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Title: ACRS JOINT SUBCOMMITTEE MEETING CONTAINMENT SYSTEMS/STRUCTURAL ENGINEERING

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UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

DATE: WEDNESDAY, DECEMBER 13, 1989

The contents of this transcript of the proceedings of the United States Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards, (date) Wednesday, December 13, 1989 ____________, as reported herein, are a record of the discussions recorded at the meeting held on the above date.

This transcript has not been reviewed, corrected or edited, and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFETY

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ACRS JOINT SUBCOMMITTEE MEETING

CONTAINMENT SYSTEMS/STRUCTURAL ENGINEERING

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Nuclear Regulatory Commission
7920 Norfolk Avenue
Phillips Building, Room P-110
Bethesda, Maryland

WEDNESDAY, DECEMBER 13, 1989

The Committee met, pursuant to notice, at 8:30 a.m., DAVID A. WARD, presiding.

ACRS MEMBERS PRESENT:

CHESTER P. SIESS
JAMES C. CARROLL
DAVID A. WARD
CARLYLE MICHELSON
CHARLES J. WYLIE
IVAN CATTON
WILLIAM KERR

ALSO PRESENT:

MICHAEL CORRADINI, ACRS Consultant

M. DEAN HOUSTON, Cognizant ACRS Staff Member

STAFF AND PRESENTERS PRESENT:

BRAD HARDIN, RES

TREVOR PRATT, BNL

BRIAN McINTYRE, Westinghouse

GEZA GYOREY, GE

GEORGE DAVIS, CE

AL IGNE, ACRS

R.J. LUTZ, JR., Westinghouse

AUDIENCE SPEAKERS:

T. ROGERS

R. HARDY

PROCEEDINGS

[8:30 a.m.]

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

This is a joint meeting of the Advisory Committee on Reactor Safeguards Subcommittees on Containment Systems and Structural Engineering.

I'm David Ward, the Subcommittee Chairman of Containment Systems.

Chester Siess, who is the Chairman for the Structural Engineering Subcommittee is here.

Other ACRS members in attendance are Mr. Carroll, Mr. Kerr, Mr. Wylie, and we expect Mr. Catton and Mr. Michelson to be here later.

We also have, as an ACRS consultant, Mike Corradini.

The purpose of the meeting is to continue our discussion of containment design criteria for future plants.

Mr. Dean Houston is the cognizant ACRS staff member for the meeting.

Rules for participation were announced as part of the notice published in the Federal Register on December 5th.

A transcript is being kept and will be made available, as stated in that Federal Register notice.

I ask that each speaker identify herself or himself and speak with sufficient clarity and volume so that she or he can be readily heard.

We have received no written statements nor request to make oral statements from members of the public.

Let me make a couple of comments, to begin.

As most of you are aware -- perhaps only too aware -- this is the third in our series what I might call information-gathering sessions on the possibilities for some new containment design criteria for a future generation of reactors. Maybe information gathering hasn't been quite the precise definition. It's opinion gathering and solicitation of opinions, but I think that's really what we've been looking for, and I think the first two meetings have been very successful in getting ideas from a variety and a cross-section of people, and I think we'll continue that today. In fact, we have kind of an interesting cross-section today.

The agenda is not -- we're not going to be under any time pressure. We originally had six speakers lined up. One of those, Bruce Spencer, from Argonne, called yesterday to cancel, with apologies. He said he'll send us some written comments, but he was unable to make it today.

One of the things that we'll want to do as a Subcommittee before the end of the day is to spend some time discussing the next step in this, what I hope is a process, and so, we'll want to talk somewhat about that, but in general, I think, although we've allotted times -- I guess, 45 minutes or so -- to each speaker, we don't really have any particular problem, except we have to honor the individual speakers' schedules that they might have.

MR. SIESS: The agenda is rather cryptic. What's Item D?

MR. WARD: Item D is where Bruce Spencer was on the last version of the agenda.

MR. SIESS: Okay. So, it doesn't mean open session. We're in open session all day.

MR. WARD: Yes.

I guess one thing I want to acknowledge is the presence of Professor Terry Rogers from ACNS. He came down from the snowy and wintry Toronto. Terry was here a few weeks ago, when we met with the ACNS, and was obviously informed and interested in this topic, and so, we invited him to come down to certainly listen, but also to participate informally, if he desires.

Chet, do you have anything you would like to add at this time, before we start with the agenda?

MR. SIESS: Nothing to add.

MR. WARD: Any other members have anything they'd like to say?

[No response.]

MR. WARD: Okay. We'll start out, then.

We have heard some thoughts from Brad Hardin of the Research Office in our previous meetings, but I think Brad's had opportunity to prepare something, and we're going to hear some further thoughts from him this morning.

[Slide.]

MR. HARDIN: Thank you for giving us this opportunity to come and talk to you today.

This is a joint effort that's been taking place before part of the staff in Brookhaven over the last couple of years, and this first slide is to give you a little background on what's happened over the last couple of years and, actually, before that, because the staff had some effort in looking at what sort of criteria might be used for severe accidents for future plants.

Starting back in 1985-86 era, Zoltan Rosztoczy's branch was involved in that, and a document was published describing what sort of recommendations they would make. That was in SECY-86-76.

Then, in 1987, as you know, the NRC was reorganized, and the assignments for this work were changed, and they were given over to Research, and the Advanced Reactors and Generic Issues branch, of which I am a member, was assigned this responsibility to look at the information that we had gained over the past years on severe accidents and to propose a plan for implementing severe accident policy for future plants, and so, we have been working on that pretty steadily for the last couple of years with our contract at Brookhaven.

As you can imagine, we've had many, many meetings, and we've had two public meetings, also, to solicit comments from the public. We have transcripts of those meetings, but essentially, what's come out of all of this work is in the form of two documents that are in draft form right now, and we're going to tell you a little bit about those, and Trevor is going to give you some of the technical details on that.

I would like to just introduce sort of the regulatory perspective that we have developed in doing this work and, also, to say that because of the diverse use that exists on this, I think one of the tasks that we've had to really focus on is not necessarily to try to develop any original thinking, but to just to solicit comments and to coordinate discussions and dialogues with all the people that have backgrounds in this area to make sure that we don't overlook some important past work, because there has been a lot of past work, and unfortunately, when you start looking into this, you find that a lot of it gets shuffled off in the corner and we forget about it.

MR. SIESS: Brad, excuse me. You're from Advanced Reactors and Generic Issues branch, right?

MR. HARDIN: That's right.

MR. SIESS: As such, you are reviewing what for the future? Advanced reactors? The DOE advanced reactors, you're reviewing, right?

MR. HARDIN: That's right. We have the responsibility for reviewing advanced reactors --

MR. SIESS: No, I want -- not general, specifically. Are you reviewing ABWR?

MR. HARDIN: Not specifically.

MR. SIESS: Or WAPWR or CE System 80+?

MR. HARDIN: If you look at who is actually doing the review on a plant like the ABWR, it covers many, many different branches, both within NRR and Research. Research is in a supporting role, and the Standard Review Plan type of review that takes place on all of these plants is done basically in NRR. The PRA reviews, the severe-accident work, is done basically by Research, because that's where most of the staff that have backgrounds in this area have been assigned. So, it's a joint effort.

MR. SIESS: Who is reviewing the EPRI LWR requirements?

MR. HARDIN: Again, that's a joint effort, with most of the Standard Review Plan aspects being reviewed with NRR.

MR. SIESS: So, when you're talking about future containment design criteria, you're talking about anything in the future, including evolutionary, revolutionary, advanced, etc. Am I right?

MR. HARDIN: Yes. In the implementation of severe-accident policy, we have focused our efforts on the -- what we would view as the next generation of plants, and this is the evolutionary designs, and so, you'll see, as Trevor and I talk some more, that we're not going to be able to say very much about even the passive designs.

We may offer an opinion on some of that, and Greg Van Tuyle from Brookhaven is here today, who has been involved in looking at some of the more advanced designs, and so, he may be able to answer some questions from his work on that, but we thought that it might be useful to present to you at least the kind of thinking that we've gone through on the evolutionary designs, because we believe that in much of that, that could be transferred, also, to the passive designs and maybe beyond some of the very basic criteria. Maybe you'll see a little bit more of that as we go on here.

MR. SIESS: So, you think that what you have done on developing containment criteria, although it's specific to particular designs that you've been reviewing, you think it might be more generally applicable as a principle.

MR. HARDIN: Yes. We have been pulled in different directions as we've gone through this work over the last couple of years, and you'll see a little bit of that in this history here.

One of the first products that came out of our work was a SECY paper, 88-248, and in that paper, we discussed various options that we could foresee for implementing severe-accident policy, and that involved everything from having rather restrictive rules with supporting documentation to having no additional regulatory requirements, but just using things like the Severe-Accident Policy Statement, and SECY-88-248 was not officially published by the Commissioners, because at one point -- I guess this was probably just about a year ago now --it was decided that there were disadvantages with having a rulemaking, that it were of such concern that it was decided that, at least for now, we wouldn't plan to have a rulemaking on severe accidents.

The main reason for that was that there was concern that a rulemaking, if not completed before the first design certification of one of the evolutionary plants, which would have been for the GE ABWR design late in 1990 -- if we were still working on a severe-accident rulemaking, it could seriously delay the design certification, and so, right now, my understanding is that the question of whether or not there will be a rule will not be decided until sometime, perhaps, after the design certification of the ABWR, at which time it's felt they could make a more intelligent decision about the advantages and disadvantages of having a rule.

But in lieu of having a rule, there has been an awful lot of review done on the -- particularly two of the evolutionary designs, the Westinghouse SP/90 and the GE ABWR, and it's been necessary to formulate some policy, because decisions had to be made so that safety evaluation reports could be drafted and, also, on the EPRI ALWR requirements document, and so, there has been, I believe, a very good cooperation between Research and NRR in meeting and making decisions about what we thought was acceptable and not acceptable on those designs, and I have a slide later to show that this work that Trevor and I are presenting to you today, I believe, is quite consistent with the present staff positions for both the GE ABWR and the EPRI ALWR Chapter 5, which is the severe accidents part of their requirements document.

The ABWR safety evaluation report is out. As you may know, the ALWR companion, the Chapter 5 SER, is being held right now. It hasn't been officially released yet, but there has been a lot of collaboration, and I think that what we have felt were reasonable requirements, if you call it requirements, for severe accidents have pretty much been complied with in those designs, and those are documented in the safety evaluation reports.

MR. KERR: When you talked, you referred to something being consistent with the staff policy. Is that sort of a working policy, or is there some document that describes this policy?

MR. HARDIN: I guess you'd have to call it a working policy, in that it was not really documented anywhere previous to the finalization of the reviews of those two areas, the ABWR and the EPRI ALWR Chapter 5.

MR. KERR: Is it documented somewhere now?

MR. HARDIN: The only place that it's documented -- well, it's documented in essentially two areas. It's documented in the safety evaluation reports that were written for both of those two efforts, the ABWR and the EPRI ALWR, and it's documented in draft form in the work that we're describing to you today.

MR. KERR: Is the policy documented in the SERs, or is the result of the policy apparent if one reads the SERs?

MR. HARDIN: It's the result, I'd say -- the result of the policy.

MR. KERR: So, there exists a policy somewhere, but it does not exist in written form at this point.

MR. HARDIN: That's right. I think that's accurate.

MR. KERR: That's a fairly significant policy, it seems to me. I would hope that the staff would want to write it down, because it seems to me it should -- the staff would want it to be subject to rather wide examination.

MR. HARDIN: Well, this is what we're here for, essentially, in our minds.

MR. KERR: But we have not seen a document prior to this meeting.

MR. HARDIN: That's right. Brookhaven has been working on two documents in parallel. One is the reg guide, which would describe, in our minds, reasonable format and content to satisfy the needs for future plants in the PRA area, and so, it would cover severe-accident topics.

The second document is a supporting document, which we have been called "the White Paper", but it's also completed in draft form now, and our intent is to tell you about both of these documents, to some extent, this morning, and after we have had a chance to iterate a little bit ourselves with Brookhaven, we have a process planned where we would start a peer review, which would involve giving copies of this to people within Research and NRR, and after we have received comments from them and written a new version of that to incorporate their comments, then we would propose that we would meet with you and start a dialogue with you in the formal sense of reviewing the document.

MR. KERR: How can we get copies of the existing draft?

MR. HARDIN: I suppose that you're requesting it now. I can ask permission to give them to you right away.

MR. KERR: I would appreciate it if you would.

MR. WARD: Do you see some particular problem with that?

MR. HARDIN: I think it's only the problem I guess everybody has with a first draft, that you'd just like to look at it a little bit first, and we have been working closely together with Brookhaven over the last -- particularly the last 6 months on this.

MR. KERR: Since I have confidence in both you and Brookhaven, I am sure it is not anything you would be ashamed of.

MR. HARDIN: No.

I was going to say, though, that there is only thing that has changed, I guess, in the last 3 months on this, that did cause Brookhaven to take another turn in direction, is that we had been told to focus only on the evolutionary designs in writing the reg guide, back about a year ago, when it was decided not to have a rule, and since then, we have been thinking about that some more, and we believe that, really, the reg guide would have more value if we could try to write it in more of a general sense, to cover not just evolutionary designs but also passive and, as well as we can, the HTGRs and the liquid metals and the other types of designs, and I don't know if Trevor was going to get into this very much.

I'll just mention, the format of that, in our minds, then, would be a first section in the reg guide that would be written very generally, to define very general requirements for containments. We're also involved not just with the containment aspects but the reliability, the front-end PRA-type areas, too, but the reg guide would have a general section, and then we'd have appendices to discuss specifics that are dependent on plant designs.

There would be an appendix for the evolutionary designs. There would be an appendix for the passive, if necessary. We're not sure yet whether there is going to be much difference between the evolutionary and the passive, in terms of our views, anyway, on what sort of criteria we might want to use.

MR. KERR: Well, now, prior the reg guide, you will have established a policy on which the reg guide is based, I assume.

MR. HARDIN: The other paper, the supporting document, the White Paper, is a paper which Trevor will give you -- fill in the technical details of that, which we have attempted to use to justify what would be in the reg guide, in terms of -- I keep using the word "requirements". We can't call them "requirements", because we don't have a rule to make them such, but --

MR. KERR: I don't understand a policy justifying what's in the reg guide. It would seem to me the reg guide would be based on a policy which has been formulated.

MR. HARDIN: Yes. Right now, I'd say that the beginnings of a policy is only documented in the safety evaluation report for the ABWR and the ALWR requirements document.

MR. WARD: This document, if one infers it, is what you said before. There really isn't a statement of policy.

MR. HARDIN: That's right. Those are the products of a policy which we are attempting to document in the combination of these two reports. Basically, the White Paper would be a statement of -- probably more of a policy than any other document that I'm aware of right now, and it would have a justification for why certain goals -- requirements, if you will -- are being proposed.

MR. WARD: Where does 88-248 fit into this? That's not published, right? That was just a draft.

MR. HARDIN: No. That's defunct, however you want to describe it. It's just on the shelf right now.

MR. WARD: But it sounds to me like you really need something like that. If you have sort of a grand policy or strategy for this really important set of issues or how you're going to deal with this important set of issues, it seems that shouldn't fall out of a reg guide or something, but you should be involving the Commission in establishing what that grand policy should be.

It almost seems like you need to try again with 88-248. You know, having done all the technical work you have done, maybe you're in a different position than when 88-248 was drafted.

MR. HARDIN: I am not the right person to answer for how the decision was made, but I guess my perception of what's happened is that the Commissioners have been given presentations on the safety evaluations for both the GE ABWR and on the ALWR requirements document, Chapter 5. I suppose that that might be viewed as -- I guess you may not want to call it an approval, but --

MR. WARD: But I think what Dr. Kerr was driving at was that it's kind of a bottom-up approach again, and a top-down approach might be applicable here or more appropriate.

MR. HARDIN: I'm afraid I can only describe to you the process as we're involved in it and as we see it. There have been other options considered and they were decided not to be followed.

This SECY-88-248 discussed other options which would be more in line, I think, with what you're talking about, but it was decided, as I said, because of concerns over schedule impacts on the design certifications, not to go the other way.

MR. CORRADINI: The other way being rulemaking?

MR. HARDIN: The other way would be to have a rulemaking in which you establish through a formal process, what the criteria would be.

MR. KERR: Well, it seems to me that if you're going to review something -- and probably the SER does represent the current state of the review, you need some criteria by which you review, and if you're not using 10 CFR 100 and the associated reg guides, then what you're using is ad hoc, which means it was formulated by the reviewers as the review progressed, which says to me that the next group of reviewers might come up -- since they don't know what criteria you used in that review, with a different set of criteria.

Neither reactor designers nor reactor reviewers know on what basis conclusions in an SER was reached.

MR. HARDIN: I agree. Stepping back a little bit --

MR. SIESS: I don't see how that applies to the LWR requirements, Bill, which is an industry proposed set of requirements.

MR. KERR: I was talking about the ABWR, Chet.

MR. SIESS: I think we need to keep clear which ones we're talking about. Is somebody going to explain what's in the reg guide?

MR. HARDIN: Yes.

MR. SIESS: Okay.

MR. HARDIN: Maybe just to make another comment on this, just to step back, when the ABWR safety evaluation report was being drafted, there had been a series of meetings between NRR and research to discuss issues having to do with severe accidents like hydrogen control and direct containment heating and all the various things that are of concern that you will see in NUREG 1150.

This work that Brookhaven and we are involved in had at that time proposed a set of criteria. At the time, we were aiming toward a rulemaking and we did have a specific set of criteria. When it came time to draft the safety evaluation for the ABWR, we had an opportunity to work closely with NRR in drafting that.

The sorts of criteria that we felt were appropriate were put into that document. So, even though there was nothing formally stating what the criteria was, without having the documentation, there was a dialogue and there was an attempt to have a consistent approach at looking at what would be reasonable among research and NRR staff people.

What we are attempting to do now, which is kind of after the fact, is to provide documents that illustrate the justification and the sort of thinking that took place in making those decisions. Essentially, that would be in this white paper.

I've got another slide here to show you that there is a hierarchy of regulations that are being applied in these reviews and that may change, but right now, it's 10 CFR, Part 52, and maybe I should just go right to that.

MR. MICHELSON: Excuse me. I think you said that the SER on severe accidents has been issued, or did I misunderstand you?

MR. HARDIN: No, the ABWR; that's been issued.

MR. MICHELSON: We've never seen it yet. We've only seen Module I, which is Chapters 4, 5, 6, and 17. We've not seen anything beyond that.

MR. HARDIN: I'm quite sure that --

MR. MICHELSON: It's probably drafted and floating around somewhere in draft form, but we have not received it. It may be in Module II, but we haven't received Module II yet, so we're at a little bit of a disadvantage in not even knowing what the ABWR is doing until we get the Module.

MR. HARDIN: I'll have to check with NRR and see if there's any reason why that hasn't been released, but my understanding is that that's been finalized and that's been approved --

MR. MICHELSON: Then we should have gotten it.

MR. HARDIN: -- opposed to the ALWR document which has not been approved for sending out to the public yet.

MR. MICHELSON: They may be waiting to bundle it together. They're sending it to us in Modules, and it may be in the next Module. I don't know yet, because they don't tell us ahead what they think is going to be ready.

MR. HARDIN: I'll try to get through rather quickly here, because I think Trevor's information will be very interesting to you.

[Slide.]

MR. HARDIN: This next slide is a section taken out fo the SECY-88-248, and it's just to give you an example of the type of very general criteria that we were thinking of for containments. It might have been in a rule.

We became sensitive very quickly that if we weren't careful and we tried to put too many specific things into a rule -- or even a Reg Guide -- that we might find that we'd be inhibiting design solutions on certain future designs. So, we've tried to come up with some kind of a general statement that would apply to a broad spectrum of different designs and this is the one that we came up with.

MR. KERR: Let me understand what you mean by that statement. You say that you don't want to do something that would inhibit designs. It seems to me that what you want is something that will guide designs -- some set of criteria or a policy or something.

Otherwise, the designer is left without any guides at all. Now, if you are going to let the reactor designers establish NRC policy, that, I suppose, is the way to proceed. The alternative is for us to have some sort of policy for containment performance and severe accidents.

That has to inhibit designs. I mean, "inhibit" is not the right word. I'd say guide, but if you let the designer come up with something, in effect, it seems to me that the policy is being established by the designer.

MR. HARDIN: I would agree with you completely and what we were attempting to do is to have something that might be in a rule that would allow enough flexibility that it could cover different solutions.

MR. SIESS: Well, that would certainly do it. The word "sufficient" appears twice and "significant" appears once. Without definitions of "sufficient or significant," what you've got up there is only slightly better than nothing.

MR. HARDIN: Well, this is where the Reg Guide would come in. The Reg Guide would be used to support the statements that are in a rule like this to explain how those would be met. We don't have the same situation now, because we don't have a rule that even has this much detail in it, but we do have an opportunity to have a Reg Guide that supports the rule that we do have, which is 10 CFR, Part 52.

MR. SIESS: What is Part 52?

MR. HARDIN: I'm going to show you that in just a moment.

MR. WARD: I'd like to comment on what Chet said. I'm sure that this sort of statement is -- you said it's a little better than nothing, but it seems to be at about the same level of generality that the general design criteria are, for example.

I think --

MR. SIESS: It's not proposed as replacing the general design criteria on containment which says that containment has got to resist the temperatures and pressures due to double-ended guillotine break of the largest pipe in the system or something like that.

This is almost motherhood. Obviously, the containment is supposed to retain fission products.

MR. WARD: This is a very general statement that says that. I think that elsewhere in the regulations, it doesn't make that particularly clear.

MR. CORRADINI: Can I ask a different question? This example of a criteria, if it were eventually put into a rule; would appear, what, as a replacement to 10 CFR 100? I'm trying to think of it in terms of what was the past and what could be the future sort of thing.

MR. HARDIN: 10 CFR 100 is being looked at right now by special groups involved in source term. Len Soffer from Research is involved at looking at what changes might be made to 10 CFR, Part 100. The sort of information that you see here might be more like the replacement for 10 CFR 50.34(f), which was a previous rule that addressed severe accidents for some specific plants.

That was the sort of structure of the regulations that we had been thinking of.

MR. CORRADINI: Well, then maybe I should ask the question just from a little bit of ignorance. Right now, what are the regulations which -- at least on the books, not from the standpoint of actually working -- on the books which control containment design? 10 CFR 100, 10 --

MR. HARDIN: 10 CFR 50.34(f) does not apply any longer to any plants. It was written specifically for a series of plants, none of which were ever built.

MR. SIESS: That was the near-term operating license, manufacturing license, the 45 PSI minimum.

MR. HARDIN: Yes, but you will see that the rule that we do have in place, which I have an excerpt of here to show you in just a moment, does refer to 10 CFR 50.34(f).

MR. CORRADINI: So your thought is that something like this would replace that?

MR. HARDIN: That was our thinking back over a year ago when we were heading in that direction.

MR. CORRADINI: Is the one that it replaces this general?

MR. HARDIN: No, it has criteria in it, particularly regarding hydrogen control, which is more like what we have in the Reg Guide right now. Trevor will talk to you about it.

MR. CORRADINI: Okay, so the logic was to keep this general and move all the specific guidance -- or all the specific numbers into the Reg Guide; is that the point?

MR. HARDIN: When we were told that there would be no continuation of work toward a rule, we were forced to go in this way, in which we would only have 10 CFR, Part 52 as a rule, and that any guidance that we could provide for severe accidents would have to be put in a Reg Guide. So this is what we're presenting today.

MR. SIESS: All of the existing criteria would be still be in force -- existing regulations and Part 100?

MR. HARDIN: That's right.

MR. SIESS: Integrated heat leak rate tests?

MR. HARDIN: That's right, all of the existing criteria, standard review plan and so forth, are being applied to the evolutionary designs as they presently exist, with the exception of a few areas in which exemptions have been requested by the designers.

MR. SIESS: So this is just going to be --

MR. HARDIN: An example of that would be --

MR. SIESS: Instead of superseding our present criteria, which are not based on anything realistic, we're going to overlay this severe accident set of criteria over the existing ones?

MR. HARDIN: That's right. That is the direction we have been going on the evolutionary designs.

We had considered reviewing the present criteria to see if there should be some changes made, and because of the schedule requirements to get some review and some decisions made on the evolutionary designs, it was decided that we just had to move ahead and to use the present regulations, as they stand, and to superimpose a severe-accident review on top of that, similar to what was done for GESSAR.

If there are no more questions on this, I will move ahead.

[Slide.]

MR. HARDIN: This next slide is something that hasn't really been formally documented anywhere, but I think it's an accurate description of the kind of hierarchy of regulations that we have that apply to severe accidents.

The first item, 10 CFR 52, is basically the only rule that we have, except that, as you'll see in a moment, Part 52 does refer to 10 CFR 50.34(f), but it does it in a way that 50.34(f) is open to interpretation. So, in my mind, Part 52 is essentially what we have in terms of rules that apply to severe accidents.

Then, in support of Part 52, we have the reg guide that we're here to talk to you about, which is presently in draft form.

This third item is an item that is licensing basis agreements. You've probably heard of the General Electric ABWR licensing basis agreement. This was established by NRR, perhaps back 3 years ago. I don't know the exact date of it. Perhaps I should have brought it with me. But this was done even before we had any discussions with NRR in terms of recommendations for criteria, but there was a tentative agreement, I guess, in discussion with GE and the NRR staff, that there were certain issues that it would be necessary to look at on the ABWR design, which involved things other than just severe accidents, but general issues for future plants. There is a document on that. This has been used by NRR, in a sense, to guide some of their thinking on what the ABWR design should have in it.

The fourth item, this supporting documentation, is our White Paper that Brookhaven has been writing with us, and this fifth item is something I just mention for completeness. It's the Standard Review Plan revisions, which have been discussed, that at some point it would make sense to have the Standard Review Plan revised, to update it to include severe accidents. I don't think there has been any work on that. It's been listed a few times as a task, but I'm quite sure that nobody has done anything about that.

MR. WARD: The last item, Brad -- what would that be based on? Would there be enough information, let's say, in items 2 and 4, to guide the revisions that would be made to the Standard Review Plan? Would that be the technical basis for those revisions, or would those just be self-evident in the revisions? Would that have to be original work?

MR. HARDIN: I can only offer my opinion that it would be basically items 2 and 4. In a sense, the NRR licensing basis agreements have been consistent in many areas in what we are working on as items 2 and 4, as well.

MR. WARD: When item 3 was written -- or I guess there are two of them. Isn't there one for the -- is there one for the PWR, too, the Westinghouse design?

MR. HARDIN: I've heard that there has been work on one, I believe, with Combustion Engineering. I don't know if there is anyone here from CE.

MR. WARD: Well, that's okay, but at the time the one was written for the ABWR certification review, items 2 and 4 weren't available.

MR. HARDIN: That's right.

MR. WARD: So, if there has been consistency, it has been achieved how?

MR. HARDIN: It's just by chance, I guess.

MR. KERR: Mr. Hardin, what part of 52, in your view, describes the requirements on containment performance that now exist?

MR. HARDIN: I have a vu-graph coming up. In fact, it's the next one here.

MR. WARD: Look at the next one, Bill. He says 52.47.

[Slide.]

MR. HARDIN: Section 52.47. That Section in 10 CFR 52 has these two subsections, subsections 2 and 5, and you will see that there is really nothing that says anything specifically about severe accidents.

There used to be some words, in Part 5, I believe, that said something to the effect that a design-specific probabilistic risk assessment will be required to investigate severe-accident vulnerabilities, something to that effect. Those words were removed during the final editing of it, so this is what it says right now. So, there is no specific reference to severe accidents, I don't believe, at anyplace in Part 52.

Item 2 here, subsection 2, is interesting. The wording that it has in there, particularly technically-relevant portions of the Three Mile Island requirements, I think you can see, provides some interpretation then as to what's technically relevant. So, it's not clear exactly how that would be applied to a future plant, as well.

MR. KERR: So, the guidance for the staff is somewhat ambiguous and, for a designer, perhaps equally ambiguous.

MR. HARDIN: Yes.

MR. WARD: And that's the top of the hierarchy.

MR. HARDIN: That's right. This is the very top.

MR. WARD: Carl, you had a point you wanted to raise.

MR. MICHELSON: I got an answer.

MR. WARD: Okay.

MR. HARDIN: There is another item that is in this section, in Part 52, that I didn't put here, because I didn't think it was as relevant, but it has to do with unresolved safety issues and generic safety issues, and that was taken from the Severe-Accident Policy Statement, and so, there is some connection there, but I didn't put it here, because it's not really specific to severe accidents.

[Slide.]

MR. HARDIN: Just quickly -- I've mentioned to you before that in spite of the different parts of the NRC at this point that are contributing to decisions on what's written in safety evaluations for these various evolutionary designs, there has been fairly good coordination, so that I think it's fair to say that there is some consistency between what we're going to tell you about today and what NRR has put in their safety evaluation reports.

We're acting as support staff to them, in a sense, and they have the final decision on what goes in the safety evaluations, but they have agreed with us on most of the severe accident technical issues, and so, there is a pretty good consistency there.

MR. KERR: So, the NRR has established the policy, they haven't told the Commission what the policy is, and you are now establishing a policy so that it will be consistent with the review process that NRR has used. Is that a reasonable assessment of the situation?

MR. HARDIN: Well, I think I would rephrase it a little bit, but I think maybe a way to rephrase it would be that we have suggested to NRR, based on our work, what we thought we be reasonable criteria. We have had a dialogue with them that's been quite extensive, in which we ended up agreeing in most parts. We have collaborated with them in writing the SERs, and so, in a sense, there has been a joint effort in establishing, if you will, the policy in the form of these SERs. We've been in concurrence with them.

MR. KERR: An SER, it seems to me, is a result of a policy, either real or imagined, but I can't see an SER as a policy.

MR. HARDIN: I agree.

MR. KERR: Okay.

MR. HARDIN: It's not really documented. I don't believe that there is anyplace that we can point to that there is any formal documentation, and that is what we are hoping to bridge a gap here, by providing some documentation in the form of a reg guide and in the form of a supporting document that would explain why certain things are important and how those would meet the proposed safety goals.

MR. MICHELSON: Now, are those documents going to available by the time the SER covering severe accidents is going to be reviewed by the ACRS? Not knowing what their schedule is, I can't say, but I assume that it's going to be shortly, since you've said you've already signed off on it. We don't have those documents, so we don't know what the policy is. It's difficult for us to judge that the evaluation has really come to the right answers, because you're looking only at answers in an SER. You don't know what the question even is.

MR. HARDIN: Well, I would, I guess, characterize the process as the policy, if it is approved through a peer review of the two documents that we're talking about, would be a process which would involve you, and so, I think that --

MR. MICHELSON: Yes, but I'm asking only about schedules. Are you going to get these basic regulatory guide and White Paper documents to us before the review of the severe accident for ABWR or after?

MR. HARDIN: I'm afraid I can't answer that.

MR. MICHELSON: I think when it comes to the Committee, if they aren't here yet, then the Committee would probably say we can't review it, because we don't have the basic documentation, even. You might just anticipate that.

MR. HARDIN: We don't have control over the safety evaluations, because those are NRR's activity, but we, in a sense, do have some control over the White Paper and the reg guide, and we do intend to get those to you.

MR. MICHELSON: Well, does it seem reasonable to you that one can review the SER without those two basic documents?

MR. HARDIN: I think so, in my opinion.

MR. MICHELSON: So, we'll review an SER without knowing what your policy is, what your requirements are or whatever, but we'll guess from the answers what the problems must be and say it's okay. That's a hard process. It's possible, but only with great effort, far greater effort than should be justified.

MR. HARDIN: It might be that you might receive all of these documents about the same time.

MR. MICHELSON: I think that would be kind of the way it would have to be to do a reasonable review.

[Slide.]

MR. HARDIN: This next slide -- maybe I'll try not to go through that in any detail to give Trevor a chance to get started here, but there are, as you know, many, many different views on severe accidents, and yet there seem to be some recurring themes that most people seem to agree on. I've listed just four here. There are other one also.

[Slide.]

MR. HARDIN: This first one is one that has to do with whether we really need guidance. There is a possibility that we could review designs for future plants and have nothing more than the documentation that we have already; just the severe accident policy statement, and yet in public meetings that we have had, there has been an expression by industry people that they feel that they need guidance in order to determine how they can satisfy the future licensing needs.

Of course, the staff needs it as well. These other three items are things that I know that you've heard many times before -- defense-in-depth and so forth. This is a little bit of a philosophy --

MR. WARD: Well, wait a minute, Brad. I am somehow dissatisfied with what you've said here. Going back to Number One, I think that is, I mean, the crux of the situation and the existing guidance, including the severe accident policy statement, is not sufficient.

Do you think -- to the extent I've understood the program you're describing, do you think it's bringing together some guidance here? It isn't clear to me that it really is.

MR. HARDIN: We have tried to look for guidance within the policy statement and to be sure that we were consistent with it throughout our work. I believe that there are parts of it that have been helpful to us.

MR. WARD: Yes, but you're acknowledging that it's not sufficient. What I want to know is; do you consider the program that you have in place is going to put together some guidance that is sufficient?

MR. HARDIN: Well, that is what our aim is.

MR. KERR: Maybe we're being too impatient. Maybe we're going to hear from Brookhaven, answers to these questions we've been raising.

MR. CORRADINI: Yes, he's nodding yes.

MR. HARDIN: Okay, this last one is just something that's come out of all of the brainstorming sessions we've had. I've mentioned this in one your meetings before, because we faced up with a constraint right away on the evolutionary designs.

That was that those had been pretty much finalized, already for some years when we were starting to look at what kind of criteria might be applied to them. As you well know yourself, in spite of our desires to perhaps look at them in a different way and to bring that into the regulatory process, just the facts of it are that it's going to be difficult to do that on anything except for some design that is more in the future.

Hopefully, the passive designs are not fixed that well yet, and if there are some approaches identified that appear to be worthwhile to apply to those designs, I just say this to emphasize that it's important that we go ahead quickly and establish some sort of criteria, because from a regulator's viewpoint, it's very difficult once something's pretty much been designed.

There are certain bandaid type fixes that we might be able to make, but in terms of looking at it from any really new viewpoint, that's difficult.

MR. SIESS: Could you give me an example? Obviously, if somebody decided that ABWR should have a vented, filtered containment, that would require some changes in design -- power

WAPA? But suppose there was a requirement that required the ABWR or the WAPA containment to be able to resist a temperature or a pressure ten percent higher than it can now resist. Is that an impossible change to make at this point in time?

What kinds of things are you thinking about here, where the existing design is so cast-in-concrete, to coin an expression, that it couldn't be changed?

MR. HARDIN: I think that the sort of change that you were talking about, Dr. Siess, the temperature perhaps could be addressed, but looking at designs from a completely different viewpoint was what I was referring to.

MR. SIESS: I don't know what you mean by a "completely different viewpoint." Containments are there to contain radioactive material under pressures and temperatures and possible open valves, et cetera.

Suppose the criterion was changed from 75 percent metal/water reaction to a hundred percent? Are these things so complete that that couldn't be accommodated?

MR. HARDIN: If we look at the ABWR being inerted, then there would be no effect because of that change, but if, for example, we were to require that the containment be sized large enough and with sufficient strength to withstand any conceivable -- not any conceivable, but some of the severe accidents that we do look at that we do feel have significantly high probability, without having the features such as venting;

that could have, in my opinion, quite serious implications.

MR. CORRADINI: I didn't mean to interrupt. Can I go back? You said something in the beginning that's now hit me; that SECY 88-248 was shelved and part of the reason was in terms of the rulemaking; that you didn't want to -- let me see if I can reconstruct what you had said -- and correct me if I'm wrong.

You didn't want to put something into the public forum that would tend to derail the evolutionary designs; is that a fair way of characterizing what I heard before?

MR. HARDIN: That's rights. There was not a consensus within the staff on that, but that's what the decision was.

MR. CORRADINI: But here's my problem, and maybe you can clear it up: I mean, I get the impression there's a rush here to get these evolutionary designs out there under the assumption that somebody's going to immediately pick it up and start building one.

But I don't see that rush somehow, so I'm curious -- I sensing -- you said the word, "quickly," and "rapidly" a few times. I'm missing the need for the rush here to get this settled in a way that you won't impose too much of a perturbation on the already-conceived of evolutionary designs.

I guess I have a view just like Dr. Siess that I don't think it's really hard matter. They're all just still paper designs. Nothing's built; that they can be changed if the requirements get tougher or different, unless they don't get incredibly tougher or incredibly different.

I can't see that happening either, so what is the -- I sense that there's a rush here underlying all of this; that we want to get ahead with this because you don't want to derail the evolutionary designs. Am I missing something?

MR. HARDIN: There's a hand back here, but maybe I'll just answer for my own view. Again, there was not a consensus on this, Mike, and yet the decision was made by management that they felt that it was just not the best way to go to have a rulemaking.

MR. CORRADINI: I understand that part.

MR. HARDIN: All of the thinking that took place to come to that decision; I can't really discuss it. I'm not aware of all the things that went into their thinking on that, but I believe --

MR. WARD: Well, Mike, you know, a couple of -- some of the vendors have committed near-term resources to completing a design, and I guess Dick Hardy probably would want to comment on that.

MR. HARDY: Yes. Dick Hardy from GE. The ABWR is not a paper design. It's been ordered by the Japanese and is under construction, so we're building it over there, but we're licensing it here simultaneously. We are under pressure to get both of those done in parallel.

MR. MICHELSON: Of course, there's no great pressure to license it in this country, since you don't have --

MR. HARDY: Correct, but we're designing it for the Japanese, but we want it to be licensable so we don't have to redesign it over here.

MR. MICHELSON: There's not great pressure not to change the design, clearly, although it already has been changed to some extent. For instance, venting the containment is not a feature that the Japanese are putting on, but they will be in this country.

Other types of features, where it's reasonable to add them, certainly ought to be entertained, and not necessarily on a schedule that's commensurate with when the Japanese will build it. But clearly, it's being already biased a little bit by working with what's there and making changes that do not necessarily cause an upheaval.

MR. WARD: It seems to me that even if one accepted the evolutionary designs as essentially complete and agreed that you weren't going to do anything but bandaid changes to those, I can't understand why the staff doesn't want to make a clear separation between that -- I mean, existing plants and those that do have a big investment in the design already; make a clear separation between those and truly future plants where there isn't a rush; where there isn't a big investment in design or in anything else.

I mean, you established the evolutionary plants and the advanced plants, but then there seems to be a desire to keep muddling them up again, instead of making a clean separation where you have the opportunity to develop, you know, some more basic changes in criteria.

MR. HARDIN: Actually, we are aiming in that direction in having appendices in the Reg Guide that apply specifically to different designs. There would be an opportunity to do that.

MR. SIESS: Why isn't the EPRI LWR document the medium to do this? That's proposed by the industry as the standard for the future. There are two standards, I suppose -- one for a big one and one for a smaller, passive one.

MR. HARDIN: That's certainly an approach that could be taken.

MR. SIESS: But is not being taken; is that the implication of what you said?

MR. HARDIN: I don't think a decision has been made, particularly, one way or the other, but I think EPRI proposed that in a Commission briefing a couple of months ago.

MR. SIESS: One of the items that you had on your list of things that are common and unchanging is the desire to maintain defense-in-depth through the use of mitigative design features and procedural strategies.

It would be possible for the Commission to come out flatly and state as a matter of policy that we don't care what you design, there shall be a containment. Is this what you mean by that; or are we going to piddle around trying to decide whether there's a containment, case-by-case, for the next ten years?

I mean, if the Commission wants a containment, in spite of core damage frequencies or in spite of fission product releases, why can't somebody come out and say that and end the argument? Then we could get on with the business of designing plants. Isn't that a containment design criterion that probably ought to be settled somewhere?

MR. HARDIN: The comment that I made in the viewgraph there was not referring to conventional containments, per se, but just the containment concept -- the retention of fission products. I am really not in a position to --

MR. SIESS: Do you have something in mind, other than conventional containments to contain fission products? You know, I'm having trouble with the abstract. If that doesn't mean containment, what does it mean? Can you give me some example of something that -- I'll quote it again -- "mitigative design features and procedural strategies."

MR. HARDIN: Well --

MR. SIESS: I assume that meant containment. Can you give me an example of what it means if it doesn't mean containment?

MR. HARDIN: That is what I was thinking of mainly when I wrote that because we do hear sometimes concerns that if the reliability of the safety systems are argued to be extremely high so that the probability of core damage frequency is very small, that there may be a tendency to want to reduce some of the capabilities in the containment design.

MR. SIESS: That's not a tendency. It's been an actual documented proposal on both the HTGR and the LWR. This is not hypothetical. It's a case that's already been confronted by your branch.

MR. HARDIN: Yes. I'm really not able to offer any strong positions or opinions on that except just the general theme keeps coming up that we want to guard against relying too much on numbers calculated by PRAs that reliabilities are extremely high, that there seems to be a pretty common desire to maintain the mitigation aspects.

MR. WARD: Thank you. Brad, do you have anything else?

MR. HARDIN: No. Thank you.

MR. KERR: Back on the slide that refers to 10 CFR 52, there's a II and a V. I can't find corresponding things in Part 52. What do these match or do they match anything in Part 52?

MR. HARDIN: Those were taken right from Part 52 so maybe I can see you afterwards and try to find the page that they took place on.

MR. KERR: All right.

MR. HARDIN: I took them right out of the document.

MR. KERR: I thought you probably did. That's fine.

MR. WARD: Thank you, Brad. Our next speaker --

MR. KERR: If I were an Intervenor and wanted to try to stop a plant being built that had been licensed under the procedure that appears to be underway, I believe it would be very easy to do because we have now known about severe accidents since 1975 and certainly since 1979 and the current licensing criteria effectively ignores severe accidents and I think a very good case could be made by an Intervenor that not the proper account in the existing license procedure has not been taken for severe accidents.

I would worry about that if I were the NRC.

MR. HARDIN: This has been an issue of contention and there hasn't been a consensus in the staff on that.

MR. WARD: Go ahead, Trevor.

[Slide.]

MR. PRATT: Okay. Thanks.

I think you got a sense from the last presentation that the program I'm going to be talking about has undergone some changes over the last couple of years. What I'm going to be trying to do is focus in on the work we've done specifically for the evolutionary light water reactors and to talk a little bit about the products that Brad mentioned to you.

I thought first I would go over a little bit the objectives in scope and approach that we took. I know you spent about 45 minutes going over some of those discussions already but perhaps just to give you a sense of where we were coming from.

You all have hand outs?

So then, I thought as the subject of the meeting is really containment, to get right into severe accident containment challenges that we think are important and then look at some of the performance requirements that we think are necessary to address some of the severe accident challenges.

MR. WARD: Trevor, I guess I just want to say that you're going to talk about the work as you said that's been focused on the requirements for the evolutionary designs and I mean, we're very interested in this as background but we're specifically -- the purpose of our meetings here, is to look at possible design criteria beyond the evolutionary plants and you realize that and I think that's what keeps getting muddled up.

MR. PRATT: I understand.

MR. WARD: If you recognized that, that would be helpful as we go along.

MR. PRATT: Yes. We don't formally have any presentations on the advanced work that we're doing. As we mentioned, Greg Van Tuyle is here from Brookhaven and he has a program looking at that.

MR. SIESS: Wait a minute. It doesn't mean advanced, if by advanced, you mean the liquid metal and the gas cooled. No, we're not talking about that. We're talking about plants beyond the existing evolutionary --

MR. PRATT: The Westinghouse 600.

MR. SIESS: Well, the improved -- the EPRI LWR requirements, our paper requirements. They are not designs yet.

MR. PRATT: Right.

MR. SIESS: Anything future that remains to be designed.

MR. PRATT: As I say, the focus of this talk will be on the evolutionary designs and on the next couple of viewgraphs I'll go over the scope of that in detail. Brad was talking about products we're producing in terms of a technical report. The technical report will really address some of the challenges and the requirements that we think are necessary to address those challenges.

Now in as much as those challenges may apply to advanced reactors, we think they would have to be addressed in that manner. The Reg Guide that we're producing --

MR. KERR: Excuse me. Maybe you're going to discuss this in objectives and if so, tell me, but are you trying to develop something to conform with what you see as an existing NRC policy on containment performance or are you trying to help them develop a policy or none of the above?

MR. PRATT: I have a slide later on that will address that.

MR. KERR: Okay, I'll wait.

MR. WARD: Another question. The evolutionary plants are designed. Their designs are sitting there. So apparently what you're developing are some tools for the NRC staff to use in reviewing those designs against criteria for which the designs really weren't based. I mean the evolutionary designs were not based on any explicit severe accident criteria but the NRC wants to review these designs against some severe accident issues and you're trying to provide some technical tools for them to do that apparently.

MR. PRATT: Yes, and I think that's what's kind of driving the whole approach that you're seeing which looks a little bit strange perhaps in some of the conversations that you've had previously. We're dealing with designs, as you say, that are designed with the current design basis in mind.

Yet, we would wish to address severe accident considerations as part of them. So the approach we've taken is to rather -- to try to complement the designs with such features that would address those severe accident issues.

That's exactly the approach we've taken.

[Slide.]

