am not sure which criteria you are talking about --

MR. LIPINSKI: Number 19.

MR. KING: -- it is referring to.

MR. LIPINSKI: Reactivity control? I do not think that is your definition because criteria 19 is protection. Eighteen is protection system functions. Nineteen is protection system reliability and testability. Twenty is protection system independence. And somewhere in one of those three I would have to come out with the idea that I have two systems that are interacting with number 24, and I do not.

MR. CARBON: I guess I do not have the feeling that your last statement is necessarily true. I can interpret 24 to be standing on its own.

MR. LIPINSKI: You do not have reactivity control defined in the front, do you?

MR. KING: No, we do not.

MR. LIPINSKI: It is a question of what the definition of reactivity control is. Can you not include the electronics or include the sensor all the way? We have other systems that deal with electronic inputs.

MR. CARBON: I can include electronics in the control system, if I use the word "system" by a broad definition.

MR. LIPINSKI: I think you will find in LWR terminology that reactivity control are the reactivity devices.

MR. CARBON: Quite so. But how about the word "systems"?

MR. LIPINSKI: It is the same. I would say there is an ambiguity in the specification.

MR. KING: We can take a look at our words to clear that up. I do not have a problem with that.

Let us talk a little bit more about 24. As I said, the intent was to require two totally independent, redundant reactivity control systems -- that is, from sensor to absorber rod. This requirement was added for a couple of reasons.

One, in the previous review back in the '76 time frame, one of the conclusions was that we should have two totally independent, diverse, redundant reactivity control systems. That was primarily thought of in LMFBRs that if you had an accident that caused sodium boiling or voiding in the core you would not have the systems that you had in LWRs. It was then felt that having a system that will scram the plant reliably was very important.

Again, we do not have boron injection capability -- that kind of thing. Therefore, we had to rely on the fast shutdown systems that had to be equivalent to an LWR to reduce the likelihood that we will have an event where the plant does not scram, that the CRBR should have two independent shutdown systems. That is why we reworded the requirement to state that.

We also added a statement in there on shutdown margin which specifies not only the plant has to shut down, but it specifies that it has to be enough to terminate the event.

These are really the only systems that add negative reactivity and we wanted to be specific on the reactivity insertion requirements for these systems, so we added that as an additional requirement.

MR. MARK: On this general point, there are in the CRBR design, as it happens, two systems which I guess when you have gone over them will meet the criterion.

MR. KING: As of a couple of weeks ago, there were not.

MR. MARK: Well, you are going to examine them with this criterion in mind.

MR. KING: That is correct.

MR. MARK: I think as it happens one of those -- I believe it is one, and I am not sure whether it was both -- one of those will act without any motive power while it is acting -- any electrical motors or anything. That is, if you have a complete loss of power, one of the scram systems still works.

MR. KING: Both scram systems will work on a loss of power.

MR. MARK: I can imagine a scram system which requires a motor to push the rods around. I guess BWRs have such things. It would not be wrong in the criteria to say that at least one of them must work in the event of a total loss of offsite power.

MR. KING: I think there is a criterion -- I cannot remember the number -- that talks about that situation, basically a fail-safe-type criterion that says on loss of power or some other phenomena that the system has to go to a safe configuration.

MR. MARK: I see. If that is the case, I missed it.

MR. CARBON: You will give consideration to Dr. Zudans' comment about deleting all or part of the last clause?

MR. ZUDANS: Mr. Chairman, I would like to add something to that comment. At least in my preliminary thinking it would be completely acceptable to define design basis events in terms of its probability of occurrence. You could say somewhere in the beginning of the criteria that the design basis should include all design basis events that have a probability of X per reactor year.

MR. CARBON: Having made that offer, suggestion, whatever, let us then go on.

MR. KING: Criterion 25 is really -- follows directly from 24. Twenty-five addresses the control systems as they anticipate operational occurrences. Twenty-five addresses them as they postulate accidents.

MR. CARBON: Excuse me. Twenty-five is identical to 24, except for the last six words. What is the difference? Twenty-five would appear to be incorporated in 24.

MR. KING: We tried to follow the -- Their 25 does not require an independent capability of the systems to shut down the plant. Their 25 requires a combined capability. The change we made to 25 was to use basically the same words that we added in 24 -- that we required an independent capability.

MR. CARBON: Maybe you and the other people understand that, but I just plain do not understand why you have 25, why it is not incorporated in 24.

MR. KING: You could combine 25 and 24, there is no question. We did not attempt to do that because we were not trying to redo the format of the lightwater criteria. We were trying to stick to the format as close as possible. They had a 24 and 25.

MR. MARK: Just because they mucked that up, there is no reason you have to follow that here.

MR. KING: Certainly we can go back and try to improve on what they have done. We did not try to do that. We felt that if the words they had got the message across, we used that, and if the format got the message across, we used that format.

Thirty-five, reactor residual heat extraction system. That is really the decay heat removal system. What we did is change the criteria to require independence and diversity in the design. Redundancy was already included in the words. We put a statement in to require that the coolant used in the reactor -- we required that at least two flow paths remain available for decay heat removal following a single failure.

MR. LIPINSKI: Do you think your criteria requires a separate RHR system for the main heat transport system?

MR. ZUDANS: No, it does not.

MR. KING: We require diversity.

MR. LIPINSKI: I can give you diversity, but I can still use the main pipes. You have not defined your diversity as to whether I have to have a separate pipe from the reactor vessel different from the heat transport pipe.

MR. KING: No. When we implement [illegible] design we will decide whether the degree of diversity is sufficient or not. We did not try to define that in the criteria, that is true.

MR. LIPINSKI: That is what is bothering me. I think the criteria should be more specific and refer to the main heat transport system and a separate diverse system that is different.

MR. KING: We thought about that. In fact, we had some words at one time generated to do that. But it seemed to us the important feature was flow paths. We wanted multiple flow paths to remove decay heat. Whether they were part of the normal HTS system or part of another system did not seem to be the important point.

MR. LIPINSKI: Well, this is the problem with LWRs right now because the criteria were not that specific to say that there should have been a separate full pressure residual heat removal system separate from the main heat transport system, and you have an opportunity now to be very specific in your criteria and not repeat that LWR mistake.

Now do you think your criteria prevents once-through systems?

MR. KING: Systems that remove heat?

MR. LIPINSKI: Do not recirculate, where I just draw water from a tank and shove it out as steam.

MR. KING: I think the criteria would permit that, yes.

MR. LIPINSKI: Okay. Now you are also allowing power operation of the system, assuming onsite power is available and offsite power is not available, and you have no requirement that the system operate without power.

MR. KING: We do not have a requirement in the principal design criteria that the plant must withstand a station blackout.

MR. LIPINSKI: Is there a specific reason that it should not?

MR. KING: We are going to require that the plant be analyzed for station blackout, but we do not consider that as a design basis event. That is why it does not show up in the design criteria. It will show up in the safety analysis of the plant. The plant will be analyzed for that event.

MR. LIPINSKI: Now you are perceiving LWRs, the direction of LWRs is to analyze the LWR plants for their capability to withstand station blackout.

MR. KING: The CRBR will be analyzed for their capability to withstand station blackout.

MR. LIPINSKI: Except the LWR criteria are written, and this is happening after the fact. You are writing your criteria; namely your criteria can require blackout capability and then you will do your analysis to see if you have met the criteria.

MR. KING: If you consider station blackout as a design basis event, something that is probable that will happen, I agree with you that should be in the criteria.

MR. LIPINSKI: It is not a question of whether it is probable that it will happen. Even if it is very probable, the consequences cannot be tolerated, and that is another consideration.

MR. KING: I think that is why we are looking at it. We are just arguing whether it should be called or thrown in the spectrum of design basis events or thrown in the spectrum of beyond design basis events. Either way, we are going to look at it.

We are going to require that the plant be able to survive it. We have not included it in the design basis event spectrum.

MR. ZUDANS: I would like to comment on this one too. We commented on this one before because where you changed it it still appears to me to contradict your footnote where you say that this requirement is not intended to preclude two-loop operation because the requirement says the system safety function can be accomplished, assuming a single failure with at least two flow paths remaining available for residual heat removal.

Are you including in your own mind the DHRS system as a second loop?

MR. KING: We are including it as a flow path.

MR. ZUDANS: So that means that if one of the three loops is shut down you have two loops and a single failure will still leave you with two flow paths. However, in accordance with this criterion, I guess I am repeating what Walt just said, you either have offsite or onsite power available.

MR. KING: Correct.

MR. ZUDANS: Don't you think this is a place where you should have natural circulation when neither offsite nor onsite power is available? That is a design basis event. Your criteria fail to address this particular design basis event.

MR. KING: The criteria requires that you assume you have lost all offsite power or all onsite power.

MR. ZUDANS: But not both.

MR. KING: Right. And LWR criteria does not require that.

MR. ZUDANS: That has nothing to do with it. Forget LWRs. You have a design that takes care of that situation and here you restrict your criterion to either one or the other source of power being available. Why not have a third criteria that says neither of them are available and what do you do then?

MR. KING: When we consider all of the loss of power, we do not consider that to be in the design basis category. That is why you do not see words on station blackout in the criteria. It is not that we are ignoring those. Those events are going to be analyzed.

MR. ZUDANS: I think the project is smarter than that. They provide for that particular situation and they can take care of it, and as you know from yesterday's discussion that was probably the most profoundly discussed aspect.

That seemed to be the only item that at least I am interested in. I know the rest will work, and here you do not address one of the key design basis events.

MR. CARBON: Having brought out these words, let us refer this to you for further consideration. Go on.

(Slide.)

MR. KING: This is a continuation of the major changes. We have added four additional criterion from the 1976 version. The first one is reactivity limits. It is essentially the same as criterion 28 in Appendix A to 10 CFR 50.

There were terminology changes to fit CRBR terminology, and I am not sure why that was not included in the original set, but I think it requires that, for instance, when you evaluate the plant for accidents that the design not allow more reactivity to be inserted in an accident than your shutdown system.

MR. CARBON: Excuse me. I presume you are saying that you have no records as to why it was not in the 1976 version and that your judgment is that it should be in there and you put it in there. Is that right?

MR. KING: That is correct. It is the same story on 58. That is identical to design criteria 29. It requires a highly reliable shutdown system. Again, we do not see any reason for not included that on CRBR and we are not sure why it was not included on the old version.

Fifty-nine and 60 are new. Fifty-nine deals with fuel rod failure propagation. There are no corresponding limits or criteria in Appendix A that are similar to 59 and 60. In 59 we have added fuel failure propagation as one of the ways which could lead to a whole core disruptive accident. We felt that requiring features to prevent that or to detect it such that you could terminate the event was appropriate for Clinch River since this was one of the initiators for a core disruptive accident.

MR. CARBON: We have talked about the fact that this is an iterative process. Give an example of what you have in mind as a design feature to meet 59.

MR. KING: Delayed neutron monitors. What is their response time, their sensitivity? Should they be part of the plant shutdown system or not? That is the kind of feature that we could look at that would meet 59.

Also design of the fuel. What is the experience in terms of failure? Has there been propagation? Do we have a good data base that says there will not be propagation? If we do, maybe we do not need to be -- delayed neutron monitors require that there be safety grade equipment. It is this kind of thought process that we are going to go through.

Right now we are putting this criteria up. We are going to meet something, but we are not sure what that something is yet.

Sixty is flow blockage. Several things have prompted this. One is the Fermi 1 experience where they did have flow blockage and they did not have features to mitigate the effects of loose parts. We do not have much experience on LMFBRs with this, about what could be expected, what size they could be, and flow blockage was not included as a design feature.

Given those considerations, we felt it was appropriate for that requirements to be added to prevent flow blockage, whether it is for loose parts or loss from hydraulic hold-down on assemblies or whatever considerations you could have that would lead to flow blockage, which would require features to prevent that.

MR. LIPINSKI: Before you take that off, I would like to go back to 57, reactivity limits. You include consideration of events such as rod ejection, yet in an earlier criteria you deleted the words "rod ejection". I am puzzled.

Here you specifically refer to it and in the other criteria you said you wanted to delete the words. You said it was not possible.

MR. KING: I remember deleting the words "rod ejection" on another criteria because we felt that was an LWR terminology.

MR. LIPINSKI: And yet in this criteria here, 57, you put them in.

MR. KING: Well, I don't think we put them in; I think it was a matter of maybe we forgot to take it out. Fifty-seven is straight from Appendix A, 10 CFR 50. We did change a couple of words like, I think, "rod ejection" we changed to "rod runout," this kind of thing.

MR. LIPINSKI: Well, on this 57 you do have "rod ejection" and "rod runout."

MR. KING: Yes, we do have "rod ejection" in that one.

MR. LIPINSKI: But on the other one you said you wanted to delete it.

MR. KING: I think that is an inconsistency. We should take "rod ejection" out of this one.

MR. LIPINSKI: Yes, criteria 23 where you deleted rod ejection. You could go to the typo where you have "not ejection of dropout." I think you want "rod ejection or dropout."

MR. KING: I think you are right. In 57 we changed "rod dropout" to "rod runout". We did not take out rod ejection and we should have. Again, the only reason is we did not want to use LWR terminology that might be confusing.

MR. CARBON: Mr. King, how far along are you in your presentation? It is scheduled for 2-1/2 hours and we have gone 1-1/2. Are you maybe 60 percent through, or 30 or 90?

MR. KING: I would say 60 to 70 percent through.

MR. CARBON: So we are roughly on schedule.

MR. KING: The only remaining vugraphs I wanted to show deal with comments that were raised by this Committee in the March 30-31 meeting and the comments we received from Dave Okrent in the July 1 letter.

MR. CARBON: Well, let's take a break at this time, then.

(A brief recess was taken.)

MR. CARBON: Let's move ahead.

MR. KING: I think we wanted to follow up or Bill Morris wants to make a statement following up from this morning's discussion.

MR. MORRIS: Bill Morris, NRC Staff.

I wanted to point out something about the general design criteria, Appendix A. We should recognize that there is an admission in the Code of Federal Regulations that additional criteria may be added in the future. That is admitted for lightwater reactors and I think we must admit to the possibility for the LMFBR.

One particular example is that that has been discussed here recently. That is the possibility of requiring some design, general design, criterion related to station blackout. The station blockout problem is an unresolved safety issue for lightwater reactor. It is being considered intensively.

If it should occur that a new general design criterion should be added to these in Appendix A because of that study, we would believe that it would be reasonable to consider the addition of an additional criterion to the principal design criterion for Clinch River. We do not want to presume what the result of that unresolved safety issue will be.

We prefer to wait. We do have some level of confidence, however, that if it were to be the case that for lightwater reactors it was necessary to mitigate station blackout that it would be possible for this design to mitigate station blackout in a comparable way. We would prefer to just wait and hold off on adding any such criterion that would include a criterion for natural circulation.

So our general policy here has been that where one could find some possible way to perhaps improve the general design criterion, if that is going to come for lightwater reactors, if it were to be applicable to Clinch River, then we would address that in the appropriate way at the appropriate time.

We do not want to go and begin to forge ahead in the lightwater reactor industry here in those areas in which the concern could be equally applied to an LMFBR as to a lightwater reactor. We have tried to consider the special and unique features of LMFBRs that should be included.

So some of your concerns, there seems to be a generic question of why don't we fix this because we know it is going to be a problem. Our answer to that is we do not believe we should get out ahead of the lightwater reactor industry in this regard, with regard to licensing. So that, I think, is a generic answer to a generic concern that you have, and I would like you to keep that in mind as we go through this and you come up with those concerns.

They do not always needs to be fixed at this time for this criteria.

MR. LIPINSKI: Given your criteria of DBA and beyond DBA, I presume you are thinking of a number like $10^{-7}$ per year.

MR. MORRIS: Maybe I have not gotten your question, but no, we do not have a threshold probability to distinguish between design basis and beyond the design basis. We do not believe the techniques for coming up with those kinds of numbers are sufficiently mature.

MR. LIPINSKI: For station blackout you have seismic frequencies that are being discussed today, even those beyond the safe shutdown earthquake. The more frequent minor ones that will remove your incoming power lines and subject the plant to a long state of offsite loss of power puts you into the requirement that you are going to require diesels to have onsite power.

If I look at diesel probabilities of .01 per diesel, if this design is coming up with ten diesels to guarantee that I am going to have onsite power to guarantee that I do not have station blackout, then the design may be acceptable. But if it is using the approach of having the minimum number of diesels, I think you are going to have a problem.

MR. MORRIS: I would point out that we do not presume to try to resolve this tough issue here. This is an issue that would extend to lightwater reactors as well as to Clinch River. We agree it is an important question and should be resolved.

We believe that if the time should come at which that generic resolution for lightwater reactors would be to add additional diesels or add more diverse kinds of motive power that that could be incorporated for Clinch River as well as it could be for lightwater reactors. Therefore, we prefer to stop short of trying to resolve that tough issue here.

MR. LIPINSKI: Don't misunderstand. I am not advocating ten diesels. I would rather see a specification that says it can operate without power -- not operate, but removes heat without power RHR.

MR. CARBON: Fine. Let us move on, then.

(Slide.)

MR. KING: I wanted to talk about the comments raised in the March 30-31 ACRS meeting. What I have done is I have gone through the transcript. I was not at the meeting and I picked out what I considered to be the major comments and tried to put a response down for each one. We have considered them all.

We have incorporated some. We have not incorporated some.

MR. LIPINSKI: Could I back you up one? I was not prepared for you to throw this one up because I did not finish with your last vugraph.

MR. KING: You want to go back to the last vugraph?

MR. LIPINSKI: Criterion 58. I had some

slides in the handout that showed the specific words for each criterion. This is the one that deals with the extreme high probability of accomplishing your safety functions. My only comment is if I go back to criterion 19 for the protection system, and criterion 24 for the reactivity control systems, you have words in there with respect to reliability.

It is just a question of whether you want to use words like "extremely high" in those specific sections. This effectively is a redundant criteria to what is already there. This is possibly a little stronger, but you already have words in those other critera.

MR. KING: I agree. There are words in those other criteria. Again, we are just following or using the same format that the LWR criteria used. They applied reliability words.

MR. LIPINSKI: Fifty-eight is a criteria you added.

MR. KING: I added it in because it had not been included in the 1976 version of the Clinch River criterion. It has been in Appendix A.

MR. LIPINSKI: I am sorry. I thought these were not in Appendix A but they were created by you.

MR. KING: The four new ones, the first two come from Appendix A, but they were not included in the Clinch River set originally. We feel they should be. The last two were ones that are not in Appendix A and are new, that we developed.

MR. LIPINSKI: Okay. That was in the first two.

MR. KING: Yes. That is identical to 29 in Appendix A.

MR. LIPINSKI: Okay.

MR. CARBON: Move on.

MR. KING: Okay. One of the questions from the March meeting was why don't principal design criteria define design basis accidents.

The principal design criteria, as we view them, define requirements on systems, components and structures. Design basis accidents are used to test the capability of the plant systems, components and structures. We put a little discussion in our draft SER section on DBAs.

DBAs are defined and discussed in Chapter 15 of the PSAR and will be discussed in Chapter 15 of our SER. Again, we talked about this this morning. There is some linkage between the two and you cannot bury your head in the sand and ignore one and do an adequate job on the other, but we did not feel that PDCs were a place where you should define design criteria. They should really deal with design requirements on plant systems.

The second question was why don't design criteria address CDAs and energetics. Again, the principal design criteria we feel should just address those systems, components and structures necessary for mitigating design basis accidents. We will address energetics and the criteria for systems that mitigate accidents beyond the design basis in a separate appendix to the SER.

(Slide.)

MR. KING: The next question was why don't the criteria specify a margin of safety for the plant for the safe shutdown earthquake, seismic events beyond the safe shutdown earthquake, and we consider beyond the design basis. We are going to look at what margin the plant has for accommodating earthquakes beyond the design basis.

I think if you read the criteria that deals with natural phenomenon it does say that you will look at the historical data in selecting your site suitability safe shutdown earthquake, and you will also look at the amount of data, and that implies you should look at what the uncertainties are in that data such that you allow adequate margin when you select the safe shutdown earthquake.

So we did not feel that putting a specific requirement in the design criteria to go beyond the safe shutdown earthquake was appropriate. We felt the words in the criteria generally imply that you should have conservative margin and that beyond the design basis earthquake will be looked at as part of the beyond design basis events.

The fourth question was why don't the criteria specify natural circulation as a requirement. We went through this this morning. We felt that decay heat removal was the real requirement and the number of paths that you should have. Whether that is by forced circulation or natural circulation I think is part of the implementation process.

If station blackout is added as a design basis event, it will probably end up that the plant will have to have natural circulation. We are looking at station blackout as an event beyond the design basis and from that standpoint the plant will be designed for natural circulation.

The fifth question was why don't the criteria address sabotage. We felt sabotage was addressed in another part of the Code of Federal Regulations and need not be duplicated here.

MR. MARK: There has been a lot of discussion for quite a few years of considering design to reduce the ease of conducting sabotage. Now that would certainly be consistent with the idea that the principal design criteria give thought to sabotage in the criterion for design.

MR. KING: Part 73 requires that that be given in the design as well. It talks about having protected areas.

MR. MARK: It probably covers the points as well as it could. It would not be a mistake, however, to have in a majestic document such as the principal design criteria some recognition of the fact that sabotage should be thought about. This is the 60 commandments. You could do without 58 and put sabotage in.

MR. KING: I do not think putting sabotage in is bad. I just think it is a duplication.

MR. MARK: This, however, is a stand-alone thing. It is impossible for anybody to read all of the 175 parts of CFR 100 and to correlate them. So the fact that it is in somewhere else is not in the least surprising.

That is just an observation.

MR. ZUDANS: There is nothing wrong in

providing a cross reference to this maze of different paragraphs and different numbers. There could be a reference made that this is treated there.

MR. KING: That could be done.

MR. ZUDANS: You do make references in other aspects. This would not be the only one, would it?

MR. KING: I do not think we reference any other parts.

MR. ZUDANS: I thought you referenced to some other appendix. I do not remember.

MR. KING: There is a QA criteria. There is also an appendix to 10 CFR 50.

MR. ZUDANS: But you reference it in these criteria, don't you?

MR. KING: We do not reference that appendix or that CFR in the Appendix itself, although a lot of detailed QA requirements are put in that appendix.

Okay. Another question was why don't the PDCs address containment retention time. I think they do in a general sense if they say the containment has to remain intact with its leak rate for as long as the accident conditions require. They do not put a time in -- 24 hours or whatever -- but we feel that the point is covered adequately.

We look at the event and make sure the

containment is there and does its job for the duration of that event. It will be a different time for a different event.

Now why don't the PDCs address station blackout. We went through that already.

Number 8, add definition of postulate accidents and fuel damage limits, and we did that.

MR. LIPINSKI: I am curious on the postulated accident because throughout the criteria you add the word "postulated". Aren't the criteria to cover accidents that are not postulated? Specifically, you could have bounding type accidents that have bee postulated, but I could have some other accidents that are not postulated but they are bounded and will occur, possibly, and the system will be able to migitate them.

MR. KING: The postulated accidents are intended to be the design basis events that envelope all the other differences or categories of events that could occur within that envelope.

MR. LIPINSKI: But that is not your definition.

MR. KING: Let me see what my definition is. They are intended to be design basis events.

MR. LIPINSKI: It just says they are selected to establish design basis. Implied is that they bound the entire spectrum.

MR. KING: Maybe I should add some words there that talk about the bounding, that these events bound the spectrum of events in that category. I agree with that.

(Slide.)

MR. KING: Okay. Those were the major points that I got from the March meeting. The next point --

MR. CARBON: I would like to ask a question of Mr. Morris. Bill, isn't the answer to these eight questions really that you are trying to keep these just as close to LWR criteria as possible and not break any new ground, and you are simply trying to stay close to existing ones? Isn't that the real answer?

MR. MORRIS: That is correct. As I said at the beginning of this session after the break, we do not want to try to go out and presume what may be resolved for lightwater reactors in the future. There should not be certain design criteria that mention sabotage here because we think that should be done in a generic form. That is an answer that goes to this as well.

MR. CARBON: I am not sure I agree with your approach to it, but that is what you are doing.

MR. MORRIS: That is our approach. We have attempted to introduce those criteria that are unique to an LMFBR to make sure that those are included, but we do not want to introduce new criteria that could just as well be introduced for an LWR.

MR. CARBON: I guess this comes from your aim to try to have the same safety for both -- whatever that means.

MR. MORRIS: We believe that you will this apprpoach will achieve that goal. Those additional criteria that one may like to see included someday, we must wait until they are included generically before including them in the CRBR criteria. We have no intent to have additional criteria added to the GDCs right now.

MR. ZUDANS: You do have two definitions in the beginning. One is the anticipated operating occurrences and the other is the postulated accidents that should encompass what is perceived as the design basis events.

The biggest negotiating point is agreeing on these design basis events. They are the key to the design because the ease or difficulty of implementing the criteria that you have here depends on a kind of a set or a subset that you select as the design basis event. So it still remains unclear to me whether this is the proper procedure.

There are many criteria that do not require it. They are self-editing, like containment leak tightness. You say very simply that it shall be available as long as it is needed. Of course, in the back of your mind you have some design basis event that will challenge the containment leak tightness. I think you do have to go back and examine this connection between design basis events and design criteria.

I am not sure that the ordering is proper. I think it could be written. I previously suggested that maybe you define design basis events as an event that has a certain frequency of occurrence, and if you can prove that a frequency is less than that, it is not a design basis event or may be beyond the design basis event.

If you cannot prove that the frequency is less, given a limit, then you have to include it in the set. I do not know whether it is even possible to think that way or not.

MR. KING: I think it would be very tough to wind up putting those events into the design basis just because you could not come up with numbers to prove that they should not be.

MR. ZUDANS: Don't you think that would be the correct thing to do?

MR. KING: I think that you would have to exercise a little judgment, looking at the number of events that could get you into that situation, looking at possible mitigating features or systems that you could have.

MR. ZUDANS: Unless you cannot perceive as a possibility to use some probablistic numbers from the probabilistic study for that kind of a resolution. Maybe that is where the difficulty is -- to agree what is a good number and again make sure that the number the applicant presents is indeed the correct number for that particular sequence.

I am told that you can get any number that you want in terms of risk value. It depends on how you jumble the pieces and bits that form the total piece. I am pretty sure that there is lots of judgment in the decisional process, but that still would be a better way, in my opinion.

I will leave the subject.

MR. CARBON: Let's go on to the next section.

(Slide.)

MR. KING: There was a letter from Dr. Okrent of July 1. The first one said criterion 2 appears to be inadequate in that it refers only to historic natural phenomena as a basis for judgment. Criterion 2 is the one that deals with natural phenomena such as earthquakes.

We looked at that and felt that the words in criteria 2 do specify that you should provide sufficient margin to account for the uncertainties of the data, which really means that you do a site-specific determination. We felt that this was an appropriate -- appropriate words for the criteria in lieu of saying some number like 50 percent beyond whatever. It is really determined on a case-by-case basis.

The second comments was on criterion 5. It refers to postulated accidents. Criterion 5 has to do with qualification of equipment. He said it is not clear whether this will limit the environmental qualification to design basis accidents and leave important functions vulnerable to other circumstances.

Equipment that is required for accommodating events beyond the design basis will be qualified for the conditions that it sees in those events. Equipment required for design basis accidents will be qualified for its conditions. A separate appendix to the SER will address this point.

MR. AXTMANN: I hate to interpret Dave Okrent's words in his absence, but I think part of his problem was calling it postulated accidents, when you really mean DBA.

