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ACRSt-1439

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the matter of:

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Subcommittee Meeting on GESSAR II

(Public Session)

Docket No.

Location: Washington, D. C.

Date: Wednesday, August 7, 1985

Pages: 1 - 177

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE MEETING ON GESSAR II

- - -

PUBLIC SESSION

Room 1046
1717 H Street, N.W.
Washington, D. C.
Wednesday, August 7, 1985

The Subcommittee met in open session, pursuant to notice, at 8:45 a.m., Jesse Ebersole, presiding.

ACRS MEMBERS PRESENT:

J. Ebersole
C. Wylie
J.C. Mark
H. Etherington

ACRS STAFF MEMBER:

R. Major

SPEAKERS:

D. Foreman
E. Solorzano
J. Yeazell

D. Hankins

D. Scaletti

C. Thomas

J. Chen

N. Chokshi

M. Rubin

T. Pratt

R. Jaung

B. Hardin

K. Shiu

PROCEEDINGS

(8:45 a.m.)

MR. EBERSOLE: This meeting will now come to order. This is a meeting of the ACRS Subcommittee on GESSAR II. I am Jesse Ebersole, Acting Chairman of the Subcommittee.

The other ACRS members present today are Harold Etherington later, Carson Mark, and Chuck Wylie.

The purpose of the meeting is to continue the Subcommittee's review of GESSAR II for final design approval applicable to future plants. The meeting will be open to the public insofar as possible, however, portions of the meeting will be closed to discuss proprietary information relating to GESSAR risk assessment and plant security.

Richard Major on my right is the assigned ACRS staff member for this meeting.

A transcript of the meeting is being kept. It is requested that each speaker first identify himself or herself, speak with sufficient clarity and volume so that he or she can be heard.

We received no written statement from members of the public and have received no requests to make oral statements from members of the public.

Do any members of the Subcommittee have questions or comments at this time.

[No response.]

MR. EBERSOLE: If not, we will proceed with the agenda.

I want to say this. I am the substitute Chairman. Dave Okrent has an illness in the family. But we are going to carry on, and I will do the best I can.

We've got lots of things to talk about. I don't want to, at this time, make any observations of my own. I won't make any observations on the design I stand critical of.

Let's hear from the Staff at this time.

MR. SCALETTI: Good morning. My name is Dino Scaletti. I am the NRC Project Manager for the GESSAR II review. With me today is Cecil Thomas, Chief of Standardization and Special Projects Branch, and other members of the Staff.

I would like to ask the Subcommittee to defer questions on Topic 2, which relates to discussion by the NRC Staff of coremelt frequency, containment performance guidelines to be used in standard plants. Mr. Bernero will be at the Full Committee meeting tomorrow to address this topic again. It is quite similar to the topic that Mr. Bernero addressed before the March 8th Full Committee, and he will be back again tomorrow to go over some of this information again.

Starting with Item No. 3, "Staff Introduction to the SSER No. 4, Summary of Outstanding Issues," SSER No. 4 addresses the resolution of all the remaining outstanding issues that were identified in Supplement 3, with the exception of relay chatter. Relay chatter is still under Staff consideration and will be resolved prior to the final Full Committee meeting related to GESSAR II.

MR. MARK: A question on that. The Staff is considering relay chatter. Are they looking at the actual types of relays which are proposed to be used, or are they taking something that might apply to a relay, whether it applies to this plant or not?

MR. SCALETTI: I don't think the review is being that specific right now. I think the Staff perceives that there is a problem --

MR. MARK: Is there a problem?

MR. SCALETTI: We think there is. We don't know for sure.

MR. MARK: Supposing they use solid-state relays. What is the chatter there?

MR. SCALETTI: The electrical boards losing contact with their connecting points. Maybe we have someone here that could address that.

MR. MARK: It would be in a quite different way than if you are using a relay with a spring, a balance weight or something. So it does make a difference whether you are using the relays they are going to use, telling them to change the type, in which case you could say there's no risk here at all, or what, or you can get a large risk if you use some 1910 type relays.

MR. SCALETTI: Well, for GESSAR II, my assumption would be that the ultimate resolution of this would be based upon the relays that GESSAR was using; however, this issue is being prioritized as probably a generic issue, and the ultimate resolution of it is still unknown.

For GESSAR II, my assumption would be that the relays would be the type that GESSAR is using. Now GESSAR does use a multitude of relays. They use solid-state relays and mechanical relays.

MR. MARK: It is being approached, however, on the basis of what GE expects to propose?

MR. SCALETTI: That's my assumption. However, it may be resolved finally as an interface item, if the information does not exist to determine if it really is a problem of the magnitude that it could be, or it may end up being an interface item which would be put onto a utility applicant who references GESSAR II to resolve this issue.

However, right now it has not been prioritized as a generic issue.

MR. MARK: I guess I have the feeling that, while it's never straightforward, that it could be an issue. It would be nice to know in advance whether it is or not.

MR. RUBIN: I'm Mark Rubin from Reliability and Risk

Assessment Branch.

To the issue of whether it is or is not a problem in our risk assessment, we have requantified the GESSAR to PRA. We did include a simplistic model. We did model very simplistically the potential impact of relay chatter. We couldn't perform a detailed mechanistic study for the very issues you just brought up. We did not know the specific interactions, the specific relays. The plant was not yet built. We did model it to the extent we thought we could, in the manner of a scoping analysis.

The results convinced us that it could potentially be a problem. We could not convince ourselves that it was insignificant. Because of that result, we have gone on to ask for a more detailed relay-specific, design-specific look, not only to understand what relays would chatter, but also to understand the systems interactions that would occur for the plant, what operator actions would be required to recover essential equipment, where those operations would take place, the timeframe necessary to perform them.

And until that information is complete, we don't know the extent of the seriousness of the issue, but we feel that it could be. Lawrence Livermore has also conducted a very limited study. They also have shown some concern in the area. We can't ignore it, at this time, is our feeling.

MR. MARK: I understand. It would sound very attractive if one could start from known characteristics of relays to be used. Then you wouldn't have to have the operator running around, if they weren't going to chatter anyway.

MR. RUBIN: There's a range of relays from some small protective relays to some large breakers. The fragility values assumed by our consultants, Jack Benjamin & Associates -- John Reed was the individual who did the work -- was .89, based on some Corps of Engineer experiments. But that is very subjective. We didn't do a specific relay inspection. The large relays were rotary relays, which are not planned for this plant and would have no chatter problem in this mode. Solid-state relays, as obviously shown, would not have the normal chatter, but could jump in the clips and an intermediate breaking of contact. We think it's really complex.

MR. MARK: Thank you. That certainly covers any questions I might have had.

MR. WILEY: Let me ask a question. The information you are getting on the relays, is this being supplied by the General Electric people, what they're planning to propose for this plant?

MR. RUBIN: Ultimately, that's the type of information we feel is necessary at this time and this stage. We do not have that information in detail.

MR. WILEY: Have you requested it of GE?

MR. SCALETTI: Not in a formal manner. We have a series of five questions.

MR. WILEY: Isn't that the obvious thing, to ask GE for information?

MR. SCALETTI: We have not really identified the problem. We don't know if it really is a problem yet. The Staff has it under consideration.

MR. WILEY: This relay chatter subject has been around for a couple of years. We've been talking about it for a couple of years.

MR. SCALETTI: We have asked the questions. GE has the questions in their possession. It may be that it's going to be a requirement that the utility applicant, the final design of the plant, all the design, total plant, balance of plant is provided. If it's provided, this situation will be resolved.

MR. WILEY: We're not talking about balance of plant. We're talking about standard design that GE is proposing here.

MR. SCALETTI: That's right.

MR. WILEY: I don't understand your comment, then.

MR. EBERSOLE: May I ask a question about relay chatter?

It seems to me, GESSAR II and, for that matter, the equivalent other advance plants we have, are probably the least effective arena to look at really. We have what -- 60, 80 plants in the field now? They all have relay chatter problems.

They are working today. Why are we fiddling around with a plant that probably we'll never build here anyway on the relay chatter mess? You just get a conclusive statement that it will resolve this issue to the satisfaction of the Staff; then go to work on the plants that are running.

MR. THOMAS: Cecil Thomas, NRC Staff.

Jesse, I think you hit the nail on the head. As Mr. Wylie pointed out, the subject has been discussed off and on over the last couple of years. During our review, PRA review of GESSAR, the subject came up again.

It was decided to go through the process and see if it really is a problem, before we really try to approach it on GESSAR. As you know, our requirements are to look at medium and high priority GSIs and USIs. The approach was to try to get a generic feeling of whether or not it's a problem to run it through the prioritization process, not only for GESSAR, but for all plants, period, to see how important it really is and what resources should be put on it.

MR. EBERSOLE: Wouldn't it take about a week to find out some critical circuits that would lock up in their own configuration, and then you say, "Ah, here's an entree into a massive general problem that necessitates a rapid action?"

MR. THOMAS: I would agree with the second part. The taking a week I might take issue with, because nothing moves that quickly in the Staff. As soon as we're convinced that it's something that is a generic problem, we will look for more specific information from GE and approach it and try to resolve it on GESSAR.

MR. EBERSOLE: Let's get a spinoff from this meeting, then. Let's get a schedule from you as to when we will converge on whether it is a problem or not, and what's the course of action to do that, and look at it as a generic problem across the board.

MR. THOMAS: We intend to do that generically. In fact, we will go back and talk to Warren Minners and see what progress they're making generically, as far as categorizing it and prioritizing it. And secondly, depending on where they are, we will pursue it on GESSAR specifically.

MR. EBERSOLE: It makes me a little nervous to think the plants may be subject to relay chatter, even in a minor earthquake, and they will lock up and disarray, be unable to do good things like they're supposed to do.

MR. THOMAS: I think the point is, the Staff is not convinced yet that it's a problem to do -- it's a problem of sufficient priority or urgency to take immediate action. We are not convinced of that yet, or else we would have done something.

MR. EBERSOLE: It's rathe. obvious what it does. It develops sequential events that are in disorder. You know valves that are supposed to open will shut. That's sounds pretty nasty to me, and vice-versa, if, in fact, the contacts moved, because there are time delays to open a valve. Then it's back in, and you've got the entire sequence of events in disorder.

Why don't we park it by saying that an adjunct schedule of some sort will be developed to handle this, and let us know when it will be picked up.

MR. THOMAS: That is certainly one approach. Of course, the approach in the past to this is to assure that the components are appropriately qualified, at least up to the design basis earthquake, to accommodate this.

MR. EBERSOLE: But that evidently did not include relay chatter; is that right?

MR. THOMAS: We believe it did. The thing is, you know, so you can show a cabinet or a relay can withstand the design basis earthquake without losing contact or without in fifty directions. We have to go the next step and assure ourselves that there's sufficient margin there to accommodate uncertainties and so on.

MR. EBERSOLE: In these tests, did they actually have continuity devices, test the contacts to validate whether or not the contacts were moving?

MR. THOMAS: I believe that's a requirement, Jesse. I'm not sure. It's really beyond the scope.

MR. EBERSOLE: It seems so ridiculous about this matter, yet it apparently has the potential for trouble.

MR. THOMAS: It has a potential, but we're not sure it's a real problem yet.

MR. EBERSOLE: We can't stand on that kind of evidence.

MR. RUBIN: Let me just add a little perspective, that our simplistic modeling of the impact of relay chatter was very pessimistic. We saw total dependence. If one relay chatters, they all chatter. You've lost all your safety response equipment. Even assuming a pessimistic approach, while it was a fairly large factor in the risk profile, it certainly wasn't catastrophe. It was about 40 or 50 percent of the total coremelt frequency, and with the design improvement additions, it becomes considerably less from the seismic impact.

So the numbers we've shown in our risk profile reflect a pessimistic relay chatter impact, and the resulting numbers are still pretty reasonable, we feel.

We hope to reduce them now. That's our intent.

MR. MARK: I believe you said, in this pessimistic approach, you assumed they were okay up until eight-tenths g?

MR. RUBIN: "Okay" is not the way it was modeled. It was a component for GLT value and it was integrated over the response --

MR. MARK: You took eight-tenths as the peak of a distribution?

MR. RUBIN: Fifty percent cumulative probability of distribution of failure at that level.

MR. EBERSOLE: That will close that topic, then.

Does the Staff have other things to say under Topic No. 3?

MR. SCALETTI: I will just briefly go through it. I would like to address Subpart (a), the results of the BNL review or the process by which the BNL review took place with regard to questions and answers.

MR. EBERSOLE: I'll make a request at this time that later on GE -- I presume you're going to listen to the discussion of the resolution and have your own comment about how the resolutions are going.

MR. FOREMAN: Yes.

MR. EBERSOLE: Go ahead.

MR. SCALETTI: The BNL questions were not specifically identified in questions to General Electric as being BNL's. They were identified only using our numbering system as questions from the Technical Review Group, which has that review in their responsibilities. These questions were sent to General Electric in a formal were -- most of them were, I might say. There are other questions that were sent to General Electric informally.

Now these were done by transmitting -- just giving them copies of memoranda from BNL reviewers to their management, addressing some concerns of the GESSAR review. However, all of these questions were responded to formally by General Electric, referencing those memoranda, and they are in the docket room. If the question is there, the answer is there, and the ACRS has received copies of all this information. However, I do have additional copies here that I will give Mr. Major, that he can do with what he so desires.

Now the reason for giving General Electric informal questions was just to expedite the review process. We've been under considerable pressure to try and get this review done. In many cases, it was just the quickest way to do it.

Quickly, with regard to the confirmatory issues, they are addressed in Section 1.9 of the supplement. It tells the status of the confirmatory issue, and the section, if it is addressed in the supplement, where it is addressed.

The interface issues again are identified in Section 1.10. There are five of them, one of them being a newly identified generic safety issue, which I must indicate, as given the characterization of the issue, was not directly applicable to GESSAR II, only to BWRs licensed before 1980.

However, the Staff has addressed it, and as part of that interfacing LOCA, required prototype testing of the valves to assure their functionability under the pressures they are designed to operate.

That's about it. If you have any questions?

MR. MARK: Question: You refer to prototype testing of the valves, which could be something like static tests. Here we put down 900 psi or 1010 psi or whatever. Does this include attempts to close valves under flow conditions?

MR. SCALETTI: I believe it does. I'm looking at the writeup in here. It says "at least on a prototype basis by performing a closing and opening test at full design differential pressure and flow across the valve disk.

MR. MARK: Pressure and flow?

MR. SCALETTI: Yes.

MR. MARK: That's an important test. A little bit tough to arrange, maybe.

MR. SCALETTI: You're probably right.

MR. EBERSOLE: That's it?

MR. SCALETTI: That concludes the Staff's presentation on Item 3.

MR. EBERSOLE: You have nothing under Item 3, "Interfacing?"

MR. SCALETTI: I discussed interfacing information. We have discussed interfacing information at previous committee meetings. I can go back and reiterate.

Our interfacing requirements are so identified in the various supplements. Supplement 2 has interfacing requirements on critical components and structures. We are looking for -- with regard to our interface information -- looking to assure that the PRA comes true. Our requirements are so specified in the documents. We do not have a great deal of quantitative requirements related to interfaces, but whatever is there are identified in the documents.

MR. MARK: Could I come back to that valve prototype test? Who is going to do that? Someone like Maryland under contract to you, or someone under contract to GE?

MR. SCALETTI: It would be someone under contract to General Electric, I assume, or the utility applicant who is applying for -- who references the design.

With regard to interfaces, let me just make a point here, such as the interfacing on containment venting, which is in Table 1.2 of Supplement 4. The interface is as simple as providing procedures and guidelines to show that venting is provided for or takes place prior to reaching the ultimate capacity of the containment. That is the extent of it.

We would review that interface information at the time that it came in to see if it meets the Staff requirements at that time.

MR. EBERSOLE: Well, on that topic, I have marked that down here as something to develop in a little bit of detail here. On page 15.2 of the Supplement 4, it says, "However, the final venting guidelines and procedures must be provided by the utility applicant who references GESSAR II."

That immediately throws me into a tailspin, because it says I really don't have a standard design at all, because at the worst end of the spectrum, the applicant can say, "I will never vent it," and the other one will vent it too soon, and I have no consistent, organized evented pattern for how we're going to handle this venting problem, beginning with the case where I'm in a venting mode to prevent coremelt, and subsequently I'm in a dirty mode trying to keep the containment from departing.

I can't see how, at least in my view, GESSAR II could be put together without a firm set of guidelines or criteria or almost proscriptive detail about how and when we're going to vent and what we're going to vent with.

I'm reluctant to get enthusiastic, at least, about leaving this open to the applicant, as we have, for instance, in the past -- such critical things as aux feedwater. I think this is highly critical to the success of the UPPS system, that we have a well-developed and integrated picture and a definitive operation for this important subsystem, that I have a lot of enthusiasm for personally. I think other people here also do.

Could you comment on this looseness with which we leave the venting option, in particular, and in particular, the fact that this looseness leaves UPPS sort of floating in space?

MR. SCALETTI: The Staff has evaluated containment failure, as well as GE I guess, in excruciating detail. It was determined that one of the most critical items -- the wetwell, obviously the pool is very critical, and the Staff was concerned that loss of the pool could result in significant consequences.

Therefore, we felt that at a minimum we should try to -- if you could not document or you could not demonstrate absolutely that you would not lose the pool due to containment overpressurization, then there had to be some mechanism by which you could assure that the pool failure would not result, and as a result, containment venting.

But I agree, it is loose, and as it stands now, that's the way it is, as long as procedures are provided to vent containment prior to reaching the ultimate strength of containment.

MR. EBERSOLE: See, that's the last phase of the venting process. The first phase, if we're going to divide it into phases, is to vent to preclude core damage, a much less difficult thing to face. That's also venting.

MR. SCALETTI: I will let someone else -- if someone else has something they would like to say on it from the Staff.

My assumption was, the reason -- the primary reason for containment venting at this time was to maintain the integrity of the pool, and with that, we have in many cases assumed the wetwell failure, the containment failure.

MR. EBERSOLE: You are then identifying venting as a process that occurs after core damage.

MR. SCALETTI: I guess, yes. That could be listed. If someone else has something to say?

MR. EBERSOLE: The premise is, you presumably have locked up the fission products, the bulk of them in the water, and you want to keep the water around.

MR. SCALETTI: Yes.

MR. EBERSOLE: You don't associate that with the operation of the UPPS system, which is also venting in a much more important mode.

MR. SCALETTI: It has venting capabilities, yes.

MR. EBERSOLE: Any comment from the Staff?

MR. RUBIN: Venting is obviously part of the UPPS system. When final design is submitted, operating procedures will be part of that which will be reviewed. So obviously, venting will be part --

MR. EBERSOLE: You'd like to leave that option up to the applicant and not predefined by General Electric as to how to do it?

MR. SCALETTI: Either General Electric or the utility applicant can do it. Once it has been locked in place or once the venting guidelines, procedures and guidelines -- guidelines and procedures have been developed, then they would be, for the most part, I assume, locked in for GESSAR.

MR. EBERSOLE: Let me put it this way. The utility I knew and worked for for so many years would be the least competent outfit to do this sort of thing, as I suspect would any utility. I would put the burden of this venting procedure and all the primaries and operations associated with it squarely on GE and say it should be part of this submission, instead of just hanging it out for the utilities to deal with. That's about the worst place I can think of to do it.

MR. SCALETTI: They do. They have to deal with it to the NRC's satisfaction. So I would guess that would be a requirement of General Electric, as well as any utility that references the document. And I would like to believe that the Staff is competent enough to --

MR. EBERSOLE: Why isn't it an integral part of this GESSAR II design to have this sort of thing? It's not just an operating procedure; it's a concept.

MR. SCALETTI: We will try to get you some more answers on that.

MR. EBERSOLE: On the Item 3(c), "Interface information," it is stated on there, "to include detailed quantitative requirements for interfaces that arose from the PRA, list of specific items, from where did they arise, and what is the specific requirement?"

Of course, I'm quoting Dave's questions. Where is this material?

MR. SCALETTI: In Supplement 3, there is a list of specific items with regard to critical components and structures. This was built upon a submittal from General Electric which identified certain critical components and structures. The Staff, at that time, felt that there should be more and specifically identified some of them. It is there in Section 15 of Table -- I guess it's in Table 15.1 of Supplement 3. Each of the supplements identifies the Staff's -- at a minimum, the Staff's additional interface requirements related to the review.

Now this is not total -- it identifies some that General Electric has provided. General Electric's interface requirements are numerous, and they're located in, I believe, Section 1.8 or 1.9 of GESSAR, and it would be just too voluminous for the Staff to repeat all of those.

So we have included only those that the Staff felt necessary to be added in the supplements.

MR. EBERSOLE: In the interfacing items here, one which is described on page 55 of the supplement in Appendix C, there is mention of interfacing LOCA, and on the bottom of page 55, a particular pair that could result in some substantial conditional consequences, the RHR suction line interface, the high-to-low pressure interface, another interface associated with the potential break of the RCFC steam lines and failure to isolate -- this is a residual from the ancient problem of the HPCI issue, which still stands today and is in the field today.

You don't mention that reactor water cleanup is another potential interface where you have a high-pressure system feeding into a low one, also running out into the auxiliary equipment area.

And I mention these in coincidence with the relay chatter problem, because these valves that open or close to keep the interface in the proper relationship are subject to relay operation, and thus to chatter, and could lead to the discouraging view that maybe a little shake from an earthquake will open the high-to-low pressure systems, and one will have sort of a substantial consequence of that. So these are interrelated and critical matters.

For instance, I would hate to think a little earthquake activity would do this to the plants in the field today. They would synthesize Event V, I believe, to create substantial consequences.

What is the current state of resolution of this sort of particular aspect of relay chatter? It's a nasty one.

MR. SCALETTI: I can't answer that. Hopefully, this will be included in the resolution of the proposed generic issue. Relating to relay chatter, perhaps I cannot answer that.

MR. EBERSOLE: Does GE take any issue with the Staff's denial of the decontamination factors that they claimed, or are they satisfied with that resolution?

MR. FOREMAN: Dr. Hankins says she'd like to cover that.

MR. EBERSOLE: In a later presentation? Okay.

Well, let's take advantage of this little time saving and jump to -- unless committee members have any further observations -- jump to Topic 4, "Selected Topics from SSER No. 4 and other Outstanding ACRS Review Items."

The first of these is design of Seismic Category I structures: foundations-sliding stability on a site-specific basis, and the questions, you see, are listed here.

Does the Staff have any comment or elaboration of these topics?

MR. SCALETTI: We do. I believe General Electric does also. We would like to give them a chance to espouse some views for awhile.

MR. FOREMAN: Dr. Enrique Solorzano will make the presentation.

MR. SOLORZANO: My name is Henry Solorzano, General Electric.

[Slide.]

What I would like to cover today is the following items of background on how we developed where we are in terms of sliding stability, what the consequences of sliding are, and highlight the piping design basis and draw some general conclusions.

[Slide.]

The FSAR shows that the auxiliary building had about the lowest factor of safety against sliding when it was submitted, and the basis of analysis utilized for calculational purposes were static approaches and were, therefore, very conservative and envelop all of the site conditions that were submitted as part of the GESSAR envelope.

Therefore, it was felt that higher margins could be shown if a more sophisticated method of analysis was utilized, and it was submitted under SSER No. 1. However, as things developed, the analytical costs and plant cancellations indicated there may be other simple approaches that could serve the same purpose, so we spent some time looking at other static approaches that were simpler than the dynamic approaches that were originally contemplated but did not really pan out and show any significant increase in the results that we were expecting to see.

[Slide.]

Therefore, we agree with the Staff as far as making this an interface item that would be done by an applicant on the basis of his site-unique location. We feel that they shouldn't have any problem in meeting some of these requirements. As a matter of fact, in the past, if one wonders will he be able to come up with higher safety factors, realistically we expect that from past experience, the more defined analysis will show larger margins, and the ASCE Manual No. 58, as a matter of fact, indicates displacement due to sliding and distortion of massive structures such as these can be neglected as part of industry practices.

Therefore, we feel that there should be ample confidence in meeting some of these requirements. The interface requirements --

MR. MARK: These analyses are within some framework of seismic magnitude. Now, the GESSAR II has an SSE proposed of .3 g.

MR. SOLORZANO: That is correct.

MR. MARK: When you speak of margins, does one relate back to .3 g and say, well, it will stand three times that, or twice it, or exactly that, or how does that go?

MR. SOLORZANO: Generally speaking, it will stand a higher number than that because the designs in most cases are not controlled necessarily by seismic but by some other considerations, such as chilling, maybe, or pressure or thermal, and when you look at it in terms of just seismic capabilities, usually much higher than it is designed for. And also there are inherent factors that one puts in when one calculates the amount of rebars, for instance, that go into the structure and the defined necessary thickness.