MR. PRATT: So, what we're really doing as I say is providing the technical assistance to the staff. We have two products which Brad has alluded to that will be out fairly quickly. One is this Regulatory Guide that will identify the challenges that we think need to be taken into account and provide guidance as to what might be an acceptable approach to dealing with those challenges.

Now, the Reg Guide when it was originally started was specifically on evolutionary designs, that is, the SP/90, the ABWR and the CESSAR plant. What we're now trying to do is to make the Reg Guide and this is where I think a little bit of the confusion arose when you were talking to Brad -- we're now trying to make that a little bit more general so that what would be in the bulk of the guide would be some general guidance as to what one might have to deal with and then we would refer to appendices where you would have very specific guidance.

MR. MICHELSON: Draft 1, which I think was what the staff has now, is that built on the idea of the appendices and the general up in front?

MR. PRATT: Draft 1 of what?

MR. MICHELSON: Yes, or whatever draft you've got.

MR. PRATT: Oh, the staff. Sorry.

MR. MICHELSON: Yes. Whatever draft the staff has received, is it formatted with the appendices for the particular projects?

MR. PRATT: We have just sent a new one in with it formatted in that way but it still requires quite a bit of work because of that. I think the second product which is the technical issues is by far the more complete document. The Reg Guide is in a little bit of a mess because there's too much -- I can't even say the word -- specifics in the main part of the Reg Guide and we have to move some of that back into the appendix.

MR. MICHELSON: Do you have any appreciation for when this Regulatory Guide might be in reasonably clean form?

MR. PRATT: Well, we're working on it fairly actively now. I hope that the draft will be improved considerably over the next month or so.

MR. MICHELSON: You mean within a month or so you might have an even cleaner form available?

MR. PRATT: That's the intention but again, that's for staff review, I believe.

MR. MICHELSON: Thank you.

[Slide.]

MR. PRATT: The next slide I have already mentioned to you. This just gives the scope of what we are looking at in the program. I won't spend too much time on it.

[Slide.]

MR. PRATT: The approach that we have taken is to provide guidance on what severe accident vulnerabilities need to be considered and what measures should be taken. And we have the word "reasonable" in there, and we would like to try to define later on, on slides, what we mean by "reasonable."

The Reg. Guide, as I mentioned, will --

MR. KERR: Excuse me. Back to the first bullet.

I don't understand what that is meant ot tell me. Is that meant to tell me that the staff has not decided what the policies should be and you are going to try to help them formulate a policy?

MR. PRATT: Well, we have guidance. I mean, we have aspirational goals that we are trying to achieve. So on later viewgraphs, what I will do is talk about how we tried to address things like reasonable measures.

MR. KERR: No. I'm not up to the reasonable measures part yet.

MR. PRATT: All right.

MR. KERR: I'm trying to understand how the policy is being formulated. And it apparently is being formulated with guidance from BNL. Is that true?

MR. PRATT: I would stop short of saying that. From what we are trying to do, we have certain guidance --

MR. KERR: Written guidance?

MR. PRATT: -- we have to respond to. So we have a

10 to the minus 5 goal on core damage frequency, a 10 to the minus 6 aspirational goal on other severe release.

MR. KERR: You interpret that as being staff policy?

MR. PRATT: Those are the guidelines that we utilized in developing the measures that we thought should be developed.

MR. KERR: I have not seen that written anywhere as staff policy up to this point.

MR. PRATT: Pardon?

MR. KERR: I have not seen that written as general staff policy up to this point.

MR. PRATT: Again, the staff would have to address that policy. Those are the criteria, if you like, that we, from a technical point of view, we have to have something to anchor ourselves to. That's what we anchored ourselves to.

MR. KERR: I do not see how you do what you are doing without some sort of policy, I agree, unless you are also assisting in formulation of policy.

MR. HARDIN: If I could, I would just offer that maybe you can start to get the picture that when we started this two years ago, we had to start this work with the best information that we had, and the proposed safety goals were things that we used as aspirational goals, which have guided us in developing our proposed criteria. And the question that you asked Trevor about, whether we are trying to establish a policy at this point, is that I would characterize it more that we are attempting to document an informal policy that may have been established somewhat "ad hoc" on the reviews of several plants, a policy which was not written anyplace, and the first time that it showed up in a sense was in the safety evaluation reports which was a summary of somewhat of a staff consensus at that time.

And in my mind, what we are attempting to do now is to document some of the reasons why decisions were made in the way that they were in defining the safety evaluation reports.

It is somewhat after the fact. But there is not an inconsistency here. It would be better if we had done it the other way. But we are just doing the best we can.

MR. KERR: There is certainly in my mind not a consistency in going through and doing a review and then on the basis of the review writing a policy that conforms to the review.

I mean, you can infer that is consistent if you want to. It surely doesn't seem to me to be consistent with anything that I have ever heard about the use of policy. Policy establishes guidelines. And then, given the guidelines, you carry out tasks.

Here you are going about it, it seems to me, in exactly the opposite direction. You've done a review, and on the basis of that review, you now are writing a policy which you hope will conform to the review. I can't see that as a consistent approach.

MR. HARDIN: I don't want to try to defend the way we're doing things. I wish it was different, too. But what I think I really want you to hear, though, is that the policy had been proposed by research through our work with Brookhaven back before the safety evaluation reports were written. And it is not inconsistent --

MR. KERR: But look, Research doesn't make policy. The Commission is supposed to make policy.

MR. HARDIN: That's right.

MR. KERR: And this is something that presumably the Commission has never seen as a stated policy, much less approved.

MR. HARDIN: Well, the order of things is certainly not in the way that you would like to have it.

MR. KERR: Is it the way you'd like to have it?

MR. HARDIN: No. No, I would certainly have preferred to have some kind of a systematic process. But it's just not the way it has happened. But proposals were made based on our review of past severe accident information. A dialogue took place. Safety evaluation reports were written. And then the Commission was approached. That's the order in which things took place. And we can only report to you in the way that things have happened.

MR. WARD: This is not exactly unprecedented in the history of the NRC.

[Laughter.]

MR. MICHELSON: Question. You are doing the development work on the Regulatory Guide. Are you also reviewing the ABWR from the viewpoint of what is covered by that Regulatory Guide?

MR. PRATT: We are reviewing all of the three evolutionary designs PRAs.

MR. MICHELSON: I know you are doing the PRAs, but there is a little bit more to severe accidents than just looking at PRAs. That's a basic document. But there's a lot of other thinking that has to go into it that doesn't clearly pop out of a PRA. Maybe it should, but it doesn't, because it is not in the models.

But are you looking at just the PRA, or are you looking at the question of ability to accommodate severe accident considerations?

MR. PRATT: The ability to -- Yes.

MR. MICHELSON: You are looking at the whole ball of wax.

MR. PRATT: Yes.

MR. MICHELSON: For the ABWR. Does the staff do its review, too, or is it depending on the contractor, on ABWR?

MR. HARDIN: It is a mutual review. Essentially, a large portion of it is done by the contractor. But the staff has people assigned to work with them on it.

MR. MICHELSON: You certainly are watching it. But they are the principal doers of the work?

MR. HARDIN: That's right.

MR. MICHELSON: I just wanted to make sure I understood the process.

MR. PRATT: What we will be doing is providing technical evaluation reports to the staff and then they usually write an SER based on that report.

MR. MICHELSON: Well, have these technical evaluation reports, are they something that I can ask for and look at and read?

MR. PRATT: Absolutely. Yes.

MR. MICHELSON: And are you going to refer to some of them today?

MR. PRATT: Well, those we have not started. Well, we are in the process of writing the Level I review now.

MR. MICHELSON: The SER purportedly is already written. How can it be written if they haven't yet seen your technical reports?

MR. PRATT: I don't believe the --

MR. MICHELSON: If they're writing the SER. Now, if you are writing the SER, I can see how you could do it. But I thought the chronology was, you write the technical reports and they do the SER.

MR. PRATT: I don't believe the SER has been written pertaining to the PRA portion of the ABWR.

MR. MICHELSON: Maybe I misunderstood earlier. I thought the SER dealing with severe accidents had already been written. I must have misunderstood.

MR. KERR: That is what I thought I heard, also.

MR. MICHELSON: Yes, I thought I did. But I'm hearing two things now.

MR. HARDIN: I am sorry. I may have spoken too generally. There has not been, of course, a finalization of the staff's views on the overall severe accident areas. But there has been a paper that has been written which I referred to as an SER. I thought that was accurate.

MR. MICHELSON: That one on Chapter 3?

MR. HARDIN: I'm afraid I don't know.

MR. MICHELSON: Because I haven't seen it come through as something to review. I did receive some material on Chapter 3 which I haven't reviewed, because the first thing I asked was, was this something now ready for review, and the answer came back no, no, it's just for your information. I haven't studied it yet. It may be buried in there. I don't know.

MR. HARDIN: I will check on that.

MR. MICHELSON: I would think that if Brookhaven is supplying technical reports to support your SER, that your SER is written after you have received and reviewed such reports. And can you give us a listing of the reports relating to severe accident that Brookhaven has written and sent to the staff?

MR. PRATT: I can get one for you, certainly.

MR. MICHELSON: Okay. If you could just get us a list of the reports, then we can look at it and see if there are some of interest to us.

MR. PRATT: Surely.

MR. MICHELSON: Thank you.

MR. PRATT: Okay. The schedule that we are working on, by the way, for the technical evaluation reports for the ABWR are around about the Spring of next year.

MR. MICHELSON: These, though, on severe accident, have they been written yet or are they about to be written?

MR. PRATT: As I say, the Level I report is, of that part of the PRA, is pretty well underway. We expect that to be completed fairly quickly.

MR. MICHELSON: So this list isn't going to be a list yet. It is a list of what you are going to send?

MR. PRATT: On the ABWR, yes.

MR. MICHELSON: On the ABWR.

MR. PRATT: On the SP/90, for example, most of the documents are there.

MR. MICHELSON: I was just interested in the ABWR.

MR. WARD: Well, I think we would be interested in both, if you are going to provide a list, yes.

MR. PRATT: There was also a preliminary evaluation of the CE, the basic CE design that came in, and then we gave feedback on that and they were going to incorporate that into their System 80-plus design. I can certainly give you those.

MR. MICHELSON: Okay.

MR. CORRADINI: One question. What isn't included in the PRA that would deal with severe accidents that you are looking at?

MR. PRATT: What is not?

MR. CORRADINI: You answered to Carlyle's question that you are looking at the whole range of severe accidents, things beyond what might be included in a PRA. What lies outside of the PRA consideration that involves severe accident?

MR. PRATT: No, I didn't interpret it quite that way. I mean, most of the things that can happen have to be taken into account in the PRA to quantify it.

One of the things that we are being asked to do now though is to look at fixes, changes to the design to deal with some of these severe accident issues, and how the risk profile may change.

MR. MICHELSON: You know, there are a number of things that are not in the way they model the PRAs presently. A lot of the errors and omission and commission and so forth. That's not in the present PRAs, though. Maybe it is going to be in their Level III. I don't know. You kind of wonder, because it hasn't been done well if at all in most cases. Fire is another one that's done poorly, if at all. Yet it is certainly a severe accident consideration.

So somehow you have to address verbally what you didn't do in the PRA.

There are things beyond the PRA that do have to be discussed when you're talking severe accidents, unless you don't think fire, for instance, is one.

MR. CORRADINI: And you're doing that.

MR. PRATT: We would be addressing those things. Whether we're quantifying them is another matter. My response, though, was more along the lines that we're going beyond what the basic design may be and the risk profile that it may present, but also looking at these issues and how things may change and whether we may want to optimize some of these situations.

So, there are extra tasks beyond the normal, the review, this looks good, fine, or this does not look good, fine.

MR. MICHELSON: Discussion and dialogue beyond the bottom-line numbers, clearly.

[Slide.]

MR. PRATT: Okay. In our discussion here, I have slipped in another vu-graph against the one that I was looking at, and this is really what we were talking about, Dr. Kerr, in terms of what we were trying to tie ourselves to technically. We have to have something to work with. We can't work with --

MR. KERR: Okay, and the staff gave you the 10 to the minus 5 core-damage frequency and the large-release frequency numbers, as staff policy.

MR. PRATT: Well, I don't want to repeat all of that.

MR. KERR: I'm trying to understand whether this was sent to you as ground rules, or whether you developed it. I'm not trying to find criminal intent. I'm trying to find out which is policy and which is technical justification.

MR. PRATT: I understand. This isn't a trick question.

These were given to us as guidance in doing our work, and in determining what we thought was reasonable assurance of what the containment might or should be, one could, from these two numbers, imply a conditional probability of containment failure or the containment failure of 0.1.

Again, we stopped short of that type of numerical guidelines, but in developing the containment requirements that we looked at, we looked at the uncertainty ranges and predicted uncertainty ranges in containment performance that we'd seen in past PRAs and studies like NUREG-1150 and tried to eliminate those uncertainty ranges. So, we were trying to aim for, if you like, a 10-percent failure -- chance of failure in our approach when we looked at these requirements.

MR. KERR: Now, in the Severe Accident Policy Statement, if I remember it correctly, the staff was asked by the Commission to examine the possibility that one might add to that policy, that the frequency of large release should be less than 10 to the minus 6 per year.

I assume the staff has done that examination and has concluded that it does make sense to do it and has so notified the Commission, since it is not being used to develop a reg guide. Is that a fair assumption?

MR. HARDIN: My understanding is that we are waiting to be given the final okay, in a sense, to use that criteria, but again, because we don't have anything better to use, we're using that to give us guidance.

MR. KERR: So, it is unofficial policy, at this point.

MR. HARDIN: That's my understanding.

MR. KERR: And all it lacks of being official is your notifying the Commission that you have determined that it is reasonable, practical, and appropriate to use it, I assume.

MR. HARDIN: It's not in our bailiwick to make that decision.

MR. KERR: Well, you're part of the NRC staff, are you not? You must be somewhat aware of the Severe Accident Policy Statement and what's going on relative to it.

MR. HARDIN: Yes, but I guess I don't view the process as one where we make the recommendation that it be used. We're being given this as the best guidance from our management that we should use until some other information is given to us.

MR. KERR: Is some part of the staff determining whether it is appropriate to use this? Maybe the management, for example?

MR. HARDIN: Yes. I believe it's with the Commissioners right now.

MR. KERR: There is a document that has been sent to the Commission recommending this.

MR. HARDIN: That's my understanding.

MR. WARD: Well, Bill, I assume what he is referring to is the paper on the safety goal policy implementation.

MR. KERR: Okay. I'll have a look at that.

MR. CARROLL: Just to understand the slide we have in front of us, Trevor, tell me what core damage is and tell me what a large release is.

MR. PRATT: Again, core damage, in the way we were referring to it, in terms of -- when we talk about developing measures, we talk about preventative, unmitigated measures. I don't intend to talk about the preventative side of what we've done, because we're focusing today on the containment, but the intent was we would define, for the purposes of calculating this, a situation where you had essentially reached a point where you'd lost your injection and you were in eminent danger of core damage. So, you'd lost your ability to cool the core and for a sufficient time, such that the core was uncovered and damage was about to follow.

MR. MICHELSON: Does that mean that it's got over 2,200 already?

MR. PRATT: Well, again, the way we do the success criteria is we have some -- for example, in NUREG-1150, there would be a point at which the level was a certain level in the core, the water reached a certain level in the core, and the temperature of the fuel was a certain temperature.

MR. MICHELSON: What is that certain temperature? I mean is that, indeed, beyond 2,200 degrees?

MR. PRATT: I believe it was thereabouts, but I have it over there. If you want to, at the break, I can give you the actual number.

MR. CARROLL: So, basically, you're defining core damage in the same sense the present draft of NUREG-1150 define it. Is that right?

MR. PRATT: Right. Also, there is a possibility, as you saw in draft NUREG-1150, that you could restore injection and terminate the core in the vessel. That's not in this 10 to the minus 5. That would be broken out as part of the containment of entry quantification process. So, this core-damage frequency is the onset of damage.

MR. CARROLL: Okay.

MR. PRATT: The way we define in the work we've done. Now, again, what staff comes up with in its final policy is something else. That's the way we interpreted it.

The frequency of a large release -- again, we had a definition that early containment failure was kind of bad and that we would try to avoid that, if possible.

Now, if you look at the definitions that have come out during the 2 years that we have been doing this work -- we have the EPRI ALWR document that suggests 25 rem at half a mile, and that's a pretty strict requirement on a definition of a severe release. In fact, I can show you later some of the calculations that we've done with just normal gas release, and you can exceed the 25 rem for quite a long time with just normal gas release at 25 rem calculation. The other one, of course, is the one fatality off-site.

Basically, what we have tried to do in the work we're dealing with is looking at any sort of early containment failure as being undesirable and trying to eliminate that or reduce the probability of that occurring to the criteria of less than 1 chance in 10 of containment failure.

MR. KERR: So, in effect, a large release is synonymous with early containment failure.

MR. PRATT: They way we did our development of the reg guides. So, the actual definition of whether it has the potential for one fatality or whether it's the potential for 25 rem was not really addressed, we don't think. I mean if the 25 rem -- almost beyond leakage will give you the 25 rem if you've got a very high source down in containment. So, it's a very strict requirement.

MR. KERR: Wouldn't it make some sense, then, to refer to that as the frequency of early release, if that's what you're really calculating and using in the reg guide?

MR. PRATT: This one?

MR. KERR: Yes.

MR. PRATT: Yes, we could, certainly.

MR. KERR: Or an early failure, I should say.

MR. PRATT: Yes. That's the way we did it.

MR. CORRADINI: Early failure meaning much less than a day?

MR. PRATT: Early failure was defined as within a few hours of the onset of vessel failure.

MR. MICHELSON: Does that 10 to the minus 6 include containment bypass events?

MR. PRATT: Yes.

MR. MICHELSON: Because those are very early containment failures.

MR. PRATT: Absolutely.

MR. KERR: Have you done enough looking to get an idea of whether the 10 to the minus 6 is more restrictive than 10 to the minus 5?

MR. PRATT: Is more restrictive? Well, depending upon how you define your severe release, but certainly, if you define your severe release as 25 rem at half a mile at 10 to the minus 6, it's very restrictive.

MR. KERR: No, but the way you defined it, which is early containment failure, without talking about the release, apparently.

MR. PRATT: Which did we find was the most restrictive?

MR. KERR: Yes.

MR. PRATT: I guess I'm not sure how to answer your question. I mean what we were aiming to do here is to look at previous PRAs, PRAs that had been done for existing plants, and then trying to say how would we, if we were -- in the light of all of the information we have got from these past studies, if we were trying to ensure ourselves that we would have a core-damage frequency of 10 to the minus 5 and a frequency of early containment failure of 10 to the minus 6, what sort of design features would we put into it? That's the way we approached the process.

So, I guess I'm not sure what you mean by which is more restrictive. It was just a process in which we developed what we thought we would need -- the levels of redundancy, the type of systems that would be needed -- to give ourselves a warm feeling that these numbers were approachable.

MR. MICHELSON: In looking at pipe breaks outside of containment as potential severe accident precursors, have you done or looked at the possibility that, when experiencing such breaks, that the motor-operated valves may be incapable of closure under such break conditions, and therefore, it's an uncontained release outside of containment?

MR. PRATT: Yes. In fact, the person who did that side of it is not here today.

MR. MICHELSON: Coming up with 10 to the minus 6 is pretty tough to do.

MR. PRATT: It is.

MR. MICHELSON: The pipe-break probability has got to be in that neighborhood.

MR. PRATT: It is.

MR. MICHELSON: And that's way beyond much smaller probabilities that we've been normally using for pipe break. You're usually using 10 to the minus 4 or thereabouts.

MR. PRATT: Right.

MR. MICHELSON: And if you don't isolate the break, then you have potential loss of all engineering safety features, at least, that are involved in the blowing down of the reactor outside of containment and the disruption of the environment.

MR. PRATT: That's exactly right.

MR. MICHELSON: That will be included in your PRA with a goal of 10 to the minus 6.

MR. PRATT: Absolutely.

MR. MICHELSON: It appears like that's what you're doing.

MR. PRATT: Yes.

MR. MICHELSON: It will be interesting.

MR. PRATT: Yes. In fact, I don't have slides and maybe I should have put them in there on that particular issue, because the way we organized it, we looked at it under inventory control, and so, we have the guidance under those items. So, I really don't have the vu-graphs here. The reg guide is here, and we can go over some of the things that Bob Youngblood came up with -- things like if you're going to design your secondary systems, try to have the pressure capability larger than the primary system and so on and design configurations and the redundancy in the valves and so forth.

So, we can go over some of those. I'd welcome your comments on the type of things that he thought were needed to do that, to achieve these goals.

The 10 to the minus 6, I think, is a tough one, in terms of these releases.

MR. SIESS: What's the difference between the second and third item there?

MR. PRATT: Between the second and the third?

MR. SIESS: Yes.

MR. PRATT: The implication is, and in fact, on some of the evolutionary designs that you have coming in, the core damage frequency itself could be on the order of ten to the minus six or even lower and the question is, if that is the case, then your frequency of a severe release is obviously lower than ten to the minus six, so you don't need a containment.

MR. SIESS: Do you think there are reasonable measures which can demonstrate that the frequency of core damage is less than ten to the minus six?

MR. PRATT: Pardon?

MR. SIESS: Your slide says, "Reasonable measures are intended to demonstrate" and I wondered what reasonable measures one would use to demonstrate that core damage frequency is less than ten to the minus six per year?

MR. PRATT: What reasonable measurements?

MR. SIESS: Yes.

MR. PRATT: That would be the bulk of the rest of the presentation.

MR. SIESS: Do you think that can be done reasonably?

MR. PRATT: Absolutely. Um-hum.

MR. WARD: Did you understand his answer?

MR. SIESS: Yes. On the last item, we frequently see that statement.

MR. PRATT: Yes.

MR. SIESS: I guess I'm not quite sure what somebody means when they say "balance." Fifty-fifty?

MR. PRATT: Pardon?

MR. SIESS: Fifty-fifty?

MR. PRATT: No, not 50/50. I think the implication is that we -- it's really juggling with these two numbers. As I mentioned earlier, if you push your core damage frequency very low, to very low numbers, then you meet this objective and you may be able to meet that objective without a containment building.

The aim of what we were trying to do was to make sure that even if you had low core damage frequencies because of uncertainty and some of the things that aren't in PRAs, we felt that there should be a containment and that we were aspiring to have a containment with an efficiency of about one chance in ten of surviving a core damage frequency.

Now one of the problems with using -- and we have this problem in the ABWR review -- as part of the licensing agreement between GE and the staff, there is a conditional probability criteria in there for containment of .1 and the way you --

MR. SIESS: Overall, or case by case?

MR. PRATT: No, overall. In other words, the way you calculate the .1 is you take the frequency of events that will result in a 25 rem or more at half a mile and divide that by the total core damage frequency.

Now, when you tend to get to very low numbers, you tend to get into accident situations that are pretty bad where containment may not be that effective and in fact in some cases, you may have situations where bypasses are dominating -- that's not the case in ABWR but you may be getting into situations where your bypass events are dominating the core damage frequency.

So, you know, that says nothing about the effectiveness of containment. So one has to be careful about dividing, you know, frequencies by frequencies. The aim is to try to ensure that for a credible core damage accident that threatens the containment integrity, that does not bypass it by does threaten it, that there's about one chance in ten that it will survive. We had a situation in --

MR. WARD: Do you mean one in ten or nine in ten that it will survive?

MR. PRATT: Sorry? One chance in ten that it will fail.

MR. WARD: That it will fail, yes.

MR. PRATT: Make sure you change that. In NUREG 1150 we had a really good example of this where the core damage frequency for Zion was relatively high. It was about ten to the minus four and the accident sequence that contributed to that was a small break LOCA with all of the containment heat removal systems operating. So we didn't fail containment. We had a very low probability of failing containment.

The ratio of station blackout to our total core damage frequency was relatively low. Station blackout events would challenge containment integrity.

MR. SIESS: I got confused when you were talking about bypass. Bypass is a containment failure; isn't it?

MR. PRATT: Yes. That's true, but I mean if we're talking here about --

MR. SIESS: How were you counting it or not counting it?

MR. PRATT: We were putting it in, certainly.

MR. SIESS: Oh, okay.

MR. PRATT: What I'm saying is it does not challenge the containment in the accepted sense of the word challenging -- pressure, temperature loads and so on -- that might cause the containment to fail. It's the failure of which we've bypassed those functions.

MR. SIESS: Who's accepted that sense of it? I haven't.

MR. PRATT: Pardon?

MR. SIESS: I said, you said in the "accepted sense." I haven't accepted that sense of containment. I'm more concerned with failure to isolate than I am with overpressure.

MR. PRATT: Oh, yes, but what I'm saying --

MR. SIESS: I haven't accepted -- you said in the accepted sense. Who's accepted that?

MR. PRATT: I think all I was alluding to is that one has to be careful about taking frequencies of events and dividing by frequencies and coming up with a conditional probability of containment failure and using that as an aspirational goal because as the core damage frequency goes low, your core damage frequency may be dominated by bypass events which are a special category of containment failures, if you like, that have to be dealt with in their own particular way.

You don't deal with them by improving the strength of the containment building, for example.

MR. SIESS: I don't understand the relation between bypass and core damage.

MR. PRATT: Well, okay, I'm talking about --

MR. SIESS: Bypass doesn't cause core damage.

MR. PRATT: -- core damage and containment bypass.

MR. SIESS: Then it's the frequency of large release that would be dominated by bypass.

MR. PRATT: That's right, and then you try to force that frequency low by looking at your goal of trying to get it down below ten to the minus six. Then you would deal with valves and design of the systems such that the frequency was low.

MR. WARD: Okay. We had better let you go ahead, Trevor.

[Slide.]

MR. PRATT: This slide I don't intend to go through at all in any great detail, just to mention though that part of what we have in the Reg Guide and in the technical document that Brad alluded to is also looking at trying to develop requirements that would ensure a core damage frequency of about ten to the minus five or lower.

MR. KERR: These are functional performance requirements for the safety systems, for example, or what?

MR. PRATT: Yes. Exactly. What we do is talk about levels of redundancy, diversity, automation and so on.

MR. KERR: You mean you don't talk about reliability in a quantitative sense?

MR. PRATT: No.

MR. KERR: Then how do you calculate that core damage frequency is driven to ten to the minus five if you don't know what the reliability of these things are?

MR. PRATT: We do not calculate that. What Bob Youngblood if I understand and characterize what he did correctly is, from the knowledge that he has of the reliability of the systems that he's seen and he went through a process of what he thought it would need in terms of redundancy and diversity and so on to ensure that he would get these types of frequencies. He was not going in there and, you know, this is not -- this is a guide saying, if you do this and this and this, we think this will be acceptable.

There's nothing at all to stop you doing something else and demonstrating that you've achieved this objective.

MR. KERR: Okay. So he's attributing a quantitative reliability to a certain amount of redundancy or diversity or whatever.

MR. PRATT: Right, and then going through the process of saying, what does he think it would take to convince himself that this system would be there. The advantage of that, of course, was that if this had all happened before we'd gone through the reviews, what the Reg Guide would have said is, we think these are necessary to show, that we think you achieve these goals, and if we then see them in the design, we would have a warm feeling that it was going in that direction.

What we have to do now, of course, is to look at the systems that are coming in and the reliability and so on that's associated with them and then convince ourselves that that makes sense.

MR. KERR: The nice thing about establishing quantitative reliability levels -- and I realize this is something that we tend to avoid in this country -- is that in terms of some of these individual channels, they can be low enough that they can be demonstrated in practice and there are some of our colleagues, as you know, who require not only that one design for that but that one demonstrate that this exists and it seems to me in your missionary role that you have with the staff, you might consider that.

MR. PRATT: Okay.

[Slide.]

MR. PRATT: Okay, this I think we've talked about already. I don't intend to go through it. It simply talks about, you know, what we were trying to do, mainly achieve the 90 percent chance that the containment will remain intact. So, let me --

MR. WARD: Let's take a break at this point. Return at 10:45.

[Recess.]

MR. WARD: Let's get started. Trevor, I would like to ask you to help pace it so you can finish by 11:15 though so we can be back on schedule.

MR. PRATT: Okay.

[Slide.]

MR. PRATT: We are getting onto the technical stuff now so it should go pretty quickly.

[Laughter.]

MR. PRATT: Just to let you know where we got our challenges from, we decided to look at what was published, what was available to us and then tried to address each of these issues, so this is just a list of the publications we looked at.

One of the perturbations that I will spend some time on that happened to us during the course of the two years is we were originally working with the first draft of NUREG-1150 and then of course we most recently got a second draft out in June of '89 which changed some of the insights in terms of containment issues from the first draft, so we tried to factor some of that into our report. That is one of the reasons why they have been modified a little bit.

[Slide.]

MR. PRATT: I don't intend to spend any time on this slide at all. It's really in there more for information than anything. I don't intend to --

MR. SIESS: Let me ask you something about it, though.

MR. PRATT: Really?

MR. SIESS: I have looked at it and I guess what startled me is that there is only one item on there that is different for a large volume and an ice condenser and that is the item on due to combustion -- whatever it is -- pressure, which I assume combustion processes -- which I assume is hydrogen burn, which is listed as a low probability on the large volume and not on the ice condenser.

That surprised me because to me the difference between a containment design for 15 psi and one designed for 60 psi I would have expected to be more than that, and here the two are just the same all the way down, have the same vulnerabilities except for that one qualitative one almost.

MR. PRATT: The purpose of the table which is taken from the report is really on potential. In other words, should we look at them or not, are they important or are they not or may they be important. What we then did is we went and looked at the detailed studies to find out how important they were, so this does not really give you, except for some qualitative notes about the fact that hydrogen is more of a problem in ice condensers than it is in large volume containments.

Essentially this is just a wish list of things that we looked at.

MR. SIESS: Just a checklist then?

MR. PRATT: Yes. Absolutely. If there isn't something on here that you think we should have looked at, that's the sort of feedback I would like on this table because if it is not here we didn't look at it.

MR. MICHELSON: Well, where is the unisolated pipe breaks outside of containment?

MR. PRATT: Where is that?

MR. MICHELSON: Somewhere in that containment bypass listing. That's not -- normally, classically people talk about interfacing system LOCAs being a case where you over-pressurize the interface due to something or other and then you bust the pipe.

I am talking about the case like reactor water cleanup on an ABWR where it is pressurized at all times and circulating reactor coolant in an eight inch pipe and if that pipe breaks outside of containment you must isolate.

Is that a part -- that's not an interfacing systems LOCA. Where is it?

MR. PRATT: That was on the -- as I say, that was on the stuff that Youngblood had done.

MR. MICHELSON: You said if it wasn't on this list you haven't looked at it and it isn't on this list.

MR. PRATT: In terms of containment performance. I understand you are saying that that is a containment performance issue but we looked at it as an inventory control.

MR. MICHELSON: Okay, so you did look at it. It just doesn't happen to be on this --

MR. PRATT: Yes, again it's a question of semantics.

MR. SIESS: Does failure to isolate include pre-existing openings?

MR. PRATT: Yes.

MR. SIESS: Then it would have certainly have been helpful to have the sub-atmospheric on there and I certainly think in terms of pre-existing openings as a difference between the inerted and non-inerted containment.

MR. PRATT: Yes, most certainly there is, yes.

MR. CORRADINI: This list was derived from the reports you showed on the previous viewgraph basically?

MR. PRATT: Yes.

MR. CORRADINI: Okay.

[Slide.]

MR. PRATT: Again, I didn't want to spend a lot of time on it. It was simply a wish-list of things that we looked at. Again, I am not going to spend too much time on this but what we were trying to do was look at the uncertainty ranges, principally in NUREG-1150, because that was the document that we understood most about in terms of where the uncertainty was coming from and try to develop requirements that would eliminate those uncertainty ranges.

MR. SIESS: And who told you they were unable to predict structural response?

MR. PRATT: I didn't say they were unable to. I said that --

MR. SIESS: It says "inability to predict."

MR. PRATT: There is an uncertainty associated with it.

MR. SIESS: It is due to the inability to predict -- I am just reading what it says.

MR. PRATT: Yes -- well, predict -- maybe certainly I mean the whole gamut of where the containment would fail and so on. In other words there is a distribution that we associate with containment failure and that is really what I was referring to there.

When we calculate the potential for containment failure we look at the uncertainty in containment structural response and --

MR. SIESS: It seems to me you'd be more interested in predicting when it didn't fail than predicting when it did fail. That can be done with a lot less uncertainty.

Everybody wants to predict something and nobody's interested in knowing. Then they get a larger uncertainty and then it becomes very important and we spend a lot of money.

[Slide.]

MR. PRATT: I am sure you have seen this many times but again what we were trying to do in earlier drafts of this work was to address these uncertainty ranges that appeared in the first draft in NUREG-1150 and I apologize for the quality of this reproduction.

The next slide I am going to show you talks about the results of the second draft of NUREG-1150, so be concerned -- here we're talking about a linear scale and this is a probability of early failure given a core melt there, an accident for the five plants that we looked at.

I think the one point that we would like to note here on Surry and Zion is that the containment performance in the first draft of NUREG-1150 indicated quite a large range of uncertainty, particular if direct containment heating was taken into account, in terms of getting, you know -- the upper end here is about the 95th sample that we calculated so it is about the 95th confidence so we have about a .9 change, the 95th confidence level of early containment failure if you take into account DCH in the first draft of NUREG-1150.

In terms of Sequoyah, most of this was coming from concerns with regard to hydrogen, combustion events. In Peach Bottom the major concern here was of course liner melt through. You have somewhat of a bimodal distribution here where if you take liner melt through into account you have quite a large uncertainty.

This is mostly coming from, if you take away liner melt, through mostly from considerations of pressurization, rapid pressurization due to steam and non-condensibles, so that early failure was occurring within a few hours of vessel failure.

MR. KERR: Does this figure reflect a higher confidence on your part in the first draft than in the second?

MR. PRATT: Well, this is the first draft.

MR. KERR: I say does this reflect a higher confidence in the first draft than in the second?

MR. PRATT: These are the results. I'm not --

MR. KERR: No, but I mean you have both and you chose to use this one.

MR. PRATT: We chose to use this one first because this is what we had first and now we have the second, so we are now using the second so it's a question of what we had when we had it and what we could do with it.

MR. CORRADINI: What did you do with it, other than just look?

MR. PRATT: The aim would be to try to take the uncertainty associated with this phenomena and reduce them down into this range.

MR. CORRADINI: By expert opinion?

MR. PRATT: No, by design features that would eliminate the expert opinion -- you know, my confidence in resolving expert opinion over the past several years has not given me a lot of confidence.

What I would prefer to do is to have design features such that I would eliminate the need to get their opinion and that is the approach we were taking and that's largely the approach that had been taken by the industry also -- you know, if you really come to a resolution then let's not discuss it, let's eliminate it by some feature that would stop us from having to worry about it.

MR. WARD: I can't argue with that but again, your whole program is directed toward existing designs that already have specific features and you are really just looking at providing help to the Staff in reviewing those designs against severe accident issues.

MR. PRATT: That's right.

MR. WARD: So how is what you were just saying pertinent to that task?

MR. PRATT: Pertinent to --

MR. WARD: To this task of providing -- I mean you are saying you would rather see design features that would eliminate the bases for uncertainties --

MR. PRATT: Right -- and to a large extent these design features have been incorporated into the evolutionary LWRs.

Now the next generation, what one would do there is I think what you all have to wrestle with and inasmuch as some of these challenges may exist in those containments then the fixes that have been suggested here would be suitable.

Some of the designs, you know, if you are not going to be faced with these problems you are going to be faced with different problem. Those would have to be addressed when you get to those.

MR. WARD: So you are satisfied that there are some features incorporated in the evolutionary designs that have come to grips --

MR. PRATT: Yes, and I'll go through each of those items.

MR. SIESS: Excuse me. You said your objective was to get down to that 10 percent level. That is the one-tenth that gave you the balance between prevention and mitigation.

MR. PRATT: Yes.

MR. SIESS: Did you say you wanted to get the 95 percentile down below that 10 percent rather than the mean or the median?

MR. PRATT: We have in the design features we have looked at, we have essentially worked with the 95th to get rid of the uncertainties.

MR. SIESS: Where in the policy does that come?

MR. PRATT: I have no idea.

MR. SIESS: Do you think that we should deal with 95 percentiles rather than means?

MR. PRATT: If you are going to try to drive a number down like this, for example, with liner melt through, the way of fixing that is don't have a direct path for the core debris to flow and contact the liner and fail it, so whether or not I am working with the mean or the 95th is kind of irrelevant. If I get rid of that mechanism to fail the containment building then I have eliminated that concern.

See, I don't know whether I believe that this is a mean or this is a mean, you know. These are judgments based on calculations. There may be a real concern or there may not.

Rather than spend an interminable amount of time trying to discuss it and resolve it by introducing new experts, you can eliminate some of these failure modes -- just get rid of them.

MR. SIESS: Well, that makes a lot of sense. If you have got large uncertainties, the engineering approach is to do it in such a way that the phenomenon will go away.

MR. PRATT: I think what I just described applies to some of these failure modes like liner melt through where you either have it or you don't.

It is more murky when you are dealing with, say, containment loads associated with DCH.

Let's say you were going to say all right, I am going to calculate the maximum load that I am going to get from direct containment heating and then design a containment building to heat that load. That's quite a different approach.

One way of getting rid of DCH is to depressurize the system so that you don't have to deal with the phenomena, so, you now, there's two approaches to some of these fixes. One, you could try to live with the uncertainty in the containment loads resulting from the phenomena or you can eliminate the phenomena.

MR. SIESS: Yes, now you see, that doesn't involve probabilities at all.

MR. PRATT: No.

MR. SIESS: Yet we are looking at lots of probabilities.

MR. PRATT: No, we're looking -- I don't know what I call these things. These are to me concerns that have been expressed which people have done calculations and analysis and which may be a problem and may not.

Rather than having things like this stand out there in the public literature I'd much prefer to see features which eliminate these concerns.

MR. WARD: All right, please go ahead.

[Slide.]

MR. PRATT: Just to re-cap, you won't find this in the second draft in NUREG 1150. What you'll find is far different graphs, and I've thrown them altogether to try to give you the equivalent of what you had on the previous viewgraph.

Again, note though that this is a log scale and not a linear scale, so what we were kind of looking at was this kind of area in the first graph. I think the most significant difference between the first and the second graph is in the performance of the large volume containment buildings.

You find that the 95th value is within the ten percent that I was talking about.

MR. LYNCH: Your interpretation of that is simply a combination of more calculations and expert opinion judgments on those calculations?

MR. PRATT: Yes, and principally, it's coming from two sources. One is that the experts gave a very high probability of primary system depressurization in the second graph than they gave in the first. But that's not all.

There is also the fact that when they looked at the containment loads a little bit more carefully, that the load distributions themselves were lower than we had in the first draft. The uncertainty ranges associated with containment performance were about the same.

Principally, we had a lessening of the loads and also a depressurization. Now, we did a sensitivity study wherein we eliminated depressurization mechanisms to look at the effect of just the DCH. This really didn't increase -- this was a design and it really did not increase very much at all.

MR. CORRADINI: Where is LaSalle in this?

MR. PRATT: It's not done yet. I mean, it's not published as a part of NUREG 1150.

MR. CORRADINI: As of yet.

MR. PRATT: As of yet. I know that it's actually underway.

MR. CORRADINI: Is there any feeling as to where that sits, because that's the most relevant to the ABWR; isn't it?

MR. PRATT: To the ABWR, yes.

MR. SIESS: What happened to Grand Gulf between the two?

MR. PRATT: What happened to Grand Gulf? It's still here.

[Laughter.]

MR. SIESS: I know, but on your previous slide, the first draft, the highest value on there was about .35, which is 3.5 times 10 to the minus 1.

MR. PRATT: Right.

MR. SIESS: Here, the highest value is one, or darn close to it.

MR. PRATT: Right. Again, one of the concerns that you have to be careful of -- and this is a discussion that we had earlier here where we're taking the ratio of the earlier failure against the core damage frequency.

In the first draft of NUREG 1150, about the only accident sequence that was important, as I understood it, was station blackout accidents. You had a very narrow of uncertainty and almost a point value where it was going to fail. I think there is a larger contribution here of other sequences and mixes.

MR. CORRADINI: That causes the failure actually to go up?

MR. PRATT: No, no, it's a ratio.

MR. CORRADINI: I'm sorry. Excuse me.

MR. PRATT: That's what the problem with this is. This is always done relative to the core damage frequency, so the core damage frequency could have plummeted, but your apparent performance is changed, and you're still dealing with this in containment.

MR. KERR: Do you remember if the Grand Gulf PRA was done before the blackout rule was implemented at Grand Gulf; was it not?

MR. PRATT: You mean the NUREG 1150?

MR. KERR: Yes.

MR. PRATT: I'm not sure that I can answer that.

MR. KERR: It could have a significant influence on that ratio.

MR. PRATT: I'm not sure. Certainly, the second draft, I think, supposedly has all modifications and changes to the plan as of the early part of last year. That's a sort of timeframe where they froze the analysis.

MR. KERR: If you're making -- particularly future -- predictions and presumably, newer plants will have the station blackout rule requirements implemented, it might be interesting to look at that.

MR. PRATT: Again, I think the main point of showing this is that the uncertainty ranges, say, for Peach Bottom and Grand Gulf are very similar to the first draft in NUREG 1150. There are, as you say, expanded a little bit, but generally a little high, and they're coming from the same types of considerations.

Liner melt is still a concern here, hydrogen combustion and so on, are still a concern in Grand Gulf. Sequoyah, the main value went down a little bit, but again, the uncertainty ranges are still rather large. Again, the main cause here is hydrogen combustion for this particular plant.

MR. CORRADINI: I know you don't want me to talk about this detail graph, but I want to look at that. Is there any insight from LaSalle at all at this point that you know of from what's being done in terms of the early containment failure chances and loads?

MR. PRATT: I'm not sure. Now, we've done a lot of work on Limerick, of course, and Shoreham, so we know the concerns there, and we took those into account when --

MR. CORRADINI: In your list?

MR. PRATT: Yes, there should be there a concern about steam explosions and downcomers and so on and so forth.

MR. CORRADINI: The only thing that I'm remembering is from LaSalle that there was a problem a lot with the geometry in terms of if the melt got out of the vessel, where-it-would-go-sort-of-thing.

MR. PRATT: Now, again, the way you address that type of concern --

MR. CORRADINI: Is this strictly a charge?

MR. PRATT: Yes.

MR. CORRADINI: Okay.

MR. PRATT: In fact, in the -- I don't have a viewgraph of the ABWR design, but it is a Mark III type of design, but the cavity configuration is -- I could sketch it for you, if you'd like me to.

MR. CORRADINI: No, that's okay.

MR. PRATT: Basically, the region under the vessel is a cavity rather like a Mark III design, if you like, and the suppression pool is on either side. The core debris would go down into the cavity.

There's no way for it to flow horizontally. There's no way for it to get into downcomers.

MR. CORRADINI: But that is similar to LaSalle, though; isn't it? LaSalle is dry -- LaSalle is directly dry beneath the vessel.

MR. PRATT: Absolutely. Now, the way you address the concerns with -- we'll get to that later -- is that in the ABWR, they're going to flood the core debris. They have a flooding device which will allow the suppression fluid, after the core debris is there, to flow into the region and cover the core debris.

You need to do that, you know, to prevent very high temperatures as well as pressures in the region. There's also a feature that if you're concerned with high pressure ejection of the core debris, the preliminary calculations indicate that you could get sweeping of that core debris into regions on what they call the upper drywell region.

There, in order to cool that, although it's not -- because it's so thin and spread out, it's not a major core concrete interaction feature. You do get high temperatures, so you do need to spray in those regions to mitigate your temperature concern there.

So, again, all these challenges, hopefully we recognize. Now, if LaSalle comes along with something that's new, we would have to worry about it, but I think in terms of looking at Limerick and Shoreham, we have a pretty good idea of where the problems are and we have design features that would address those concerns.

[Slide.]

MR. PRATT: I've got ten minutes, I guess, to keep you on track.

MR. WARD: Well, let's look realistically at that. Do you think you can cover this in ten minutes?

MR. PRATT: Maybe rather than going through every one individually, I'm sure a lot of this you probably have already been made a ware of. You know, we can skip over a lot of the first viewgraphs here.

MR. WARD: Let me ask the Committee. We have plenty of time in toto. It's just a matter of, you know, schedule for speakers we've asked to come in. Let's see whose --

[Slide.]

MR. PRATT: I will try to move through this fairly quickly. A lot of this is really background. You know that in the Westinghouse in combustion designs, they're basically large volume containments. The ABWR design is rather like a Mark II containment.

MR. SIESS: You just finished telling us that the ABWR was like a Mark III. On that slide, it says it's like a Mark II.

MR. PRATT: I should draw it. It's very similar to a Mark II, but there are certain configurations that are more like a Mark III. It's a two and a half.

MR. SIESS: It's similar to a Mark II -- it has an annual suppression pool and the vents are horizontal, which is what the Mark III --

MR. PRATT: Well, no, they come down like this. I don't know if you can see that very well, but basically, this is the configuration. The vessel sits down in this region. This is the drywell. This is the drywell and this is the wetwell.