MR. KING: Postulated accidents does mean DBA the way we are using it, if that is what Dave meant. We can clear that up in the definition. I agree we need some words there.

MR. LIPINSKI: On 5 in your justification, this is where you deleted the words "include loss of coolant accidents." This is motivated by the fact that you know the design meets the requirements, but I do not see why you deleted the loss of coolant accident words.

MR. KING: We deleted them because they are a set of words that are usually associated with lightwater reactors.

MR. LIPINSKI: But they are still words to be associated with an LMFBR such that you will not take that coolant and put it somewhere else within the containment building. The design should meet the requirement that you not lose your coolant and you will put in guard vessels and guard pipes to prevent this.

MR. KING: We had a separate criteria that talks about the features to mitigate -- to retain the sodium in the event of a leak. That is a separate one from 5.

MR. ZUDANS: That is a lower level.

MR. LIPINSKI: I know it is still a lower level, but it still is a requirement for an LMFBR.

MR. KING: We do have a different criteria that addresses that point. Five is really addressing --

MR. LIPINSKI: The natural phenomenon.

MR. KING: The environment equipment sees in the event of an accident.

MR. STRAWBRIDGE: Twenty-seven is the one you are looking for.

MR. KING: Twenty-seven? Right. Twenty-seven is the one where we intend to require that they retain the coolant.

(Slide.)

MR. KING: Dave's third comment was criterion 7 used the term "single failure." Why is single failure okay? That is sodium heating systems.

We considered application of the single failure criterion to be acceptable on systems that did not directly affect the ability of the plant to shut down or to remove decay heat. On those systems that do provide shutdown capability or remove decay heat we have added some additional requirements for diversity, redundancy and independence, as well as, in the case of decay heat, that flow paths remain available after single failure such that additional failures can be accommodated beyond the single failure.

I think the criteria that implemnt those additional failures are 20, 24 and 35.

MR. LIPINSKI: The real issue on single failures is that it implies that you are getting additional reliability and that having met the single failure criteria you do have the desired level of reliability. But the single failure criteria in itself does not guarantee that having met the single failure criteria that you still have a system that meets a desired level of reliability.

MR. KING: I cannot argue with that statement.

MR. LIPINSKI: I think that is the entire issue throughout here where you are using the term "single failure" to imply that having met the single failure criterion that you now have a level of reliability that is adequate. I think the single failure criteria is a minimum and in addition to it you need statements that say that you have the demonstrated level of reliability.

MR. KING: Reliability does show up in the criteria that deal with shutdown systems and decay heat removal.

MR. LIPINSKI: In your electrical systems, I think you have the single failure criterion and you do not discuss the level of reliability. That is part of your shutdown heat removal system because you are going to require your diesels.

But I think you should take a look. This appears ten or more times throughout the criteria, that the single failure appears to be adequate.

MR. KING: There is a specific set of words that show up.

MR. LIPINKSI: In my judgment, I don't think it's sufficient to just say single failure. If I have a probability of single failure of .9 in two systems, and I take the single failure, the probability that the other one is going to fail is .9. To me, that doesn't indicate that you still have an adequate system just because you met the single failure criterion.

MR. CHECK: Walt, are we having the same discussion we had earlier? We may be annoying you, but I would have to say again and again, what we are trying to do is derive something that is consistent with what is done in water reactors.

MR. LIPINKSI: It is the same discussion.

MR. CHECK: We know in many cases single failure isn't enough, but that is what we are putting up for this step in the process. This is why we are putting up the principal design criteria. We could have done more, but we explained why we didn't. If it isn't enough, it's not enough. I would ask if the committee feels strongly about this, if they are moving against the general design criteria in the same way, because they have the same weaknesses.

MR. KING: I am not sure if because the words are the way they are in the general design criteria that we are ignoring reliability.

MR. ZUDANS: In number 7, you state redundancy requirements with a single failure. That is already halfway there. If the redundancy was supplemented with the redundancy and reliability, that would take care of the concerns.

MR. KING: The word "reliability" does show up in the criterion.

MR. ZUDANS: Not in number 7. It only states redundancy.

MR. KING: That's right, the reason being that that is not a system that is used to shut down the plant or to remove decay heat.

MR. ZUDANS: How long would it take for the primary system to freeze up if you lost this heating system and you had no heat removed through those loops?

MR. KING: I don't have an exact number, but it would probably be in the neighborhood of hours, not days or weeks.

MR. ZUDANS: Hours. And --

MR. KING: This is the type of system where if you lose the heating, you do not immediately lose you shutdown systems and your decay heat removal systems.

MR. ZUDANS: No, as long as you have natural circulation, because if you lost your heat, you would also lose all your power, almost certainly.

MR. KING: You could lose your heating systems without losing your power, if the control system failed.

MR. ZUDANS: Yes, you could. The fourth comment was, criterion 11 does not give any guidance on reliability requirements for instrumentation and control. Criterion 11 is the instrumentation and control criterion. Again, it is the same logic we talked about on 3. Criterion 11 does not deal with systems that shut down the plant nor remove decay heat. They are monitoring systems. We used the reliability terms criteria to include reliability in those systems that deal with decay heat removal or shutdown systems.

Again, that is no different than in the LWR criteria.

(Slide.)

MR. ZUDANS: I am not quite completely understanding what you said. Criterion 11 doesn't cover any instrumentations and controls covering the shutdown systems?

MR. KING: It does not.

MR. ZUDANS: It does not. When you are talking about systems, that is included in part of the other criteria that specifically mentions such systems?

MR. KING: Criterion 11, the way I read criterion 11, in interpreting it, is, it deals with the other instrumentation and control systems in the plant, but not the plant shutdown systems.

MR. ZUDANS: You mentioned the fission product, the reactor coolant boundary.

MR. KING: Did you want to go on?

MR. ZUDANS: Yes.

MR. KING: Okay. His comment again was the same question on single failure. The term here applies to the electrical criterion 15. Again, the logic is the same, that for those systems that deal with shutdown or decay heat removal, we have added additional requirements so that you can accommodate more than a single failure, so that you can protect against common mode failures.

MR. LIPINKSI: How is that reflected in the DC power systems? Your second paragraph just says single failure for the battery, yet you find LWR designs that are going well beyond that for DC systems without having been required in the general design criterion. You are admitting that a dual battery system meets your criterion.

MR. KING: I guess I am not familiar with why LWR's are going beyond the dual battery system.

MR. LIPINKSI: Because dual batteries are not sufficient to give you the reliability that you need.

MR. KING: Again, I think these systems are going to be looked at from a reliability standpoint. We don't have words in the general design criterion on it. Maybe in terms of electrical power we should re-look at that.

MR. LIPINKSI: The same with diesels. A double diesel with the probability of start is 10$^{-2}$ start per diesel, which is a very low reliability.

MR. MARK: It is really more than 10$^{-2}$, if you ask it to start in two seconds.

MR. LIPINKSI: The number doesn't get in much better.

MR. MARK: You can bring in a new one in an hour.

MR. KING: I would anticipate that if you take a criteria like 35 that deals with residual heat removal there, it does use -- I believe it uses the term "reliability," or 26 does. It is the function that we did add some additional requirements for diversity, redundancy, additional paths so that we could accommodate more than a single failure.

In looking at the implementation of that criteria, if electrical power is needed for decay heat removal, I would look at the electrical power systems that supply that power as having to meet the additional -- being able to accommodate or support having those systems withstand more than a single failure.

If there is an interconnection between the two -- I guess I am having some second thoughts on 15. Maybe we should look at the words on that, because of the strong interconnection to that with the decay heat removal systems.

MR. LIPINKSI: You are going to admit electrical power into the decay heat systems.

MR. CHECK: The intent was that if you had a criteria for decay heat removal where you have electrical power needs to perform its function, that the reliability and the requirements of that decay heat removal spec would also have to carry over into that portion of the electrical system that supports that system.

I agree, we didn't carry the same words over into the electrical power area, and maybe we should take a look at that. The sixth comment was, criterion 17, which is on the control room, is obscure as to whether it deals with a fire in the control room. The intent is that that criteria would apply if there is -- one of the events that that criteria is intended to help mitigate is a fire in the control room, where it talks about alternate shutdown locations. It doesn't use the words "fire in the control room," but that is one of the events for that criteria.

MR. RAY: That is your interpretation of it, but what about the licensee? Is he going to design for that?

MR. KING: The design has alternate shutdown locations.

MR. RAY: Yes, but is that alternate shutdown location going to be affected if you have a fire in the control room and still maintains habitability? In your justification for this criterion, the emphasis is on the availability of alternative shutdown facilities. In the event the control room is uninhabitable, I can conceive of a situation where you are going to need these external shutdown facilities, even when the control room is habitable, the requirement being such that you have lost your controlling instrumentation within the control room, so you have to go to some other location.

If you have a limited fire, for instance, that impacts the instrumentation and control but doesn't impact the environment in the control room, it remains habitable but it can't operate. So it seems to me your wording on the paragraph under criterion 17 talking about the equipment external to the control room should emphasize that these external control facilities be operable regardless of the availability status of the similar equipment in the control room.

MR. KING: I think that is the intent.

MR. RAY: But that is not what it says.

MR. KING: I think you have a good point. Let me fix some words there.

MR. LIPINKSI: If you had a fire in the control room and it destroys that wiring, there is no specification that says wiring has to be arranged such that the alternate location functions.

MR. RAY: That is the point. Now we are getting down to detail, and that is not what you want, but there should be switching provided in the area of that alternative control area that you can isolate the wiring from the facilities of that control room, and that is not clear here.

MR. KING: I think that is the intent, and I think the design is such that I would ask the applicant to confirm that.

MR. RAY: We are back to the original point you cited back here, that this kind of thing is what is provided in LWR's, but in this specific detail, several of the applications I have seen in the plants I visited, where we talk about their remote control panel, they did not have switching facilities, and if you had a fire within the control room that impacted the wiring there for controls and instrumentation, it also impacted the wiring available at the alternative shutdown panel, and they now must retrofit that plant to correct it.

So, what I'm saying is that in many of these cases, and this is a specific one, there are deficiencies in what the LWR design criteria require.

MR. CHECK: We grant that, and in the case of LWR's, there were guides, requirements, regulations promulgated to cover that. I think we are touching on what is called Appendix R, I believe.

MR. RAY: That is in the fire protection.

MR. CHECK: Yes. It will apply to this particular plant.

MR. RAY: Where do you cite Appendix R in the CRBR?

MR. CHECK: When we get around to that part of the SER that deals with this.

MR. RAY: I see, so your intent there is to invoke Appendix R in your SER revisions.

MR. CHECK: Yes, in the same way we are going to do for light/water reactors.

MR. RAY: Well, I think Dave's underlying concern was more than fires. It's the kind of thing we are talking about now on that remote control panel. Your justification emphasizes uninhabitability of the control room, and I think his comments go beyond that. It would be well to add a couple of words in this paragraph to make that clear.

MR. KING: I understand.

MR. LIPINKSI: On criterion 17, you had a five rem whole body requirement, but it doesn't specify the persons remaining in there for any period of time, because I can rotate personnel. They say, each receive a five rem dose. And as I interpret the criterion, it is ambiguous. I could leave a minimum crew in that control room until I got a five rem dose, and I could remove them and replace them, and I could keep doing that indefinitely until I ran out of people.

MR. KING: If you've got an accident where you've got five rem in the control room, if the guy goes outside of the control room, he is going to get a heck of a lot more than five rem.

MR. LIPINKSI: How do I interpret your criterion on five rem whole body? Does that imply that the individuals are there at the beginning of the accident and remain during the accident? Let's take a TMI 2 accident. It started on a Wednesday. It wasn't over until a Friday, but fortunately, their control room didn't have that high level dose. But let's assume something starts on a Wednesday, it is going to finish on a Friday. How do I interpret the five rem?

MR. KING: If the guy is in that control room for the whole period of time, he is going to get the five rem.

MR. LIPINSKI: But you are allowing me then to rotate personnel?

MR. KING: If he can rotate them without exceeding the dose requirements, rotate them.

MR. LIPINKSI: Your interpretation is rotation up to five rem.

MR. KING: Yes, if that can be done acceptably.

(Slide.)

His last two points again talk about the "single failure" words in 22 and 26. 22 deals with the shutdown systems. I think what we have done in 24 and 25 to require redundancy, diversity, and independence of two shutdown systems are requirements that make the systems be designed for more than a single failure. 26 deals with the heat transport system, and it is interrelated with 35, the decay heat residual heat removal specification.

I think what we did in 35 adds requirements on the design such that it has to withstand more than a single failure.

(Slide.)

MR. KING: That was the end, unless there are any more questions.

MR. MARK: Well, I mentioned at the start that I had a number of almost textual items. Am I interrupting? I don't know if this is the time to run through them. It won't take very long.

MR. AXTMANN: (Presiding) The subcommittee chairman left word to adjourn at 11:10. You have at least seven minutes.

MR. MARK: Do you have your copy of the things there?

MR. KING: Yes.

MR. MARK: On number 2, where you mention a variety of natural phenomena, they are all plural with the exception of Tsunami. I don't think that's quite right.

MR. KING: All right, I will check that.

MR. MARK: It is a Japanese word, not a Latin word.

Number 9, where you ask that there be a negative reactivity feedback, I just should know this but don't. The temperature coefficient pure and simple in sodium must be positive. As you void sodium, you gain reactivity. Does the doppler temperature coefficient override that?

MR. KING: Yes, when you consider all the feedbacks, the doppler is the predominant one, and it overrides any positive effects you get due to the voiding or the positive effects you get due to bowing.

MR. MARK: Okay. I just wanted to be reminded how those stood.

And number 11, the word "variable" should be plural. It is on the very last line.

MR. KING: Okay.

MR. MARK: On 14, your justification, postulated accident conditions are the only conditions where the containment barrier is needed, I question that. You certainly need it for beyond the design basis mitigation, too, so the statement is not very persuasive the way it reads.

On 24, under normal operation, do you include startup?

MR. KING: Yes, startup, shutdown. I think that is defined in the definitions.

MR. MARK: Oh, I forgot to check that. Reactivity control is needed in startup just as well.

MR. KING: That's defined on page 8. It includes startup and shutdown.

MR. MARK: Just as a matter of taste, I suppose, 46, 47, and 48, you manage to include, a single check valve may not be used, an automatic shutdown valve, twice in 47, once in 48. It seems to me that statement could be made once in the main body of 46, and say that here, as in 47 and 8, a single check valve may not be used, and it will improve style and avoid the sort of feebleminded looking iteration that you get from the impression --

MR. KING: The words are straight from Appendix A.

MR. MARK: Yes. I didn't see any reason why you should slavishly copy a poor example.

(General laughter.)

MR. MARK: And 59, you introduce the abbreviation PDC in 59, but it is only in the justification. It has not been used anywhere else that I am aware of.

MR. KING: All right, I will spell that out.

MR. MARK: And then on 60 you are worried about flow blockage while the assemblies are in the reactor core. Why on earth is that phrase in there? When else in the world would you worry about flow blockage?

MR. KING: The reason that is in there is, we don't want to give the impression that we had to go back to put features in the fabrication line to make sure all the holes are drilled right.

MR. MARK: You are worried about flow blockage and flow restrictions. That really only happens in the reactor core. There is no flow down at the fabrication point. It seems to me that that phrase -- it would be an advantage to delete it.

Now, the justification won't be in the final document, so the fact that you say, while the assemblies are in the core, as a justification, it is not quite so offensive to me as having it in the principal design criterion.

Also, you make a reference here and for the first time to the applicant. That is really meaning, I understand these are specific for the CRBR, so it might be all right to apply to the applicant, but that is only down in the justification, so that's right. That's all.

MR. CARBON: Walt?

MR. LIPINSKI: I have some comments that haven't been covered. Criterion 20, protection system independence, my question is, how does defense against NaK get specified? This goes along with your earlier comment where you talk about control systems, but is this the place where the protection system is to be specified to be split into a double system to be into the other specification?

MR. KING: I didn't follow your question.

MR. LIPINKSI: The electronics in terms of what would activate a primary scram system and a secondary scram system. Here you are talking about redundant channels, but we are not talking about redundant systems, that each have redundant channels.

MR. KING: I think maybe what we need to do is take a look at these words to make sure. They talk to protection systems, and that that includes the portion of electronics as well as mechanical hardware.

MR. LIPINKSI: All right, because I can't get to that in here yet.

MR. KING: All right. Let me look at that.

MR. CARBON: Did you have more comments, Walt?

MR. LIPINKSI: Yes. I was trying to get to the appropriate page here. In criterion 31, you are specifically talking about the residual heat extraction system as being part of the intermediate cooling system. This then implies that I don't have a direct path from the primary system to an RHR system.

MR. KING: Thirty-one, you say?

MR. LIPINKSI: Yes, first sentence. This specifically limits the RHR to the intermediate system.

MR. KING: The RHR includes main loops as well as the direct heat removal system.

MR. LIPINKSI: But intermediate system, the main heading, we know I'm on the other side of the primary system, now I've got an RHR.

MR. KING: Maybe we have a semantics problem. The intent was, the safety requirement on the intermediate cooling system was to provide an intermediate path so you could remove decay heat. I didn't intend by putting those words, "reactor residual heat extraction system," to mean anything other than that. It's a path to remove decay heat out to the water system, the water steam system that eventually comes into the atmosphere.

MR. LIPINKSI: Okay, and on page 28, with your explanation of -- the second sentence from the left says, "Additionally, since there are no containment isolation valves in the intermediate system, it is considered a closed system, and acts as an extension of containment." My question is, which way? Into the containment or from the containment out to the steam generators?

MR. KING: From the containment out.

MR. LIPINKSI: To the steam generators?

MR. KING: To the steam generators.

MR. LIPINKSI: And one last one. Under criterion 45, piping systems penetrating containment, I guess it is implied that it includes the intermediate system in the listing, yet the intermediate system does not have any valves.

MR. KING: The intermediate system may be considered a closed system. There should be a criterion that addresses that.

MR. LIPINKSI: Criterion 45 doesn't discuss whether it is open or closed. It says, if I have a pipe penetrating containment, I have to be able to have isolation, yet in the previous statement you said the intermediate system does not have isolation valves.

MR. FLOYD: Forty-eight is the one you were looking for.

MR. KING: Closed systems penetrating containment. I think the intermediate system falls under 48, which allows you to have a system without a containment isolation valve.

MR. LIPINKSI: It says, "shall have at least one isolation penetration valve," and you are saying that the secondary system is seismically qualified all the way through to the steam generator, so it is not demonstrated, it is not required?

MR. KING: That's correct. It's built to the ASME code.

MR. LIPINKSI: That is all I have, Mr. Chairman.

MR. CARBON: Any other? Bill.

MR. KASTENBERG: Yes, just kind of a question. If the design changes appreciably in this iterative process, do you have a provision for changing the design criteria, or will they be frozen at the SER stage?

Let me give you an example. We discussed the guard vessel this morning. You eliminated a requirement for coolant makeup. Suppose in six or eight months the applicant comes along and says, gee, we want to eliminate the guard vessel or guard pipe for whatever reason. Do you have an option then to go back and review the criteria, or are they going to be frozen?

MR. KING: I think you always have an option to review the criteria. The intent would be to assess any design changes against the requirements in place at that time.

MR. KASTENBERG: The point Walt was making, you left the criterion out because there is something in the design.

MR. KING: There is a requirement to retain the coolant. It doesn't use the words "guard vessel," so if you remove the guard vessel, you would have to demonstrate whatever takes its place or whatever is left does the same thing that was intended by that design criteria.

MR. KASTENBERG: So is the answer then that the iterative procedure could continue up to the time the design is frozen, or even beyond that if there are design changes, or will the criteria be frozen at some point and that is it?

MR. KING: The intent is to freeze these as much as possible, but I can't say that we'll never make changes to them.

MR. LIPINKSI: Could you be more specific as to which criteria you are talking about on the coolant inventory?

MR. KING: I think it was 27.

MR. LIPINKSI: Yes. Yes, that's covered.

MR. CARBON: Any other comments? If not, I guess that concludes it and we can move on to the next topic.

MR. CLARE: While Paul is handing out the package of vu-graphs that cover the presentations that both Paul Dickson and I will be making, I would like to make a few comments that address a subject that was discussed yesterday in the thermal hydraulics working group, as well as reflect a little bit on the discussion you have been having with the staff on the general design criteria.

Yesterday, late in the day, Dr. Carbon, you asked me about a reliability number. At that time I gave you an answer. Having had some discussion with the other people who are in the audience over the evening last night, I think I probably answered a question other than the one you asked, and I doubt that I know the answer to the question you asked.

MR. MARK: I doubt that Max knows what question he asked.

MR. CLARE: That's a possibility also.

MR. CARBON: I know the one I thought I asked.

MR. CLARE: I would merely emphasize what I said then, that you needed to take what I said with a grain of salt, and perhaps that would be an appropriate subject of discussion later on, and I would recommend also that maybe the best thing to do would be to work that in with our PRA results when those are available.

MR. CARBON: Is this my question on how often you expected the DHRS to be called upon?

MR. CLARE: That was one of the questions that might have been asked during that exchange. Yes, it was the one where we were talking about numbers.

The comments I would like to make on the general design criteria are ones I would like to make having spent a number of years working with the plant designers who have been struggling to interpret the general design criteria and turn them into real steel and wires and transistors and things like that.

The changes that Tom King has talked about this morning have certainly not been part of our discussion over the past ten years. However, the Appendix A criteria have been looked at in detail. The criteria that were issued by the staff back in 1976 were looked at in detail, and I think the comments I make will apply to all the criteria that have been discussed this morning.

First of all, with respect to the question of design basis accidents, you don't find the words "design basis accidents" in the general design criteria. To make it clear, when we talk about design basis accidents, what we mean is the set of accidents which in the general design criteria are called anticipated operatonal occurrences and postulated accidents. That combination of events discussed in the general design criteria are identical to the set of accidents we talked about as design basis accidents.

So, just to be careful that we don't get involved in a semantic problem there, I don't think it is a problem. The terminology is just slightly different.

The other comment I would like to make is about the level of detail, the level of generality in the general design criteria or the principal design criteria for the CRBRP. The general design criteria vary a tremendous amount. There are some 60 of them. They overlap with each other. Some are at a very high plane, as though they had come down from a cloud. Some, on the other hand, are quite detailed.

Dr. Mark pointed out a case where the criteria were telling you one type of valve was good and another type of valve wasn't good. Very detailed prescription to the design.

I think if you look at the sum of the design criteria, what it reflects is an attempt by the people who put those criteria together over the years to balance what they thought they really did know about the plant, a plant, any plant, what they felt they knew about the design approach that they wanted to implement, and the things that perhaps they wanted to leave some flexibility on.

Let me try to give you some examples. The containment. There is apparently a consensus among the regulators and the designers that one should take a passive approach to containment, and that one should design a containment so that failure of a containment is not part of a design basis accident. There is no design basis accident that I know of that involves the failure of any containment for any reactor.

The general design criteria are very specific and very detailed to make sure you achieve the high level of reliability that is appropriate to that assumption. That reflects the approach where you make the criteria detailed, and you have already decided what your postulated accidents are going to be.

Balancing that are the cases where you want to leave some flexibility. We have been talking about pipe leaks. We have talked about loss of coolant events. Criterion 27, that was just discussed, is a general criterion. It says, make sure you have enough coolant to remove decay heat. And it leaves the flexibility to the applicant and to the regulator to determine what the best design approach is to achieve that.

We might decide the guard vessels are right. We might decide that emergency core cooling is right.

You will note in the case of the light/water reactor criteria the regulators have gone ahead and prescribed the way that they want to have that done, and they have prescribed that that should be an emergency core cooling system. The general requirement number 27 would in fact require some system to be provided, but it doesn't say an emergency core cooling system.

So, I would urge you to take an across the board look at the criteria, recognize that there is a tremendous mix, a tremendous amount of overlap, and that it does reflect an attempt to balance the various types of concerns that you have expressed, and I think appropriately so, this morning.

With that, I would like to go into my prepared presentation on the discussion of the selection of the design basis accidents. As you pointed out this morning in your comments on the general design criteria, that is a very important phase in determining the adequacy of the safety features of the plant.

(Slide.)

MR. CLARE: The presentation we have prepared for you this morning falls into three parts. I will discuss at this point the overall approach that we have used to the specification of design basis accidents. Paul Dickson will follow me with a discussion trying to pick up some examples of bounding events that we have applied to the reactor, and the safety features that protect the reactor, and I will close with a discussion of a couple of examples of the bounding events, the bounding design basis accidents that we have chosen to assess the adequacies of the safety features away from the reactor.

(Slide.)

MR. CLARE: The first question is, what is a design basis accident? Well, if you look at 10 CFR 50, you can get a little guidance on that. 10 CFR 50.2 says that you use these postulated accidents to specify design bases for the plant safety features.

(Slide.)

MR. CLARE: The design bases are things that determine what the safety functions are. I think we all know from history that there are three basic, fundamental safety functions. You shut down that reactor, you cool it, and you contain any radioactivity releases. But within those three general categories, there can be variations. So, we use design basis accidents to identify those variations of safety functions.

We also use the design basis accidents to specify the controlling parameters, the functional process requirements that the safety functions have to meet. For example, a safety function is to shut down the reactor. The controlling parameter would be how much reactivity are you going to insert how quickly so that you have to counteract that with your safety features.

(Slide.)

MR. CLARE: The general approach we have used to specify our design basis accidents is summarized on this vu-graph. Our accidents have been conservatively defined using judgment to integrate the available information. I emphasize the word "judgment" here. It is an engineering judgment call. As Bill Morris mentioned this morning, the staff and certainly we haven't reached the conclusion that we know enough about PRA techniques and data base to use PRA to specify the design basis accidents for the plant. So, we do use judgment. If you would like to, you can think of that as a qualitative PRA, but we use that engineering judgment to integrate the available information.

I have tried to list here what some of the available information is. We do have a considerable body of sodium reactor plant experience running back to Clementine, EBR-I, EBR-II, Fermi, SEFOR. Those are the domestic plants. In addition, there are foreign plants up to and including Phoenix, perhaps the most advanced of the foreign plants.

We also have sodium test facility experience. In general, the test facilities are not as large as the facilities we would have in our plant. They are also not designed to the kind of criteria, stringent design criteria we have in the plant. However, we do feel we can gain a lot of knowledge about the behavior of equipment, about what things you need to watch out for with sodium, how it behaves from test facilities.

Of course, there are both domestic and test facilities from which we can gather that data.

Light/water reactors have a lot of domestic technology. However, there are certain technologies that overlap a great deal. We have been talking about containment. Many of the aspects of containment for an LMFBR are the same as for an LWR. Also, we have to spin a turbine at the end of our heat transport systems. To do that, we have to have a steam water system. Much of that steam water system is similar to what you find in a light/water plant.

So, when you try to specify design basis accidents involving those kinds of systems, we do so considering the experience with light/water reactors. We do that by and large considering the light/water reactor experience. That is our largest body of data and that with which we are most familiar.

In addition to this experience, we consider, of course, licensing regulations, guidelines, and precedents. I have listed here 10 CFR 50, which is the portion that deals most directly with accidents, Regulatory Guides, providing fairly firm guidance on how we define design basis accidents, and the kind of assumptions we make as to what they would be.

Standard format and content defines what you have to have in your preliminary safety analysis. That is taken into consideration. The standard review plan, which is really a guideline for the staff reviewer to use, but it tells us what that reviewer is trying to see and the conclusion he is trying to reach in the safety analysis, so we do look at that. There are a number of unwritten rules in licensing, what I have called LWR licensing experience, the kind of precedents that have developed over the years. They are reflected in the practice of licensing, but not necessarily in the documentation.