You don't just make it three-quarters of an inch or three feet, 3-3/4. You round it off to the next higher number. Therefore, you have inherent added margin. So generally speaking, you will have a much larger capability than the .3 g, which was, I believe, also discussed as part of the PRA.

MR. EBERSOLE: Can you tell me what the merits of having buildings like this, rather than having them structually interlinked trying to keep them, relatively speaking, in proper spacial orientation?

MR. SOLORZANO: We did some optimization studies with that when we first got started. That was one of the very crucial items we looked at. There are many different parameters that come into the picture. When you consider them all and their total net effect, it was found that lower seismic accelerations in some of the more critical structures were obtained utilizing this method. The amounts of material employed were less, and the construction sequencing of it was also improved by doing it by separate mats rather than having one big, large foundation from which we would be fitting from one structure into the other seismic excitations.

MR. EBERSOLE: The interconnecting piping and any other equipment between the buildings. You have especially designed features to allow for not nearly the estimated differential movement by considerably more than that?

MR. SOLORZANO: That's correct.

MR. EBERSOLE: What is this, U-bends or what?

MR. SOLORZANO: We have provided large areas for accommodation of displacements which were calculated on the basis of the envelope SSE when you are going between buildings, and that is one of the topics --

MR. EBERSOLE: That will come out later?

MR. SOLORZANO: The very next slide, as a matter of fact. I just want to mention the SSER Table 1.2 shows that interface specification for this requirement.

[Slide.]

It was discussed previously that twice the maximum allowable -- I shouldn't say allowable, but actual tolerable movement of three inches comes out to be six inches, can be easily tolerated by interconnecting straight piping.

MR. EBERSOLE: What is the configuration of that piping?

MR. SOLORZANO: Straight piece of pipe.

MR. EBERSOLE: Is it abutted building to building or is it in an S-curve?

MR. SOLORZANO: Straight piece of pipe between the two buildings.

MR. EBERSOLE: You don't, then, deliberately convolute it to take a deflection.

MR. SOLORZANO: No. Six inches would represent about 5 percent strain maximum. The pipe is 120 inches long, which is really a very, very small amount. The maximum expected actually is 3 inches. The foundation gap between the mats is 3 inches, and therefore, these buildings cannot move more than 3 inches in any one direction. So even looking at it conservatively, you still have quite a bit of capability in the piping.

MR. EBERSOLE: This pipe you refer to, it's not embedded in the reinforced concrete, is it?

MR. SOLORZANO: No. It goes from structure -- from piping system to piping system, anchor point to anchor point.

MR. EBERSOLE: The deflections occur well within the building?

MR. SOLORZANO: That's correct.

MR. EBERSOLE: So you do have a flexibility design from anchor points within the building?

MR. SOLORZANO: That's correct. We have the seismic anchor movements incorporating into the piping design as well.

MR. EBERSOLE: You depend on a guaranteed degree of freedom where it penetrates the wall.

MR. SOLORZANO: That's correct.

MR. EBERSOLE: How do you get that?

MR. SOLORZANO: Oversized holes with some sort of bellows at the penetrating point.

MR. EBERSOLE: Is it a frangible bellows or flexible or what?

MR. SOLORZANO: I don't recall. The details vary depending on the pipe sizes. Exactly which one we are talking about would vary. In some cases one is more convenient than the other.

MR. EBERSOLE: So your real piping run is not really six feet. It might have been ten feet.

MR. SOLORZANO: Ten feet. The worst case is ten feet. The others have -- for instance, running through the annular space between the containment and the shield building, which allows you a great deal of flexibility, and those we don't even worry about, so we have picked the very, very worst condition we could think of here just to illustrate the point that 5 percent --

MR. EBERSOLE: So it's just a case of piping movement at the supports.

MR. SOLORZANO: Right. We are assuming those supports would be moving no more than six inches, which is, as I said, twice the possible expected when you have got only a

3-inch gap between the buildings.

The other thing to consider is it's not a simplistic movement that's going to occur. These things are not just going to move in space out, away and beyond each other, but they interlocked like two horseshoe-shaped buildings around a central cylindrical concrete building, and they will have some distortion in terms of tortional effects since the centers of mass, centers of gravity and rigidity don't coincide.

MR. EBERSOLE: What is the substance between the buildings? Is it fill?

MR. SOLORZANO: No, we have a special pullout device that gets covered afterwards, so that there is an actual gap. In other words, they put a crushable material, then it gets pulled up afterwards. There is all kinds of QC near the construction to make sure you do get your three inches.

MR. EBERSOLE: How do you know the hole is going to be left empty, it won't just silt up and become solid?

MR. SOLORZANO: That is part of our QC of construction --

MR. EBERSOLE: Whenever I hear QC, it is administrative controls.

MR. SOLORZANO: We have to see it signed off by the inspector that in fact the cap gets covered with architectural treatment so it is protected so debris doesn't fall into it.

MR. EBERSOLE: Or somebody in 20 years wouldn't say look at that empty slot, fill it with compacted sand?

MR. SOLORZANO: It is not just an empty slot; it's covered with protective material like plates that slide over the top of it, anchored at one point but slides over the other.

We have also included displacements. The calculated SSE displacements are small. Differential settlements. We are using analysis. They are in the range of 5 inches. Part of the envelope considering the subsoil conditions. Naturally, at the bottom where we are concerned with, rotations are small.

[Slide.]

MR. EBERSOLE: Do you have cable runs between these buildings and duct work or other envelopes?

MR. SOLORZANO: Yes, we do, and we do provide flexible conduit-type material if they go across the buildings.

MR. EBERSOLE: Okay. Thank you.

MR. SOLORZANO: In terms of the piping, the design basis is the ASME Section III requirements, and more specifically, in sections of the FSAR, 3.7 and 3.9, there are a multitude of details, but highlighting some of the more specific ones, it is a linear elastic analysis, a conservative analysis done for the OBE, and the results are double for the SSE, without taking into account higher dampening factors or any of the other contributions.

We do include displacements into the analysis of the piping seismic anchor movements that we just talked about a few minutes ago. They are again described in the section listed here in the Vu-graph.

[Slide.]

If I can summarize, the piping in general does not fail, the maximum expected displacement being 3 inches. It neglects embedment effects of the structures. The bottom of the auxiliary building, for instance, and the reactor building are not at the same level, the auxiliary building bottom being higher than the bottom of the reactor building, which tends to act as an anchor point, if you will, for the auxiliary building, which therefore does not account in all of these calculations, which leads us to believe it is a very conservative approach that we have taken.

So the agreement to have the applicant do a definite, unique analysis for his particular application should have really no problem in meeting the Staff requirements. The calculations for six inches also indicated no piping distress on top of that. So with all of that, we feel pretty safe in what we have agreed to.

MR. EBERSOLE: Is it all based on flexible piping behavior?

MR. SOLORZANO: Yes, it is all linear elastic.

MR. MARK: I must say that first conclusion is not well designed to raise an enthusiastic level of confidences. Perhaps just the wording. It doesn't generally fail. It leaves it open that it fails here and there. From time to time it might vary, but it won't fail always. It is kind of a weakly-posed conclusion.

MR. EBERSOLE: Yes, that is a bad word.

MR. MARK: You want to give some thought to that. If it were possible to say, it would be more reassuring, perhaps, that under motions up to 6 inches, there is no indication of failure, and there is no likelihood of a motion as bit as 6 inches. It would come out a little more persuasively.

MR. SOLORZANO: That is a well-taken point.

MR. EBERSOLE: Couldn't you really say that you will use stress levels that they used in ordinary piping practice for piping movement rather than the unusual challenge of an earthquake?

MR. SOLORZANO: Right.

MR. EBERSOLE: And fall into the statistics, then, of piping hanger design in general.

MR. SOLORZANO: Right.

MR. EBERSOLE: I certainly agree with what you say, "generally fail," in view of the fact that it just takes two pipes and you have had it.

MR. MARK: Is the type of material in the piping specified item?

MR. SOLORZANO: Yes, it is required that the materials --

MR. MARK: Be steel of a certain characteristic?

MR. SOLORZANO: Stainless for some others, 316 nuclear grade and so on.

MR. EBERSOLE: I take this opportunity to ask a question that has come in view about piping and hanger in this type of design. In your type of design, is your design -- is there a requirement which is standing or has it come as a result of standard practice that says if any given hanger fails for whatever reason, that the piping is not in duress. This would have helped out at Diablo Canyon.

MR. SOLORZANO: I don't recollect that as a specific criteria.

MR. EBERSOLE: I wonder if you could look into the merits of having that said and thus alleviate the consternation we have about individual hanger failures.

MR. SOLORZANO: You know, they are going through the exercise of leak before break type of things. I'm sure that is going to be one of the areas that will be touched upon as part of that review, but we can take a look.

MR. EBERSOLE: I have been told experience shows that is generally true but it is not an explicitly required design.

MR. SOLORZANO: Specifically if you don't put all of the loading conditions that go into the original design when you look at it.

MR. EBERSOLE: I don't think it is unreasonable at all to require that any hanger be sawed off andthe pipe is not in duress, do you?

MR. SOLORZANO: It depends on what loading conditions you apply to --

MR. EBERSOLE: I would design the loading conditions to allow that.

MR. SOLORZANO: In that case, it should be no problem.

MR. EBERSOLE: If you just do it.

MR. SOLORZANO: Sure.

MR. EBERSOLE: But the question is, of course, will you do it? Is it in your design here?

MR. SOLORZANO: To my knowledge, no, we don't do it nowadays.

MR. EBERSOLE: Why don't we have a look at the implications of single-hanger failures as sort of a local view into how your design has got conservatism. There has been a lot of flap about poor anchorages in some of these. It's not the hanger itself; it's the anchor plates.

MR. SOLORZANO: Yes.

MR. EBERSOLE: Any further questions on this particular topic?

[No response.]

MR. SOLORZANO: Thank you.

MR. EBERSOLE: At this time there was a scheduled break at 10:20, but we are doing so well. Does the Staff wish to comment on this?

MR. SCALETTI: I believe the Staff has something to say on item 4, yes. Dr. Chokshi.

MR. CHOKSHI: My name is Nilesh Chokshi. I am with the Structural and Geotechnical Engineering Branch of NRR. I am going to repeat a lot of things that G.E. just presented in their presentation, so I will try to be very brief.

[Slide.]

I think the two buildings which have been the subject of discussion in SSER 4 are the auxiliary building and control building. The sliding stability of these two buildings did not meet the acceptance criteria defined in the Standard Review Plan. For those structures the sliding stability is not in issue to comply with Staff criteria.

Just to give a feeling for the location of the buildings, auxiliary building as mentioned in the G.E. presentation, has a foundation mat like the reactor building, and it is approximately 170 feet by 120 feet. It is 11 feet thick. The top of the mat is about 23 feet below the grade level, so it is enveloped on three sides. The side against the reactor building, however, is free.

Again, as mentioned earlier, there is a 3-inch gap between all the foundations of the separate buildings. The control building is basically surface founded, has a 5 foot thick mat, roughly 104 feet by 88 feet. The top of the foundation slab is about 2 feet 2 inches above the grid.

MR. EBERSOLE: I picture, then, that there are deep slots between these buildings, open areas?

MR. CHOKSHI: That's right. There is a 3-inch gap at the foundation level. As you go up higher, there is a wider separation.

MR. EBERSOLE: What is the vertical distance of the slot?

MR. CHOKSHI: The foundation levels are at various levels. The auxiliary building and the reactor building -- the reactor building is the most deeply embedded, about 34 to 40 feet.

MR. EBERSOLE: So I have got an open slot 34 feet high?

MR. CHOKSHI: Yes, between the two. You have a foundation mat, then a step, and there will be fill material under the auxiliary building foundation mat.

MR. EBERSOLE: These slots are empty?

MR. CHOKSHI: Yes.

MR. EBERSOLE: They are supposed to have some sort of seal on it.

MR. CHOKSHI: My understanding is there is compressible material in the joint.

MR. EBERSOLE: That is what I was getting around to. I would rather have something in there that you couldn't put anything else in.

MR. CHOKSHI: The safety analysis report mentions there would be a compressible material.

MR. EBERSOLE: That is not what was said a while ago. I think you said it was covered and left empty.

MR. SOLORZANO: That was my impression, but I did not check that.

MR. EBERSOLE: Don't you think this is better because you can't silt it or otherwise invalidate it? And do you get any contributions from damping effects from this stuff rather than having --

MR. CHOKSHI: Oh, yes. If you don't take into account --

MR. EBERSOLE: Now the picture is you are going with a crushable material or elastic material?

MR. CHOKSHI: Compressible. Some elastic.

MR. EBERSOLE: Like what?

MR. CHOKSHI: Styrofoam.

MR. EBERSOLE: Crushable?

MR. CHOKSHI: Crushable.

MR. EBERSOLE: Styrofoam won't give you the resistance.

MR. CHOKSHI: I think there is some other commercial --

MR. WYLIE: You are 40 feet down to the foundation, basically.

MR. CHOKSHI: Twenty-three feet, top of the slab. Foundation is generally 11 feet thick.

MR. EBERSOLE: Won't it be saturable wi h water?

MR. CHOKSHI: There are different si'e conditions.

MR. EBERSOLE: If it is saturable with water, it will load up with water. It will become essentially solid.

MR. SOLORZANO: We have water stops all around the joints.

MR. EBERSOLE: Brown's Ferry's basement is leaking like a sieve. It is supposed to have water stops all through it. It will fill up with water.

MR. CHOKSHI: Dr. Chen of the Staff has comments.

MR. CHEN: This is John Chen from the NRC Staff.

In general, when the grade level below the ground, the gap was filled with styrofoam so the water would not accumulate.

MR. EBERSOLE: Is it a porous material that will absorb water?

MR. CHEN: The styrofoam itself is the material. The water can't go in there.

MR. EBERSOLE: Is it closed pore?

MR. CHEN: It's left in place.

MR. EBERSOLE: If it fills with water under rapid movement, it becomes a solid.

MR. CHEN: There are stresses in there. Primarily you have the stress that is calculated based on the side pressure that was in their design.

MR. EBERSOLE: Didn't it include th effect of saturating?

MR. CHEN: That is groundwater level, yes. Up to the groundwater level. So it has been designed for that.

MR. EBERSOLE: All I wanted to know was whether it was accounted for in the saturated stage.

MR. CHOKSHI: Just to give you some idea of why these two buildings are -- these are the factors of safety present in the FSAR for these two buildings as shown here. This is less than the Staff Acceptance Criteria 1.1 for SSE load combinations.

These calculations were based on a very simple zero static type of approach, where we have both and peak, horizontal, and vertical forces were considered in static loads, and simply resisting force was provided by not vertical and the coefficient of friction.

This report is known to have very conservative results. It does not really take into account reverse single motion. Also, the taking the peak vertical and horizontal forces simultaneously is very conservative, because of the substantial peak vertical forces.

Furthermore, in g calculations, what they did for SSE case was simply vertical B loading, which does account for higher energy losses in the soil and in the structure during the higher ground motion. That factor is, again, very conservative.

So it was felt at that time if you take a more realistic look, you could alleviate this problem. G.E. had proposed earlier to look at the time history type approach which was proposed for San Onofre and submitted on the San Onofre docket, which took into account dynamically-induced shield stresses at the interface within the soil and the foundation.

However, as mentioned by Henry, they decided not to pursue this approach and to try some ordinary schemes, simplified schemes to calculate the factors of safety. However, again, these ordinary, simplified schemes did not seem to give the proper answers.

[Slide.]

Just to give you an idea of what the envelope approach was, and why this is not a problem that should be looked at site specific: here are the best shears resulting from the full soil cases. As you can see, the order of magnitude, there is a factor of 2 from a critical case, which is soil case 9, to case 7, which is the fifth base case.

MR. EBERSOLE: The units of the shear.

MR. CHOKSHI: These are in kips. Except for one or two soil-type conditions, basically soil case 9, they can show they can meet acceptance criteria. So based on this, it was recommended that this issue be resolved on a site-specific basis because there are a number of options available at the site. For example, looking at the site-specific seismicity, which would be probably less than the criteria.

Also underlying this recommendation was a strong belief that zero static matter is conservative and is really not a good indicator of actual potential of sliding.

[Slide.]

This is not the exact interface condition. It was recommended future applicants do a site-specific calculation for these two buildings and show that they meet all requirements. I just indicated what are the current acceptance criteria. However, the specific criteria are not listed in the interface condition.

MR. EBERSOLE: Are the piping penetrations below -- would they possibly be below the standing water line in any of these sites? I was told a while ago that they were frangible member-type supports.

MR. CHOKSHI: I don't have information to state that at this time.

MR. EBERSOLE: I heard the piping went through the walls with either bellows or frangible membrane or something. Would there be any potential for fracturing or relieving at this point which would subsequently become a leaking point for groundwater?

MR. SOLORZANO: The only one we have below water is the one that I brought out that we looked at for the 6-inch movement. All the others come up above the water and down into the pool.

MR. EBERSOLE: What do you do about the one below water?

MR. SOLORZANO: It is a straight piece of pipe. It is seamless, 10-feet long stainless steel pipe.

MR. EBERSOLE: That is between the buildings?

MR. SOLORZANO: That's right.

MR. EBERSOLE: It is supported internal to the building someplace.

MR. SOLORZANO: Yes. It is anchored to the containment.

MR. EBERSOLE: When it penetrates the wall, what is the water tightness picture after an earthquake? After you have an earthquake and you have flexed or otherwise used the penetration where the pipe runs through the wall. Is it then subsequently leak tight?

MR. SOLORZANO: Supposedly it went through the earthquake without any damage or major damage.

MR. EBERSOLE: Including the member through which it goes through the wall?

MR. SOLORZANO: Sure. That is designed for that kind of seismic acceleration.

MR. EBERSOLE: So its impermeability to water is maintained.

MR. SOLORZANO: It's not even supposed to go to yield. It's all linear elastic design.

MR. EBERSOLE: It suggests sort of a bellows. I don't know what you have got.

MR. SOLORZANO: That one is a straight piece of pipe that we figure is the worst, as I mentioned. The others inherently have some sort of flexibility built into them because of the annular, 5-feet annular space between the two buildings. So they never go right straight from containment to shield building, but they run in that free space.

MR. EBERSOLE: The whole thrust of my question is is it water-tight after an earthquake?

MR. SOLORZANO: Yes, it is.

MR. CHOKSHI: This is all I will say about the sliding issue. The piping is -- I'm going to just briefly summarize the analytical techniques.

[Slide.]

The linear elastic method was used and all the procedures and criteria were in compliance with current Staff SRP symptom criteria. I would call this a very conventional state of the art approach. There is nothing unusual in the piping analysis.

Unless you have specific questions, it is really a very routine type of analysis approach.

MR. EBERSOLE: Right. Any questions?

MR. MARK: I can roughl/ follow the kind of analysis that has been gone through. Namely, you allow the building to float in the air because of the vertical seismic thrust. Then you ask what is the resistance to sidewise thrust that might come on at the same time and get an answer.

Has sliding ever been observed in large mass of buildings of anything like this type?

MR. CHOKSHI: No. In fact, there is a draft report put together by the Seismic Safety Margin Panel. Their conclusion is you don't observe sliding of engineering structures which are embedded to some extent. Where you see sliding is when the structure is on a slope or embankment type situation, but here there is no observation of sliding of structure, massive --

MR. MARK: Have you applied similar analysis to this to some buildin, in which failure to slide was observed and found that it ought to have slithered across the field?

MR. CHOKSHI: I don't know of any. You know, the nature of the seismic motion is reversible. I can't see any sustained motion in one direction.

MR. MARK: That was really my feeling, that although the analysis is straightforward, the facts are not.

MR. CHOKSHI: That is right. It's a drastic simplification.

MR. MARK: I was wondering if anybody has observed the building moving a few feet.

MR. CHOKSHI: I don't know of any case unless there is a gross soil figure, such as in the construction of some kind of soil, bearing pressures are affected or something.

But in general, the buildings don't move.

MR. MARK: Thank you.

MR. CHOKSHI: Thank you.

MR. EBERSOLE: Are ther any questions here?

[No response.]

MR. EBERSOLE: We are doing so well, I'm going to call a brief intermission here until 10:05 so we can stoke up with coffee and so forth because we have a two-hour run after that before lunch. So let's have a brief intermission until 10:05.

[Recess.]

MR. EBERSOLE: Is it an actual member into which the straight pipe penetrates? Is it flexible? Will it accommodate the 3-inch movement? Do you understand what I am meaning? I don't want any water in the building from groundwater.

MR. SOLORZANO: Usually we have piping penetration detail which is either in the form of a flute head or a sleeve or some kind of an oversized penetration device that is larger in diameter by several inches than the main piping that goes through it.

MR. EBERSOLE: Okay.

MR. SOLORZANO: When you go across the buildings, you have the sleeve going all the way through the two buildings. In fact, not being tied in one and tied in the other.

MR. EBERSOLE: The sleeve itself, then, is passage for the pipes.

MR. SOLORZANO: It is passage for the pipes.

MR. EBERSOLE: What about the sleeve embedments?

MR. SOLORZANO: There are pipe hangers sort of like a collar around the sleeve, which act as --

MR. EBERSOLE: Okay. Then the impervious seal is between the sleeve and the concrete.

MR. SOLORZANO: That is correct.

MR. EBERSOLE: What is the nature of that? Is it frangible in an earthquake? Is it such as to be of a size that would give you substantial problem as you had high groundwater?

MR. SOLORZANO: I don't remember.

MR. EBERSOLE: It's just a detail. I don't know why I'm pursuing it, but it has got to be fixed because I know in the field right now there are some substantial leakage problems.

MR. SOLORZANO: I don't remember exactly the details. It has been quite a few years since I looked at it last.

MR. EBERSOLE: The problem with this is it would not be revealed until an earthquake showed on the scene, and then it might be troublesome.

MR. SOLORZANO: What we had to do is meet all the criteria requirements that were specified for the movement of that particular device at that particular joint. So all of the details, I am sure, accommodate that. Just exactly how they do it, I just don't have that recollection, but we did accommodate, for instance, vertical displacement of about 5 inches in the vertical direction, so you know it has to have that kind of give to it, at least that much.

Now, how it was accomplished, I just can't give you those details.

MR. EBERSOLE: This is a G.E. detail?

MR. SOLORZANO: Yes.

MR. EBERSOLE: Well, let's move on to the next topic, which is item No. B.

[Slide.]

MS. HANKINS: Debra Hankins, General Electric.

The next topic concerns various hydrogen issues, and what I have tried to do is just specifically list answers in the order in which the items were mentioned in the agenda.

In terms of the rates and amounts of hydrogen generation -- and recall, this is for a full core melt sequence, we did not analyze partial core melt sequences -- but if one were to assume from the standpoint of the CPM metal rule, hydrogen control provisions, that the melt were arrested in vessel, we see rates that vary from .4 to 1.6 pound mass per second.

Those were in the range of generation rates that are being tested in the HCOG experimental programs. They have total in-vessel hydrogen production of 1300 to 2300 pound mass, depending on what type of sequence. The high pressure sequences producing more mass of hydrogen than the low pressure sequences.

There is only enough oxygen in the containment of the standard plant 238 containment to the support combustion of 2480 pound mass of hydrogen. So, in other words, if you look at the rule that says you have to assume 100 percent of the active clad metal-water reaction, in reality it doesn't matter whether it is 70, 75 or 100 percent because there is only enough oxygen to burn for 67 percent.

Relative to hydrogen detonations, when we originally did the PRA, we did not have a lot of information --

MR. MARK: Could I go back to your rate and amounts topic just for a second? How are those rates, .4 to 1.6 pounds hydrogen per second, come on? That goes with a certain quantity of water. It must be about a gallon of water per pound of hydrogen.

MS. HANKINS: I'm not familiar with what the values are.

MR. MARK: A pound of hydrogen goes with 9 pounds of water, and I guess a gallon is 8 pounds, so in order to get up to that 1.6 pound per second, you have got to have had 10 gallons of water per second, or 600 gallons per minute. Isn't that enough to keep the reactor cool so that this isn't happening at all?

MS. HANKINS: You are right. The rate varies with time, and usually the large rates are for very short periods of time, so you could have a burst, say, when you are depressurizing --

MR. MARK: I can see a large rate. If you don't have all the zircalloy into a pool at the bottom, then you could get stuff going very quickly, but I have seen numbers of times in which, if you have that much steam going through, the reactor was cooled by the steam and so it wasn't hot.

MS. HANKINS: These values came from the MARCH Code calculations.

MR. EBERSOLE: Is this a contradictory aspect of this whole thing: if you get enough water to produce it that fast, it's not going to get that hot?

MS. HANKINS: You would have to balance the water very carefully in order to assure that you keep the core cool.