The suppression pool is here. The venting comes this way and comes out horizontally.

MR. MICHELSON: There is also a connection both vertical and horizontal -- both ways.

MR. PRATT: Yes, but basically in terms of volume, design capacity and so on, the total volume is closer to a Mark II than a Mark III, right.

MR. SIESS: Go ahead.

MR. PRATT: But the point that Mike was bringing up is that if core debris comes out the bottom of the vessel here, what's going to happen to it? Well, it's basically going to accumulate down here, and then they have a horizontal flooding system which would allow this water to flood into this region.

Now, you know, on some of the other designs for the Mark III's, the vessel was here and the water could be here, may not be here; you may have downcomers, you may not, and so on. Most of the concerns here have been eliminated by this configuration.

[Slide.]

MR. PRATT: The next couple of viewgraphs I don't really want to go through in detail. I think I summarized those on looking at the conditional probability drafts that I showed you. This simply talks about what was important in terms of challenges to containment and what was not important and therefore, it gives us the basis for developing the various criteria requirements that we came up with.

So, cut of all of that we address basically these types of areas. We look at problems associated with hydrogen combustion, high pressure meltdown, and we feel that even though the experts came up with a lower probability of early containment failure from high pressure core meltdown events in the second draft that nevertheless, one should perhaps look at this and be concerned. It just does not seem to be a good idea to melt the core.

MR. KERR: What does "look at it and be concerned" imply to a designer?

MR. PRATT: We would say that you would have to deal with it in terms of some feature. The ones we have recommended were essentially based on the first draft but we have not proposed to change those as a result of the results of the second draft.

MR. SIESS: Prevention.

MR. PRATT: Pardon?

MR. SIESS: Prevention -- not mitigation.

MR. PRATT: Well they are mitigation although there is a preventative side to them. We'll get to that.

MR. SIESS: I'm sorry. I'm confused now. High pressure meltdown means direct containment heating?

MR. PRATT: Yes. Well, prevention in the sense of preventing the DCH process from occurring but certainly not prevention from the point of view of preventing core damage.

MR. SIESS: Oh, no, no.

MR. PRATT: We tend to distinguish.

MR. SIESS: The division between prevention and mitigation, okay. Prevention of DCH.

MR. PRATT: Yes. We always think of, even though these are -- anything after core damage as mitigation and things preventing it from occurring as prevention, just for terminology purposes.

[Slide.]

MR. PRATT: In terms of hydrogen combustion, the aim is to try to reduce the probability of early containment failure from hydrogen combustion. There are a number of options that we have suggested that are available and again, you know, what the guide is saying is you don't need to do any of these. You can do what you want but these are what we consider to be acceptable ways of dealing with the situation.

One is simply to provide sufficient containment design margin to accommodate credible hydrogen burn events and on the next slide, I'll talk about the types of conditions one has to consider when doing those calculations and to be concerned about the possibility of local pocketing of hydrogen and so on and the potential for detonation.

Another one is to provide for controlled ignition. If you do not wish to provide sufficient margin to take the pressure temperature loads, then you could control the hydrogen burning through the use of an igniter system or alternatively, to use an inerting system.

MR. SIESS: Doesn't controlled ignition lead to the same pressures as uncontrolled ignition, or, is the first bullet only detonation?

MR. PRATT: It may or may not. I think what the igniters do for you is ensure or hopefully ensure that you're burning at reasonable concentrations and not allowing the hydrogen to build up to large concentrations before they ignite. It's an insurance measure.

MR. SIESS: You're worrying about detonation then?

MR. PRATT: Pardon?

MR. SIESS: You're worrying about detonation in the first item then?

MR. PRATT: In the first one?

MR. SIESS: Yes.

MR. PRATT: I think the main concern, yes, is if you're going to provide a large capacity containment building which has the capability to take the pressures and temperatures associated with a large hydrogen burn, then you might worry about any local concentrations which could be rather high and which could lead to detonations.

I think when we get it into ths application, it might become a little bit clearer. I think the main issue in this area really is how much hydrogen should one consider for these accidents, how one deals with local and global concentrations that may be detonable and if you're looking at igniters, the type of power supply that should be in there and equipment survivability and so on.

Now the industry would like to go with a metal water reaction of 75 percent of the active fuel and a hydrogen concentration of 13 percent. So, in other words, if you have a containment building that is designed such that when you oxidize 75 percent of your active cladding, you take that hydrogen and put it into your environment, that concentration is lower than 13 percent, then you're okay in terms of hydrogen.

The staff is tending to go with a more conservative criteria, the 100 percent metal water reaction and a 10 percent hydrogen concentration.

MR. SIESS: Now let's see, the 13 percent means, you get the 13 percent hydrogen and even if you get there without burning any of it, that won't be detonable.

MR. PRATT: That's the assertion in the EPRI ALWR document.

MR. SIESS: That means you don't need igniters?

MR. PRATT: That means you don't need igniters, right.

MR. SIESS: Are they trying to get away from igniters?

MR. PRATT: No, I'm saying that they're saying that this -- their contention is that if this was met, you do not need them. That doesn't preclude the use of igniters. For example, on SP/90, when we reviewed that particular design, they felt they needed -- even though they met this requirement, they felt that they needed igniters above the end containment tank of water because for transient events, the steam and hydrogen would be released to that pool and would come off rather rich in hydrogen.

So locally, above the pool, rather like in the Mark III situation, we'd have rather high hydrogen concentrations. So, they decided to put igniters in to deal with that concern there. So again, this is a general statement I think from EPRI. There's nothing to preclude the individual designers from, if they have a concern for local pocketing of hydrogen, to elect to ignite it locally.

MR. KERR: Did you make any recommendations to the staff?

MR. PRATT: Yeah, I think basically, well, let's see. Next slide.

[Slide.]

MR. PRATT: I think in looking at some of the calculations that we had on the amount of hydrogen that might be produced during a severe accident, we were favoring more worry about 100 percent metal water reaction as being a sort of an enveloping number on the amount of hydrogen that could be produced, not only in-vessel but ex-vessel and we looked at a number of calculations.

I don't have the details to go through with you but 75 percent metal water reaction looked like a fairly good enveloping estimate of what you might get in-vessel and we allowed for an additional 25 percent metal water reaction ex-vessel but again, that was assuming that the core debris was fairly well spread out and cooled, covered with water, and that you would not have extensive core-concrete interactions going on because when we talk here about 100 percent metal water reaction, we're talking about 100 percent of the active cladding.

Of course, there's a lot more zirconium in the core region and there's a lot of other metals that could oxidize and produce hydrogen. So if you allow the core debris to be concentrated in rather tight configuration ex-vessel and you don't put water on it, then you could expect a lot of ex-vessel hydrogen generation.

MR. SIESS: If you have 100 percent metal water reaction, whether the concentration is 10 percent or 11 percent or 12 percent depends on what, the volume of the containment only?

MR. PRATT: Yes. From a practical point of view, as far as the designer is concerned, that's true. Now, in terms of looking at some of these designs, from a practical point of view, what you'll find is that if you design a containment building to the early design basis events, okay, large break

LOCA and so on, you can just about meet the original recommendations, the 75 percent metal water reaction and 13 percent concentration.

What this tends to do is if you wanted to design a containment building to incorporate these two numbers, you may have to go to a larger volume than you would get from your design basis calculations, perhaps. It depends how you do it.

MR. SIESS: Is that strictly volume, it doesn't make much difference about the pressure?

MR. PRATT: No, but again, when the design --

MR. SIESS: Only when you burn it does it make the difference in the pressure.

MR. PRATT: That's right.

MR. KERR: Did you in arriving at your recommendation for 100 percent look at the applications of that to be certain that you were indeed making a conservative recommendation?

MR. PRATT: The applications of?

MR. KERR: The implications.

MR. PRATT: Oh, the implications.

MR. KERR: Yes.

MR. PRATT: Yes, I think so. Right. I mean the implications for the --

MR. KERR: I don't know what they are. I would think you would want to look and make sure that in an effort to be conservative, you weren't introducing something else that --

MR. PRATT: Right, and again as I mentioned, I think that --

MR. KERR: What did you look at, for example? What implications?

MR. PRATT: What implications?

MR. KERR: Well, I mean, you have to do something from what you said. You have to change the size. You have to put in igniters. You have to inert. I mean, whatever.

MR. PRATT: Yes.

MR. KERR: And all of these can, I mean inerting, for example, makes it more likely that somebody will get suffocated, I assume. I don't know what. I'm simply asking.

MR. PRATT: Yes. Yes. In the early days of the program, what we were looking at was cost benefit arguments with regard to some of these modifications. I'm sorry. That's the type of thing that you were thinking about. If you would pose a certain requirement, then it may have negative effects and so on.

MR. KERR: Yes.

MR. PRATT: Yes, yes. Absolutely. As you say, inerting was one. The ignition system was another, looking at some of these things. Yes.

I'm sorry, I didn't pick up what you were saying?

MR. CARROLL: Your 100 percent metal water reaction and 10 percent hydrogen concentration as an enveloping limit is a surrogate also for carbon dioxide?

MR. PRATT: Yes. Yes.

MR. CARROLL: That's been considered in that whole enveloping process?

MR. PRATT: Yes. Really this should -- that's right -- this should be talking about -- now you can combine CO and hydrogen to give you a combination that gives you equivalent detonability limits but what we were suggesting later on is that we would select concrete materials that would minimize the evolution of gases as a result of core-concrete interactions.

MR. CARROLL: So that's another requirement -- CO2 --

MR. PRATT: This is assuming that you have rapidly cooling of the core debris so we spread it out and also some material that's not going to generate a significant amount of those types of materials.

MR. CARROLL: A question on the ABWR containment inerting -- it is intended that there would still be a 24-hour period following startup that the containment does not have to be inerted or something of that nature?

MR. PRATT: I believe that's the case. Perhaps we could --

MR. CARROLL: Has that been looked at from a PRA point of view and found acceptable?

MR. PRATT: Yes, it's generally considered to be a small contribution. That's right.

MR. CARROLL: That takes into account the fact that the first 24 hours after startup, although the fission product inventory is not equilibrium or close to it, it is a period of high vulnerability to bad things happening in as much as you've presumably just completed a refueling outage and you may have misadjusted a pipe hangar on the vessel and tear a line off the reactor vessel or something like that.

MR. PRATT: I do know that this was an issue that was specifically looked at as part of the containment performance program. I'm not quite sure what the resolution of that was.

MR. MICHELSON: How do you do that in your PRA? How do you accommodate this consideration in your PRA?

MR. PRATT: Well, it's just -- you look at the effective life of the plant and those two -- the time intervals that you're dealing with and look at the probability.

MR. MICHELSON: Yes, but that's -- on time basis. That would not be the correct basis, as was just pointed out. There are a number of different considerations during startup than during normal full power operations.

MR. PRATT: Right. Well, I think this is --

MR. MICHELSON: Clearly the probability of failure is greater during that first 24 hours than it is in the subsequent 24 hour periods. Is that in your PRA?

MR. PRATT: Well, no. As I said, what was in the PRA was looking at what the probability --

MR. MICHELSON: Yes, the time increment. Yes, on that basis, you could disregard it but not on a real world basis.

MR. PRATT: No, and my understanding was -- as I say, I unfortunately can't give you an answer. My understanding was that that was being looked at as part of the Mark I containment performance program specifically, as an issue in there. Just how it got resolved, I'm not sure.

MR. MICHELSON: But not necessarily reflected in the PRA though?

MR. PRATT: Well, again, in the ABWR PRA --

MR. MICHELSON: The ABWR.

MR. PRATT: -- that would be something we would look at under that. Absolutely, yeah.

MR. MICHELSON: I'll watch for it then. Thank you.

[Slide.]

MR. PRATT: Now in terms of worrying about high pressure core meltdown events, again the aim is to reduce early containment failure and two options are available. One is to provide for effective depressurization of the primary system. Another one is basically to provide sufficient margins in the containment in terms of volume, ultimate pressure capability and configuration.

Configuration would be configuring the reactor cavity and regions around it to inhibit the dispersion of the core debris during the high pressure injection process. Some of the key considerations that are discussed in the document is to what pressure should the system be depressurized in order to preclude concerns regarding direct containment heating, when should the --

MR. KERR: Does the Reg Guide just raise those questions or does it answer them?

MR. PRATT: It gives some indications of pressure loads. I think we would have to look at those, you know. Those are evolving as we speak. There is going to be another meeting in Annapolis on Monday and Tuesday on DCH.

MR. KERR: You mean as a result of that meeting, answers to those questions --

MR. PRATT: We have numbers in there now which we think are fairly conservative in terms of the lowness of the pressure level that you have to get down to.

MR. KERR: I am skeptical of conservative numbers. How do you know they're conservative?

MR. PRATT: Well, in the sense that if, I mean, obviously if it's down at the same pressure as in containment, you don't have any driving force to drive the thing out. So, I mean, you can get down to levels where you really don't have to worry at all.

The question is, people would not like to guarantee that the vessel pressure will be at the pressure of the containment building because that's a low pressure and you could repressurize a little bit. The question is it 600 p.s.i.? Is it 200? What is the number?

MR. KERR: I'm just looking up there, to what pressure and at what rate should the system be depressurized? When should the system? What design requirements, and you're going to have answers to that as a result of the meeting next week?

MR. PRATT: Oh, no. No, no. What is in the Reg Guide now is what we think to be reasonable numbers. Now, again, we have to remember, we're in two different situations. These are, I think, real problems for existing plants that are out there. If they want to get rid of DCH by depressurization, they have to worry about relief capacity. They have to worry about getting rid of primary inventory and losing time.

MR. KERR: Okay. Let's stipulate those things. Now, where are you going to get the answers?

MR. PRATT: We are now dealing with new plants. For example, the one that we've looked at extensively is SP/90. In that particular case -- in fact we presented the results of this just a month or so ago to the ACRS -- depressurization there actually is very good from a preventative point of view because they have available large tanks of water which come in at the lower pressures and inject passively into the primary system.

So depressurization there will take a transient event which would lead to core damage in maybe 300 minutes out to maybe 700, 800 minutes.

MR. KERR: So you're telling me, I think, that for the ABWR, you don't know the answers or for the -- evolutionary PWR but for some future design, you do know the answers.

MR. PRATT: What I'm saying, no, I think for the evolutionary designs, we know that what they're doing is pretty good in terms of responding to this issue. What I'm saying is some of these issues may be of more concern for existing plants than for the evolutionary plants.

MR. KERR: Okay. So they're not really questions. They're not --

MR. PRATT: Well, they're questions which were asked and were addressed and we think have been fairly well addressed.

MR. KERR: Okay, in other words, the questions arose as a result of existing plants but the designers have answered them.

MR. PRATT: Right. Yes. But again, I think these questions still apply to any schemes that the industry may come up with there to worry about DCH because there are plants out there that may not have relief capacity, that if they do relieve, they may do it too slowly or they may do it too quickly, bring forward in time, the time they would run into core damage.

So there are negative effects that have to be concerned. Those negative effects I think have been well addressed by this particular design and are being addressed by ABWR.

MR. MICHELSON: Now when you do the severe accident type PRA examination, do you include errors of omission or commission which are quite possible when you talk about when you decide and how you do it and so forth in a manual mode which even ADS is not automatic for an hour or so later, kind of thing.

Clearly there's a finite probability that you won't do it like you're supposed to have done it. Is that included in your PRA?

MR. PRATT: Some of that thinking is certainly included and certainly, some of the thinking mostly in the preventative side of it which Bob Youngblood could have gone through with you and some of his thinking that he went into to try to get the core damage frequency low. He did a lot of that type of thinking.

MR. MICHELSON: I'm thinking more of, you've got the problem now and now you have to decide when to actuate ADS. Clearly, that's a manual operation.

MR. PRATT: Right.

MR. MICHELSON: It's possible that the operator will make some bad decisions or some incorrect actions but that would have to be in a severe accident PRA if you are to understand what your severe accident possibilities really are.

MR. PRATT: The same here. Now here we think it works pretty well because it brings into play additional injection systems which are --

MR. [illegible] it's all manual. I'm not that acquainted with [illegible] but what is that -- I think it's probably all manual for severe accident.

MR. PRATT: I'm not sure it's all manual.

MR. MICHELSON: Isn't there some kind of severe accident actuation signal? I don't think so.

MR. PRATT: No, I'm sure.

MR. MICHELSON: It's got to be again the same basic questions of, what's the likelihood that we'll do this right.

MR. PRATT: Part of the assessment, of course, on all of this is again, the ground rules, like to see procedures for all of this in place and so that we can evaluate it. In fact, we just went through this on Limerick where we were looking at a series of mitigated measures there and we essentially went to the plant, looked at the procedures, walked down. They had to get special equipment from various cabinets and so on and check that all of this stuff was there and whether there was a reasonable likelihood that it would all happen.

MR. MICHELSON: Is there any possibility the procedures will even match the situation if you get into it.

MR. PRATT: Right.

[Slide.]

MR. PRATT: Okay. In terms of core debris containment boundary interactions, what we were concerned with here and again, I went through the challenges that we were worried about. We did not want a direct pathway for the core debris to contact the liner and cause early containment failure, sufficient floor area to enhance debris spreading and coolability. Again, we'll talk in the next slide about what sufficient means and also provide for flooding of debris bed and the selecting of the materials to reduce generation of noncondensable gases as a result of contact with the core debris.

These are very consistent with the EPRI ALWR requirements and also what's going into the evolutionary AWRs. In terms of what depth is sufficient to cool the core debris, this is something that's been discussed quite a bit. In the EPRI document, they have a specification of .02 meters squared per megawatt thermal as being an area which would, if water were on top of the core debris, would enhance coolability.

In the generic letter that went out on the IPEs, there was a famous 25 centimeter depth of the core debris, and again, how effective is flooding and should water in the cavity before or after the core debris. So these are some of the key considerations that were brought up.

[Slide.]

MR. PRATT: Let me show you one graph -- we had a series of calculations that we performed just to see how much hydrogen you might get. What this is, again, from SP/90 here, this is basically -- we used the SP/90 core and configuration to do the initial calculations but what we were looking at is floor area. We varied the floor area and we looked at the amount of hydrogen that would be generated in the equivalent metal water reaction coming from that hydrogen and we did it for a range of initial temperatures.

To give you an idea, this is the EPRI number sitting in here. That's about the starting point for the calculations and then we kind of spread the core debris wider to look at the amount of hydrogen you might generate. Down in this region, I would question the applicability of CORCON to those types of regimes because it's spread out over a very large area, rapidly cools, and so on. I don't believe the modeling is particularly appropriate down in there but what we are showing is that you do get a significant amount of ex-vessel oxidation of the metal even in the presence of water using the CORCON model.

Now, of course, the CORCON model puts crusts above the core debris and stops ingress of the water into the core debris whereas the MAAP code would tend to calculate debris quenching and so on. However, there's a recent report that has just been issued by Fauste & Associates, I guess, in support of the EPRI ALWR document which does take into account additional oxidation after vessel failure in their particular calculations. Mostly it's coming from oxidation of the core debris that's left in the reactor vessel, you know, steam evolving and so on rather than anything that may be down in the cavity.

So anyway, these are the types of considerations that we've come up with. What this led us to believe is, although there are questions about the applicability of CORCON to some of these configurations that one should allow for an additional oxidation of hydrogen in the ex-vessel configuration even though we are predicting the cooldown and determination of the core-concrete interactions over some period of time. I forget the time it took to cool the core debris and stop the interactions in this particular case.

MR. CORRADINI: For SP/90, what's the depth of the material at the EPRI value?

MR. PRATT: I forget the numbers. I did that calculation. I think it's very close to the 25 -- very, very close to the 25 centimeters.

Just one point here. In terms of implications for the evolutionary LWRs, we feel that even with the core debris spread out to the regions that we're talking about, we do have to worry about some ex-vessel hydrogen generation. But also the flooding of the core debris, I think, is an important point. You were talking about negative impacts of some of these fixes. What flooding the core debris does for you is increase the pressurization rates of the containment building in the absence of containment heat removal quite significantly.

In other words, when we did the base case calculations for SP/90, where we had, initially, water available which dried out, and then pressurization was a result of core concrete interaction, the pressurization rates were very slow. In fact, over the 48 hour period of time, we were not close to the ultimate pressure capability of the containment building. The temperatures were rather high, but the pressure limits were very low. When you put the flooding device down in there, you significantly increase the pressurization rates. So if you do not have containment heat removal, you are going to bring forward the time at which you reach your ultimate pressure capability; you may have to do something else. Okay? So that's one of the negative impacts of --

MR. KERR: Why does spreading make that much difference?

MR. PRATT: It's not the spreading. It's the transferring of heat to the water, and the boiling of the water. In other words, if you're taking all of the decay heat and putting it into water, boiling it in pressurized containment, that's a much more efficient mechanism for pressurizing the containment than taking the heat, putting it into concrete and releasing non-condensable gases to steam. So, it's just a more efficient way of pressurizing the containment.

MR. KERR: And the heat can't get to the water if it isn't spread, is that --

MR. PRATT: Well, you are boiling the water.

MR. KERR: Oh.

MR. PRATT: I mean -- yes. I mean we take --

MR. KERR: I mean you are still going to be boiling some water because you can't isolate it completely; but it's apparently -- if you spread it, the transfer to the water is much better than transfer to the concrete?

MR. PRATT: Yes, yes. You pressurize the containment significantly faster.

MR. KERR: You have a lot of confidence in that calculation.

MR. PRATT: Pardon.

MR. KERR: You have a lot of confidence in that calculation.

MR. PRATT: Those I have, yes. That's all Dalton's Law and just boiling water.

MR. KERR: But this doesn't have to do with the amount of heat available and the amount it takes to boil water. It has to do with how much you are transferring to what.

MR. PRATT: Well, in these calculations, you know, we did it both ways. We did it the MAAP way, which quenches the core debris and takes all of the decay heat and puts it into the water, and we also did the CORCON way, which takes some of the heat and puts it into the concrete and takes the rest of the heat from boiled water; and the pressurization rates are faster for MAAP than CORCON and then dry. I have a table which I could give you which shows the different pressurization rates, but in this particular case on the ABWR, it's quite important because it does significantly increase the pressurization that's relative to what they had before. Because the SP/90 has a larger volume, larger heat sinks, it's less critical.

MR. KERR: Maybe we should persuade GE to use a bigger containment volume for the US version.

MR. PRATT: Maybe.

MR. CARROLL: Trevor, one of the questions that was on your list of key considerations was, "Should water be in the cavity before or after core debris?"

MR. PRATT: Oh, yes. Thank you for reminding me. I think this is almost a personal choice. I think you have both ways in the evolutionary designs we're looking at. The

SP/90 is basically going to open, as I understand it -- and somebody correct me if I am wrong -- open up a path from the in-tank water to the cavity, such that the cavity will be pretty well flooded. The ABWR design has fusible plugs between the suppression pool and the cavity, so they'll be actuated on high temperature; so, the water there will be flowing on top of the core debris after the core debris is there. Now, you'll still be getting more core debris coming down at later stages, into the water pool, but those are the two designs. I think there's a number of --

MR. CARROLL: So, what's the reg guide going to advise?

MR. PRATT: Well, I'm trying to think which -- I don't know that we have necessarily have come down in one particular way or the other. We talk about the relative concerns from both directions. If you have a large amount of water available and you drop the core debris into it, then that's almost desirable, because you would expect some form of fuel coolant interactions and the fragmentation and breaking up of the core debris, which should enhance debris bed coolability; but, you also have the problem of rapid steam pressurization and steam explosions to concern yourself with. So, a lot of the concern there is your particular configuration -- whether you believe that those pressurization rates can be handled or not. Now one of the things that I know was important in the latest version of Grand Gulf and NUREG 1150 that contributed, as well as the accident, next to the increase in the conditional probability of the early containment were those types of pressurization rates within that pedestal region, and whether or not they could be relieved or where they would crack the wall and cause the vessel to tip, and so on.

So that was a concern that was expressed for Grand Gulf in NUREG 1150. But again, you know, you have to look at your particular configuration to see how important it is.

For the other situation, if you're dropping the water on top of the core debris, then I think you're in a situation where it's harder to envisage the ingress of the water into the core debris, past the crust. You know, you'd have the water to be levitated on top of the core debris and it'd take some time to get in the fluid. So, it's a less effective way of cooling your core debris. I think if you have a sufficiently wide area that you're spreading the core debris out on, and you're putting water on top of it, then the heat transfer surfaces with the core debris should be sufficient to cool it in a reasonable amount of time. So again, it depends on the configuration. I believe the Reg Guide is written along those lines.

[Slide]

MR. PRATT: Okay, let's talk about long term heat removal. This is not an early containment failure concern, but again, it's a concern that if you do confirm a containment building late -- this is several hours after vessel failure -- the fission product release is significant, certainly it'll exceed 25 rem at half a mile probably. So the idea is to look at the options for controlling situations where you've lost containment heat removal and you may be faced with reaching the ultimate capacity. One is to provide an alternative means of removing decay heat and I'll talk about several things that have come up there.

MR. KERR: This is based on some sort of scenario where you've lost electric power --

MR. PRATT: Yes.

MR. KERR: And it hasn't been restored --

MR. PRATT: Right.

MR. KERR: Even after several days?

MR. PRATT: Well, we don't need several days --

MR. KERR: Well, what's long?

MR. PRATT: A couple of days --

MR. KERR: What's long term?

MR. PRATT: Well, I think if you looked at the ABWR, you're talking about less than a day of reaching its ultimate capacity and SP/90 within two days.

MR. KERR: Well, buy you've already designed it so that there's a only about a 10 to the minus 6 probability that you'll have early containment failure. And the "early" was defined as about -- what -- 30 hours?

MR. PRATT: Right.

MR. KERR: So, we don't have to worry about that.

MR. PRATT: Right.

MR. MICHELSON: Well, early could be almost immediate.

MR. KERR: No, but his design is going to insure that with less than 10 to the minus 6, you get containment failure in less than, let's say a day.

MR. PRATT: Right.

MR. KERR: And so this assumes that you will not be able to get electric power within a day.

MR. PRATT: Right.

MR. KERR: And that likelihood is fairly small, isn't it? Ten to the minus 8 maybe?

MR. PRATT: Well, no.

MR. MICHELSON: Fire could do it, for instance, outside a containment.

MR. KERR: Well, you'd have to burn up the containment building, almost --

MR. MICHELSON: No, no, no, no, no. You'd burn up the power sources to what's cooling the suppression pool.

MR. KERR: But you could bring in portable power sources in a day.

MR. MICHELSON: Not to provide the cooling. You could bring water in, but you can't cool a containment. You could make up water to the core.

MR. KERR: You mean, there's no way you can get electricity under the containment from outside sources.

MR. MICHELSON: Well, it's not into the containment. It's into the RHR pumps that are circulating the water that take the heat out of the containment.

MR. KERR: Well, you can't get it to those pumps.

MR. MICHELSON: Well, it's what you have to look at. But there are a number of events for which you might get into this, which we are supposed to consider as severe accidents.

MR. KERR: But you also are supposed to consider probabilities at some point.

MR. PRATT: Yes. No, I think in terms of -- well, let me go to the next one.

[Slide.]

MR. PRATT: This is just, again, a list of questions which we asked. I don't need to go through that. But let me get to the implications for the particular plants.

[Slide.]

MR. PRATT: What we are looking at in terms of addressing this issue on the ABWR is that they need to include venting as an option to address this concern in their particular design. And again, we are talking, as I said before, of having to do this in about the 24-hour time period or less.

Now, the SP/90 design, because it has more like a couple of days to deal with this event, is not thinking in terms of venting at all. But the last meeting, what they were looking at was the external cooling, spraying of their steel shell and the practicalities of doing that. And if they can come up with a system which does that, then they don't have to worry about opening up the containment building.

MR. CORRADINI: So that is just the AP/600?

MR. PRATT: Yes. Now, they had problems with doing this in SP/90. as I recall from the presentation that they gave at the last meeting, where a lot of the water collecting on the outside of the shell between the Shield Building and the containment shell was causing them a problem and they would have to open up a path to drain that, and that was getting them into trouble with meeting the existing requirements. But they are looking at that and that is one option that they are looking into.

MR. CORRADINI: Why is the buildup of water causing a problem?

MR. PRATT: Well, just that they have to get rid of it and drain it. And in doing that, they are opening the building. And the Shield Building, you know, they were having trouble meeting the existing requirements because of that. It was just a small point. But it was a design consideration that they were coming up with.

MR. KERR: Do you mean they have put in an opening?

MR. PRATT: In order to get rid of the water. But again, don't quote me. This is just what I heard at the presentation when they were here the last time.

MR. KERR: Okay.

MR. PRATT: But they were looking into that as an alternative to spraying internally, and they didn't want to vent it all.

MR. CARROLL: Let's see. A third bullet would be the EPRI document. And it recommends against venting for either type of reactor, right?

MR. PRATT: It recommends venting?

MR. CARROLL: Against venting.

MR. PRATT: Against venting. Yes. Yes. That's my understanding. Right. Absolutely.

MR. CARROLL: For either boilers or --

MR. PRATT: Oh, I'm not sure. The last time I read the document, it talked about a dedicated heat removal system which would be attached to the spray. So they did not include venting as an option.

[Slide.]

MR. PRATT: Let's assume there was a calculation that we did at Brookhaven, just to help us in some of this decision-making process. And it is kind of interesting. We were looking at the EPRI consideration of 25 rem at half a mile. Oh. There seems to be a second one missing here. Yes. I thought I remembered two.

But basically, we just took the noble gas release as a function of time after scram, and looked at a couple of durations, a two-hour duration, which is slightly spread out, and a half-hour duration, which is a tighter flume release, and looked at the dose at half a mile.

So that what this is really showing you is, if you want to try to get your 25-rem requirement, then you are talking about times out here on the region of 14 hours before you would want to vent the containment building, in order to stay within that requirement.

MR. CORRADINI: In essence, that is the definition of early containment failure, from a dose standpoint.

MR. PRATT: If you accept the 25 rem, that is right.

MR. WARD: This is noble gas, though? Is that what you are saying?

MR. PRATT: Yes. Just purely nobles. Nothing else.

I think in your handout it is -- I hope it is -- a better reproduction than this.

[Slide.]

MR. PRATT: Now, the other thing I asked them to do as well was because there is uncertainty in the iodine release, and again this is reproduced badly, you know, we always throw in a half a percent or a percent, because we don't know whether it will be in the volatile form or whether it will be cesium iodide.

This gives you just again the same type of calculations for the 1 percent release and the 3 percent release. And if you are looking at the 1 percent release, you are 25 rems in here. So it is going to stay fairly flat out there in terms of those types of calculations.

This is just to give you a guidance on when you might want to do some of this stuff.

MR. CARROLL: This is the effect of iodine on whole body dose; is that what I'm seeing here?

MR. PRATT: Acute red marrow, yes.

MR. CARROLL: So you are not trying to relate iodine in this context to thyroid dose?

MR. PRATT: I don't believe so.

[Slide.]

MR. PRATT: Okay. I think in summary, what we've tried ot show is that you can develop containment performance requirements that do provide, and I hope we've defined what reasonable is, assurance that these evolutionary containments will have a high probability of remaining intact during the severe accident.

These requirements are fairly similar to the EPRI ALWR requirements. We differ in a number of small situations.

But generally, they are similar. And I think most of them, if they are not already in there, are or will be in the evolutionary designs that we're looking at.

That really summarizes all I have to say. As again, the focus was really on the evolutionary designs.

MR. KERR: In arriving at the ratio between containment failure probability and core melt probability, you had to use some set of containment behavior sequences, I assume, to get at that probability.

MR. PRATT: Containment behavior sequences?

MR. KERR: Or containment failure sequences, or whatever you want to call them.

MR. PRATT: Yes.

MR. KERR: Now, you have, therefore, in effect, defined design basis severe accident sequences?

MR. PRATT: Yes.

MR. KERR: Okay.

MR. PRATT: Yes.

MR. KERR: And so that is also part of the policy? I mean, it is. I'm not opposed to this policy. In fact, I think it is almost inevitable. But it seems to me you now have a policy that there shall be a set of severe accident sequences which determines containment performance goals.

MR. PRATT: Yes. The way I prefer to look at it, rather than -- Yes. I think that is reasonable. I mean, I would like to think of identifying challenges.

MR. KERR: But the challenges depend on your having defined, with careful forethought, judgment, expertise, all this sort of thing, a set of design basis severe accident sequences.

MR. PRATT: That's right.

MR. KERR: And it seems to me that is inevitable if you are going to use this approach.

MR. PRATT: Yes. So you identify them; you hope you have a complete list; and then you eliminate them --

MR. KERR: Or at least a representative list. Yes.

MR. PRATT: That's exactly right.

MR. KERR: Okay.

MR. PRATT: And at this point I feel pretty comfortable with where we are.

MR. SIESS: Now, what comes out of this for me is that the containment design criteria have to be much more than simply a pressure, a temperature, a volume, an energy, to be accommodated. But they are really criteria for the design of a containment system, and the containment system includes not only the structure, but the cooling systems, igniters if you have them, inerting systems if you have them, flooding systems, et cetera.

MR. PRATT: Yes.

MR. SIESS: Up to and including, I guess, depressurization systems.

MR. PRATT: Yes. Right.

MR. SIESS: And there are a number of different combinations.

MR. PRATT: That's right.

MR. SIESS: I assume the case of not depressurizing the primary system, is that acceptable? Theoretically, I guess, you could say I will not put in anything to depressurize the primary system, but I will design a containment that can take the pressures and temperatures due to direct containment heating.

MR. PRATT: Yes. I think it is acceptable.

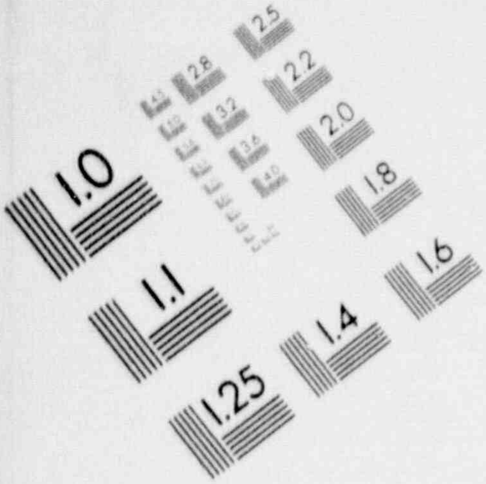
MR. SIESS: Is that a practical option?

MR. PRATT: I personally don't think so.

MR. SIESS: Because of uncertainty, or because of the pressures being too large?

MR. PRATT: Well, because of uncertainty in the loads, causing us to produce a rather large, expensive design, I would expect. I don't know. I have not done those calculations.

MR. CORRADINI: That would be interesting. I was going to ask a different question. But you have raised it in an interesting way. If you go with your 100 percent and 10 percent -- 100 percent of metal-water reaction and 10 percent concentration by volume in the containment -- my question is,



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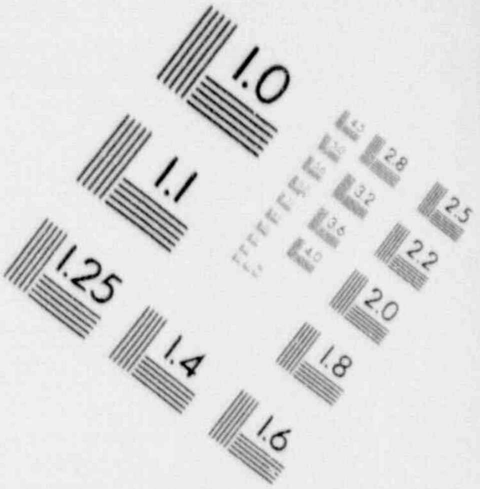

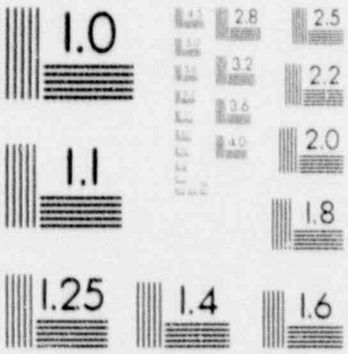

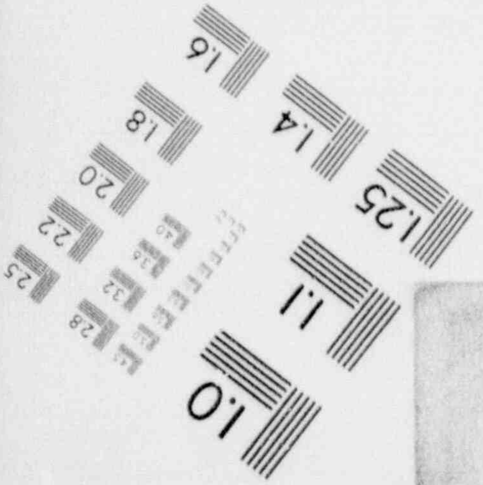

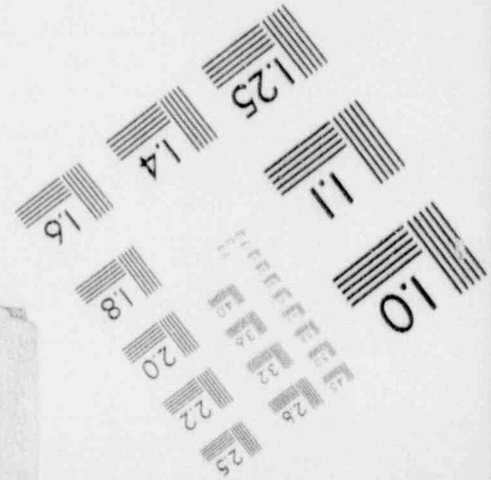

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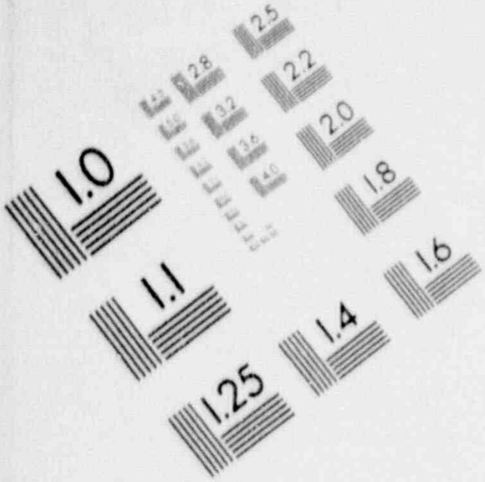

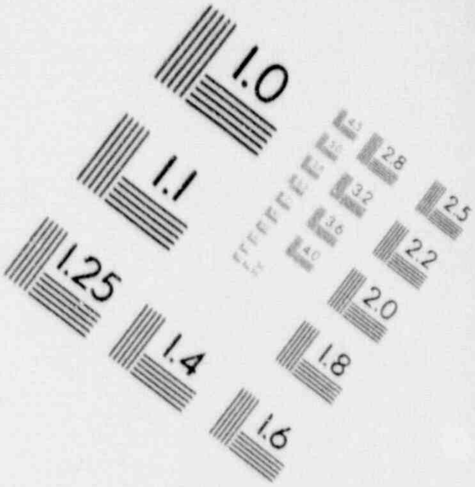

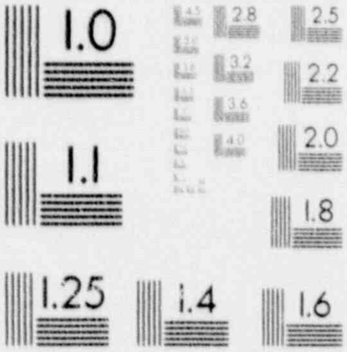

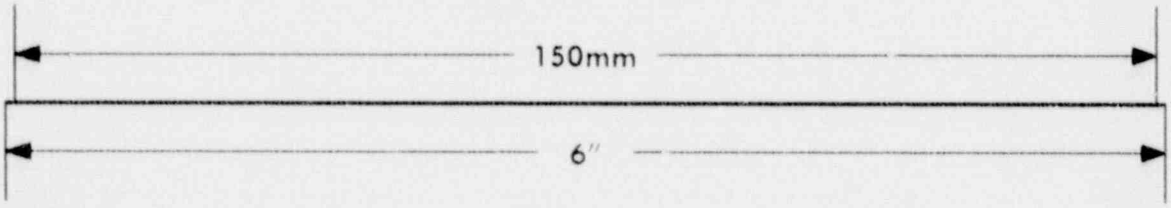

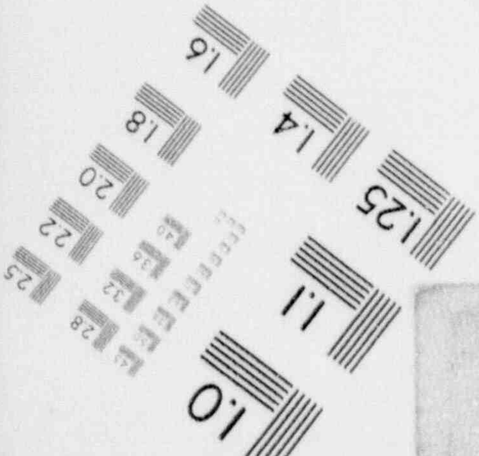

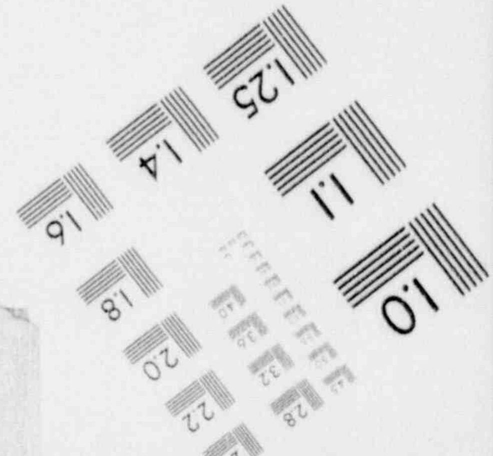

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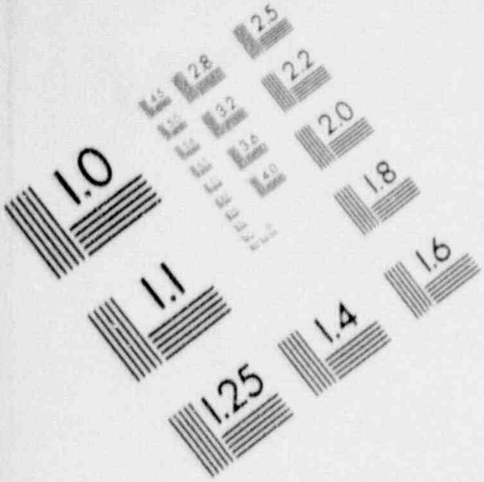

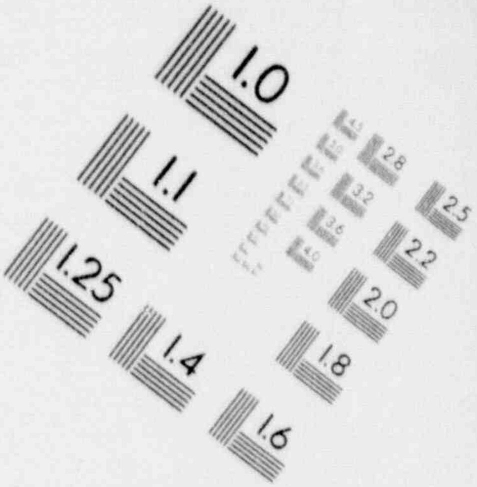

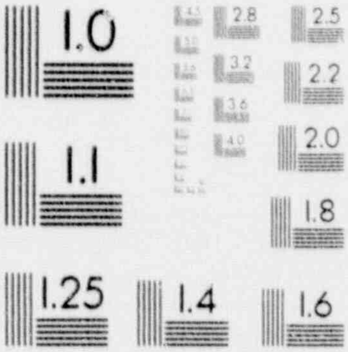

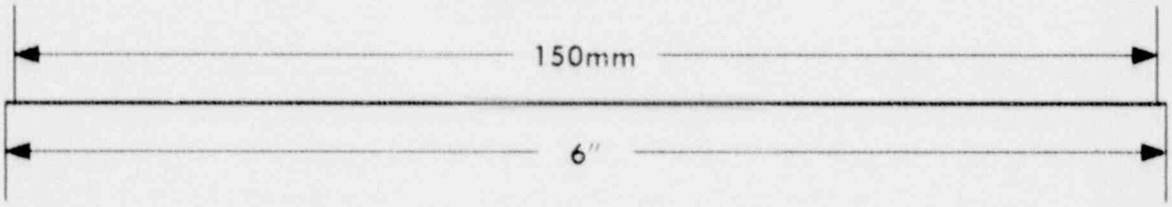

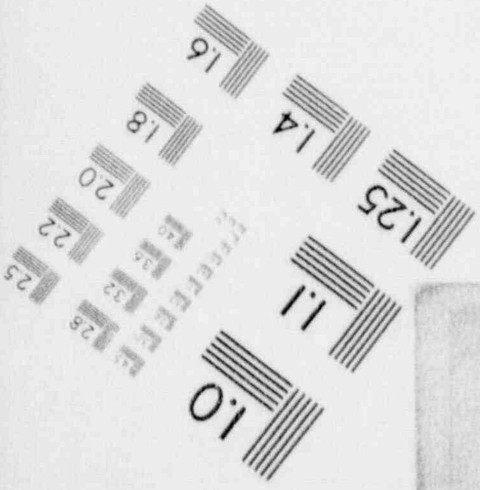

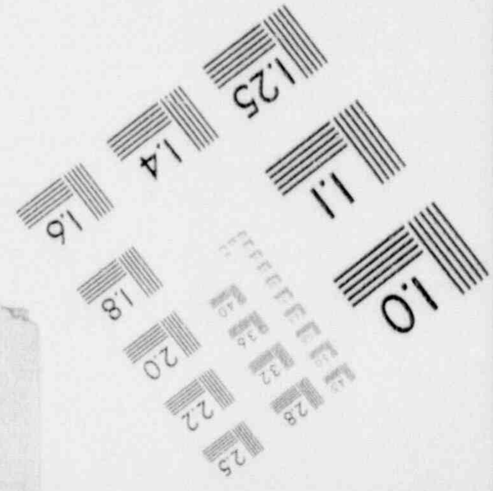

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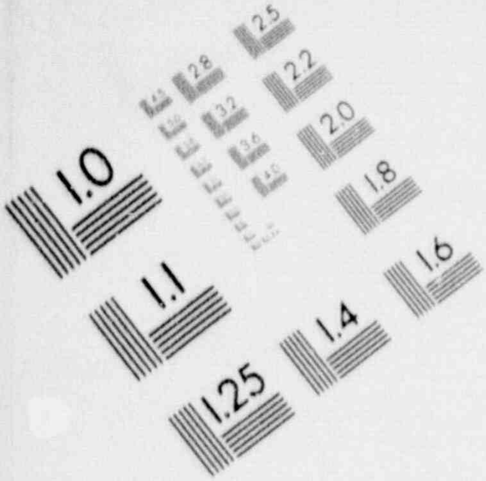

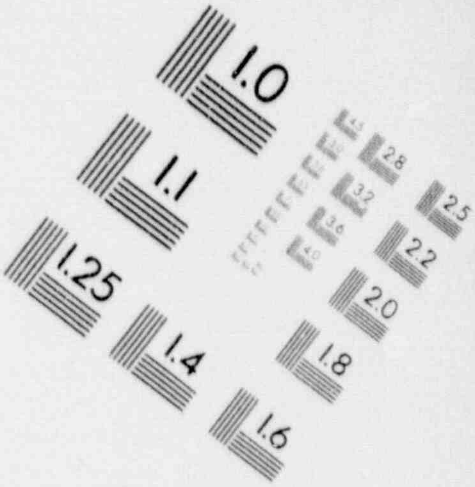

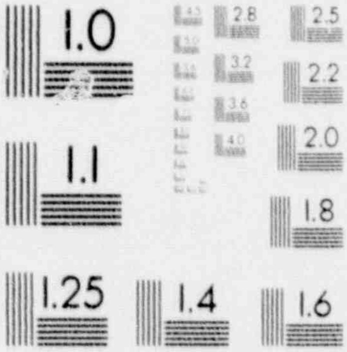

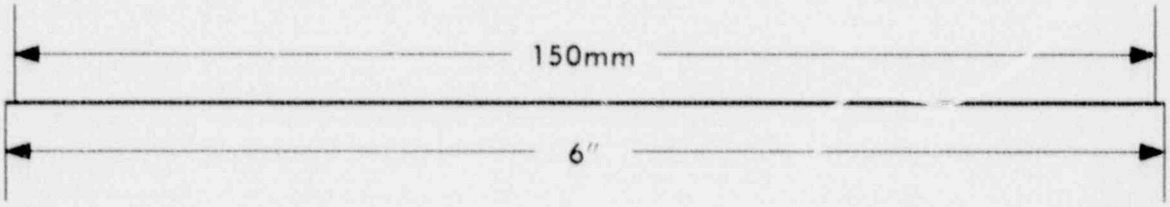

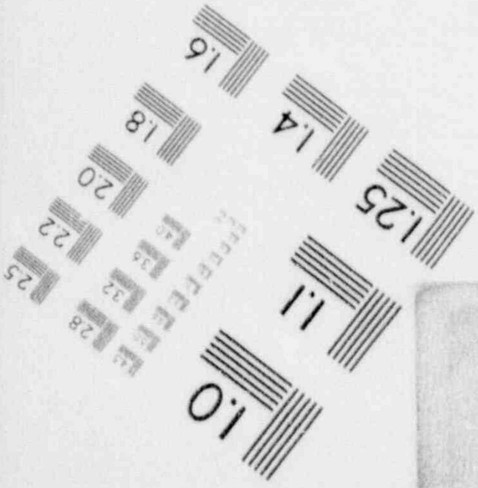

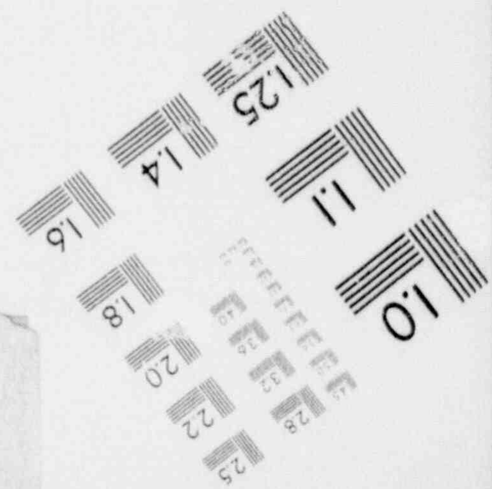

would that cause a containment that would be actually smaller or bigger than if you were to say I am not going to design a depressurization system, just simply accommodate the loads from a high-pressure melt ejection?