And, of course, there was a safety review of FFTF. The facility wasn't actually given a license by the NRC, but the regulators did identify their concerns with respect to design basis accidents. Those are the kinds of things that should be looked at in FFTF, and we do consider that in the specification of our design basis accident.

(Slide.)

MR. CLARE: To show you how we do that in a little more detail, to do that, I want to break up the discussion into three pieces. I do that because we think that there are three important aspects, three pieces of the specification of every design basis accident. The first is, what is the accident initiator. Something starts the process of the accident. In addition to that initiator, we assume in this event that there are some additional equipment failures. Certain things work, certain things don't work. And specifying those failures is part of defining this design basis accident scenario.

Then, when we evaluate the effects of the design basis accident, we specify assumptions to be used in the analysis of that event, the analysis of the consequences, and we do that on a conservative basis. That is the third piece of the specification of every design basis accident.

(Slide.)

MR. CLARE: Let's take a look at some examples as to how we get at those. The initiators are chosen by conservatively integrating the available information. Some of the most pertinent are the sodium reactor test facility experience for the sodium facility, the sodium light/water reactor plant experience. We of course take this general experience, combine that with our knowledge of the general characteristics of CRBRP as well as the design details of the plant. We impose on top of that the licensing regulations, guidelines, and precedents for initiators of design basis accidents, and we come up with what the specific initiators are.

I have tried to put up a couple of examples of how this was done. First, I will talk about control rod withdrawal. You had a discussion a little while ago about control rod ejection. I purposely used a word here a little different, control rod withdrawal, that reflects the fact that in a light/water reactor you consider ejection where in a pressurized system you can eject that thing, whereas in our case, considering the sodium experience and the details of our design, all you can do is to withdraw that rod using the control rod drive mechanism. If something were to come loose up there in the support system, rather than being driven by pressure out of the reactor, the control rod would actually drop back down in.

So, I considered the light/water precedent, where a control rod will move, and combine that with the general experience and the detailed design, and come out with a similar but slightly different initiator for my design basis accident.

Another example is the steam generator leak. There have been leaks -- rather than getting into that in detail, I will be addressing that later in plant experience. Let me just mention that steam generator leaks is a kind of initiator I get from looking at all of the sources, and I will explain that in some detail.

MR. ZUDANS: You are not saying that you would look at the whole population of all kinds of initiators at the very beginning, and then you would cull the number of them based on some other criteria? You begin with the fact that you are probably only looking at initiators that are leading to something safety-related? So far, you haven't mentioned that. You just said three factors, initiators, additional equipment failures, and conservative analysis assumptions. You look at all the initiators that you can get from experience, regardless of their ultimate result.

MR. CLARE: Perhaps I left out an example. I mentioned that we do know just from fundamentals what the three basic safety functions are to protect the public health and safety. You want to shut down the reactor, you want to cool it, and you want to contain any radiation releases.

MR. ZUDANS: You didn't start with that, but that answers the question.

MR. CLARE: What we do, we start with those three basic categories, and then try to look at the kind of accident initiators that can present challenges to those basic functions.

MR. ZUDANS: That is okay. I must have missed that statement.

(Slide.)

MR. CLARE: The second aspect of the design basis accident is the additional equipment failures. We again use the conservative judgment to integrate all the available information. In this particular case, one of the most important input parts of the data base is in fact the licensing regulations or guidelines. I have tried to list some of them here. We have been talking about them this morning. The traditional regulations, guidelines, and precedents are that you assume the loss of off-site power or on-site power for the design basis accidents.

We have also talked this morning about some other events. For some other events, we go beyond that, but for the design basis accidents, this is the set of assumptions that are required for licensing. Further than that, there is a requirement that a single active failure should be considered in a number of cases, and that stems largely from the general design criterion.

Something that is not stated quite so explicitly in the general design criteria is that we assume that non-safety related equipment does not function to mitigate these design basis accidents. We talked yesterday about shutdown heat removal. We do have a capability to remove heat out through the condenser with the turbine. That is not safety related equipment, not seismic category 1 equipment.

So, we assume that equipment is not available.

MR. LIPINKSI: That on your list is a single passive failure, but it's in the criterion.

MR. CLARE: There are requirements of various sorts in these licensing regulations and guidelines on single passive failures. The one that sticks out in my mind is in a branch technical position, which is part of the standard review plan, which says, in addition to whatever initiating event you may have, you have to assume that if you try to bring your auxiliary feedwater system into play, that you have a break in the line, in one of the lines by which you are trying to deliver auxiliary feedwater to one of your steam drums.

That is an example where the staff in writing its guidelines has gotten well beyond what the general design criterion specifies as a single active failure for the decay heat removal systems.

MR. LIPINKSI: The criteria we just reviewed says, either assume a single active failure that the passive equipment works or assume that the active equipment works, and assume a passive failure. in the criteria we just reviewed.

MR. CLARE: Was that in the containment area?

MR. LIPINKSI: No, I think it is probably with respect to residual heat removal. Could the staff help?

MR. CLARE: I missed that point. It could very well be there.

MR. KING: There is a definition of single failure in Appendix A which we have used unchanged. It says -- there's a footnote to that definition which we have also included in our appendix, our GDC.

MR. CLARE: I didn't intend to say anything different from that in my discussion here.

The only place we have gone beyond the single failure is where we required number 35, residual heat removal specification criteria, where we have required that after the single failure, we still have two flow paths available for decay heat removal.

MR. CLARE: That certainly would imply that if I were to get a passive failure out in my portion of -- the sodium portion of my DHRS, I would still be able to remove heat by another path. The words are not quite there, but I believe the implication is clear that if you have a failure in one, you could take care of it with another.

We have also recognized in the next point in terms of the additional protection against failure which comes from a special LMFBR consideration, I have identified it here as an example, the reactor shutdown system. We do not depend on the light/water reactor precedent. Essentially, the staff is saying, they are going to incorporate the special LMFBR consideration into this plant, and require that the shutdown system be able to accommodate more than a single active failure.

MR. KING: Each of the independent systems must be able to withstand a single failure for the shutdown system.

MR. CLARE: And then, of course, in determining what additional equipment failures we assume for a particular event, we do consider the detailed design of Clinch River, what equipment is safety related, what isn't, how well do we go about designing something.

(Slide.)

The conservatisms, the analysis assumptions that we specified for each of our design-basis events are done specifically to envelope the uncertainties in both the design parameters. My fuel pin might be a little fatter than I really intended for it to be, or a little skinnier than I intended it to be. So that there is a little uncertainty there.

There is also some uncertainty in the accident phenomenology heat transfer coefficients, for example. And I have listed some examples here. The pump head, not delivered quite at the head of my design point, so I specify in my analysis uncertainties. If high head is worse, I would assume a somewhat higher head in my analysis; if a lower head were worse, I would specify a somewhat lower head.

Similarly, pressure drops in the core around the loops, I provided uncertainties on heat transfer characteristics, and as an example of another sort, since we do burn sodium in some of our plant accidents, the sodium burning chemistry has some conservative uncertainties that we specify for the evaluation of the consequences of the design-basis accident.

Now, as I mentioned earlier, we would like to spend a while talking about some examples of these events and how we have -- examples of what we have specified for the initiators and why what we specified is for the additional specifications.

Paul Dickson will talk about those examples related to the reactor and specifically the reactor shutdown system because it is a reactor shutdown system that is a safety feature that provides function to protect directly against the kinds of events he will be talking about.

We do have both the primary reactor shutdown system and the secondary reactor shutdown system to mitigate those accidents.

MR. ZUDANS: You gave me the answer before, and I just want to make sure that I properly understood it. This is the first picture you should have flashed.

MR. CLARE: I thought about that.

MR. ZUDANS: And you should have said, we will now proceed to identify the initiators and the other two items, additional equipment failures and so on and so forth that fall within this set. Then I would have had no questions, and I would have been very happy about it. Obviously, you thought the same way, but you chose to give it in a different way. That was the reason for my question.

Now, tell me as a professional, if you look at this picture, forget about other things specifics, plant specifics, isn't this here a statement that should proceed the design criteria and you should be able to draw the principal design just based on this particular input in terms of what you are designing against? For example, Criterion 27 satisfies one of the aspects; right?

MR. CLARE: I think one could say that even before you develop the General Design Criteria, that you could say that these are the three key things I am trying to achieve with high reliability by specifying those General Design Criteria. And in fact, those items are identified in 10 CFR 100 as being the key general charcteristics, general requirements on the plant that must be provided.

MR. LIPINSKI: When I look at your confinement, containment confinement, isn't that there because you are going beyond the DBA, not for the DBA?

MR. CLARE: No.

MR. LIPINSKI: We were just told you don't need a containment cooling system because you never get up to the containment condition.

MR. CLARE: That's correct. This confinement does not involve containment cooling.

MR. LIPINSKI: No. But the fact that you would have the double concept with the containment steel shelves surrounded by the concrete, if I look at all your DBAS I do not really need the confinement, do I?

MR. CLARE: That is basically correct. The exception I will note is not really a design-basis accident but it is a radioactivity release inside containment which we take as a de facto design-basis accident for the DBA, the site suitability source term. This is designed for the site suitability source term; and since the intent of the site suitability source term is to bound the design-basis accidents from the standpoint of siting the plant, we have provided the features in the containment confinement system as if that were essentially a design-basis requirement. But it does not involve cooling of containment.

So to summarize where I think we have been, these are the three traditional top-level safety functions to be performed. What we have to do is to specify design-basis accidents that esesntially challenge these functions so that we know what the features are that we are going to provide, the detailed safety functions and what the parameters are, the accidents that we have to be able to mitigate with those systems.

I mentioned that Paul Dickson will address reactors. I will come back and address some examples out of these two categories (indicating), and I will note that while we think generally of heat transport loops and heat sinks and diesel generators as being important to shutdown heat removal in specifying our design-basis accidents we have found that there are some related safety functions that have to be performed on this particular plant anyway in order to assure the continuation of the shutdown heat removal function following one of our design-basis accidents.

We have to be able to mitigate sodium fires out in our steam generator building. If we did not mitigate those properly, the effects of the fire might be such that we would disable these systems somehow, some fraction of these systems. So that is a safety function related to shutdown heat removal. Sodium-water reaction, if we did not properly mitigate a sodium-water reaction, it might affect our shutdown heat removal capability. So that is a safety function.

Those spent fuel is not stored in the reactor. It is fuel which we have to remove decay heat from, so we have a safety function to remove decay heat from our spent-fuel storage pool. Similarly with the mitigation of radionuclide releases, we, of course, have the containment and confinement systems in addition in order to prevent sodium fires in certain cells in our containment from being a challenge to containment integrity, we provide cell liners. So that it is a safety function for the cell liners that relates back to the mitigation of radionuclide releases.

Also, as we talked about a while back, control room habitability is important. I suppose I could also put that up here under shutdown heat removal. When I made up the slide, I was thinking about habitability from a radiation protection standpoint, and because it was from that standpoint, I identified that under radionuclide release.

However, the reason you need to be in the control room is, of course, to be able to principally assure your continuing to remove heat from the reactor. So this, I think, is a pretty good summary of the detailed safety functions that we have found are necessary in our plant in order to achieve the three principal objectives for protecting the public health and safety. And we will talk about the details and a few examples.

MR. CARBON: I am puzzled a little bit as to why you don't have a fourth one there which would be Number 1; that is, that you don't have accidents in the first place.

MR. CLARE: We certainly feel that that is a very important objective in the design of the plant. The topic of discussion is design-basis accidents, which inherently assumes that somehow I have not achieved that first objective of having an accident. Again, that tends to be a traditional outlook in the licensing field, I guess, from my perspective.

We do feel it is important. We spend an awful lot of time making sure we do not have accidents. However, that is not part of a discussion on what are your design-basis accidents, so I did not include it here.

MR. ZUDANS: I would like to comment because I like this picture very much in the sense that now I could imagine a Monte Carlo process where I throw in a number of initiators and I look for the one that challenges or a specific system. That then becomes the design basis for that specific system, and I can proceed ad infinitum.

And, of course, you cannot do an infinite number of exercises, so you go back to past experiences. And that is another way of finding DBAs for a specific component by which to design that. That is the objective.

The criteria we discussed this morning should really only look at this set and not the other set. The other set is only the result of set targets at this level to find some specific in mechanics as to how to design a component, that these would not be violated.

MR. CLARE: I think that is right. The only thing I would do is couple them to your Monte Carlo process, with admitted limitations, is what was suggested by one of the judges on the Atomic Safety and Licensing Board, which is to combine that with some horse sense. And, of course, we take bounding assumptions without having examined all the subsets.

MR. ZUDANS: Of course, I don't disagree. That's good.

MR. CARBON: But, Xenon, your General Design Criteria do not all flow from these. It seems to me that you are saying they do, and they really don't.

MR. ZUDANS: I am saying they don't. Some of the General Design Criteria, like 27, fit the scheme very nicely; others don't.

MR. CLARE: I don't know of any General Design Criteria that don't fit this scheme, I might add.

MR. CARBON: Number 1 says quality assurance.

MR. CLARE: Quality assurance just says that whatever system I come up with -- my reactor shutdown system, for example -- I will implement with a high quality in order to achieve a high reliability.

MR. CARBON: Perhap it is semantics, but from my way of using the words, Number 1 says you don't need a reactor shutdown system.

MR. CLARE: I also apply quality assurance to those type of systems.

MR. STARK: While we are waiting for Dr. Dickson to get ready, I Xeroxed something that I think addresses Dr. Lipinski's comments this morning.**I think he made a comment stating you are asking whether the single failure and independence requirements can continue on into the electrical protection system.

MR. LIPINSKI: Right.

MR. STARK: What I have Xeroxed here, and I will give it to the chairman, is 50.55.A paragraph (h), which discusses protection systems. It basically says, for construction permits issued after January 1, 1971, protection systems shall meet the requirements set forth in addition to revisions to IEEE 279. And, in fact, I have also Xeroxed IEEE 279, and in it they provide definitions for single failure criteria and channel independence. And I will submit the whole package that I think addresses your question.

MR. LIPINSKI: That won't resolve the issue, because when you are talking reactivity control system, by definition those are the mechanical drive and reactivity absorbers. Your criteria does not go back and say, the electronic systems have to have two independent sets of channels that are redundant and multiple within themselves.

MR. STARK: But they are part of the protection system.

MR. LIPINSKI: Yes. But that is what I am saying. Your protection system criteria does not get that idea across.

MR. STARK: But they are required by the regulations --

MR. LIPINSKI: No, this does not require primary/secondary system, it just says -- 279 allows me to have a two-channel system. That specification says I can get by with two channels. It does not say I have to have a triplicated system. I can take one channel and put it in a test mode so long as the interval is short compared to the reliability I need to guarantee a safety function with one remaining channel in operation.

There is no connotation that says I have to have two triplicated sets of measurements to peak primary and secondary systems.

MR. STARK: I believe they even address testability, too.

MR. LIPINSKI: Yes, you will find a statement on a two-channel system. You can take one out of service --

MR. MORRIS: Maybe we should make it clear that the Staff interprets "systems," the terminology "reactor shutdown system," to include all the systems, including the electronic components. That's the general interpretation. That is what you will see reflected in the detailed criteria that are developed in the SER that emanate from this general criterion.

I think you recall that at the subcommittee meeting on electronic controls that this was brought out in pretty good detail at that time that that is what would be coming forth in the detailed design. But generally, we interpret "systems" to include the whole system.

MR. LIPINSKI: In the LWR they are requiring a backup boron injection system so that you don't have the problem of trying to find out what's going on with the rods in the plant protection system. In your case, you do not have the equivalent of the boron system, so now you have to be very precise in your definition as to how you are accomplishing that equivalent function for the LMFBR.

All I am saying is as I read your criteria I do not come away with what you are requiring for the protection system; I do for the rods. If you are defining reactivity control systems to include sensors, then I don't have a problem, but your definition doesn't say that specifically.

MR. KING: I thought I agreed this morning to take a second look at those words to make sure it is clear.

MR. DICKSON: Shall I go on?

MR. CARBON: Yes.

MR. DICKSON: What I am going to cover are three events. One is an undercooling event, and two are overpower events.

(Slide.)

The undercooling event I will touch on is not really a design-basis accident, because it's a natural-circulation event. In the liquid metal plant in general, and in CRBR in particular, the undercooooling events rarely have much of an effect on the core. Steam line breaks and events out in the intermediate system have no effect on the core. The core just thinks it's a normal scram.

A few events do have some effect on the core, such as a pump seizure, there is a slight temperature rise. The most dramatic effect on the core is from natural circulation events. So we look at that event as a bounding case for the core. Of course, the initiator for that is loss of off-site power.

(Slide.)

Then following the format George laid out earlier, the other additional equipment failures that we assume is all three diesel generators fail to start. Then the two out of three logic systems is all that's required to trip either shutdown systems. So by definition, one train in that logic system in either shutdown system can fail and that shutdown system will still work.

On top of that, only one rod in the system that does work fails to insert. Now, in the natural-circulation event it really makes very little difference, one rod or the fact that only one shutdown system is used.

(Slide.)

MR. CARBON: Is there ever a time when one of the three logic circuits is disabled for maintenance or that kind of thing?

MR. DICKSON: For testing, yes, sir.

MR. CARBON: Is that very much time?

MR. DICKSON: There is a relatively short interval of time.

Can you be specific, George?

MR. CLARE: It would be a relatively short interval of time. But the other pertinent aspect of that is when it's undergoing a test, I believe without exception the reactor is put into a tripped condition so the two remaining channels are in a one-out-of-two configuration.

MR. DICKSON: That's a good point.

MR. LIPINSKI: They can test channels of two-out-of-three logic, but the logic that the system propagates out from the channel and tells the rods to go is never functionally tested to drop the rods. They go as far as the breakers. The system is never totally defeated.

MR. DICKSON: No, it's not. In fact, as George said, when one of the three trains is under test, when either of the other two gives a trip signal, it will trip.

MR. CARBON: That takes care of my question. Either of the other two will.

(Slide.)

MR. DICKSON: In addition to that, there are a variety of assumptions. You have seen them before. Take the minimum pump head initially, a maximum core and system pressure drops -- that's not only initially, but throughout the event. We do this in all our accidents.

So this is not really a different list. You will see it again, although I will not dwell on it each time.

For this one it is a little different. We assume the pumps stop with the maximum impeller backpressure; that is, it stops in its worst location. We take a worst-case doppler coefficient, including all uncertainties, minimum control at shutdown worth, which is one stuck rod, as I mentioned before, 3 sigma hot channel and hot spot factors and that's an abbreviation for a combination of direct factors plus statistically combined uncertainty factors.

We looked at the highest power and the highest temperature hot rods at the worst time in life. For the natural-circulation event that means we look at the beginning of life for the fuel when it is hottest and at the end of the cycle for the blankets when they are the hottest.

We take the worst end of the uncertainty range for all properties, for example, fuel CP and fuel clad gap conductance. At the present time we don't take credit for inter- and intra-assembly flow need redistribution. We are developing a code that will take care of that, and that will be eliminated not to take out any conservatism but because it will more reasonably describe what is going on in the core when you account for that flow distribution.

All negative reactivity feedbacks are neglected. We take a conservative 2/10ths of a second delay for the PPS logic scram breaker and the control rod, unlatched time delays. All those assumptions are assumed to occur at the same time.

MR. CARBON: In your general analyses, though, you do allow for doppler, do you not?

MR. DICKSON: Yes, sir.

MR. CARBON: So your third-to-the-last bullet, should you really be correct to say "except doppler"?

MR. DICKSON: That is correct. That is an overstatement. I shouldn't say "all negative." Just the slower ones are neglected.

MR. KASTENBERG: How sensitive are your calculations to the stuck rod, whether you have one or two or none?

MR. DICKSON: In that event it doesn't make much difference because just a few dollars in it was already just critical and the negative reactivity insertion goes in before the flow coasts down. So you get slight difference early on in the amount of neutrons still bouncing around. But it is small compared to the sensible heat and the decay heat. So you almost don't see a difference there. That's why I commented. On that chart it was gilding the lily, I guess, but since we do it as a matter of form on every event, we do it on that one.

(Slide.)

This one is going to be covered in 2. This is not our worst reactivity insertion event, but it's the worst reactivity insertion event -- let me correct that -- the worst reactivity insertion event is the SSE. This one is a little different, so we decided to cover both of them. It's the rod runout, which is not as bad as the SSE, but as I said, it's different. So we cover it.

(Slide.)

The initiator of that event, of course, is the controller failure. You could also include in this under "controller" meaning control room operator as well.

(Slide.)

The additional failures we assume then is that our high flux blocking circuit fails. We have a blocking circuit at 103 percent of full power that it will stop the rod from moving out.

This goes back to your comment, Dr. Carbon. We want accidents not to happen rather than to take steps to mitigate them. So we have blocking circuits to make sure that the accident doesn't happen. I believe at the INC meeting the designer of this system said his objective was to never challenge the PPS system. And that's what he is working on.

Also, there is a flux to flow mismatch blocking circuit. A rod bank position limiter circuit. This one is still being designed. It is not yet in the design, nor is it described in the PSAR. But it's under design because we want to have a rod bank position limiter circuit.

There is a single rod out of alignment blocking circuit that is designed. There are actually two trains of this. One comes from the absolute position indicator, which is a measure of where the drive line is. An average of those are all taken, and the furthest one away from the average is then compared.

A second train looks at the relative position indicator, which comes from counting the number of steps that has been stepped in by these control rods, keeping track of those, again taking an average and determining which one is furthest out. If any one is out by more than half an inch, it will block and prevent any further out-motion until the system is corrected.

In addition to both of those blocks, those two signals, one from the absolute indicator and one from the relative indicator, are compared. And if they differ by more than a set amount, an alarm goes off in the control room to let the operator know that one of the systems may not be telling them quite the right story.

Then again, the two-out-of-three logic to trip either shutdown system. Only one shutdown system operates, and one rod in that system fails to insert.

MR. CARBON: In your two-out-of-three logic, does the operator always know right away if one of the three logic trains is inoperable?

MR. DICKSON: Yes.

MR. CARBON: How does he know this?

MR. DICKSON: I don't know the details.

MR. CARBON: Lights light up, or alarms?

MR. DICKSON: Alarms sound in the control room. And you can query the computer to determine just exactly what the failure is.

MR. LIPINSKI: There is a regulatory guide that deals with the bypass and inoperable safety systems. They have to be indicated to the operator in the control room.

MR. CARBON: He would know immediately?

MR. LIPINSKI: Yes.

MR. DICKSON: I guess since Dr. Mark isn't here, I can comment on our inoperable status monitor which when I mentioned it some months ago he objected to, did we not want the status monitor to operate? But I was only quoting the regulations.

MR. CARBON: Is shutdown required right away?

MR. LIPINSKI: No. With the single-channel failure the system is still operational. If you have a legitimate call for scram, the system would still function. If the channel -- what happens if it's inoperable when you put it in that state, they immediately go to one out of two.

MR. CARBON: Does the reg guide require that they immediately go to one out of two, shift over?

MR. LIPINSKI: That I don't recall in detail. I believe it does. You are supposed to indicate that the system is out of service, and if you know it's out of service, then you go to a lower level of redundancy, maybe one out of two.

(Slide.)

MR. DICKSON: In analyzing this event, we take the rod bank operating at the core midplane which has the highest differential worth so you get the highest amount of rod runout worth. We take the maximum rod worth assumed for rod runout, which says that that had a plus 3 sigma value on its worth. Now the rest of the rods that go in are all minus 3 sigma on their worths.

And since some of those cannot happen in opposite directions in any one given set of rods, it is an overly conservative assumption. But we can live with it.

Again, we take the so-called thermal hydraulic design value conditions; that is another way of saying the minimum pump head and the maximum pressure drops throughout, which includes in those maximum pressure drops fouling of the steam generators and plugging of steam generator and IHX tubes over the lifetime of the plant.

And we take an extra 20 degrees in the temperature on top of the normal thermal hydraulic design value. Again, worst-case doppler. Minimum control rod shutdown worth, 3 sigma hot spot factors and so on. I won't go through that whole list again, but I will note them only to reemphasize that that is the type of conservatism that we do take in these events.

(Slide.)

I might also note that I did include among those failures the failure of the speed controller, but for the analysis in Chapter 15 we also assume the speed controller of the rod that has run out has also failed so that it runs out at its maximum mechanical speed of 72 inches per minute. That was the design requirement that has been met, and the speed control is really limited to about 45 inches a minute. We still use the 72. On the rod bank runout, we do not assume that it runs out at higher than its design speed because it would take failure of six independent separate speed controllers to change from a normal design speed.

The next one is the SSE reactivity insertion.

(Slide.)

I want to explain that a little bit with some pictures partly because I like pictures better than words, I guess, and I had to get one or two in here. This is a cutaway of the lower internals of the CRBR. These are the lower inlet models shown up here with no fuel or blankets inserted. They would get inserted into the holes that you see at the top of the modules.

So that fuel and blanket and control rod assembly or control duct assembly structure are cantilevered here and then are fastened -- not fastened -- but constrained at two former rings that have an interconfiguration that matches the outer configuration of the core. At this place right here (indicating), which is referred to as the above-core load pad and here, the top load pad (indicating).

(Slide.)

I might leave this on to keep you oriented while I put this one on. These are the inlet nozzles of all of the assemblies as they stick into the lower inlet modules. And then the core has a gap between the assemblies and even a gap at the load pads except that it is a smaller gap at the load pads. There is one plane here at the lower core former and another one at the upper core former.

The whole objective of this system is that when it's cool at refueling temperatures they will be loose enough that they can be inserted and removed without excessive force. But when the system expands at temperature, they will be locked into place, maintaining a core configuration with a certainty as to where the control rod locations are and so that the assemblies do not move.

If that is the only mechanism that happened, simple thermal expansion, that would be relatively easy to do. We do have two other mechanisms at play.

(Slide.)

One is differential thermal expansion. The other is radiation creep and growth that has a comparable effect to differential thermal expansion except it is over a longer time period. That is illustrated on this next slide.

(Slide.)

Here we see an off-power system and nice straight fuel rods. Those are not irradiated rods because they would have some bow to them. And the bowing from the radiation creep and swelling would aggravate the condition I am talking about. But basically it is illustrated here.

When you go on power, these shield assemblies would tend to not expand, or rather bow, because they are rather uniformly heated. But most of the other assemblies will tend to bow in this type of configuration, moving away from the above-core load pad and constraining themselves tightly at the top load pad. They do that of course because they have a gradient across them, a thermal gradient across them, as well as a neutron fluence gradient across them.

The bowing is not uniform because the temperatures are not uniformly decreasing as you go from the center out. Even if we didn't have a heterogenous core, they wouldn't be uniform because you would have cooler control assembly locations. But with our combination of both control assemblies and blanket assemblies in the core, this bowing is quite complex.

Now, as these things went to bow and form a tight portion in through this region and leave a gap out at the side, they won't always fit exactly perfectly. If any one of the hexes is turned slightly, it can conceivably leave a little bit of a gap. The concept is, with that little bit of a gap, if you rattle it as in an earthquake and it only has a little gap because it's been turned, it can then rotate and slip into position and close up some of that gap.

So it's been held a little apart by virtue of some stackup of some gas. And then when it's shaken during an earthquake, the gaps close. The assumptions we used in this analysis is the power is lost to the pumps and the reactivity insertion due to core compaction effects comes in at the worst time in the event to delay in control system scram speed due to seismic-induced forces on the drive line and the guide structure is also included.