MR. EBERSOLE: In the calculation, do you take into account the cooling effect of the water to accomplish --

MS. HANKINS: You take into account some cooling.

MR. EBERSOLE: At the same time, you are producing hydrogen?

MS. HANKINS: Yes, if it is sufficient. The problem with hydrogen is once you get started, the heat addition from the metal/water reaction tends to keep feeding the reaction, so the decay heat level, for example, becomes moot after a few minutes because the heat addition is all coming from metal/water reaction. So even though 600 gallons per minute may have been enough to cool the core when you had decay heat, now that you have the extra heat addition from the metal/water reaction, there probably won't be.

MR. EBERSOLE: I see. So the metal/water reaction will override the cooling effect of the water necessary to supply the reaction.

MR. MARK: Yes or no. The steam has got to be hot before it will react, and the heat of the reaction doesn't heat the steam until it reacts. So it is a very messy, slippery sort of business, I think, and I'm not sure that the MARCH Code is enough to establish the facts.

In any event, these rates of hydrogen are the ones you have allowed for in the consideration.

MS. HANKINS: Correct.

MR. MARK: I'm sorry I interrupted, so why don't you go on.

MS. HANKINS: If there are any more questions relative to hydrogen production in the estimates using MARCH Code, I think Dr. Pratt is probably more of an expert on that subject than I am.

Relative to hydrogen detonations, as I said, when we first did the PRA back in 1982, we did not have very good understanding of hydrogen detonations and their effects and at what concentrations one would expect to have different hydrogen phenomena. So we developed hydrogen event trees which we felt were very conservative in that once a concentration, either locally or globally, in the containment reached the detonable level, we assumed if the hydrogen was then ignited, we would have a detonation.

We found that even given what we thought were very conservative estimates of detonations, that the risk in the PRA results was indeed very low for the MARK III. Our current understanding is that the likelihood, in particular of a global detonation, is very small and maybe even impossible with the MARK III geometry.

That is based on testimony that was given by Dr. Bernard Lewis in the Perry hydrogen hearings. He had stated there was no way that one could get detonations in the MARK III geometry, but even, again, given the fact that our analysis allowed for detonation, the Staff BNL analysis allows for detonations and the consequences.

The internal event risk reduction, looking at the Staff BNL results shows no risk reduction for the addition of hydrogen control, shows about a factor of 2 for the seismic risk, and this is based on the assumption that local detonations fail the drywell, and G.E. disagrees with that assumption.

We also feel that there may have been an oversimplification in the analysis of the seismic events in that it was assumed that the majority of events led to local detonations with drywell failure in a location that did not allow quenching in the core. That is a different assumption than was made in the internal events analysis by the Staff BNL review, and I will let the Staff respond to that.

But if seismic was treated consistent with the internal events, it would not show this factor of 2 risk reduction for a seismic event. G.E.'s commitment was originally to provide a hydrogen control system that was consistent with the outcome of HCOG's testing and the NRC review of that testing.

In SSER 4, we are required to supply a diverse power system for igniters. Again, this is related to risk reduction shown for seismic events. This is beyond the HCOG position of having the igniters connected to the emergency diesel generators. We find no technical justification for that requirement. However, because it is required in the SER, G.E. will require with that requirement.

Again, our position is unchanged from four years ago. We believe the hydrogen control is unnecessary. The absolute risk is already low. Certainly no justification for igniter system, and this is even consistent with what was said in the SER on a cost-benefit basis.

MR. EBERSOLE: You really feel you have been hammered into this by the Staff.

MS. HANKINS: Absolutely.

MR. MARK: Could you remind me the relative size of the internal and seismic components of the total risk of core melt?

MS. HANKINS: I have a table here from the SER.

[Slide.]

These are the Staff's BNL numbers. Obviously, G.E.'s numbers are coupled -- I guess three orders of magnitude lower. Again, they are showing 30 man rem per year risk, total risk. This is GESSAR today. This is GESSAR with UPPS. If you add igniters to that, there is no change in the risk.

Staff assessment has been there is about a factor of 2 reduction for seismic, predicated on the assumption in the majority of cases --

MR. MARK: What fraction is seismic to the total? I can't quite find it.

MS. HANKINS: Seismic is almost all of the total.

MR. MARK: You are coming close to putting a factor of 2 on the total risk, according to the Staff's way of estimating it. You don't see that. G.E. doesn't see it, I mean.

MS. HANKINS: I believe there is a technical inconsistency in the calculation going from here to here.

MR. MARK: But that is the BNL handling.

MS. HANKINS: BNL will be addressing that.

MR. EBERSOLE: As a practical matter, Ms. Hankins, igniters are hardly more than a Christmas tree string in relative cost context, and the Staff has added an interesting use of the MG set to include upgrading the battery capacity in lieu of putting in big batteries in SSER 4.

MS. HANKINS: We are required to upgrade the batteries to ten-hour capability in addition for the igniters providing an independent power supply.

MR. EBERSOLE: Couldn't a case be made for not upgrading the batteries but relying on the MG set to keep them charged? What is the cost differential there?

MS. HANKINS: I don't know.

MR. EBERSOLE: I don't know what the cost of ten-hour addition to battery capacity is relative to the cost of an MG set, but I should think a battery cost would go up higher.

MR. RUBIN: We did a trade-off of the dedicated power source for a small battery charger as opposed to putting in larger batteries, which was one of the design modifications G.E. analyzed.

MR. EBERSOLE: Didn't the larger battery cost a great deal more than the charger?

MR. RUBIN: The larger batteries would. However, we are still asking for ten-hour capacity, which does not require some larger batteries but load shedding, some breaker orientation, some procedures.

MR. EBERSOLE: It's just management?

MR. RUBIN: Management with some small hardware changes to allow them to shed the required loads early in the event.

MR. EBERSOLE: So you are not going to put a ten-hour battery with the overload logic. You are just going to manage the load.

MR. RUBIN: We want to be able to manage the load.

MR. EBERSOLE: That's not a physical addition in any major sense, as I understand it.

MR. RUBIN: Not by our definition of major. There are some capital costs.

MR. EBERSOLE: Is the notion of putting a rectifier charge here on the MG set for the igniters more practical than putting two independent MG sets? One small one for the battery and somewhat larger -- or vice-versa, small one for the igniters and a larger one for the chargers?

MR. RUBIN: We were trying to be clever and size --

MR. EBERSOLE: I saw the packaging, but why bother with the multi-purpose use when a couple of rotary machines might be more simple in the first place?

MR. RUBIN: I'm not sure I follow you.

MR. EBERSOLE: It looks like that could be G.E.'s option, to extend the battery capacity with either a rotary charger or one driven off the MG set for the igniters. I would suspect a couple of small rotary sets would be better, but that's just a guess.

MR. RUBIN: We were looking at a capacity of 20 --

MR. EBERSOLE: Whatever it is, it disappears like a fly speck in the cost of a plant.

MR. RUBIN: In our view, a single unit could provide both functions.

MR. EBERSOLE: But you wouldn't object to two if it turned out to be equally or more practical?

MR. SCALETTI: I think the Staff would entertain alternatives if they did the same function.

MR. EBERSOLE: The thrust of this, I guess, is the notion that the hydrogen detonation is associated with loss of power, and that locks you into an idea, however realistic it is. It's a follow-on.

MS. HANKINS: But most of this risk comes from your loss of power events, station blackout events. What I am saying is if you show no risk reduction on internal events, you have to wonder why are you showing it on seismic, and if you start digging into reasons, you find they are related to the assumptions on detonations, assumptions being different for seismic events. I don't know why a seismic event would cause different hydrogen phenomena than an internal event.

MR. EBERSOLE: I thought it had to do with some strain on the drywell. Am I wrong?

MS. HANKINS: The combustion phenomena of hydrogen should not be different just because the event was initiated by a seismic event.

MR. EBERSOLE: No, it would not change it. Then the difference has to be to some mechanical effect of the earthquake.

MS. HANKINS: I think the difference is in the analysis that was performed.

MR. EBERSOLE: Can the Staff comment on that?

MR. RUBIN: A number of people should probably comment. We are missing one of them at the moment. He is making a phone call. Mr. Shiu, who did the systems analysis. One aspect would be the seismic response of the UPPS system, which is preventive and would prevent the necessity for hydrogen control. The seismic capacity of the UPPS system as proposed by G.E. is relatively small, which would account for more hydrogen.

MS. HANKINS: Mark, the difference we are talking about is UPPS here and UPPS with igniters. The difference between 560 and 260 is related to phenomenology. It is not related to the operation of the UPPS system. We have UPPS in both cases. I think Dr. Pratt will cover that in his presentation.

MR. PRATT: Would you like me to cover it in the presentation? I can make some statement now.

MR. EBERSOLE: Go ahead and cover it later. It may be more practical.

MS. HANKINS: I have only got one more chart.

[Slide.]

The last issue was the effect of standing flames on the drywell seals. I think when the agenda originally came out, it had to do with containment seals. It was later revised to drywell. As you know, because of our position -- that is, maintaining the drywell integrity and the pool integrity -- whether or not you have containment integrity is really a moot point. I have addressed this only to the drywell seals and their potential for leading to a pool bypass sequence.

If you look at the equipment hatch on the drywell, you will find it has a 5 foot concrete plug in front of the seals. Likewise, personnel airlocks also have concrete plugs, and the electrical penetrations themselves are over 5 feet long and they are potted with a Portland cement type mixture. So our assessment was the standing flames in the wetwell region would have absolutely no effect on the drywell integrity even though in the PRA we made an assessment that there was a potential for actually burning a hole through the LPCI guard pipe leading to pool bypass.

Our current understanding of hydrogen phenomena as a result of the HCOG experiments is the flames would not stay in one place long enough to ever cause that failure; but again, the original PRA results did assume the failure of the LPCI guard pipe leading to pool bypass.

MR. EBERSOLE: Take a case in point for electrical penetrations, the monsters that you have that feed the main coolant pumps. They are big ones. Does your answer pertain to them?

MS. HANKINS: Yes.

MR. EBERSOLE: Potted with cement mixture. That's 4 kv circuitry, isn't it? What is it, solid metal electrical links that penetrate this?

MS. HANKINS: My understanding is -- well, we have others here who know more about the containment.

MR. RUBIN: I'm not sure.

MR. EBERSOLE: I was just guessing that it had to do with penetration of elastomers or something like this that acted in the capacity of electrical insulation. I don't know what it means by potted with Portland cement mixture with 4 kv circuit.

Charlie, would you know?

MS. HANKINS: Some of the early containment designs like the MARK I. There was a question relative to the integrity of the electrical penetrations given high temperatures, and that was based on the fact that they were potted with material that at high temperatures became fluid and would allow, given a pressure differential, will then allow leakage.

What we said is with GESSAR, the material that we used is different and will not become liquid or soft at high temperatures. We don't have the same kind of concern as in the earlier designs.

MR. EBERSOLE: You do not now have a detailed picture of this penetration, I guess.

MS. HANKINS: I did not bring one with me.

MR. EBERSOLE: Is there one available in the stack of papers somewhere that we have got?

MR. SOLORZANO: GESSAR has it.

MR. EBERSOLE: I will look it up. Thank you.

MS. HANKINS: That is all I had to say on hydrogen.

MR. SCALETTI: I have a question here, if I may, commenting question.

Dr. Hankins, on the third bullet, G.E. commitments, my understanding is the commitment related to hydrogen control also includes UVPS, not strictly conformance to HCOG.

The second item under that bullet, where G.E. finds no technical justification for diverse power source, do I interpret that as disagreement? We had discussions with G.E. technical staff and with G.E. management, who have agreed to these design modifications.

MS. HANKINS: As I stated, we would comply with what is in the SER. There is a difference between compliance and agreeing with the technical basis.

MR. SCALETTI: Certainly there is. I just want to make sure that is still the case.

MS. HANKINS: Yes. We will comply.

MR. FOREMAN: That is the case.

MR. EBERSOLE: Any further questions?

MR. FOREMAN: And we agree with you also it is an oversight, that the UPPS should have been part of the hydrogen commitment.

MR. EBERSOLE: Thank you.

Item C is the effect of core melt on vessel support integrity. By the way, I forgot the Staff.

MR. SCALETTI: Dr. Pratt from Brookhaven National Laboratory.

MR. EBERSOLE: Sory.

MR. PRATT: My name is Trevor Pratt. I am with Brookhaven, and I have a large packet of Vu-graphs there for you today.

We have, I think, made two presentations before to you related to hydrogen, one in June and one in July. Most of the Vu-graphs I think you have seen at one stage or another in the past. We can again go through them today in whatever detail you need to address the issues.

MR. SCALETTI: Trevor, I believe you said you had some G.E. proprietary information in your slides in your presentation.

MR. PRATT: That is correct. I think there are certain of the additional package of information attached to the Vu-graph package.

MR SCALETTI I believe the court reporter has them also, and I think we should close this portion of the transcript We have G E proprietary information If they are not going to isolate the slides from the total package, he may be using some of them We better close the meeting

[Whereupon, the open session of the meeting was recessed and the subcommittee reconvened in closed session]

[Whereupon, the subcommittee reconvened in open session.]

MS. HANKINS: The question arose at the last full committee meeting relative to ablation, the RPV pedestal. The slides that Jack Rosenthal presented were an analysis that was done basically for a pedestal that is representative of the Grand Gulf design. The GESSAR design, GESSAR pedestal is a composite. It is two concentric rings of steel which provide the support to carry the loads. These two concentric rings of steel, they are 1-1/2 inch steel plates, are connected with steel shear ties, and then the spa e in between is filled with concrete. But the majority of the support is provided by the steel, not by the concrete.

We did an assessment assuming that the first of 1.4 meters of concrete in the inside steel shell were ablated away. We basically ignored them as though they don't exist. We then said let's take the outer steel shell to a temperature of 1100 degrees Fahrenheit, which we feel would be a bounding temperature that the steel would see. The ablation temperature of concrete is about 1800 degrees. There would still be about .4 meters of concrete left.

We look at the dead load on that outer steel shell. There is about 6100 thousands pounds divided by the area of the steel shell. Again, it is 1.5 inch thick ring. You see the load is about 3.4 KSI. The yield strength of steel at 1100 degrees Fahrenheit is about 21, so there is a tremendous amount of margin between the capability of the steel shell and the load that we are asking it to carry.

Our conclusion was, because of that substantial margin, there will be no failure of the pedestal, and as a result, there will be no loss of drywell or containment structural integrity.

MR. EBERSOLE: What is the physical state of the core now at this?

MS. HANKINS: The core is eating away into the concrete. At 1.4 meters --

MR. EBERSOLE: How did it get that far and why did it stop?

MS. HANKINS: At 10 hours. That was the assessment that Jack presented the last time. Basically we just took his condition that said -- the question is his chart said the integrity of the pedestal is doubtful, and we said, okay, let's take his conditions and look and see what we think about the integrity of the pedestal. We don't think there is any doubt.

MR. EBERSOLE: You took it at 10 hours. What happens at 10 hours? What stops it?

MS. HANKINS: There is nothing to stop it at 10 hours. We even looked at the condition at which you would ablate all 1.8 meters of the pedestal, and said what could ultimately happen to the RPV?

Unless there was a simultaneous seismic event to topple the vessel, the worst thing that could happen would be that the vessel would come straight down.

MR. EBERSOLE: As the steel support shell melted more.

MS. HANKINS: Right.

MR. EBERSOLE: So there is no sudden shock. It just caves in.

MS. HANKINS: Right.

MR. PRATT: Just to add, one of the reasons why Jack may have focused in on ten hours is that typically when we use a new source term methodology, particularly the COR/CON VANESSA Code, it is over that sort of period of time that we would get these fission products produced. I think what he was thinking of is if he could clear the 10 hours, the generation of fission products from that source would be sufficiently diminished.

MR. EBERSOLE: Did the Staff have a presentation on this? Any comment by the Staff?

Would the gist of all this finding be that eventually perhaps you would have a gradual descent of the vessel to some lower position but that is about it?

MS. HANKINS: In the worst case.

MR. EBERSOLE: Yes, right.

MR. PRATT: Okay.

[Slide.]

I think the three topics that we wanted to discuss here -- and Debbie has already touched on some of them -- the ablation of the support; the significance of loss of integrity following any slippage of the vessel should it occur; and then the last item that we have on the list was to look at the effect of containment venting.

We have discussed this a little bit this morning already in terms of how you would factor in procedures. I have one Vu-graph on that, which is really my thoughts. They are not terribly different from yours, but we will go through that a little bit.

In the interest of time, I don't plan to go through all of these calculations that I believe Jack Rosenthal has already presented to you.

[Slide.]

They are on some of the earlier handouts. I think we can skip over them quickly. Basically, Jack was talking about the penetration, the core debris sitting down here, and survivability of the walls in this region. And, as Debbie said, most of the support is coming from steel in here. She is not too worried about degradation of the early surface. A good deal of the load will be taken on the outer surface.

Perhaps a contribution we could make here would be to skip over a lot of the Vu-graphs you have there, looking at the movement of the ablation and the calculations for thermal gradients into the concrete, and look at the impact on risk in terms --

MR. EBERSOLE: Let me ask you this. It seems to me the issue would be at what point, under what conditions do you come into some sort of equilibrium where things stabilize. I hear in the worst case, which you don't want to admit, the vessel will sump down, and then it sits there. I don't understand but what it becomes a melting pot for the residual fraction of steel in the containment, and I wind up with a nice pot full of containment steel, pressure vessel steel.

What are the implications? I am trying to find an equilibrium point someplace.

MR. PRATT: Remarkably enough, when we were looking at the floating nuclear power plant to be installed, they were to be required to install a core ladle. The effect there was how quickly would the various cavity configurations melt down and be added into the melt, so a lot of the calculations that we did there were kind of relevant to this.

If, for example, you put down a refractory material in here, you can melt significant amounts of steel. What that tended to do was to a large extent dilute the melt, and would tend to cool down the process at these later times.

The calculations that I have, though, to put it into perspective, what I tried to do is really not get into the discussions about when it would occur.

[Slide.]

I just did a couple of limiting calculations to show you how the risk would change as a result of this phenomenon.

Assuming this occurred relatively soon after core-concrete interactions begin. In other words, you drop this molten core down there. It degrades the whole thing such that these events occur. You can get a measure of the effect of this event occurring by looking at Table 15.9 of the Supplement IV to the SER.

Basically what would happen is if if you lost your integrity as a result of this event, then sequences such as the late containment failure sequences, the Ls in our designator would become intermediate failures, and this, again, is a very upper bound calculation because the intermediate failure is assuming it occurs very soon after vessel failure.

So, by going into this table, you can see how the risk would change by simply moving the probability of these events into these events. And if you would go one step further and assume that the containment integrity plus the loss of drywell integrity -- in other words, penetration is also in the drywell -- then again those scrubbing sequences that were originally fully scrubbed, the 3 designator here, would then become partially scrubbed, 2 designator.

So again you would move the frequencies around and see how that changed.

[Slide.]

Basically all I am saying is if you look at this particular graph, it's the events such as the 3s would become 2s and so on. It's just changing those frequencies.

A summary of that is shown on this Vu-graph.

[Slide.]

If you lose containment integrity early as a result of this event, then really there is very little effect at all. This was a value without UPPS, and it would go from about 131 to 139, and this is implying a good deal more accuracy than I think we would give to three significant figures here. Early loss of containment integrity plus loss of drywell has slightly more effect, but again, it is less than a factor of 2.

So this may be helpful in putting it into perspective. These are absolute upper bounds on what one would expect from this phenomenon.

I think Debbie has shown that she would expect degradation of these structures over a very much longer period in time than this. So this is certainly very high, and it is unlikely that one would achieve that.

[Slide.]

The final Vu-graph I had dealt with containment venting. I won't spend too much time with this. These are really, I think, going over the points that you already made earlier this morning. The clean venting attempts to mitigate the Class II sequence and the ATWS sequence. Again, you can use that type of table to estimate the effect of this.

Of course, as we said before, the Class II sequence, because of the venting capability built into the UPPS system, significantly reduces that also. Again, in our assessment, as I understand it, we didn't take too much credit for the ability of venting to turn around the ATWS sequence. To me this is something one would have to address as a result of the procedures rather than the attempt to control by venting, given very high venting rates for an ATWS. So this is a very fast-acting sequence.

I think you can do better by operator action and try to manage the event itself rather than the venting process.

Again, in terms of the venting after core damage, the impact on the PRA I don't think would be terribly large because there originally we did not have hydrogen control, so I don't think one would get rid of sufficient oxygen early on to change the phenomenon we were discussing earlier this morning.

So again, I think you would need some hydrogen control in this event to control the hydrogen. AGain, those are principally my thoughts on this, not necessarily Staff's.

MR. EBERSOLE: In the matter of venting after core damage, I should think this would be the most critical part of considering venting.

MR. FRATT: Yes.

MR. EBERSOLE: And that would involve whether or not you had suppression bypass. In essence, what was the concentration of the stuff you were venting? It certainly must be better to vent than to allow the containment to blow up, in any case, but if you are that far down the road and are going to be obligated even in concept to vent radioactive gases, I suppose it is getting beyond the conceptual limits to say I must vent in an external suppression pool of some sort like a pond.

Has that ever been brought into the conceptual picture?

MR. FRATT: Where I see this -- this is, again, a personal view -- where I see venting after core damage as being important for boiling water reactors is in the MARK I and MARK II design rather than the MARK II. There I think you have, because of the potential for failure in the drywell, and the drywell is the containment there, you do have a significant potential for bypass.

MR. EBERSOLE: What this suggests to me is if you are going to be forced to say you are going to have to vent, if you get that far down the degradation road, then something like a spray pond someplace, except it's a suppression pond, dug into the dirt, if you wish, would be an effective and inexpensive way to cope with impossible damage.

I don't know how far this has been carried in the conceptuals.

MR. PRATT: I'm not sure in that regard.

MR. EBERSOLE: Has G.E. ever looked into venting in collaboration with some sort of external suppression process, you know, like a spray pond, like they have, for instance, for cooling, or even through, for that matter, the storage water tanks which are still functional?

MS. HANKINS: No.

MR. EBERSOLE: There is no attempt so far to look at scavenging the venting stream with something -- I know about the studies later on.

MS. HANKINS: You do it with the suppression pool.

MR. EBERSOLE: Right. External cheap suppression pool.

MR. SCALETTI: Provisions have to be in containment for possible venting if necessary. Now there is supposed to be an equivalent 3-foot diameter penetration provision made for that. That is there. But the filtered venting, there are no requirements.

MR. EBERSOLE: Not now. Not even suppression.

MR. SCALETTI: Correct.

MR. EBERSOLE: External suppression. Okay. That is that?

MR. PRATT: Yes.

MR. EBERSCLE: Any further questions on this topic?

[No response.]

In the agenda here we are doing pretty well. Why don't we take an hour and ten minutes for lunch since we have such fantastic progress here.

Let's come back at 1:00.

[Whereupon, at 11:50 a.m. the meeting recessed, to reconvene at 1:00 p.m. the same day.]

AFTERNOON SESSION

[1:00 P.M.]

MR. EBERSOLE: I would like to resume the meeting here with this item No. D, residual problems from fission products collected in the suppression pool, a G.E./Staff joint presentation.

Who wants to be first?

MS. HANKINS: We didn't put together a presentation. We just wanted this to be a discussion.

MR. EBERSOLE: All right.

MS. HANKINS: It seems to me there were three part to it. The first part was what are the long-term requirements after a possible loss of containment integrity. We took this to mean either the case where you are venting the containments or events from loss of heat removal, or the case where the containment integrity has been lost, say, as a result of a hydrogen event after core damage.

At 30 hours after the event, you would need 120 gpm makeup to the pool to balance off the decay heat, so if you are venting or if it's a case where you have lost containment integrity, you need a very minimal amount of water to balance off the decay heat. By the time you get out to 100 hours, it's only 80 gpm.

If you look in terms of how long until you uncover the vents, we have calculated it takes on the order of 60 hours until you would be required to have around 80 to 100 gpm makeup capability to prevent loss of uncovering the vents. I think by that time -- and Dr. Pratt can back me up on this -- the core-concrete reaction is going to be very minimal in any fission product scrubbing of the pool at that time.

MR. EBERSOLE: When you talk about uncovering the vents, that presumes you have the drywell and you are still suppressing.

MS. HANKINS: Correct. I took all these questions to mean the case where either, again, you had loss of heat removal and had to have a long-term heat removal, or you had core damage, you had the fission products in the pool and you have to keep supplying water to make up for the decay heat that is being put to the pool.

MR. EBERSOLE: So in essence, the pool is boiling.

MS. HANKINS: The pool is at saturation.

MR. EBERSOLE: What is the carry-over of fission products at that time, or is that an appropriate question, carry-out to the atmosphere?