MR. PRATT: I think there are two questions there. One is what you get from worrying about DCH.

MR. CORRADINI: No, I understand. But both are going to be driving it to a somewhat large free volume.

And my question is, I am wondering which one is more restrictive. I think you might be surprised that it might be the hydrogen, and not necessarily the DCH.

MR. PRATT: I think, if you go with your second draft of NUREG 1150, I would agree with you.

The first draft, the loads were a lot worse that we had to deal with there.

MR. WARD: Mike, isn't there a greater uncertainty associated with the DCH loads than with the hydrogen loads?

MR. CORRADINI: He answered it by justifying it on the 1150. I don't know if I would need to use 1150 to justify, would I, because those are all simply parametric calculations.

MR. PRATT: But, then, in earlier drafts of the Reg. Guide we had very specific postulates. And we said in order for this to be what we think to be reasonable, you are going to have to eject X amount of core debris, at a certain amount of temperature, assuming hydrogen burns and so on, in direct heating, starting from a certain base pressure. So we had a very specific scenario, as Dr. Kerr mentioned, as to what we thought you would have to have capacity to take.

MR. CORRADINI: The reason I'm asking the question is, because long ago, before DCH came up as a problem, if it is a problem, the thing that always popped up, and I thought really was a problem, that hadn't really been resolved, it just kind of got buried, was this worry about at the time of vessel breach producing a lot of steam combined with burning of hydrogen.

And somehow I am worried that that is -- I've looked on your list; it's there -- but I am worried that that has gone away. I'm still wondering, with the hydrogen rule or the suggested guidelines we have, that may push you to a large enough volume that those two things may be automatically accommodated.

Nobody has really looked at that, per se, have they?

MR. PRATT: Well, what we said in the guide, and the main reason I didn't walk through that was that the hydrogen control measures that we talked about, namely, igniting or inerting, those two were really designed for situations where you had a depressurized primary system.

In other words, your igniters are not going to help you with the high-pressure ejection.

MR. CORRADINI: No. I didn't mean it that way.

MR. PRATT: Or a high-pressure coredown event where you don't have DCH, but what you do have is a lot of hydrogen that is locked up in the primary system, rushing out at once.

MR. CORRADINI: No, I didn't mean it that way. I just meant that that guideline, or that criteria, might be more limiting than the others.

MR. PRATT: It's quite possible.

MR. CORRADINI: Has anybody checked that out, per se?

MR. PRATT: You mean compared the two?

MR. CORRADINI: Yes. Taken the SP/90, for example, and gone through the calculation to see.

MR. PRATT: I may have those calculations. I would have to go back and check it.

Certainly, we looked at the hydrogen requirement, the 10 percent and the 13, and looked at what impact that would have on the designs.

And as I say, some of the existing designs that are out there can easily meet the 13 percent, 75 percent metal-water reaction. But the other one is a little tough to me, based on existing DBA calculations.

MR. WARD: Okay. Any other questions?

[No response.]

MR. WARD: Thank you very much, Trevor.

We will break for lunch, and come back at 1:00 O'clock. Mr. Lutz will be the first speaker.

[Whereupon, at 12:02 p.m. the hearing was recessed for lunch, to reconvene the same day, Wednesday, December 13, 1989, at 1:00 p.m.]

AFTERNOON SESSION

[1:02 p.m.]

MR. WARD: Our next speaker is Mr. Lutz of Westinghouse.

MR. LUTZ: Good afternoon. My name is Bob Lutz, a Fellow Engineer with Westinghouse Electric. I am doing the Westinghouse presentation that is scheduled for today.

I would like to make a couple of introductory comments.

[Slide.]

MR. LUTZ: First of all, I was not completely sure exactly what you wanted to hear, and what we should be talking about, other than the general guidelines of containment design and containment criteria. So what I did is put together a rather brief formal presentation that is about six or seven slides long. And I will sort of deviate from that as questions come up. We can take off and talk about areas that might be of interest to you.

What I want to do is try to describe the containment design and the performance of the containment for severe accidents, particularly with respect to the new, evolutionary designs.

And as it came up this morning, when I talk about containment design, what I am really talking about is the containment structure plus the containment safeguard systems, the heat removal systems, the containment isolation system, all of those things that affect containment performance. And it could even be extended to, as was suggested this morning, to the depressurization of the reactor coolant system, as that has an impact on the containment design and the containment performance for severe accidents.

I would like to talk about four areas.

One is the containment functions, which is rather brief, and which we have all probably heard at least 10 or 15 times this week. this is only Wednesday.

The second is a review of containment performance that we have seen from the plants that we have analyzed in terms of severe accidents, and particularly since the Zion plant has been analyzed by a number of different investigators, some of the insights in terms of containment performance from that plant, and the extrapolation of that a bit to other plant designs, and how that affected the future design concepts.

The third is problem areas, in terms of the existing regulations, or regulatory practice. And I had the one example, and it sort of came up this morning in Trevor Pratt's presentation, about the double containment on the SP/90 design. And I can talk a bit about that.

And then lastly, the future containment concepts, particularly the SP/90 and the passive PWR, which we call AP/600.

[Slide.]

MR. LUTZ: I was trying to think how to start the presentation. And I think the best way is to simply state that the function of the containment and the containment systems is to provide the third and final barrier to prevent the release of radioactivity to the environment in the event of an accident.

There are secondary functions of the containment, which include shielding in the event of an accident, both in terms of offsite doses, and when we start talking about accident management, which is something that is having a bit more emphasis in the past year here, particularly to the onsite personnel, in the event of an accident. If you are containing all of the radioactivity within the containment, and you are asking the operating staff to think about accident management and severe accident coping strategies, we have to start worrying about the onsite dose rates, particularly the shielding that is afforded the containment and the habitability of various places in the plant.

The other secondary function of the containment is, it acts as a leakage collection system for plant normal operation, which is really of no concern in the discussions that we are talking about in severe accidents.

[Slide.]

MR. LUTZ: In terms of being an international vendor, and looking at Europe and Japan also, there is another aspect that containment, especially in terms of future concepts, plays there. And that is in terms of emergency planning.

The emergency planning in the U.S., with the 10-mile emergency population zone, is predicated on certain containment performance for severe accidents that allows that distance to be set at 10 miles.

Now, I know, particularly, some of the European countries, such as Italy, are looking at having no offsite emergency planning in the event of severe accidents, no emergency plan per se, but only having enough time to institute ad hoc types of emergency planning. So, in terms of talking about containment design criteria and containment performance for severe accidents, we, as Westinghouse, are also looking at that, the impact on emergency planning, for some of our international possibilities.

At present, the primary criteria that impact the containment design are really three places in the regulations. One is the General Design Criteria in 10 CFR Part 50, Appendix A, which requires a system to mitigate the consequences of an accident, of a design-basis type of accident; 10 CFR Part 50, Appendix J, which is the containment leak-rate testing; and finally, 10 CFR Part 100, which has the offsite dose criteria for deterministically-prescribed, maximum hypothetical accidents. And those specifically impact containment design in terms of the maximum leak rate from the containment, and the containment safeguard system performance, particularly the fission products scrubbing of containment spray systems for PWRs.

So, with that as the overall criteria for containment design, all of which were promulgated long before we started investigating and worrying about severe accidents, these, I think, form the basis of the containment design for PWRs that we have out there today, and given that there are no changes in the regulations, these would be the set of regulations that would govern the design of new containments for the new evolutionary plants, in terms of the Commission's regulatory guidance.

[Slide]

MR. LUTZ: What I would like to do is just briefly try to describe for a large dry PWR containment, such as a Zion type of containment, what those three criteria have resulted in, in terms of design, and the capability of that design to handle severe accidents, even though the original design was not predicated on severe accidents and, I think it's fair to say, in most cases, did not consider severe accidents, but when we look at severe accident sequences for those containments and look at the containment performance, we find that, in general, the large dry containments have a very large margin for accommodating severe accidents. Some people use the words "a very robust design".

For the most part, containment integrity can be shown to be maintained during the early dynamic portions of severe accidents, and I'm talking up to and through reactor vessel failure and for the few hours after reactor vessel failure, with a rather -- in my opinion, a rather high degree of confidence, when you consider all of the severe-accident phenomena that one would predict to occur on a best-estimate basis.

Secondly, we find that containment integrity can be maintained and is maintained in the long term following a severe accident if containment heat removal is available, one of the active containment heat-removal systems, and for the large dry PWRs, we're talking about either containment spray in the recirculation mode, with the heat exchangers in operation, or for those plants which have safeguard-grade fan cooler systems, those fan cooler systems, and in fact, we've found that, even in the case of severely-degraded heat-removal capability from those systems, we can still maintain long-term containment integrity.

An example of that, for the Zion plant, the design basis for the fan cooler is three out of five units in operation. If we look at the long-term containment pressure, containment heat removal for an accident and have only one fan cooler unit, out of five, in operation, the pressure still remains well below design -- the design pressure and is on a decreasing type of trend.

So, we can stand, for the most case, severely-degraded heat-removal capability because of the large margins, again, in the design basis.

What we find, generally, for the large dry containments is that containment failures that we would predict, and these are over-pressure type of failures that I'm talking about, occur as a result of failures of the active containment heat removal system, and they are generally predicted to occur at times greater than 1 day.

In the PRA studies that we do, we go through and we calculate failure occurs at greater than 24 hours, but you have to realize that one of the assumptions in that analysis is that there are no operator actions taken to try to terminate the event, even in that long period of time. We're talking and Trevor was talking this morning of 24 and 48 hours for a containment failure.

The ground rules for most of these analyses are that if the procedures are not -- if there are not procedures written that are part of the station emergency operating procedures, than no credit is given for any operator actions, when in fact, if we're talking about times greater than 1 day and on the order of 2 days, there are certainly a number of measures that could be taken to prevent containment failure from occurring altogether.

So, when we talk about those long times, that's without any heroic operator intervention at all.

MR. KERR: When you talked earlier about large drys having a large margin for dealing with severe accidents, what is the meaning of "large margin" in this context?

MR. LUTZ: The large margin -- if you look at the best estimate or mean value of the containment ultimate capability, in terms of either pressure or temperature, and then track what the transient pressures and temperatures during any number of severe-accident sequences -- what they are predicted to be, that there is a large margin between the prediction and the ultimate number for failure, the ultimate value for failure.

MR. KERR: If I have a sequence in which I lose containment heat removal capability, apparently I get failure in slightly more than 1 day, judging by your bullet there. Is that a large margin?

MR. LUTZ: I would consider that a large margin, in my opinion, particularly when we compare that to the original predictions in WASH-1400, which were predicting containment failures in several hours.

MR. KERR: I just wanted to know what you meant by "large margin".

MR. LUTZ: For this case, the margin, I am saying, is the margin in the time for operator action to reverse the situation.

MR. KERR: And you are apparently ignoring the prediction of direct containment heating. I don't criticize you for that, but apparently you are, when you make that statement.

MR. LUTZ: That is a technical difference of opinion.

MR. KERR: No, but I mean, you are ignoring it.

MR. LUTZ: That's correct. We do not believe that they are of sufficient magnitude to challenge the integrity of the containment.

MR. KERR: Sufficient magnitude or likelihood?

MR. LUTZ: Magnitude.

Even in the study we did in 1983 for Zion, we did predict that the core would be swept out of the cavity region.

MR. KERR: Okay.

MR. LUTZ: So, I am talking magnitude of the pressure increase.

MR. KERR: Okay, but your argument must not have been very convincing as far as the staff is concerned.

MR. LUTZ: Well, the staff's function is to provide critical review, and quite often, they come up with independent models, and we have technical disagreements.

MR. KERR: Thank you.

[Slide]

MR. LUTZ: I sort of led in a bit to the next slide that I had and the point being made that containments that have been designed to the existing criteria, the large dry PWR containments, can generally accommodate both short-term and long-term accident phenomena.

In particular, we're talking about the hydrogen levels. They generally have sufficient volume to maintain hydrogen levels below detonable limits, and in addition, in terms of local pocketing, not only is there generally predicted to be good mixing within these containments, which is based on geometry, but also the overall geometry is not conducive to the transition to detonation phenomena.

In other words, they are large, open structure, whereas transition to detonation requires some confinement of the flame front. It's very difficult at, for example, 13 or 14 volume percent hydrogen, to have a transition to detonation in a very large, open volume.

MR. CORRADINI: This is a detail, but I'm curious: In terms of mixing, you're familiar with the recent HDR experiment and the benchmark on it, where they saw the pocketing of hydrogen in portions of the HDR containment. Is your feeling that that's peculiar because of the compartmentalization of the containment?

MR. LUTZ: I have not had the opportunity to go through that in sufficient detail to comment on it right now.

MR. CORRADINI: In between the times, one of the members of the audience mentioned to me that one of the criteria that isn't there but is tacitly assumed is that 13 percent is implying well-mixed, or the 10 percent, whatever the criteria may be, and whether or not it's well-mixed is going to be a function of the geometry.

MR. LUTZ: Very much so, yes.

MR. CORRADINI: Okay. So, along with saying that you meet the criteria, you have to do some sort of calculation or some sort of argumentation that you can have a well-mixed situation, rather than pocketing.

MR. LUTZ: That's absolutely true, or conversely, to be able to show that you can handle the pocketing.

In general, we believe that the containment geometry is not conducive to large-scale direct containment heating that would produce pressure sufficient to challenge the containment integrity.

MR. WARD: What do you mean by "large-scale" in that sense?

MR. LUTZ: I don't think that anybody can argue that there will not be some amount of core debris that may be swept into the -- finely particulated and swept into the containment atmosphere. What we're talking about is the degree to which -- or the amount of that.

If we look back at even some of the early IDCOR reports in 1985, I believe, where they were saying there is no direct containment heating, if you read it very carefully, they were predicting a few kilograms of core material, and they were calling this no direct containment heating. This is certainly dependent on the containment geometry as to exactly what amount you might predict or what range of amounts you might predict.

When I'm talking about large, I'm talking about the numbers that, for example, are the NUREG-1150 report, that will cause containment failure, where we're getting -- I think the number is upwards of 50 percent or more of the core debris into the containment.

MR. SIESS: What kind of pressures are those? What kind of pressures come out of that?

MR. LUTZ: Excuse me?

MR. SIESS: What kinds of pressures, what orders of magnitude of pressure come from those values for direct containment heating?

MR. LUTZ: From the --

MR. SIESS: The ones you just mentioned.

MR. LUTZ: -- few kilograms?

MR. SIESS: No, any of them.

MR. LUTZ: I don't recall exact numbers, but something like 50 percent of the core debris, with the reaction of the unreacted metal, the oxidation of the unreacted metal plus the hydrogen burn would give something like 9 bars pressure, delta pressure increase -- something on that order.

MR. SIESS: Delta pressure over what?

MR. CORRADINI: Over the starting pressure.

MR. LUTZ: Over the starting pressure --

MR. SIESS: Starting pressure is used close to atmospheric, isn't it?

MR. CORRADINI: Well, for Surry, where I have seen this done, the pressure is just before vessel breech. So, it's like 2 bars, 2 1/2 bars.

MR. SIESS: So, we're talking about 11 bar. That's not much beyond the capacity of --

MR. CORRADINI: That's the point I think he is making.

MR. LUTZ: Yes, that's exactly the point. We don't believe that you can get 50 percent of the core debris into the containment atmosphere for almost any of the large dry PWR designs. Now, there may be one or two out there that we haven't looked at.

But in general, the amount of core debris that we would be predicting that would be finely particulated, that could participate in direct containment heating would be on the order of a few kilograms or a few tens of kilograms which would give you pressure increases on the order of 1 or 2 p.s.i.

MR. SIESS: I guess it's clear, isn't it, that we're leaving ice condensers out of this?

MR. LUTZ: Yes.

MR. SIESS: That was a mistake we're not going to make again in terms of --

MR. LUTZ: I think we can say that the evolutionary plants will not be modeled after the ice condenser.

The last point is that the reactor cavity geometry in general for the large drive PWRs is conducive to core coolability. On most of the designs, there is a way to get water rather easily into the reactor cavity region or for that matter, any region on the bottom of the containment where the core debris might be and secondly, there is sufficient area for quenching and heat removal of the core debris that would reside there.

Most of the plants quite easily meet either the NRC or the EPRI criteria that were presented this morning, the .02 square meter per megawatt criteria or the 25 centimeter depth criteria.

MR. WARD: Let's see. Bob, on that, your qualifier "generally accommodate" in the first, at the top there, is that because of the range of phenomena or is it the range of specific containment designs that are actually out there?

MR. LUTZ: The reason I put "generally" -- if you go down through, you'll notice the word "geometry" appearing in almost every one of the bullets here and geometry plays a very, very strong role in the capability or the containment performance during a severe accident in terms of these phenomena that can potentially challenge the containment under some containment geometry conditions.

Now, we have not gone through the IPE process, you know, and looked at plant vulnerabilities on all the large drive PWRs out there. So, I used the word "generally" just to be on the safe side.

MR. WARD: Okay.

MR. LUTZ: Based on the ones that we've done like Seabrook and Zion, Millstone-3, those that have PRAs done already, I think every one of these fits those plants.

MR. WARD: Okay, but do you have reason to believe that there might be some geometries that could be problems? No, no, I'm wondering about existing plants. I guess I'm concerned about whether the IPE process is going to be able to identify geometries, containment design details, that could be problems with -- opposite these concerns.

MR. LUTZ: I think maybe I can give you an example without mentioning any names but just that they're German plants and they're KWU designs. We have done some work over there in the severe accident area --

MR. WARD: Other than that, you won't mention any names.

[Laughter.]

MR. LUTZ: -- and have found this not to be true, this not to be true -- in fact, every one of them not to be true on one -- not all at the same time on a given plant but we have found PWR designs that have not met each one of those criteria.

MR. SIESS: But you do know the geometric criteria well enough to specify them for a future design.

MR. LUTZ: I'll get into that. In terms of the future design, we think we know what the right way to do things is. The other two areas that can impact containment performance and I don't have them on the handout material but I'll come to it later so I might as well mention it now, is the containment bypass and the containment isolation problems or issues.

In general, I think the later analyses that we're doing show that the probability of those events are rather low although they can lead to rather large releases that could be classified in the large release type of category but some of the more recent analyses are putting the probability of those events at a rather low point -- below the ten to the minus six or ten to the minus seven range.

MR. SIESS: Does that include pre-existing openings?

MR. LUTZ: That includes pre-existing openings, yes.

MR. SIESS: There are some recent studies that reduce that down to ten to the minus five? The most recent study I've seen put it at 95, I mean.

MR. LUTZ: You're talking about the ANI, American Nuclear Insurer's study?

MR. SIESS: Yes. Fairly persuasive.

MR. LUTZ: Yes, if you take that and we have taken that and used that as the basis of our data and looked at those events for the PWR on a particular plant, that would be physically impossible. There were a couple of problems in there and I forget the specifics right now, that were not generally applicable to some of the newer containment designs.

So, when we're talking about Zion-type containment designs, the probability of pre-existent openings is not -- can be derived from that data but you can't use the numbers directly.

MR. SIESS: Have you given any thought at all to using an operating procedure that would detect pre-existing openings operating against a slight pressure -- plus or minus?

MR. LUTZ: That is one of the considerations in the evolutionary plant design that I have on my last slide.

[Slide.]

MR. LUTZ: Let me just point out, it was sort of brought up this morning in Trevor Pratt's presentation, in the process of translating the information that we have on the containment performance for the existing designs like the Zion or the Seabrook design and taking that type of information, what we can learn in terms of new plant designs and looking at the new plant designs, we did identify one conflict, so to speak, that affects containment design that would require either a change in regulation or regulatory practice which we believe would increase the overall level of safety afforded by the containment.

In the SP/90 plant which is a 1,300 megawatt PWR, the containment is a steel shell, cylindrical steel shell with an annular region and then a concrete shield building and for that design and it's not very much different than some of the plants that are out there, you have to have the double containment in order to meet the 10 CFR Part 100 off-site dose criteria for the steel shell containments, similar to maybe Prairie Island or the Vogtle plant.

This is based on the deterministic criteria of the TID 14844 type of releases.

MR. WARD: Is that because of leakage where it -- penetrations, or what?

MR. LUTZ: It's the overall leakage from the containment. It's very difficult to get it down to the .1 volume percent per day from the primary containment.

MR. SIESS: There's an assumption usually made that it leaks into the annulus and leaks out of the annulus without any mixing, a dilution.

MR. LUTZ: No. No. That's not true.

MR. SIESS: It used to be.

MR. LUTZ: Okay, on the SP/90 designs --

MR. SIESS: I'm not talking about the SP/90. I'm talking about plants like Prairie Island and some of the others. The staff always assume that you couldn't pull a vacuum in the annulus until 15 minutes after the accident and that what leaked into the annulus leaked out of the annulus without any mixing. That may have changed.

MR. LUTZ: Okay, I don't know about Prairie Island. I'm pretty sure in Vogtle, the Georgia Power plant, that there was credit for that throughout the event. I think they run it during normal operation even at a quarter inch of water, negative pressure. So it's there initially on that plant.

MR. SIESS: Staff has changed the basis because everybody ran that way. There may be a change in what the staff has been assuming but I think they assume that the expansion of the steel containment is enough to reduce that negative you had on it and bring it up.

Go ahead.

MR. LUTZ: Okay, but anyhow, the point is that under the current regulatory practice for evaluating that type of containment with the design basis leakage rates that are typical of that, you need the double containment to meet the off-site dose criteria in Part 100.

What that does, in severe accident space, it would be very nice to provide an external spray on that containment shell, means of spraying water on the outside, you get very good heat conduction through the shell and we've done some preliminary analysis to show that you could probably keep it below the failure pressure so long as that external spray was working and that you would never reach the ultimate containment failure pressure.

The problem is, the water runs down there, collects at the bottom, and as you continue spraying, it builds up and the hydrostatic head causes problems with some of the equipment and the structure itself. The easy way to fix that would be to put some drains at the bottom but then you couldn't maintain it at negative pressure very easily.

MR. CORRADINI: Can't you use the check valves, lip seal.

MR. SIESS: You have to maintain it at negative pressure in order to meet the 25 rem at half mile for a severe accident condition? Are we still talking about the hypothetical --

MR. LUTZ: We're still talking about the Part 100 criteria.

MR. SIESS: We're now talking fictitious licensing basis and not real life.

MR. LUTZ: That's absolutely correct.

MR. WARD: That's the point he's making, I guess.

MR. LUTZ: That's the point that we've identified.

MR. WARD: So you need the drains? You don't have to vent that space to have effective cooling?

MR. LUTZ: And vent. Sorry, I left that off.

MR. WARD: You have to vent if off.

MR. LUTZ: The drain is one consideration. The vent is the other consideration.

MR. CORRA..NI: I am missing why you need the vent. I'm sorry. Why do you need the vent? If it's a closed volume and you're just adding water and taking water away through the bottom?

MR. WARD: I presume it's evaporative cooling; isn't it?

MR. LUTZ: There's also some evaporative considerations.

MR. CORRADINI: Fine.

MR. SIESS: Does that secondary containment help you for any realistic scenario?

MR. LUTZ: Not that we have identified. The only thing that it does do in terms of severe accidents and realistic accidents is it provides significant additional shielding so that the dose rates on-site in the vicinity of the buildings are quite --

MR. WARD: But that doesn't have anything to do with being sealed.

MR. SIESS: You need -- look -- you need the secondary containment. It's tornado, missile protection, a few other things but I'm trying to get at the radiological consequences other than direct shielding.

MR. LUTZ: There are no big benefits from it that we have identified.

MR. WARD: How much would those Part 100 requirements or those criteria have to be relaxed to permit you to use this sort of design? I mean, I guess you run into the 25 and the 300 rem?

MR. LUTZ: It's really the thyroid.

MR. WARD: The thyroid dose, okay.

MR. LUTZ: The 300 rem thyroid that we'll run into.

MR. WARD: Okay, and if you have a vented secondary annulus, that 300 goes up to 30,000 or 500 or what? Do you have any feel for that at all? You must have.

MR. LUTZ: I forget what the number is. It's not 30,000. It's on the order of 600 to 1,000 maybe.

MR. WARD: Is that right?

MR. SIESS: I think you skipped the previous slide that said --

MR. WARD: He's going to come back to that.

MR. SIESS: But no changes in the reg requirements except this one because this one is a negative effect, but are there any other regulatory requirements that don't necessarily have a negative effect on public health and safety but don't have a positive effect like the integrated leak rate test?

MR. LUTZ: There are, I think --

MR. SIESS: In real scenarios, does the integrated leak rate test reduce risk?

MR. LUTZ: In my opinion, the integrated leak rate test is not nearly as important as the capability to assure containment isolated, or, that the containment is isolated. That's where your big risk is and if by doing integrated leak rate tests, you discover large, gross types of leakages that you don't discover any other way, then it's a benefit.

MR. SIESS: Has that ever happened?

MR. LUTZ: I don't recall that there has been anything that's been more than maybe a factor of two over the tech spec.

MR. CARROLL: That's because you do all the local tests before you do the integrated tests and it really isn't a real test.

MR. LUTZ: That's correct.

MR. SIESS: But there's no way you're going to go in there and make a surprise integrated leak rate test.

MR. LUTZ: To answer your other question though, the only other regulation that may impact and I haven't really evaluated or I've never seen evaluated, is the equipment qualification, the dose rates that are used for equipment qualification. They're based on the old TID -- at least, the last time I looked, they were based on the old TID 14844 values instead of the realistic values that we'd be predicting for severe accidents.

MR. WARD: Bob, what about existing -- this is a little off the subject -- but existing containments at Westinghouse plants, let's say large drys -- do they all have or what fraction of them have this annulus between the steel containment shell and the shield building which could conceivably accommodate a spray if this regulation were changed?

MR. LUTZ: I think all of the ice condenser plants, I think, have that -- Kewaunee, Prairie Island, Vogtle -- I don't think Ginna does. I think that's about it.

MR. SIESS: What's the question? Are there any steel?

MR. WARD: Yeah, how many of them, I guess, are steel -- double steel containments with an annulus --

MR. SIESS: The only steel containments I know that don't have the annulus -- Big Rock -- that's not a Westinghouse -- Yankee --

MR. WARD: Well, they named a number of them.

MR. SIESS: I think he was naming ones that had the concrete shielding; weren't you?

MR. LUTZ: Yeah. Yeah, that's what we were naming.

MR. SIESS: The ones that don't have it -- LaCrosse didn't, that's a boiler, I guess -- Big Rock's --

MR. WARD: No, I was asking how many have the double containment or the inner containment as a steel shell which conceivably could be accessible to a spray.

MR. SIESS: Most of the steel ones do. Crystal River, a whole bunch of them.

[Slide.]

MR. LUTZ: So, given that, the question then became, how do we apply what we know to future containment designs and I think the first point that needs to be made is really the second one here, and that is that PRA must be used as a design tool, as a tool for design of containment and containment systems. Now, if we go back up to the No. 1, this is exactly what EPRI has tried to do in putting forward their design guidance and we would encourage the acceptance and use of that design guidance for evolutionary containment designs, new containment designs, containment system designs.

Let me briefly describe some of the things we have done in both SP/90 and the AP-600 work for some of the severe accident issues that will help ensure the containment integrity and what we have done for the most part is taken an approach that any of these issues where there are technical differences or large uncertainties between the industry and the staff, we would try to design the phenomena away, in other words, provide a design such that everybody could agree that it was impossible for the phenomena to occur.

We've done that in a number of cases. The design of the SP/90 and the AP-600 has sufficient containment volume and sufficient openness for mixing to accommodate hydrogen generation without achieving detonable types of mixtures, based on the EPRI requirements of 75 percent metal water reaction, 13 volume percent in containment. What we have done on top of that in both designs is included hydrogen igniters in the design. That makes the whole question go away -- as long as we can show that there's adequate mixing.

In fact, as Trevor had stated this morning, we even looked at placement of the igniters and for example, over the relief pool, the in containment RWST type of concept where the pressurizer pressure relief goes, is a strong candidate for hydrogen igniter location because of the potential for higher hydrogen concentrations in that area.

So, we've taken and essentially through design tried to eliminate this problem both through containment volume, containment geometry for mixing and the hydrogen igniter systems.

Second point is that we have intentionally designed these with sufficient reactor cavity area to accommodate long-term cooling by water cover and -- I think I missed it here but we've also provided a way to get water into those areas and in fact, on the AP-600 design, that is the lowest point in the containment and everything has to run in that direction or defy Newton's law of gravity. We've looked at containment --

MR. CARROLL: When you talk water cover, Bob, you're talking water in the cavity before or after the debris, both? The cavity has water in it before?

MR. LUTZ: Before vessel failure and long-term after vessel failure.

MR. CARROLL: That requires operator action to get it in before.

MR. LUTZ: On the AP-600 design, no, because whatever is lost from the primary system, first -- there's a small curb that, by the time you get to core melt, you have water down there on that design.

MR. CARROLL: But on the SP/90, it requires operator action.

MR. LUTZ: At the present time, yes, it does.

MR. CARROLL: Okay. All right.

MR. LUTZ: The one I left off here was the correct containment heating, and in both of those plants we have looked at the reactor cavity region and the instrument tunnel region and designed that to try to reduce the potential for any dispersion of core debris out of the reactor cavity, and secondly, we have provided means for reactor coolant system depressurization.

On the SP/90, that is a manual action by the operator that will be written into symptom-based procedures, and on the AP-600, it already includes that as part of the normal safeguard system. So, that's part of the whole logic of the passive system. So, we're at low pressure there.

So, we feel that those two things eliminate direct containment heating in those designs.

MR. WARD: Are those functions or the equipment to perform those functions, depressurization, what we usually think of as safety-grade equipment, and it's redundant?

MR. LUTZ: Well, in the AP-600, it certainly is, because its design-basis LOCAs and everything else depend on it.

MR. WARD: Okay. What about the SP/90?

MR. LUTZ: I don't know, because that's more a conventional plant that you would be using pressurizer PORVs, and I am not -- at this point, I am not clear what the pedigree is on those PORVs in that design.

MR. KERR: Explain to me how PRA can be used to generate sufficient containment volume to accommodate hydrogen generation without achieving detonable mixtures.

MR. WARD: It tells what "sufficient" is, maybe, or what it probably is.

MR. LUTZ: Could you repeat the question?

MR. KERR: Well, as I read that, it says PRA must be used as a tool for the design of containment and containment systems, and the first bullet says -- presumably this is one of things it's going to be used for -- determine sufficient volume to accommodate hydrogen generation without achieving detonable mixtures, and I'm puzzled as to how PRA can achieve that.

MR. LUTZ: I'm using PRA in a very general sense, to include severe accident analyses and severe accident considerations. I'm not talking the probabilistic part of PRA.

MR. KERR: What is probabilistic about that?

MR. SIESS: Nothing.

MR. LUTZ: In this case, the probabilistic part, you could say, is the metal-water reaction, the amount of metal-water reaction, and the timing.

MR. KERR: Now, clearly, the current staff thinking is not going to use PRA to determine metal-water reaction, because they are talking about 100 percent.

MR. LUTZ: But that is based on severe accident analyses that use that as an upper limit.

MR. KERR: But that's not probabilistic. That's a bounding calculation.

MR. WARD: How bounding is that? That's just 100 percent of the zircalloy clad in the active core, and there are other sources of hydrogen.

MR. KERR: I'm simply saying that nobody used probability to arrive at that result. It was arbitrary, and by arbitrary, I don't mean capricious. It was an arbitrary decision.

MR. SIESS: Let's face it. You can't use PRA to design, period. They can't design anything with PRA. PRA is an analysis, and that's not design. That's the inverse of design.

MR. LUTZ: It's a tool.

MR. WARD: You certainly use it to evaluate the design and to evaluate certain design choices you make.

MR. SIESS: You can use it to evaluate design choices. You can use insights from PRA to decide which things you want to design against and which things you can ignore, but I think, in your response to Dr. Kerr, you are mixing up severe-accident analyses with PRAs, and a severe-accident analysis is not a PRA and vice versa.

MR. LUTZ: The wording on the slide is wrong.

MR. WARD: Just say you're sorry.

MR. LUTZ: It's severe-accident analysis.

MR. SIESS: The probability that the severe-accident analyses are correct is something else.

Did you comment on that first bullet, as to acceptance of the EPRI guidance? Which particular features of the EPRI guidance? Does that include the 75-percent metal-water and the 13-percent? Is that essential?

MR. LUTZ: What I am more concerned about than exact numbers is that we have a set of -- or some guidance in place that is agreed on between the industry and the Commission, that gives us some values as designers that we can use to know that a design that we come up with will be acceptable in terms of regulatory review and licensing.

MR. SIESS: Does the EPRI criteria now -- does the document now address those five items in your second bullet? I know it addresses some of them.

MR. LUTZ: Numerically, it may not address these two in a numerical sense. I don't recall at this point. These are mentioned in the document, but I'm not sure how they are set out as criteria.

MR. CARROLL: Back to the issue of water in the cavity before debris, Trevor mentioned some down-sides to that. What's your response to those? Steam explosion, for example. Why is that better?

MR. LUTZ: Based on the conditions in the plant at the time of vessel failure, whether you're talking high-pressure sequence, low-pressure sequence, you can evaluate each separately, but we don't think that a steam explosion of sufficient magnitude to threaten the containment is credible for the large dry PWRs. Therefore, water being down there is not a detriment in terms of early containment failure or something that can threaten containment integrity at the time of reactor vessel failure.

Now, I agree with Trevor that it causes a much faster pressurization rate than if we didn't, but when you stop and start considering accident management, you have a plant sitting there for 12 hours. You know that the vessel has failed, the core is on the bottom, there is no water, it's eating through the containment. You're going to do something, and that's put water in, and you're going to find a way. You're just not going to sit around and wait for things to happen.

So, in our view, it's better to get the water in there first, keep the core cool, and given even the timeframe that we have with the faster pressurization rate, we still have on the order of 24, 36, or 48 hours to do something to get heat removal established.

MR. CORRADINI: A couple of questions: I am curious about -- I asked the question of Trevor -- I guess I should ask it of you, too -- and that is, if you were to think of from a design standpoint, you could come up with a way to design the containment such that, even if you have an energetic boiling event down in the cavity, it would be of no concern because of the overall pressurization.

Have you done calculations to see what's more limiting? That is, if I take a couple of criteria, one being the hydrogen, 100 percent metal-water reaction, 10 percent by volume in the containment, well-mixed, and then allow for a steam spike at the time of vessel breech, which is more limiting? Have you done those sorts of calculations to look at various type of criteria which may be more limiting for the SP/90, or am I not making myself at all clear?

MR. LUTZ: I know exactly what you mean, and I'm just trying to recall.

We have done those types of calculations, where we have treated each phenomena parametrically, and at this point, I was just trying to recall, and I cannot recall which was the bounding.

MR. CORRADINI: I'll bring up one of the things that worries me, and that is I would not like to have a cavity design and have a lot of water down there, because then I would have a water-locked cavity.

MR. LUTZ: That's absolutely true.

MR. CORRADINI: And if I have a water-locked cavity, I wouldn't need much of the melt to get down before I start worrying about blowing things apart just because I have got all sorts of liquid locking up the system to the local structure. So, I mean, having water is good, but the question is how much, also.

MR. LUTZ: Yes, or by proper design of the cavity, you can eliminate that.

MR. CORRADINI: Right.

MR. WARD: What do you mean by water-locked? Sealed?

MR. CORRADINI: Well, I mean that I have got the whole thing completely sealed, all the way up to the point where the vessel is going to be breached, and I just pour in -- I essentially just pour in melt into a cavity that's so completely full of water that if I have any pressurization at all, I immediately communicate to a boundary, to a pressure boundary, and I start breaking structure because of liquid-phase pressures.

MR. CARROLL: That's like vent pipe clearing on a pressure suppression containment.

MR. CORRADINI: Exactly.

MR. WARD: Okay.

MR. LUTZ: I agree that that's definitely a consideration. There are a lot of nuances to a lot of these.

MR. CORRADINI: Yes. I guess the nice thing, at least the way I look at it -- the nice thing is we can bring up all these things, because in a sense, even though the design is "fixed", I don't believe the design is really fixed, in the sense that you can actually look what's the limiting criteria and worry about that relative to the size of the cavity and the relative geometry.

MR. LUTZ: Let me talk just for a few minutes on this containment bypass sequence.

There are two types of containment bypass sequence that we have traditionally considered. One is the break in a line that is directly connected to the RCS system, and the other is the steam-generator tube rupture. In both cases, the core melt is caused by a loss of inventory outside of the containment, whereby you do not have capability to go to core-cooling recirculation, is the primary core-melt sequence.

What we have done, for example, on the steam-generator tube-rupture sequence is we have provided automatic steam-generator overfill protection, which vents back to the in-containment emergency water tanks, so that, in a tube rupture, if the steam generator fills, the water goes back to the containment, so that you always have the capability to go to recirculation. You always have sufficient water within the containment, and you're keeping the water within the closed system of the containment.

For the "V" sequence type of thing, on one of the designs, we have go to an in-containment recirculation system, RHR system, which greatly reduces the size of the largest line that goes outside of the containment that is directly connected to the primary coolant system, and I forget what the size of the line is, but it's significantly smaller than the 8- to 10-inch RHR lines that we generally consider, and when we did the analysis on that, we found that even if you broke the line, it was something like 24 hours to core uncovery, or 36 hours, some very long time to core uncovery for that "V" sequence type of event, and given those long times and accident management types of considerations, we feel that we have done something very constructive in terms of looking at those sequences.

MR. CARROLL: For your steam generator overfill protection, where you're returning the water into the containment, is there any concern that one could continue to put feedwater in, in addition to the primary water, and potentially cause problems or even over-pressurize the containment as a result of filling it with feedwater?

MR. LUTZ: I don't believe that that is -- I think the time to get into problem is so long for that type of event that the operator -- and there is sufficient control room information -- that the operator would terminate the feedwater, would be able to diagnose the event and terminate the feedwater to that generator.

MR. CARROLL: But, probably, unless somebody gets clever and puts firewater into the condensate storage tank, you probably don't have enough water anyway.

MR. LUTZ: Yes. Normally the flooding limit on containments is half of the CST, anyhow, in addition to the entire RWST.

MR. CARROLL: Okay.

MR. LUTZ: In terms of containment, the assurance of containment isolation; we've been looking at a couple of things. One is the use of fail closed valves, air operated fail closed valves with their own little gas bottle.

It seems like there's a switch to go away from the motor operated types of isolation valves, because of the reliability in terms of assuring a closed system under all types of severe accident sequences.

MR. MICHELSON: You have another problem, then, of assuring that the bottles have gas in them when the non-essential air system fails.

MR. CARROLL: The check valve problem.

MR. MICHELSON: The check valves may not be working and, we know, they're not easy to test.

MR. LUTZ: That's part of the whole thing that we're looking at, but we are looking at those isolation valves and how to improve the reliability of those. In addition, we're looking at, or at least doing some preliminary investigations into some sort of a monitoring system to detect un-isolated containment penetrations. We're looking at a number of different concepts there.

Equipment --

MR. MICHELSON: Did you use inflatable seals at all for personnel air locks and equipment air locks or equipment hatches, rather?

MR. LUTZ: At this point, I'm not familiar with what is in the two designs.

MR. MICHELSON: You might want to look at it some time, because, of course, then you have to worry about the integrity of the air supply to the inflatable seal and you also have to worry about the temperature capabilities of those seals for prolonged periods for severe accident.

MR. LUTZ: We have looked at the containment integrity in terms of temperatures and the organic sealant materials. We did that very early.

MR. MICHELSON: At the air locks in that regard or just the --

MR. LUTZ: I would suspect that that was investigated. I can't say for sure right now.