MR. CARBON: Do you end up with a greater reactivity step than you would, say, with fresh cold fuel, more than one good-size gap?

MR. DICKSON: Well, the fresh cold fuel is one of the lowest insertion points in time. We look at this over a variety of cycles and find the worst place in time to apply this event. It is not at the end of cycle 4. It is not at the end of cycle 4 because the fuel is cooling down towards the end although the irradiation is worse then, the irradiation bowing. It's somewhere in the middle of the equilibrium cycle that it has the largest potential.

I might note that what we analyzed for is 60 cents. Nominally, what could happen -- and that "nominal" is based on as-measured FFTF assembly dimensions -- it's only a 14-cents event. There is a significant amount of uncertainty in that analyses, however, and the amount of uncertainty is even greater than the nominal value. It is 30 cents of uncertainty. So our prediction is on the 3 sigma basis we are talking about a 44-cent event as far as the core restraint system is concerned with an allowable of 60 cents which is what is analyzed for.

When I say "what is analyzed for," I mean again a two-out-of-three logic to trip either shutdown system, only one shutdown system operates and only one rod in that system fails to insert.

(Slide.)

On this basis it is the primary system that works, or both. We don't even anticipate any failures. If the secondary system only works, then you would have some fuel failures. But we are a long way from sodium boiling and core cooling geometry lost. Again, the same type of conservatisms are noted.

(Slide.)

The conclusion is that the undercooling and overpower transients have been looked at. We looked at the worst cases on an extremely conservative basis, and all events meet the acceptance criteria of Chapter 15.

MR. CARBON: These calculations you have come up with are quite a bit higher total sodium void worth than some accident conditions than we used to calculate 5 years ago or something. Is there any chance that some people feel the 60 cents or whatever is really an inadequate amount?

MR. DICKSON: No. The 60 cents is not related to sodium void worth.

MR. CARBON: I know that.

MR. DICKSON: The 60 cents is related strictly to the amount of gap you can have there.

MR. CARBON: I am saying some of our calculations seem to change with time, for reasons that I do not understand.

MR. DICKSON: Well, some of them do. The sodium void worth, for example, changed somewhat from the change from ENDF/BIII to ENDF/BIV. In fact, if you take rod data from ENDF/BIII to ENDF/BIV you will find a fairly significant change. If you take either of those and normalize them to the critical experiments, say, the ZPPR-11 experiments, you get essentially the same result.

The reason for that is, of course, when you normalize to reality, you must predict reality. What you have to do with the ZPPR-- with the ENDF/BIII analyses is increase it, put on a positive bias to match the ZPPR-11 and with ENDF/BIV it's a very small negative bias to match ZPPR-11. But since we do have very good data from ZPPR-11, including good uncertainty data and have analyzed it thoroughly, we feel very comfortable that we have a very good handle on where our sodium void worth is and what our uncertainties are relative to that sodium void worth at this time.

MR. CARBON: You also feel very confident about the compaction of the reactivity?

MR. DICKSON: Oh, yes. We have had a base program underway for a number of years in which we have a full-scale mockup of the Clinch River-type fuel assemblies. They are mocked up at least to the extent of the load pads being the right configuration, although they are in air, not sodium.

We have subjected that particular rig to a variety of tests over some at least 5-year time period, checking for the type of misalignments one can get, the type of stackup one can get. We feel we have a very good handle on that. There is still some residual base program going on in this area to define the creep and swelling equations that one must use. That's probably the most uncertain part in the whole thing, which is why we have a 14-cent nominal and a 30-cent uncertainty on top of that for a total of 44 cents.

I can't conceive of the uncertainty growing that much larger or any other change making it that much larger. In fact, some of that uncertainty will disappear when we have as-built measurements. That uncertainty includes an uncertainty on the size of the load pads itself or the size of the gap you get. When you measure the assemblies as they're built, you have a way to eliminate that one set of uncertainties. And that is a fair amount of it.

MR. MARK: I am sorry I had to be out for a while. You probably went over this. How confident are you that you have got, A, the right plutonium isotope set and the cross-sections to go with those? Or does it matter very much?

MR. DICKSON: It matters to the extent that it changes your loadings if you change the isotope set, and it matters to the extent that you would have a different source term if you had larger amounts of certain isotopes. From the standpoint of --

MR. MARK: I was thinking more of the criticality than of the source term, of course.

MR. DICKSON: Because of the uncertainty, one of our requirements is to be able to operate this plant either with the grade of fuel that is being loaded into FFTF and for which there is a supply for us, or with effluent from a light-water reactor. We have looked at both. There is no particular problem.

I might note that at the time this project started we intended to have light-water reactor recycled plutonium to use because at that time there was a plan to have recycled plutonium available. That disappeared over time, and we had to go to alternate sources. We can use either plutonium source of any isotopic composition. As we recycle it in Clinch River, we gradually convert it to the same form either way.

I might note that we do not, as the light-water reactors do, build up the plutonium isotopes 238 and 241, which are particularly bad actors from a radiological health standpoint. Rather, we burn them out. If we started with light-water reactor plutonium and continued to recycle it, we would build up plutonium 239 and burn out the 238 and 241.

MR. MARK: I wonder if anyone happens to have here any samples of the isotope set that you would expect to encounter at one or two stages in your cycling?

MR. DICKSON: We have taken FFTF-grade

plutonium and run it through 18 cycles, starting a recycle after 4 years. You don't get enough back to be able to recycle early, putting a little feed into the fifth year, then continuing to recycle.

MR. MARK: I would be interested in the relative abundance of 238, 239, 240, 241, 242.

MR. DICKSON: Plutonium-238, wherever it starts off, burns down in Clinch River at equilibrium, which may be 20 or 30 years, I'm not going to tell you we get to equilibrium quickly, but it will ultimately equilibrate at .13 percent, which is trivial. It is less than we use in either FFTF grade or light water reactor recycle. The worst case from a radiological dose standpoint is our assumption that our fuel gets made 5 years before it is used with a fairly large amount of plutonium-241 because from that we build up americium-241, which leads to increased amounts of curium isotopes, which is the major source for early buildup of plutonium-238.

Once we get into a recycle mode, we then burn down, as I mentioned, the plutonium-238 as well as the plutonium-241. I don't recall the equilibrium value of that, but it is below the original source of either FFTF-grade or the light-water reactor recycle.

MR. MARK: I am wondering if I could trouble someone, perhaps this applies to Paul Boehnert, a couple of samples like the Starkey and after a certain amount of beating up slightly the isotope list. The reason for asking the question is yesterday we were favored with -- I don't know if you were still here --

MR. DICKSON: Yes, I was.

MR. MARK: -- favored by Tom Cochran, and he used the particular isotopic distribution there and it wasn't clear to me whether that was the one that should have been used for Clinch River or not.

MR. DICKSON: In Dr. Cochran's analyses he made the assumption that recycling plutonium through a light-water reactor through Clinch River would be the same as recycling it through a light-water reactor.

MR. MARK: I believe he did, because he listed some recycle light water isotope lists.

MR. DICKSON: And he used that as a basis of increasing the dose.

MR. MARK: Precisely.

MR. DICKSON: On the contrary, we burn out the isotopes that he suggested.

MR. MARK: That's why I would like to see what should have been used there.

MR. DICKSON: Can we provide him that? I am asking the Staff.

MR. CHECK: Certainly.

MR. DICKSON: All right. Yes.

MR. CHECK: My goodness, I didn't realize I had that -- certainly, yes, of course.

MR. MARK: Well, I would just like to see a sample in order to clear up in my mind where Cochran's statement came from.

MR. DICKSON: Do any of you happen to have a copy of it?

(No response.)

MR. CLARE: Dr. Mark, the information I think you are looking for is available both in our environmental report with the fuel cycle effects and also in the Staff's supplement to the Final Environmental Statement, a draft of which is available. And the supplemental is scheduled to come out very shortly and within a very short period of time I am sure we could make that information available.

MR. DICKSON: I am sure that was in there, but that full run of 18 cycles, I didn't think it had been published.

MR. MARK: Well, I have left Boehnert with those suggestions, and he will be able to find some numbers for me. Thank you.

MR. KASTENBERG: I have a question. Yesterday we saw the results of some calculations for the SSE in the thermal hydraulics meeting. If I recall, on one table it showed for one specific case that you exceeded the fuel melting temperature or reached the fuel melting temperature for one case that you ran. I wonder if you consider that as part of the design basis -- unless I am missing something.

MR. DICKSON: I am not sure what you mean. Do we consider fuel melting as part of the design basis?

MR. KASTENBERG: In one of the cases I believe you showed you reached the melting temperature somewhere in the core. We were talking about the General Design Criteria, and I would think fuel melting would be excluded from the design basis.

MR. DICKSON: We exclude fuel melting for all anticipated upset or emergency events. For faulted events we only require core-coolable geometry as our ultimate criteria. We have further defined that as being no coolant boiling. And we are not even close to coolant boiling in that particular event.

MR. CLARE: I think a clarification would be helpful. That was reached at the center of the fuel pin. That is not an indication that anything close to an assembly or even one pin would actually meet the melting temperature or exceed it over any significant fraction of its area.

MR. KASTENBERG: Are you saying the General Design Criteria permits you to reach melting?

MR. CLARE: At the centerline of the fuel pellet, yes.

MR. ZUDANS: That contradicts all the discussions. These events we are discussing right now are not included in the design-basis events. This is the power blackout, which is supposed to be considered generically and independent of GDC.

MR. CLARE: What we are discussing here is the safe shutdown earthquake which inserts a 60-cent step of reactivity.

MR. ZUDANS: But that is not part of the GDC. These events are bounding events for natural circulation.

MR. DICKSON: No, sir. He is talking about an SSE, not natural circulation.

MR. KASTENBERG: The subject of this talk is design-basis events. That's the subject of his talk. He has a case where he reaches fuel melting, and I am asking him whether that is permitted under the General Design Criteria.

MR. DICKSON: Yes. Centerline melting over a fairly small range of the fuel of as much as 17 inches -- I am sorry, 17 percent of the cross-sectional area, for one pin under the conditions that I outlined, all the uncertainties and the secondary scram only. That does not challenge core-coolable geometry at all. Pins have been operated for long periods of time. I might also try to put that in context with a curve.

MR. CARBON: Excuse me. Let me add something in relation to the principal design criteria. If you look at the definition for fuel damage limits on page 6 of that final draft, it has under that definition, "Allows a limited amount of melting." So it does allow some limited amount of fuel melting in the core-basis events.

MR. DICKSON: If I could put that in a little more context here, the amount of time we are talking about is on the order of a second or two.

MR. CARBON: Did you say Criterion Number 6?

MR. KING: Page 6. Definition of fuel damage.

MR. ZUDANS: These three events that you have just described, one was an undercooling event and, two, the reactivity insertions, you can get out of them only by the fact that you have natural circulation available.

MR. DICKSON: No, sir, no. The only event that involved natural circulation was the natural-circulation event.

MR. ZUDANS: If you lost power to all your pumps, what else do you have there to remove the heat?

MR. DICKSON: I haven't lost power to all the pumps in the other two events. I still have motive power. In the case of the SEE, I have lost off-site power.

MR. ZUDANS: You say power lost to pumps. I assume you lost all power. You don't mean that?

MR. DICKSON: That is not well worded. That is the pumps are tripped from full power because that is what provides the power for -- that's what provides -- I am sorry. The motive power for full power is the off-site power. The diesels only run this pony motor.

MR. ZUDANS: That makes a big difference if you have the pony motor still running. You can run it about 10 percent of your flow in natural circulation. What about the other event?

MR. DICKSON: The rod runouts are still power-available.

MR. LIPINSKI: What if one of the diesels fail to start?

MR. DICKSON: I didn't mean to imply all three of those events happened at the same time. Those are three separate events.

MR. LIPINSKI: The loss of power is loss of off-site power and the first set in that second set of assumptions was the diesels fail to start.

MR. DICKSON: That applied to one event.

MR. LIPINSKI: That was station blackout?

MR. DICKSON: Yes. But the next two events, the rod runout and the SSE, were not combined.

MR. ZUDANS: I am glad you corrected my understanding, because you did not say the pony motor was still running. So you did lose all the power. The only time you lost all the power was in bounding core undercooling event.

MR. DICKSON: That's correct.

MR. ZUDANS: And the only way youcan get out of that is by natural circulation?

MR. DICKSON: That is correct.

MR. ZUDANS: And that is not a design-basis event?

MR. DICKSON: That's correct, but it bounds for the reactor all design-basis undercooling. It bounds all design-basis events, and no other design-basis event.

MR. ZUDANS: If that's the case, it totally contradicts, if that is the case, which it is, I can see, I can't see how it could be left out of the General Design Criteria if it is a bounding event. You are designing to it. It is not mentioned. Well, what I heard from Staff was station blackout is a different generic issue and it will be resolved for other plants and it will be resolved for this one. But you have already resolved that for design, and it's hard for me to understand why that's left out.

MR. CLARE: I think we have to understand that there is a difference between saying we have designed for natural circulation in the main coolant systems and saying that we have accommodated the station blackout is a design-basis accident. There is a difference between those two. We chose the presentation of the natural-circulation event here because in a sense it is the only interesting undercooling event there is. If you go beyond that, if you go back down from that to something that is in the design basis, it's really not very interesting. This is essentially a normal scram, as Paul pointed out in his presentation.

MR. ZUDANS: I have no complaints with you guys. I have complaints with Staff. I don't understand how you cannot make this part of the package of the General Design Criteria.

MR. MORRIS: Bill Morris, NRC Staff. Perhaps part of our reservation with regard to the station blackout in regard to making it a design-basis event is that there is a precedent. When you have a design-basis accident, the safety systems that mitigate that accident must meet certain criteria. One of those criteria is the single-failure criteria.

We think that at this time it would be a compounding of the number of failures that would have to occur before you get to a station blackout situation and then in addition require that the single-failure criteria be met by the systems to mitigate the event. For instance, the stream-driven turbine, that would meet the single-failure criterion. We dont' think that that's a reasonable thing to do. That is one of the reasons that we stop short of thinking of this as a design-basis accident. We think that there is just too much that would be an unreasonable compounding of failures.

I think that is part of our hesitancy in going ahead and including that under the spectrum of the DBAs. Perhaps the Applicant has another view of that. But that, in conjunction with the fact that there is an unresolved safety issue, we would like to see where we step before we change what the LWRs are doing.

We think we are just about in the right spot. We are taking cognizance of the fact that it can occur. We are looking at the event. We expect that the event will be adequately mitigated, but we do not think that it is yet reasonable to say we must mitigate it the same way we would mitigate other design-basis accidents.

MR. KASTENBERG: Could I go back to the question I raised before? I was thumbing through the material you handed out, and it does define fuel damage limit. And one of the things in fuel damage limit is fuel melting.

I noticed somewhere like in Criterion 26 it says something like provides fission cooling to prevent exceeding acceptable design limits. But it never says what the limit is. I am asking how much fuel melting are you prepared to accept? Have you specified that?

MR. KING: That's not in the criteria. That's something that we can address when we implement the design. I don't have a number for you today.

MR. KASTENBERG: So we can't tell whether the case we saw yesterday meets the General Design Criterion or not?

MR. KING: We do not have a position on the case that we saw yesterday.

MR. CARBON: Let's go on then to the third topic.

MR. CLARE: We will move a bit away from the reactor at this point and talk about the design-basis accidents that we have looked at out in the plant. The first subject I want to discuss is the containment design-basis accident.

(Slide.)

I note first that with respect to this accident we did cover it in detail on May 24, 1982, before the subcommittee. And perhaps if I don't cover something in sufficient detail here, you might find it of interest to turn to the transcript of that meeting.

To summarize our thought process that was discussed at that meeting with respect to the containment design-basis accident initiator, we did look at the significant radioactive inventories present in the containment building. That included the reactor fuel, the cold traps, the cover gas, and the reactor coolant.

We found that the release of coolant into an air-filled cell would be the bounding source. We would note that we would only have a significant quantity of primary coolant in an air-filled cell during a maintenance condition where we had deinerted that cell in order to perhaps do in-service inspection or preventive maintenence on some of the equipment itself.

Now, I put a little bullet in here that says that LWR practice is somehow consistent with this. We would merely note that when one thinks of the design-basis accident for an LWR, what one thinks of is the release of the reactor coolant into the containment building. That release does provide a radioactive inventory and does provide an energy source which can create the driving force to exacerbate any leakage from the containment.

Similarly, we have a release of the radioactive primary coolant in the containment. The burning of that coolant does increase the temperature and pressure in containment, and it provides the driving head for increasing the leakage from the containment building. So considering light-water practice as applied to this accident initiator, there is some correspondence there, and that gives us a feeling that maybe we are on the right track.

Now, when we go to try to specify in somewhat more detail what the initiator would be in containment, one thing we do in a kind of horse-sense approach is we look for the largest single inventory that's available during any maintenance activity in an air-filled cell. We find that that inventory is what is in what is called the primary sodium storage tank, which is just a big tank down in the bowels of the containment building where we can store the equivalent of something more than one full loop's worth of primary coolant.

Now, in discussing how we come up with initiators, I said we try to factor into our thinking the experience that has taken place. With regard to this, we would specifically factor in the experience at sodium reactor facilities and sodium test facilities. The conclusion, having looked at that, is there have been no significant sodium fires. And that if one were to baldly apply that experience, one would say there are no sodium fires that are of significance and one should not bother with that for the containment design.

We have been conservative. We have ignored that experience that says it is not a problem and said we indeed will take the leak in the primary sodium storage tank during maintenance for our contaiment design-basis accident.

(Slide.)

The equipment failures -- I have used the word "equipment" here loosely -- that we couple with this leak in the primary sodium storage tank is violation of the plant procedures, which will require a very small inventory in that cell prior to deinerting the cell. And by doing so, we would assure that should a leak occur during maintenance there would not be a significant radioactivity inventory, there would not be a significant source of the thermal energy which exacerbates containment leakage.

It would also have to be a violation of what I have termed health physics guidelines because of the presence of the large sodium volume -- and we are talking something on the order of 35,000 gallons now -- is a major gamma source for periods well beyond plant shutdown and any maintenance activities in that cell would give high operator doses.

So one would actually have no motivation to deinert that cell and go into it when you had this large volume in. We assume the good sense of the operators fails there and we go ahead and deinert that cell, even with a large volume there. The tank that that sodium volume is stored in is an atmospheric tank -- a seismic category 1 tank. Presumably any leak from it would probably be a small leaking kind of leak. It could be extinguished manually. We assume that no manual action is taken to extinguish that fire.

Beyond that, when it comes to the containment isolation system that would have to operate to mitigate the event, we assume various combinations of failures in the containment isolation system. I will note that this practice of assuming failures in the containment isolation system is consistent with the practice in lightwater reactors.

We have, just as we do in the plant protection system, two sets of logic. Each set of logic is a two-out-of-three logic. The sensors for the two systems are radiation monitors. One set is diverse in terms of the type of radiation that would be sensed. So when we consider the design basis accident we consider the failure of one complete set of the monitors or, as an alternative, failure of one train of the logic that those monitors feed or failure of the containment isolation valves that should be closed by that logic.

In addition to that, we would assume failure of one of the three diverse radiation monitors feeding the logic and feeding the valves for the other set of containment isolation valves.

Now the analysis conservatisms that we couple with that accident scenario are that the sodium inventory in the primary sodium storage tank is at a maximum. The tank is as full as it can be.

(Slide.)

MR. CLARE: We assume the spill of the entire 35 gallons is instantaneous. There is no mechanism, just all of a sudden that sodium ends up on the floor of the cell. We assume the maximum reaction energy. We look at the chemistry of sodium burning and even though experiments suggest that some sodium $Na_2O2$ would be formed, in fact we assume it is all monoxide formation which, because this is an oxygen-limited fire increases the thermal energy that is deposited into the containment. As I mentioned, we consume 100 percent of the oxygen.

The cell that this tank is contained in is way down in the bottom of containment. In fact, there are no direct connections between the operating floor of the containment and this particular cell. However, we go ahead and assume that for purposes of the fire analysis the convection of the reaction products up into the containment, the convection of oxygen down into the area where the pool is burning there is a direct interchange which exacerbates the burning in that cell.

From a radiological standpoint, we assume an end-of-life sodium contamination. We assume we have been operating since day one with fuel that is failed to the extent that one percent of the fission gases can leak out. We also consider end-of-life plutonium contamination of the sodium -- that's 100 ppb of plutonium.

We do assume there will be leakage from containment at the specified leakage rate. As I believe has been suggested by some of the Committee members in earlier meetings, because of the sodium aerosol that would be present, it is quite likely that any leakage paths that did exist would be plugged by that sodium. We take no credit for that.

Once any radionuclides get outside containment we assume no fallout getting to either the site boundary or the low population zone where we do our dose calculations, and we couple that with a 95 percentile meteorology, which is again a lightwater practice in doing the accident evaluation.

(Slide.)

MR. CLARE: That then is representative of the kind of accidents we looked at from the containment standpoint. That is a bounding accident for the containment.

The other example of an event I would like to talk about is also one we touched on back at our June 25 meeting of the Subcommittee. That is the sodium-water reaction in the steam generator that would result from a steam generator leak.

Looking at the information that is available to us in trying to define what the accident initiator is, we find that indeed steam generator leaks have been postulated in lightwater reactor licensing procedures. In fact, steam generator leaks have occurred not only in lightwater plants but also steam generator leaks have occurred in sodium facilities.

However, there have been no rapidly-developing sodium-water reactions. These are sodium-water reactions, when I say "rapid" I mean sodium-water reactions that would exert a significant pressure that would somehow challenge the intermediate heat transport system or the intermediate heat exchanger.

I should have noted up front that the safety function with respect to the sodium-water reaction would be the relief of that pressure from the evolution of the gases in that reaction, so there would be no challenge to the intermediate heat transport system piping or the intermediate heat exchanger that might then result in the release of some significant amount of radioactivity.

The experience base tells us there has been no guillotine tube failures in sodium-water reactions. That would be, in fact, a rapidly developing one. It just has not occurred. We have specifically done experiments trying to investigate the phenomenon of sodium-water reactions, and we found there is very slow propagation. If we had a leak in one tube, it would take a considerable period of time before the effects from the sodium-water reaction of that would cause some adjacent tube to fail in the steam generator.

Not being satisfied with the results of the experiments, we did some bounding analysis, set ourselves up an adiabatic problem to see how fast we could heat up an adjacent tube and cause it to weaken to the extent it would fail, and we found that propagation would be no faster than a second -- a very conservative bounding analysis.

We looked at foreign sodium reactor plants to see what their licensing assumptions are in terms of their design basis accidents. We found that they assumed anywhere -- I actually could have put zero here. Some foreign reactors, to the extent we can determine, do not assume any steam generator tube failures in their licensing processes. Some consider up to three tube failures.

So the initiator we selected, conservatively integrating this information, is that we would have some small leak that could cause damage on adjacent tubes and also pressurize slowly our intermediate heat transport system, followed by the equivalent of one double-ended rupture of a steam generator tube, in spite of the fact that none has occurred. And then we postulated two additional double-ended guillotine failures at one-second intervals following the initial failure.

This, in spite of the fact that the experience shows slow propagation. We have just taken the time to get a bounding answer from our adiabatic problem.

(Slide.)

MR. CARBON: If I remember correctly, this last assumption -- two additional one-second intervals -- it was much more conservative than any of the foreign LMFBR tube failures. Is that correct?

MR. CLARE: That is almost correct. I believe in the UK they assume exactly what we do, which is to say three tubes at one-second intervals.

MR. CARBON: In any case, there is no foreign experience operation where they take a more conservative assumption.

MR. CLARE: To the best of our knowledge, that is correct.

(Slide.)

MR. CLARE: The additional equipment failures that we combine with that event are listed here. I mentioned that we would identify a precursor that could initially raise the pressure on our system. That precursor would create a leak detection system that would alarm in the control room and tell the operator to do something about it. We assume a combination of that leak detection and the operator failed to do anything.

We also failed a set of rupture discs that relieve at intermediate failure. We assume that fails.

From the standpoint of the radiological consequences, we assume that there is a preexisting undetectable IHX leak. This would be a leak in an IHX tube that was so small we could not detect it with any of our plant instrumentation.

That is important because if as a result of this event we depressurize the intermediate heat transfer support system some sodium might migrate and by reaction with the water could eventually be taken up out of our relief system. So that is a conservative assumption from a radiological consequences standpoint.

From the standpoint of the actual pressure developed as a result of the sodium-water reaction, we assume the loss of offsite power that would trip the plant and initiate a transient in our steam generator system just prior to the sodium-water reaction. What that does is to create an adverse condition in the evaporator module of the steam generator system.

It essentially overcools the water. The water becomes more dense and if you had a leak at that point in time you would inject more water mass because it would be more dense through a double-ended guillotine rupture of a tube and it would be exacerbated in the steam generator.

(Slide.)

MR. CLARE: The analysis conservatisms having established the scenario, well, again, I have included this precursor fails to burst the rupture. I do not mean to take double credit for it -- pardon me for that. We do assume the tube failures are instantaneous. It takes no time for these double-ended ruptures to occur.

At one second, instantaneously we are dumping water in as calculated by the RELAP-4 code, which is a conservative blowdown cose which has been well established by GE in the licensing of their boiling water reactors.

We have taken these tube failures at the worst failure locations and the failure locations vary as to the relative severity. In the evaporators, it turns out the worst location, I believe, is up towards the top at the upper tube sheet, and the superheater the worst location is at the bottom at the lower tube sheet.

In modeling the rupture discs that would be burst by the high pressure in the intermediate heat transport system, we make a conservative model of the rupture disc in our TRANSRAP code, which is the computer code we used to analyze this event. The model of the rupture disc that is in TRANSRAP that has been modeled to be conservative based on test data, where we specifically went out and tried to characterize the behavior of those discs.

The reaction model, which is to say the chemical reaction model, where we have the sodium combining with the water, we assume the reaction is instantaneous, as soon as the water gets into the sodium side. The efficiency of that, and the transfer of hydrogen gas that would be developed in the reaction is all conservative test data.

Finally, when we try to evaluate the propagation of the pressure wave down the heat transport piping to examine its damage there, we conservatively neglect the effect of energy absorption in the structure and straining of the pipe itself, also any energy absorption by the motion of the pipe which would actually transfer energy into the snubbers by which the pipes are supported. So we conserve all the energy in the fluid as that pressure wave travels down the pipe and we evaluate the effects on the intermediate heat exchanger.

Now I mentioned in my earlier portion of this presentation that the sodium-water reaction is related to the decay heat removal function in the plant. The way that is related is if I get a sodium-water reaction in one loop I want to be sure that the effects of that are accommodated within that loop, so that any gas releases, sodium releases associated with that will not propagate temperature or pressure effects over into another loop. They would disable that other loop for its decay heat removal function.

By performing this analysis and assuring that our pressure relief capability for this rupture disc, we believe we have accommodated this event and protected our decay heat removal function from the effects of the sodium-water reaction.

This, then, completes my discussion of a couple of examples of how we have specified our design basis accidents out at the plant. I hope it gives you a feeling for how we did it. We would be here all afternoon if we tried to do that.

MR. ZUDANS: I would like to return to your design basis accident for containment. You do not have to put up the slide. We discussed it before in the previous meeting, I remember, and I am still having some doubt in my mind whether or not this is the limiting design basis event.

The rationale for not assuming any major primary coolant pipe breaks or maybe in the intermediate context is not too convincing as yet.

MR. CLARE: Perhaps we have not been clear.