MS. HANKINS: It's an appropriate question. It's something that we have addressed before. Because you have so much cesium hydroxide that has been put into the pool along with the iodine -- iodine is really the only one that we have been concerned about in terms of the carry-over -- our chemists tell us that the carry-over is negligible. It is very much less than the amount that made it through the pool in the first place, which indicates --

MR. EBERSOLE: You know what you are telling me, an external suppression pool is a pretty good machine.

MS. HANKINS: I prefer to think the internal suppression pool is even better.

MR. EBERSOLE: It is better, but the external one works.

MS. HANKINS: It would work, yes, if you had pool bypass. We tend to believe bypass is too improbable to work.

MR. EBERSOLE: Yes, I know. I was thinking about the venting, deliberate venting, and the hypothesis that I might like to vent to an external suppression pool. You know, one of those engineering features --

MR. ETHERINGTON: That 120 gpm maintains the water inventory and removes the decay heat?

MS. HANKINS: Correct.

MR. MARK: That's how much you would vaporize the decay heat at that time.

MS. HANKINS: Correct.

MR. MARK: 120 gpm.

MS. HANKINS: It's 120 at 30 hours, 80 at 100 hours.

MR. EBERSOLE: The regular emissions you would get from that, is the control room a habitable place? Have you designed for that, radioactive emissions from that condition?

MS. HANKINS: The majority of the emissions, if you have had core damage, will have taken place at the time of the loss of integrity or the type of venting. The majority of radioactivity is going to be released as noble gas.

MR. EBERSOLE: I'm trying to get a feel as to whether everybody has had to go home or not or they can stay there.

MS. HANKINS: I don't think iodine evolution of the pool is of any concern to the control room. We are talking about one part in 10 to the 4th.

MR. EBERSOLE: In that context, at any time during these degraded circumstances do I suffer a problem in the control room that implies abandonment?

MS. HANKINS: I think the control room is designed to Reg Guide 1.3-type source terms.

MR. EBERSOLE: I know that is the antique notion before severe accidents, am I not correct, whether there is standard leakage?

MR. SCALETTI: I believe so.

MR. EBERSOLE: Well, does this conversation have implicit in it that everybody has run off and left the plant to die its own death?

MR. SCALETTI: I assume --

MR. EBERSOLE: Why don't you tell us, then. I think that is worth talking about.

MR. SCALETTI: Could you just rephrase that?

MR. EBERSOLE: As I degrade through these hypothetical sequences, at what point do I have to go home and leave the plant to fend for itself, if ever?

MR. SCALETTI: You want that tomorrow, probably.

MR. EBERSOLE: I don't know.

MR. SCALETTI: Is this one of the topics for tomorrow that you want us to answer?

MR. EBERSOLE: I don't know whether it is appropriate to ask it for tomorrow, but it sounds like it might be worth knowing. It's a long-standing issue, except it applied in the past to a degraded plant next to a good plant, which is just about the same scenario for a two-unit station or a multi-unit station. These are questions from the subcommittee on Dave's topics here.

MS. HANKINS: I guess I'm not sure what the question was. I think we have answered the question on long-term requirements and the pool boiling. I don't know exactly the point of what is the effect of drywell heating. I guess I don't know the basis for that question.

MR. EBERSOLE: I cannot imagine -- well, it's loss of bypass if it went to damage in the drywell, I guess. Well, by this time the reservoir of water above the drywell has been dumped, hasn't it?

MS. HANKINS: Something less than 50 percent of the volume in the upper pool has been dumped.

MR. EBERSOLE: Does the membrane up at the top ever become dry and subject to radial heating to degrade it?

MS. HANKINS: The only time the area up there is dry is G.E.'s calculations would be if we have a large detonation because failure of the drywell hadn't drainaged the water into the drywell. In that case you quenched the --

MR. EBERSOLE: Are the elastomer seals up there --

MS. HANKINS: I can't answer that.

MR. EBERSOLE: They would go if they were there, wouldn't they, under the dry heating condition? Or maybe you are telling me it is what?

MS. HANKINS: I don't know.

MR. EBERSOLE: I'm just trying to second guess the thrust of the question here.

MS. HANKINS: Neither BNL nor G.E. was able to second guess that.

MR. MARK: It would have been my impression, Jesse, that the only circumstances which would lead to having to scuttle out of the control room would be that you had had some complete bypass of the core material not going into the containment but getting around to the parts of the building or that a venting that you might have engaged in went wrong, the wind blew back in your face. But the iodine, or all the fission fragments in the containment can't really see through to the control room, surely.

MS. HANKINS: Right. I can't imagine the circumstances in which you would evacuate the control room.

MR. MARK: There is some radiation level outside the containment if you have got the atmosphere full of fission fragments. I don't know what that is, but there are several feet of shielding.

MS. HANKINS: And filters on the air intakes.

MR. FOREMAN: The air intakes are redundant and separated on opposite sides of the building.

MR. MARK: I realize. I was just saying something really went wrong because you are designed to be all right unless it does, or even if it does.

MR. SCALETTI: Another point would be that there are two remote shutdown panels that are diverse, remote, independent of each other that can be used to shut the plant down.

MS. HANKINS: If you are worried about fission products, you have already melted the core.

MR. EBERSOLE: The source of the question apparently is after some period of time like 10 hours or something, and you presumably have them out there in the pool. Can they get away?

MS. HANKINS: That is the way I took the question. That's why I was describing the water makeup that would be required and at what time it would be required.

MR. EBERSOLE: You were holding the suppression process, anticipating emissions continuing, even though I should think the bulk of them had already gone in.

MR. MARK: You mentioned decontamination factor for iodine of 10 to the 4th. Is there general agreement that that is what one could count on?

MS. HANKINS: I think we could get general agreement if we could get agreement on waht is the particle size distribution. I think there is general agreement that scrubbing takes place. Scrubbing is different for different-sized particles, and if we could ever agree on what size the particles were --

MR. MARK: And if they are the right size.

MS. HANKINS: The right size. Then I think we could agree on the DFs. I think the models are coming closer and closer to the predictions. I have also got some experimental data that I will be presenting in my later presentation.

MR. MARK: Good.

MR. EBERSOLE: I am about to close this topic. Does anyone want any further development of it?

[No response.]

MR. EBERSOLE: All right. We get into item No. E, consideration of potential design improvements. I think this is going to be a most interesting area.

[Laughter.]

There are about four that are listed here discretely, starting with UPPS. I am open to how we shall take this up. The Staff first?

MR. SCALETTI: We will go first. We will have two people. We will have Mr. Rubin and also Mr. Hardin make presentations on this topic.

MR. RUBIN: Good afternoon.

I will be speaking to you briefly on design improvements on GESSAR II, and Mr. Brad Hardin from the Staff will be supplementing my comments. We also have consultants to speak on various areas of these issues if you have specific questions on details of some of the analyses that were carried out in support of our decision process on design improvements.

The area of design improvements developed out of the actions of the Severe Accident Policy Statement, which required us to investigate reasonable changes that would supplement containment core cooling. We have utilized insights as well as engineering judgments to arrive at what we feel are reasonable and effective improvements on the basic GESSAR II design as proposed by General Electric.

Basically, we have attempted to focus on the areas of plant vulnerability and areas of uncertainty that arose from the PRA, but we were not limited solely to findings of the PRA or results of PRA analysis. We did try to supplement with what we thought were reasonable engineering approaches.

The design modification process occurred in a number of stages. Mr. Hardin, who will speak after me, will go into more detail on what occurred in the various stages, if you are interested. I will give you a very brief overview of the stages and will focus primarily on our final list on design modification candidates and what our conclusions and recommendations were in those areas.

Briefly, the various stages that the Staff went through involved, the first stage about a year and a half ago, various Staff groups proposing a large list of potential design modifications. This was carried out by Mr. Hardin's group, with him in the lead, but various NRC groups were involved in adding to this list, culling through them trying to arrive at fruitful areas of study, not necessarily areas that should be implemented at this time but areas the Staff thought were worth a close look in relationship to the GESSAR design.

This list of modifications, which entailed about 85 before the Staff was finished, was sent to General Electric for review and for them to consider in a detailed cost-benefit analysis in order to allow the Staff to view General Electric's assessment of what the risk reduction impact potentials were from the various modifications.

Our guidance to General Electric was to conduct a cost-benefit study and at the same time add any modifications they thought were worthwhile modifications to their design and report back to the Staff on their findings. These analyses by G.E. utilized their own PRA core melt and risk estimates. This was different from the Staff's later assessment of design modification candidates, where we relied more on the Staff and BNL's modified risk reduction results.

The G.E. analysis did use their original PRA core melt frequencies and risk estimates. Because of this, the Staff felt that the bottom line numerical results could not be applied directly to our decision-making process but would be very useful as a screening tool to give some order of importance and relevance of the issues that were reviewed.

In addition, the Staff considered in later phases of the design modification process a number of other studies. There was an independent study on mitigation features conducted by RDA Associates, which has reported to the subcommittee in previous meetings.

After we had the RDA report and after we had the initial G.E. assessment, Staff took another close look at the issues, looked at the relative rankings and the quantitative results of the G.E. cost-benefit analysis. We looked at the RDA results, as I said, and again, a number of Staff groups participated in determining what they thought the most effective and beneficial design improvements would be, which we could look at in a more detailed way, applying further cost-benefit analyses, utilizing what we thought were more representative cost-benefit numbers from the BNL and Staff's reassessment of the GESSAR II PRA.

The final candidates which we thought were worth a close look involve the UPPS system, which when we started our study was not incorporated into the design but subsequently was included.

Possible seismic upgrades to the UPPS system, extending the station battery capacities to ten hours following a station blackout. This originally was proposed by General Electric, but in a later submittal when they incorporated the UPPS system, it was withdrawn as a committed modification.

We also looked at the possibility of having a small dedicated DC charger which would be available to provide DC power only during station blackout event, and we looked at various combinations of hydrogen control schemes.

From this final list of design modifications, the Staff, in consultation with Brookhaven, developed what we thought were reasonable postulated approaches to model these modifications. There were not design details available on the majority of these features. Instead, in a very rough way, working with BNL, they were included into the GESSAR PRA and making systems modifications where necessary to reflect what change these potential modifications have on the plant performance during severe accident or the time leading up to severe accident.

The analysis basically relied on the BNL revised core melt frequencies and the BNL revised consequence assessment and person-rem impact on the general public.

[Slide.]

Because the various modifications have the effect of interacting with each other, we didn't feel it would be realistic to treat them independently and just report the results to you in that way, so for our decision-making process, we looked at a number of combinations of modifications. This is shown in our SER Supplement 415.7, which you have in the packet this afternoon. That will show you the basic combinations we looked at, starting with the base case, which is what is in the GESSAR PRA, looking to their modified base case, which includes proposed UPPS.

We looked at various combinations and permutations of what we felt would be the current modifications to be considered, including such things as seismic operated UPPS, ten-hour battery, small dedicated DC charger, and UPPS and charger, perfect hydrogen control in various combinations, as you can see there.

A modification in one area, for instance, could wipe out the benefit from another modification later on if the majority of risk reduction was achieved by the previous modification. That's why we used a number of combinations for a final decision process.

Basically, then, BNL in the first step of its process calculated the system impacts of these changes to reflect core melt reductions due to implementing the proposed modifications, and we received frequency contributions for each accident class.

MR. WYLIE: Mark, let me ask a question. The DC charger. When you say by diverse small generators, do you mean small motor?

MR. RUBIN: We were looking at a small diesel-powered generator, whether it would be industrial, Allison diesel or a Sears charger, something small, something relatively simple and not expensive.

MR. EBERSOLE: Mark, G.E. going to -- and the ABWR -- abandon this crazy dump volume design we have on this plant? I am going to later on give you the drawing from the FSAR, PSAR, to discuss the characteristics of it again. I realize I am going to beat this horse to death, but I am going to put that on the record every time I have a G.E. meeting.

I wonder why you stand just so happy with the dump volume in its present configuration with the several events that have happened at Hatch, Oyster Creek and so on, and why that isn't up there on the list, why you dismissed it. We will be talking about that a little bit later in the context of sabotage.

MR. RUBIN: I don't think we dismissed it. Later on Mr. Hardin will be discussing some of the issues where we did not take action. I think you will find that a large area of residual risk is ATWS for this plant.

MR. EBERSOLE: That's why we want to work on it.

MR. RUBIN: Be glad to discuss it with you.

MR. EBERSOLE: Good.

[Slide.]

What we have here is a result of the initial stage of the Brookhaven analysis. We show various combinations of design improvements with the core melt frequency contribution for the various plant damage stage action classes. Let's concentrate on the bottom line numbers here at this time.

We show from the original Supplement II of the GESSAR SER, internal events we estimated, 3.8 to the minus 5 core melt frequency. As we reported to you in a previous subcommittee, we show it can be reduced about 8 to the minus 6 with the addition of the UPPS system, which is currently implemented in the plant, and we can show some small further reduction if some other actions are taken, such as the DC charger and the generator in combination with the UPPS.

This is the limiting case right here. What we have done is we have included UPPS with unlimited DC power. This would incorporate both a ten-hour battery supply, which would give the operator time to make some decision what action he needed during a blackout, in addition to having a long-term small DC generator. We can get no better than this because this is perfect unlimited DC power.

Here you see a higher end limiting case where we have just a ten-hour battery. We see some reduction from the base case but not as good as is achieved by the UPPS alone. So we see the various combinations where we can range anywhere from 40 to the minus 5 all the way down to the minus 6. So there is a prett good potential here for reduction, but we get most of it with a system that is already included in the design, UPPS.

This was, of course, only the first stage because we had only core melt included in this assessment. We certainly wanted to look at public risk.

[Slide.]

So combining the front end assessment on core melt with the back end risk using a modification of the G.E. source term, we used what the Staff felt would be an upper range but realistic source term estimate. Mr. Hardin will speak to this in more detail.

MR. EBERSOLE: Let me ask you a question about UPPS in relation to another previous requirement which came out of Appendix R. It was admitted in Appendix R that we might have fires that would gut the control room and spreading room, and we have that design, so we erected the first barrier to that, which was the auxiliary shutdown panels.

Surely UPPS does what they will do and more. Is there consideration of some curtailment of the requirements on auxiliary shutdown panels? Is there a presence of UPPS? Can we go back and pick up some things which don't need to be done in the auxiliary shutdown because of the presence of UPPS?

I think there should be some compensatory process, Every time we put in a more comprehensive system, to go back and say what, in fact, can we do to this cheap, simple system here which overrides what an inferior system had been doing before?

MR. RUBIN: Perhaps they should -- we didn't explicitly in this case. Now, the UPPS is a nonsafety-grade system. It's a system of last resort. It's not a system normally used.

MR. EBERSOLE: I think that is true of the aux shutdown.

MR. RUBIN: I believe there are, it seems to me, electrical requirements of shutdown that aren't included in the UPPS system. Not to argue the point with you. The process really wasn't done in the manner you are suggesting.

MR. EBERSOLE: Certainly UPPS will do everything that aux shutdown was able to do.

MR. RUBIN: In some cases it will do more.

MR. EBERSOLE: Of course it will. It will put water in because it has got the mechanical functional capabilities, whereas auxiliary control was just that, a control function.

MR. RUBIN: Right, but you have no way to control the plant other than very basic level function with UPPS.

MR. EBERSOLE: That has to be associated with the frequency of major fires. You know what I mean.

MR. RUBIN: I understand. I think one of the problems we encountered was that UPPS is an acronym. We don't have the plant design so we weren't in a position, really, to start trading off details of one versus the other.

MR. EBERSOLE: We are in the darkness with UPPS. I think that is one basic criticism that has to be put down. We have not integrated UPPS yet. The suggestion is made we are going to make it seismic, but it is still scattered all over the place. I don't see it compartmentalized or defended as a unitized concept, or perhaps even extending to make it a basic defensive mechanism against sabotage. That is one thing, not to mention Appendix R.

MR. RUBIN: Dr. Shiu had a comment.

MR. SHIU. Kelvin Shiu from Brookhaven.

I would like to respond to your earlier question about giving credit to the remote shutdown panels because you have now implemented an additional system which is supposed to provide injection as well as other prevention or mitigation features for core melt.

I think if one would have to do a risk analysis in the proper context, one would have to look at competing risk effects in a careful way, and it is important to not look at only one system. For instance, the UPPS system that we have described here assumes a certain system configuration using particularly the fire pumps, diesel fire pumps, for instance, and I can imagine in fire situation one cannot take credit for the UPPS because it is already dedicated to fire suppression.

Do you follow what I'm getting at?

MR. EBERSOLE: You mean it supplies fire. Fire suppression water.

MR. SHIU: Because they are for fire suppression purposes.

MR. EBERSOLE: That's a minor matter of capacity.

MR. SHIU: I am not discussing the degree. I am saying one had to look at the whole system from a very broad context, and what we have done here is to look at it in an isolated instance and say, well, we have UPPS systems that within the scope that we have defined, core melt given a transient, core melt given seismic events, we can get these benefits.

The remote shutdown panel, for instance, in this case most of the time does not even come into the picture because the remote shutdown panel is used -- assuming, for example, cable spreading room is in jeopardy. The underlying assumption of that is that there is a fire in the cable spreading room, so now all of a sudden we go from all these initiators into a fire situation, which goes back to the requirement of the fire. Fire pumps have to be in operation at that time. So hence you cannot really take credit for the UPPS if I have a fire.

Do you follow? We have gone one circle around, going back to the requirements of the UPPS pumps. And I would be reluctant to off-hand -- and we really didn't do that analysis -- to give any credit for the UPPS systems given a fire. Maybe we could if we looked at it in detail.

MR. EBERSOLE: What I am saying, that is a product of the way you designed it, and the question is, should it be designed that way? It is a very simple system. It is far simpler, as a matter of fact, than the aux shutdown systems.

MR. SHIU: One can argue that instead of using the diesel fire pumps, maybe you can put in other diesel pumps.

MR. EBERSOLE: You can put in stored water, so you are doing like, you know, most designers do if they don't want to do something: they design it so it won't work.

MR. RUBIN: I don't think that was our objective. We wanted to utilize equipment that was provided in an efficient way. We thought we could get multiple benefit on what was available in the plant with modification. We wanted to try to be sufficient. Where we thought it wouldn't be sufficient, like a power source to the igniters, we made changes.

MR. EBERSOLE: My whole thesis is to enhance a simple system, if I can, in preference to enhancing a complicated system.

MR. RUBIN: We are trying to keep it simple.

[Slide.]

I guess you can build a dam up on the hill that would head up your water --

What we have here is the internal event risk contribution for the various design modifications. We have the various release categories. Again, I will focus down on the totals here on the bottom.

The GESSAR without UPPS the Staff estimated showing yearly risk contribution of about 130 person rem. With perfect hydrogen control, which in our estimate would require pre or post inerting, this could be reduced to about 60 person rem. Just internal events, now.

Various combinations show you various reductions.

Just with UPPS as currently installed, we get a very large reduction and after we have achieved this, which we have, we feel, at this point, very little remains. We put the igniter system in with UPPS, save a couple of man rem. Unlimited generator and UPPS and igniters, maybe 6 man rem reduction further. So there is some small risk reduction benefit to be achieved from modifications just past UPPS for internal events, but not a whole lot.

MR. EBERSOLE: In your table, UPPS is seismically competent, isn't it?

MR. RUBIN: It varies. It doesn't mean anything on this analysis because this does not include seismic events.

MR. EBERSOLE: I'm looking at the column, "UPPS and Hydrogen Control," and your attempt --

MR. RUBIN: It is nonseismic, but it wouldn't make any difference in this case because it is not seismic events they are actually including in this assessment. On the next table you will see the impact you are talking about.

MR. EBERSOLE: Okay.

MR. RUBIN: So we have a fairly good range. We have already achieved pretty good risk reduction just with the UPPS.

Some of the risk reduction we see here weren't even reflected in the previous table you had on core melt reduction because they were mitigated features such as hydrogen control in various combinations rather than a reduction in the accident initiation frequency, so it will show on this table rather than the previous one.

MR. MARK: We have talked quite a bit about hydrogen, and yet from this last table you have had on the screen, perfect hydrogen control does a little better than a generator and UPPS, but really not a large looking amount, they go from 25 to 22. G.E. has said, of course, they didn't think hydrogen control added up to a lot, and on this table it adds up to very little.

MR. RUBIN: The next table, it becomes significant, the external events. Total risk profile is internal events plus external events considered together. This is just the first half, internal events.

MR. MARK: I can appreciate that. I know this is just internal. For internal events, you wouldn't be sure whether you wanted to invest much in hydrogen control of any kind.

MR. RUBIN: From a strict risk assessment perspective in the PRA, I would say yes. We are trying to use a somewhat more global perspective to provide a little more judgment. What we have here is a plant that is most vulnerable to loss of offsite power accidents, and you have a hydrogen control system which has been mandated by the Commission, which will not be effective for the predominant type of severe accident, loss of offsite power followed by loss of AC.

It seemed reasonable to us if it was possible at a reasonable cost to upgrade the hydrogen control system so it would be operative following the predominant expected severe accident.

MR. MARK: Loss of offsite power is not always categorized as an external event. It might accompany a seismic event, but you also think of it in design basis considerations.

MR. RUBIN: That is certainly true. It was modeled as one of the initiating transients for the internal event analysis by Brookhaven. We included it now.

MR. MARK: So it is in here except for the seismic imposition of loss of power.

MR. RUBIN: Right. The seismic element of it is included in the next Vu-graph.

Looking at the seismic events, we show some combinations of improvements. This is the frequency of various release categories due to seismic events. Going to our base case as we presented a couple of subcommittee meetings ago, about 6.7 to the minus 5, which includes quite a bit of relay chatter in there, about 4 to the minus 5 in contribution to the relay chatter.

The imposition of UPPS will drop that slightly. The reason there is only a small benefit is UPPS has no seismic pedigree whatsoever. We don't have a system design. What we asked our clever consultants out at Brookhaven to do was to attempt to model the fragility of what would be a likely UPPS system installed and built to normal control grade standards.

MR. EBERSOLE: Let me ask Staff a question at this point. As you know, we made a deadly mistake years ago to turn over aux feed to the AEs and vendors. We turned over the auxiliary feedwater systems on PWRs because they were not regarded as safety systems. That was fundamentally a mistake. I wouldn't want to repeat that.

Isn't the system here of such significance to this design that it should be pre-integrated with the burden of integrating and making it effective carried by the vendor?

MR. RUBIN: UPPS will be supplied by General Electric, it is my understanding.

MR. EBERSOLE: Should it not be so identified as to be an integral package with the original GESSAR submission rather than wait to be tacked on under the influence of some applicant?

MR. RUBIN: I think that would be our preference, but their detailed design does not exist at this time.

MR. SCALETTI: Mr. Ebersole, the Staff will consider the General Electric final design approval to provide us with the UPPS design. I believe that will be along with or prior to the first application referencing GESSAR II.

MR. EBERSOLE: Is it just a practical matter of scheduling to get this out of the way, that this cannot be pre-identified and made an integral part of GESSAR at this time? Is it at this time a complicated process we don't want to wait on? What are the penalties for getting it identified and encapsulated, if you wish, in GESSAR-II?

MR. SCALETTI: It is a relatively simple system, I believe, and we do have --

MR. EBERSOLE: That's what shakes me up.

MR. SCALETTI: We do have information on it. There is some information that we are lacking, but I think the Staff believes they can proceed now and they feel confident that the system will do what it is supposedly designed to do.

MR. EBERSOLE: Do you have other systems in limbo like this waiting for an applicant that I could see?

MR. SCALETTI: I am sure there are some systems that are like that. They are interfaces that are waiting for applicants. I know there are a couple of conditions on FDA-1 now which are not being resolved. Part of it is -- the details to the hydrogen control system is waiting on HCOG resolution.

MR. EBERSOLE: I see. So you see no real problem with that?

MR. SCALETTI: I don't think --

MR. EBERSOLE: Can you just as well integrate it later as now?

MR. SCALETTI: Yes, I believe it can.

MR. EBERSOLE: Would you set down some criteria, however, that would say, as you already have, that it is seismic, et cetera?

MR. SCALETTI: We have identified in Supplement 4 that certain precautionary measures should be taken with regard to seismic upgrade, placement of the bottles, anchorage, stuff like that.

MR. EBERSOLE: Do you envision it as a unified system in a physical context, in which the components are not scattered all over the plant as it is now, at least as one would envision it in the pictorial representation?

MR. SCALETTI: I would envision the components are scattered --

MR. EBERSOLE: It almost approaches the concept of residual heat removal system, or could be made to do that. I don't know whether you want to say some words to that effect or not, you know, to bound it physically and to pay attention to its integration as an entity which is integrated.

MR. RUBIN: There is a downside risk with that approach. If you move, for instance, the ECCS actuators out to some blockhouse out in the yard, you are increasing the length of the pressure piping runs.