The last item that we've been looking at a bit is some equipment survivability and looking at hydrogen burns and, particularly, things like the capability of the fan coolers to operate after a hydrogen burn.

They are particularly sensitive to hydrogen burns since steam is removed on the condensing coils which can leave you with a hydrogen-rich atmosphere just downstream of the cooling coils in the fan coolers. So assuring their integrity is something that we're looking at.

I guess, in conclusion, I took this off too fast. We don't see the need for any changes in regulatory requirements or regulatory practice, other than possibly sorting out the inconsistency between the severe accident analysis methodology and the deterministic source term methodology.

In terms of requirements and practice, however, we do encourage and urge guidance, design guidance in terms of severe accidents, along the lines of the EPRI design guidance.

MR. WARD: You'd view some sort of formal endorsement by the NRC of the EPRI criteria as something different from regulation?

MR. LUTZ: Yes, I would.

MR. MICHELSON: Have you mentioned your position on containment venting for the large drys?

MR. LUTZ: No, but I will.

MR. MICHELSON: If you will.

MR. LUTZ: We don't believe that containment venting is necessary for the large dry PWRs and, particularly, for the evolutionary PWRs. Let me sort of start out at today's existing PWRs.

For the large dry containments, the time predicted to failure of the containment by long term over pressurization is very long and we believe that when we get into this accident management strategies or coping plans, whatever you'd like to call them, over the next couple of years, that we can define ways of recovering coolability of the containment such that -- and actually lay out some formalized coping strategies that can be implemented in the timeframe that we have, and thereby eliminate the need to ever release anything intentionally.

On the evolutionary designs, particularly the AP-600 design, we're going through a design process to ensure that even if no active cooling is provided to the containment, that it will never overpressurize to its failure pressure.

We're doing that by using convective air flows on the outside of the steel shell. Our analyses indicate that we think we can achieve that for the evolutionary design.

MR. KERR: If I understand you correctly, what you are recommending is that there be no changes in the regulatory requirements, even in the face of the fact that the existing regulatory requirements were formulated without taking any account of severe accidents.

MR. LUTZ: Yes. I think my opinion is that even though they were formulated in that era, that they have done -- for the large drive PWRs -- that they have done a rather good job for severe accidents.

MR. KERR: Since we have never had a severe accident in a large dry containment, it seems to me that it's difficult to know for certain. But in that sense, I guess they've done a good job because -- I can't understand the situation in which the only time there is any significant risk to the public is when one has a severe accident.

When a containment is designed to protect the people, the one with criteria which did not take the severe accident into account, but perhaps that logic is lost on the --

MR. CARROLL: Your statement is regulation, regulatory requirements, and regulatory practice. By the latter, I guess you mean what's currently evolving in terms of the way you look at severe accidents. Is that not right?

MR. LUTZ: Yes. What I'm suggesting is that we don't need any change or I don't see a need to change the regulations. What I do see is a need to somehow -- and maybe somehow you call that regulatory practice -- to use something along the lines of the EPRI design guidance.

MR. SIESS: Let's assume for a moment that I'm a structural engineer trying to design a containment. I've got an overpressure. What I see is you would pick the volume to accommodate the hydrogen. That's what it says. That's the first item.

How would I get the pressure? Use the LOCA type analysis of the present regulations; largest guillotine pipe break to get a design pressure, and then use the ASME Code to get the design, the appropriate load factors, safety factors, etcetera?

MR. LUTZ: I believe that that would be a way to go.

MR. SIESS: How would I get the temperature? That would give me something that we have now and we know that we're good for about two-and-a-half times that and so forth. But the temperature that I'd get from the present requirements from a large LOCA is not going to be as high as the temperature I would get from severe accident, is it?

MR. LUTZ: No. Your saturation temperature for severe accidents at two-and-a-half times design pressure is probably going to be controlling provided that you have assurance of having water in a coolable core debris.

MR. SIESS: But I've got all sorts of penetration seals and stuff that are temperature sensitive. Are they good enough if I design them for the LOCA temperature?

MR. LUTZ: Generally, we have found -- we have done some investigations of some of those sealant materials and I believe it's something like 400 or 450 degrees fahrenheit is where they begin degrading.

MR. SIESS: Well, inflatable seals that were recently tested for personnel locks degraded at 400 without any load on them, without any pressure on them. That was, I think, above what the severe accident temperatures are. Again, I'm just wondering, are the present requirements good enough for temperature or do we have to look at real life again?

MR. LUTZ: I think that as a minimum you have to, shall we say, bounce it off of real life to see if it makes sense. If you define severe accident phenomena or severe accident sequences; for example, one of the things that we're worried about is hydrogen burns. Now, you have to go through some thermal lag analyses on things like transmitters and things, but we're looking at temperatures that are created by hydrogen burns in terms of equipment survivability.

If we're going to put igniters in the containment to burn hydrogen, we better look and see what the effect of that is on the equipment that we might want to use or the instrumentation that we might want to use to diagnose what's going on. So it's an integral part of the process.

MR. KERR: But you wouldn't want that same temperature to be used for containment design.

MR. LUTZ: I said with the appropriate thermal lag analysis. In other words, given a hydrogen burn, what --

MR. KERR: I thought you were talking about equipment survivability when you use that terminology. I'm talking about containment design, which is what I thought you were recommending no changes in regulatory requirement for.

MR. LUTZ: That is correct. I'm trying to think of the place in the regulation where the temperature, you're just talking about the local pressure.

MR. KERR: I would assume that a designer of a concrete containment would want to know something about the temperature of operation that would be appropriate. Maybe it doesn't make any difference.

MR. LUTZ: Or normal, yes.

MR. KERR: But if it is going to contain, it seems to me one would like to know whether it would contain at the temperatures that might be encountered in a severe accident.

MR. LUTZ: Okay. And I believe that that is generally saturation temperatures.

MR. KERR: If you are talking about a large-break LOCA as the most severe accident; or are you? If you aren't, then Part 100 does not deal with this, I believe.

MR. LUTZ: Well, that is part of the whole inconsistency with Part 100 and severe accidents.

MR. KERR: Okay. If you agree that the existing regulation are inadequate, then I have no more.

MR. WARD: But your word is just a "source term," though. You are complaining about the inconsistency in the source term.

MR. CARROLL: But that is what Part 100 is about.

MR. LUTZ: If we go back to the previous slide, I identified the source term problem as a problem with Part 100, and then, and I didn't verbalize this when I put the slide up, that there are or may be other conflicts as a result of using deterministic methodology, which is not consistent with current severe accident methodology, instead of PRA methodology.

MR. SIESS: You are not saying that what we are doing now is correct; you are just saying you are not going to argue about changing it. That was the EPRI approach on the LWR requirements. There are things they recognize that don't make sense, but it is easier to accept them than it is to get in there and change them.

MR. LUTZ: Yes. They are not causing us that much grief, or not causing anything to be done that we would not want to do.

MR. WARD: Okay. Bob, thank you very much for a very useful presentation.

Gentlemen, I will ask you now whether you want to take a break at this point. We have two more speakers. And hearing no advice, I will say let's take a break. Let's come back at 20 minutes of 3:00.

[Brief recess.]

MR. WARD: Gentlemen, our next speaker is Geza Gyorey of General Electric. And I think we will get a little bit of a change of pace here.

[Slide.]

MR. GYOREY: My name is Geza Gyorey. I am Manager of Safety and Licensing at General Electric's Advanced Nuclear Technology operation.

We are the prime contractor to the Department of Energy on the advanced liquid-metal-cooled reactor design program.

[Slide.]

MR. GYOREY: My presentation objectives are to provide a perspective from the point of view of the liquid-metal-cooled reactor program, which is quite different than the water-cooled reactor, in many aspects. And to do this, I would like to give you a quick presentation on the basic approach which was involved in this design program, the tradeoffs we have faced, and some of the unique characteristics which affect our view of containment and how the integrated design turned out.

[Slide.]

MR. GYOREY: To start with, this is my personal view of the current containment situation.

Before I go on with any statements, I would like to say that I believe that the existing operating plants do meet the safety goals with direct containments as they are. And when I talk about passive systems, or added margins, and so forth, what I am really talking about is greater confidence and larger margins beyond the established safety goals.

The current containment concepts, of course, are for water-cooled reactors, which have the two key characteristics stated there: high pressure and high stored thermal energy. And certainly the designs up to this point have been dependent on many active systems.

And the reason I mention this is because perhaps a different approach may be appropriate for systems which have quite different characteristics.

Again, my observation is the tendency has been, and we have run into this in our design, to emphasize the form of containment as opposed to the containment function, function depending on many things in present design, certainly on many active and inter-relating things, and systems.

Now, the current related trend now is to, as has been discussed here this morning and this afternoon, to start examining the containment functions for very low probability severe core-disruptive events. And this, in my opinion, gets one immediately into the very difficult area of event selection at very low probabilities, perhaps event selection and judgments at event probabilities below the level of the safety goal.

And that selection has to draw a line somewhere; I think it has drawn a line somewhere, and found certain events which are relegated to a residual risk category. And that is one of the things that makes things difficult. And some of them are mentioned there, like vessel rupture, and several other events which are physically possible but very low probability have not been selected for examination for severe accidents.

[Slide.]

MR. GYOREY: Let me proceed now to the advanced liquid-metal-cooled reactor program, and start with its safety basis.

We are in the conceptual design stage, so a lot of things are not quite defined, not quite nailed down. You have to view what I say in that context.

Furthermore, when this conceptual design process started, around 1984, 1985, a lot of the guidance from either the staff or from you, regarding how to meet safety goals and so forth, have not been available. And since then, many things have happened.

So when we started, of course, the fundamental requirement was a system that burns all the uranium, rather than 1 percent, for long-term energy assurance. That's why the system is the way it is.

The safety goal was already out and the advanced reactor policy was out. We have focused on the safety goals. And one of our fundamental objectives was to meet the safety goals and be highly responsive to the advanced reactor policy.

The advanced reactor policy specifically called for simpler systems, passive systems, longer time constants available to take corrective action, less dependence on operators, and less dependence on the balance-of-plant.

We then imposed further requirements -- and by "we" I mean both the designer and the customer, the DOE, together -- further objectives and requirements. And the most important one was this: a level of safety such that we can get away from the troubles of evacuation exercises and sirens.

In order to do that, our judgment was that we need to go to a very highly passive system. And in the most important aspects of it -- which are decay heat removal, reactivity control, containment -- we wanted to ideally go to completely passive systems, or at least as highly passive systems as possible.

So we asked for passive decay heat removal. And also, very importantly, we asked that the system have benign response to anticipated transient without scram events through passive means alone, both in reactivity control and in the decay heat removal after the ATWS event.

to get high reliability, we also wanted this system to be very highly resistant to operator errors, ideally have the system such that the operator cannot damage the core by operating the controls.

Up to this point, we have not found a way for the operator on the system to damage the core from the control room. We may find one later. But we hope to design so he cannot do that.

Finally, we have started immediately down the path of a system which will undergo standard design certification, and a full-scale prototype test.

I need to mention another important aspect of the system. That is, it is a modular system with small reactors, small units, equivalent of 155 megawatt electric apiece. So a large power plant would have nine small reactors.

So an observation based on this, when you look at these requirements, we concluded that these requirements will probably lead to a system which may very well meet the safety goals through prevention alone. We felt that an ounce of prevention was worth a pound of mitigation, and that the mitigation capability of a system would then provide hopefully additional margins beyond the prevention to meet the safety goals with high margin.

MR. CARROLL: The third bullet; the emergency planning issues; did I understand you correctly that these are DOE criteria or guidance?

MR. GYOREY: Yes, yes, the DOE requirement to us was; come up with a system so that -- you still have an emergency plan. It's prudent to have an emergency plan, but come up with a system so that the emergency planning and the testing and the exercising of the emergency planning does not need to include the exercising of the public and many public agencies, send sirens out in the neighborhood and so forth.

MR. CARROLL: Thank you.

MR. GYOREY: These have been the very bothersome points that we've experienced during the last several years.

MR. CARROLL: We're very well aware of that.

MR. GYOREY: That was a DOE requirement on the design.

MR. CARROLL: Okay.

[Slide.]

MR. GYOREY: The more recent guidance that has been received by the NRC staff and from you, many of them, but the key ones are listed here. These pertain to event selection and reactivity release limits.

I'm going to keep emphasizing those two because we think those are key in guiding and controlling the design, very specifically, the NRC staff key issues papers, SECY 88-203, which I understand will now be revised during the next several months, and your series of letters on the implementation of the safety goals.

The NRC key issues paper has addressed event selection and what do you need to do if you want to get away from the detailed evacuation exercises. They have come up with a series of event categories down to these kinds of per-year probability levels and a graded release probability as indicated there.

This addition, meeting the protective action guidelines for 36 hours, they added. That's what the recommended one should meet in order to get away from the off-site emergency plan exercises and the sirens.

These are, of course, their recommendations to the Commissioners and they have not been approved by the Commissioners. Then, in addition, we have picked up your -- these are somewhat -- are mostly consistent with the recommendations that the ACRS has made in implementing the safety goals or certainly 10 to the minus 6 is -- not necessarily these limits, but the 10 to the minus 6 is.

Then you added in your letter, a mitigation requirement, a minimum mitigation requirement. We read that to say that no matter how good you are with dimension, even if you can show you can meet the safety goal with prevention, we want an order of magnitude mitigation.

So we have added that to our -- these are what we right now are working toward and, of course, they're all recommendations. They have not been put into any reg guides and the Commissioners haven't approved them. That's what we have.

The observation that I would like to make on this is that certainly our opinion is that these criteria are much more restrictive than the safety goals. Even if I take 10CFR50, which is 25 rem, down to 10 to the minus 6, that seems to me at least an order of magnitude more restrictive than the safety goal.

If I add the lower level of protection action guidelines which is one rem whole body for 36 hours, that in effect says that you can't even have a very small release down to the 10 to the minus 6 per year probability and now I think we're probably two orders of magnitude beyond the safety goals.

Some of this compounding does concern us, because we're not quite sure where this is going to stop.

[Slide.]

MR. GYOREY: Now, let me go to the dwelling of the highly passive system. Our fundamental objective was to achieve very high reliability based on passive features alone in the important functions that are shown there, because those functions are interdependent. Now, there are various definitions of what is inherent and what is passive.

We have chose to go with what I regard as a rather strict definition of passive, which is shown here. All we're relying on are the laws of nature and structural integrity. There are other less restrictive definitions of passive. For example, we've got several EPRI and several other bodies who are working on these.

One opening on some less restrictive definitions is that you can have a single active action initiating the passive system, like the opening of a valve, for example. Some other ones also allow local DC powering valves and instruments and then there is quite some controversy on to what extent you should allow operator interaction.

You've mentioned both errors of omission and commission. In addition to this, there certainly is a wide range of robustness on passive systems in terms of how vulnerable they are, both to operator actions and to operator errors and to structural failures.

[Slide.]

MR. GYOREY: We recognize that, and on the next chart on the passive decay heat removal, I indicate that there is a tradeoff that we have immediately run into on this point of robustness and failure tolerance of passive systems. As I mentioned, we asked for passive decay heat removal and some of the key considerations on that are indicated there.

We looked then at the various heat sinks available. We looked at all of the four greek elements, fire, water and earth and air -- to be complete. Fire is what we're trying to get rid of, so that leaves the other three.

We found that water most probably will require, at least in the long term active systems -- we very much wanted to see if we could eject heat through the earth alone, but the conductivity just did not allow that, so we went to natural circulation air.

Now, here is where you run into a design tradeoff immediately on the failure resistance and robustness of passive systems. The first little cartoon indicates the way -- the conventional way and indirect way of removing decay heat from a liquid metal cooled reactor and that is with a circulating pipe system of sodium or -- going to ultimately air out at the top.

Now, the earlier designs had active systems; that is pump systems. People are now looking at natural circulation systems and it certainly can be done with natural circulation. However, the system will most likely require active initiation.

We think it will require active initiation, at least in opening the dampers up here to let the air circulate, because otherwise there will be much, too much heat loss during normal operations. As single passive failure, a single pipe leak or break, of course, will defeat the system because the sodium will run out.

You'll probably need valves -- you will need valves, perhaps isolation valves, somewhere on the system to isolate portions of it for maintenance, or at least a drain valve to drain the sodium out it for maintenance. This then makes it immediately subject to human error intervention.

So we decided to go to a direct air cooling which we felt had natural circulation air through very large ducts, very large interconnected ducts. This system does not require active initiation. You can let it run all the time, because to a great extent, it depends on radiative heat transfer out across two boundaries, which I'll get to in a moment.

That is pretty much self-regulating of the T-fourth law on temperature.

MR. WARD: So therefore, the heat loss at normal operation --

MR. GYOREY: Is quite tolerable.

MR. WARD: -- is not marked.

MR. GYOREY: It's tolerable and, in fact, this air circulation does a fine job of cooling whatever concrete structures we might have. I mentioned the small modular nature of the system. I also want to mention that in our design, grade is here. The system is essentially underground, except some of the stacks for this natural circulating cooling system.

The system, since it has large ducts and large interconnective ducts, is quite resistant to structural failure. We found that you can block it at any particular place as much as 90 percent and it will still -- you will still meet ASME code limits.

Because there are no valves in it, it is highly resistant to human interaction, however, you've got to get the air closer to the heat source than in the indirect system. Another item to mention is that the sodium pool has a very high heat capacity and you could stop this system completely for in excess of ten hours without exceeding the ASME limit.

So that's the source on the passive decay heat removal. Let me go on to the other item which can bear on containment integrity and that is reactivity excursions.

[Slide]

MR. GYOREY: The key item here is that we have required that for anticipated transient with scram, loss of flow, loss of heat sink, and control-rod run-out, we maintain a safe state -- that is, meet the ASME limits, wide margins to sodium boiling -- entirely with passive means.

On that rod run-out, I might mention that with the metal fuel and the breeder nature of the reactor, it is possible to design the core to a very low burnup cycle reactivity swing, so that one does not have to hold down much reactivity -- we were trying to lessen the dollar -- with control rods. So, a control-rod run-out or even all control-rod run-out from full power may not be a very large problem. It may be a problem that can be handled.

Now, this is the prevention side, and this is pretty much where we were going at the beginning of the program. More recently, we have started working, and we have a lot more to do on that, is to show the additional mitigative capability such that to show that the impact on the system boundaries is tolerable due to very low probability reactivity excursions, which may be energetic excursions, due to either sodium boiling or fuel motion. A fast breeder core is far from its maximum reactivity state in its normal operating mode. Fuel motion can certainly introduce large amounts of reactivity.

So, our objective was, then, to -- next objective -- mitigative objective was to look at the system boundaries and show that, even for the extremely low-probability events -- and we try to assure by all these other means that we never get there, but even if we get there, we do meet your 90-percent probability of -- your recommended 90-percent probability for no large release.

MR. WARD: How are you defining that, that 1 in 10 failure probability? What's the numerator and what's the denominator?

MR. GYOREY: Well, we took your definition, which I believe you asked for 90-percent probability that there is not a large release for the whole spectrum of core disrupting. I think you called it core melt. I call is core disruptive events.

Now, there have been a number of studies done around the world, in the past, on trying to bound these reactivity transients for sodium-cooled reactors, and there have been some bounding limits reasonably well-established. We want to re-examine those for our system. Numbers such as $50 to $100 per second and several hundred megajewels have been calculated for FFTF, the Clinch River reactor and by the Europeans, as to pretty much the enveloping event that one can physically postulate, never mind what kind of preventive capability you have.

So, we are now looking at our system under those kinds of conditions, and our early look showed that the system can take those with quite substantial margins. So, we think we can meet your 90-percent probability.

MR. WARD: Well, the reason I ask is that I think we suspected that might be a requirement that was easier for us to state than for someone else to calculate.

MR. GYOREY: It certainly is.

MR. WARD: I think where we made that statement, there were some words that a requirement or a criterion, something like this might be appropriate, but we had -- some of us had considerable concern that there was really a practical definition that could be made.

Do you feel there is a practical definition there?

MR. GYOREY: Well, my whole message to you, the central message to you in all this is going to be that what all this leads to is a problem of event selection and, really, its limits. I heard you discuss here that the designer, the structural designer, needs to know pressures and temperatures. I may be very fortunate. My structural designer doesn't ask me that. I may have a much better structural designer than others.

He comes to me and says, Gyorey, what are the events? You tell me what are the events I have to design for and what release am I allowed? He will calculate the temperatures and pressures, but he wants those things from me, and all this, all those probability ranges that the NRC staff is proposing in its key issues paper and this idea of examining the systems capability to severe core disruptive events, to me, immediately leads me into event selection and drives me into event selection at very low probabilities, and I want to reiterate my point that I wish it wasn't so, but I believe there always will be some events which will be -- will have to be in the residual risk category, in your 10-percent probability, for example, which may very well break the containment -- they may not, but there is some probability that they will. That's really my biggest problem.

MR. KERR: I don't believe that our letter said all severe accident sequences. It seems to me it said something like a representative set. I don't think even we were quite that all-embracing.

MR. GYOREY: Well, in the probabilistic risk assessment, we, of course, attempt to think of everything physically possible. So, there is that resource to mine, with all its limitations, to look at event selection.

MR. WARD: Right, but even in a PRA, this has to be -- although the goal is to think of everything, it has to boil down to a set of surrogates which you assume represents everything.

MR. GYOREY: Yes.

MR. WARD: And that's what you're doing here.

MR. GYOREY: The point that hasn't been made about containment is, of course, containment is -- the ultimate containment is very good to have, because it will save you for things that you haven't thought of, and unfortunately, I cannot tell my structural designer to design to that, because he -- I'll have to define the event to him.

[Slide]

MR. GYOREY: Okay. So, on to the containment function, and that gets us to boundaries. So, how did we proceed there?

Again, a few key consideration: We do recognize that active isolation and connected systems can, of course, impact the containment function.

Now, here is where we have an entirely different system.

Our system, at full power, runs at atmospheric pressure. The coolant is well below the boiling point, well apart from saturation, and even during low-probability events, such as anticipated transients without scram, it continues to stay well below the boiling point, and we have, certainly, low-pressure stresses on all these boundaries, because they're running at atmospheric pressures.

We do have this consideration in the sodium system: We don't want to lose the sodium. We don't want to uncover the core. So, below the sodium surface, we use -- clearly, you should use two boundaries, and you should use two very high reliability boundaries.

They are two vessels. There are no penetrations in them at all, so they are passive boundaries, and they have large temperature and pressure margins, certainly, at the normal operating level, between normal operating level temperatures and pressures and their ultimate capability, and even between fairly low-probability events, such as anticipated transients without scram, in their capability.

The ASME Level D capability of the primary vessel, it turns out, at normal operating temperatures, is somewhere around 700 psi, and of the second vessel, the containment vessel, is around 300 psi, and this head structure, the first boundary at the head, the weak points are the seals and their ASME Level D capability is in excess of 100 psi, and we're operating at 0 psi, gauged during operation.

Then we go to above to above the sodium surface. There is cover gas above the sodium surface, again at atmospheric pressure. So, if you poke a hole, nothing tries to get out very quickly.

The first boundary is the vessel head, which is a heavy steel structure -- again, large temperature and pressure margins, as I indicated before. Now, all the penetrations required go through there.

But again, we wanted to have a passive boundary, so we designed to a system where all these penetrations during normal operation are either sealed -- there are seals in them and then they're seal-welded on top -- or the very few number of pipes that go through here, which are used during shut-down for clean-up of either the cover gas or clean-up of the sodium, are during normal operation isolated with double isolation valves. You cannot start the reactor. The reactor-protection system will prevent you from starting unless those double isolation valves are closed.

The second boundary above the sodium surface, and this is now a little different. Some of you are in the

Advanced Reactor Subcommittee, and when we talked with you maybe as much as a year ago, we did not emphasize mitigation as much as we are doing today.

So, we're now looking at the second surface above the sodium surface, which is this head access area building with its stop at grade, as a mitigative second boundary.

MR. WARD: Geza, does that mean you have made some changes in the concept?

MR. GYOREY: Yes.

MR. WARD: Okay.

MR. HARDIN: Yes. We have made some changes both in approach and in design, and the change in approach I mentioned before. We really did not look -- previously, when we talked to you last time -- at those core-disruptive reactivity and possibility energetic events, and we did not -- and since then, in design, we beefed up the second boundary to be low-pressure. Right now, it's 2 psi capability with filtered vent on it.

This, interestingly, is not only very similar but essentially the same as the European -- the current European sodium-cooled reactor design, Superphenix II, and we're also looking at the latest EFR, European fast-reactor design, and they are moving in this direction, also.

We are trying to see how to make this as passive as possible.

The last important boundary is the secondary sodium system which, during normal operation, removes the heat, and that comes in here. It is completely sealed, and that is designed to a very high design pressure -- namely, 1,000 psi, and it's running at around 30 or 40 psi during normal operation. So, that is a rather robust boundary, and then, now, as I indicated, we're analyzing all these boundaries for the severe core-disruptive events which we didn't do before.

[Slide.]

MR. GYOREY: Finally, the recommendations based on all this -- the recommendations are really in two groups here. The first five bullets, down to about here, are reasonably generally in nature. Again, these are from the perspective of the liquid metal cooled reactor. I don't intend to go into the requirements for or the point of view of the water cooled reactors and our message is that please consider in your work and deliberations these systems which are quite different in pressure, stored thermal energy and in the level of passive systems.

For example, it's an interesting question. How would you compare the reliability and the capability of a single strong boundary which is passive, that is, completely closed during operation, versus two equally strong boundaries or maybe even strong boundaries but which are open during operation and require active systems to close them -- isolation.

The second part of these down here really addressed this idea, this item of event selection which I've discussed before and my main problem, to describe to the design just what events he must design for, what events may fall into the residua risk category which he doesn't have to analyze against, a PRA will but the design doesn't, and what kind of release limits to have and would like to mention, reiterate to you, our concern that in this area of event selection, we do see a trouble, some tendency, to go orders of magnitude beyond the safety goal.

We'll commit to meeting the safety goal and, of course, how do you know you meet the safety goal? The way you know is that NRC and you and your peers accept your probability numbers because that's the only way you'll know at these very low probability levels.

Finally, that for the mitigative capability, we get down into event selection at even lower levels, we believe for our systems, well below the probability levels mentioned in the safety goal and then we have to draw the line between those that we analyze and those that we put into the residual risk category.

That concludes my presentation. If you have any further questions, I'll be glad to attempt to address them.

MR. WARD: Very good. Any questions for Mr. Gyorey?

MR. SIESS: I am trying to formulate one.

When you talk about event selection, am I correct that you are talking about the same thing some of the other speakers have called "challenges to containment?"

MR. GYOREY: I really -- I am really talking about something broader than that, some -- certainly the lower -- certainly some of those events will be events challenging containment. I'm really addressing the whole spectrum which is on here.

[Pause.]

I don't know whether you would call a small number of fuel failures but no major fuel melting, no fuel motion, a challenge to containment. I guess it's a small challenge to containment.

MR. SIESS: Well, the containment is there to keep any fission products away from the environment.

MR. GYOREY: Yes. Yes.

MR. SIESS: So the presence of a fission product presumably is some kind of a challenge to the containment.

MR. GYOREY: Some kind of a challenge, but my point is, down here we have events -- here is an event category in the range of ten to the minus two to ten to the minus four per year where now the NRC staff is putting in a 10 percent of 10 CFR 100. That's something new. Well, the thing between this and this and maybe that's not terribly logical but there is something there.

MR. SIESS: Is that really new or isn't that the old like steam line break criterion for water reactors?

MR. GYOREY: I don't know. This is in -- I'm getting this out of here. I'm not aware of whether there's anything for --

MR. SIESS: They've always had a requirement for something. It was a substantial fraction of Part 100. I'd have to go back and look. You know what I'm talking about?

MR. WARD: Yes. Yes. I think that's a steam -- the iodine from leaky fuel, given a steam generator rupture.

MR. SIESS: Yes. They had a category in there at about that probability level. I don't know that it's in the regulations anywhere.

MR. GYOREY: There is another point that I might add. This is quite simplified and there is a little more to it. There are two more items to add to this. Down in this region, Event Category III, going down to an aggregate probability of ten to the minus six but in individual event probably of ten to the minus seven according to the key issues paper, that's fine. We can do that. We have when we started, added in effect into that category the anticipated transient without scram events even if you would, by analysis, calculate them to be below this probability but you mentioned challenge of containment. Really what the design requirement we placed upon ourselves that we take that low probability event, anticipate a transient without scram without challenging the containment because we asked for no significant fuel failures.

Then when we made our submittal to the NRC staff, which incidentally, our first submittal was in November, '86, well before any of this came out, the NRC then added -- they accepted, they certainly accepted our anticipated transient without scram events and they added to it or tightened them up. They added a set which they called bounding events.

They put them into this Category III here, irrespective of how low the probability might be and then things got a little fuzzy. It's not quite clear whether they're asking for meeting 10 CFR 100 which we think we can do but then they also ask well, show us that there are no significant fuel failures which gets us into this problem of do you really -- that was my problem in answering your question -- do you really challenge the containment or not. In effect, what they asked us is, really do not -- show us that you do not challenge the boundaries for those low probability events.

MR. SIESS: What would I look at to satisfy myself that the probability of rupturing the tank, the inner tank, is sufficiently low that I -- I don't know what I'd do with it. I have to rupture two tanks; right?

MR. GYOREY: You have to rupture two. Rupturing a single tank is design basis, is a design basis event. We took that as a design basis event irrespective of its probability.

MR. SIESS: By just non-mechanistically rupturing it.

MR. GYOREY: Yes. Yes. A requirement on the second tank is to take the failure of the first tank.

MR. SIESS: And then the challenge to the second tank is what?

MR. GYOREY: The challenge then -- if the first tank has ruptured, then a challenge to a second tank is hold together long enough until I unload the fuel.

MR. WARD: Anything else?

MR. KERR: This is not a question but just an observation.

You talked about your inability to tell your designer to design for things you hadn't thought of. I don't think that's quite what we have in mind. It isn't altogether the results that one hasn't thought of so much as it is initiators that one hasn't thought of and when you're trying to keep the probability less than ten to the minus six, you think of that population of things that have probability of ten to the minus seven per year which might produce a challenge to containment. It only takes ten of them to get you to that and it's that sort of uncertainty, I mean the population of things that have a probability of ten to the minus seven is fairly large. It's that that we worry about -- not the consequences so much, those which you design against really more than you do, I think, the initiators.

A second thing, which is just an interesting, to me, comment. The first containment, so far as I know that was ever built in this country and perhaps in the world was designed not for a disruptive core accident but to contain the energy generated by burning the sodium that was expected to be in the SIR. It turned out that it was never put in there so it was reanalyzed. So, it wasn't designed for what we usually think of as a core disruptive accident or core melt, necessarily.

MR. GYOREY: You'll find this today round the world in sodium-cooled reactor design. Sodium fire is one of the -- I guess it's analogous to the pipe breaking in the water reactor. It doesn't necessarily hurt the core but it could compromise the boundary.

Then, to your point on the things we haven't thought of, the way we're trying to take care of that is we tell the designer, well, design for this energetic event and never mind how it happened. I think that's consistent with what you said. Never mind what the initiator is but here is pretty much the worst thing we can think will eventually happen or as a consequence. Look at the system and see if it can take it.

MR. WARD: Thank you very much, Geza. We appreciate that.

Okay, our next speaker is Mr. Davis, George Davis of Combustion Engineering.

[Slide.]

MR. DAVIS: First of all, I want to thank you for the opportunity to be here. It's been quite a while since I've had a chance to talk to the ACRS so I'm glad to be here again.

I also want to say it's a sad day when people in Connecticut have to fly all the way down to Washington to see snow. It seems like all the storms miss us and come through here instead.

Take it back? Well, I was down Friday. I caught the last snowstorm and I'm down again to catch this one. They seem to be a regular thing.

I wanted to talk today about what the containment design considerations are for our System 80 Plus standard nuclear plant design. System 80 Plus is our large evolutionary light water reactor which is based upon substantial improvements to our previous System 80 design that was built at Palo Verde.

I would also like acknowledge that I have Bill Fox from Duke Engineering Services with me who will be making part of the presentation to describe the containment features along with Dr. Regis Matzie, who is Director of the Advanced Water Reactor Projects at Combustion Engineering. I also have Bob Jaquith back in the audience from our probabilistic risk analysis group to help me out if we get into something I can't handle there.

[Slide.]

MR. DAVIS: I would also like to mention that the discussion you'll hear from us as far as our views on the criteria needed should be pretty consistent with what you heard from EPRI back in September on what they are doing for the requirements document and what you heard from Bob Henry from Fauste & Associates in the ARSAP Program, the Advanced Reactor Severe Accident Plant Program.

We are implementing those requirements into our design so we should be pretty consistent. The difference here is you'll get to see some details of how we have actually implemented those requirements.

I would like to first talk about the traditional containment design bases that exist in the current NRC regulations and guidance, what the severe accident issues are and how they are addressed. The containment description will be handled by Bill Fox and then I'll get back up and talk about some of the analyses we have done, methodology we're using and give a brief conclusion.

[Slide.]

MR. DAVIS: As far as the design approach, we have essentially broken things into two categories for design considerations.

First, there is the traditional design bases, which we say are based upon, quote, "licensing analyses," all of the very conservative, defense-in-depth type of analyses and criteria that are applied based on things like double-ended guillotine breaks.

However, we realize that for future plants it is clear the intention of the Commission is to require that future plants be safer -- 10 CFR-52, the new standardization rule, specifically addresses severe accident policy as something that needs to be addressed and so we recognize we need to supplement the traditional design bases with severe accident mitigation features.

However, because we are talking extremely low probability events, we are basing these upon best estimate analyses rather than the highly conservative defense-in-depth that are talked about for the more traditional type events.

[Slide.]

MR. DAVIS: Let me just very briefly go over the current design bases. These basically are the 10 CFR-50 regulations, the general design criteria, the reg guides, ASME Code Section 3 which applies to steel containment vessels. It includes a number of design conditions, both internal, external loads like missiles, jet impingements, deadload, things like that, pressure temperature calculations based on again very conservative double-ended guillotine break assumptions, natural phenomena such as earthquakes, tornadoes, et cetera, construction loads, hydrodynamic and addresses various loading categories. Service levels A through D is talked about in the

ASME Code.

[Slide.]

MR. DAVIS: The criteria, the actual criteria for traditional design bases are pretty much spelled out in the various documents, the codes, the Standard Review Plan, but there is no specific acceptance criteria for ultimate capacity of the containment traditional design basis.

[Slide.]

MR. DAVIS: I wanted to take a minute and point out that there are a lot of conservatisms in the current bases that should be recognized as providing a substantial amount of defense-in-depth and that's what gives us the strong, rugged containments that we have in existing plants today.

First of all, we do design containment to pressure temperatures based on double-ended guillotine breaks of the largest pipes in the system, in the rapid coolant system and the steam lines. However, if we look at leak-before-break, which is being applied to elimination of pipe break restraints we do put our leak-before-break analyses and put restrictions on leakage detection systems, et cetera, for the primary coolant piping and for the steam lines, we would find that the largest double-ended guillotine break we'd have to assume would be a feedwater line break and the result of pressures that result from a feedwater line break are about half of what we see in a double-ended guillotine break of the steam line or the reactor coolant system.

MR. KERR: I don't understand this illustration since we are talking about a device which I believe we all recognize now is designed for severe accidents and not for design basis, at least it is primarily useful for severe accidents and not the old design basis accidents, so to say that it's conservative by 50 percent or something and then use a design basis accident as an illustration of this seems to me to be slightly irrelevant.

MR. DAVIS: Well, only in that in this example here illustrates -- we currently are going through the System 80 Plus changes that were made, increase the volume of the reactor coolant system, the volume of the steam generator secondary system, both to give the operators more time for actions, smooth out responses to transients and that type of thing, and as you push up the volumes in the primary and secondary system a literal application of double-ended guillotines breaks pushes you to larger containments, stronger containments and you have to ask yourself how rigorous should be we in applying the traditional design bases.

The only point I am really trying to make here is that traditional design bases are something that are so conservative that maybe we don't need to be that rigorous in how they are applied.

MR. KERR: Well, I don't think we should be rigorous on how they are applied at all. I think we ought to start thinking about the accidents against which we are trying to protect --

MR. SIESS: On that slide where --

MR. KERR: -- severe accidents.

MR. SIESS: -- you say accidents, you mean design basis accidents, right?

MR. DAVIS: On this slide we're talking design basis accidents, yes.

To finish going through this slide, the ultimate pressure capacity of the containment is about four times greater than design pressure limits, so in other words we are not talking about brittle containments, the ductile -- there's a lot of margin there. When you calculate your accident pressures there's some margin between that and the actual design limit of the containment. We are conservative in that service B loading combination combines the peak accident pressure with the peak OBE.

I still don't see what the connection is of why there is a chance of having an earthquake with the peak accident but again, that's the conservatism there.

Next there is the analysis that's performed using static pressure and response spectra approach for the peak design pressure and earthquake loadings, respectively, instead of a time history approach.

Again, the probability of having the peak pressure occur some seconds after the accident started and happening to get the peak loading from an earthquake, which is cyclic, occurring exactly the same time, is incredibly small but still that is the conservatism in the design.

Finally, keep in mind that the purpose of containment isn't so much to keep water and steam in as it is radiation. It's the radiation you are trying to keep in and the source terms are recognized to be very conservative based on data that has become available since the TMI event.

The point here is that there is a lot of conservatism in the current design basis that leads us to very strong, rugged containments. However, we recognize that in itself is not enough, that there have to be some considerations --

MR. SIESS: You didn't say ductile, did you?

You said strong and rugged. Did you say ductile somewhere back earlier?

MR. DAVIS: Yes. Yes, I did.

MR. SIESS: How many containments have been tested to failure?

MR. DAVIS: I don't know of any full-size containments.

MR. SIESS: How many of any size?

MR. DAVIS: What's that?

MR. SIESS: How many of any size?

MR. DAVIS: Well, there were the Sandia tests on the steel and --

MR. SIESS: Was that a ductile failure? I thought that was a fairly brittle failure.

MR. DAVIS: That was taken to the optimum strength. That was because they did not measure any -- they did not try to model the penetrations to see whether there would be any leakage before you got to failure, so that one did explode, yes.

[Slide.]

MR. DAVIS: As far as the severe accident issues are concerned, again, these should be pretty similar to what you have seen from EPRI and the ARSAP people.

Severe accident issues are combustible gas control, in that we need to consider how much hydrogen can be produced from metal/water reaction of the cladding; is there adequate mixing of hydrogen in the containment to avoid local pockets that could be detonable; and what limit of hydrogen, what percentage can you get to before you have to worry about detonation.

MR. KERR: Has anybody looked to see whether hydrogen detonation would hurt a large, dry containment?

MR. DAVIS: Well, there has been quite a bit of study on it. That is where there is a difference between the EPRI and the ARSAP analyses and the staff's.

MR. KERR: Have you people looked at it to see whether you think hydrogen detonation would be harmful?

MR. DAVIS: Would actually be harmful? No, we haven't done that yet. No.

The assumption is it would be. But we haven't actually analyzed to see whether you could live with it even if it did occur. We're taking the conservative approach, and assuming that it is.

Core debris coolability. There is the issue of getting enough space, floor area in the reactor vessel cavity so that the core could spread out, if you had a core melt, to drop from the bottom of the vessel, and provide some reliable means of cooling that debris once it was on the cavity floor.

Direct containment heating, there is the issue of having a potential pathway for high pressure ejection and getting molten core material up in the containment atmosphere.

And then under containment venting, there is the issue of should we have vents, and what criteria should be used for actually using the vents.

Now, that just gets the issues on the table. Bill Fox will talk about how our containment design actually addresses those.

[Slide.]

MR. DAVIS: Before Bill gets up, however, I do just quickly want to summarize what our containment looks like.

When System 80 was under construction back in the '70s and '80s, there were five different balance-of-plants and five different containment designs mated with the System 80 and SSS. So in our program here, we went through to look at the different types of containments, and decide which type we wanted to incorporate as a part of the System 80-plus design. And we decided that the base we wanted to work from, to make design changes, was the Cherokee/Perkins containment design, which was partially built by Duke Power.

We felt that it was an excellent containment design. It has a lot of features in it that should be useful for future plants.

First of all, it does provide a dual containment function. The concrete shield building around the steel sphere with the annular space in between does provide the opportunity to provide filtration of any leakage from the containment.

Secondly, there is the large size. It is 200-foot in diameter. It is a big containment. Cherokee/Perkins was originally 190 feet in diameter. We have increased it to 200 feet.

The spherical shape provides a lot of space for maintenance and access in the containment, provides a lot of the containment volume at the operating deck level, rather than high up in containment, like you have in a cylinder. And we think that provides a lot of benefits for maintenance in the plant during operation, or during outages, I should say.

We have designed the containment to mitigate severe core damage events. Bill will talk about that right after this slide. And we thought the spherical shape would provide substantial benefit by providing a space below the sphere for housing safeguard systems.

And Bill will describe, in his presentation, just what those safeguard systems look like and how they are laid out below the sphere.

So let me get Bill up here for a few minutes, and then I will come back.

MR. CARROLL: Is it also true that this can be converted into an underwater movie studio if all else fails?

[Laughter.]

MR. DAVIS: Yes. It makes a very good movie studio. The movie "The Abyss" was filmed there last year. I understand that that area was painted black and flooded.

[Slide.]

MR. FOX: Good afternoon. It is good to be here with you.

I'm from Charlotte. And we were talking to Mr. Wylie just a few minutes at the break. You-all may have snow and Connecticut may have snow and ice. But we have Hugo, that we are still recovering from, and it is still not a pleasant sight around the city.

Now, you talked about a movie studio at Cherokee. We were down there visiting the site about a year ago when they were filming that movie with Earl Owensby, the producer. And he was also converting the CCW lines that came from the service water pond, he was converting them to an underwater roller coaster, or an underground roller coaster, through these pipes. He's got quite an imagination.

Okay. Some of the technical information on the containment.

A steel sphere. It is a 200-foot diameter, using steel of SA-537 Class 2 materials. 1-3/4-inch wall thickness. Free volume of 3.4 million cubic feet. That should be a plus 6 on your handouts.

MR. SIESS: We are so used to probabilities.

MR. FOX: Everybody is working with probabilities.

And design pressure, 40 pounds.

MR. SIESS: At an inch and three quarters, you don't have to stress relieve?

MR. FOX: Inch and three quarters was chosen because it is exempted in the code for stress relieving.

MR. SIESS: That is right at the limit.

MR. FOX: Right at the limit.

MR. SIESS: So essentially, you can design this containment by deciding what volume you want in there to accommodate all your equipment and so forth, and then making it just as thick as you can without stress relieving, and you have a design, right, that is as good as anything you could do?

MR. FOX: Right. But if you get above the limit, you go to stress relieving.

MR. SIESS: And at that design, 49 PSI, it will take.

MR. FOX: It will take 49 pounds. And this is the standard design.

MR. SIESS: With all the factors,

MR. FOX: So we're working with the side envelope for seismic considerations as well, which, you know, for large seismic areas, for poor soil conditions, this design, these parameters will meet the design requirements set forth in the current codes.

The shield building of course is a concrete structure three feet thick with a 210-foot diameter, which provides a five-foot annular space around the outside.

[Slide.]

MR. FOX: What I am going to do here next is show a series of pictures, maybe to help visualize what we are talking about.

This is the same picture that George showed on his overview slide, with a little bit more detail.

I would like to point out just some of the enhancements that are made in this design.

George mentioned the accessibility for maintenance and access, making it, with the spherical shape it puts space at the operating floor in lieu of up top where you need it up here. Some of the major enhancements to this design, too, we have the direct vessel injection, which shows up here; this containment is sized such that the steam generators can be removed in one piece without major modification to the buildings, which is pulled up through the polar crane and laid down on the operating deck and moved out through the hatch. And the other point, which is the most significant for the System 80-plus containment is the refueling water storage tank inside, which is this light blue area.

The green area is subsphere plus shield building, and the blue area represents the internal structures.

MR. SIESS: Excuse me. Many of the early small plants in this country used a spherical containment. Yankee, San Onofre-I, Big Rock, Dresden-I.

Why did we switch from a spherical containment to a cylindrical containment? And now, why are we going back?

You have given me the reason you are going back to the sphere. Why did we get away from the sphere?

MR. FOX: We have seven operating units on our system. And all of those are cylindrical containments.

When it came time to buy another plant -- the Cherokee/Perkins six-pack, we called it -- at that time, we went through an extensive review of containment types available at that time.

MR. SIESS: What had changed between then and the time that some of the other cylindrical steel containments were built?

MR. FOX: I'm not sure of the philosophy that they were thinking about. There's advantages after advantages of the sphere. And I can't answer that question.

MR. SIESS: If anybody knows, I would like to find out sometime.

MR. KERR: Maybe some of the architect-engineers didn't know how to design spheres.

MR. SIESS: Well, no, I had heard once that there was a difficulty in erection, at that size, to put a large sphere up. It is certainly more difficult than putting a large cylinder up.