Let me back up and try to do that.

We do postulate significant leakages and spray fires in the inerted cells, even to a size well beyond what we have actually specified in the design basis. Our cells would be capable of mitigating those within the cell. Indeed, one reaches very high pressures, relatively speaking, high pressures and temperatures in the cell in which a leak would occur.

We do not mean to say anything else. However, the cell itself is designed to contain those effects. Hence, there would be no challenge outside that cell to the containment boundary itself.

Now in evaluating our containment we do go ahead and assume that, for example, the cell leaks. We leak radioactivity out of that primary heat transport system cell and we evaluate the potential for those radionuclides offsite and indeed the doses are low.

MR. ZUDANS: I do not disagree with that statement. That is okay.

Suppose you had a break someplace where you lose the primary coolant inventory? It is not the cell I am concerned about. I am concerned about your heat removal capability at that point. You could have a break in one of the primary coolant pipes, and since you cannot stop the leak you cannot refill it fast enough because your refilling capability is something like -- what was it -- 5060 gallons on the DHRS system.

What are you going to do in that case? What am I missing there?

MR. CLARE: We explored that briefly yesterday in the working group meeting. We provided the elevated piping catch guard vessel approach to contain that leaked inventory. That does depend on the pumps tripping and we have provided a pump trip function as part of our plant protection system, essentially the same set of logic and instrumentation that provides for the control rods to insert into the core.

It trips our primary coolant pumps to assure that that will be done. We could detect any significant leak before the volume of sodium in the system had dropped far enough that it would be -- that it would endanger the long-term decay heat removal capability.

MR. ZUDANS: I guess you are probably right, that you have looked at many of the scenarios where you are nicely protected, but if I were to just walk along the primary coolant pipe I would find some locations where it is not enclosed in a protected system that would maintain that volume.

Supposing I just postulate a break at that location?

MR. CLARE: If you postulate a leak at any point in our primary piping, what I just said about maintaining the inventory remains true.

As I said yesterday, that elevation is such that when combined with the tripping of the main motors of the pump, which limits very much the pressure available to push sodium up and over the top of the guard vessel or to that elevated portion of the piping, you will find that the inventory is protected.

MR. ZUDANS: Supposing you had a break. Let's assume the pipes run out in less than 100 seconds. They do not pump too much sodium out. I do not know how much they would pump out if I postulated a break, say, on the cold leg in an unprotected area. What would be left in the system after it goes back and pumps it up?

MR. CLARE: For any size leak we use in our design basis, and you are using the term "break" and I do not want to misrepresent it, we do not consider a double-ended rupture in our design basis.

MR. ZUDANS: I know you do not.

MR. CLARE: But for any leak at any location we feel we will have enough. We feel we can perhaps come back with all the numbers of volumes and elevations and pumps heads and flow rates if you would like to go over that in detail.

MR. DICKSON: A simple answer that could be given to that is that for a leak at any point, the guard vessels have all been sized so that the minimum safe level is a little over two feet above the outlet nozzle of the reactor vessel. That is where it will settle out from the leak at any point.

MR. ZUDANS: That is the leak if you assume a certain-sized break.

MR. CLARE: That is essentially independent of the leak size.

MR. DICKSON: It is independent of the leak size, so long as the pumps trip.

MR. ZUDANS: If it is independent of the leak break size, look at the scenario where you make the cold leg -- double-ended guillotine break. What will happen to the inventory?

MR. CLARE: From an inventory standpoint, you will be just fine.

MR. ZUDANS: What happens to your capability to remove the decay heat after that because your DHR will not function because of the overflow.

MR. CLARE: That is correct, but you would still have the heat removal capability through all three of your other loops.

MR. DICKSON: Two, George.

MR. CLARE: At the inlet nozzle I would still
have a capability to remove heat through that loop. I
could postulate places in the loop where that would not
be available.

MR. ZUDANS: Are there not places where there
are points higher than that nozzle?

MR. CLARE: It is higher than the inlet
nozzle. We specifically arranged that to be the case.

MR. ZUDANS: Your pumps are in the hot leg.
The pumps' center line is eight feet below your free
level in the reactor vessel.

MR. CLARE: The minimum safe level is above
the impeller level in the pump. We have demonstrated in
the water test and will demonstrate in the sodium test
that the pony motor, the pump operating on the pony
motor will continue to circulate sodium, given a leak
that fills up a guard vessel, et cetera.

MR. ZUDANS: Those two loops, you are telling
me now, they are still functional in a double-ended
guillotine break?

MR. CLARE: I do not want to mislead you that
the guillotine in the cold leg is not something that we
can perfectly accommodate.

MR. ZUDANS: I am not asking you to
accommodate it. I am asking to hear whether you make

that statement, because in fact I thought you made that statement that you still have two loops to cool.

MR. CLARE: That is correct.

MR. ZUDANS: Will you be able to pump in those two loops?

MR. CLARE: We will.

MR. ZUDANS: If so, you are not in bad shape.

MR. CLARE: We definitely will have capability to circulate sodium using the pumps in that kind of a scenario.

MR. ZUDANS: How are you going to stop the sodium from flowing through a break in that loop? There is no reason for the sodium level not to be the same in a broken loop as it is in an unbroken loop.

MR. DICKSON: Under pony motor flow, the loops are at negative absolute pressure. The pony motors can develop five foot of head, which is only enough to raise the sodium level to about the lip of the guard vessel. That is what defines the minimum safe level with relation to the pony motor head.

MR. ZUDANS: And the negative pressure exists in the highest point in the loop?

MR. DICKSON: That is correct.

MR. ZUDANS: Therefore, the level in the reactor --

MR. DICKSON: This gets back to the level of the reactor vessel plus the foot of head. If you have not turned up the pony motor in that loop, you would go to the minimum safe level plus about four to five feet, which takes you up to about the lip of the guard vessel. If you leaked into the guard vessel, then you fill the guard vessel.

If your leak is outside in the elevated piping outside the guard vessel, then the leak stops.

MR. ZUDANS: What you are also saying is the negative pressure at the hot leg outlet at the reactor vessel is --

MR. DICKSON: Not at the outlet of the reactor vessel. That would have about two feet of sodium head.

MR. ZUDANS: Let us say the two feet of sodium head is enough to provide the sodium inlet losses in that pipe and still leaves a reserve so that negative pressure can be developed later at a higher point in the pump.

MR. DICKSON: Correct.

MR. ZUDANS: This what I think we really need to see, because that would set my mind to ease if you could show what the calculated pressures and flow rates are at different points in the system.

MR. DICKSON: We will do that. What we did, we set the elevations of the pump, the pump impeller, the minimum safe level allowed in the pump all with regard to that very concept that a leak anywhere should not disable the other two loops because you will not lose the inventory.

We also sized the guard vessels on the same basis. In some cases we would like them larger to make inspection easier, but they must be sized to accommodate just the amount of sodium loss.

MR. CLARE: There is a complete discussion of this in section 5.3 of our PSAR. Perhaps we can work with Paul and get you a copy.

MR. ZUDANS: I have the whole thing. I do not think that has enough detail for me. That would eliminate one issue completely.

Now whether or not you can cope with a sodium leak through that double-ended guillotine break, that is another aspect -- whether or not the containment can cope with it. That is another aspect. But the fact that you can assure the residual heat removal under those conditions is very significant. It seems like you had that in mind all the time when you designed.

MR. CLARE: The consideration is essentially the same, regardless of the leak size.

MR. ZUDANS: For example, the following

situation. At some point in a transient the pump suction will be big enough to depress the reactor vessel and suck in the argon gas.

MR. CLARE: We have sized everything so that will not occur.

MR. ZUDANS: You will have to show me.

MR. CLARE: We will bring the numbers in.

MR. ZUDANS: I do not think I can find that.

MR. CLARE: We will provide a section number.

MR. CARBON: Please do take that as a specific request.

How much sodium would leak out in that case? How much would you pump out -- appreciably more than the 35,000 gallons?

MR. CLARE: Oh, no. Significantly less in terms of anything that would get out of --

MR. CARBON: It would still be in an inerted cell.

MR. CLARE: Yes, it would.

MR. CARBON: So you go through the same assumptions here. It would seem that you would not challenge the containment as much there as you would under the case you gave us.

MR. CLARE: That is right.

MR. CARBON: And you said you did not want to mislead us and imply that you could not handle it. What is it that you could not handle?

MR. CLARE: A double-ended rupture of the cold leg pipe leads to -- would lead to an immediate reduction of flow through the core. You have essentially provided an alternative for sodium to get out of the inlet plenum of the reactor. One could have -- one would have a reduction in the heat removal capability running through the core.

Then it is a question of the race between the reactor shutdown system to bring the power of the reactor down quickly enough so that the flow would still provide adequate heat removal for whatever the heat flux being delivered into the sodium would be, and because of the piping integrity considerations, which we believe suggest that it is appropriate to move that double-ended rupture of an inlet pipe well beyond the design bais. We have not specifically provided shutdown system capability to win that race

MR. ZUDANS: Well, I think that is a good argument. If you rely on piping integrity analysis as a reason for not looking into that thing.

MR. CLARE: That is right.

MR. ZUDANS: Then you have to remember that there does exist something called Murphy's Law.

MR. CLARE: We have tried to take that into consideration.

MR. ZUDANS: There is no reason for anybody to believe that these pipes are any better than the LWR pipes. Their walls are thinner. They are long and complicated. They have lots of elbows because of the tremendous thermal expansion problems they have there. They are essentially like beer cans.

MR. CLARE: We probably are not the best ones to discuss that. We do have a meeting set up for November 17, 18.

MR. ZUDANS: Unfortunately, I will not be here.

MR. CLARE: That is right. You are going to go where the sun shines.

MR. CARBON: If you also could define specific questions.

MR. ZUDANS: I have already defined that. I think it is clear enough that they show what happens with the flow rate and the other flow loops can function, and they would also know how much the temporary loss of flow is to the core and how it shuts down. We find that the situation is not as bad as we think.

MR. DICKSON: That is more than I thought you asked for. I thought you asked for material we already had, which is the elevations and what happens after a leak and why we still are assured of having sufficient inventory.

Now you are saying analyze a 30-second transient and flows.

MR. ZUDANS: No. I understand you to imply that you look at the guillotine -- the double-ended guillotine break in the cold leg and you had the associated flow rates and elevations to the system. If you did not have them, you do not have the answer in the PSAR.

MR. DICKSON: We do not. We did not look at the cold leg pipe break with the transients involved while the pumps are down.

MR. ZUDANS: I am not so much interested in your heat removal aspect of transients. I am only interested in whether or not you have capability to pump sodium through the remaining loops.

MR. CLARE: From a volume --

MR. ZUDANS: That is right.

MR. CLARE: I think our analysis evaluates that. It is essentially independent of flow rate, but we will provide what we have.

MR. ZUDANS: You have only analyzed a limited break size through the pipe.

MR. CLARE: From the standpoint of the maintenance of the inventory, I think we can conclude by looking at a few of the volume numbers and perhaps the flow rate is not a terribly important parameter in that evaluation. But let us get together what we have. We understand your concern and will try to address it.

MR. CARBON: One more question there. You said that you had not -- that it would be a race between shutdown cooling and so on. What sort of temperatures would you anticipate in a case like that?

MR. CLARE: I really do not have those numbers, and to the best of my knowledge we have not actually performed a calculation on that event for the present core design. There were some numbers on the docket many years ago for our earlier core design -- the so-called homogeneous core design -- and other than the fact that I believe we believe in some assemblies we reach the boiling temperature of sodium, I cannot tell you any more.

MR. CARBON: Any other thoughts before we break for lunch?

(No response.)

MR. CARBON: Well, let's go break for lunch and meet again about 2:20.

(Whereupon, at 1:23 o'clock p.m., the meeting recessed, to reconvene at 2:20 o'clock p.m., the same day.)

AFTERNOON SESSION

(2:20 p.m.)

MR. CARBON: Let's reconvene and proceed with the NRC presentation.

Mr. Becker.

(Slide.)

MR. BECKER: I am Richard Becker, Dick Becker, and I'm with the staff, the CRBR Program Office; and I am the reviewer, in conjunction with some other reviewers. I have the primary responsibility for the accident analysis section.

I intend to cover very briefly today the status of the review and also to touch on a little bit of some of the rationale in our reviewing of the accident and the accidents delineated for the design basis analysis for Clinch River.

(Slide.)

We have helping us as consultants Brookhaven National Laboratory, Los Alamos, and Idaho National Engineering Laboratory working with us to help us evaluate the accidents for Clinch River.

Basically, we have had as far as Chapter 15 goes, the accident analysis evaluation, we've had two specific meetings with the applicant on that, on Chapter 15. I indicated several other chapters because there are a number of chapters that hinge on Chapter 15. The accident analyses are in Chapter 15, but a great deal of detail associated with those accident analyses are in other chapters. For example, Chapter 4 handles the reactor core and the core internals, fuel and this type of thing, the neutronics, what have you. Chapter 5 is associated with the heat transport systems. And those PSAR chapters all go together basically and are a strong basis of support for Chapter 15.

I didn't indicate all of the meetings that have been held as far as those chapters are concerned because I think there has been some indication in the discussions that have passed that there have been a number of meetings associated with those.

There are some other chapters. There are things associated with the piping integrity, a number of meetings that have been held with the applicant. And I just wanted to indicate basically that -- the status of that interaction with the applicant.

(Slide.)

I didn't intend, since you have already had a thoroughly extensive discussion of the applicant's rationale as far as their selection of the design basis accidents, I didn't intend to go into that since we're in the process of review, and we are evaluating that, and that will be included, of course, in our safety evaluation report.

Is this microphone picking up well?

What I intended to do was give some idea basically of how we are conducting the review, of what kinds of things we're looking at, and to try to perhaps bring up some of the questions that would result as to how the review is being conducted and as to how we try to evaluate whether the base -- the design base that is presented to us is complete, whether it fits the situation, this type of thing.

MR. CARBON: Excuse me. Are you trying to review what design basis accidents are or the accidents themselves?

MR. BECKER: I guess the answer to that is both.

MR. CARBON: Then I guess you are saying you have not yet decided where you will draw the line on what are and what are not design basis accidents?

MR. BECKER: We have not, I would say, made a final determination as to what that -- where that line, if you can picture it, is, that's right.

MR. ZUDANS: That is not the question. If I understood, the question is whether you have decided which accidents are DBA accidents.

MR. BECKER: Oh, I think we have decided which accidents of those that we now know are DBAs, yes. The question I thought you meant was are there DBAs that have not been -- have not been considered.

MR. CARBON: No. I was trying to ask this latter question, the question have you decided what are and what are not DBAs. And I guess you said you have.

MR. BECKER: I guess the answer to that was yes, we have.

MR. CARBON: Do you agree fully with where the project divides what they consider DBAs? Do you agree fully? And what they don't do you agree fully?

MR. BECKER: I think at the state of our review right now I would say we have found no reason to disagree with what they have proposed as DBAs.

MR. CARBON: Do you have any reason to agree?

MR. BECKER: Well, we're considering -- we are looking at the spectrum they presented to us, and we are evaluating whether we agree that there are accidents outside that spectrum. Of those accidents that have been presented to us we have no disagreement with.

MR. CARBON: It seems to me, though, that you're saying on the one hand that you have decided what are DBAs and what are not, but then in the next sentence it seems to me you are saying you have not yet decided what are and what are not.

MR. BECKER: We have not yet made the decision that the spectrum that we are evaluating is complete.

MR. ZUDANS: Could you also phrase it you have not decided that the set of DBAs you have now identified, this is complete?

MR. BECKER: I think that's correct.

MR. ZUDANS: There could be DBAs that you have not yet analyzed that the applicant has proposed?

MR. BECKER: That's right.

MR. CARBON: But all of them that you are aware of, that you've thought of, you're in agreement with the project of which they say are and are not DBAs?

MR. BECKER: Yes.

MR. RAY: At which stage in your review will you consider accidents beyond the DBA? Is that to come?

MR. BECKER: Well, I think that we considered accidents beyond the DBA from the outset. I think the evidence shows that we are looking at those things that clearly can be identified as accidents beyond the DBA and are including provisions to mitigate those accidents in the design. Those you can clearly specify are beyond the design basis. The core disassembly accidents, that type of thing, are clearly identifiable as beyond DBA.

I think the question this morning about

station blackout being an accident or a situation which is really outside the design basis accident is one of those that is clearly identified on that basis. And I think Bill Morris gave a very cogent answer as to why that is -- because the multiplicity of failures that have to occur conflicts basically with the definition of almost all of the other spectrum of design basis accidents.

MR. RAY: Is it possible that your review will generate additional actions for which you would want mitigation beyond the DBA?

MR. BECKER: I think you can always say that possibility exists, yes. Well, I just sketched here basically in looking at the accidents that have been presented to us, stepping back and taking some idea as to how you might consider the design basis accident, on what basis you would identify those, you can categorize them in several ways.

(Slide.)

You can categorize them by accident type, or you can make a categorization by dose limit; and those are not always necessarily the same, although they may be falling into both categories.

We also look at the categorization of the frequency of the accidents that are proposed into what category they fall as far as whether they are expected occurrences or they are likely faults or highly unlikely faults.

We also evaluate the adequacy of the engineered safety features proposed to mitigate or to accommodate the design basis accidents: how well they function, do they function under the right situations, do they also adhere to all of the methodologies associated the way a design basis accident is analyzed, and how the engineered safety features respond to those things.

Then finally, as I said just previously, we evaluate the completeness of the spectrum.

MR. KASTENBERG: Do I read anything into the word "limit" after dose? That's the only place you've used it. Does it mean something special?

MR. BECKER: I don't think I would infer anything special except the federal regulations basically are guidelines, and I've interpreted that basically as the limit essentially.

MR. KASTENBERG: But you wouldn't look at a frequency limit at this point?

MR. BECKER: I would not look at a frequency limit in that sense, no.

(Slide.)

We touched on this, and I want to give a caveat to this. This is a conceptual slide. Do not take it too literally.

Basically, I wanted to get some slide which would give you some feel for the words that what we're doing when we are looking at this, basically we are scanning, if you will have it, the design basis envelope. We can clearly identify those things that are things which we know we want to have outside the design basis, envelopes such as the CDAs, and the kinds of things where if we're looking for accidents it should be inside the design basis but might be missed.

We are really looking at what I call a buffer zone. I called it that simply because I had no term that I felt would be more descriptive for that particular area. That would be the area I think for accidents that have not been identified for the design basis would lie.

It's conceivable we may be looking at an area where we may not identify any accidents. But in essence that's what we're doing when we look for completeness. We're looking in that particular area.

I wanted to simply have a slide that would give me something to focus the attention on that particular aspect.

(Slide.)

There are several ways that you can go about trying to assure yourself that the set of design basis accidents are complete. There is no prescription as far as I know or anyone else has been able to guide me, so what you will have to do when you are trying to decide whether or not you have things complete is to look at things in at least two or as many ways as you possibly can.

So when you are looking at the completeness of the design basis envelope, there are several ways that will give you some assistance at least that we believe will be able to derive or arrive at any accidents which have not been completely delineated by the set of accidents that we have at hand or anything else that we are currently considering.

One of the ways is to look at the mechanistic sequence, to say this component fails, what happens in that sequence, and that, I think, perhaps is maybe the historic way to look at things. A way to verify that sequence, the group exposed that way is complete, is to look at it in a generic sense. I think there was some discussion of that this morning, generically saying, what categories of things do I have like overpower events, what categories of things do I have that are undercooling events, what category of things do I have about radiation, radioactivity, fuel handling accidents, these types of things, and cross-compare that particular method.

There are some failure modes in effects analysis which is another methodology that is possible to show you some accident, coming up with some accident perhaps that has not been thought of, has not been evaluated, something of that nature. You can also look at what other people have thought about, look at the foreign experience, for example, evaluate what the design basis spectrum for other reactors is.

I think that in some cases this is useful and good. In other cases, it is very difficult to get a good handle on it. I think one thing that strikes me is the Russian experience, for example. It is difficult to evaluate what the Russians think about their plants.

Finally, probabilistic risk assessment is another method which can augment your thinking in other areas. Perhaps reliability analysis is more correct to say rather than PRA, but those are the kinds of things that are available to you to test essentially the completeness of the group of accidents that you have.

MR. KASTENBERG: Just a quick question. Some time in the spring, the subcommittee had a presentation on the PRA. The question came up as to whether the NRC staff would be doing its own parallel PRA. Was that ever resolved?

MR. BECKER: I would have to ask Bill Morris.

MR. MORRIS: Bill Morris, NRC staff. The staff has engaged consultants to review the PRA being performed by the applicant, and we believe that that is the appropriate response.

MR. MARK: Mr. Becker, could you in two or possibly three words explain to me the difference between a FMEA and a PRA? F-M-E-A.

MR. RAY: Maybe it's a phoneta.

MR. BECKER: Actually, when I said a PRA is the probabilistic risk assessment, which takes you through the consequences, I actually, I think, should have used reliability analysis, in which you are not really concerned perhaps about the consequences as you are about the probability associated with certain sequences leading you to certain things you don't want. The failure modes and effects analysis, to my understanding, is looking at the detailed hardware and evaluating where they might possibly fail and what things they may lead to.

MR. MARK: That is great. In a PRA, do you not also have to assess the probability and the kinds of things that can happen and what the effects are?

MR. BECKER: I think the difference -- the answer, I believe, is yes. I think the difference is in level at which you look at these.

MR. MARK: Which is the more intense?

MR. BECKER: I think the failure modes and effects analysis is the more -- the intensity, I am not sure it differs between the two. I think the level of detail differs, though, in the two. In one, you look at more macroscopic, whereas the other, you look more in detail at the finite pieces of given equipment.

MR. LIPINSKI: In your mechanistic sequence, do you look at operator errors, or do you always assume that if an operator can do something, he does it right?

MR. BECKER: Generally, it depends on whether the action is required on a short-term basis or a relatively long basis. The operator action in most of the events that we look at is not required. It is an automatic sequencing type of thing. For example, the overpower, there is no operator action associated with it. It's a plant protection system type of thing. The undercooling accidents, most of those -- in fact, in general, I think one of the accidents that was discussed just before lunch, the overpower, there is a slow overpower accident that basically is a malfunction of the plant controller. We take no advantage of the fact that the operator is there and could correct that.

MR. LIPINSKI: I was thinking more like something at TMI 2. You have high pressure injection, but an operator turns off high pressure injection when he is not supposed to, and aggravating the condition. I haven't looked at your sequence to give any detailed thought to it, but the question is, if something is in progress, can an operator intervene and make it worse?

MR. BECKER: I think -- well, I guess the answer to that has to be, if the accident is a short sequence accident, he has very little chance of intervening. If it is a long sequence accident, yes, the operator can intervene and could conceivably make that accident worse. I think we look at it with the operator having no involvement one way or the other unless with a few -- there is one sequence of operation that is not in the design basis accident, but there is one sequence of operations in which the operator has to act, but it is not in the design basis accident envelope.

MR. LIPINSKI: That was my next question. If there are some within the DBA envelope, and the operator intervenes in the wrong direction, it is probably a low probability event, but it could throw you into something beyond the design basis accident.

MR. BECKER: Well, in short sequence accidents, he does neither, as I said. In the longer sequence accidents, it is assumed that the operator basically does the correct thing.

MR. LIPINSKI: I thought that was one of the lessons we learned from TMI 2.

MR. MORRIS: Excuse me. I think that you are right, that subsequent to TMI, the staff was engaged in a great deal more effort to assure that operators were properly trained, and human factors were considered so that this kind of incident will not occur, but to us, that would be a failure of the operator training and the operator's procedures for him to intervene in an accident in an incorrect way. We believe it is unlikely that that will occur now that these measures that have been taken subsequent to TMI have been developed, because those measures will be implemented in the CRBR.

So, we do not believe that this kind of operator complication is necessarily a part of establishing a design basis spectrum.

MR. LIPINSKI: I will give you a case in hand, the design of the simulator. The operator was going through a sequence using the written procedures. He turned two pages at one time, so he went from the bottom of one page to the top of two pages later, and continued to execute the sequence, so that it was not a deliberate error on his part in turning two pages at the same time. He put them in the wrong part of the sequence.

MR. MORRIS: This was a training exercise? I think that is the purpose of training exercises, to ferret out these kinds of problems, to teach the operator not to do that.

MR. LIPINSKI: But that doesn't ensure that that won't happen in the control room.

MR. MORRIS: No, we can't assure you that there will be no operator errors. You would have to have the human factors people in here to discuss it in more depth, if you wish, but here we are talking about something that is generic to LMFBR's and LWR's, and we see no more inherent opportunity for the operator to cause this kind of complication for this plant than for an LWR, and we believe the operator training measures that have been implemented will be sufficient to make those kinds of complications very unlikely. We don't think that they have to be introduced into the design basis spectrum.

MR. LIPINSKI: They are unlikely, but if the consequences are intolerable, it would be nice to know about them in advance. It is generic to both reactors.

MR. MORRIS: I think as we approach the time for the granting of the operating license for the plant, that by that time there will be a contingent of trained operators who have gone through all the permutations of events that could occur and will be prepared to handle these events. I think that is a thing that will occur late in the review process.

MR. MARK: I agree with you that the extra training, the extra care about the writing of procedures and so forth are all fine, and they will reduce the probability that an operator will out of ignorance do the wrong thing, but all you can ever claim for this is that you will reduce the probability, because as Walt points out, the probability of turning two pages is a little hard to assess and can never be said to have been removed, and if somebody was eating caramels one day and the pages stuck together, the likelihood that he might turn two at once is increased.

MR. MORRIS: Again, we do recognize the possibility that operator errors could complicate accidents and lead to some severe consequences. This in part is one of the reasons attention is being paid to severe accidents at Clinch River. That is, we don't believe these kinds of complications should be included in the design basis, but we take further steps to assure that if you should get into a severe accident situation because of it, that the plant will accommodate these kinds of things.

MR. MARK: You can and you must admit all the time that you have not done enough, cannot possibly do enough to exclude the possibilities of something different happening. That is all.

MR. MORRIS: Yes, I agree with that.

MR. RAY: Mr. Becker, is the applicant required to make analyses of failure modes and effects, or does the staff do this?

MR. BECKER: That, I believe -- I would like to ask Mr. Morris. That is a staff function, doing the failure modes and effects analysis?

MR. MORRIS: I think there are requirements on the applicant to do failure modes and effects analysis.

Some of these have already been done, but others will be spelled out in the SER. Particularly in Chapter 7, there are some measures now included in the standard review plan that require that it be demonstrated that the failures of sensor lines or the failures of electrical components, for instance, will not cause events to occur that would be beyond those that are examined in the design basis analysis in Chapter 15. Those are requirements on the applicant, that he provide those kinds of failure modes and effects analysis.

There is another failure modes and effects analysis that the applicant has done or will be doing that is part of the inherent program. I think I would say that it is heavily weighted on the side of the applicants to perform these analyses.

MR. RAY: In those cases, are those his choices, and are they tuned to the mechanistic sequence, for instance?

MR. MORRIS: I think we would examine them, and if we found -- we felt that there should be additional analysis done, we would expect and ask him to do those.

MR. ZUDANS: I would like to add a little bit to this. I understand the gist of the conversation, of course, but it somehow strikes me as a little bit difficult to have the situation where the design basis accident otherwise would become beyond design basis just because of some human error. I am just wondering whether such things should not really be covered in the margin of design basis events. Each design basis event really is there to have the limits on a given component on the system. That is what it is for. Otherwise, you would not be in there.