MR. EBERSOLE: I agree. You pray you get a return on the price you pay. And you want to leave this up in the air for the moment?

MR. RUBIN: We want to take a real close look at it when the design comes in until we have established some basic concepts for protection.

MR. EBERSOLE: Does G.E. have any notion or preference that they want to control this design far more tightly than is implied here? I get an uncomfortable sensation you are going to throw it to an AE utility.

MR. FOREMAN: No, G.E. will control the design.

MR. EBERSOLE: In both the physical and system sense? Do you envision it as a module within its own building?

MR. FOREMAN: No.

MR. EBERSOLE: Do you envision it scattered around?

MR. FOREMAN: Yes.

MR. EBERSOLE: And you are going to defend the process of scattering it rather than unifying it as a package? You know, attempting to approach the notion of a heat removal system?

MR. FOREMAN: I understand. As we get into the security presentation --

MR. EBERSOLE: That's where it's going to come up. Okay, go ahead.

MR. RUBIN: All right. Just to show you the summary frequencies for the various combinations, design improvements.

[Slide.]

We started out a percentage of about 6.7 to the minus 5. With the UPPS currently installed, we get some seismic protection due to the residual component fragility values. Not much. Up to 6 to the minus 5. If we upgrade the UPPS system seismically to something -- I guess I should use the words "close to seismic Category 1," not with all the pedigree.

We have looked at the vulnerabilities and the potential weaknesses which would appear most likely to limit the seismic response of the UPPS system, and we feel that by eliminating those, you can upgrade it for a reasonable amount of money. Our estimates were about $1 million, but we certainly can't justify them at this time. We can improve the response a fair bit. Even at that, approaching Category 1, the core melt frequency reduction is only 15, 20 percent.

The further reduction, including some of the hydrogen control, of course, has no effect on the initiation frequency of an event, but going to the generator, for instance, we really don't see much further benefit. Too small, really, to measure. So the best we thought we could get through seismic upgrades would be about from the base case of 6.7 to the minus 5, to about 4.6. Small but measurable. The real improvement --

MS. HANKINS: Excuse me, Mark. That's not the difference between really the base case and seismic upgrades.

MR. RUBIN: That was the initial GESSAR design, of course, not UPPS.

MS. HANKINS: I think you should be comparing UPPS with UPPS and seismic upgrades.

MR. RUBIN: We will compare these two columns, then. I would like to indicate, though, that it is very subjective because we were not able to do a seismic systems analysis on the UPPS system because it wasn't designed in sufficient detail. These are estimates of BNL and their consultants based on what we think are reasonable assumptions of what the system will look like.

We had a report from Brookhaven looking at the vulnerabilities of potential UPPS system.

MR. EBERSOLE: Let me ask something. I see the V-event up there stays steady across the board. UPPS can't deal with that.

MR. RUBIN: Kelvin, which break was that, the event that released that?

MR. SHIU: What you are looking at here are the release categories, and I would like to take you back to an earlier one for core damage frequencies. When we go on from there, then we can see whether we can explain to you what you are asking. I think what you are asking, if I may try to repeat the question, is S-V is the LOCA release category, why hasn't UPPS been able to do anything as far as the reduction of that frequency is concerned?

With respect to LOCA, and if we go back a couple of slides, when we look at the initiating frequency, the core damage frequencies --

MR. MARK: Can you go back maybe two slides?

MR. EBERSOLE: Before you throw that down, let me look at the V-event. As I understand the V-event, the principal component of damage is a continuing discharge of fluids into the critical assembly machinery rooms. It is not a dose problem at all. It is disablement of mitigative systems. It's a regressive accident in that the consequences destroy the mitigative systems.

It should not destroy UPPS, and UPPS may or may not have depressurization capability to correctly diminish the V loss of fluid and catch up.

MR. SHIU: I'm sorry. I misunderstood. I was looking at the S-V-E1.

MR. EBERSOLE: I thought you were looking at the wrong one.

MR. SHIU: The V-events here deals with the seismically-induced V-events, and the reason for the occurrence of such events is due to the relative movements from the buildings.

MR. EBERSOLE: That can be due to relay chatter.

MR. SHIU: It could be due to relay chatters, but my point is that if you do have a relay chatter, the consequence

-- and again, here it goes into the assumptions used in modeling relay chatter. When we model relay chatter, we assume that there is one weakest fragility for all the relays and -- for the chatters, and all the relays will chatter. Then given such an event, we will have a Class 1 type of accident, not a Class V type of accident.

MR. EBERSOLE: The V-event is primary -- it is a failure of the primary systems into the low pressure systems. It is destruction of low pressure systems and degrading the mechanical-electrical apparatus that feeds water into the core and keeps it cooled.

MR. SHIU: I don't know whether I will go that far.

MR. EBERSOLE: Maybe the physical design here in GESSAR precludes that by providing --

MR. RUBIN: This isn't a traditional V-event as was done in terminal event analysis, which is a Category BNL assembled to represent a certain type of seismic failure.

MR. EBERSOLE: And what is it? What is the failure?

MR. SHIU: The failure is the inter-building piping failures, and also other types of failures to isolate. For instance, RWCU.

MR. EBERSOLE: It is the V-event. It is the coupling of high to low systems.

MR. SHIU: Right, but not because it is initiated by a transient, because it is initiated by a seismic event. And given that type of event, especially when you have building failures, UPPS cannot do anything.

MR. EBERSOLE: Why not?

MR. SHIU: Because your UPPS pipe has to go through the building.

MR. EBERSOLE: Not yet. It might come out of containment and be encapsulated in its own house.

MR. SHIU: When I see that, I will do my calculation according to that, but the little schematic that I have received --

MR. EBERSOLE: The vulnerability is built into it in the present concept; correct?

MR. SHIU: That is one of the --

MR. EBERSOLE: Right. We will have to get around to the degree of enthusiasm we have for designing UPPS before we are done.

MR. MARK: I guess there is some -- at least a couple of typoes in the last right-hand column. How does the V-event become ten times more probable? By adding seismic upgrade and perfect hydrogen for any other combination.

MR. RUBIN: It should be the same.

MR. EBERSOLE: May I return to the V-event -- go ahead.

MR. MARK: I can't see from here what is on that slide. I'm just looking at the handout. 2.2 to the minus 6.

MR. RUBIN: Should be minus 7, I believe. I believe it's a typo. Yes.

MR. MARK: It is 2.3 minus 7 across the board until we get here. Then the same thing relates to the second, the top entry, which perhaps should be moved up a line?

MR. RUBIN: I think it should be dropped down one line. I think we are slightly off the vertical axis.

MR. MARK: Then the 1.4 minus 7 at the bottom is probably not right either.

MR. RUBIN: Yes.

MR. MARK: I believe the numbers are probably all intended. They are just misaligned.

MR. MARK: That is correct.

MR. EBERSOLE: If I could return to the V-event just a little bit, in the older design there are three sources to it. There is the HPSI steam line, RCIC steam line, there is reactor water cleanup, that couple from high to low pressure systems. Any one of these three systems. If it breaks and becomes nonisolable, you have a discharge into that region of the plant, whatever it is, which may or may not become compartmentalized, I expect, in G.E. here it is, and therefore may or may not lead to regressive loss of the features that mitigate that loss of water if you don't isolate it in the physical context to avoid disabling the apparatus in the aux building?

MR. RUBIN: I don't believe we have any isolation capability following a station event. You would have a station blackout.

MR. EBERSOLE: Does the GESSAR design envision these water systems isolated by concrete walls to discharge the contents of a V-event into open atmosphere rather than run back into the machinery rooms? Limerick did that. Do you know what I mean, if you have a continued discharge? You ought to throw it to open atmosphere, not back into the house that's got all your equipment in it.

Limerick was prudent enough to design it that way. Most plants didn't, in which case the accident is probably regressive, and I don't see any way to really terminate it. You can't go in and shut the valves off if you are reduced to manual operations. You disable the critical mechanical-electrical equipment, so you lose the capacity to restore the water, and off in the distance it would appear to be a reasonable need to make UPPS begin to help out by depressurizing and providing makeup, but that would take some design attention.

I am saying the V-event is a very nasty event unless you have physical isolation principles to cope with it.

MS. HANKINS: There is a great deal of physical separation of the systems. They are in their own little cubicles.

MR. EBERSOLE: I wonder if that has produced this kind of protection incidentally, if not deliberately.

MS. HANKINS: Maybe when we get into the security area --

MR. EBERSOLE: We might talk about it. Okay. Go ahead.

MS. HANKINS: Mark, I would like to ask you a question. The difference you are showing between UPPS and UPPS seismic upgrade is a difference between 5.9 times 10 to the minus 5, 4.6 times 10 to the minus 5. With all the uncertainties that are involved with seismic analysis, is there any difference between those two numbers?

MR. RUBIN: I certainly wouldn't argue that there is a defensible difference between them. We do point estimates as we propagate it through design modifications. It is small.

[Slide.]

Of course, you could always increase the UPPS seismic design to rather high g level. Then you could see perhaps a significant reduction of core melt frequency. We were basing it on SSE .3 g. All we have here is an equivalent person-rem risk calculation for various combinations of design improvements for seismic event similar to some of the internal events.

The base case prior to the UPPS addition to the system, we showed about 630 man rem. With the inclusion perfect hydrogen control, we felt that would be dropped to about 145.

The current position from the Staff and BNL estimates is about 560 person rem. With the UPPS and the igniter system which the Staff proposed, we show a reduction to about 260, and we show various combinations able to reduce it -- we should ignore that number. It's wrong. It should be 440. The other combinations can reduce it somewhat below what we are proposing for a final fix, but I will get into that in more detail in a later slide.

With perfect hydrogen control, we can get it down to what we feel is about 130 person rem per year. Again, perfect hydrogen control in an RS event would require pre-inerting system with rather high cost. I would like to add there are uncertainties on the effectiveness of a post-inerting system which would be more most effective for GESSAR through the large containment effect. They plan to have access during operation. Pre-inerting would be close to impossible for the present system.

We took all these results and compiled them in a summary form to make them a little easier to view while making our final decisions.

MS. HANKINS: Mark, before you leave that slide, I would like to reiterate what I said this morning. That 300 man rem reduction you are showing over there is, I believe, the result of a technical error. I would be interested in seeing when the reassessment comes in because I don't believe you will be showing anywhere near a 300 rem reduction.

MR. RUBIN: I believe BNL is going to be discussing that with G.E. to see what their feelings are on Dr. Hankins' comments. We will report to you if there are going to be changes in these findings.

I would like to comment, though, that the modification we proposed for the dedicated power source to the igniter which gave us that reduction is quite inexpensive, and if the benefit was very small, it would still make sense from a cost-benefit standpoint. Again, I would like to repeat that we don't feel that cost-benefit is the only decision-making criteria. We think engineering judgment, defense in depth should certainly be considered for a design such as this.

[Slide.]

A little summary table here for you. What we show are some composites of both core melt and risk for various combinations, for our final combinations that we considered. The pre-UPPS base case with the large relay chatter contribution, which we have told you is a pessimistic analysis, scoping analysis, was about 1 to the minus 4. With the UPPS addition, which is what we currently have, we have 6.7 to the minus 5. If relay chatter is fixed or further study shows it is not the contribution which we feared it might potentially provide, this would be down to about 2.3 to the minus 5.

To give a seismic upgrade to UPPS, we do have a small further reduction, insignificant as it may be, and same thing on the UPPS and DC charger. A very small reduction in frequency.

Looking to public risk, with the currently installed UPPS we have about 600 person rem per year. With the seismic upgrade to UPPS, we have 120 minimum reduction on top of that. We can drive it all the way down to 150 from our estimates if you go from seismic UPPS upgrading and perfect hydrogen control.

MR. EBERSOLE: I guess I just can't begin to understand why you have up there that double asterisk: core melt estimate includes a large contribution from relay chatter. I think we should throw out relay chatter and say GESSAR-II will not have relay chatter problems, period.

MR. RUBIN: With the currently installed --

MR. EBERSOLE: Just by edict.

MR. RUBIN: What is it worth to correct it? The residual risk from the plant is relatively low, from our calculations. With all the uncertainties, there may be unanticipated failure mode sequences that we are not aware of.

MR. EBERSOLE: Relay chatter right now to me means -- it is rather undefined. I don't know whether I get it in a small earthquake or just in large ones. But I'm being pessimistic --

MR. RUBIN: This is modeled over the site hazard function for the postulated GESSAR.

MR. EBERSOLE: Besides, in respect to UPPS there ought to be so few relays, like that many or less, that I can buy a solid gold relay in which there is no relay chatter.

MR. RUBIN: The UPPS system is not the save-all. It requires human action in a short period of time.

MR. EBERSOLE: Relay chatter is still up there as a double asterisk.

MR. RUBIN: That is not just relay chatter for the UPPS system; that is relay chatter for all sequences.

MR. EBERSOLE: I was taking the view that UPPS will work if there is relay chatter somewhere else that fouls up the rest of the plant.

MR. RUBIN: UPPS may work if there is relay chatter. We hope UPPS will work.

MR. EBERSOLE: I should hope so.

MR. RUBIN: But this models all the action sequences with the UPPS system installed.

MR. EBERSOLE: You are saying relay chatter may produce phenomena that UPPS can't cope with. I can't believe that, but I don't know.

MR. RUBIN: It requires human actions. Human action is not 100 percent reliable. The operators do not respond in a short period of time to initiate UPPS when they lose, if they lose all the response systems. You will have a core melt. If the relay chatter impact on study turns out to be as large as we see here, I would imagine --

MR. EBERSOLE: There is one parameter in a boiler on which all life depends. It is the core covered with water.

MR. RUBIN: That is included in the UPPS system.

MR. EBERSOLE: I don't see any relays in that.

MR. SHIU: May I interject a comment on this point? I want to impress upon you that the UPPS system is not a perfect system.

MR. EBERSOLE: Oh, yes, I know.

MR. SHIU: The UPPS system is subjected to a number of vulnerable components, if you will, and I think we discussed one earlier, that is, the piping that has to go through buildings.

MR. EBERSOLE: You put it through the buildings arbitrarily.

MR. SHIU: Not arbitrarily. Based on the information that I have received, that looks like this is the way the UPPS system will go through, and I have discussed this with General Electric. So should someone feel they ought to improve on that particular aspect, the studies have demonstrated one vulnerable point that we all could work on.

MR. EBERSOLE: Sure. All right.

MR. SHIU: The second area is the actuation of the UPPS system. Again, I think in our report to the Staff, we have mentioned that the procedure has not been written. Of course, very little effort has been spent to identify what signal and what plant condition will initiate or requires the operator to initiate such a system. Again, it is very critical, and how much credit can you give to the operator for his ability to initiate the UPPS systems within a certain period of time, let's say, for instance, in 30 minutes.

That can be a big parameter, and again, we are talking about seismic events that can further diminish its capability.

MR. EBERSOLE: You better read the daily accident --

MR. SHIU: I do not want to get involved in this discussion where it is, but I want to point out there are a number of components, a number of factors that directly affect the effectiveness of the UPPS system. Now, the UPPS system in our modeling did not include any relay chatter failure because it is a very simple system and because it is highly manual. We do not assume that the relay chatter is affecting the UPPS system. Therefore, the UPPS system is capable to mitigate a lot of the relay chatter-related accidents that we talked about earlier.

I don't know whether that clarifies your question.

MR. EBERSOLE: I think you are denying that double asterisk.

MR. RUBIN: No, that represents the plant response assuming relay chatter and the UPPS system as postulated modeled by BNL. You will have a challenge to the UPPS system due to relay chatter. Now, if we don't have that challenge because you don't chatter, it would be somewhat less.

MR. EBERSOLE: That's what I was after. In other words, if I were saying the UPPS system will cope with relay chatter because it will have non-intrinsic to itself and it will deal with that which occurs elsewhere.

MR. RUBIN: That is what we have modeled here, but not with 100 percent certainty.

MR. EBERSOLE: Okay, let's go on.

MR. RUBIN: As shown in SER Supplement No. 4, the Staff has arrived at various conclusions and recommendations, requirements for the GESSAR-II design. Our final list of required design modifications includes the acceptance of the G.E.-proposed UPPS system with seismic upgrades. We have asked for a design study when UPPS is completed of the seismic vulnerabilities, and that it be made seismically robust, and the Staff will review G.E.'s analysis of that system's design.

We have asked for dedicated power source to the igniters and that the dedicated power source be made available to one DC battery charger to provide vital DC loads during station blackout event, and we have asked that particular care be made that interbuilding movement does not damage the power surging through the igniters or the DC battery chargers since the differential movement has shown to be a large contribution for risk to this plant for seismic events beyond SSE.

MR. EBERSOLE: Is that in the pipes?

MR. RUBIN: You have motion of the basement. If you put a cable through a penetration and the difference of movement --

MR. EBERSOLE: You just put the cables in sand trenches. You can tie them in a knot. That doesn't hurt them.

MR. RUBIN: Right. We are just asking that it be considered, that there be enough give in the system to accept the differential movements. We are talking about small power cable. It should be quite easy to do with forethought.

MR. EBERSOLE: Sure.

MR. RUBIN: We have also asked for a 10-hour station blackout battery capacity. You may feel that the DC charger and the extended battery capacity is somewhat redundant. We would agree with you. We are proposing this change in defense in depth. We feel since station blackout is such a large contributor to this plant's risk profile, that to bolster the DC power station blackout capability is a prudent action. The ten-hour capability can be achieved through relatively small csot, some changes to breakers to allow you to shut loads when the station blackout occurs, some procedures that would give you approximately ten hours to maintain cooling through the RCSI system if it is available.

We have also asked that a look be made at the RCSI room cooling situation to see if it is possible through simple means to provide longer-term cooling to the RCSI system either through opening doors or areas that would allow more air to move. We have asked that the igniters be powered from the same power source.

We said these are conceptual requirements. If G.E. has some better means to achieve these goals, we will consider them when submitted.

MR. EBERSOLE: In this degraded state where you are running on RCIC and worry about heating up the rooms, you are going to have no AC. You have DC and inverters.

MR. RUBIN: For ten hours.

MR. EBERSOLE: Right. The control room under these conditions doesn't have any heat generation to degrade its environmental conditions, does it?

MR. RUBIN: You will still have instrument DC.

MR. EBERSOLE: There is not any heat in that, so you have got an unlimited ability to stay in the control room, and so do the instruments?

MR. RUBIN: We didn't explicitly look at that. My guess would be yes.

MR. EBERSOLE: Yes. You stop the heat input except for a few instruments. Okay.

MR. RUBIN: We feel the modifications we have arrived at are reasonable ones, ones that don't pose an unreasonable cost or impact on the plant and, at the same time, can offer a reasonable risk reduction, as is shown here on this table. We feel these modifications will result in a reduction to public risk of approximately a factor of 2.5 from what the plant with the UPPS system is, to UPPS with igniters, and our recommendations are as you see in Supplement 4.

Mr. Hardin will provide you some more details of issues that were not included in the final list of design modifications. He will give you as much detail as you care to hear on the detailed processes gone through by the various groups that contributed to the design modification package.

MR. EBERSOLE: Thank you.

MS. HANKINS: One question before you leave, Mark. If you show no risk reduction past UPPS for seismic events in the same manner as you did for internal events, would you still be asking for all these modifications?

MR. RUBIN: I wasn't the only person who made that decision on the design modifications.

MS. HANKINS: I'm asking you.

MR. RUBIN: My feeling is from a defense in depth standpoint, modifications make sense.

MS. HANKINS: Wouldn't you tend to want to look at some modifications that didn't result in a risk reduction?

MR. RUBIN: Try me one more time?

MS. HANKINS: If your calculations on the seismic risk line had shown the same trend as the numbers on the interval of that risk line -- in other words, once you have implemented UPPS, there is essentially no significant risk reduction. Would you still be asking for those modifications or would you be looking at some other modification that might actually give you a risk reduction?

MR. RUBIN: We quite possibly could have -- well, we didn't look much further on. It would have been possible we would have looked at some others, perhaps changes to your scram volume, for instance, to attack the ATWS contribution, which is the residual risk at this stage. We would have looked further, I would have imagined.

MS. HANKINS: I just wondered if your numbers turned out to be wrong.

MR. RUBIN: Perhaps we would have some more modifications for you to do. In our SER, you will have justifications for both risk reduction and the defense in depth arguments to show you how we do our conclusions.

MR. HARDIN: My name is Brad Hardin, from the Reactor Systems Branch. I am going to try to put on a different hat here now.

Mark has given you sort of the positive aspects of the design changes from the Staff viewpoint, and since it was in the agenda that we try to address why we did not require some additional changes, we will try to give you a little of the philosophy of what the Staff was thinking as we went through the review of the large list of potential design changes.

As far as I know, GESSAR is the first plant where we have taken such a systematic and extensive look at potential changes beyond those that had been proposed by a vendor, and we did not have any set criteria or guidelines on how to go about this.

There was a great deal of agonizing that took place among many, many Staff members on exactly how best we should do this. There are just a few of us here presenting this work, but there were many groups involved in this, people that were experts in power systems and instrumentation, containment systems and many other areas than those that we represent here. We had to rely extensively on their opinions and engineering judgment because I think, as Mark has mentioned and we feel very strongly, we don't want to rely too much on numbers that we present here and that we have calculated. Cost-benefit calculations are only one piece of information that we wanted to use here, and we feel very strongly about that.

[Slide.]

This a partial list of the various items that were looked at by General Electric. It includes only 25 items, and these are ones that have been ranked as the top 25. We have to be careful when we refer to these as the top 25 because of the very large uncertainties that we recognize in these cost-benefit calculations. These have been ranked by the calculations that General Electric did on cost-benefit.

MR. EBERSOLE: Why aren't the comparatively low-cost modifications that could be done to the dump volume logic as well as design included in this package?

MR. HARDIN: When you raised this question a few minutes ago, Jesse, we had a little conference back there. I am afraid we do not have the right people here to go into a great deal of detail, but I will try to do the best I can to answer possibly why we don't have that on this list.

We did not spend a great deal of time looking into the possibilities, improving the dump volume design. I think the main reason that that is so is that the Staff had done an earlier review of the GESSAR design based on our deterministic criteria from the Standard Review Plan, and we had been satisfied that the GESSAR design satisfies our ATWS rule criteria as we presently perceive it.

They have abided by a generally approved fix. So frankly, we did not go, I think, beyond that. The improvement in the discharge volume was one of the items on this list of about 85 items that Mark mentioned. G.E. did respond to that in their formal document to us in NEDE 30640. It is a very brief response, but I think I could just summarize it in that they claimed also that they were committed to abiding by the ATWS rule, and other than that, we did not get further information from them on potential design improvements, and we did not ask for it.

MR. EBERSOLE: I don't know why my mind keeps being thrown back to Davis-Besse while you are talking about this, and the potentiality for common mode which was exhibited at that plant along with independent sequence failures. Is this a good place to talk about this topic or shall we wait till we get to security?

MR. HARDIN: If you will wait just a moment. I guess one thing that we can offer you is that we have agreed that we will go back to the Staff and see if we can find if there is anybody else who can add further to your question. Because of Davis-Besse, there may be other groups that are involved in looking at this. We don't have the right people here to comment on that.

I just put this slide up mainly just to indicate that these are the types of things that we looked at.

It turns out that the things that appear to be most worthwhile to us probably show up on this page. Although there are approximately 60 other items, I guess, that were looked at, General Electric did evaluate each one of those and they wrote basically at least a paragraph or so on each one, which is a useful document, I think, to look at their view on each of these items, many items.

I am going to come back to this in a minute, but right now I think it is useful to try to go into just a little bit of the philosophy of what caused us to stop looking on the design changes.

[Slide.]

This is a very nice Vu-graph that was prepared by Ed Throm, the Division of Systems Integration, and it shows for only internally-generated severe accident events what the effect is as we go through some of the various design improvements. It shows monetized risk as a function of what the particular design improvement might, and monetized risk, as some of you may or may not know, is sort of a measure of what type of dollar value we might achieve in terms of reducing the risk to zero for each of these design situations.

So the farthest bar on the left here is the original GESSAR design without UPPS. We debated on whether or not we should even report that or not because UPPS is a part of the GESSAR design now and we recognize that, but just to show, I think, partly what the improvement is that G.E. has proposed themselves, we put that up as kind of an initial case.

The dollar cost is based on somewhat arbitrary value of $1000 per person rem averted. So basically, we look at the Brookhaven calculations for the original GESSAR design and we use the estimates of what the total risk would be for the original design, we convert it into person rem, we assign a value of $1000 per person rem, and we could calculate a measure of what the averted risk would be if we can reduce the risk to zero.

MR. EBERSOLE: You go back to the universal number of $1000 per man rem. What about the averted cost in terms of capital investments lost, generation lost, and the other aspects of loss not related to $1000 per man rem? I'm of the impression that unless you include that, for a variety of reasons, you don't get enough money to do any good.