MR. MATZIE: I think it is certainly perceived as being a more difficult task, and part of the reason that both Duke and TVA had entertained the spherical containment is because of the, let me call it technology transfer they had with the Germans. And they saw the excellence of those containments and they developed an erection procedure, which at the time included floating the lower part of the containment in water and constructing it in place and then lowering it into position.

So I think it is the perception of the difficulty, because you are working in multiple coordinates.

[Slide.]

MR. FOX: Let me put up section from a different view. One thing you'll notice right off the bat is the end containment refueling water storage tank, along the different axis. This is an axis looking in-line along this line of the two steam generators. It completely surrounds now the reactor vessel and its cavity down low in containment.

One other feature that this allowed us to do is provide what we call a hold-up volume which extends down here one side, and I'll show you plan views in a minute which more clearly identify this.

But all the water that is routed through containment from spray eventually will find its way at this elevation and be filtered down through a hold-up volume, and then there are several ways, there are several mechanisms to get that from the hold-up volume either back to the RWST, the refueling water storage tank we call it, or you can route that water to the reactor vessel cavity.

MR. WARD: Are you going to tell us more about that route? I mean, does it take valves, motor operated valves to be opened and go from that hold-up volume underneath the vessel?

MR. FOX: Duke and CE jointly now are working on -- it's strictly a communication problem between getting the water from here to the reactor cavity or the hold-up volume. But the route from the spray, the building is open. These look -- it didn't come out very well, but there's basically a very open containment, free.

This is grading over here and there is grading all the way down through this building for the water to flow down. Once it gets to this elevation right here, it all gets routed around to this side of the RWST and then flows back.

One thing I'll point out, with the advantage of the sub-sphere region, these are the safety injection pump rooms and containment spray and shutdown cooling pump rooms. There is direct communication from the RWST in line to the safety injection pumps.

MR. WARD: What do you mean by -- a pipe with no valve in it, you mean, or what?

MR. FOX: It's a very short pipe run and very direct, straight down.

MR. WARD: Again, what about from the hold-up volume to the reactor cavity? What's that route?

MR. FOX: That route is going to have to be the way of piping and valves that we're in the process of developing that right now. I do not have an answer for that immediately.

MR. WARD: All right.

[Slide.]

MR. FOX: Some characteristics -- let me bring up what I mentioned, the sub-sphere. Let me just show you very quickly. Irrelevant to containment design, but a feature of the System 80 Plus. This is the plan on the sub-sphere on the foundation level. It is quadratized for separation of division. This goes completely up. You can't access from one side to the other unless you leave the building.

We also have divisional separation for each train along this axis for flooding, for flood lockout, sabotage protection, and so forth.

Here's the safety injection pumps, which are completely quadratized; containment spray pumps, shutdown cooling pumps. I'll get some feedwater pumps around here. Again, looking at maintenance, accessibility, and removability of equipment, dedicated aisle ways for access and dedicated space for pipe runs and electrical runs.

MR. WARD: So you can't go from one quadrant to the other without going outside, but the water can?

MR. FOX: You can go from a quadrant within each division. This is a wall that only goes up about 20 feet and you can access through these stairs.

MR. MICHELSON: Outside containment.

MR. FOX: This is still outside containment in the sub-sphere area.

MR. WARD: I see, now. Thank you.

MR. MATZIE: Let me just clarify that. To be more specific, there are two electrical trains in this plant and those electrical trains are completely segregated all levels of the sub-sphere with that wall that looks horizontal up there.

We go from mechanical trains that are driven off the given electrical train and that is the vertical wall that you see. Then you can get from one of the mechanical trains to the other in that electrical division. But at this particular level, there's a wall that goes all the way up for flooding and fire resistance.

[Slide.]

MR. FOX: Let's pop back inside the containment and talk about the refueling water storage tank; some of its structural characteristics. Torodial in shape. It uses the internal containment boundary as its structural boundary.

It's located low in containment. Optimal space; it's using space that is there for local water in previous designs. Anyway, it's improved return water path. Some of its functional characteristics are, of course, for normal plant operations for refueling, it also has the emergency core cooling water stored there.

The 500,000 gallon capacity is dictated by refueling operations and not accident considerations. There is enough water after we go through the cycle of containment spray and so forth that the net positive suction head for the pumps are maintained as it regenerates itself.

MR. SIESS: That's a reenforced concrete structure with the stainless steel lining.

MR. FOX: That's correct. It's the ultimate -- or the energy heat sink for the safety depressurization system, which George will address in a few minutes. Eliminates the need for the recirc mode on the emergency core cooling. The traditional designs call for a switchover from the outside tanks to the containment sumps.

This greatly improves -- this RWST improves from the PRA standpoint. It is a source of water for reactor cavity flooding to mitigate severe accident features, and I'll show you that in a few minutes.

It scrubs radioactive material from discharge of pressurized safety valves from the depressurization system.

[Slide.]

MR. FOX: Now, let's get to a plan view where you can better see the torodial shape, a donut shape. This is the reactor cavity bottom plan. The instrumentation tubes will come out of the reactor, then, and come up through the ISI chase vertically here, which is isolated at an elevation a few feet above the bottom.

Everything in light or this greenish color here is the refueling water storage area. The area right here, if you recall, and I'll bring that section back up, this is the hold-up volume. So right above this elevation, we have a concrete floor which will collect the water, route it around through the screens, down into the hold-up volume and, from there, it can communicate back to the RWST or into the reactor cavity.

These structures are just the steam generator supports and D walls coming down. I'll also point out the four safety injection and spray suction headers located at a point above the bottom of the tank, but there is always adequate -- there's plenty of adequate water there.

[Slide.]

MR. FOX: This is not the next slide in your handout, but a similar version. You have a slide that has a couple of arrows. Those are really -- you have this slide, but there's a couple of arrows along the edge here which point down. That's really the section cut for the section above it on your handout.

Basically, a graphic representation of the end containment refueling water being able to supply the reactor vessel cavity.

[Slide.]

MR. FOX: We will talk about some of the reactor cavity design characteristics. As George mentioned, we have a large floor area for debris bed coolability. There are features to retain core debris to minimize direct containment heating. The issue and ability for the reactor cavity to be flooded from the IRWST.

The graphic representation on that -- let me bring this up a bit. Once the water is down here to catch the melted core, over here we have the flat area for the core to spread out on. We also have what we call a core debris chamber which is sized to catch a pressurized release of core and maintain it from going directly into containment; where this provides a very cumbersome open path for the steam in other pressure tubes to release while keeping the core in the cavity.

This addresses the direct containment heating issue, keeping core outside or off the containment because it is protected once it gets above the operating floor by the cylindrical frame wall, which goes all the way up to support the frame at some point.

Provides adequate floor area for debris bed spread out in cooling. It also has the water there.

MR. CARROLL: I take it from what you have said that the approach in your design is to allow a melt to be ejected before you put water into the cavity?

MR. FOX: The objective of our design is going to have the water there before the core melts through. I believe we're going to talk about that.

MR. DAVIS: Let me explain it. We're in the process of performing our severe accident analyses and the very scenarios that can lead to core melt. After we complete those analyses, then we'll put together the severe accident management procedures that would give the guidelines to the operator on when to actually flood the cavity, based on what the analyses have shown.

So at this point, we haven't reached a decision on whether he would flood before or after. It may depend on the scenario where -- hopefully, we could find a situation where we just say do it the same all the time, but that's going to depend on after we do the analyses and write the procedures.

MR. CARROLL: So your design is keeping that option open.

MR. DAVIS: Exactly. When Bill said earlier that we haven't laid out the system yet of actually how we're going to valve from the refueling water tank to the reactor cavity, we're trying to keep the flexibility so that we can do that once we see the severe accident scenarios and write the procedures.

MR. WARD: There seems to be a sort of conflict here between -- you described the containment before as being open so that the water can run down freely but here you've got restrictions in it so that the core debris can't spray around freely in there. Is that accomplished primarily by, I forget, you call this thing a chamber or something down there or do you see the rest of this going up above it as essential to that, preventing a lot of direct containment heating?

MR. FOX: The open containment is to get the water back down and the next slide will address post-containment ventilation. The philosophy of the core debris chamber is to catch the ejaculated core as it comes out under pressurized release, knock it back down in the water, and at the same time provide -- the question earlier in the day was to provide or prevent a buildup of pressure within the chamber itself.

This can happen. This will go through a very -- if any core gets out here, it has to make a lot of turns as it goes up here. It's a deliberate design with a lot of turns preventing the steam to release and get out and mix into open containment but at the same time ensuring the core as well.

These are grading levels as it goes through.

MR. WARD: So it's sort of a labyrinth but what -- the idea is, the core stays behind? What's getting knocked out in the labyrinth path; that's what I'm trying to --

MR. FOX: The core.

MR. WARD: The core is. Okay. The debris.

MR. FOX: This doesn't show up very well. I think you have a slide that shows it much better. That's a little clearer. That's just an arrow turned down. It might be confusing.

MR. MATZIE: I think the concept here on the core debris collection is that if it's a high pressure ejection, that core has to make a lot of turns and you figure you're going to collect a lot of it every time it has to turn and the first major area is that core debris chamber where it would hopefully catch most of the molten core debris.

The real process we're hoping would be the accident management. The operator would know ahead of time to depressurize the reactor coolant system and as you'll see from George Davis coming up, there's a safety depressurization system to do that.

MR. SIESS: Why does that chamber -- there's a large arrow going up there and then there's a little chamber off to the right.

MR. MATZIE: That's it.

MR. SIESS: Now in the plan, is there a large difference in the areas represented by those two?

MR. MATZIE: That place called a chamber is where we would expect to collect most of the molten core.

MR. SIESS: Why does it go all the way over there instead of going up where the big arrow is?

MR. CARROLL: Centrifugal separator chip.

MR. MATZIE: Exactly.

MR. SIESS: Okay. I can't find the plan view of it.

MR. FOX: This might help answer that. In plan, we're talking about an area that is existing over here. Remember, the ICI tubes which come out which the core is going to tend to follow too has a series of plates and supports. It's going to be much easier to go over here. This wall, the labyrinth wall that comes out comes all the way across at this area which will knock the core back down and therefore the steam and so forth will be able to be released.

MR. SIESS: Thank you.

[Slide.]

MR. FOX: I guess the last thing that I want to talk about is the open containment and post-containment cooling. You have a much simpler slide of this in your handouts but the principle is the same. This is the cross section of the plant looking at the two generators. The HVAC system in this plant is designed to minimize with minimal amount of duct work, using the natural features of the building to act as HVAC plenums. We would use the natural convection paths generated.

If you picture these being the crane wall, being a cylindrical shape, as the heat is being produced, it goes up. It's being pulled down and in through areas that were taken advantage of the structure, open areas and continually flowing in a circular manner and also as it flows through, we have vent paths which allow any hydrogen that's generated within the IRWST which is closed to come out, mix freely with the air and disperse.

It's a pretty open containment and these convection paths set up naturally in the post-accident.

MR. WARD: What's cooling the atmosphere to make it flow down there? The heat transfer through the cylinder, I mean the sphere or what?

MR. FOX: I'll point out now that the advantage of a sphere is its annular space -- we talked about it a little earlier or the possibilities of providing post- or outside containment cooling with a water system and we're in the process now of evaluating the need for that or usefulness.

MR. WARD: Is that what you're talking -- I mean, in order to get this circulation loop, you have to be cooling the air on a downward lake.

MR. FOX: Well, you also have spray here as well with the containment being wetted at that point internally.

MR. WARD: Internally.

MR. KERR: Those arrows plainly show that the air will circulate.

[Laughter.]

MR. WARD: Why in that direction, Bill?

MR. CARROLL: Because that's where the arrow is.

MR. FOX: I'm going to turn it back over to George now to conclude with the depressurization systems and the summaries and will certainly be around to answer any additional questions.

[Slide.]

MR. DAVIS: Okay, as Bill explained to you, the System 80 Plus containment is laid out such that we could handle a pressurized ejection of molten core material but certainly would prefer to avoid that so we have added a system called a safety depressurization system which would be used by the operator to prevent a molten core ejection under high pressure.

It also provides some other functions which I'll address here. First of all, it does provide a safety grade means of venting non-condensable gases from the reactor vessel and pressurizer. It provides a safety grade means of depressurizing to cool down when the normal pressurizer sprays are unavailable. We still, by the way, still maintain the auxillary spray system as a means of depressurization but that's no longer considered safety grade. So this is the safety grade means.

It provides for RCS depressurization, initiate bleed and feed flow if you did have a total loss of feed water event and needed to bleed and feed in conjunction with a high pressure safety injection pump, of course, and then for severe accident scenarios, the ability to depressurize.

The -- of the system are powered off of the station batteries so that they would operate in a station blackout situation where you had a loss of AC power. The system looks something like this in which -- off of the pressurizer, we have the safety valves and then we have the safety depressurization valves which are motor operated valves and they lead to the in containment refueling water storage tank. There will be spargers located in that tank so that any release to the tank will be condensed, if there's any small releases.

We also have the gas venting system through here, through small lines and off of the reactor vessel and from the pressurizer going to reactor drain tank.

MR. SIESS: What did you call that?

MR. DAVIS: The reactor gas vent system.

MR. SIESS: Would you tell me what those little circles with things in them mean? What's HS and PI?

MR. DAVIS: These are just the operators for the valve.

MR. SIESS: HS means something?

MR. DAVIS: Let's see.

Regis, do you remember the?

F means solenoid. M means motor-operated, and HS means hand switch -- to be able to locally do it.

MR. SIESS: PI and TE?

MR. DAVIS: Pressure indicator, I believe, temperature. The other's temperature.

These are motor operated valves. Rather than going to something like PORVs which are full open, full closed, we felt the motor operated valves would be much more reliable as far as being able to close them and also the operator could control how far they opened, only crack them open as far as he needs.

MR. CARROLL: These are DC valves?

MR. DAVIS: Right. In other words, they are powered from the batteries, or can be powered from the batteries. So if you had a loss of AC.

MR. SIESS: There are four different sources?

MR. DAVIS: I believe that's the case. Right, Regis?

MR. SIESS: 101, 102, 103, 104?

MR. MATZIE: That's correct.

MR. DAVIS: Yes, I'm sure it's the case, in fact.

MR. WARD: George, this is all single failure tolerant; is that it?

MR. DAVIS: Yes. Yes. All followed the standard safety grade as far as environmental qualification, redundancy, earthquake, everything.

MR. WARD: Did you tell us what the PSVs are? Are those combination?

MR. DAVIS: They're safety valves. Pressurized safety valves which are the same safety valves we had on System 80.

MR. WARD: Okay. So, what you would call the PORVs are these motor-operated valves?

MR. DAVIS: They take the place. Instead of having PORVs, we use motor-operated valves.

MR. WARD: Okay.

MR. DAVIS: You'll remember from the discussions years ago on System 80 --

MR. WARD: I remember.

MR. DAVIS: -- we had concerns about the reliability of PORVs in re-closing.

MR. WARD: Yes.

MR. DAVIS: Here we're including motor-operated valves, because we feel they are much more reliable, and instead of just dumping into containment atmosphere, they'll dump into the --

MR. WARD: Yes. Okay.

MR. DAVIS: -- refueling water tank spargers, which will condense any steam in an inadvertent release.

MR. CARROLL: Is it the intent that one of a pair be left open, normally?

MR. DAVIS: No. No. These would be normally closed?

MR. CARROLL: Both?

MR. DAVIS: Both would be normally closed, and it would only be opened by the operator. So, it would be an intentional depressurization.

MR. WARD: And what sort of capacity do you have there?

MR. DAVIS: These valves are a little bigger than standard PORVs.

MR. WARD: So, if you only get one side open, you can remove -- you can feed and bleed immediately after a scram or what?

MR. DAVIS: That's right, within 2 hours or something like that.

MR. WARD: Okay. One side.

MR. DAVIS: Yes.

MR. WARD: Okay.

MR. DAVIS: Yes, that's right.

MR. KERR: And an alternate path is through this vertical system?

MR. DAVIS: Through the reactor vent system?

MR. KERR: Yes.

MR. DAVIS: That wouldn't be a feed-and-bleed path. This is only a 1-inch line, intended for gas venting. It could provide you a very slow depressurization, but not a rapid depressurization or a feed-and-bleed.

MR. CARROLL: Okay, and you are aware of the line-loss problem that people encounter with DC MOVs. I'm talking about power. Most people -- a number of people have been fooled and didn't recognize that you go to the valve and through the field and back to the motor-control center and back the motor again, and the line drop has done them in, in terms of closing torque. There's a couple of bulletins on that. Just an aside.

MR. DAVIS: Okay. Well, I'm sure our electrical engineering people have looked into that. I'll make sure of it when I get back.

MR. CARROLL: It appears to have been a common trap.

[Slide]

MR. DAVIS: The analyses for severe accidents -- the approach we're taking is consistent with the EPRI recommendations, using the probabilistic risk analysis to establish the particular sequences that result in core damage and then using best-estimate deterministic models -- in particular, the MAPP code -- to analyze consequences. We're using a later version of the MAPP code that's been updated to include the modifications that we have made to the design, such as the incorporation of in-containment refueling water storage tank.

In doing analyses, when we're doing best-estimate analyses, we want to make sure that we rope around any uncertainty in performing these analyses. First of all, whenever there is as concern about whether we really solved the problem, we're trying to put in design features that overwhelm the problem -- a belt and suspenders approach.

We're trying to use conservative assumptions to feed into the models. So, although the model itself is best-estimate, we try to use conservative assumptions, and then we perform sensitivity analyses to make sure that a small change in some parameter doesn't have major perturbation on the results that we didn't expect. So, we do some sensitivity calculations and make sure that we have, indeed, enveloped it and aren't surprised by a slight change.

We're doing analyses in accordance with the EPRI ground rules and assumptions document for performing PRA and severe-accident analyses, and there also, by the way, were a number of ASARP studies that have fed into that.

To summarize the severe-accident issues and how we have addressed them: The issue of combustible gas control -- we have arranged the containment to facilitate hydrogen mixing, and we have the ability to add igniters, if they are required. If the staff were to accept the EPRI position of 75-percent hydrogen for generation and 13 percent for detonability, then we would not need igniters in the System 80 Plus containment.

MR. CARROLL: You've made in the containment refueling water storage tank.

MR. DAVIS: With the possible exception -- the first analyses we did showed that there were locally high concentrations in the IRWST space, and we're now looking at whether we could open the ventilation path from that space to promote mixing better, and if we can't get that down, or get down the concentrations, we'd have to have local igniters there.

If the staff maintains the 100-percent hydrogen generation and 10 percent detonability, then we'd have to have igniters globally in the containment, but there's nothing in the arrangement right now that would preclude us from putting the igniters in.

On the recoolability, the cavity flow area was modified to provide enough space to meet the 0.02 square meters per megawatt thermal for spreading, and we advocate the ability to flood the IRWST. We're still working out the design details of what that system will look like, but we will have that capability.

Direct containment heating is addressed by a belt-and-suspenders approach, where we have a safety depressurization which should eliminate the potential for a high-pressure injection, or ejection, from the vessel to the cavity area, and we also have designed a cavity area to trap molten debris, even if we did have a high-pressure ejection.

The issue of venting containments -- we haven't precluded the potential for putting in a vent. We don't currently have it in the design yet. It would be relatively simple, since it is a steel shell.

As I mentioned a little bit earlier, we're doing the severe-accident analyses for System 80 Plus, looking at all the various scenarios and consequences. After we have completed those analyses, we'll take a look at whether including vents would provide any benefit.

An alternate to that, as Bill mentioned, was the possibility of a spray system on the outside, external to the steel sphere, as a means of cooling the containment.

So, we are going to look at that after we have completed the severe-accident analyses and make our decision. If we do put a vent in, we're going to need some guidance from the staff about the criteria for operating the vents, when it would be allowed to be used. I think probably that issue is going to get forced sooner because of the MARK I containments that are putting in vents.

MR. KERR: Do you think that the PWR emergency operating procedures have criteria from the staff as to when they can be used?

MR. DAVIS: Do I think we have those criteria now?

MR. KERR: No. Do you think the PWR people have them? I don't think they do.

MR. DAVIS: No.

MR. KERR: The staff may not give you criteria.

MR. DAVIS: I get your point. When I talk about what they're doing for the MARK I, it's BWR, and they may not be doing anything for PWR on that.

MR. KERR: Would you prefer that the staff decide when you could use them, rather than your having to make the decision?

MR. DAVIS: Well, our intent would be to come in with recommendations on what we would propose for criteria on when those valves would be used. The point I was trying to make with this bullet is that it's going to be a very sensitive political issue in establishing criteria of when vents can be used, and that's going to need some sort of a blessing by the NRC on the procedures.

MR. SIESS: You have mentioned vents. You haven't mentioned filtered vents.

MR. DAVIS: No, I haven't, and the question of whether the vents would need to be filtered would again depend on the severe-accident analyses. If they show that it's beneficial, we'd look at filtering the vent, as well.

MR. SIESS: If you had highly-effective filtering, would there still be a question of when it can be used?

MR. DAVIS: I think that probably would depend more on politics than technical input.

MR. MATZIE: Combustion Engineering's current position is we don't believe we need vents, and only if there was an overriding consideration from the severe-accident analyses would we entertain the viability of vents.

MR. CARROLL: Why is that you don't have the same problem Westinghouse has with respect to the tradeoff between site boundary doses and double containment?

MR. DAVIS: The tradeoff between site boundary and double containment; we do have dual containment which we think is a big benefit. I realize in the passive design where you have to have the air ventilation on the outside to remove heat, you can't have that. It's a tradeoff of whether you want passive cooling or the ability to reduce the dose.

The dual containment provides a real benefit for the design-based events, the ones that are higher probability. It doesn't provide you as much benefit in the severe accident scenario.

MR. CARROLL: You've answered my question. I didn't realize this was a double containment.

MR. DAVIS: Yes, it is. We think that's a very important feature of it. When we selected the containment, like I mentioned earlier, before Bill go up, we looked at different containment types and felt that was a real important feature for future plants.

[Slide.]

MR. DAVIS: We've done a couple of analyses on severe accident events. Like I said, the analyses are currently underway, but we've done a couple of them, and I wanted to show you the results of those. This is for a station blackout without recovery which leads to core melt.

We look at the concrete ablation depth versus time. What we find is that the -- this didn't show up on the slide, but this is the depth of concrete in feet versus time. What we find is that a little after three hours after the event is initiated, the reactor vessel would be calculated to fail and discharge core into the reactor cavity.

In a dry cavity scenario where there is not water in the cavity, we would find that the ablation would proceed at the rate such that within about 50 hours, which is just a little over two days, we would reach the bottom of the concrete in the cavity and reach the underside of the steel sphere which is between two layers of concrete.

MR. KERR: Now, does that assume no heat removal from the containment during that period, or since you have heat removal --

MR. DAVIS: As I recall, this conservatively assumes that there is no heat removal from the containment.

MR. KERR: [illegible] do not get containment rupture for the first 50 hours, even if you aren't removing heat?

MR. DAVIS: The pressure -- it's not shown on this curve, but if we show pressure versus time for a dry cavity scenario, we see the pressure was almost zero. There's no significant pressure buildup after 50 hours.

MR. SIESS: Now, what happens after you go through the sphere? You've got more concrete.

MR. DAVIS: You've got more concrete. The sphere is sandwiched between two layers of concrete, inside and outside containment. We assume the containment's failed at that point, but in reality, there is some sort of filtration that's got to get through that space.

MR. SIESS: How much more concrete do you have to have to get through the rest? How much poured concrete do you have?

MR. DAVIS: I think it's about ten feet or more.

MR. FOX: Right below the bottom of the sphere, there's about a six foot pedestal, we call it, that the concrete is sitting on. Below that, the base mat is ten feet thick.

MR. SIESS: So that's 16 feet from the sphere to the soil, roughly.

MR. DAVIS: Right.

[Slide.]

MR. DAVIS: Now, I have a curve for the similar event -- for the same event, really -- station blackout without recovery, except here I show containment pressure versus time for a flooded cavity scenario.

In this case, if we assume the cavity is flooded, then we are going to have significant pressure buildups in containment. Again, at this point, in about three hours, we're going to see failure of vessel and we see the containment pressure rising.

The ultimate strength of the containment is such that it would be predicted to fail at about 220 PSI.

MR. SIESS: That's the ultimate strength.

MR. DAVIS: That's based on the ultimate strength.

MR. SIESS: How much strain would you have at that load?

MR. DAVIS: Can you answer that, Bill?

MR. FOX: The ultimate strain?

MR. SIESS: Yes.

MR. FOX: It goes back to -- based on the ultimate capacity of the steel, it's not a fracture mechanic analysis or a crack propagation analysis. It's just goes back and is based on the ultimate capacity of the steel; a stress of 80 PSI in the steel.

MR. SIESS: What kind of strain? There's always a strain that goes with the stress.

MR. FOX: I don't know that right off.

MR. SIESS: You've only got 5 percent strain before you hit the shield wall.

MR. FOX: Right.

MR. SIESS: Long before you get to 5 percent, you're going to have serious problems at that knuckle where it's restrained by the concrete for the lower 90 degrees or so. That's what the Germans calculated in their analysis. There's no way you're going to get to that pressure with an in-tact containment, I don't believe.

MR. MATZIE: Actually, I believe the Germans will contend that there will be relief occurring through penetrations before the containment would yield like that, and that's something that's not modeled here, obviously.

MR. SIESS: I don't think you can reach that stress in that containment without breaching it. If you look at your diagram, you've got the bottom part of that containment confined by concrete.

If you go a few feet above that, and it wants to move out to 5 feet at 5 percent strain. I'm sure the stat was 5 percent strain.

MR. FOX: The radial deflections generally throughout the sphere is four inches at that pressure.

MR. SIESS: At that pressure?

MR. FOX: Yes.

MR. SIESS: Ultimate?

MR. FOX: Yes.

MR. SIESS: Four inches? One third of one percent at ultimate for that steel?

MR. FOX: That's correct.

MR. SIESS: One third of one percent strain? Come on. That's pretty brittle.

MR. DAVIS: Let's take a look at that and get back to you to verify it.

MR. SIESS: I think I'll get that elastically. If I went to 89 KSI elastically, I'll have a third of a percent, I think.

MR. MATZIE: Let me just say something about this curve. This was -- this is a calculation basically of what is predicted pressure and when we reach the ultimate strain, we just said failure would occur. That was the analytical model.

We hadn't modeled the mechanics that you're talking about.

MR. SIESS: I think that's a mistake to call it containment failure up there.

MR. DAVIS: I think it may be a bit misleading. Like I said, this is preliminary work that we've done so far. The intent was to show that with the ultimate strength of the containment, we expect it to be somewhere out in the 50 hour time range, a couple of days.

MR. SIESS: I don't think you can count on getting much beyond the yield. I don't know what the stress/strain curve looks like for the steel, but once you get past yield, one percent strain is a foot of movement.

With that restraint that you've got there at that level --

MR. WARD: That means you might only get out 20 hours of something -- half that time.

MR. SIESS: Yes.

MR. DAVIS: We'll look into that and get back to you.

MR. DAVIS: In any event, when we look at the details of it, and find out what the real limit is, --

MR. SIESS: In one of the containment conferences that Sandia put on, the Germans showed an analysis that would give us the large definition. They were bumping against projections and they were having trouble at that knuckle and it was a pretty good study.

MR. DAVIS: As I recall, there was some redesign of that knuckle to provide more flexibility there so that you could take strain.

MR. SIESS: We've got some containments now that have concrete in the bottom, the ones with the elliptical head on the bottom and cast in concrete.

MR. DAVIS: I think in reality, once we do the final analyses of this and have all the scenarios laid out, we're going to want to look at avoiding getting to this kind of a pressure anyway. We're gonç to look at whether we want to vent or use external sprays, but we think we'll be able to show that there is a very significant amount of time before something has to be done before you fail containment.

MR. SIESS: As I mentioned earlier, what you have to be interested in when you're looking at venting scenarios is a pressure at which it will not fail, not the pressure at which it will fail. The pressure at which it will not fail can be determined at any level of confidence you want.

MR. DAVIS: That's right.

MR. SIESS: A lower level of confidence, the higher the pressure.

MR. DAVIS: I think you're absolutely right. What we find is that we had established some pressure at which you wanted to either initiate vents or an external spray, unless, indeed, the times turned out to be so long that it really wasn't a concern. I expect that we'll wind up looking at the benefits of venting or spraying the outside of the sealed sphere to avoid getting above a certain pressure.

This was just intended to show you where we stand in some of the analyses we are doing right now.

[Slide.]

MR. DAVIS: The conclusions are, from the presentation, that we are continuing the use of the traditional design bases. Although we think they are very, very conservative, they are there in the regulations and in the guidance. They do result in strong, robust-type containments, with a lot of conservatism in them. And on top of that, we still have to do something to address severe accident issues. There are still criteria that need to be met to show that you can live with core melt scenarios, and they can be mitigated. In fact, you are doing things to prevent them.

Some of the features that we have talked about as far as hydrogen, direct containment heating, et cetera, are things where EPRI has proposed criteria. The staff, as you heard this morning, is working on guidance to actually put forth criteria, which will hopefully be pretty consistent with what EPRI has recommended. And that is what we are actually implementing into our designs.

So we think with those criteria established and agreed to, we will be able to show the designs indeed are much safer than previous plants, which is what the Commission was ultimately after in its severe accident policy.

MR. SIESS: Let me ask one question about the traditional design bases.

You pick a steel for your containment and you pick a thickness -- inch and three quarters -- which you can go to without stress relief in place.

Now, you then do a design basis LOCA calculation. Is that the calculation that determined the size of your containment, the 200-foot?

MR. DAVIS: No. The size of the containment is not based on the safety analyses. The size is based upon structural layout.

MR. SIESS: Okay. Now, what does your 49 PSI design pressure mean? Is that what the LOCA pressure is, or is that what this thing can stand at the ASME code allowable stress?

MR. DAVIS: That is the ASME code allowable stress for a LOCA plus OBE.

MR. SIESS: That is where the 49 comes from?

MR. DAVIS: Right.

MR. SIESS: Now, the actual LOCA pressure, if you went through that calculation, would presumably be somewhat less than 49?

MR. DAVIS: Right.

MR. SIESS: Obviously, it won't be more.

MR. DAVIS: Exactly. It will be somewhat under.

MR. SIESS: So you didn't really size this thing on a traditional design basis. You picked a volume, you picked a thickness, put them together, and that was it.

MR. DAVIS: We verified that it satisfied the traditional design requirements, and we actually modified it to assure that it would satisfy the severe accident criteria.

The big difference is that the traditional criteria have lots of conservatisms and margin in them. The severe accident criteria are more best estimate.

MR. KERR: What are these severe accident criteria? You mean the ones that EPRI has proposed?

MR. DAVIS: The ones that EPRI has proposed.

MR. KERR: Oh, okay.

MR. DAVIS: As far as core spread out area.

MR. KERR: I'm with you, if that's what you meant.

MR. DAVIS: Okay.

Well, that concludes my presentation. If you have any more questions, I will be glad to try and answer them.

MR. KERR: May I ask one unrelated to this?

Are the two Korean units going to use this containment, or do you know?

MR. DAVIS: No. The Korean units are using the containment designed by Sergeant & Lundy, which is a concrete containment.

MR. KERR: Thank you.

MR. WARD: George, thank you very much.

MR. DAVIS: Okay. Thank you for the opportunity to be here.

MR. WARD: Off the record.

[Whereupon, at 4:40 p.m. the meeting was adjourned.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission

in the matter of:

NAME OF PROCEEDING: ACRS Joint Subcommittee Meeting Containment Systems/Structural Engineering

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, Maryland

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

Marilynn M. Nations

MARILYNN NATIONS
Official Reporter
Ann Riley & Associates, Ltd.

CONTAINMENT DESIGN CRITERIA FOR
FUTURE NUCLEAR PLANTS

BACKGROUND INFORMATION ON THE NRC OFFICE OF RESEARCH'S ONGOING PROGRAM FOR IMPLEMENTATION OF SEVERE ACCIDENT POLICY

BRAD HARDIN
ADVANCED REACTORS AND GENERIC ISSUES BRANCH
OFFICE OF RESEARCH

PRESENTATION TO
ACRS JOINT SUBCOMMITTEE MEETING
CONTAINMENT SYSTEMS/STRUCTURAL ENGINEERING

DECEMBER 13, 1989
BETHESDA, MARYLAND

HISTORICAL BACKGROUND

- CRITERIA FOR CONTAINMENT DESIGN FOR FUTURE PLANTS WAS PART OF THE PREVIOUS STAFF STUDIES INTO THE IMPLEMENTATION OF SEVERE ACCIDENT POLICY THAT WERE PERFORMED IN THE REGULATORY IMPROVEMENTS BRANCH OF NRR. THIS WORK WAS DOCUMENTED IN SECY-86-76.

- RESPONSIBILITY FOR PREPARING A PROPOSED PLAN FOR IMPLEMENTATION OF SEVERE ACCIDENT POLICY FOR FUTURE PLANTS IS CURRENTLY ASSIGNED TO THE ADVANCED REACTORS AND GENERIC ISSUES BRANCH (ARGIB) IN THE OFFICE OF RESEARCH.

- ARGIB HAS BEEN ACTIVELY WORKING IN THIS AREA FOR THE PAST 2 YEARS WITH BNL AS ITS PRINCIPAL CONTRACTOR.

  PRODUCTS FROM THIS WORK INCLUDE:

  1. SECY-88-248, "IMPLEMENTATION OF THE SEVERE ACCIDENT POLICY FOR FUTURE LIGHT WATER REACTORS"

  2. DRAFT REGULATORY GUIDE, "REGULATORY GUIDANCE ON TECHNICAL ISSUES, FORM, AND CONTENT OF PRAS PERFORMED FOR ADVANCED DESIGNS"

  3. DRAFT SUPPORTING DOCUMENT, "TECHNICAL BASIS FOR FUNCTIONAL PERFORMANCE REQUIREMENTS FOR EVOLUTIONARY LWRS"

SAMPLE OF PERFORMANCE ORIENTED SEVERE ACCIDENT CRITERIA FOR CONTAINMENTS IN FUTURE (NEAR-TERM) LWRS

(taken from Enclosure 3 of SECY-88-248)

Containments shall be designed, maintained and operated with sufficient margin to provide reasonable assurance that in the event of a severe core damage event and the likely consequential phenomena (e.g., molten core dispersal from the vessel and containment pressurization), sufficient retention of fission products would be maintained. This requirement is applicable only to those severe accident events considered to be significant potential contributors to risk to the public health and safety.

PLANNED HIERARCHICAL STRUCTURE FOR REGULATION OF SEVERE ACCIDENTS IN FUTURE REACTORS

1. 10 CFR 52
(LEGAL REQUIREMENT THAT SEVERE ACCIDENTS BE ADDRESSED THROUGH PRA IN ALL FUTURE LICENSE APPLICATIONS)

2. REGULATORY GUIDE "REGULATORY GUIDANCE ON TECHNICAL ISSUES, FORM, AND CONTENT OF PRAs PERFORMED FOR ADVANCED DESIGNS"
(PRESENTLY IN DRAFT FORM)

3. NRR LICENSING BASIS AGREEMENTS

4. SUPPORTING DOCUMENTATION FOR REG GUIDE "TECHNICAL BASIS FOR FUNCTIONAL PERFORMANCE REQUIREMENTS FOR EVOLUTIONARY LWRs"
(PRESENTLY IN DRAFT FORM)

5. STANDARD REVIEW PLAN REVISIONS
(NO PRESENT ACTIVE PLAN FOR PREPARATION)

10 CFR 52 EXCERPTS RE PRA AND SEVERE ACCIDENTS

SECTION 52.47 CONTENTS OF APPLICATIONS.

(II) DEMONSTRATION OF COMPLIANCE WITH ANY TECHNICALLY RELEVANT PORTIONS OF THE THREE MILE ISLAND REQUIREMENTS SET FORTH IN 10 CFR 50.34(F).

(v) A DESIGN-SPECIFIC PROBABILISTIC RISK ASSESSMENT

CONSISTENCY OF THE RES WORK ON SEVERE ACCIDENT POLICY IMPLEMENTATION WITH OTHER RELATED NRC ACTIVITIES

NRR LICENSING BASIS AGREEMENT FOR GE ABWR:

- FAIRLY CONSISTENT

STAFF ABWR SER:

- GOOD CONSISTENCY

DRAFT STAFF SER ON CH. 5 OF EPRI REQUIREMENTS DOCUMENT:

- GOOD CONSISTENCY

IN SPITE OF COMPLEXITY OF SUBJECT OF CONTAINMENT DESIGN CRITERIA FOR FUTURE PLANTS AND THE CORRESPONDING DIVERSITY OF VIEWS, SOME THEMES APPEAR TO BE COMMON AND UNCHANGING:

1. THERE IS AN EXPRESSED NEED FOR GUIDANCE IN THIS AREA FOR USE BY BOTH THE INDUSTRY AND THE NRC REVIEWERS. THIS NEED HAS BEEN EXPRESSED BY BOTH PARTIES. EXISTING GUIDANCE, INCLUDING THE SEVERE ACCIDENT POLICY STATEMENT, IS NOT SUFFICIENT.

2. THERE IS A DESIRE TO MAINTAIN DEFENSE-IN-DEPTH THROUGH THE USE OF MITIGATIVE DESIGN FEATURES AND PROCEDURAL STRATEGIES (IN SPITE OF POSSIBLE CLAIMS OF EXTREMELY LOW CDFs).

3. AVOID EMPHASIS ON "BOTTOM-LINE" PRA NUMBERS. USE INDIVIDUAL ACCIDENT SEQUENCE CONTRIBUTIONS TO CDF AND INDIVIDUAL SYSTEM FAILURE CONTRIBUTIONS TO CDF TO IDENTIFY RELATIVE IMPORTANCE AND TO PRIORITIZE MORE DETAILED FOLLOW-UP EVALUATION.

4. TREAT PROPOSED SAFETY GOALS AS JUST THAT-GOALS AND NOT ACCEPTANCE CRITERIA.

POTENTIAL CONSTRAINTS TO CHANGING REGULATORY CRITERIA FOR CERTAIN FUTURE REACTOR CONTAINMENT DESIGNS:

1. EVOLUTIONARY REACTOR CONTAINMENT DESIGNS HAVE BEEN RELATIVELY COMPLETE FOR SOME TIME NOW. RESISTANCE TO CHANGING DESIGNS TO ACCOMODATE NEW REGULATORY CRITERIA WITHIN BOTH THE INDUSTRY AND THE NRC.

2. SAME COMMENT (BUT TO A MUCH LESSER DEGREE, HOPEFULLY) FOR THE "PASSIVE" DESIGNS NOW STARTING TO RECEIVE ATTENTION AT THE NRC.

TECHNICAL BASIS FOR FUNCTIONAL PERFORMANCE REQUIREMENTS FOR EVOLUTIONARY LWRs

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Presented to ACRS Joint Subcommittee Meeting
Containment Systems/Structural Engineering

December 13, 1989

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OUTLINE

- Objectives, scope, and approach
- Severe accident containment challenges
- Containment performance requirements
  - H_2 combustion
  - High pressure meltdown
  - Containment bypass
  - Core debris/containment boundary interactions
  - Long-term decay heat removal

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OBJECTIVES

- BNL is providing technical assistance to NRC staff in developing guidance on implementation of severe accident policy for future plants:
  - New regulatory guide
  - Supporting technical basis and documentation

SCOPE

- Initial effort is specifically intended to support the ongoing licensing reviews of evolutionary LWRs:
    - GE ABWR
    - W SP/90
    - CE CESSAR System 80+
- And also to support review of EPRI ALWR requirements document

APPROACH

- Provide guidance on what severe accident vulnerabilities need to be considered, reasonable measures that should be taken to address these issues and required documents

- Reg. guide will:
  - List specific severe accident vulnerabilities which evolutionary designs must address
  - Provide guidance on form and content of PRAs

APPROACH (Cont.)

Reasonable measures are intended to demonstrate:

- Core damage frequency below 10^{-5} per year
- Frequency of large release below 10^{-6} per year
- Provide reasonable assurance that containment can effectively mitigate a range of severe accidents

- Aim is to provide balance between prevention and mitigation

APPROACH (Cont.)

- Prevention:
  - Functional performance requirements were developed to drive core damage frequency to 10^{-5} or lower
  - Performance requirements derived for key safety functions:
    - Reactivity control
    - Inventory control
    - Decay heat removal
  - Addressed by requiring levels of redundancy, diversity, automation, and independence

APPROACH (Cont.)

- Focus of today's meeting is on mitigation
- Aim is to develop containment performance requirements that give reasonably assurance (approximately 90% chance) that containment remains intact given a core melt accident
- Significant challenges to containments at existing plants were identified
- Performance requirements were developed for those challenges found to be important contributors to uncertainty in containment performance

SEVERE ACCIDENT CONTAINMENT CHALLENGES

- Severe accident challenges identified from:
  - Published PRAs
  - PRA reviews
  - Containment performance program
  - NUREG-1150
    - First draft (February 1987)
    - Second draft (June 1989)
  - NUREG/CR-4920
  - Industry programs

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Potential Containment Vulnerabilities for Existing Plants Identified by Previous Studies

Potential Vulnerability	Large Volume	Ice Cond	Mark I	Mark II	Mark III
Containment Bypass:					
- Interfacing systems loss-of-coolant accident	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]
- Failure to isolate containment	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]
- Steam generator tube rupture	Yes[1]	Yes[1]	N/A	N/A	N/A
Early Structural Failures:					
- Overpressurization with high temperatures:					
- due to noncondensible gases and steam	Yes[2]	Yes[2]	Yes	Yes	Yes
- due to combustion processes	Yes[2]	Yes	No	No	Yes
- due to direct containment heating	Yes	Yes	Yes	Yes	Yes
- Missiles or pressure loads:					
- due to steam explosions	No[2]	No[2]	No[2]	Yes[3]	No[2]
- Melt-through:					
- due to direct contact between core debris and containment	No	No	Yes	No	No
Late Structural Failure:					
- Overpressurization with high temperatures:					
- due to noncondensible gases and steam	Yes	Yes	Yes	Yes	Yes
- due to combustion processes	Yes	Yes	No	No	Yes
- Melt-through:					
- due to basemat penetration by core debris	Yes	Yes	Yes	Yes	Yes

Notes:

N/A = Not applicable.

[1] Relatively low probability but potentially high consequence.

[2] Low probability.

[3] Possibility of steam explosion in downcomers of some Mark II designs.