If in that sequence there is some human action required or number of actions, and if there is an incorrect action, however improbable it might be, it might make this event way beyond design basis. So I would like to see those margins covering such expressions.

MR. MORRIS: I am not sure I can completely reply to this question. I know that the subject has been addressed at length by the staff in a number of different forums. I recall that after TMI and the TMI hearings, there was a question raised, a contention, as a matter of fact, raised regarding the necessity for having interlocks on the switches to prevent an operator from interfering with the safety coolant injection.

The staff, as I understand it, the staff has consistently taken the position that it is preferred that you do not design measures in to prevent the operator from interfering in an accident, that what you would lose then would be the capabilities for handling many events that we have not yet been able to anticipate, and that is something that would simply be imprudent.

This whole issue is something I would have to refer to some people from the Human Factors Division, Instrumentation and Controls Branch, but that is my interpretation of the policy that has been implemented heretofore, and we acknowledge that if the operator gets too excited, he can defeat safety functions, and once having acknowledged that, it is hard to know just how you would go about preventing him, once he has made that decision. I don't know how you can design to prevent that.

MR. ZUDANS: In these analyses that are being done in the PRA and other ones, there are sequences set up, and operator actions that are clearly identified, and the consequences are also known, if they do it wrong. That might mean that in some cases you tighten up the specification or something else. So I am also pretty sure that the PRA includes operator errors.

MR. CLARE: George Clare, Westinghouse.

Yes, indeed, our PRA will be looking at operator action trees.

MR. ZUDANS: Not intentionally criminal errors, but, you know --

MR. CLARE: Errors of omission and errors of commission.

I would also like to echo a combination of the comments that Dick Becker and Bill Morris made and just point out that we have indeed attempted to provide automatic initiation and control of essentially all, not quite, but nearly all of our safety features on the plant. By doing that, we achieve a couple of things. We don't depend on the operator then to go do something, and by putting him in a position where his hands are off the control, standing back from the control panel and standing there watching things happen, we also reduce the chance that I think he would do something inadvertently that he wasn't supposed to do, as well as decreasing the chance he would do something -- he would fail to do something.

I would emphasize what Bill said in his last set of comments, that although in the evaluation of the design basis accidents themselves there hasn't been a tremendous emphasis on operator actions, in the review of our instrumentation and control systems, the staff has put us very hard to the task of demonstrating that the automatic instrumentation and controls will be resilient to operator errors.

Just as an example of that kind of thing, let's take the auxiliary feedwater system. We get into some event where auxiliary feedwater is required. The operator goes over to the controls and turns off all the auxiliary feedwater pumps, but just as soon as the water level comes down to a point where we should be pumping in more feedwater, those pumps will automatically start up again. As long as the operator shuts them off, the control system will turn them back on again, and he cannot turn them off if the system is demanding feedwater, no matter how hard he tries.

MR. ZUDANS: I am sure that is a good feature, and you have looked at what stops the operator from opening or closing the wrong valve.

MR. CLARE: Well, when you start working with the operators out in the plant, you do find yourself in a position, as Dr. Mark suggests, that there is only a certain limit that you can provide for that kind of situation. If the operator sets his mind to it, you cannot completely prevent him from taking some improper action. Perhaps the security discussion later this afternoon will try to address some of those.

MR. CARBON: Maybe that is a good place --

MR. LIPINSKI: The discussion on aux feedwater is good, but in TMI 2 they locked out the diesels. Is your design going to prevent that?

MR. CLARE: I don't think I have the answer to that question. You comment isn't fully consistent with my knowledge of the TMI event.

MR. LIPINSKI: At one point, those diesels started. They stopped and they put them in the lockout position so they wouldn't start automatically. That was recovered late in the event, and somebody told them to restart them, but they were sitting there for minutes in the lockout position. Are you going to have a simulator that is going to be an exact replica of your control room?

MR. CLARE: Yes.

MR. CARBON: It looks like we are falling behind schedule. Could we move on, Mr. Becker, and try to get back on it?

MR. BECKER: I can go pretty quickly through these others. I just had a couple of slides here to perhaps kind of flesh out a little bit. There are two kinds of approaches in looking at these things.

(Slide.)

MR. BECKER: One I define as a mechanistic accident definition. Basically, that is the kind of thing we are looking at the component failure. It also includes historic accidents, things that have happened like Fermi, the Fermi fuel melt and SL-1 and many other things, for example, looking at all the potential accidents. I indicated just a few items that, for example, you look at the pump failure, seizure, loss of electric power to the pump, these kinds of things. They have become rather accepted ways to look at accident scenarios.

(Slide.)

MR. BECKER: Then, just to kind of flesh out the generic approach that I talked about, basically, when you look at the reactivity, reactivity flow interaction kinds of things, the sodium voiding, the reactivity feedback associated with that, or undercooling flow, both loss of system flow or local flow, flow blockages, those kinds of things, and compare those back with what you have, basically, the broader categories of accidents, and cross-compare those with the mechanistic sequence, and compare and see, do you have those kinds of things that fill out your design basis map.

(Slide.)

MR. BECKER: Then I said, one of the other things we look at is the categorization of these events as to what their frequencies are. This is one of the things we evaluate, the frequency of the event, is it consistent with the categorization of it. This is simply the definition, basically. The incidence of moderate frequency, the anticipated fault, the infrequent incident or unlikely fault, or limiting faults or extremely unlikely faults.

The applicant has defined an acceptance criteria or a limiting criteria which we also are evaluating, and if you will just keep this in mind, I have got a slide which correlates with this, basically, with the criteria for accepting the accidents which are based on this categorization.

MR. MARK: This particular vu-graph, this particular notion that is represented there really cries out for numbers of the sort that Zenon Zudans was talking about earlier. I quite admit and agree, we are not prepared to put them on, but where are the break points between those three different categories? What do you mean by extremely unlikely? What do you mean by unlikely? And what do you mean by anticipated? They really cry out for a definition in terms of once per reactor life or once per year or once per never, things like that.

MR. BECKER: I think I agree with you. I think this falls into the same category as -- It would be nice, for example, to put a number on the design basis. What is the design basis envelope? Everything that is smaller than this is outside, and everything that is --

MR. MARK: That is enough. It would be nice. I don't think we are prepared to do it. I think at some time we should anticipate and hope that it might be done.

MR. BECKER: I was going to add just one point. I think it has been said before, but it is perhaps worth saying again. That is that the uncertainty associated with trying to put those numbers down is, I believe, the thing which keeps us from relying heavily on those. The things that have very low failure frequencies have large uncertainties to them. They are very difficult numbers to measure and establish. So it is really engineering judgment which is the thing that establishes what those are, and that is what we look at and review to see if we agree with the articulated frequency, essentially, not looking at the numbers.

Take some guidance from that perhaps from numbers, but we do not rely on the absolute magnitude.

MR. KASTENBERG: Is it clear that frequency is the only number you might attach to those? You might consider dose or some pseudo-consequence to go along with those rather than frequency itself that may have a narrower uncertainty.

MR. BECKER: It is possible that you might attach some other significance to it, except as far as dose is concerned, while there has been no attempt to delineate it in that fashion. But you are right. It is possible that there might be other numbers.

MR. KASTENBERG: Or combinations of other numbers.

MR. ZUDANS: I think that would be a completely incorrect view of the issue, because we are talking here in defining design basis events. Then we are going to take those and define components so that they do not get damaged, so we do not expect any releases. So there is nothing to measure.

MR. KASTENBERG: That is why I said there could be some other pseudo consequence such as a fuel temperature, a clad temperature, a coolant temperature.

MR. ZUDANS: That is right, yes. There could be some limits of that sort rather than probabilistic.

MR. BECKER: That is right. Categorization of a criterion, an acceptance criterion. I think that is right and that is what is proposed. There is no question about that. I am not sure as far as dose is concerned because I think you would be artificially putting steps in-between.

(Slide.)

MR. BECKER: This is almost a redundant slide to the applicant's this morning. They went through it in much greater detail. One of the things -- there are certain methodologies associated with what are implied by design basis events. These things are generally applied, and that is one of the things that we evaluate.

The difficulty we have, I think, with looking at events which have been covered, such as the station blackout and mitigating features for events outside the design basis, is how do you establish how you should evaluate that particular event. Do you do it in the conservative fashion of design basis? If you do it in the conservative fashion of the design basis, you have almost drawn it inside the design basis by fault, so the systems tend to lose their distinction.

They tend to become confusing to the Staff, I think, and they also become confusing to the public, so that is why we have elected to clearly separate the two.

Chapter 15, looking at the design basis events, and appendix, looking at beyond the design basis, and the criteria for those systems are discussed in a separate fashion.

(Slide.)

MR. BECKER: Finally, recalling back that slide on categorization, for most of the -- I think this acceptance criteria basically covers all of the design basis accidents and it is keyed to the categorization of events. This is the acceptance criteria proposed by the applicant. It is one which we are evaluating. Basically, it is a step below the principal design criteria. I think it can be said it is consistent with the general design criteria and it is conservative in the sense that it is being proposed, we believe.

MR. KASTENBERG: Does this relate back to the question I raised this morning about the fuel temperature where you have an extremely unlikely fault? You have a dash in there.

MR. BECKER: That is right.

MR. KASTENBERG: So that is something you will resolve at some point?

MR. BECKER: That is something we will

resolve, yes.

MR. ZUDANS: Is part of this DBA the view also that touches upon emergency operator procedure development?

MR. BECKER: We have nothing that -- no. In fact, the answer to that is no. There are cases where emergency procedures are definitely implied, for example.

MR. ZUDANS: But they are not developed as yet for this plant?

MR. BECKER: No. The station blackout, for example, is an emergency procedure situation.

MR. ZUDANS: Well, has the applicant already presented some emergency operating procedures for some of these?

MR. BECKER: No. There have been no emergency procedures. Their discussions require no emergency procedures, nor have they presented any.

MR. ZUDANS: I guess this would be mostly for beyond design basis events.

MR. BECKER: Mostly for beyond design basis events, yes. I think there are certain things that are indicated. Emergency procedures generally are indicated for most design basis accidents, but they are not necessarily required in order to make those accidents acceptable, or the mitigation of those accidents acceptable.

MR. ZUDANS: There is another question that I am not quite clear on. There is a bunch of DBAs being defined and you are reviewing them, and there are a number of automatic actions that kind of channel that particular event in its proper path, so to speak.

Are you looking at the tools used to identify that this is indeed the kind of event that is being mitigated by automatic actions, or is it possible that automatic actions could respond in an erroneous way just like the operator could do because this total symptom package is not unique for a particular event?

MR. BECKER: The controls and instrumentation are evaluated as well as all other aspects of the plant in this sense, yes. I am not sure whether that directly answers your question or not. The tools part of the question --

MR. ZUDANS: We discussed just a minute ago how operator actions are excluded from the DBAs because it is assumed that automatic actions by the control system or by the protection system would be handling and guiding the event in its proper path.

MR. BECKER: That is correct.

MR. ZUDANS: What I am asking is is the

identification of a particular event so unique that the automatic actions on the protection system will always be correct? Could the protection system think it has something and it does not really have that and it makes an action that is not in error, it is based on symptoms? It is the question of selection of symptoms that certain actions are being initiated by.

Who looks at that? That is a design phase, really.

MR. BECKER: It is a composite of looking at the accident and also looking at the control and instrumentation required to do those things, and that is part of the review.

MR. ZUDANS: So this is in addition to human error.

MR. BECKER: Well, if we have done our job correctly, I think that the human error is minimized and our review process basically says that the plant is doing what the applicant says it is supposed to be doing. We are basically validating and reviewing what they have said it was to do, and basically when we come out with our safety evaluation report we have said that we will have essentially made that assurance.

I think maybe Bill Morris wants to give an addition to that, but that is --

MR. ZUDANS: It is an unfair question, really, because it digs into how the design is made.

MR. LIPINSKI: But if you do your failure modes and effects analysis and feed that into a PRA, you should be able to go up and down all these different paths and get the probabilities down with the path to show whether it is a reasonable path or whether it is too much of a probability.

MR. BECKER: Yes. The distillation of all these things should give you that assurance, that is does what you say it is going to do and basically that it does.

MR. CARBON: Carson?

MR. MARK: On that slide you say solidus, but this is a design basis event and it is allowed -- the fuel temperature --

MR. BECKER: This is melting of the clad.

MR. MARK: So the slide is not exactly complete. Now what is the temperature at which the clad melts the 304 stainless or whatever it is that they are using?

MR. BECKER: 2,475.

MR. MARK: So you have a 2,475 margin in there. It is kind of small compared to the error of the temperature-measuring devices.

MR. BECKER: Well, that is a limit.

MR. MARK: Fine. Anyway, the stuff does not melt?

MR. BECKER: That is the intent, that you do not melt.

MR. KASTENBERG: I am just curious about one thing, though, with respect to the solidus. I would think an anticipated fault is something you might anticipate occurring during the lifetime of the plant, even though in the design basis concept you have certain conservatisms.

MR. BECKER: That is correct.

MR. KASTENBERG: We know that for mixed oxide fuel element you start to get sufficient fission gas release well below melting -- that is, if you have a transient. I guess -- did you consider that in your review of accepting, say, on an anticipated fault that you would allow the fuel to go up close to the solidus? It would almost seem that that fuel loading may be shot at that point, even though it is measured correctly.

MR. CARBON: I do not think they mean to imply that the fuel will get to that very high temperature in the anticipated fault case.

MR. KASTENBERG: They pose it as a limit. I guess I am trying to understand how you interpret that.

MR. BECKER: The statement that I guess I gave you on the slide is that this is the criteria proposed by the applicant and is under evaluation. I think we take into account those things. I cannot give you a judgment right now whether that criteria is applicable. That is the criteria that we are evaluating and it is under evaluation.

MR. CARBON: Any other questions of Mr. Becker?

(No response.)

MR. CARBON: If not, thank you very much.

The agenda now calls for a closed session on plant safety and security, and rather than go into that, it would seem to work out best logistically if we had any discussion or if we had a discussion on the first two topics -- design criteria and the rationale for DBAs -- at this time, and then we will go into closed session, with that essentially ending the open portion of the meeting.

So let us discuss the presentation, our questions, comments and so on on the design criteria.

As you are fully aware, the hope and intention of the Staff is to bring a discussion of the topic to the full Committee meeting next week. Will you be seeking some sort of word from the full Committee or do you simply want to present what you are doing?

MR. MORRIS: We would like an endorsement of the principal design criteria, if possible.

MR. MARK: Max?

MR. CARBON: Yes, Carson.

MR. MARK: Anticipating next week, I think that the Staff, if you will, might find it worthwhile to explain more not in length but perhaps in greater clarity and precision how your approach has been determined -- the approach you have taken -- to the full Committee to avoid or soften some of the questions which kept emerging today.

Why don't you have this in there? Why don't you have in there? And make it clearer. It seems to me there was something that was not much said today that probably is in your mind and certainly you would have to understand it if it were, if you do not wish to incorporate in this set of criteria things which would open up doors in the LWR criteria for litigation or heaven knows what.

That is, you do not have station blackout in the LWR criteria. If you put them in here, then you are going to have to expect that there will be the question from someone -- why don't you have station blackout in the LWR criteria. And there are a few other points like that that you have carefully held back from, as I picture it, in order not to open up a bigger can of worms than you have already got affecting the rest of the system.

MR. MORRIS: Yes. I said something along these lines this morning. It is maybe not for the same reason you said, it is just that we believe it would be premature for us to make a judgment about what an appropriate criterion for station blackout would be while there is still an unresolve safety issue. We would prefer to have that completed.

And there are similar other cases

MR. MARK: Yes, there are.

MR. MORRIS: And we would not want to move into new territory.

MR. MARK: I believe it would be worthwhile for you to point out a couple of those and say that is why they are not changed, because of the fact that it is either premature, they are generic to both sets of reactors, and we cannot really live with the situation when we put something down here that is not there, to be there when it is not there already.

Things of that kind, I believe, could be explained and would be helpful and smooth the discussion, and I think that was the main point I wanted to make. Single failure is probably another example of that same broad sort.

While you said it this morning, it seems to me it could be said with more emphasis. This is not CRBR and if there are any further LMFBRs there will need to be general design criteria for them which you think will look at lot like this but will not necessarily be identical.

MR. CARBON: I would like to add to that and suggest that the kinds of things Carson is speaking of are more the kinds of things that you explained rather than Tom did, so I would urge that at least a significant chunk of the time next week be devoted to these broader points that Carson is raising -- the philosophy, the background, your limitation and so on. And then perhaps Tom could follow with some details, if you wish, but this basic part comes first and I think you are the individual who will probably have to present.

MR. MARK: Unless Paul Check is still in town.

MR. CARBON: Well, Paul is fine.

MR. MORRIS: We understand.

MR. CARBON: Other comments? Jerry? Bill? Walt? Zenons?

(No response.)

MR. CARBON: I guess you have heard all our comments all day, so I would not repeat specific ones.

I would comment that I have the agenda for next week and this is scheduled for 2:30 to 4:30 on Thursday afternoon -- 2:30 to 4:30 total.

MR. RAY: That is the fourth.

MR. CARBON: It is a fairly short time. Can you -- you will need to summarize and hit things pretty hard and precisely, I believe. Are there any other comments?

If any of you three gentlemen have any comments you care to write down as you travel home or anything, I will welcome them.

MR. ZUDANS: I assume the transcript will be available in time for the Staff to review before the meeting next week. I think it is really difficult to state it more concisely than we did during the discussion. In fact, I do not even remember.

(Laughter.)

MR. CARBON: It will be interpreted differently.

MR. ZUDANS: You will probably observe that as the meeting proceeds and we get a better understanding of what each party wants, it becomes a moving target as to what we really want, to some extent. We must recognize that the Staff has good reasons for what they do and applicant has good reasons for what they do, and we have good reasons for what we want, and they may not be compatible.

MR. KASTENBERG: I just have one point of information. Will we have a session which will explore your appendix to the SER which covers mitigation beyond the design basis before you actually issue the SER and your acceptance criteria for the design basis accident?

MR. MORRIS: I believe we have on the schedule the 18th or 19th core disruptive accident energetics. That will not have criteria in it as such. The past in other sessions earlier we did discuss this criteria in a general form. I believe when the SER comes out, it will have more specific details than what you have seen in the past and I think we will just do what you wish.

If you wish to have that at some future date, another session to go into that in more detail, I think we can have that. Ultimately, we may be able to provide to you some preliminary portions of the SER that would help you look at that and then subsequently have another meeting to try to resolve that.

MR. CARBON: Certainly there are more topics to be discussed down the road -- the CDA on the 19th, as mentioned. We are planning more discussion and comment on such things as sodium-concrete interactions and challenges to containment. There is further discussion coming, and maybe that is on the 18th, of the seismic margins.

MR. MORRIS: If you mentioned a meeting already planned for sodium-concrete interactions, that is related to the criteria for beyond design basis accidents.

MR. CARBON: I do not know of any meeting specifically planned, but we will need discussion.

MR. MORRIS: If you need another discussion of that, that is coincident. It is the same subject essentially as criteria for beyond design basis mitigating systems.

MR. CARBON: Let's go to the second topic, then, the rationale for DBAs. Are you expecting any sort of definitive action from us -- information?

MR. MORRIS: I might say one thing. I believe we all recognize that even though we cannot articulate it and cannot make that crisp a connection between the principal design criteria and the DBAs that there is some connection. We admit to you that it is a difficult connection to make. We hope you will understand that eventually we will have a set of principal design criteria, specific criteria, and a set of DBAs.

I just want to emphasize that this session on DBAs I think has some bearing on your opinion about the principal design criteria, although I hope you will recognize that I believe, and I think others believe, the principal design criteria perhaps are directed more towards the general types of DBAs rather than towards the specifics, and in that connection we do not expect a specific statement from you in the near future, but there is a relation.

MR. CARBON: Does anyone have any comments they wish to make?

MR. ZUDANS: I would like to comment on what you just said, Bill. I think we understand the difficulty in identifying whether the chicken or egg came before, but I think there is something that is definitely before, and that is the three objectives or three things that each nuclear power plant has to satisfy, as stated by Mr. Clare.

You have reactivity control, residual heat removal and mitigation of the consequences of release. That is a general design criteria that everyone can agree upon without any further comment. It is like axioms in any particular mathematical theory, and if you do those, many of your criteria respond directly to these things. Many other criteria go and respond to and identify the DBA.

So that is where kind of a mix comes into the picture. Whether or not you can completely clean it up is really difficult to say. I appreciate the tremendous task, but that is the way it should be if it is possible at all.

MR. CARBON: I would still make the comment that I really do not agree until you add in the criterion for preventing accidents, but I said that this morning.

MR. ZUDANS: You are quite right, but many accidents start out with initiators that have nothing to do with your wishes. The weld breaks down, something busts -- that is it. You cannot prevent that because each component in the system has its own kind of a failure probability. It has its own particular reliability.

Now there is no question that that is the ultimate objective. It is better to prevent than to mitigate.

MR. CARBON: Well, we should not get into an argument across the table.

MR. ZUDANS: I think we agree.

MR. CARBON: We seem to use different words, so let's just stop.

Walt, do you have any comments?

MR. LIPINSKI: No, nothing further.

MR. CARBON: Bill, Jerry, Carson?

(No response.)

MR. CARBON: Well, I believe that ends our discussion, then. Does either the project or the Staff have anything else to bring up on these two subjects in these two areas?

(No response.)

MR. CARBON: If not, then I believe we are through with the first two-thirds of the meeting. We will take a short break and go into closed session and at the end of the closed session we will adjourn the meeting. We will not take a transcript.

(Whereupon, at 3:30 o'clock p.m., the Subcommittee recessed, to reconvene after a brief recess in closed session.)

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

______________________________________________

in the matter of: ACRS/Subcommittee on Clinch River Breeder Reactor

Date of Proceeding: October 27, 1982

Docket Number: ____________________

Place of Proceeding: Washington, D. C.

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

Jane N. Beach

Official Reporter (Typed)

Jane N. Beach

Official Reporter (Signature)

# CRBR PRINCIPAL DESIGN CRITERIA

10-27-82

T1

# PURPOSE

## 10CFR50

The Principal Design Criteria establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems and components important to safety; that is, structures, systems, and components that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

## HOW ACCOMPLISHED

THE INTENT OF THE CRITERIA IS TO EXPRESS THE BROAD REQUIREMENTS WHICH MUST BE MET TO ENSURE THAT THE SAFETY OF CRBR IS COMPARABLE TO LWRS AND THAT CORE DISRUPTIVE ACCIDENTS ARE OF SUFFICIENTLY LOW LIKELIHOOD THAT THEY CAN BE EXCLUDED FROM THE PLANT DESIGN BASIS. THIS IS ACCOMPLISHED BY:

(A) ESTABLISHING REQUIREMENTS FOR THOSE STRUCTURES, SYSTEMS AND COMPONENTS (WHICH ARE COMPARABLE TO STRUCTURES, SYSTEMS, AND COMPONENTS IN LWRS) EQUIVALENT TO OR MORE CONSERVATIVE THAN THE CORRESPONDING REQUIREMENTS FOR LWRS.

(B) ESTABLISHING REQUIREMENTS FOR THOSE STRUCTURES, SYSTEMS, AND COMPONENTS UNIQUE TO CRBR WHICH ARE CONSISTENT WITH THEIR IMPORTANCE TO SAFETY AND WHICH REFLECT AN EQUIVALENT OR MORE CONSERVATIVE SAFETY APPROACH THAN THAT GENERALLY APPLIED TO LWRS.

(C) ESTABLISHING REQUIREMENTS ON THE CRBR DESIGN WHICH WILL MAKE THE LIKELIHOOD OF CORE DISRUPTIVE ACCIDENTS SUFFICIENTLY LOW THAT THEY CAN BE EXCLUDED FROM THE CRBR DESIGN BASIS.

# CRBR - PRINCIPAL DESIGN CRITERIA - APPROACH USED IN DEVELOPMENT

1) WHERE THERE WAS NO SUBSTANTIAL DIFFERENCE BETWEEN CRBR AND LWRs - THE GDC FROM 10 CFR 50, APPENDIX A, WAS ADOPTED IN ITS ENTIRETY.

2) WHERE THE INTENT OF A GDC APPLIED TO CRBR, THE GDC WAS ADOPTED TO THE MAXIMUM EXTENT PRACTICAL WITH MODIFICATIONS ONLY TO ADAPT TO CRBR SYSTEMS OR TERMINOLOGY.

3) WHERE SIGNIFICANT OR UNIQUE DIFFERENCES EXIST BETWEEN CRBR AND LWRs, ADDITIONAL CRITERIA WERE DEVELOPED TO ADDRESS THE SAFETY-RELATED CONCERNS OF THESE DIFFERENCES.

4) CONSIDERATION WAS GIVEN TO PDCs OF SEFOR AND FFTF, PREVIOUS LMFBR EXPERIENCE, AND ANS 54. IN JUDGING COMPLETENESS.

5) THE CRITERIA ADDRESS STRUCTURES, COMPONENTS, AND SYSTEMS ASSOCIATED ONLY WITH DESIGN BASIS EVENTS AND THOSE FEATURES WHICH REDUCE THE LIKELIHOOD OF CORE DISRUPTIVE ACCIDENTS SUFFICIENTLY THAT THEY CAN BE EXCLUDED FROM THE DESIGN BASIS.