MR. HARDIN: You are getting into an area that we have a lot of troubles with. There doesn't seem to be --

MR. EBERSOLE: What is suggested is your available investment is way suppressed beyond what it should be. Why don't we get together on this with the other departments that are looking at this. My understanding is now you are obligated to consider averted costs beyond $1000 per man rem.

Am I correct? Does anybody want to shoot me down on that? Staff, aren't we behind the times here?

MR. HARDIN: I guess we could say we are waiting for a safety goal to be finally decided.

MR. THOMAS: We are the wrong people to be commenting.

MR. EBERSOLE: I think we ought to stay up with current events. It sounds like it is oncoming, I would think.

What is G.E.'s observation on this? You are stuck with $1000 per man rem, that's all, as available investment? Is that right? And no other averted costs?

MR. FOREMAN: In doing the assessment, certainly, we are stuck with that.

MR. EBERSOLE: Is it appropriate that I ask the question of the Staff that they continue on this road? How are we going to integrate our thoughts here?

MR. HARDIN: That may be a question for Bob Bernero tomorrow. He might be able to offer some thoughts on it.

MR. EBERSOLE: Let's put that on the agenda and be sure we cover that. All right. Very good.

MR. HARDIN: There is something very interesting about this bar chart that does help a little bit, I think, and that is, right away, if you go from what the initial monetized risk was on GESSAR to looking at what you get when you look at UPPS as proposed by G.E., it takes a very significant drop, and Mark reported numerically, but you can see it very nice graphically here.

If you look as to what we might do beyond UPPS with hydrogen control and applying a generator for charging the batteries and so forth, you can see we are starting to bump up against the ATWS contribution. We have looked at ATWS, and we, I guess, are not capable at this point of recommending any further changes that would reduce this green area, and so this is basically the best that we know how to do right now. And certainly up for criticism, if you may, but it would indicate that there really doesn't appear to be too much that we know how to do right now beyond UPPS.

And using engineering judgment and defense in depth, as Mark mentioned, we have tried to suggest some things that we thought would be prudent from an engineering viewpoint, but I think this is an interesting bar chart if it is at all accurate. And again, we have done the best we can on it.

MR. MARK: I am a little puzzled. The man rems that we saw just in the previous presentation, the highest value was 600. How do we get -- by multiplying by 1000, we get to six-tenths of a million, I guess? Where does this $5.3 million come from? There is something else in there, surely. Is that putting on ten years life?

MR. HARDIN: We are assuming a 40-year reactor life here. I think they are fairly consistent. They may not be completely consistent, but I think they are fairly close if you take all the factors together and look at the tables.

MR. MARK: It's not discounted; it's just multiplied by four eight?

MR. HARDIN: That's right. So this was a consideration in our deciding when to stop looking at GESSAR for further improvement in that that bar chart suggests there really isn't much more that you might achieve, at least from a risk reduction, cost-benefit viewpoint.

[Slide.]

And this is for seismic. We have some things that we want to check on this, but this one indicates again, as Mark has, that UPPS doesn't show an improvement significantly for seismic events, but if we add hydrogen control, we are going to check on what these values are. But you can see some improvement, at least, shown in this analysis here. But I think now maybe we can go into some of the items that we didn't choose specifically and talk about them.

[Slide.]

This is a table that shows the results from the R&D Associates group out in California. They had sort of a multiple role here in this work. They were given the task of doing basically a generic review in a number of areas on mitigation designs for severe accidents, and a part of their assignment was to break out of the generic mode and to look at a few plants more specifically.

They looked at Limerick first and they looked at

GESSAR, so they worked with us and they worked with Brookhaven, and they took a completely independent view as to some things that they might propose to improve the plant.

In addition to that, they also offered advice and we used them as a sounding board on the other work, work that we worked with more directly with Brookhaven, but they investigated a very large number of potential mitigation schemes. I refer you to their reports if you are interested. There are a series of five reports that are coming out of their work, and they are referenced in the Supplement No. 4.

But this just summarizes some of the major things that they did. It shows four options. There are three options that are shown here, and we have the cost in thousands of dollars, and what it would take to make some of these design improvements. Then down at the bottom we have the reduction in person rem that we would expect from those changes, and then we have a cost-benefit number which has been put in a format where you can compare it with $1000 per person rem again.

The first three options are all involving what we are referring to as the high pressure containment. This would be using a containment similar to one that G.E. has proposed. This fourth option over here is one that RDA looked at. It's a low pressure containment with a chilled filter, which in concept would make it unnecessary to have a high pressure design because if you were to have a release, it would pass through a chilled filtered region. I think we have had some presentations to the subcommittee before by Bill Kastenberg from UCLA, who is a part of the RDA group.

Just to get down to the bottom line, more or less, if you look at the cost-benefit numbers that have been calculated by RDA, they range from about $1500 to a little over $2000, as compared to our measure of $1000 per person rem. So they are kind of close to $1000 per person rem, but you might, let's say, put them in the interest of being cost-effective but they don't quite make it.

And a very important perspective to keep in mind on this is that when we were analyzing GESSAR for cost-benefit and we began to make judgments as to whether things are marginally acceptable, should we look at them closer? If they are close, do they deserve more attention? Might they be acceptable if we took a closer look at them?

You need to understand that these numbers were calculated using what we call upper range source term values, and that means not that we think they are not credible. We think they are credible values, but they are values that Brookhaven has developed in looking at all the available information on source terms right now, including the ASPER work, and we felt that we need to have some measure of what the upper bound values may be, both from looking at design changes and from trying to make judgments on the overall risks for the plant.

We, I think, have identified before and in the SER that we may have differences in risk as much as a factor of 1000 from the values that G.E. would calculate. We believe that G.E.'s values are also credible, but they are in the lower bound. When I say lower bound, in the lower area of possibilities. But what I am trying -- I guess the point I am trying to make here is if you use the upper range source term values as we did here, and you calculate numbers that are a little bit higher than you would accept from a cost-benefit viewpoint, you might argue that you don't need to look further because it is very likely that you are going to make them become even less attractive when you look at things closer.

Right now, for simplicity and for a lack of knowledge, we used numbers which are somewhat upper bounding. I hope that is clear, but basically, it is an argument in a negative sense. If you can't show a benefit from it using this means of calculation, you are probably not going to show a benefit when you look at it in more detail and put more effort into it.

MR. EBERSOLE: Again, you are using just dose averted?

MR. HARDIN: We are not including cleanup or power replacement costs.

MR. EBERSOLE: That is another department. I think the wind is drifting in that other department to consider onsite averted costs.

MR. HARDIN: Again, the RDA report, their recommendations on how these things may be evaluated, incorporated into the regulatory environment.

MR. EBERSOLE: As I recall, the thesis is it is a public cost not lost to the utility. It is going to be spread as a public cost, and it is thus rational.

MR. HARDIN: I guess we have not been given the go-ahead to do that yet officially, but I know there are people that believe it should be done, including RDA.

MR. EBERSOLE: It changes the picture rather drastically.

MR. HARDIN: Yes, it does, very much. But it starts to put us into a difficult technical position because then we have trouble calculating further risk reductions due to the uncertainties that we know exist and the source terms, and also that we are getting down into areas such as the ATWS, that there are people who believe that their estimates of the ATWS risk are probably high due to limitations on our ability to calculate the phenomena.

So we just may be years too early to see further improvements on that. We keep our eyes on it and try to do the best we can.

MR. EBERSOLE: All right.

MR. MARK: What assumptions were made in deriving these numbers about the decontamination factor of the suppression pool?

MR. HARDIN: The decontamination factors that we used in these calculations were the ones Brookhaven developed, and those did disagree to a considerable extent with those that General Electric uses. As Debbie mentioned, it's focused a great deal on what we understand about particle size distribution.

MR. MARK: I understand the problem in deciding what the number must be. But is that factor not just about the same as the factor between 11 person-rems and 5000 person-rems?

MR. HARDIN: It certainly has a large part of that. It has a large contribution to that. But there were other things as well. There are various areas in the treatment of the source terms beyond the pool, that we tried to be sure that we looked at what the effect would be of assessing worst cases beyond what GE did, even though we could not assign a best-estimate value and we didn't want to go to worst case, necessarily. We just tried to look at what the effects would be, and so there are other things beyond the suppression pool scrubbing, things such as, I guess, potential increases in the bypass -- on a bypass around the pool, for example.

Brookhaven did some sensitivity studies on things like that. One thing that is also important to recognize on the RDA work is that it did not take into account any credit for UPPS. RDA started this work, I guess probably about a year and a half or so ago, before we were aware of UPPS. And if we were to incorporate UPPS into these calculations, these numbers here that are 1500 to 2000 dollars per person-rem would all certainly increase and become less attractive.

[Slide.]

I'm almost finished here. But I guess we were asked specifically to take a look at some of the items that we did not choose in our recommendations for further improvements.

Again, back to this table that's in the Supplement No. 4, on the righthand side, we have the cost/benefit value. It's been rounded off to the nearest ten, or even more later on here. These are numbers calculated by General Electric.

The column next to it is a notation to identify certain of these changes, which were claimed by GE to be already either included in UPPS or else to have been addressed by UPPS.

The ten-hour blackout, as Mark mentioned, the battery capability for that, we have recommended that that one be included mainly from a defense-in-depth concept.

Ultimate plant protection system is the next one. The improved or additional low-pressure system. The one is one that is noted to be addressed by UPPS. And as we have stated in our SER supplement, Staff looked at GE's claims on this, and we tended to agree with them. We would probably qualify some of it, but I'm sure they would, too.

AC bus crossties, GE notes that they feel the importance of that is reduced. I guess we agree with that. But in addition to that, the Power Systems Branch at the NRC looked at this in some detail, and they feel that the potential common mode failure with AC bus crossties is just not understood that well right now. We don't have extensive analyses on it, and we don't think it would be wise for us to require that.

MR. EBERSOLE: Wouldn't that depend on the relative reliability of the diesel plants versus the load complex that it feeds?

MR. HARDIN: Yes, I'm sure that it would be a very plant-specific thing. I think there's more work required there, if that was to be looked at with some interest.

MR. RUBIN: Also, I'd like to add that the benefit would be for a Division 3 crosstie to provide some long-term cooling and basically get that from the UPPS system for the function we have.

MR. EBERSOLE: All right. Thank you.

MR. HARDIN: The next one here is an interesting one, because it falls in the category of a number of things that have to do with operator action. This is improved maintenance procedures and manuals.

Maybe we should go on to the next one below that, because that's sort of the same thing. It's computer-aided instrumentation. This subject, helping the operator to try to ensure that he will perform more effectively during a severe accident, is one that we feel is a very worthwhile area to try to continue to focus on. We have not tried to put any requirements in the review of GESSAR for this, because other than noting we feel it's important, we don't know exactly how to go about implementing this, beyond the work that is ongoing.

There is a fair amount of work that is ongoing. I don't know if it has a great deal of priority, but there are groups that are looking at how you would write special procedures for severe accidents, and that is coming along.

We basically have not highlighted it, because we don't know quite how to handle it in terms of the requirement.

Alternate AC power source, we show that that's being addressed by UPPS. We agree with that.

Batteries for DC pump power, I guess we have looked at the various improvements to be made by adding batteries, increasing battery capacity. It appears that we just don't see a specific need for making a requirement there.

Increased battery capability for 16-hour blackout, we believe that the recommendation that we have made for 10-hour blackout would give a significant improvement from a defense-in-depth viewpoint, and that 16 hours would not give that much more improvement beyond the 10 hours.

MR. MARK: There has never been a 16-hour loss of offsite power.

MR. HARDIN: Yes. I guess it's the thought of the Staff that if you can make it up to 10 hours, another six hours probably would not gain you that much.

MR. MARK: The Staff has a study, or certainly EPRI does, on blackouts as they have occurred -- I think the longest one is eight and a half hours -- in quite a few reactor years.

MR. HARDIN: Yes.

MR. RUBIN: Let me also add, in our battery capacity, which is part of the package for resolution of A-44, that what we finally arrived at with the 10-hour capacity was slightly in excess of what the generic resolution was, about eight hours.

MR. HARDIN: Unless somebody is interested in talking about any of the other specific items here, I think just to try to summarize, we did not add any of these other items to our recommended list of requirements, basically because it was either something that UFPS appeared to address, or else it did not appear to be cost-beneficial, or in using our engineering judgment, we just did not feel that it was something that warranted further requirement for GE.

MR. EBERSOLE: Item No. 23 sounds like an overshoot on your capacity to identify these.

MR. HARDIN: Yes. This list was meant to be sort of an all-inclusive list, and we put things on there that are difficult to deal with.

MR. EBERSOLE: I think you could reduce them, and if we knew what they were, there would be a lot more than that.

MR. HARDIN: Yes. That item probably covers a lot of other things on that list, too.

MR. EBERSOLE: What was the uninterruptible power supply, No. 14? You already have what is called -- basically they ought to carry nothing but the clocks and the computers.

MR. HARDIN: I don't know if I can answer that, and we don't have the electrical people here. But I think that it may have been a power supply that did not have a lot of relays and so forth connected to it, so that it was immune from those types of problems -- something like a generator that just runs and is hardwired to some system. I think that's what that was.

So this is an area that again we do not have a lot of experience in doing this type of review before, and this reflects a great deal of judgment on the part of a fairly large number of people. We tried to get them all involved, and we showed them where we were heading as we progressed, and we asked them if they wanted to change anything, did they have any comments on improvements we could make, and this is what we have ended up with after that process.

MR. EBERSOLE: Thank you.

MR. MARK: I'm glad you didn't bring the other 60 operators.

[Laughter.]

I really find that it is startling to read No. 10 under "General Classification of Design Modifications," when it refers to simulator training. It doesn't sound like a design modification exactly.

MR. HARDIN: Well, again, the intent here was to not look at just hardware fixes, but to look at anything we thought might improve the response to severe accident. So it's one of the items that is similar to maintenance and procedure improvements and so forth.

MR. WILEY: In the matter of dollars, do you have a feel for how much money you're talking about there, the simulator training, the benefit?

MR. HARDIN: I don't believe that we actually ever had a dollar value assigned for that. In some of these cases, General Electric provided us their thoughts on it, written in NEDE-306-40, and we did not pursue it further than that. We agreed pretty much with what they said.

Sometimes the information given to us by GE was fairly qualitative. We told them we would accept qualitative information. I have a feeling that is the case there. We can look in the document and see. I don't think there's any dollar volumes assigned for that.

I think there are other groups of the NRC, though, that eventually will be able to provide more information on that, the Division of Human Factors Safety, I think. If we had somebody here today, they might be able to help on that.

MR. EBERSOLE: Are there further questions on that.

[No response.]

MR. EBERSOLE: Before we take a break, there's a short topic -- I omitted an invitation for you to comment on this. Do you have anything to say on this long list?

MS. HANKINS: I will be very quick. I think everything has been said.

[Slide.]

There may be editorial comments on this part. I think we've talked enough about what UPPS does. We've changed from our previous cost/benefit analysis, as SSER 4 requires a seismic upgrade. This is not full Seismic Category 1. This table lists the different risk reductions, based on the BNL analysis with and without the seismic upgrades. You see no effect on the internal events. There's a small effect on the seismic events.

Again, we believe these numbers are going to change when there's a reassessment of the seismic consequences. Based on GE studies with and without the seismic upgrade, there is again very little risk reduction for the upgrade on ATWS. The seismic risk was about five percent of the total risk, and that is the reason why we see very little difference in the risk in the GE numbers, with and without the seismic upgrade. Making the seismic provisions increases the cost of the UPPS system by about a factor of two.

MR. EBERSOLE: May I ask a question on that score?

What you have got now, you use a fire pump for injection. This is not a very big pump, not a big horsepower. This is a diesel-driven pump, no big money.

The fire protection system right now is not seismic at large, is it? It never has been required by the Staff. This brings some problems, because it may start protecting when there's no fire, all over the place, which is one of the interactive problems.

I would venture to guess you'd probably save money and complications by putting your own pump in for UPPS and defining a source of water -- did you look at this? -- because of the chickenfeed nature of the size of the pump, and then the fact that you could, as a unit, seismically qualify?

MR. FOREMAN: Actually the cost of a pump is not included in UPPS. What's included in UPPS is the capability to supply power with whatever pump might be available. It might be from a fire truck; it might be from some other outside source.

MR. EBERSOLE: In any case, that pump and its engine is not big money.

MR. FOREMAN: Right. We assume --

MR. EBERSOLE: It costs more to talk about it than to buy it.

MR. FOREMAN: We assume that pump is readily available without being included in the --

MR. EBERSOLE: Sure. You can buy it already on skid mounts or whatever, so it's intrinsically seismically competent without carrying the burden of the fire protection system along with it.

MS. HANKINS: Again, I think what we found in our evaluation and also true in the Brookhaven evaluation was the limitation on UPPS effectiveness was not so much availability of the pumps, as the operator action reliability of the operator. It's not equipment limited; it's human action limited.

MR. EBERSOLE: David-Besse will be a revelation as to what operators can do, both to get in trouble as well as out.

MS. HANKINS: Of course, TMI was the other extreme.

[Laughter.]

MR. EBERSOLE: Well, they were running a little bit of a boobytrap.

MS. HANKINS: Nevertheless, I will stress again, GE will comply with the requirements in SSER 4, in that we will include the seismic provisions on UPPS.

[Slide.]

You all know how much we love the hydrogen ignition system. Again, our previous commitment in the system on which we based our cost/benefit analysis is one that was consistent with HCOG resolution of hydrogen control. Changes in that SSER 4 require a dedicated power supply. Obviously that's going to increase the cost of the system.

Looking at Brookhaven's numbers, there's essentially no risk reduction for internal events. They showed a large risk reduction for seismic. Again, this number is under evaluation. I firmly believe that number is going to come down substantially. Based on GE's evaluation, again essentially no risk reduction for having an igniter system.

Even assuming dedicated power, one assumes the inclusion of the heat removal system, which was the original basis of our cost/benefit analysis, the system cost is about $10 million.

MR. EBERSOLE: What is the incremental system?

MS. HANKINS: Containment sprays.

MR. EBERSOLE: Containment sprays.

MS. HANKINS: The most probably way you get into this, you don't have your low-pressure ECCS available, so you wouldn't have the containment sprays available. This would allow you to have a dedicated system to operate containment sprays.

MR. EBERSOLE: So your igniter system is carrying the burden of containment sprays?

MS. HANKINS: In this $10 million cost figure, yes.

MR. EBERSOLE: And if you didn't have containment sprays? I think you said the critical use of containment sprays, whether you had them or not, was related to the probability of whether you had bypass or not. Some of the plants don't have containment sprays.

MS. HANKINS: Correct. The original purpose in having containment sprays in a GESSAR design, the original sizing was based on steam bypass for the drywell. Realistically, we don't know whether there's going to be any --

MR. EBERSOLE: You have now fixed the design so that can occur, but not as likely.

MS. HANKINS: We fixed the design, but still have containment sprays. I am saying, if in reality we had containment sprays available, we'd rather be putting that water on the core and not have the hydrogen to deal with. The difference is the alignment of one valve.

MR. EBERSOLE: I understand that.

MS. HANKINS: So this would be saying, we'd have a backup supply to power the containment sprays, independent of the rest of the diesel system.

MR. EBERSOLE: How does the igniter system look now without the containment sprays, without all the cost burden of it? I suspect that's a factor of about 9 to 1 in cost.

MS. HANKINS: $1.2 million was our estimate, ballpark estimate.

MR. EBERSOLE: 10 to 1, when you add the sprays. I didn't realize the igniter system was carrying the burden of the sprays along with it. Does that make sense?

MS. HANKINS: I think the reason -- again, Dr. Pratt, you can back me up -- even now he's recalculating the seismic risk.

Do you want to hear what the question is going to be? I think the question is, our original perception, in many of the analyses that were done for HCOG, they assumed the availability of containment sprays for heat removal for when any of the hydrogen sequences were ignited to operational, so based on that, we had used the $10 million figure, which included the heat removal, for our cost/benefit of the igniter system.

If one did not have sprays as a heat removal source, would the igniters still function as designed to maintain containment integrity? I guess I haven't seen enough of the HCOG analyses to know if that's true or not.

MR. PRATT: I think again, the HCOG was dealing with degraded core events, and it got pretty close for some of the assessments that were performed.

One of the points that was made earlier on the graphs that were presented in terms of the changing risk due to perfect hydrogen control and the effect of igniters, perhaps the stress on perfect hydrogen control -- the way the analysis was performed, the calculation for perfect hydrogen control assumed that it was either inert or the ignition devices controlled the hydrogen in such a manner that you never fail the drywell or the containment building.

MR. EBERSOLE: Does that require sprays?

MR. PRATT: Again, the way we did the analysis, we made the assumption that it probably would fail. That's why we didn't put the word "hydrogen control, perfect hydrogen control with igniters" on the title.

MR. EBERSOLE: But if you do not have the sprays, what do you come out with?

MR. PRATT: The calculations that I have seen performed, as I said before, were for degraded core events for the amounts of hydrogen produced in-vessel, and we were coming rather close to the capacity of the containment building, but not the ultimate capacity of the containment building.

MR. EBERSOLE: So the sprays are an adjunct to hydrogen control, and you say a necessary one, you think?

MR. PRATT: They certainly took away the doubt in terms of the assessments that were done for the degraded core events. That was one of the things that led us on to the conclusion. For one, we were looking at the focal meltdown. Without the sprays, we weren't sure that the hydrogen control device would maintain containment integrity and drywell integrity for the full range of core meltdown.

MR. EBERSOLE: I understand there are plants in being now that don't have sprays, that do have igniters. Am I correct? Lots of them?

MR. PRATT: I'm not sure.

MR. EBERSOLE: I can understand now why you don't like igniters, on account of you don't like sprays. The igniters are just a bunch of Christmas lights inside, almost, I think. You know, $300,000 would cover them.

MR. PRATT: Again, I think tomorrow we do plan on having some of the people from the Containment Systems Branch.

MR. EBERSOLE: We might take that up tomorrow.

MR. PRATT: I think they might be able to address that in more detail.

MR. EBERSOLE: I can see, for heaven's sake, if you're carrying the burden of the sprays.

MS. HANKINS: I think relative to BWR-6s without sprays, don't they have other containment systems?

We will try to find the answer to that question.

MR. EBERSOLE: Okay.

MR. SCALETTI: Debbie, what else is that $10 million. Isn't that the buy-in cost to HCOG in that also?

MS. HANKINS: I don't remember.

MR. SCALETTI: I thought there was a sizable amount of that.

You don't remember?

MS. HANKINS: I think it is the cost of the heat removal system, plus the igniters, because I know where the original cost figures come from, and that would not have included a buy-in to HCOG. There may have been some R&D in there. But, I don't think it included buy-in to HCOG.

Look at the NEDE document. Unfortunately the author couldn't be here today, so I am trying to sub in here.

(Slide)

Ten-hour station batteries. This is part of our ten-hour station blackout provisions we assessed in the NEDE document. Essentially no additional risk reduction.

Again as was mentioned earlier, there has got to be some procedures laid down for load shedding in order to achieve that ten-hour capability. So, it is not so much the difference in the batteries, as much as the difference in the load shedding.

(Slide)

We just talked about the AC cross-ties. There was a potential common mode failure, if one does that.

Again, we only looked at it from the standpoint of heat removal, primarily because we were uncertain as to how quickly the cross-tie can be accomplished. And as such, did not assess it for injection capability. But, since you have a fairly long time before heat removal is required, we felt there was a better possibility that you could use a cross tie for that function.

Again, it was an insignificant risk reduction, because loss of heat removal events were not significant to GESSAR. Now, especially with the addition of UPPS -- UPPS is an alternative to this, so this would be an alternative to UPPS.

MR. EBERSOLE: That was a strictly manual operation, wasn't it?

Do you all have a set of rules at GE that says in regard to operator action versus automated action, in a case like this, or other cases when you invoke automatic operation and when you leave it to the manual?

Do you have a set of criteria or rules on human factors considerations that define when you automate and when you don't automate?

I've been looking for that everywhere, so if you say no that will just be another of a thousand cases.

MR. FOREMAN: I'm not aware of any.

MR. EBERSOLE: The question always comes up; when do I automate, when don't I automate?

MR. FOREMAN: I'm sure that that is taken into consideration by the designer, but we don't have a set of rules.

MR. EBERSOLE: I remember a case here, where this had to do with valves, where you wanted the valves to move quick. It was a post-LOCA and this transfer action was automated through a set of supervisory apparatus.

MS. HANKINS: There is a rule in NRC requirements that you cannot take operation action for ten minutes.

MR. EBERSOLE: That's a general thing pulled out of the sky about 1966.