UNCERTAINTY IN CONTAINMENT PERFORMANCE

- Uncertainty in containment performance is due to inability to predict:
  - Containment loads (pressure, temperature, etc.)
  - Structural response
- Approach was to develop performance requirements that address important containment loads
  - Initially based on first draft of NUREG-1150
  - Recently updated by results of second draft

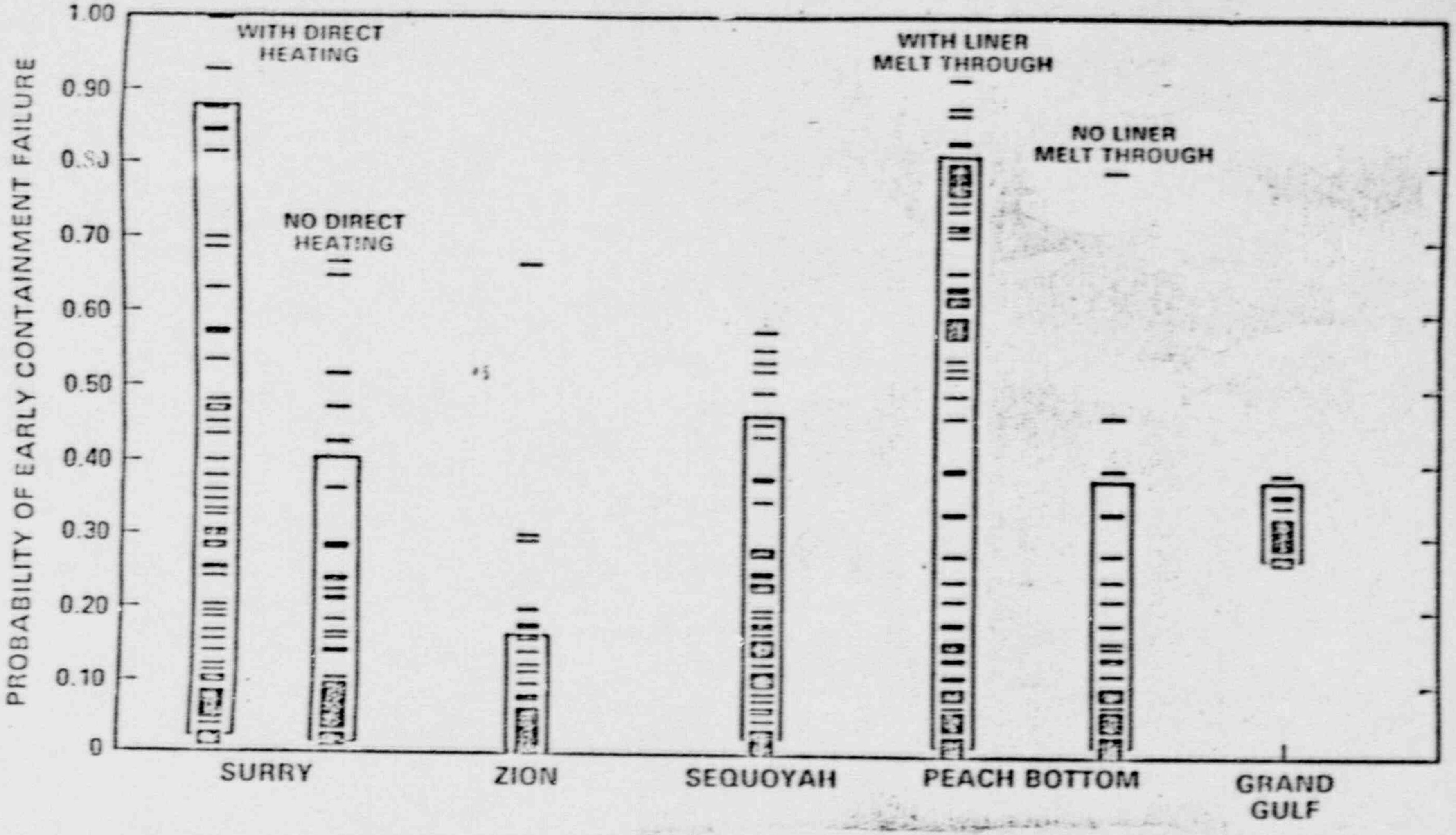

Figure 5.1 Comparison of early containment failure probabilities. (Reproduced from First Draft of NUREG-1150, February 1987)

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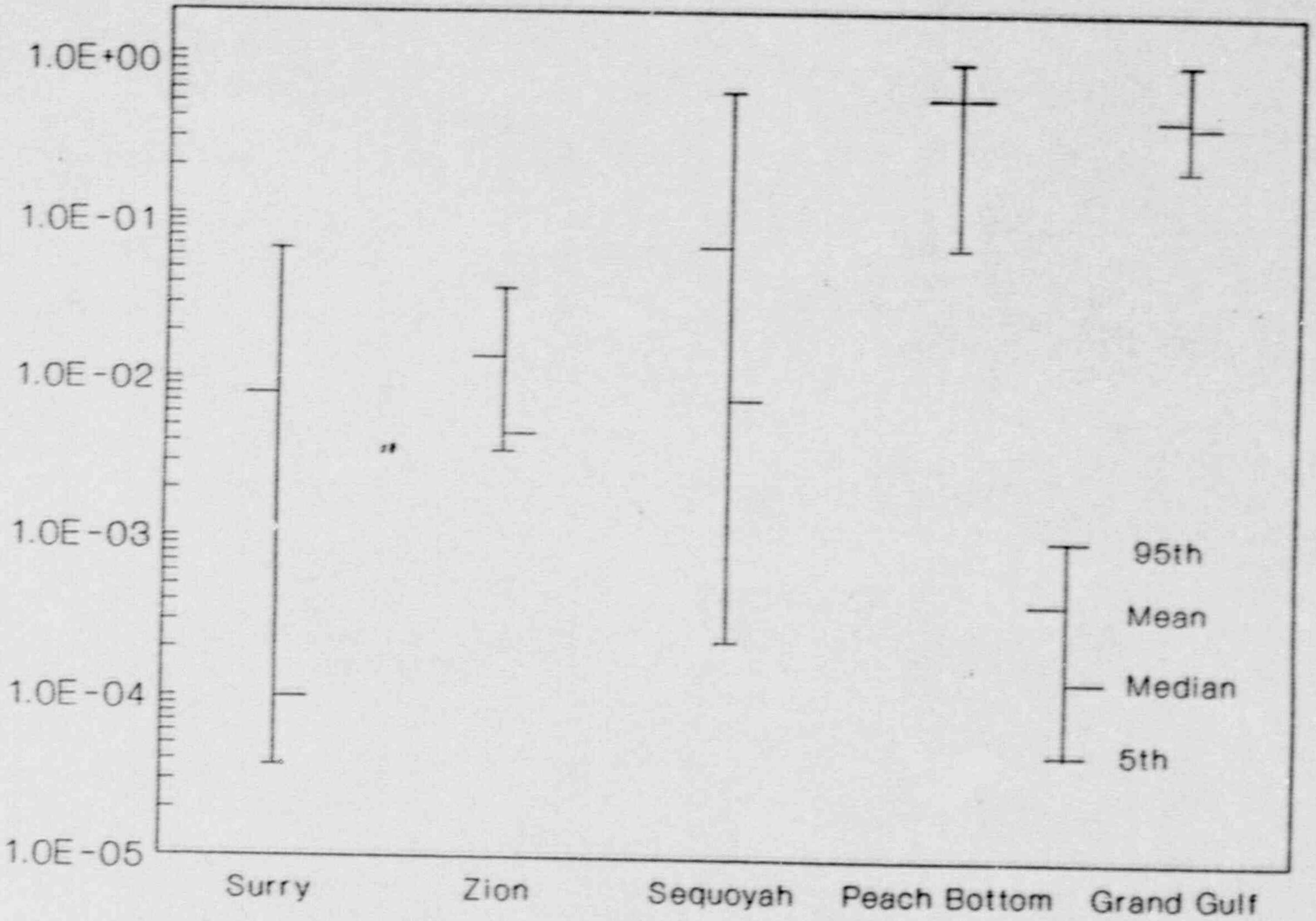


Figure 5.2 Comparison of early containment failure probabilities.
(Reproduced from Second Draft of NUREG-1150, June 1989)

EVOLUTIONARY LWR CONTAINMENT DESIGNS

- W SP/90 and CE CESSAR system 80+ have large volume containments
- GE ABWR has a containment design similar to an existing Mark II containment (GE has agreed to inert ABWR containment during operation)

IMPORTANT CONTAINMENT CHALLENGES -- PWR LARGE VOLUME CONTAINMENTS

- First draft NUREG-1150:
  - Probability of early failure relatively large for high pressure core meltdown accidents (direct containment heating, H_2 combustion, and induced steam generator tube rupture)
  - Probability of late failure large if CHRS fail because of long-term pressure buildup
- Second draft of NUREG-1150:
  - Probability of early failure relatively low because of depressurization of primary system by various mechanisms (stuck open valves, high temp. failure of hot leg, etc.)
  - Because of low probability bypass events are important contributors

IMPORTANT CONTAINMENT CHALLENGES -- BWR MARK I CONTAINMENTS

- Both drafts of NUREG-1150:
  - Probability of early failure high because of:
    - Direct contact of core debris with containment boundary (drywell shell meltthrough)
    - Rapid pressure buildup (steam pressurization and DCH)
  - Late failure can also occur

CONTAINMENT PERFORMANCE REQUIREMENTS

- Based on the results of NUREG-1150 and related studies performance requirements were developed to address the following five challenges:
  - Hydrogen combustion
  - High pressure meltdown
  - Containment bypass
  - Core debris/containment boundary interactions
  - Long-term decay heat removal

CONTAINMENT PERFORMANCE REQUIREMENTS

- The proposed severe accident containment performance requirements will supplement current design basis considerations

- Formulation of the requirements was done on a best-estimate basis with consideration given to uncertainty

HYDROGEN COMBUSTION

- Aim is to reduce likelihood of early containment failure from hydrogen combustion

- Options:

  - Provide sufficient containment design margin (volume, design configuration, and ultimate pressure capability) to withstand effects of hydrogen burns and maintain global and local hydrogen concentrations below detonable concentrations, or

  - Provide for controlled igniting which maintains global and local hydrogen concentrations below detonable concentrations and controls hydrogen burning such that containment integrity is maintained, or

  - Provide for containment inerting that prevents oxygen concentrations from exceeding 4%

HYDROGEN COMBUSTION (Cont.)

- Key considerations:
  - Amount and rate of metal-water reaction (MWR)
  - Detonable concentrations (global and local)
  - Power supply if ignitors are used
  - Equipment survivability
- EPRI ALWR document suggests:
  - MWR 75%
    H_2 concentration < 13%
- 10 CFR 50.34(f) calls for:
  - MWR 100%
    H_2 concentration < 10%
- Should 10 CFR 50.34(f) H_2 requirements be applied to evolutionary LWRs?

HYDROGEN COMBUSTION (Cont.)

- Staff recommend 100% MWR and 10% H_2 concentration
  - Based on 75% MWR in-vessel plus allowance for ex-vessel H_2 generation
  - 25% MWR ex-vessel assumes core debris is spread over large area and flooded (i.e., rapidly cooled)
- Implications for evolutionary LWRs:
  - GE ABWR containment will be inerted
  - W SP/90 (and possibly CE CESSAR Sys. 80+) will need ignitor system

HIGH PRESSURE MELTDOWN

- Aim is to reduce likelihood of early containment failure from accidents with the primary system at high pressure

- Options:

  - Provide for depressurization or primary system, or

  - Provide sufficient margin in containment (volume, configuration and ultimate pressure capability) to withstand effects

HIGH PRESSURE MELTDOWN (Cont.)

- Key considerations:
  - To what pressure and at what rate should the system be depressurized?
  - When should the system be depressurized?
  - What design requirements should apply to the depressurization system?
- Implications for evolutionary LWRs:
  - W SP/90 includes depressurization system (because of large capacity passive water injection at low pressure, depressurization significantly extends time to core uncovery)
  - GE ABWR includes ADS

CORE DEBRIS/CONTAINMENT BOUNDARY INTERACTIONS

- Aim is to reduce likelihood of early containment failure due to interactions with core debris, including core-concrete interactions

- Options:

  - No direct pathway for core debris to contact and cause failure of the containment wall, and

  - Sufficient floor area to enhance debris spreading and reduce the potential for other structural degradation that could lead to containment failure, and

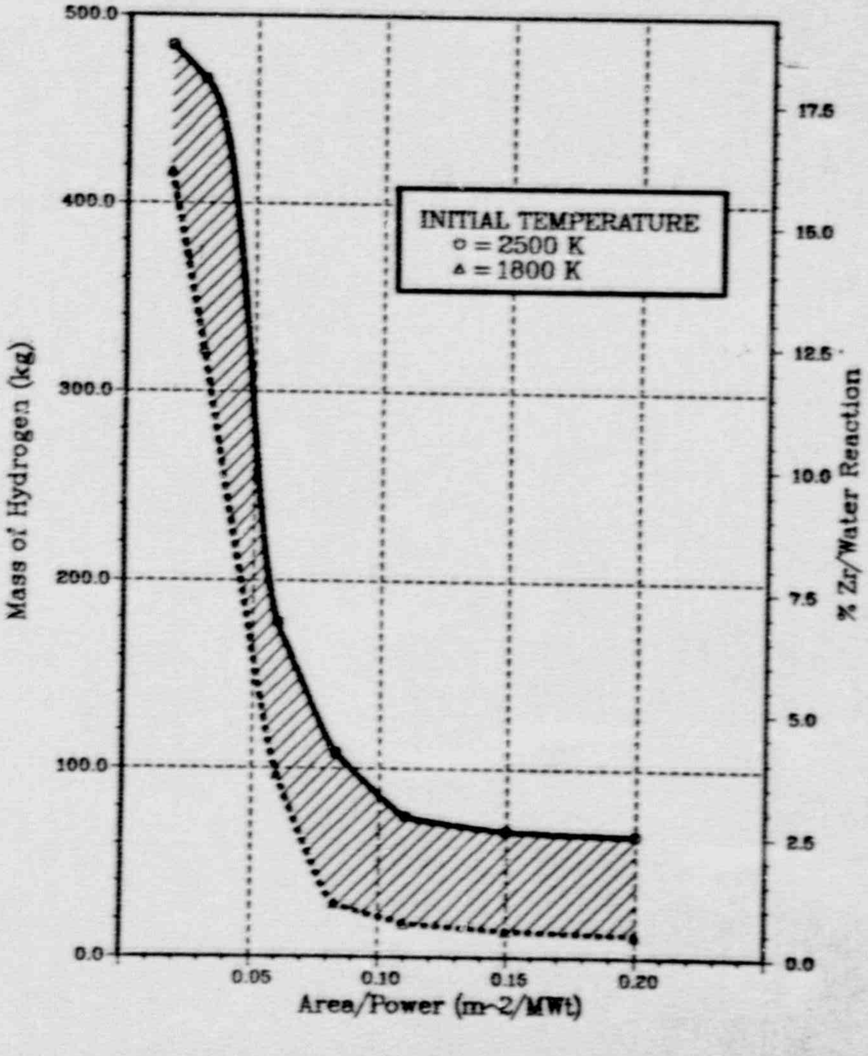
  - Provide for flooding of debris, and

  - Select materials to reduce generation of gases as a result of contact with core debris

CORE DEBRIS/CONTAINMENT BOUNDARY INTERACTIONS (Cont.)

- Key considerations:
  - What area/debris depth is sufficient to cool debris
    - EPRI ALWR document, 0.02 m^2/MWt
    - Generic letter No. 88-20, 25 cm
  - How effective is flooding and should water be in cavity before or after core debris

HYDROGEN GENERATION FROM SP/90



CORE DEBRIS/CONTAINMENT BOUNDARY INTERACTIONS (Cont.)

- Implications for evolutionary LWRs:
  - Some ex-vessel H_2 generation must be considered
  - Flooded core debris results in significantly faster pressurization rates:
    - GE ABWR reaches ultimate pressure within 24 hours
    - W SP/90 reaches ultimate pressure within 48 hours

LONG-TERM DECAY HEAT REMOVAL

- Aim is to reduce likelihood of late containment failure caused by loss of or inadequate containment heat removal

- Options:

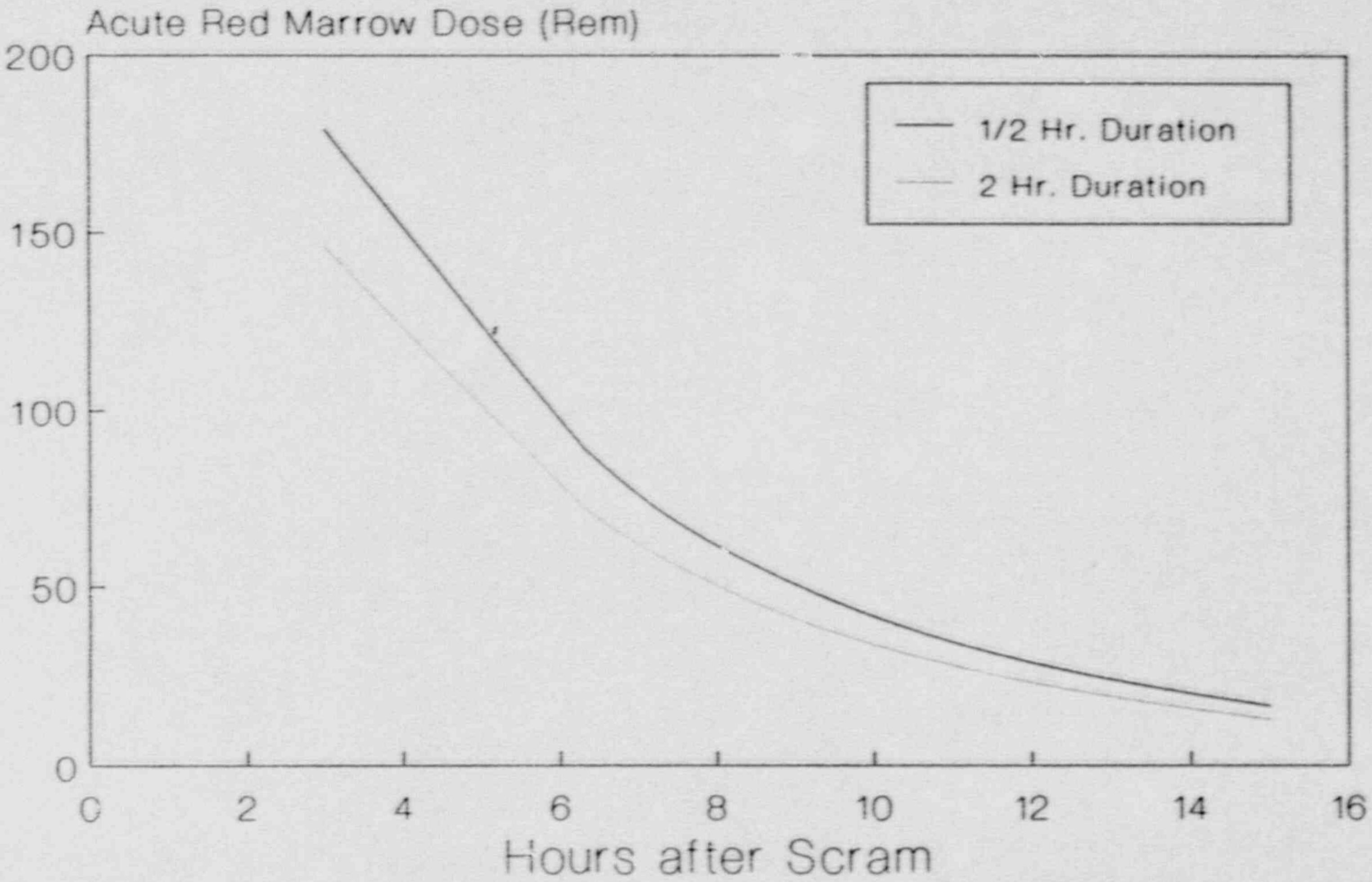
  - Provide an alternate means of removing decay which is capable of functioning in core melt environment, or

  - Provide controlled containment venting capability

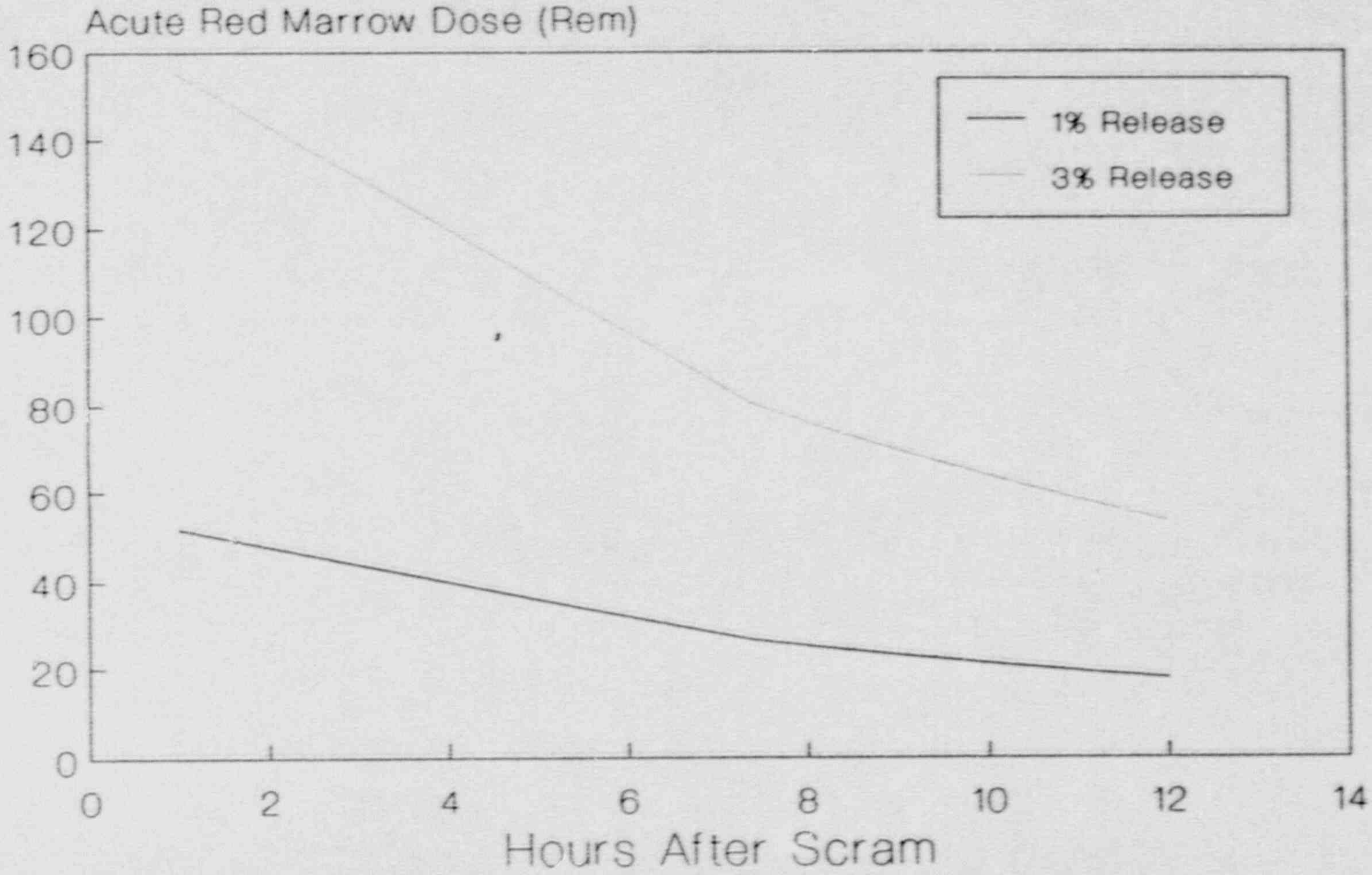
LONG-TERM DECAY HEAT REMOVAL (Cont.)

- Key considerations:
  - Power supply and support cooling capability for decay heat removal system
  - Equipment survival
  - Should venting be an option
  - When should venting occur
  - When is filtering necessary
  - What design requirements apply to a venting system

Dose at 0.5 Mile for Noble Gas As a Function of Time of Release



Dose at 0.5 Mile for Iodine
As a Function of Time of Release



LONG-TERM DECAY HEAT REMOVAL (Cont.)

- Implications for evolutionary LWRs:
  - GE ABWR proposes to include venting
  - W SP/90 does not plan to include venting and is investigating external cooling of the steel containment shell

SUMMARY

- Containment performance requirements have been developed that provide reasonable assurance that evolutionary LWR containments will have a high probability of remaining intact during a core melt accident
- These requirements are similar to those recommended in the EPRI ALWR document
- Most of the requirements have been (or will be) incorporated into the W SP/90 and GE ABWR designs

Insert

CONTAINMENT CONCEPTS

PRESENTATION TO THE

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

BETHESDA, MARYLAND
13 DECEMBER 1989

R. J. LUTZ, JR.

FELLOW ENGINEER

WESTINGHOUSE ELECTRIC CORP.

CONTAINMENT CONCEPTS

1. CONTAINMENT FUNCTIONS
2. REVIEW OF CONTAINMENT PERFORMANCE
3. PROBLEM AREAS
4. FUTURE CONCEPTS

CONTAINMENT FUNCTIONS

- THE PRIMARY FUNCTION OF THE CONTAINMENT IS TO PROVIDE A THIRD AND FINAL BARRIER TO PREVENT THE RELEASE OF RADIOACTIVITY TO THE ENVIRONMENT IN THE EVENT OF AN ACCIDENT.

- SECONDARY FUNCTIONS OF THE CONTAINMENT INCLUDE:

  - SHIELDING OF THE IMMEDIATE SURROUNDINGS IN THE EVENT OF AN ACCIDENT TO REDUCE THE DIRECT RADIATION DOSES, PARTICULARLY TO ONSITE PERSONNEL, AND

  - COLLECTION OF RADIOACTIVITY THAT EMANATES FROM LEAKAGE DURING NORMAL PLANT OPERATION

CONTAINMENT PERFORMANCE

- THE PRIMARY CRITERIA IMPACTING THE CONTAINMENT DESIGN INCLUDE:
  - 10 CFR PART 50, APPENDIX A [GENERAL DESIGN CRITERIA]
  - 10 CFR PART 50, APPENDIX J [CONTAINMENT LEAK RATE TESTING]
  - 10 CFR 100, [GENERAL SITING CRITERIA]
    - SPECIFIES OFFSITE DOSE CRITERIA FOR A DETERMINISTICALLY PRESCRIBED MAXIMUM HYPOTHETICAL ACCIDENT WHICH IMPACTS THE CONTAINMENT DESIGN FOR:
      - MAXIMUM LEAK RATE FROM CONTAINMENT, AND
      - CONTAINMENT SAFEGUARDS SYSTEM PERFORMANCE

CONTAINMENT PERFORMANCE

- o LARGE DRY PWR CONTAINMENTS DESIGNED TO THE EXISTING REGULATORY CRITERIA GENERALLY HAVE AN LARGE MARGIN FOR ACCOMMODATING SEVERE ACCIDENTS.
  - CONTAINMENT INTEGRITY IS MAINTAINED DURING THE EARLY DYNAMIC PORTION OF A SEVERE ACCIDENT
  - CONTAINMENT INTEGRITY IS MAINTAINED IN THE LONG TERM DURING A SEVERE ACCIDENT IF ACTIVE CONTAINMENT HEAT REMOVAL IS AVAILABLE, EVEN FOR HEAT REMOVAL CAPABILITY WELL BELOW THE DESIGN BASIS.
  - CONTAINMENT FAILURES AS A RESULT OF FAILURES OF ACTIVE CONTAINMENT HEAT REMOVAL ARE PREDICTED TO OCCUR AT TIMES GREATER THAN 1 DAY
    - \+ LATE RECOVERY OF CONTAINMENT HEAT REMOVAL OR ALTERNATE HEAT REMOVAL MEANS HAVE GENERALLY NOT BEEN CREDITED IN PRA ANALYSES.

CONTAINMENT PERFORMANCE

- LARGE DRY CONTAINMENTS CAN GENERALLY ACCOMMODATE BOTH SHORT TERM AND LONG TERM SEVERE ACCIDENT PHENOMENA.
  - SUFFICIENT VOLUME TO MAINTAIN HYDROGEN LEVELS BELOW DETONABLE LIMITS,
  - CONTAINMENT GEOMETRY IS NOT CONDUCIVE TO TRANSITION TO DETONATION
  - CONTAINMENT GEOMETRY IS NOT CONDUCIVE TO DIRECT CONTAINMENT HEATING
  - REACTOR CAVITY GEOMETRY IS CONDUCIVE TO CORE COOLABILITY
    - CAN GET WATER TO THE CAVITY REGION
    - SUFFICIENT AREA FOR QUENCHING AND HEAT REMOVAL

FUTURE CONTAINMENT DESIGN

- ENCOURAGE THE ACCEPTANCE AND USE OF THE EPRI DESIGN GUIDANCE

- PRA MUST BE USED AS A TOOL FOR THE DESIGN OF CONTAINMENT AND CONTAINMENT SYSTEMS

  - SUFFICIENT CONTAINMENT VOLUME TO ACCOMMODATE HYDROGEN GENERATION WITHOUT ACHIEVING DETONABLE MIXTURES

  - SUFFICIENT REACTOR CAVITY AREA TO ACCOMMODATE LONG TERM COOLING BY A WATER COVER

  - REDUCTION IN PROBABILITY AND/OR CONSEQUENCES OF CONTAINMENT BYPASS SEQUENCES

  - ENHANCEMENT OF ASSURANCE OF CONTAINMENT ISOLATION

  - EQUIPMENT SURVIVABILITY IN SEVERE ACCIDENT ENVIRONMENTS
    (E.G. FAN COOLERS)

- NO CHANGES IN REGULATORY REQUIREMENTS OR REGULATORY PRACTICE ARE REQUIRED FOR FUTURE CONTAINMENT DESIGNS, EXCEPT THE INCONSISTENCY BETWEEN PRA AND DETERMINISTIC SOURCE TERM

PROBLEM AREAS

- ONE PROBLEM IN CONTAINMENT DESIGN HAS BEEN IDENTIFIED WHICH WOULD REQUIRE A CHANGE IN THE REGULATIONS OR REGULATORY PRACTICE TO INCREASE THE LEVEL OF SAFETY AFFORDED BY THE CONTAINMENT
    - SP/90 LONG TERM COOLING VS. DOUBLE CONTAINMENT FOR OFFSITE DOSE CRITERION

      PRESENT DESIGN INCLUDES TRADITIONAL DOUBLE CONTAINMENT TO MEET 10 CFR PART 100 CRITERIA
        - SECONDARY CONTAINMENT MUST BE "CLOSED" TO MAINTAIN LEAKAGE COLLECTION FUNCTION
        - PROHIBITS ADDING WATER ON EXTERIOR OF STEEL CONTAINMENT SHELL FOR DIVERSE LONG TERM HEAT REMOVAL
- OTHER CONFLICTS MAY ARISE AS A RESULT OF USING DETERMINISTIC METHODOLOGY WHICH IS NOT CONSISTENT WITH CURRENT PRA METHODOLOGY

PRESENTATION TO THE ACRS JOINT SUBCOMMITTEE
ON
CONTAINMENT DESIGN CRITERIA FOR FUTURE NUCLEAR PLANTS

GEZA GYOREY
MANAGER, SAFETY AND LICENSING

GE ADVANCED NUCLEAR TECHNOLOGY
US-DOE ADVANCED LIQUID METAL COOLED REACTOR PROGRAM

DECEMBER 13, 1989

PRESENTATION OBJECTIVES:

PROVIDE PERSPECTIVE FROM THE POINT OF VIEW OF THE ADVANCED LIQUID METAL COOLED REACTOR (ALMR) PROGRAM

BASIC APPROACH

TRADEOFFS

UNIQUE CHARACTERISTICS

RECOMMENDATIONS

A VIEW OF THE CURRENT CONTAINMENT SITUATION

- EXISTING OPERATING PLANTS AND DESIGNS MEET THE SAFETY GOALS
- CONTAINMENT CONCEPTS EVOLVED FOR WATER COOLED REACTORS
  - WITH HIGH PRESSURE AND STORED ENERGY
  - DEPENDENT ON MANY ACTIVE SYSTEMS
- TENDENCY IS TO EMPHASIZE FORM (STRONG STEEL AND CONCRETE WALLS) RATHER THAN CONTAINMENT FUNCTION (DEPENDENT ON ACTIVE SYSTEMS FOR ISOLATION AND COOLING AND SUBJECT TO HUMAN ERROR)
- TREND NOW IS TO EXAMINE CONTAINMENT FUNCTION FOR LOW PROBABILITY, SEVERE CORE DISRUPTIVE EVENTS; REQUIRES EVENT SELECTION
- THERE IS A RESIDUAL RISK DUE TO VERY LOW PROBABILITY EVENTS (E.G. VESSEL RUPTURE, LARGE WORTH ROD EJECTION, VERY LARGE EARTHQUAKE)

ALMR PROGRAM SAFETY BASIS

- SAFE, ECONOMIC SYSTEM FOR LONG TERM ENERGY ASSURANCE
- MEET SAFETY GOALS, BE RESPONSIVE TO ADVANCED REACTOR POLICY, MEET OTHER APPLICABLE REQUIREMENTS
- LEVEL OF SAFETY SUCH THAT OFFSITE EVACUATION EXERCISES AND EARLY WARNING ARE NOT REQUIRED
- PASSIVE DECAY HEAT REMOVAL
- PASSIVE REACTIVITY CONTROL FOR BENIGN RESPONSE TO ATWS EVENTS
- HIGHLY RESISTANT TO OPERATOR ERRORS
- STANDARD DESIGN CERTIFICATION BASED ON FULL SCALE PROTOTYPE TEST

REQUIREMENTS LEAD TO SYSTEM LIKELY TO MEET SAFETY GOAL
WITH PREVENTION; MITIGATION PROVIDES ADDED MARGIN

ALMR - SUMMARY OF RADIATION RELEASE CRITERIA

BASED ON CURRENT NRC STAFF AND ACRS RECOMMENDATIONS

- NRC STAFF KEY ISSUES PAPER SECY-88-203
- ACRS LETTER ON SAFETY GOALS MAY 13, 1987

	PROBABILITY LESS THAN:	PER PLANT YEAR TO EXCEED:
I	10^{-2}	10CFR50 APPENDIX I
II	10^{-4}	10% OF 10CFR100
III	10^{-6}	10CFR100 AND PAG FOR 36 HOURS
IV	10^{-1} FOR LARGE RELEASE FOR THE FULL SPECTRUM OF SEVERE CORE DAMAGING EVENTS	

OBSERVATIONS:

THESE CRITERIA ARE MUCH MORE RESTRICTIVE THAN THE SAFETY GOALS

THE 36 HOUR PAG LEVEL IS ESSENTIALLY LIMITING, IMPLIES A HIGH LEVEL OF PREVENTION

ALMR - HIGH EMPHASIS ON PASSIVE SYSTEM FEATURES

OBJECTIVE IS TO ACHIEVE HIGH RELIABILITY WITH PASSIVE FEATURES IN:

DECAY HEAT REMOVAL, REACTIVITY CONTROL, AND CONTAINMENT FUNCTION;

VIRTUALLY IMMUNE TO OPERATOR ERRORS

A STRICT DEFINITION: A FEATURE WHICH RELIES ONLY ON THE LAWS OF NATURE AND THE STRUCTURAL INTEGRITY OF MATERIALS, REQUIRING NO SENSING, SWITCHING, MOTIVE POWER, OR HUMAN ACTION, AND WHICH IS NOT DEFEATED OR IS DIFFICULT TO DEFEAT BY HUMAN ACTION.

EXAMPLES: THERMAL EXPANSION, HEAT CONDUCTION, NATURAL CIRCULATION

LESS STRICT DEFINITIONS ALLOW:

ACTIVE INITIATION OF PASSIVE SYSTEMS (ONE-TIME VALVE MOTION)

DC POWERED VALVES AND INSTRUMENTS

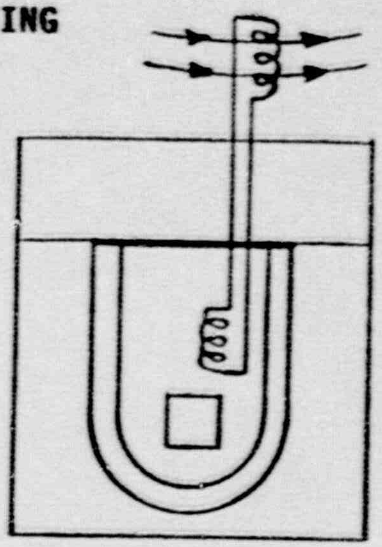
OPERATOR INTERVENTION

IT IS RECOGNIZED THAT THERE IS A WIDE RANGE OF ROBUSTNESS IN PASSIVE SYSTEMS IN TERMS OF VULNERABILITY TO STRUCTURAL FAILURE OR HUMAN INTERVENTION

ALMR - PASSIVE DECAY HEAT REMOVAL

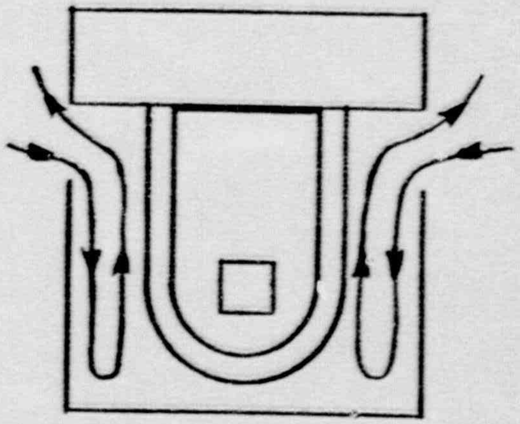
KEY CONSIDERATIONS:

- o FAILURE OF DECAY HEAT REMOVAL CAN IMPACT CONTAINMENT FUNCTION
- o INTERRUPTION BY OPERATOR CAN DAMAGE CORE
- o HEAT SINKS CONSIDERED: WATER - REQUIRES ACTIVE SYSTEM
  EARTH - CONDUCTIVITY IS LIMITING
  AIR - NATURAL CIRCULATION



INDIRECT AIR COOLING - CONVENTIONAL

VIA PIPED NATURALLY CIRCULATING LIQUID
LIKELY TO REQUIRE ACTIVE INITIATION
LEAK OR BREAK FAIL SYSTEM
REQUIRES VALVES FOR MAINTENANCE
SUBJECT TO HUMAN INTERVENTION



DIRECT AIR COOLING - SELECTED FOR SUPERIOR RELIABILITY

VIA NATURAL CIRCULATION IN LARGE DUCTS
RUNS AT ALL TIMES
CONTINUOUSLY MONITORED
TOLERANT OF LOCAL STRUCTURAL FAILURE
RESISTANT TO HUMAN INTERVENTION
REQUIRES AIR FLOW CLOSE TO HEAT SOURCE

SODIUM POOL PROVIDES LARGE THERMAL MASS:

ASME LIMITS NOT EXCEEDED UPON TOTAL LOSS
OF DECAY HEAT REMOVAL FOR OVER 10 HOURS

ALMR - PASSIVE REACTIVITY CONTROL

KEY CONSIDERATION:

- REACTIVITY EXCURSION OR ATWS CAN IMPACT CONTAINMENT FUNCTION

APPROACH:

- METAL FUEL WITH HIGH CONDUCTIVITY AND FAVORABLE REACTIVITY FEEDBACK CHARACTERISTICS
- VERY LOW CYCLE BURNUP REACTIVITY HELD DOWN BY CONTROL RODS
- FOR ATWS EVENTS (LOSS OF FLOW, HEAT SINK, ROD RUNOUT)

  PASSIVE MEANS TO ASSURE
  - NO SIGNIFICANT FUEL FAILURES
  - MEET ASME LIMITS
  - WIDE MARGINS TO SODIUM BOILING

- FOR ADDITIONAL MITIGATIVE CAPABILITY SHOW THAT THE THREAT TO THE PRIMARY AND CONTAINMENT BOUNDARIES BY SEVERE CORE DISRUPTIVE OR ENERGETIC EVENTS
  - SODIUM VOIDING
  - FUEL MELTING AND RELOCATION

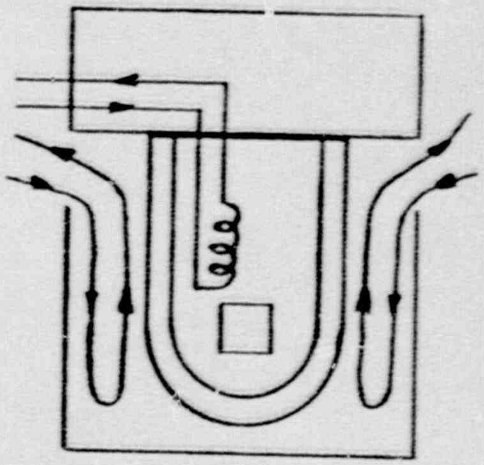
  IS WELL BELOW A ONE IN TEN FAILURE PROBABILITY

ALMR - PRIMARY SYSTEM AND CONTAINMENT BOUNDARIES

KEY CONSIDERATIONS:

- FAILURE IN ACTIVE ISOLATION AND CONNECTED SYSTEMS CAN IMPACT CONTAINMENT FUNCTION
- ATMOSPHERIC PRESSURE SYSTEM, COOLANT FAR BELOW BOILING POINT, LOW STRESS ON BOUNDARIES
- SINCE SODIUM IS DIFFICULT TO REPLENISH, CORE UNCOVERY MUST BE RELEGATED TO RESIDUAL RISK

APPROACH:



- DOUBLE BOUNDARIES BELOW SODIUM SURFACE
  - PRIMARY AND CONTAINMENT VESSELS
  - NO PENETRATIONS - PASSIVE
  - LARGE STRUCTURAL MARGINS
- FIRST BOUNDARY ABOVE SODIUM SURFACE - VESSEL HEAD
  - LARGE STRUCTURAL MARGINS
  - ALL PENETRATIONS SEALED OR ISOLATED DURING OPERATION - PASSIVE
- SECOND BOUNDARY ABOVE SODIUM SURFACE - HEAD ACCESS AREA BUILDING
  - LOW PRESSURE WITH FILTERED VENT (SIMILAR TO SUPERPHENIX II DESIGN)
  - TO PROVIDE MITIGATION
- SECONDARY SODIUM SYSTEM DESIGNED TO TAKE FULL STEAM PRESSURE
- SHOW VERY LOW PROBABILITY OF BOUNDARY FAILURE FOR SEVERE CORE DISRUPTIVE EVENTS

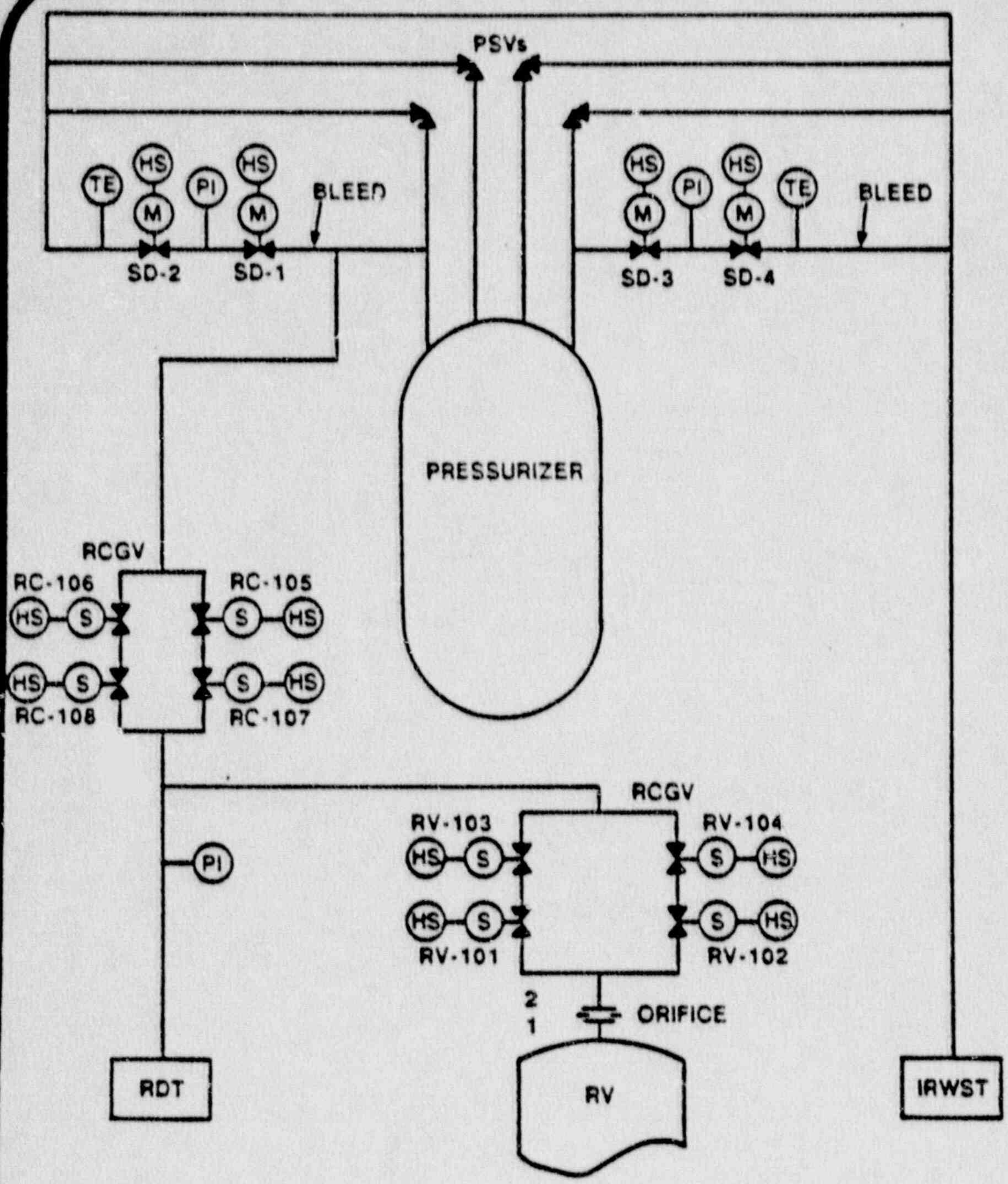


FIGURE 8 SAFETY DEPRESSURIZATION AND VENT SYSTEM

METHODOLOGY FOR SEVERE ACCIDENT ANALYSIS

- USE PRA TO ESTABLISH SIGNIFICANT ACCIDENT SEQUENCES

- USE BEST ESTIMATE, DETERMINISTIC MODELS (MAPP) TO ANALYZE CONSEQUENCES.