# FUNCTIONS OF CRITERIA

PROVIDE REQUIREMENTS ON THE DESIGN TO ENSURE:

- CONTROL OF REACTIVITY AND THE FISSION PROCESS
- PRESERVATION OF THE BARRIERS TO RADIOACTIVITY RELEASE
- QUALITY OF DESIGN, FABRICATION AND TESTING
- RELIABILITY
- PROTECTION FROM FIRES
- SUFFICIENT COOLANT INVENTORY
- PROTECTION AGAINST NATURAL PHENOMENA
- SUFFICIENT DECAY HEAT REMOVAL
- PROVISIONS FOR TESTING AND INSPECTION
- SYSTEM INTEGRITY
- CONTROL OF THE RELEASE OF RADIOACTIVITY TO THE ENVIRONMENT
- CONTROL OF PARAMETERS IMPORTANT TO SAFETY

# SUMMARY OF CHANGES

## 1976 VERSION:

OF THE 55 CRITERIA IN 10 CFR 50, APPENDIX A

- 9 WERE OMITTED
- 10 UNIQUE ONES WERE ADDED FOR A TOTAL OF 56
- OF THE 46 APPENDIX A CRITERIA USED, 23 WERE MODIFIED IN SOME WAY TO APPLY TO CRBR

## PROPOSED VERSION

OF THE 55 CRITERIA IN 10 CFR 50, APPENDIX A

- 7 ARE OMITTED
- 12 UNIQUE ONES HAVE BEEN ADDED FOR A TOTAL OF 60
- OF THE 48 APPENDIX A CRITERIA USED, 27 HAVE BEEN MODIFIED IN SOME WAY TO APPLY TO CRBR

# CRBR CRITERIA IDENTICAL TO 10 CFR 50, APPENDIX A, CRITERIA

#1 - QUALITY STANDARDS & RECORDS (1)
#2 - DESIGN BASIS FOR PROTECTION AGAINST NATURAL PHENOMENA (2)
#3 - FIRE PROTECTION (3)
#6 - SHARING OF STRUCTURES, SYSTEMS, COMPONENTS (5)
#9 - REACTOR INHERENT PROTECTION (11)
#10 - SUPPRESSION OF REACTOR POWER OSCILLATIONS (12)
#14 - CONTAINMENT DESIGN (16)
#16 - INSPECTION & TESTING OF ELECTRICAL POWER SYSTEMS (18)
#19 - PROTECTION SYSTEM RELIABILITY & TESTABILITY (21)
#22 - SEPARATION OF PROTECTION & CONTROL SYSTEMS (24)
#28 - QUALITY OF REACTOR COOLANT BOUNDARY (30)
#43 - CAPABILITY FOR CONTAINMENT LEAKAGE RATE TESTING (52)
#44 - PROVISIONS FOR CONTAINMENT TESTING & INSPECTION (53)
#45 - PIPING SYSTEMS PENETRATING CONTAINMENT (54)
#47 - PRIMARY CONTAINMENT ISOLATION (56)
#50 - INSPECTION OF CONTAINMENT ATMOSPHERE CLEANUP SYSTEM (42)

T2

## CRBR CRITERIA IDENTICAL TO 10 CFR 50, APPENDIX A, CRITERIA (CONT'D.)

#51 - TESTING OF CONTAINMENT ATMOSPHERE CLEANUP SYSTEM (43)

#52 - CONTROL OF RELEASES OF RADIOACTIVE MATERIALS (60)

#54 - PREVENTION OF CRITICALITY IN FUEL STORAGE & HANDLING (62)

#55 - MONITORING FUEL & WASTE STORAGE (63)

#58 - PROTECTION AGAINST ANTICIPATED OPERATIONAL OCCURRENCES (29)

# CRBR CRITERIA SIMILAR TO 10 CFR 50, APPENDIX A, CRITERIA

#5 - ENVIRONMENTAL & MISSILE DESIGN BASIS (4)
*#8 - REACTOR DESIGN (10)
#11 - INSTRUMENTATION & CONTROL (13)
#12 - REACTOR COOLANT BOUNDARY (14)
#13 - REACTOR COOLANT SYSTEM DESIGN (15)
#15 - ELECTRICAL POWER SYSTEMS (17)
#17 - CONTROL ROOM (19)
#18 - PROTECTION SYSTEM FUNCTIONS (20)
#20 - PROTECTION SYSTEM INDEPENDENCE (22)
#21 - PROTECTION SYSTEM FAILURE MODES (23)
#23 - PROTECTION SYSTEM REQUIREMENTS FOR REACTIVITY CONTROL MALFUNCTIONS (25)
*#24 - REACTIVITY CONTROL SYSTEM REDUNDANCY (26)
*#25 - REACTIVITY CONTROL SYSTEM CAPABILITY (27)
#29 - FRACTURE PREVENTION OF REACTOR COOLANT BOUNDARY (31)
#30 - INSPECTION OF REACTOR COOLANT BOUNDARY (32)
*#35 - REACTOR RESIDUAL HEAT EXTRACTION SYSTEM (34)

## CRBR CRITERIA SIMILAR TO 10 CFR 50, APPENDIX A, CRITERIA (CONT'D.)

#38 - ADDITIONAL COOLING SYSTEMS (44)
#39 - INSPECTION OF ADDITIONAL COOLING SYSTEMS (45)
#40 - TESTING OF ADDITIONAL COOLING SYSTEMS (46)
#41 - CONTAINMENT DESIGN BASIS (50)
#42 - FRACTURE PREVENTION OF REACTOR CONTAINMENT BOUNDARY (51)
#46 - REACTOR COOLANT BOUNDARY PENETRATING CONTAINMENT (55)
#48 - CLOSED SYSTEMS PENETRATING CONTAINMENT (57)
#49 - CONTAINMENT ATMOSPHERE CLEANUP (41)
#53 - FUEL STORAGE & HANDLING & RADIOACTIVITY CONTROL (61)
#56 - MONITORING RADIOACTIVITY RELEASE (64)
#57 - REACTIVITY LIMITS (28)

* - INDICATES MAJOR CHANGE FROM APPENDIX A CRITERION.

# UNIQUE CRBR CRITERIA

#4 - PROTECTION AGAINST SODIUM & NaK REACTIONS

#7 - SODIUM HEATING SYSTEMS

#26 - HEAT TRANSPORT SYSTEM DESIGN

#27 - ASSURANCE OF ADEQUATE COOLANT INVENTORY

#31 - INTERMEDIATE COOLANT SYSTEM

#32 - FRACTURE PREVENTION OF INTERMEDIATE COOLANT BOUNDARY

#33 - INSPECTION & SURVEILLANCE OF INTERMEDIATE COOLANT BOUNDARY

#34 - REACTOR & INTERMEDIATE COOLANT BOUNDARY & COVER GAS PURITY

#36 - INSPECTION OF REACTOR RESIDUAL HEAT EXTRACTION SYSTEM

#37 - TESTING OF REACTOR RESIDUAL HEAT EXTRACTION SYSTEM

#59 - FUEL ROD FAILURE PROPAGATION

#60 - FLOW BLOCKAGE

## 10 CFR 50 - APPENDIX A CRITERIA NOT USED BY CRBR

#33 - REACTOR COOLANT MAKEUP

#35 - EMERGENCY CORE COOLING

#36 - INSPECTION OF EMERGENCY CORE COOLING SYSTEM

#37 - TESTING OF EMERGENCY CORE COOLING SYSTEM

#38 - CONTAINMENT HEAT REMOVAL

#39 - INSPECTION OF CONTAINMENT HEAT REMOVAL SYSTEM

#40 - TESTING OF CONTAINMENT HEAT REMOVAL SYSTEM

# MAJOR CHANGES FROM 1976 VERSION

#8 - REACTOR DESIGN - REQUIREMENT ADDED TO HAVE THE DESIGN PROVIDE MEANS TO PREVENT FUEL MANAGEMENT ERRORS.

#24 - REACTIVITY CONTROL SYSTEM REDUNDANCY - REQUIREMENT CHANGED TO HAVE THE DESIGN PROVIDE TWO TOTALLY INDEPENDENT REACTIVITY CONTROL SYSTEMS, EACH CAPABLE OF TERMINATING ALL DESIGN BASIS EVENTS AND TO SPECIFY SHUTDOWN MARGIN REQUIREMENTS.

#25 - REACTIVITY CONTROL SYSTEM CAPABILITY - REQUIREMENT CHANGED TO HAVE THE DESIGN PROVIDE TWO TOTALLY INDEPENDENT REACTIVITY CONTROL SYSTEMS, EACH CAPABLE OF TERMINATING ALL DESIGN BASIS EVENTS.

#35 - REACTOR RESIDUAL HEAT EXTRACTION SYSTEM - REQUIREMENT CHANGED TO HAVE THE DESIGN INCLUDE INDEPENDENCE AND DIVERSITY, TO REQUIRE COOLANT COMPATABILITY WITH THE REACTOR COOLANT AND TO REQUIRE AT LEAST TWO FLOW PATHS REMAIN AVAILABLE FOLLOWING A SINGLE FAILURE.

## MAJOR CHANGES FROM 1976 VERSION (CONT'D.)

#57 - REACTIVITY LIMITS - NEW CRITERION ADDED - IT IS SIMILAR TO GDC #28.

#58 - PROTECTION AGAINST ANTICIPATED OPERATIONAL OCCURRENCES - NEW CRITERION ADDED - IT IS IDENTICAL TO GDC #29.

#59 - FUEL ROD FAILURE PROPAGATION - NEW CRITERION ADDED - IT REQUIRES THE DESIGN INCLUDE FEATURES TO LIMIT FUEL ROD FAILURE PROPAGATION.

#60 - . FLOW BLOCKAGE - NEW CRITERION ADDED - IT REQUIRES THE DESIGN INCLUDE FEATURES TO MINIMIZE THE POTENTIAL FOR FLOW BLOCKAGE.

<u>CRITERION 8 - REACTOR DESIGN</u> - THE REACTOR AND ASSOCIATED COOLANT, CONTROL, AND PROTECTION SYSTEMS SHALL BE DESIGNED WITH APPROPRIATE MARGIN TO ASSURE THAT SPECIFIED ACCEPTABLE FUEL DESIGN LIMITS ARE NOT EXCEEDED DURING ANY CONDITION OF NORMAL OPERATION, INCLUDING THE EFFECTS OF ANTICIPATED OPERATIONAL OCCURRENCES. IN ADDITION, MEANS SHALL BE PROVIDED TO PREVENT FUEL MANAGEMENT ERRORS THAT COULD RESULT IN FUEL DAMAGE LIMITS BEING EXCEEDED.

CRITERION 24 - REACTIVITY CONTROL SYSTEM REDUNDANCY AND CAPABILITY - TWO INDEPENDENT REACTIVITY CONTROL SYSTEMS OF DIFFERENT DESIGN PRINCIPLES SHALL BE PROVIDED. EACH SYSTEM SHALL BE CAPABLE OF RELIABLY RESPONDING TO REACTIVITY CHANGES TO ASSURE THAT UNDER CONDITIONS OF NORMAL OPERATION, AND ANTICIPATED OPERATIONAL OCCURRENCES AND WITH APPROPRIATE MARGIN FOR MALFUNCTIONS SUCH AS A STUCK ROD, SPECIFIED ACCEPTABLE FUEL DESIGN LIMITS ARE NOT EXCEEDED. EACH SYSTEM SHALL HAVE SUFFICIENT WORTH, ASSUMING FAILURE OF ANY SINGLE ACTIVE COMPONENT, TO SHUT DOWN THE REACTOR FROM ANY OPERATING CONDITION TO ZERO POWER AND MAINTAIN SUBCRITICALITY AT THE HOT SHUTDOWN TEMPERATURE OF THE COOLANT, WITH ALLOWANCE FOR THE MAXIMUM REACTIVITY ASSOCIATED WITH ANY ANTICIPATED OPERATIONAL OCCURRENCE OR POSTULATED ACCIDENT. ONE OF THE SYSTEMS SHALL BE CAPABLE OF HOLDING THE REACTOR CORE SUBCRITICAL FOR ANY COOLANT TEMPERATURE ASSOCIATED WITH NORMAL OPERATION.

CRITERION 25 -REACTIVITY CONTROL SYSTEMS CAPABILITY - THE REACTIVITY CONTROL SYSTEMS SHALL BE DESIGNED TO HAVE AN INDEPENDENT CAPABILITY OF RELIABLY CONTROLLING REACTIVITY CHANGES TO ASSURE THAT UNDER POSTULATED ACCIDENT CONDITIONS AND WITH APPROPRIATE MARGIN FOR A STUCK ROD, THE CAPABILITY TO COOL THE CORE IS MAINTAINED.

CRITERION 35 - REACTOR RESIDUAL HEAT EXTRACTION SYSTEM - A REACTOR RESIDUAL HEAT EXTRACTION SYSTEM SHALL BE PROVIDED TO TRANSFER RESIDUAL HEAT FROM THE REACTOR COOLANT SYSTEM TO ULTIMATE HEAT SINKS UNDER ALL PLANT SHUTDOWN CONDITIONS FOLLOWING NORMAL OPERATION, ANTICIPATED OPERATIONAL OCCURRENCES AND POSTULATED ACCIDENT CONDITIONS. A PASSIVE BOUNDARY SHALL NORMALLY SEPARATE REACTOR COOLANT FROM THE WORKING FLUIDS OF THE REACTOR RESIDUAL HEAT EXTRACTION SYSTEM. ANY FLUID IN THE RESIDUAL HEAT EXTRACTION SYSTEM THAT IS SEPARATED FROM THE REACTOR COOLANT BY A SINGLE PASSIVE BARRIER SHALL NOT BE CHEMICALLY REACTIVE WITH THE REACTOR COOLANT.

SUITABLE REDUNCANCY, INDEPENDENCE AND DIVERSITY IN SYSTEMS, COMPONENTS AND FEATURES, AND SUITABLE INTERCONNECTIONS, LEAK DETECTION, AND ISOLATION CAPABILITIES SHALL BE PROVIDED TO ASSURE THAT FOR ONSITE ELECTRICAL POWER SYSTEM OPERATION (ASSUMING OFFSITE POWER IS NOT AVAILABLE) AND FOR OFFSITE ELECTRICAL POWER SYSTEM OPERATION (ASSUMING ONSITE POWER IS NOT AVAILABLE) THE SYSTEM SAFETY FUNCTION CAN BE ACCOMPLISHED, ASSUMING A SINGLE FAILURE, WITH AT LEAST TWO FLOW PATHS REMAINING AVAILABLE FOR RESIDUAL HEAT REMOVAL.*

---

*THIS REQUIREMENT IS NOT INTENDED TO PRECLUDE TWO-LOOP OPERATION PROVIDED THE SYSTEM SAFETY FUNCTIONS CAN BE APPROPRIATELY MET.

CRITERION 57 - REACTIVITY LIMITS - THE REACTIVITY CONTROL SYSTEMS SHALL BE DESIGNED WITH APPROPRIATE LIMITS ON THE POTENTIAL AMOUNT AND RATE OF REACTIVITY INCREASE TO ASSURE THAT THE EFFECTS OF POSTULATED REACTIVITY ACCIDENTS CAN NEITHER (1) RESULT IN DAMAGE TO THE REACTOR COOLANT BOUNDARY GREATER THAN LIMITED LOCAL YIELDING NOR (2) SUFFICIENTLY DISTURB THE CORE, ITS SUPPORT STRUCTURES OR OTHER REACTOR VESSEL INTERNALS TO IMPAIR SIGNIFICANTLY THE CAPABILITY TO COOL THE CORE. THESE POSTULATED REACTIVITY ACCIDENTS SHALL INCLUDE CONSIDERATION OF EVENTS SUCH AS ROD EJECTION (UNLESS PREVENTED BY POSITIVE MEANS), ROD RUNOUT, STEAMLINE RUPTURE, CHANGES IN REACTOR COOLANT TEMPERATURE AND PRESSURE, COLD SODIUM ADDITION.

CRITERION 58 - PROTECTION AGAINST ANTICIPATED OPERATIONAL OCCURRENCES - THE PROTECTION AND REACTIVITY CONTROL SYSTEMS SHALL BE DESIGNED TO ASSURE AN EXTREMELY HIGH PROBABILITY OF ACCOMPLISHING THEIR SAFETY FUNCTIONS IN THE EVENT OF ANTICIPATED OPERATIONAL OCCURRENCES.

CRITERION 59 - FUEL ROD FAILURE PROPAGATION - FEATURES SHALL BE PROVIDED TO LIMIT PROPAGATION OF STOCHASTIC FUEL ROD FAILURES. THESE FEATURES MAY BE INHERENT IN THE DESIGN OF THE FUEL AND BLANKET ASSEMBLIES TO ELIMINATE OR MITIGATE PROPAGATION OR MAY INCLUDE MONITORING SYSTEMS TO DETECT PIN FAILURES IN TIME TO PERMIT APPROPRIATE MEASURES TO BE TAKEN. THE FEATURES PROVIDED SHALL BE SUFFICIENT TO LIMIT PROPAGATION OF EACH FAILURE TO THE ASSEMBLY IN WHICH IT IS LOCATED.

<u>CRITERION 60 - FLOW BLOCKAGE</u> - THE REACTOR INTERNALS AND CORE ASSEMBLIES SHALL BE DESIGNED TO MINIMIZE THE POTENTIAL FOR FLOW BLOCKAGE OR FLOW RESTRICTION TO ONE OR MORE CORE ASSEMBLIES, WHILE IN THE REACTOR CORE, BY LOOSE PARTS OR BY CORE ASSEMBLY LOADING ERRORS SUFFICIENT TO CAUSE FUEL DAMAGE LIMITS TO BE EXCEEDED.

# DISPOSITION OF COMMENTS RAISED BY ACRS-CRBR SUBCOMMITTEE AT 3/30 - 3/31/82 MEETING ON PDCs

1) WHY DON'T PDCs DEFINE DESIGN BASIS ACCIDENTS (DBAs)?

   - PDCs DEFINE DESIGN REQUIREMENTS ON SYSTEMS, COMPONENTS, AND STRUCTURES. DBAs ARE USED TO TEST THE CAPABILITY OF THE PLANT SYSTEMS, COMPONENTS, AND STRUCTURES. DEVELOPMENT AND REVIEW OF DBAs IS DISCUSSED IN THE INTRODUCTION TO SER SECTION 3.1.

2) WHY DON'T PDCs ADDRESS CDAs AND ENERGETICS?

   - PDCs ADDRESS DESIGN REQUIREMENTS FOR SYSTEMS, COMPONENTS, AND STRUCTURES NECESSARY FOR MITIGATING DBAs AND REDUCING THE LIKELIHOOD OF EVENTS BEYOND THE DESIGN BASIS SUCH THAT THEY CAN BE EXCLUDED FROM THE DESIGN BASIS SPECTRUM. CDAs AND ENERGETICS (INCLUDING CRITERIA) ARE TO BE ADDRESSED IN A SEPARATE APPENDIX TO THE SER.

## DISPOSITION OF COMMENTS RAISED BY ACRS-CRBR SUBCOMMITTEE (CONT'D.)

3) WHY DON'T PDCs SPECIFY A MARGIN OF SAFETY FOR THE PLANT FOR THE SSE?

   - EVENTS BEYOND THE SSE ARE CONSIDERED AS BEYOND THE DESIGN BASIS. THE MARGIN AVAILABLE AT THE SSE WILL, HOWEVER, BE EVALUATED AND WILL BE THE SUBJECT OF A FUTURE MEETING.

4) WHY DON'T PDCs SPECIFY NATURAL CIRCULATION AS A REQUIREMENT?

   - THE CONCERN IS DECAY HEAT REMOVAL AND THE CRITERIA ADDRESS THIS. THE PLANT IS BEING ANALYZED FOR NATURAL CIRCULATION AND IT IS EXPECTED THAT THIS CAPABILITY WILL BE DEMONSTRATED.

5) WHY DON'T THE PDCs ADDRESS SABOTAGE?

   - SABOTAGE IS ADDRESSED IN 10 CFR 73.

## DISPOSITION OF COMMENTS RAISED BY ACRS-CRBR SUBCOMMITTEE (CONT'D.)

6) WHY DON'T THE PDCs ADDRESS CONTAINMENT RETENTION TIME?

   - THEY DO IN A GENERAL SENSE IN PDC #14.

7) WHY DON'T THE PDCs ADDRESS STATION BLACKOUT?

   - STATION BLACKOUT IS A SPECIFIC EVENT FOR WHICH THE PLANT WILL BE ANALYZED ALTHOUGH IT IS NOT IN THE DESIGN BASIS CATEGORY. PDCs DO NOT ADDRESS DBAs BUT RATHER DESIGN REQUIREMENTS ON SYSTEMS, COMPONENTS, AND STRUCTURES.

8) ADD DEFINITION OF "POSTULATED ACCIDENTS" AND "FUEL DAMAGE LIMITS."

   - DONE.

## RESPONSE TO D. OKRENT COMMENTS OF JULY 1, 1982

1) CRITERION 2 APPEARS TO BE INADEQUATE IN THAT IT REFERS ONLY TO HISTORIC NATURAL PHENOMENA AS A BASIS FOR JUDGMENT.

   - CRITERION 2 SPECIFIES THAT SUFFICIENT MARGIN SHOULD BE INCLUDED TO ACCOUNT FOR THE UNCERTAINTIES OF THE DATA. THIS ALLOWS A SITE SPECIFIC DETERMINATION.

2) CRITERION 5 REFERS TO "POSTULATED ACCIDENTS." IT IS NOT CLEAR WHETHER THIS WILL LIMIT THE ENVIRONMENTAL QUALIFICATION TO DESIGN BASIS ACCIDENTS AND LEAVE IMPORTANT FUNCTIONS VULNERABLE TO OTHER CIRCUMSTANCES.

   - ALL EQUIPMENT, WHETHER REQUIRED FOR DBAs OR FOR EVENTS BEYOND THE DESIGN BASIS WILL BE QUALIFIED TO ITS APPROPRIATE ENVIRONMENT. CRITERION 5 ADDRESSES THIS FOR EQUIPMENT ASSOCIATED WITH DBAs. A SEPARATE APPENDIX TO THE SER WILL ADDRESS THIS FOR EQUIPMENT ASSOCIATED WITH EVENTS BEYOND DBAs.

RESPONSE TO D. OKRENT COMMENTS OF JULY 1, 1982 (CONT'D.)

3) CRITERION 7 USES THE TERM "SINGLE FAILURE." WHY IS SINGLE FAILURE OK?

- APPLICATION OF THE SINGLE FAILURE CRITERION IS CONSIDERED ACCEPTABLE IF FAILURE OF THE SYSTEM OR COMPONENT TO WHICH IT IS APPLIED WILL NOT DIRECTLY AFFECT THE ABILITY OF THE PLANT TO SHUTDOWN OR REMOVE DECAY HEAT. TO PROVIDE ADDITIONAL MARGIN IN THE PLANT SHUTDOWN AND DECAY HEAT REMOVAL AREAS REQUIREMENTS FOR DIVERSITY, REDUNDANCY, AND INDEPENDENCE ARE APPLIED SUCH THAT ADDITIONAL FAILURES CAN BE ACCOMODATED (SEE PDC 20, 24, 35).

4) CRITERION 11 DOES NOT GIVE ANY GUIDANCE ON RELIABILITY REQUIREMENTS FOR INSTRUMENTATION AND CONTROL.

- STATEMENTS ON RELIABILITY ARE USED ONLY IN CONJUNCTION WITH SYSTEMS THAT PERFORM AN ACTIVE SAFETY FUNCTION. CRITERION 11 ADDRESSES SYSTEMS THAT MONITOR AND CONTROL BUT DO NOT PROVIDE THE PLANT WITH AUTOMATIC PROTECTION. HOWEVER, RELIABILITY OF THESE SYSTEMS WILL NOT BE IGNORED BUT RATHER WILL BE CONSIDERED FOR INCLUSION IN THE APPLICANT'S RELIABILITY PROGRAM.

## RESPONSE TO D. OKRENT COMMENTS OF JULY 1, 1982 (CONT'D.)

5) CRITERION 15 USES THE TERM "SINGLE FAILURE" FOR ONSITE POWER SUPPLIES, WITHOUT JUSTIFICATION IN TERMS OF RELIABILITY OF COMMON CAUSE FAILURES.

   - IF COMMON CAUSE FAILURES AFFECTING SAFETY ARE IDENTIFIED, THE DESIGN WILL BE CHANGED TO ELIMINATE THEM. FOR THOSE SYSTEMS ASSOCIATED WITH SHUTTING DOWN THE PLANT AND REMOVING DECAY HEAT, REQUIREMENTS ON DIVERSITY AND INDEPENDENCE HAVE BEEN ADDED TO HELP ELIMINATE THE POSSIBILITY OF ANY UNKNOWN COMMON CAUSE FAILURES FROM VOIDING THE FUNCTION OF THESE SYSTEMS.

6) CRITERION 17 IS OBSCURE AS TO WHETHER IT DEALS WITH A FIRE IN THE CONTROL ROOM.

   - CRITERION 17 IS INTENDED TO COVER A FIRE IN THE CONTROL ROOM.

RESPONSE TO D. OKRENT COMMENTS OF JULY 1, 1982 (CONT'D.)

7) CRITERION 22 AGAIN USES THE TERM SINGLE FAILURE WITHOUT CONSIDERATION OF POSSIBLE COMMON CAUSE EVENTS.

- SEE #5 ABOVE.

8) CRITERION 26 AGAIN USES "SINGLE FAILURE."

- SEE #5 ABOVE.

# CLINCH RIVER BREEDER REACTOR PLANT

CRBRP PROJECT

BRIEFING FOR

## ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) WORKING GROUP

# DESIGN BASIS ACCIDENTS

OCTOBER 27,1982

T6

10-82-3058-17

# BRIEFING ON

# CRBRP DESIGN BASIS ACCIDENTS

FOR THE

## ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) WORKING GROUP

WASHINGTON, D.C.