MS. HANKINS: Whatever. So, for anything that has to operate within that ten minutes has to be automatic.

MR. EBERSOLE: Right.

MS. HANKINS: I think the Standards Review Plan suggests 20 minutes until operator action.

MR. FOREMAN: I think the question is, do we have a design spec out of all our design specs that is called Human Factors Design Spec.

MR. EBERSOLE: Which says this is too messy to leave for the operators, that I must now automate with a weighting of factors that lead you to that conclusion.

MR. FOREMAN: No, we don't have something like that.

MR. HARDIN: If I could make a comment on that. This is Brad Hardin from Reactor Systems Branch.

We are asked to review the Chapter 15 Transient Analyses as just a normal review process on each of the plants. So, we have to have some criteria for whether you accept operator action at short times, which sometimes is assumed in the analyses by the vendors and utilities.

And the number of ten minutes sometimes comes up, and twenty minutes. And there have been some guidelines that have been written by the Human Factors people, which I think there has been an attempt to use those.

But I think basically what is done is, that we try to look at the operator actions that are required in our review of the plant. We ask specifically what each of the actions are and how long it would take. And, if the time that is required or assumed for operator action is down in the ten-minute range, we try to look very closely at those to ensure that they are very simple actions and straightforward.

MR. EBERSOLE: Unfortunately, there is no negative instructions that say "you shall not operate until ten minutes have elapsed, and you have thought out items A, B, and C" and so forth.

Again, if you look at Davis-Besse, you find you got into trouble because they jumped into trouble by manual action too quick without thinking and punched the wrong switches. Then they saved themselves by the same process.

It certainly was not deliberate in trying to recover feedwater and punch total isolation.

By the way that gets up to the general topic, we still seem to carry a burden of philosophy and so forth, to try to isolate and lock potential losses of fluid with radiation in it. You do with the dump volume logic. At Davis-Besse you will find its main trouble was due to excessive implementation of isolation philosophy, which also turned off feedwater.

MS. HANKINS: You make it so reliable that it is unsafe.

MR. EBERSOLE: There is a parallel here, which is why I bring up Davis-Besse as a related matter. The isolation philosophy overrides the need for continuity of critical functions, and I think that is wrong.

(Slide)

MS. HANKINS: Some of the other modifications that were looked at, and why they were eliminated.

Diverse power to ride an additional high pressure system, low pressure, battery driven system. Again, those are alternatives to UPPS. They did not have as much capability as

UPPS has.

16-hour battery, DC bus cross ties. Again, they showed no improvement over the 10-hour battery capability, substantial improvement.

We did implement the RCIC starting improvements. Computer-aided instrumentation. We actually have a proposal out to utilities on that. And if we do sell one to the utilities, we will implement it on standard plan.

All the other items -- the cost-benefit ratios were too high to warrant further considerations.

(Slide)

This is just simply a summary of those other modifications. These are the modifications that we will be implementing on the design. These are the next six improvements, and here are some of the additional improvements.

You can see the cost-benefit ratios were very high.

MR. EBERSOLE: In the gas turbine case, did you account for it as a peaking plant which has a real value on line short-term peaking?

MS. HANKINS: I think so. This was a dedicated power source to the emergency core cooling.

MR. EBERSOLE: It was not an auxiliary peaking plant?

If you did it that way, the cost might be erased by that.

MS. HANKINS: At least get some use out of it, instead of having it sit there waiting around for an accident.

MR. EBERSOLE: Sure.

Any further questions?

(No response)

Why don't we call a ten-minute break and come back at about 3:25. We are doing very well on schedule, I think.

(Recess)

MR. EBERSOLE: Back on the record.

I'm looking at Topic F. As I recall, we have had considerable discussion of the source term by GE itself.

What I am going to do here is offer the Staff an opportunity to discuss its views on the scrubbing, since I see they take issue with the GE estimates, and defend their position that the GE number is not conservative.

Then, get a rebuttal from GE on this matter.

I am looking at Item F. Is that all right with the Staff?

MR. SCALETTI: I don't know if that is how we had planned to approach it. We will address it.

MR. EBERSOLE: GE, do you want to review the source term scrubbing first, before they take up their counterargument that you are too weak? I don't care.

MS. HANKINS: I don't think there is anything new in here that we haven't seen before.

MR. EBERSOLE: I only note that in the Supplement 4, that you take issue with their scrubbing efficiencies, and I think it might be appropriate to say why you do that, to defend your position that they are not conservative.

MR. PRATT: Right.

I think what we can do is walk through -- we did the thing in two stages. There is a historical perspective there which might help.

MR. EBERSOLE: Sure. Right.

MR. PRATT: (Slide)

You all have a copy of the handout. What it might help to do, to put the way we did the calculations in perspective, is to go through a discussion on the approaches that we took in the review, describe the sensitivity study that we initially performed, and then give you some of the results of the calculations that we performed, based on the new systems of codes that are being developed by the Accident Source Term Program Office at the NRC, and we will do some comparison.

(Slide)

This was the first application to our review of PRAs to methods other than those used in WASH 1400. And the aim was to try to utilize the emerging technology that was going on in the source-term area.

However, we were a little bit restricted in how we could do that, because when we started the assessment, we didn't have the full suite of computer codes that were being developed by thge Accident Source Term Program Office. So, we originally did a sensitivity study based on the MARCH system of codes. We had CORSOR, the CORRAL code and the SPARC codes available at that time, and we adjusted some of the parameters in there based upon the emerging technology to see the range of values that one might expect in these calculations.

So the first step was to make an approximate sensitivity study to give us some idea as to which of the various phenomena was sensitive and important. And then we were to compare that against the mechanistic calculations based on ASTPO methods.

So again, I don't know whether this was focusing specifically on our concerns regarding pool scrubbing. But we felt in our initial calculations we had to deal with a range of numbers, a sensitivity study rather than a point estimate, simply because we did not have the most up-to-date information from the source term office.

In fact, I was at a meeting last week with another subcommittee of the ACRS where the NRC were finally presenting their integrated picture on this new code system. That was the Class 9 subcommittee. So, while we were doing this work about a year ago, we were, if you like, an emerging field, and felt that this was a more appropriate way of going.

I can give you some indication of the way we performed the sensitivity studies.

(Slide)

You can do a series of calculations and generate a very simple equation which relates the fraction, for example, of fission products that could be released in the vessel to the various flow paths that you would see. Also, the decontamination factors they would see as a result of going through the various flow paths.

You can adjust the parameters to see the effectiveness of the various phenomena that are of interest.

Those parameters that we thought were particularly sensitive are listed here.

(Slide)

We were concerned about in-vessel holdup, for example. How many of the fission products could be held up in the primary system. And of course how we do that is the release of these fission products.

The suppression pool decontamination factors, of course, you have identified as an area of concern, also.

And, we varied these.

And then we also looked at the releases due to molten core/concrete interactions. This is a major area in terms of differences between the calculations performed in the reactor safety study and the latest calculations that one would get using the ASTPO suite of codes.

One of the things we did not vary was the in-vessel fission product release as a function of time. The calculations we had seemed to be fairly consistent. This is one area that research has varied and thinks there is some uncertainty.

Again, the in-containment transport was based on the CORRAL model. The most up-to-date calculations would be the NAUA code, and how that would change things. But this is the range that we looked at.

(Slide)

I have some examples in the handouts, which I think we can move over, which show the in-vessel releases. They were not specified as they were in WASH 1400, but calculated as a function of the accident sequence using the CORSOR computer code. As an example, one can see there isn't a great deal of variability between the releases of the various species from what one had predicted in WASH 1400 and the CORSOR calculations with the exception of tellurium.

(Slide)

This, of course, is the uncertainty associated with whether or not the tellurium goes with the zirconium, the unoxidized zirconium, or not.

(Slide)

I have some Vugraphs here which indicate the inputs to the sensitivity study. These were largely described in Supplement 2 to the SER. I think it is in this area where there was a concern in terms of the variability of pool scrubbing that one would see.

The in-vessel holdup fractions were based basically on TRAPMELT calculations, and these were a little bit different to the values used and assumed in the GESSAR PRA, the re-emitted fractions. This was not considered by GE in their assessment.

We looked at the maximum decontamination that one might expect by assuming the values that the GE assumed. We looked at a minimum calculation here based on SPARC calculations in that time, and particle size distribution from QUEST. These are relatively low numbers. I know General Electric are concerned about the use of these low numbers across the board. They apply to one specific plart of accident sequence, ex-vessel core concrete interactions. But again, within the limitations of the sensitivity study we had, we did not have the capability to vary the decontamination factor as a function of time throughout the accident sequence.

Okay. So we were looking in our sensitivity studies at the broad range of possible answers.

When we look at the mechanistic calculations, you will see that we did calculate the pool decontamination factors as a function of the accident sequence. It does vary over quite a wide range.

MR. MARK: You referred to the core/concrete interaction.

Does that stuff go through the suppression pool?

MR. PRATT: It depends on the accident sequence, again. For certain of the accident sequences, such as in L3, if you have a 3 in the designator, that implies not only the in-vessel release, but also the ex-vessel release goes through the pool.

If it is an E2 or an I2, then the ex-vessel release would bypass the suppression pool.

Again, it depends on whether or not there is a bypass of the pool. So again, you know there may seem like there was wide variation in the differences here. Indeed, the numbers do look very large. Minimum values here were based on the minimum SPARC calculations, if you like, for one point in the accident sequence, and applied to the whole thing.

MR. EBERSOLE: I want you to explain something to me. I suppose it is a fairly well established science that decontamination factor is dependent on particle size.

In the matter of identifying the aerosol particle size itself, how do you come to grips with that?

MR. PRATT: This is something we alluded to earlier. It is rather difficult.

The calculations that we do in the mechanistic calculations, I will be going through that later, we would get the output coming out -- for the in-vessel phase -- coming out of a code called TRAPMELT. In other words, you specify an input from CORSOR. I have a line diagram of the codes.

MR. EBERSOLE: Have there been physical experiments done with the core or the experiment in somewhat similar configuration temperatures and so forth, that illustrate these particle sizes being emitted from the damage to the core?

MR. PRATT: I'm really giving these Vugraphs for Dr. Ludwig. He could address this better than I could.

I believe there are experiments, and Debbie, I think, will be going through some of them.

MS. HANKINS: Particle distribution form the core? Other than some of the small-scale experiments like PBF, the closest thing to the full-core melt types of particle generation would be the MARVIKEN experiments. Those would be the only truly large scale. They had fairly large particle size distribution.

MR. PRATT: Again, that was an artificially generated particle size. It wasn't somebody would melt down something. They were generated. And the aim there was to look at the behavior within the containment of those species, as I understand it.

MS. HANKINS: In the vessel.

MR. PRATT: Right. As I understand it, it was a manufactured number.

And again, we do do these calculations. But to some extent they are predicated on the input that one puts into them. But again they are now calculated in a self-consistent manner in terms of, you would get a specific distribution coming from the ex-vessel release, which would be different from that calculated from the in-vessel. The ex-vessel would recognize during core/concrete interactions, you are taking up a lot of aerosol as a result of the decomposition of the concrete, and so on.

So, there is an attempt to do that. How good that is, I am not sure that I'm qualified to --

MR. EBERSOLE: During the course of degradation of the core, as it heats up and approaches the melt state, or even partially melts, wouldn't there be a heavy dependency on whether then at that time you initiated cooling in a red-hot condition, an aspect to emission of fission products?

MR. PRATT: Yes.

MR. EBERSOLE: Then the particle size would be -- to me it would be incalculable. I don't know how you would go at it.

MR. PRATT: All of these calculations are performed basically in a steam-starved environment.

MR. EBERSOLE: In a quiescent, rather than violent?

MR. PRATT: Yes, sir. We are having a hard enough time analyzing that situation.

MR. EBERSOLE: What bugs me is the extreme academic nature of this, rather than practical realization of these numbers.

MR. PRATT: It was interesting. I sat through a couple of days with the ACRS last week. I wasn't giving presentations, the NRC Staff were. And one of the major areas that remain to be addressed in these codes -- something we are going on to next -- is the in-vessel natural circulation and the effect that that has on fission product release, because the CORSOR code which calculates the fission product release is strongly dependent upon the flow of gases past it, and we don't know that very well. At present we are in a steam-starved environment. It is one-directional flow.

Certainly it seems to be more important for PWRs in high pressure, where we do see the possibility for in-vessel circulation. It is less important here where we are in the depressurized situation most of the time.

MR. FOREMAN: I would like to interrupt at this point. The slide just previous to this we notice contains proprietary information. Further back in the presentation there are others that are marked "GE Proprietary." It is necessary to close the meeting.

MR. PRATT: I apologize.

MR. EBERSOLE: Is it closed to your satisfaction to people that you know?

MR. FOREMAN: Yes. It is just the transcript will have to be closed. I don't know that there is anything in the discussion that has taken place so far. But so far as the attachment is concerned --

MS. HANKINS: It is in the handout.

MR. EBERSOLE: Can you steer clear of this in your discussion?

MR. PRATT: Towards the end I did want to show some comparisons. But, you can read those comparisons and I can just go to the final Vugraph. So, I can avoid that.

MR. EBERSOLE: All right, let's do that. We will keep this presentation open, and insert the Vugraphs in the closed portion of the transcript.

MR. ETHERINGTON: A substance like iodine that has an appreciable vapor pressure, is there any subsequent release of iodine when the vapor phase becomes depleted?

MR. PRATT: When the vapor --

MR. ETHERINGTON: Well, we heard that the suppression pool is cooled by evaporation at some later stage. Isn't that going to strip the iodine out of the water?

MR. PRATT: Oh, yes. That, I guess, was one of the points which I was not sure was of concern to the ACRS in the item in terms of long-term -- we are assuming most of the cesium will be cesium hydoxide. If a lot of it is held up in the pool, the chemistry, depending upon the pH value could start to release iodine. That is a concern.

Oak Ridge, as I understand it, is looking at this in terms of experiments, and they have some correlations.

We were talking with them last week as to whether or not we should be taking them into account, and thought they were a little bit premature at this point. But, it is something that is of concern and that we should be aware of. If we continue to push the source terms low, then effects of this nature, which in the old days were considered to be secondary, may become more important.

But again, I think it is a long-term effect over a long period of time.

MR. ETHERINGTON: What are the elements of concern? Iodine? Cesium? Is there any bromine of importance?

MR. PRATT: Yes. Again depending upon some of the calculations that we have been doing now with core/concrete interaction model coming out of Sandia. Some of the more refractory fission products are now getting out in greater quantities. From an offsite health consequence, they can be very damaging. The lanthanite group, for example.

MR. EBERSOLE: I look at these tables and I see that they are identified by elemental identification. And yet, as we all must know in physical form they are combinational.

There are physical combinations which are not shown here.

MR. FRATT: Yes.

MR. EBERSOLE: And I doubt -- it will be a rare thing, isn't it, that I find these in elemental states, which is to influence the transport mechanism.

Why don't I see in these tables a reflection of whatever you thought the physical state was, not necessarily predominantly in that element, even.

MR. FRATT: Again, the whole code system is in kind of an interesting state. We have just gone through trying to standardize the treatment of the various species as the various codes handle them. Certain of the codes group them in certain ways in which they think are similar and will behave in a similar fashion.

A large number of the elements are tracked.

MR. EBERSOLE: As elements?

MR. FRATT: Yes.

MR. EBERSOLE: Irrespective of the physical state?

MR. FRATT: Well, if you are talking about them going through various transformations, that is not taken into account. In fact, one of the things that Hans Ludwig, who should be giving the presentation, has been wanting to hear, it doesn't stay in this form. It goes through transformations at later times. That is not in there at present. There is concerns that these various things will change during the time.

MR. MARK: Jesse, they are just listing the radioactive isotopes, which is a matter of concern. It is true they come in oxides, iodine combines with cesium and on and on. They try to take account of that in the aerosol treatments.

MR. PRATT: Right.

MR. EBERSOLE: Well, in these experiments they had, they measured the elmental presence anyway, irrespective of the physical form.

MR. MARK: Well, they try to get it in the physical form if it is relevant.

MR. EBERSOLE: Okay.

MR. PRATT: In fact, the unbending that we have of the number of species we have quoted, is larger than is normally done. It is larger than the number of groups in WASH 1400, for example. And that was done largely because the people who do the CRAC calculations felt that some of the more refractory fission products should be separated out, because in the CRAC code, if you handle these by groups they would take the releases in the original fraction, mass fraction of the constituents in the original core.

What we were predicting is that they were coming out in quite different ratios. So, we did unbend, for example, that technetium was broken out and so on, to give a better representation.

Okay. I have a number of Vugraphs.

(Slide)

These give the core/concrete interaction range, which again was basically based on calculations that we had coming from the core/concrete interaction studies that have been performed to that date.

When we did the initial sensitivity study, we did not have the VANESA code, which was used by Sandia in the BMI 2104 series of volumes. So, we had to base our releases on what data was available in the literature and as we obtained the code we found site differences in the release rates of various of the constituents.

I don't know how much detail you want to go into in terms of the rest of these Vugraphs. I know we have a half hour presentation, and I am taking a rather long time.

(Slide)

This gives you an idea of the range that we had in the sensitivity study. And again, we were looking at release fractions. And this, to a large extent, is based on judgment.

We had some calculations, but again we were trying to give some idea as to how much of the fission product would be retained in the primary system based on the calculations we had.

The only other study, which again was not available when we did this, was the QUEST study performed under NRC Research, and they assumed much wider ranges of these variables than we did, and consequently came up with a higher range of uncertainty in our estimates. But, this gives you a feeling as to the ranges that we calculated.

The one that you had expressed interest in was, I guess, the suppression pool decontamination factor. I guess I am not sure whether these numbers are proprietary. Are they, Debbie?

MS. HANKINS: Not the 10,600.

MR. PRATT: Okay. But you can see a very significant difference here in the calculations.

Again, the number 6 here really refers to a specific calculation for a specific particle size at a specific time. It is a little bit extreme to apply that across the board to the whole process. And you will see when we do our mechanistic calculation, which hopefully comes somewhere between the two here, how this number would vary as a function of time.

(Slide)

Let me move on rapidly to some of the comparisons. Let me put this one up just to show what a miserable job it is running these codes. This is something we generate. Research tends to make life a lot simpler than this.

But, you can imagine that there is a tremendous amount of interfacing to run these codes in a system. The MARCH computer code consists of various subroutines, which in turn feed about eight separate computer codes. So, there is a tremendous amount of data transfer between codes.

We get core heatup histories feeding CORSOR code, which gives you fission product release.

Fission product release then goes to TRAPMELT, to calculate primary system retention.

In order to know what the primary system retention is, we need to know the thermal hydraulic conditions calculated in a separate code called MERGE. And so on.

This would deal with the primary system retention, and this is where you get the fission product species and the distribution as a function of time from this code, which then feeds SPARC, if, indeed, the fission products in the primary system go into a suppression pool to calculate the pool DFs.

If, however, there is a bypass, it would go directly to the NAUA code to give you aerosol agglomeration settling int he containment building.

And again, if you go to the ex-vessel stage, CORCON was used to drive the gas flow to give you the fission product release from core/concrete interactions, which then fed the NAUA code or could feed the SPARC code, depending upon the accident sequence.

Again, there were certain inconsistencies in the original code because in the original MARCH calculations we had the intersubroutine modeling core/concrete interactions, which fed the thermal hydraulics in the containment building, which was then matched together with the aerosol and the agglomeration code NAUA.

And there was an inconsistency, because we were feeding aerosols to the containment building via this route, and we were feeding thermal hydraulic conditions by that route, and the core/concrete interaction predicted in these two models were quite different.

So, again, we have changed those and upgraded them, and are trying to make this now an integrated code package which can be used for future calculations.

So, I will skip over the next Vugraph, which contains the proprietary information. You can look at that, and it will show you basically the range of the BNL high and the BNL low, based on the sensitivity study, and compares that against three calculations.

One calculation taken from BMI 2104 for Grand Gulf Volume 33. Another one Grand Gulf IDCOR analysis. Another one, a GE analysis. You can see the GE analysis tends to tend toward the BNL low estimate, whereas BMI 204 calculations using the suite of codes I have just described, tends towards the BNL high.

MR. MARK: What is listed in this paper you are not showing? Is that the fraction of the material that leaves the primary system that gets into the containment?

MR. PRATT: That gets from there to the environment.

MR. MARX: To the environment, not the containment?

MR. PRATT: That's right.

(Slide)

This one is not proprietary, and this shows the calculations. Again in the handout, we have lots and lots of calculations, and you can look at some of those.

The aim was to compare the mechanistic calculation against the sensitivity study that we performed, as I say, about a year ago, to give us an idea as to where we were in the calculation.

I think it is interesting to note that we are now calculating, for example, a much lower release of the technetium than we would have done based on our old calculations. And this was largely based on some very preliminary results that we had from CORCON and VANESA at that time, which tended to overpredict this particular specie.

So, this is one area where we feel the BNL low was somewhat higher for one particular species.

Again, in terms of the differences between our calculation and GE on pool scrubbing.

(Slide)

This again was a Vugraph that was presented by NRC

Research last week to the Class 9 Subcommittee by Jocelyn Mitchell, and shows the sensitivity of decontamination by the two-particle diameter. One can see in this range it is relatively low.

This is for a particular sequence in which, judging by the flow rates, there is core/concrete interaction going on. We are talking about 457 centimeter depth of the entrance -- so this gives you some feeling as to what you would get out of the code.

(Slide)

I have also put in here a Vugraph which shows the variation of decontamination factor as a function of time through the accident sequence that would correspond to one of our mechanistic calculations. And there you can see that early on, for example, we have a relatively high decontamination factgor, when we are dealing with a relatively large flow rate of water, at the time, steam.

Later on, as we get a higher fraction of hydrogen, the contamination factor goes down.

And then later on, still, when we are dealing with core-concrete interactions, we have a lower submergence, we also get a lower decontamination factor.

So, you asked questions about the effect of temperature. I really haven't separated those out. But it is also strongly a function of the amount of fraction of noncondensables in the gas flow going in as well as the particle size distribution.

I think that is really all I have to say.

MR. EBERSOLE: The main thrust of this discussion is to uncover substantial disagreements between GE and the Staff and its consultants. Are there any comments from GE on this presentation?

Do you take issue with anything?

MS. HANKINS: Yes. But I think it would be easier -- I have got about four charts in my presentation. It might be easier just to cover them now.

MR. EBERSOLE: All right.

MR. FOREMAN: Since that first slide in her presentation contains proprietary information, and since the next topic is security, we probably ought to just close the rest of the meeting.

MR. EBERSOLE: That's true. We can close the rest.

(Whereupon, the open session portion of the meeting was adjourned. The closed portion follows in a separate transcript.)

CERTIFICATE OF OFFICIAL REPORTER

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of: ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Name of Proceeding: Subcommittee Meeting on GESSAR II (Public Session)

Docket No.:

Place: Washington, D. C.

Date: Wednesday, August 7, 1985

were held as herein appears and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission.

(Signature) Mimie Meltzer

(Typed Name of Reporter) Mimie Meltzer

Ann Riley & Associates, Ltd.

HYDROGEN ISSUES

- o RATE AND AMOUNT
  - GENERATION RATES VARY FROM 0.4 TO 1.6 LB_M/SEC
  - 1300-2300 LB_M TOTAL IN-VESSEL HYDROGEN
  - ONLY ENOUGH OXYGEN TO SUPPORT COMBUSTION OF 2480 LB_M HYDROGEN (~67 PERCENT OF ACTIVE CLAD MWR)

- o HYDROGEN DETONATIONS
  - INSIGNIFICANT RISK REDUCTION FOR ADDITIONAL HYDROGEN CONTROL (BASED ON PRA RESULTS WITH DETONATIONS)
    - CURRENT UNDERSTANDING--LOW LIKELIHOOD OF DETONATIONS IN MARK III
    - RISK EVEN LOWER THAN ORIGINAL PRA RESULTS
  - SER SHOWS NO RISK REDUCTION FOR HYDROGEN CONTROL FOR INTERNAL EVENTS, FACTOR OF 2 FOR SEISMIC RISK (BASED ON DRYWELL FAILURE BY LOCAL DETONATIONS, GE ANALYSES DISAGREE)

- o GE COMMITMENT: PROVIDE A HYDROGEN CONTROL SYSTEM CONSISTENT WITH OUTCOME OF HCOG PROGRAM AND NRC REVIEW
  - NRC REQUIRING DIVERSE POWER SUPPLY FOR IGNITERS (BEYOND HCOG POSITION OF POWER FROM EDG)
  - GE FINDS NO TECHNICAL JUSTIFICATION FOR DIVERSE POWER SOURCE

- o GE POSITION:
  - HYDROGEN CONTROL UNNECESSARY--ABSOLUTE RISK ALREADY LOW
  - NO JUSTIFICATION FOR IGNITER SYSTEM ON COST-BENEFIT BASIS

EFFECT OF STANDING FLAMES ON SEALS

- ISSUE: CAN STANDING FLAMES FROM HYDROGEN DEGRADE DRYWELL SEALS LEADING TO POOL BYPASS?