- OVERWHELM UNCERTAINTIES BY:

    O DESIGN FEATURES

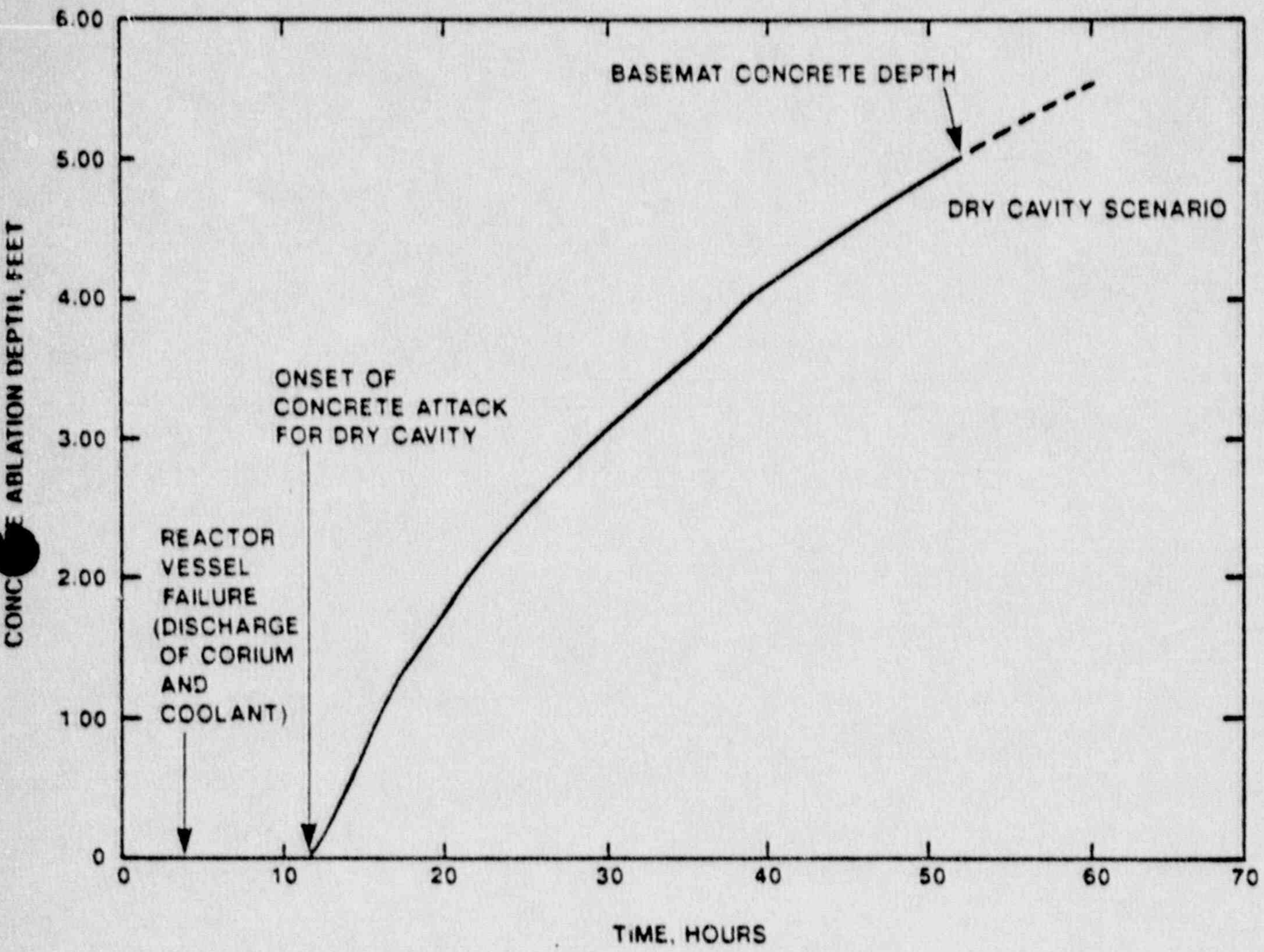
    O CONSERVATIVE ASSUMPTIONS

    O SENSITIVITY ANALYSES

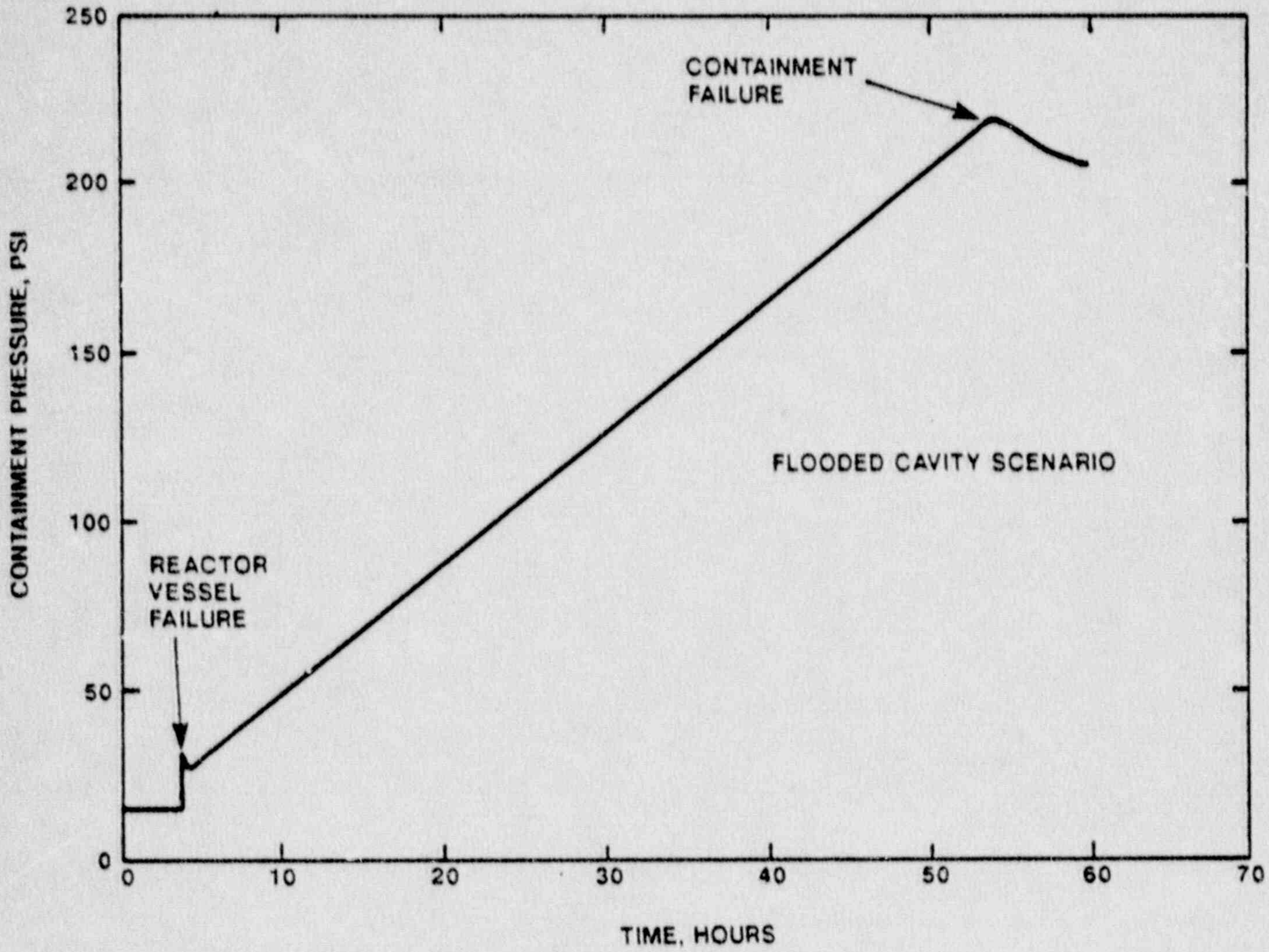
- USE EPRI GROUNDRULES AND ASSUMPTIONS AND ARSAP STUDIES AS BASES FOR ESTABLISHING ACCEPTABLE METHODS

SEVERE ACCIDENT ISSUES ADDRESSED BY SYSTEM 80 PLUS DESIGN

- COMBUSTIBLE GAS CONTROL
    - O CONTAINMENT ARRANGEMENT TO FACILITATE MIXING
    - O ABILITY TO ADD IGNITORS IF REQUIRED
- CORE DEBRIS COOLABILITY
    - O CAVITY AREA OF 0.02 M^2/MW(T) FOR SPREADING
    - O FLOODING FROM IRWST
- DIRECT CONTAINMENT HEATING
    - O SAFETY DEPRESSURIZATION SYSTEM TO PREVENT HIGH PRESSURE EJECTION
    - O CAVITY CONFIGURATION TO TRAP DEBRIS
- CONTAINMENT VENTING
    - O VENTS NOT PRECLUDED
    - O ADDITION TO STEEL SHELL RELATIVELY SIMPLE
    - O ANALYSIS OF NEED FOR VENTS NOT COMPLETE
    - O REGULATORY CRITERIA FOR OPERATION NOT ESTABLISHED



STATION BLACKOUT WITHOUT RECOVERY
CONCRETE ABLATION DEPTH IN CAVITY VS. TIME



STATION BLACKOUT WITHOUT RECOVERY
CONTAINMENT PRESSURE VS. TIME

CONCLUSIONS

- CONTINUED USE OF "TRADITIONAL" DESIGN BASES IS APPROPRIATE.

- COMBINED WITH "LICENSING" TYPE METHODOLOGY, THESE DESIGN BASES RESULT IN RUGGED, CONSERVATIVELY DESIGNED CONTAINMENTS.

- IT IS PRUDENT TO INCLUDE FEATURES TO MITIGATE SEVERE ACCIDENTS, IF BASED ON A DETERMINISTIC, BEST ESTIMATE APPROACH.

RECOMMENDATIONS:

IN ESTABLISHING CONTAINMENT CRITERIA FOR FUTURE REACTORS:

- EMPHASIZE CONTAINMENT FUNCTION RATHER THAN FORM
- ALLOW FOR SYSTEMS VERY DIFFERENT THAN CURRENT LWR'S
- AVOID CLOSING OUT INNOVATIVE APPROACHES
- ENCOURAGE PASSIVE FEATURES
- RECOGNIZE INTERDEPENDENCE AMONG CONTAINMENT, DECAY HEAT REMOVAL, AND REACTIVITY CONTROL FUNCTIONS; AND POSSIBLE TRADEOFFS
- SPECIFY EVENT SELECTION CRITERIA AND RELEASE PROBABILITIES CONSISTENT WITH THE SAFETY GOALS
- SETTLE EXTERNAL EVENT REQUIREMENTS (ESPECIALLY LARGE EARTHQUAKE)
- RECOGNIZE THAT ANALYZING MITIGATION REQUIRES EVENT SELECTION AT VERY LOW PROBABILITIES, LIKELY TO EXTEND BEYOND THE LEVEL OF THE SAFETY GOALS
- RECOGNIZE THAT THERE ALWAYS WILL BE A RESIDUAL RISK

CONTAINMENT DESIGN CONSIDERATIONS
FOR
THE SYSTEM 80 PLUS^{TM}
STANDARD NUCLEAR POWER PLANT DESIGN

COMBUSTION ENGINEERING, INC

DECEMBER 13, 1989

AGENDA

I. SYSTEM 80 PLUS CONTAINMENT DESIGN BASES

II. SEVERE ACCIDENT ISSUES

III. CONTAINMENT DESCRIPTION

IV. SEVERE ACCIDENT ANYALYSIS METHODOLOGY

V. CONCLUSION

CONTAINMENT DESIGN APPROACH

- MAINTAIN TRADITIONAL DESIGN BASES (DOUBLE ENDED GUILLOTINE BREAKS, ETC.)
    - O "LICENSING" ANALYSES
- SUPPLEMENT WITH SPECIFIC SEVERE ACCIDENT MITIGATION FEATURES
    - O "BEST ESTIMATE" ANALYSES

SYSTEM 80 PLUS
CURRENT CONTAINMENT DESIGN BASIS

- CODES AND STANDARDS
  - o 10 CFR 50, REG. GUIDE 1.57, ASME SECTION III
- DESIGN CONDITIONS
  - INTERNAL/EXTERNAL LOADS
  - PRESSURE/TEMPERATURE
  - NATURAL PHENOMENA
  - CONSTRUCTION LOADS
  - HDRODYNAMIC LOADS
- LOADING CATEGORIES
  - O SERVICE LEVEL A THROUGH D

ACCEPTANCE CRITERIA FOR CONTAINMENT DESIGN

- ASME CODE CRITERIA
- SRP SECTION 3.8.2, "STEEL CONTAINMENT"
- STABILITY (BUCKLING) INCLUDES REQUIRED SAFETY FACTORS
- SERVICE LEVEL A AND SERVICE LEVEL B ARE CHECKED TO SAME STRESS INTENSITY LEVELS
- NO ACCEPTANCE CRITERIA FOR ULTIMATE CAPACITY

CONSERVATISMS IN CURRENT DESIGN BASES

- USE OF LEAK-BEFORE-BREAK WOULD REDUCE PEAK ACCIDENT PRESSURES BY APPROXIMATELY 50%

- ULTIMATE PRESSURE CAPACITY OF CONTAINMENT IS APPROXIMATELY 4 TIMES GREATER THAN DESIGN PRESSURE LIMITS

- MARGIN EXISTS BETWEEN DESIGN PRESSURES AND ACCIDENT PRESSURES (GDC 50)

- SERVICE LEVEL B LOADING COMBINATION COMBINES EFFECTS OF PEAK ACCIDENT PRESSURE WITH PEAK OBE

- ANALYSIS GENERALLY PERFORMED WITH STATIC PRESSURE AND RESPONSE SPECTRA APPROACH FOR PEAK DESIGN PRESSURE AND EARTHQUAKE LOADINGS RESPECTIVELY (IN LIEU OF TIME HISTORY APPROACH)

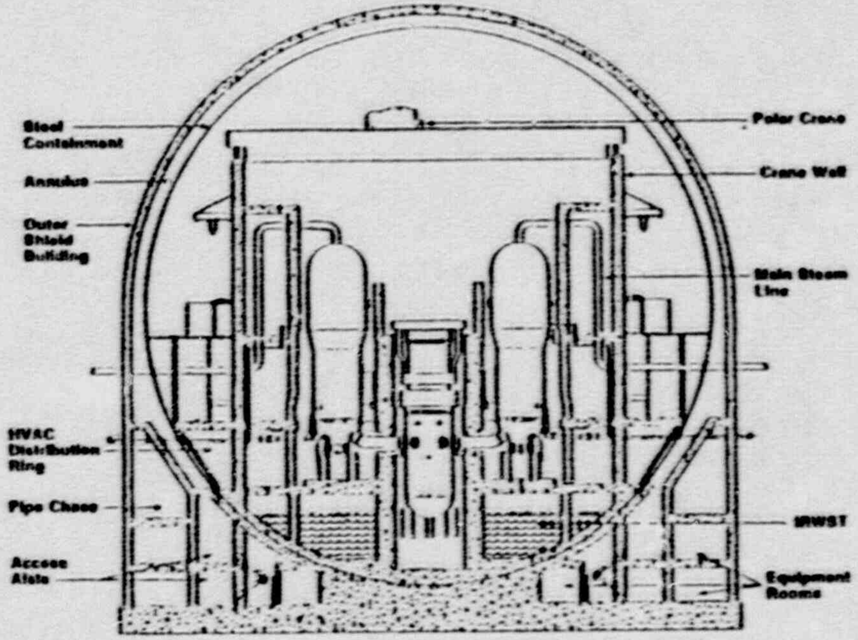
- CURRENT SOURCE TERMS CONSERVATIVE BY ORDERS OF MAGNITUDE

ADDITIONAL TECHNICAL ISSUES:
SEVERE ACCIDENTS

- COMBUSTIBLE GAS CONTROL
  - O METAL/WATER REACTION OF CLADDING
  - O ADEQUATE MIXING IN CONTAINMENT
  - O DETONATION LIMITS
- CORE DEBRIS COOLABILITY
  - O ADEQUATE AREA IN REACTOR CAVITY
  - O RELIABLE METHOD TO COOL CORE DEBRIS
- DIRECT CONTAINMENT HEATING
  - O POTENTIAL FOR HIGH PRESSURE EJECTION
  - O PATHWAY TO CONTAINMENT VOLUME
- CONTAINMENT VENTING
  - O MARGIN TO FAILURE
  - O CRITERIA FOR INITIATION

LARGE, STEEL SPHERICAL CONTAINMENT

- Dual Containment
- 200 Ft. Diameter
- Increased Space For Maintenance & Access
- Designed To Mitigate Severe Core Damage
- Shadow Area Houses Safeguard Systems



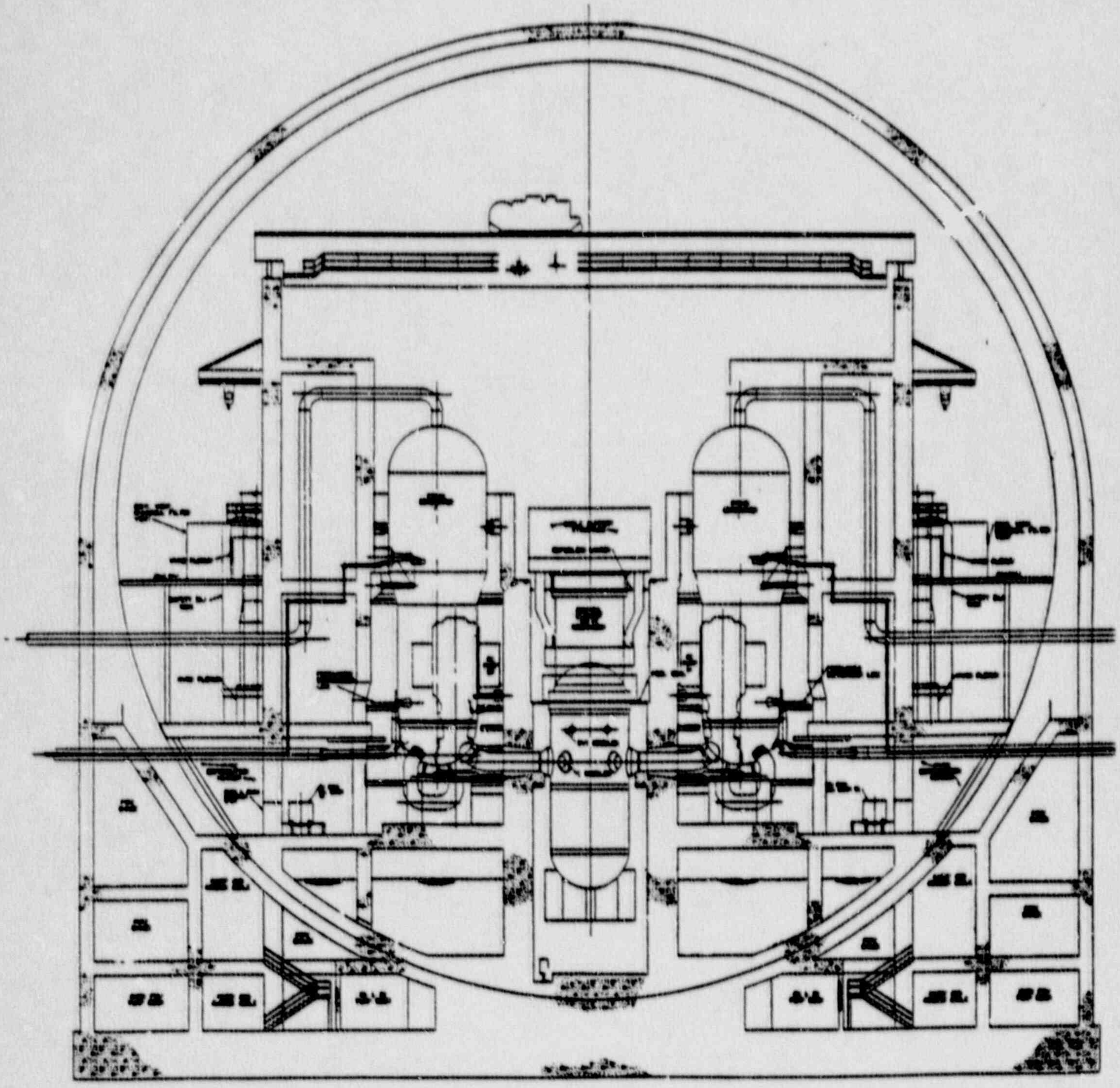
CONTAINMENT TECHNICAL DATA

CONTAINMENT:

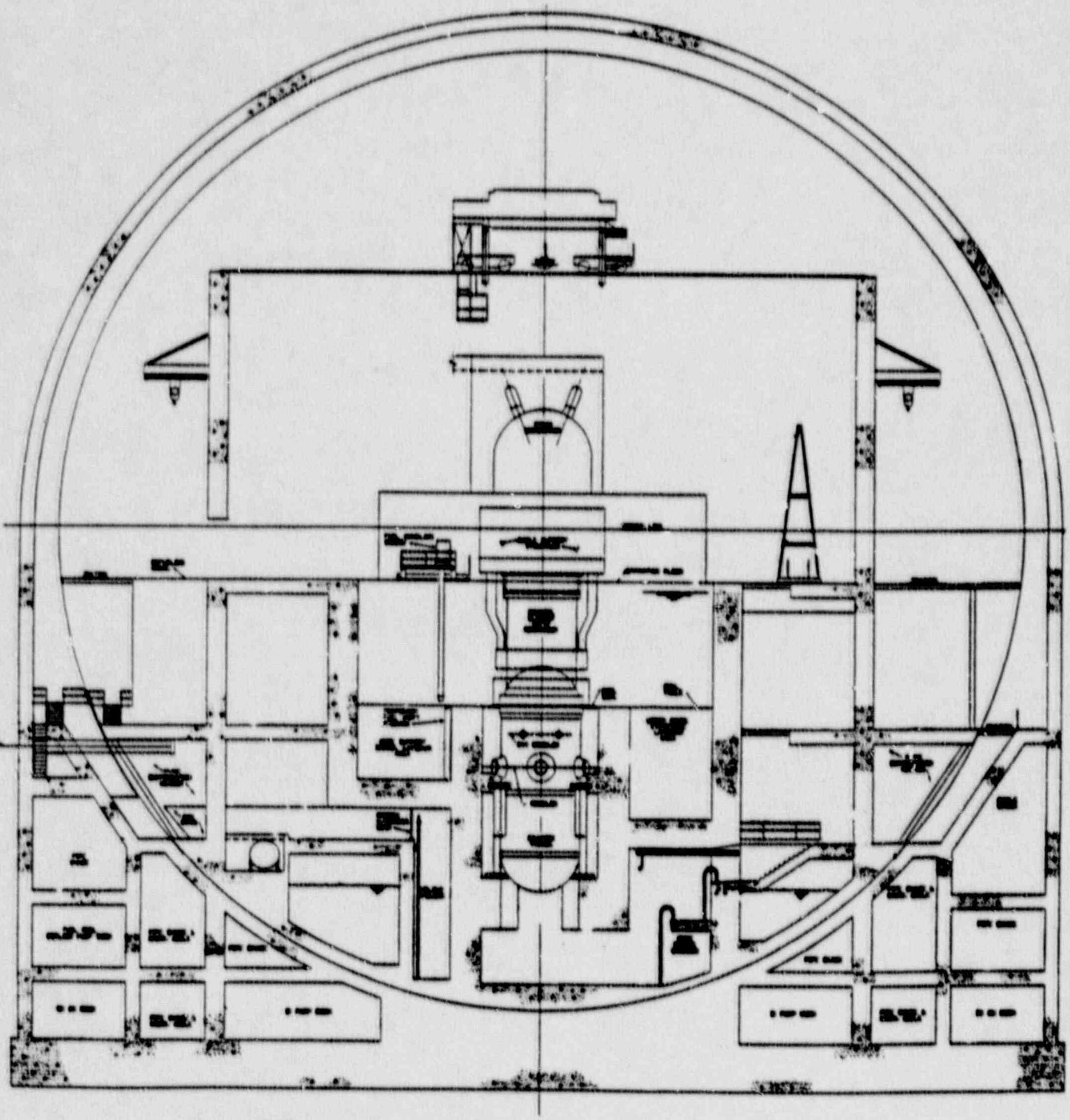
CONTAINMENT TYPE	STEEL SPHERE
STEEL TYPE	SA-537 CL. 2
INTERNAL DIAMETER	200 FEET
WALL THICKNESS	1.75 IN
FREE VOLUME	3.4 x 10^{-6} CU. FT.
DESIGN PRESSURE	49 PSIG

SHIELD BUILDING

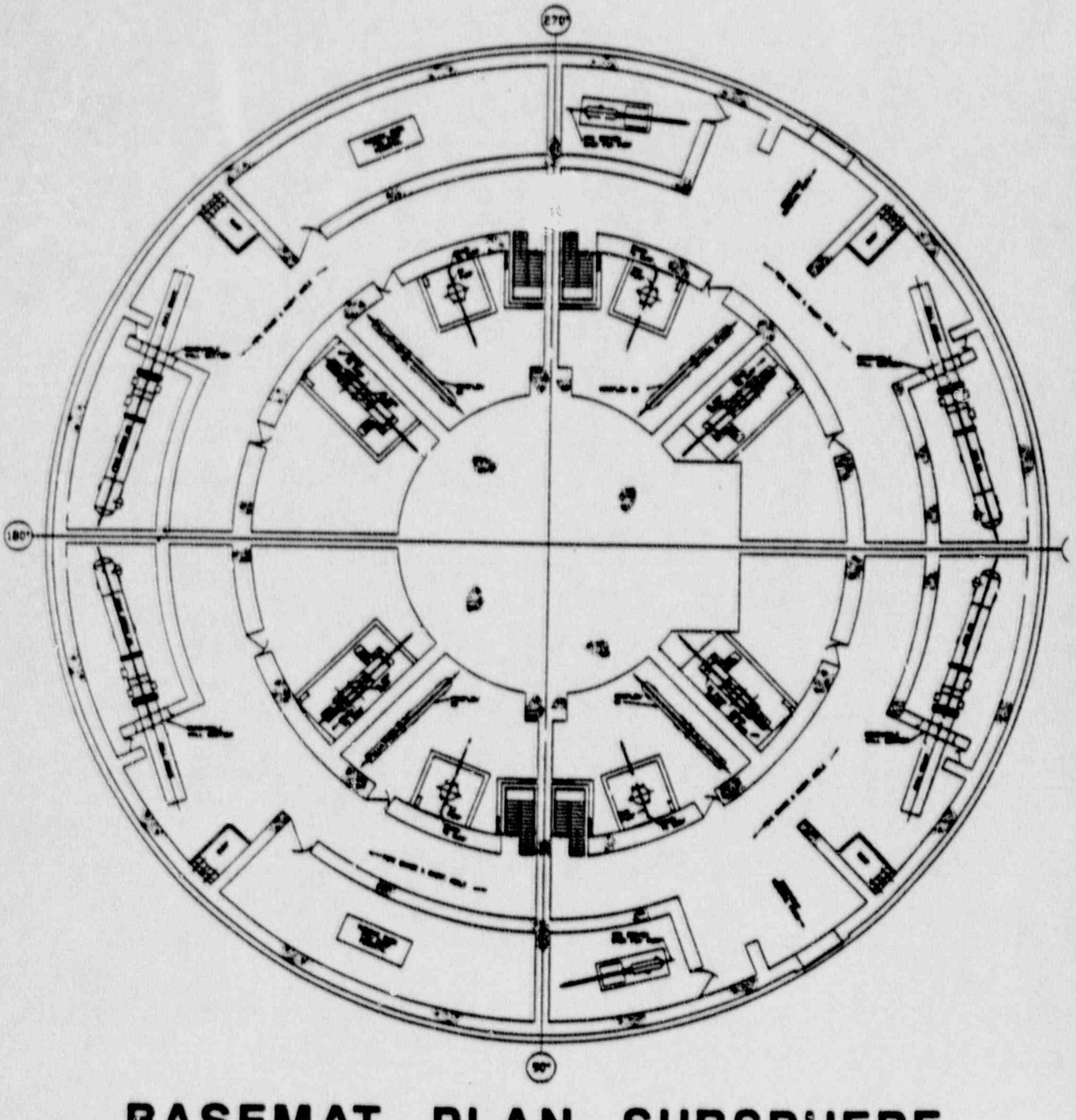
TYPE	CONCRETE
INTERNAL DIAMETER	210 FEET
WALL THICKNESS	3 FEET



SECTION VIEW 90 - 270
SYSTEM 80+



SECTION VIEW 0 - 180
SYSTEM 80+



BASEMAT PLAN SUBSPHERE
SYSTEM 80+

IN-CONTAINMENT REFUELING WATER STORAGE TANK (IWRST) DESIGN CHARACTERISTICS

O STRUCTURAL CHARACTERISTICS

  O TORODIAL, USING CONTAINMENT INTERNAL STRUCTURE AS BOUNDARY

  O LOCATED LOW IN CONTAINMENT FOR OPTIMAL SPACE UTILIZATION AND IMPROVED WATER RETURN PATH

- FUNCTIONAL CHARACTERISTICS

  O CAPACITY IN EXCESS OF 500,000 GALLONS

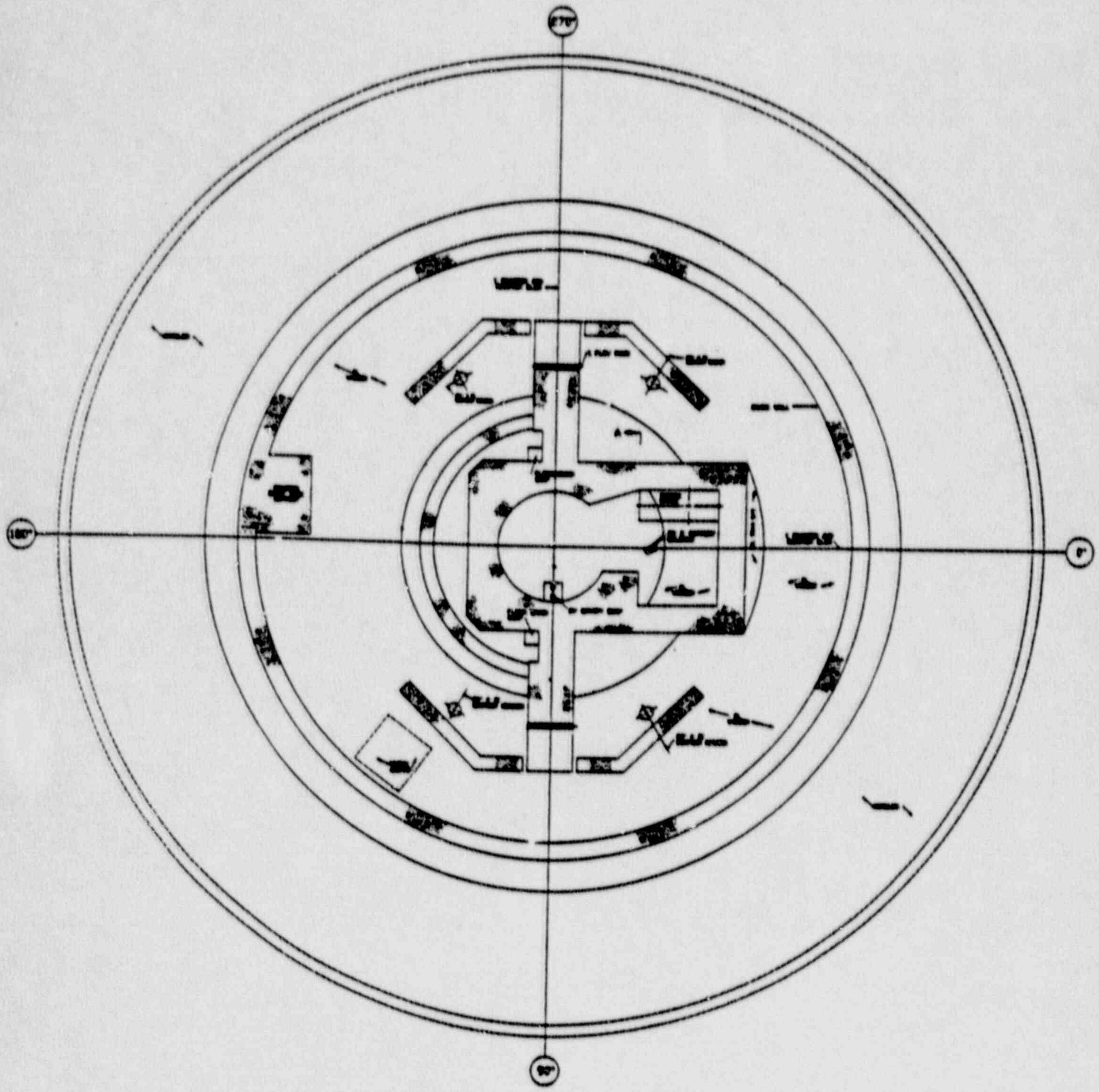
  O PROVIDE WATER FOR EMERGENCY CORE COOLING AND REFUELING

  O PROVIDE ENERGY SINK FOR SAFETY DEPRESSURIZATION SYSTEM

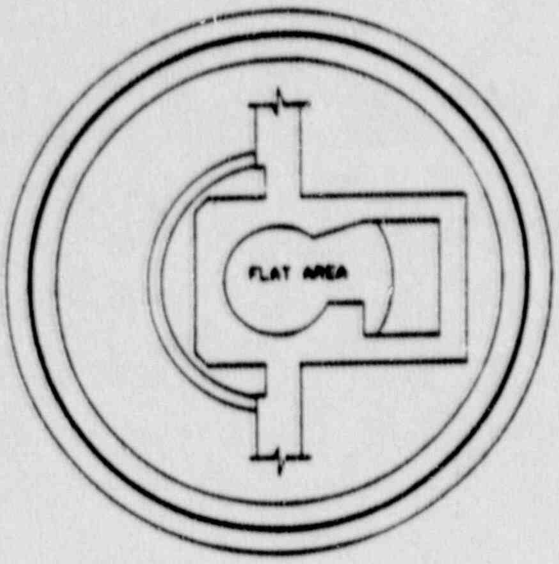
  O ELIMINATES NEED FOR RECIRCULATION MODE OF EMERGENCY CORE COOLING

  O PROVIDE SOURCE OF WATER FOR REACTOR CAVITY FLOODING

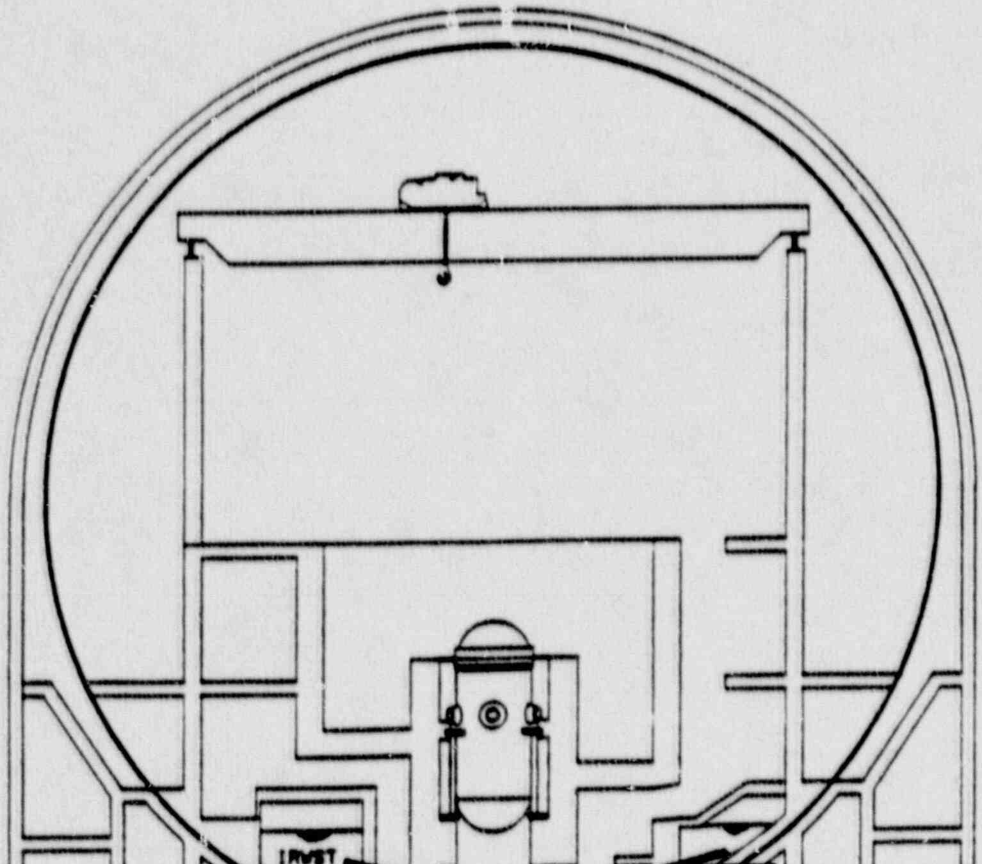
  O SCRUBS RADIOACTIVE MATERIAL FROM DISCHARGE OF PRESSURIZER SAFETY VALVES AND SAFETY DEPRESSURIZATION SYSTEM



IRWST PLAN
SYSTEM 80+



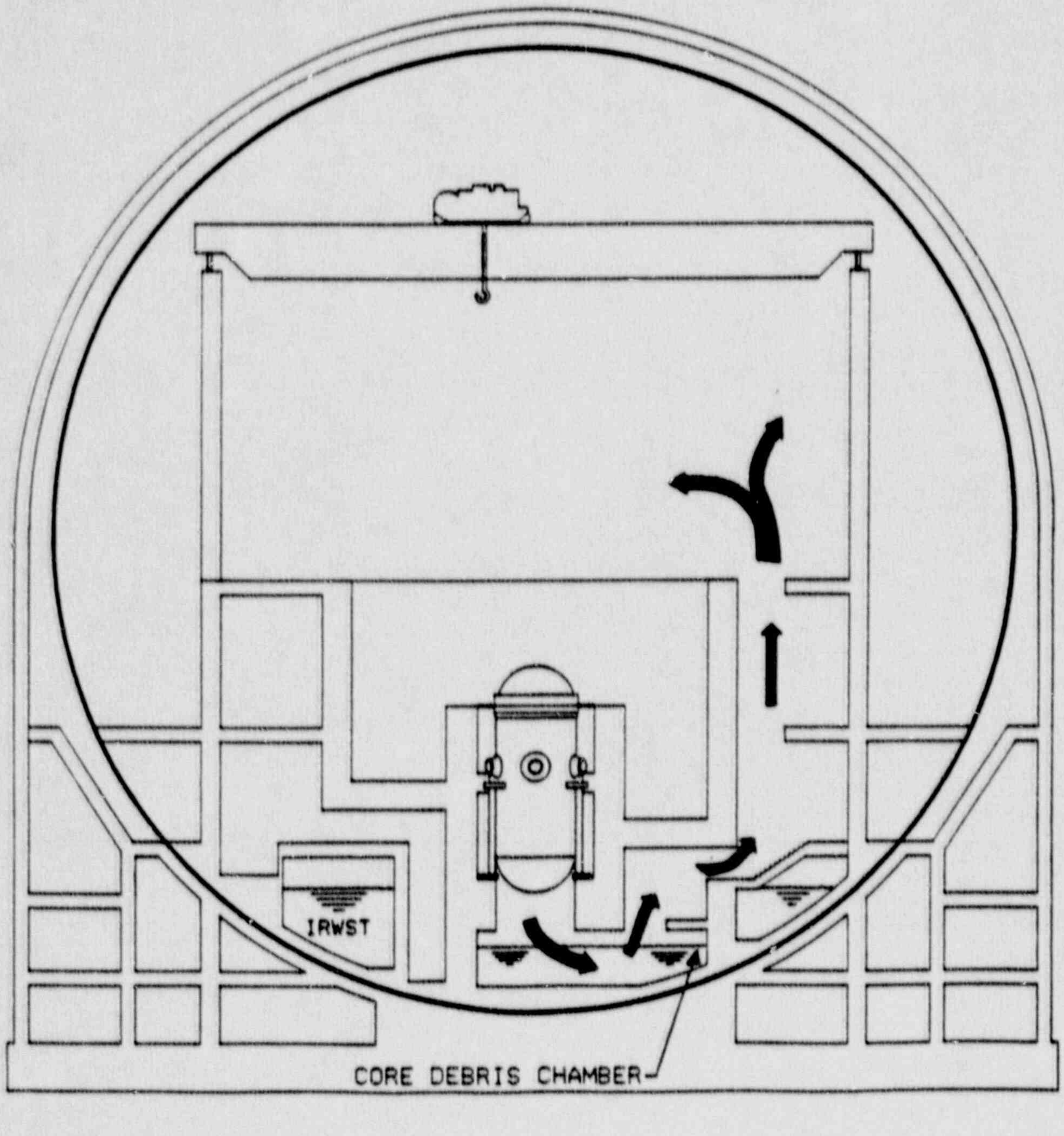
SECTION



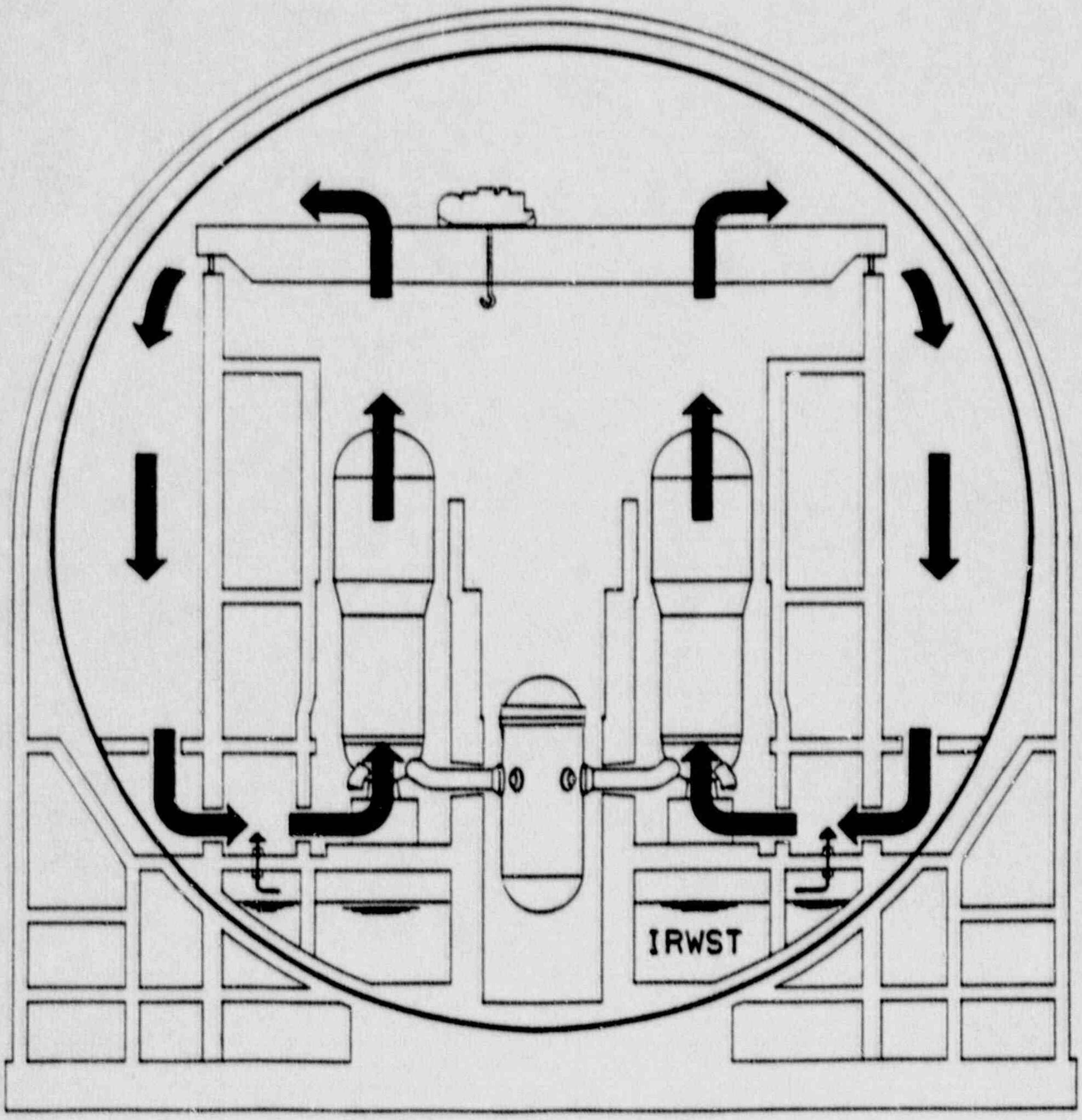
IN CONTAINMENT REFUELING WATER STORAGE TANK

REACTOR VESSEL CAVITY DESIGN CHARACTERISTICS

- ADDRESS SEVERE ACCIDENT CONCERNS
  - O LARGE FLOOR AREA FOR DEBRIS COOLABILITY
  - O FEATURES TO RETAIN CORE DEBRIS IN CAVITY TO MINIMIZE DIRECT CONTAINMENT HEATING
  - O ABILITY TO FLOOD CAVITY FROM IRWST FOR DEBRIS QUENCHING



SEVERE ACCIDENT MITIGATION



POST-ACCIDENT VENTILATION

SAFETY DEPRESSURIZATION SYSTEM

- PROVIDES SAFETY GRADE PRESSURIZER AND REACTOR VESSEL POST-ACCIDENT VENTING OF NON-CONDENSIBLE GASES

- PROVIDES SAFETY GRADE RCS DEPRESSURIZATION AND COOLDOWN WHEN NORMAL PRESSURIZER SPRAYS ARE UNAVAILABLE

- PROVIDES FOR RCS DEPRESSURIZATION TO INITIATE BLEED AND FEED FLOW IN UNLIKELY EVENT OF SUSTAINED TOTAL LOSS OF FEEDWATER FLOW

- PROVIDES FOR CONTROLLED RCS DEPRESSURIZATION DURING SEVERE ACCIDENT SCENARIOS