OCTOBER 27, 1982

## AGENDA

| | |
|---|---|
| • OVERALL APPROACH | G. H. CLARE |
| • REACTOR ACCIDENTS | P. W. DICKSON |
| • PLANT ACCIDENTS | G. H. CLARE |

# CRBRP DESIGN BASIS ACCIDENTS

BRIEFING FOR

## ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) WORKING GROUP

# OVERALL APPROACH

PRESENTED BY:

GEORGE H. CLARE
LICENSING MANAGER, CRBRP PROJECT
WESTINGHOUSE-OR
ADVANCED REACTORS DIVISION

OCTOBER 27, 1982

# THE PURPOSE OF DESIGN BASIS ACCIDENTS IS TO PROVIDE ''DESIGN BASES'' FOR THE PLANT SAFETY FEATURES

- SAFETY FUNCTIONS
- CONTROLLING PARAMETERS

**REFERENCE 10 CFR 50.2(U)**

# DESIGN BASIS ACCIDENTS ARE CONSERVATIVELY DEFINED USING JUDGEMENT TO INTEGRATE THE AVAILABLE INFORMATION

- SODIUM REACTOR PLANT EXPERIENCE
  - DOMESTIC
  - FOREIGN
- SODIUM TEST FACILITY EXPERIENCE
  - DOMESTIC
  - FOREIGN
- LIGHT WATER REACTOR PLANT EXPERIENCE
  - DOMESTIC
- LICENSING REGULATIONS, GUIDELINES AND PRECEDENTS
  - 10 CFR 50
  - REGULATORY GUIDES
  - STANDARD FORMAT AND CONTENT (LMFBR EDITION)
  - STANDARD REVIEW PLAN
  - LWR LICENSING EXPERIENCE
  - FFTF ''SAFETY REVIEW''

# THERE ARE THREE IMPORTANT ASPECTS OF EACH DESIGN BASIS ACCIDENT

- ACCIDENT INITIATOR
- ADDITIONAL EQUIPMENT FAILURES
- CONSERVATIVE ANALYSIS ASSUMPTIONS

# ACCIDENT INITIATORS ARE CHOSEN CONSERVATIVELY BY INTEGRATING AVAILABLE INFORMATION

- SODIUM REACTOR PLANT EXPERIENCE
- SODIUM TEST FACILITY EXPERIENCE
- LIGHT WATER REACTOR PLANT EXPERIENCE
- CRBRP GENERAL CHARACTERISTICS AND DESIGN DETAILS
- LICENSING REGULATIONS, GUIDELINES AND PRECEDENTS

**EXAMPLES: CONTROL ROD WITHDRAWAL, STEAM GENERATOR LEAK**

# ADDITIONAL EQUIPMENT FAILURES ARE SPECIFIED CONSERVATIVELY BY INTEGRATING AVAILABLE INFORMATION

- LICENSING REGULATIONS, GUIDELINES AND PRECEDENTS
  - LOSS OF OFFSITE POWER OR ONSITE POWER
  - SINGLE ACTIVE FAILURE
  - NON-SAFETY RELATED EQUIPMENT FAILS TO FUNCTION
- SPECIAL LMFBR CONSIDERATIONS
  - REACTOR SHUTDOWN SYSTEM
- CRBRP DESIGN DETAILS

# CONSERVATISMS USED IN THE EVALUATION OF DBA CONSEQUENCES ARE SPECIFIED TO ENVELOPE UNCERTAINTIES IN DESIGN PARAMETERS AND ACCIDENT PHENOMENOLOGY

**EXAMPLE:**

- PUMP HEAD
- PRESSURE DROPS
- HEAT TRANSFER CHARACTERISTICS
- SODIUM BURNING CHEMISTRY

T7

# SAFETY FUNCTIONS FALL INTO THREE TRADITIONAL CATEGORIES

- REACTOR SHUTDOWN
  - PRIMARY REACTOR SHUTDOWN SYSTEM
  - SECONDARY REACTOR SHUTDOWN SYSTEM
- SHUTDOWN HEAT REMOVAL . . . . . . . . . . . . . . . **RELATED:**
  - MAIN HEAT TRANSPORT LOOPS
  - STEAM GENERATOR AUXILIARY HEAT REMOVAL SYSTEM
  - DIRECT HEAT REMOVAL SERVICE
  - SUPPORTING SYSTEMS

  RELATED:
  - CATCH PANS
  - AEROSOL MITIGATION
  - SWR PRESSURE RELIEF
  - SPENT FUEL COOLING
- MITIGATION OF RADIONUCLIDE RELEASES . . . **RELATED:**
  - CONTAINMENT INCLUDING ISOLATION SYSTEM
  - CONFINEMENT; RCB AND RSB
  - CELL LINERS

  RELATED:
  - CONTROL ROOM HABITABILITY

# CRBRP DESIGN BASIS ACCIDENTS

BRIEFING FOR

## ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) WORKING GROUP

# CRBRP PSAR REACTOR ACCIDENTS

PRESENTED BY:

DR. PAUL W. DICKSON
TECHNICAL DIRECTOR, CRBRP PROJECT
WESTINGHOUSE-OR
ADVANCED REACTORS DIVISION

OCTOBER 27, 1982

# BOUNDING CORE UNDERCOOLING EVENT
# INITIATOR

- LOSS OF OFFSITE POWER

# BOUNDING CORE UNDERCOOLING EVENT
# ADDITIONAL EQUIPMENT FAILURES ASSUMED

- ALL THREE DIESEL GENERATORS FAIL TO START
- TWO OUT OF THREE LOGIC TO TRIP EITHER SHUTDOWN SYSTEM
- ONLY ONE SHUTDOWN SYSTEM OPERATES
- ONE ROD IN THAT SYSTEM FAILS TO INSERT

# BOUNDING CORE UNDERCOOLING EVENT
# ASSUMPTIONS

- MINIMUM PUMP HEAD INITIALLY
- MAXIMUM CORE AND SYSTEM PRESSURE DROPS INITIALLY
- PUMPS STOP WITH MAXIMUM ROTOR BACKPRESSURE DROP
- WORST CASE DOPPLER COEFFICIENT INCLUDING UNCERTAINTIES
- MINIMUM CONTROL ROD SHUTDOWN WORTH (ONE STUCK ROD)
- $3\sigma$ HOT CHANNEL SPOT FACTORS
- HIGHEST POWER AND TEMPERATURE HOT RODS AT WORST TIME IN LIFE
- WORST END OF UNCERTAINTY RANGE USED FOR PROPERTIES (e.g., FUEL Cp) AND FUEL/CLAD GAP CONDUCTANCE FOR BOTH POWER AND TEMPERATURE CALCULATIONS
- MAXIMUM DECAY HEAT LOADS INCLUDING $3\sigma$ UNCERTAINTIES AND TIME IN LIFE EFFECTS
- NO CREDIT TAKEN FOR INTER- AND INTRA-ASSEMBLY FLOW AND HEAT REDISTRIBUTION
- NEGATIVE REACTIVITY FEEDBACKS NEGLECTED (e.g., CORE RADIAL EXPANSION, BOWING, AXIAL EXPANSION OF FUEL AND CLADDING)
- CONSERVATIVE 0.2 SECOND DELAY USED FOR PPS LOGIC, SCRAM BREAKER AND THE CONTROL ROD UNLATCH TIME DELAYS
- ALL ABOVE ASSUMPTIONS ASSUMED TO OCCUR SIMULTANEOUSLY

# WORST REACTIVITY INSERTION EVENTS

- ROD RUN OUT
- SSE

# ROD RUN OUT
# INITIATOR

- CONTROLLER FAILURE

## ROD RUN OUT

# ADDITIONAL EQUIPMENT FAILURES ASSUMED

- FAILURE OF HIGH FLUX BLOCKING CIRCUIT
- FAILURE OF FLUX/FLOW MISMATCH BLOCKING CIRCUIT
- FAILURE OF ROD BANK POSITION LIMITER CIRCUIT
- FAILURE OF SINGLE ROD OUT-OF-ALIGNMENT BLOCKING CIRCUIT
- TWO OUT OF THREE LOGIC TO TRIP EITHER SHUTDOWN SYSTEM
- ONLY ONE SHUTDOWN SYSTEM OPERATES
- ONE ROD IN THAT SYSTEM FAILS TO INSERT

## ROD RUN OUT

# MAJOR ASSUMPTIONS USED IN TRANSIENT HOT ROD ANALYSIS

- ROD BANK OPERATING AT CORE MIDPLANE (HIGHEST DIFFERENTIAL WORTH)
- MAXIMUM ROD WORTH ASSUMED FOR RUN OUT ROD
- CONSERVATIVE PLANT THDV INITIAL CONDITIONS (e.g., 750° REACTOR INLET)
- WORST CASE DOPPLER COEFFICIENT INCLUDING UNCERTAINTIES
- MINIMUM CONTROL ROD SHUTDOWN WORTH (ONE STUCK ROD)
- $3\sigma$ HOT CHANNEL SPOT FACTORS
- HIGHEST POWER AND TEMPERATURE HOT RODS AT WORST TIME IN LIFE

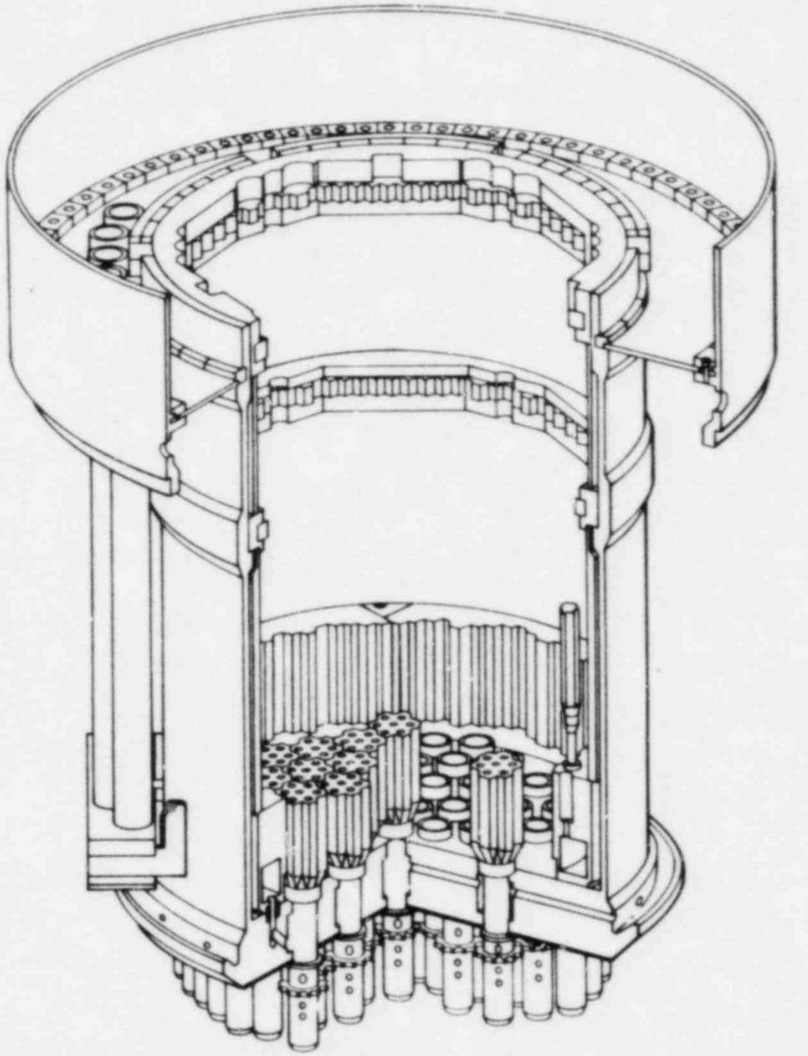
## ROD RUN OUT

# MAJOR ASSUMPTIONS USED IN TRANSIENT HOT ROD ANALYSIS (CONT.)

- WORST END OF UNCERTAINTY RANGE USED FOR PROPERTIES (e.g., FUEL Cp) AND FUEL/CLAD GAP CONDUCTANCE FOR BOTH POWER AND TEMPERATURE CALCULATIONS
- MAXIMUM DECAY HEAT LOADS INCLUDING $3\sigma$ UNCERTAINTIES AND TIME IN LIFE EFFECTS
- NO CREDIT TAKEN FOR INTER- AND INTRA-ASSEMBLY FLOW AND HEAT REDISTRIBUTION
- NEGATIVE REACTIVITY FEEDBACKS NEGLECTED (e.g., CORE RADIAL EXPANSION, BOWING, AXIAL EXPANSION OF FUEL AND CLADDING)
- CONSERVATIVE 0.2 SECOND DELAY USED FOR PPS LOGIC, SCRAM BREAKER AND THE CONTROL ROD UNLATCH TIME DELAYS
- ALL ABOVE ASSUMPTIONS ASSUMED TO OCCUR SIMULTANEOUSLY

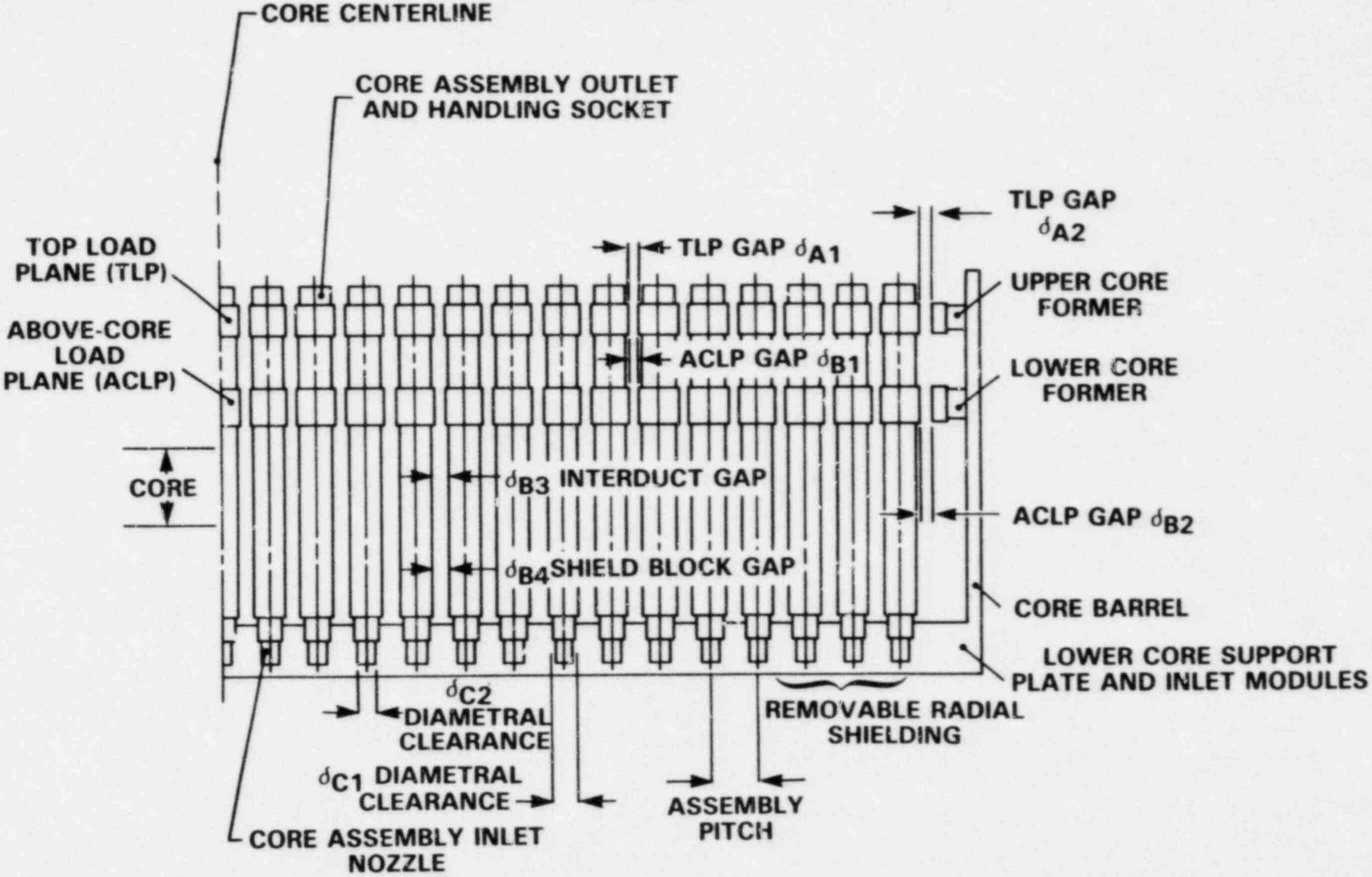
# SSE REACTIVITY INSERTION

# CRBRP CORE SUPPORT STRUCTURE



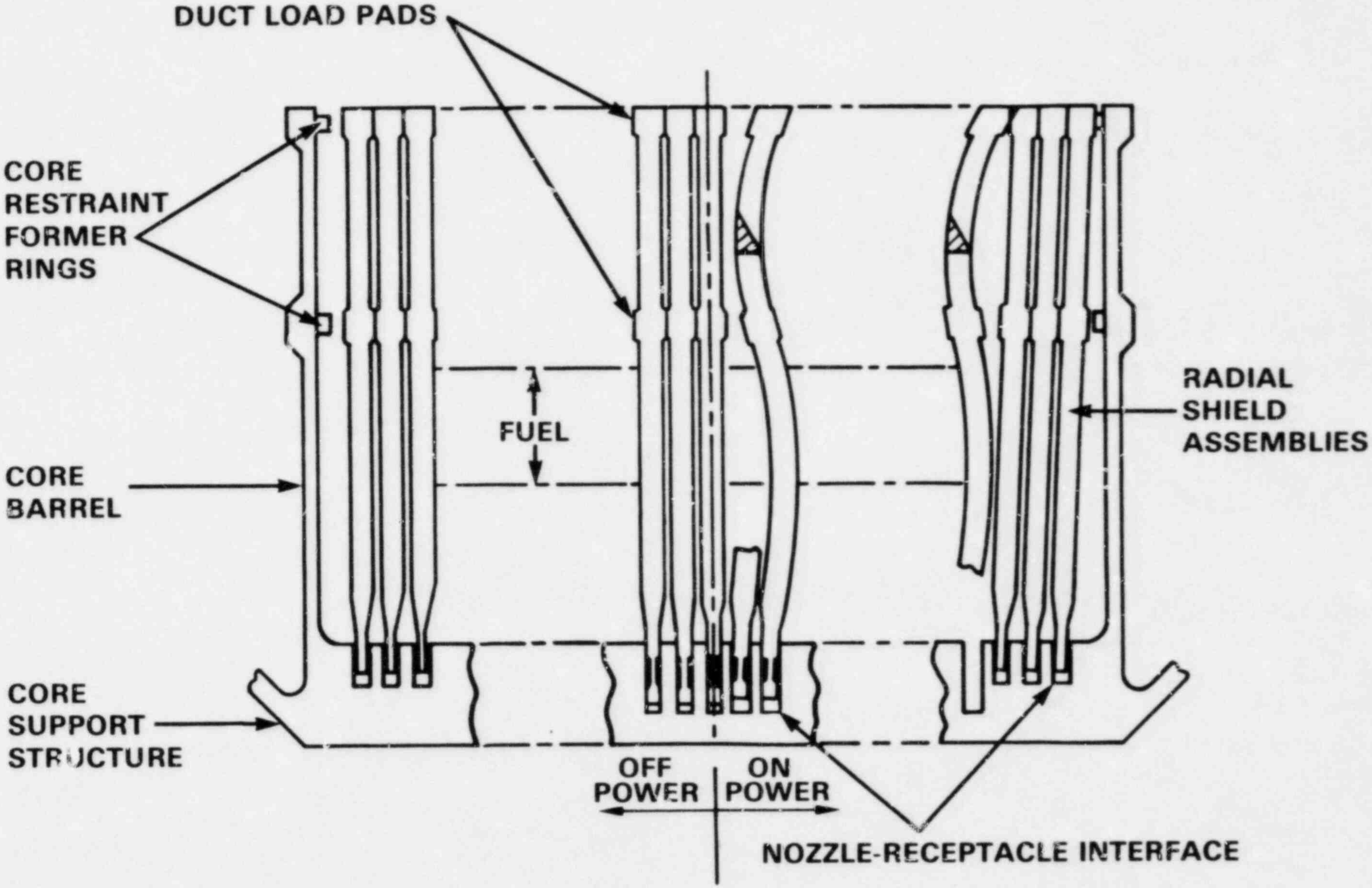
5-78-PO1380-11-1

# CRBRP CONCEPTUAL CORE RESTRAINT DESIGN



10-82-2390-2-1

# CONCEPTUAL DIAGRAM FOR THE LIMITED FREE BOW RADIAL CORE RESTRAINT FOR THE CRBRP



# ASSUMPTIONS USED FOR SSE ANALYSES

- POWER LOST TO PUMPS
- STEP REACTIVITY INSERTION DUE TO CORE COMPACTION EFFECTS
- DELAY IN CONTROL SYSTEM SCRAM SPEED DUE TO SEISMIC INDUCED FORCES ON DRIVELINE/GUIDE STRUCTURE

# ADDITIONAL EQUIPMENT FAILURES ASSUMED

- TWO OUT OF THREE LOGIC TO TRIP EITHER SHUTDOWN SYSTEM
- ONLY ONE SHUTDOWN SYSTEM OPERATES
- ONE ROD IN THAT SYSTEM FAILS TO INSERT

# MAJOR ASSUMPTIONS USED IN TRANSIENT HOT ROD ANALYSIS

- CONSERVATIVE PLANT THDV INITIAL CONDITIONS (e.g., 750° REACTOR INLET)
- WORST CASE DOPPLER COEFFICIENT INCLUDING UNCERTAINTIES
- MINIMUM CONTROL ROD SHUTDOWN WORTH (ONE STUCK ROD)
- $3\sigma$ HOT CHANNEL SPOT FACTORS
- HIGHEST POWER AND TEMPERATURE HOT RODS AT WORST TIME IN LIFE
- WORST END OF UNCERTAINTY RANGE USED FOR PROPERTIES (e.g., FUEL Cp) AND FUEL/CLAD GAP CONDUCTANCE FOR BOTH POWER AND TEMPERATURE CALCULATIONS
- MAXIMUM DECAY HEAT LOADS INCLUDING $3\sigma$ UNCERTAINTIES AND TIME IN LIFE EFFECTS
- NO CREDIT TAKEN FOR INTER- AND INTRA-ASSEMBLY FLOW AND HEAT REDISTRIBUTION
- NEGATIVE REACTIVITY FEEDBACKS NEGLECTED (e.g., CORE RADIAL EXPANSION, BOWING, AXIAL EXPANSION OF FUEL AND CLADDING)
- CONSERVATIVE 0.2 SECOND DELAY USED FOR PPS LOGIC, SCRAM BREAKER AND THE CONTROL ROD UNLATCH TIME DELAYS
- ALL ABOVE ASSUMPTIONS ASSUMED TO OCCUR SIMULTANEOUSLY

# CONCLUSIONS

- PSAR UNDERCOOLING AND OVERPOWER TRANSIENTS HAVE BEEN EVALUATED ON AN EXTREMELY CONSERVATIVE BASIS AND ALL EVENTS MEET THE ACCEPTANCE GUIDELINES OF TABLE 15.1.2-2

# CRBRP DESIGN BASIS ACCIDENTS

BRIEFING FOR

## ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) WORKING GROUP

# PLANT ACCIDENTS

PRESENTED BY:

GEORGE H. CLARE
LICENSING MANAGER, CRBRP PROJECT
WESTINGHOUSE-OR
ADVANCED REACTORS DIVISION

OCTOBER 27, 1982

# CONTAINMENT DESIGN BASIS ACCIDENT
# INITIATOR

- COVERED IN DETAIL ON MAY 24, 1982.
- SIGNIFICANT RADIOACTIVE INVENTORIES: REACTOR FUEL, COLD TRAPS, COVER GAS, AND COOLANT.
- COOLANT IN AIR-FILLED CELL (MAINTENANCE) IS THE BOUNDING SOURCE
  - LWR PRACTICE
- PRIMARY SODIUM STORAGE TANK (PSST) CAN HOLD THE LARGEST INVENTORY
- SIGNIFICANT SODIUM FIRES HAVE NOT OCCURRED

**INITIATOR: LEAK IN THE PSST DURING MAINTENANCE**

T8

# CONTAINMENT DESIGN BASIS ACCIDENT
# ADDITIONAL "EQUIPMENT" FAILURES

- VIOLATION OF PROCEDURES REQUIRING LOW INVENTORY PRIOR TO DEINERTING
- VIOLATION OF HEALTH PHYSICS GUIDELINES; LARGE SODIUM VOLUME IS A MAJOR GAMMA SOURCE, ENTRY IN CELL WOULD GIVE HIGH DOSES
- FAILURE TO MANUALLY EXTINGUISH FIRE
- FAILURE OF ONE SET OF CIS RADIATION MONITORS

  OR

  FAILURE OF ONE TRAIN OF CIS LOGIC OR VALVES

  - LWR PRACTICE
- FAILURE OF ONE OF THREE DIVERSE CIS RADIATION MONITORS
  - LWR PRACTICE

## CONTAINMENT DESIGN BASIS ACCIDENT ANALYSIS CONSERVATISMS

- MAXIMUM SODIUM INVENTORY; INSTANTANEOUS SPILL
- MAXIMUM REACTION ENERGY (100% $Na_2O$ FORMATION)
- 100% OF $O_2$ IN RCB CONSUMED
- DIRECT GAS EXCHANGE BETWEEN CELL AND RCB ATMOSPHERE - NOT CONSIDERING EQUIPMENT
- END OF LIFE SODIUM CONTAMINATION; CONSTANT 1% FAILED FUEL
- NO PLUGGING OF CONTAINMENT LEAKAGE PATHS
- NO AEROSOL FALLOUT OUTSIDE CONTAINMENT
- 95% METEOROLOGY

# SODIUM WATER REACTION
## (STEAM GENERATOR LEAK)
# INITIATOR

- COVERED IN DETAIL ON JUNE 25, 1982
- STEAM GENERATOR LEAKS HAVE BEEN POSTULATED IN LWRS
- STEAM GENERATOR LEAKS HAVE OCCURRED
- NO RAPIDLY DEVELOPING SWRs HAVE OCCURRED
- NO GUILLOTINE TUBE FAILURES HAVE OCCURRED
- EXPERIMENTS HAVE DEMONSTRATED SLOW PROPAGATION; BOUNDING ANALYSIS SHOWS PROPAGATION NO FASTER THAN ONE SECOND
- FOREIGN LMFBRs ASSUME ONE TO THREE TUBE FAILURES

**INITIATOR:**

- **PRECURSOR**
- **EQUIVALENT D.E.G. FAILURE**
- **TWO ADDITIONAL D.E.G. FAILURES AT ONE SECOND INTERVALS**

# SODIUM WATER REACTION

## (STEAM GENERATOR LEAK)

# ADDITIONAL ''EQUIPMENT'' FAILURES

- LEAK DETECTION AND MANUAL TERMINATION DO NOT OCCUR
- PRESSURE RELIEF FAILURE
- PRE-EXISTING ''UNDETECTABLE'' IHX LEAK (ENVELOPED BY PIPE LEAK EVENT)
- LOSS OF OFFSITE POWER JUST PRIOR TO SWR (ADVERSE CONDITIONS AT INITIATION)

# SODIUM WATER REACTION
## (STEAM GENERATOR LEAK)
# ANALYSIS CONSERVATISMS

- PRECURSER FAILS TO BURST RUPTURE ON EXPANSION TANK
- TUBE FAILURES ARE INSTANTANEOUS
- WATER INJECTION PER RELAP4 (BWR PRECEDENT)
- WORST FAILURE LOCATIONS
- CONSERVATIVE RUPTURE DISK MODEL BASED ON TEST DATA
- CONSERVATIVE REACTION MODEL BASED ON TEST DATA
- ENERGY ABSORPTION IN STRUCTURES NEGLECTED

# ACRS CRBR SUBCOMMITTEE MEETING

OCTOBER 27, 1982

# DBA ACCIDENT ANALYSIS
# STATUS AND RATIONALE

RICHARD BECKER
NRC/CRBRPO

T11

# ACCIDENT ANALYSIS STATUS

## CONSULTANTS

BROOKHAVEN NATIONAL LABORATORY

LOS ALAMOS NATIONAL LABORATORY

IDAHO NATIONAL ENGINEERING LABORATORY

## MEETINGS

| | |
|---|---|
| CHAPTER 15 | FEBRUARY 28, 1982<br>APRIL 5, 1982 |
| CHAPTER 4 | |
| CHAPTER 5 | |
| CHAPTER 3 | |

# CRBR

# DESIGN BASIS ACCIDENT

# REVIEW

- CATEGORIZATION BY ACCIDENT TYPE
- CATEGORIZATION BY DOSE LIMIT
- CATEGORIZATION BY FREQUENCY
- ADEQUACY OF ENGINEERED SAFETY FEATURES
- COMPLETENESS

# CRBR

## ACCIDENT COMPLETENESS REVIEW

- DESIGN BASIS ACCIDENT ENVELOPE
- BUFFER ZONE
- BEYOND THE DESIGN BASIS ACCIDENT

REVIEW

# COMPLETENESS METHODOLOGIES

- MECHANISTIC SEQUENCE
- GENERIC TYPE
- FAILURE MODES & EFFECTS ANALYSIS (FMEA)
- FOREIGN EXPERIENCE
- PRA

# MECHANISTIC
# ACCIDENT DEFINITION

- HISTORIC ACCIDENTS
- COMPONENT FAILURE SCENARIO
  - PUMP FAILURES
  - FLOW BLOCKAGE
  - FEED WATER/VALVE FAILURES

# GENERIC

# ACCIDENT DEFINITION

- OVERPOWER
  - REACTIVITY
  - REACTIVITY FLOW INTERACTION
- UNDERCOOLING
  - FLOW
    - SYSTEM
    - LOCAL
- FIRES
- FUEL HANDLING & RADIOACTIVE STORAGE
- MISCELLANEOUS

# CATEGORIZATION

| | |
|---|---|
| NORMAL OPERATION | |
| INCIDENTS OF MODERATE FREQUENCY | ANTICIPATED FAULT |
| INFREQUENT INCIDENTS | UNLIKELY FAULT |
| LIMITING FAULTS | EXTREMELY UNLIKELY FAULT |

# DESIGN BASIS ANALYSIS

SINGLE FAILURE CRITERION

CONSERVATIVE ANALYSIS

UNCERTAINTIES

MOST CONSERVATIVE CONDITION

INSTRUMENT UNCERTAINTIES, ERROR & RESPONSE

## DESIGN BASIS EVENTS
## ACCEPTANCE CRITERIA

| EVENT CLASSIFICATION | FUEL TEMPERATURE | CLADDING TEMPERATURE (°F) | COOLANT TEMPERATURE (°F) | DOSE GUIDELINES |
|---|---|---|---|---|
| ANTICIPATED FAULT | SOLIDUS | 1500 | --- | 10 CFR 20 |
| UNLIKELY FAULT | SOLIDUS | 1600 | --- | 10 CFR 20 |
| EXTREMELY UNLIKELY FAULT | --- | 2475 (SOLIDUS) | SATURATION | 1/10 OF 10 CFR 100 |