- ASSESSMENT:

  - DRYWELL EQUIPMENT HATCH HAS A 5 FOOT CONCRETE SHIELD PLUG

  - PERSONNEL AIRLOCKS ARE DOUBLE SUBMARINE DOORS WITH CEMENT SHIELD PLUG ON WETWELL SIDE

  - ELECTRICAL PENETRATIONS ARE 5 FOOT LONG AND POTTED WITH A PORTLAND CEMENT MIXTURE

- CONCLUSION:

  NO EFFECT OF STANDING FLAMES ON DRYWELL SEALS

DAH

ABLATION OF RPV PEDESTAL

- o PEDESTAL IS A STEEL-CONCRETE COMPOSITE CONSTRUCTION
  - TWO CONCENTRIC STEEL SHELLS
  - CONNECTED WITH STEEL SHEAR TIES
  - CONCRETE FILLED BETWEEN THE SHELLS

- o EVALUATED SUPPORT CAPABILITY AFTER ABLATION
  - ASSUME LOSS OF 1.4M OF CONCRETE
  - ASSUME ONLY SUPPORT IS OUTER STEEL SHELL
  - ASSUME OUTER SHELL TEMPERATURE IS 1100°F

- o RESULTS
  - LOADS ON OUTER SHELL

WEIGHT OF RPV	2300 KIPS
WEIGHT OF SHIELD WALL + EQPT	2700 KIPS
WEIGHT OF PEDESTAL	1100 KIPS
TOTAL	6100 KIPS

  - COMPRESSION IN STEEL SHELL = 3.4 KSI
  - YIELD STRENGTH OF STEEL AT 1100°F = 21 KSI

- o CONCLUSIONS
  - PEDESTAL WILL CARRY LOADS - SUBSTANTIAL MARGIN
  - NO LOSS OF PEDESTAL, DRYWELL OR CONTAINMENT STRUCTURAL INTEGRITY

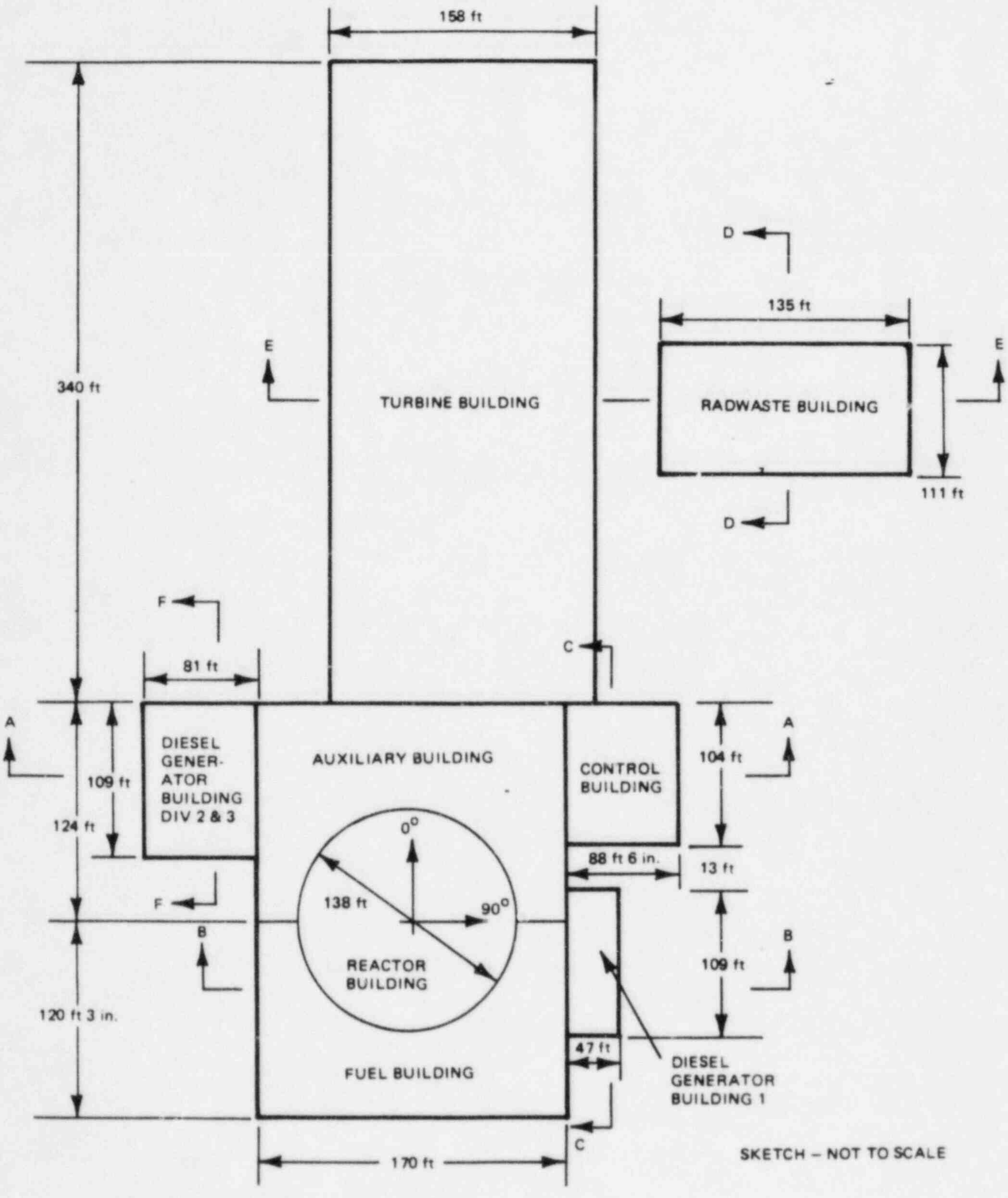

Figure 3A-8. Plan View of Nuclear Island and Turbine Building Arrangement

SLIDING STABILITY

BUILDING	GESSAR II CALCULATED S.F	SRP ACCEPTANCE CRITERIA
AUXILIARY BUILDING	1.02	1.1
CONTROL BUILDING	1.04	1.1

$$\text{SLIDING S.F.} = \frac{\text{RESISTING FORCE}}{\text{(BUILDING SEISMIC SHEAR FORCE SSE)}}$$

RESISTING FORCE = COEFF. OF FRICTION X (DEAD LOAD - VERTICAL SEISMIC LOAD)

AUXILIARY BUILDING SLIDING STABILITY ANALYSIS

	SOIL CASE 2	SOIL CASE 3	SOIL CASE 9	SOIL CASE 7
MAXIMUM BASE SHEAR	13,130	15,710	22,440	11,030

SOIL CASE 2 75-FT SOIL WITH AVERAGE PROPERTIES

3 75-FT SOIL WITH UPPERBOUND PROPERTIES

9 150-FT SOIL WITH UPPERBOUND PROPERTIES

7 FIXED BASE CASE

INTERFACE CONDITION

APPLICANTS REFERENCING GESSAR II DEMONSTRATE ADEQUATE FACTORS OF SAFETY (SRP ACCEPTANCE CRITERIA - 1.5 FOR OBE, 1.1 FOR SSE) AGAINST SLIDING FOR THE AUXILIARY AND CONTROL BUILDINGS FOR THEIR SPECIFIC SITE CONDTIONS.

GESSAR II

SEISMIC PIPING DESIGN

DIVISIONAL RESPONSIBILITIES

--- NSSS

- o GE ANALYSIS
- o REACTOR COOLANT SYSTEM
  (MS INSIDE CONTAINMENT)
  (REACTOR RECIRCULATION)

--- BALANCE - OF - PLANT

- o C. F. BRAUN ANALYSES
- o ALL OTHER PIPING SYSTEMS

PIPING ANALYTICAL TECHNIQUES

--- DYNAMIC METHODS

o NSSS

AMPLIFIED RESPONSE SPECTRA

TIME HISTORY ANALYSIS

o BOP

AMPLIFIED RESPONSE SPECTRA

TIME-HISTORY ANALYSIS

STATIC

--- ALL PIPING ANALYSES ARE BASED ON LINEAR ELASTIC METHODS.

--- R.G. 1.92 MODAL RESPONSE COMBINATION

--- R.G. 1.61 DAMPING VALUES FOR SEISMIC DESIGN OF NUCLEAR POWER PLANT

--- SEISMIC ANCHOR MOVEMENT (SAM)

SECONDARY STRESS IN PIPING DESIGN

NRR STAFF PRESENTATION TO THE
ACRS

SUBJECT: CONSIDERATION OF POTENTIAL DESIGN IMPROVEMENTS FOR GESSAR II SEVERE ACCIDENT DESIGN

DATE: AUGUST 7, 1985

PRESENTER: W. BRAD HARDIN

PRESENTER'S TITLE/BRANCH/DIV: REACTOR SYSTEMS BR. DIVISION OF SYSTEMS INTEGRATION

PRESENTER'S NRC TEL. NO.: 492-8507

SUBCOMMITTEE: ACRS GESSAR II

Table 15.5 GESSAR II potential design improvements, ranked by cost-benefit ratio (C/B)

Rank	Design modification	C/B	Note
1	Increased battery capability for 10 hour blackout (3.10a)	< 10	1
2	Ultimate plant protection system (UPPS) (App. A)	< 10	-
3	Improved or additional low-pressure system (3.2e)	< 10	2
4	AC bus crossties (3.9c)	< 10	2
5	Improved maintenance procedures/manuals (3.1c)	< 10	-
6	Computer aided instrumentation (3.1b)	< 10	-
7	Alternate pump power source (3.8j)	< 10	2
8	Batteries for dc pump power (3.10c)	< 10	-
9	Increased battery capability for 16-hour blackout (3.10.1)	< 10	-
10	Simulator training for severe accidents (3.1.h)	< 10	-
11	Improved high-pressure system (3.2.a)	< 20	-
12	DC bus crossties (3.10.d)	< 20	2
13	Additional active high-pressure system (3.2.b)	< 50	-
14	Uninterruptible power supplies (3.9b)	< 50	2
15	Fuel cells for diverse dc pump power (3.10.c)	< 50	2
16	Additional diesel generator (3.9.a.1)	< 50	2
17	Gas turbine (3.9.d)	< 50	2
18	Passive high-pressure system (3.2c)	< 50	-
19	Steam-driven turbine generator (3.9.f)	< 50	2
20	Increased electrical divisions/diesels (3.9.2)	<100	2
21	Increased design margins (3.12b)	<100	-
22	Jockey pump system (3.2.g.1)	<100	2
23	Reduction of common-cause dependencies (3.8c)	<150	2
24	Passive ultimate heat sink (3.4b)	<150	2
25	Improved operating response (3.8b)	<150	-

Notes:

(1) The number/letter in parentheses is the NEDE-30640 section in which the item is discussed.

(2) Included in UPPS, according to GE.

Figure 2 - Monetized Risk Potential for Further Risk Reduction In GESSAR-II for Internally Generated Severe Accidents

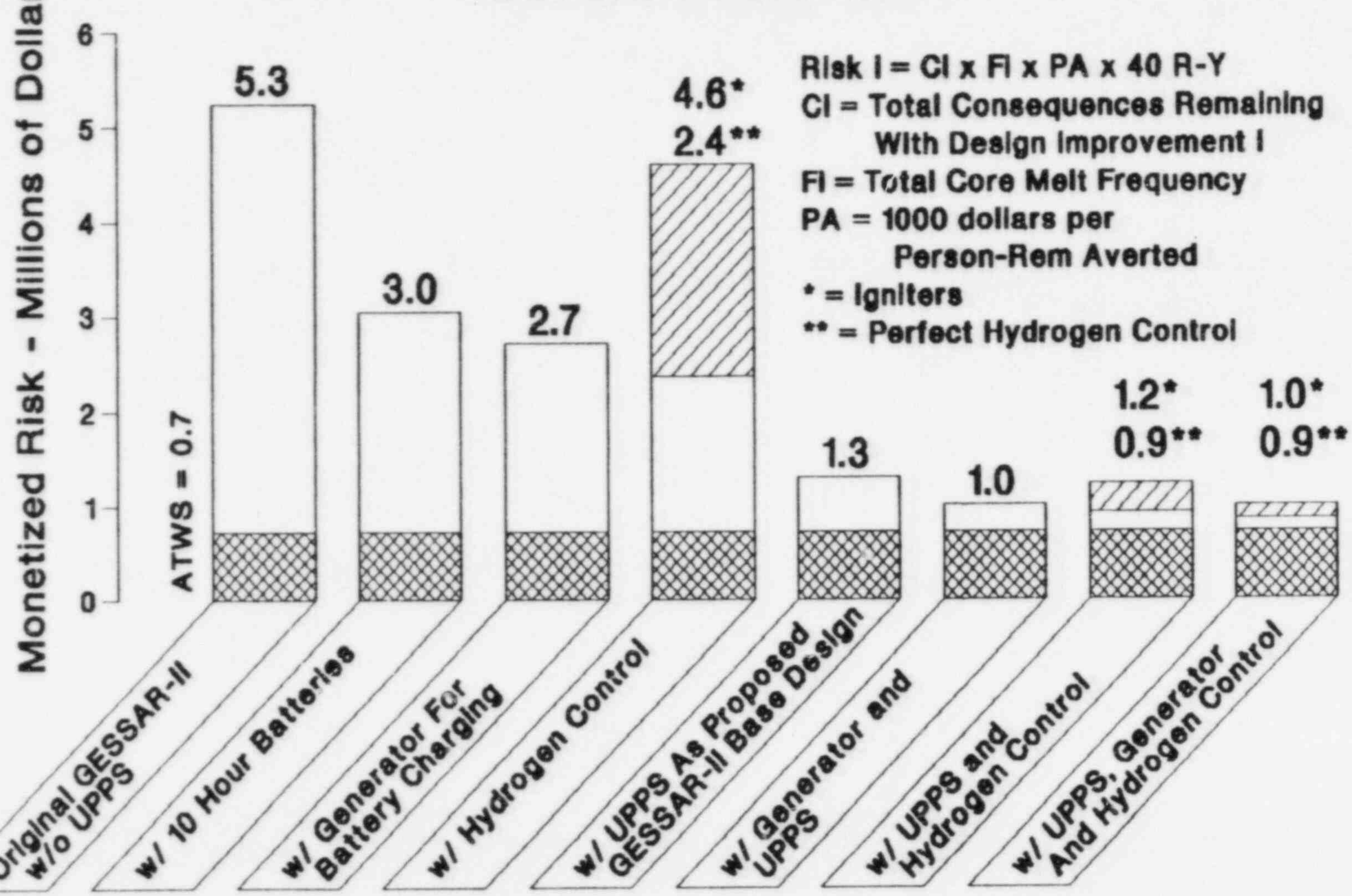

Figure 3 - Monetized Risk Potential for Further Risk Reduction In GESSAR-II for Externally Generated Events (Seismic)

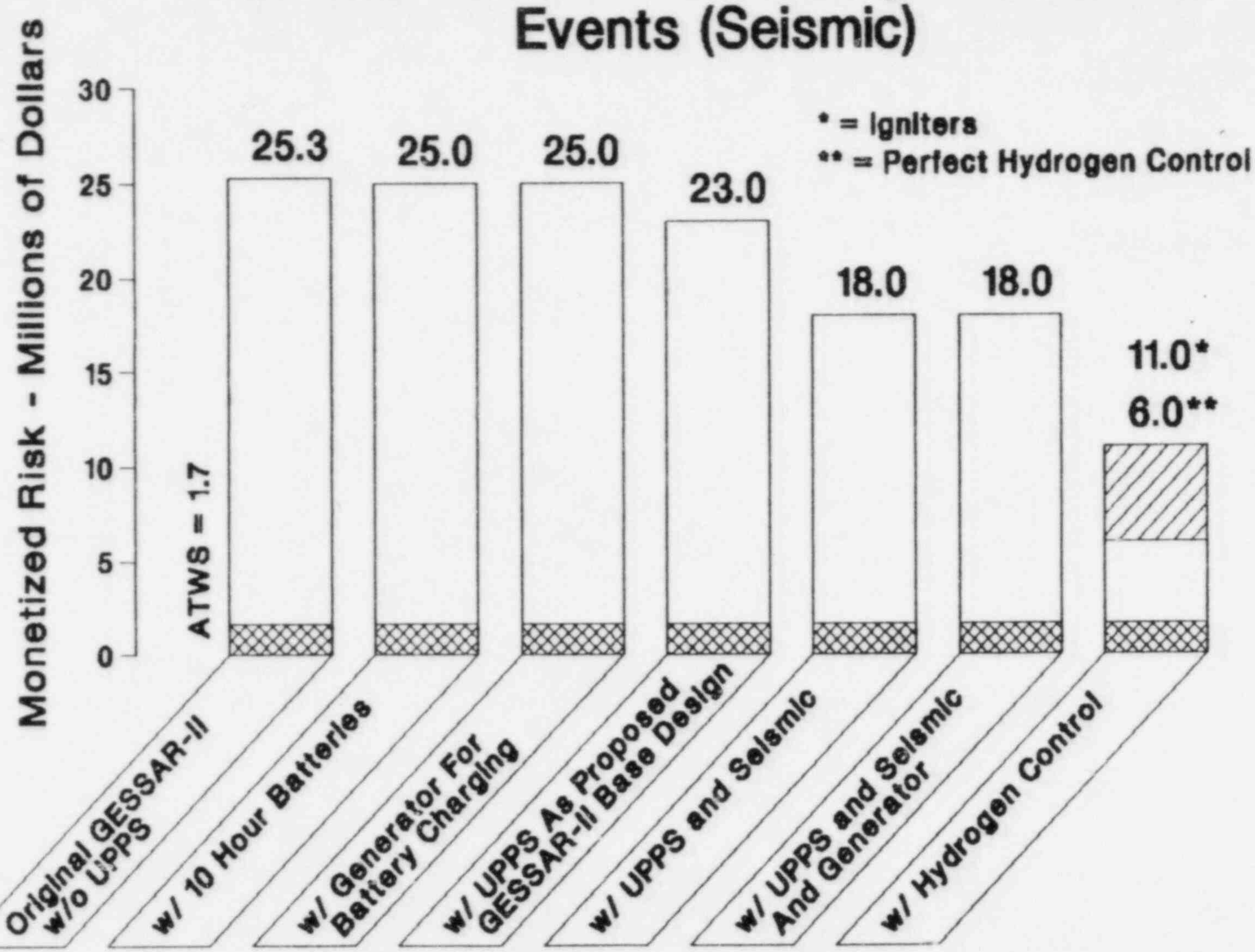

Table 15.6 RDA study results for GESSAR II, Mark III containment mitigation

COST ($ thousands)

Function	Equipment	High-pressure containment (Mark III) Option 1	Option 2	Option 3	Low-pressure containment w/chill. filt.
Heat removal					
Pool	Dedicated cooling	2,085	2,085	2,085	2,085
Spray	Drywell sprays plus external feed	565	565	565	--
Core control	Basemat rubble bed	--	744	744	--
	Dry crucible	2,295	--	--	2,295
Pressure protection					
Overpressure	Igniters	--	--	300	300
	ATWS clean vent	1,579	1,579	1,579	--
	Filtered vent	1,950	1,950	--	--
	Nitrogen inerting	1,557	1,557	--	--
Underpressure	Larger breaker	865	865	865	--
Both	Chilled filter	--	--	--	2,938
Total costs (impact)		10,896	9,345	6,138	7,618
VALUE (or BENEFIT) (person-rems averted)					
Estimator					
GE		11	11	11	11
NRC		5,240	5,240	5,240	5,240
COST/BENEFIT ($/person-rem)					
Estimator					
GE		9.9E5*	8.5E5	1.6E4	6.9E5
NRC		2,060	1,780	1,170	1,450

*9.9E5 = 9.9×10^5.

NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: GESSAR II

DATE: AUGUST 7, 1985

PRESENTER: MARK RUBIN

PRESENTER'S TITLE/BRANCH/DIV: RISK ANALYST

RELIABILITY AND RISK ASSESSMENT BRANCH

DIVISION OF SAFETY TECHNOLOGY

PRESENTER'S NRC TEL. NO.: 492-8315

SUBCOMMITTEE: GESSAR/PRA

Table 15.7 Designs and design modifications evaluated

Design/modification	Impact considered
Base Case	This represents the plant design as presented in the GESSAR II PRA. Modified core-melt values, given in the SER, are taken from the BNL PRA review for the national average grid site. Consequences reported have been predicted using the staff/BNL upper range source term values. The values used are believed to be physically realizable and should not be construed as being upper bounds.
Case 1: GE-proposed UPPS	These values reflect the impact of UPPS proposed by GE. This represents the actual new base case.
Case 2: UPPS with seismic upgrade	Impact of UPPS with seismic upgrade equivalent to component and structure capacity values expected from seismic Category I systems.
Case 3: 10-hour battery capacity	Impact of the base GESSAR II design with the addition of 10-hour station batteries.
Case 4: DC charger	Impact of the base GESSAR II design with the addition of a dedicated dc battery charger driven by a diverse small generator.
Case 5: UPPS and charger	Impact of UPPS combined with dc charger/generator.
Case 6: Perfect hydrogen control	Impact of base GESSAR II design with assumed perfect hydrogen control.
Case 7: Seismic UPPS and dc charger	Impact of combining seismic UPPS with dc charger.
Case 8: Seismic UPPS and perfect hydrogen control	Impact of combining seismic UPPS with perfect hydrogen control.
Case 9: UPPS and igniters	Impact of combining UPPS with hydrogen control from igniters having a dedicated power supply.
Case 10: Seismic UPPS and igniters	Impact of combining seismic UPPS with hydrogen control from igniters having a dedicated power supply.

Table 15.8 Estimated frequency of core damage resulting from internal events for GESSAR II base case and with design modifications

Class*	Base case (nat'l avg.) loop	UPPS	UPPS and some seismic upgrade	10-hour battery capacity	DC charger generator	Unlimited dc power and UPPS
CT1-T	1.1(-6)**	9.0(-7)	9.0(-7)	1.1(-6)	1.1(-6)	9.0(-7)
CT1-Pa	1.1(-5)	1.3(-6)	1.3(-6)	4.4(-6)	3.4(-6)	4.4(-7)
CT1-Pb	1.9(-5)	2.28(-6)	2.28(-6)	7.6(-6)	5.76(-6)	7.6(-7)
CT2-T	3.8(-6)	3.8(-7)	3.8(-7)	3.8(-6)	3.8(-6)	3.8(-7)
CT3	1.3(-7)	1.3(-7)	1.3(-7)	1.3(-7)	1.3(-7)	1.3(-7)
CT4	3.2(-6)	3.1(-6)	3.1(-6)	3.1(-6)	3.1(-6)	3.1(-6)
CT2A	1.2(-7)	1.2(-7)	1.2(-7)	1.2(-7)	1.2(-7)	1.2(-7)
CT1L	3.0(-9)	3.0(-9)	3.0(-9)	3.0(-9)	3.0(-9)	3.0(-9)
CT2L	1.4(-8)	1.4(-8)	1.4(-8)	2.4(-8)	2.4(-8)	1.4(-8)
CT5	2.3(-11)	2.3(-11)	2.3(-11)	2.3(-11)	2.3(-11)	2.3(-11)
CT6	1.2(-9)	1.2(-9)	1.2(-9)	1.2(-9)	1.2(-9)	1.2(-9)
CT7	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.8(-5)	8.2(-6)	8.2(-6)	2.0(-5)	2.7(-5)	5.7(-6)

*See Table 15.14 for description of the containment failure classes.
**1.1(-6) = 1.1×10^{-6}.

Table 15.9 Public risk from internal events (person-rems per unit per year) for GESSAR II base case and with design modifications

Release*	GESSAR w/o UPSS	Perfect H_2 control	Base case with UPPS	UPPS and perfect hydrogen control	10-hour battery capacity	DC charger generator	UPPS and igniters	Unlimited generator and UPPS	Unlimited generator and UPPS and perfect hydrogen control	Unlimited generator and UPPS igniters
1-T-E2	3	-	0.5	-	1	1	-	0.3	-	-
1-T-E2Q	1	-	0.2	-	0.4	0.3	-	0.1	-	-
1-T-E3	23	-	4	-	10	8	9	2	-	4
1-T-I2	22	-	3	-	9	7	-	1	-	-
1-T-I2Q	31	-	4	-	12	10	-	1	-	-
1-T-I3	12	-	2	-	5	4	2	0.5	-	0.5
1-T-L2	-	-	-	-	-	-	-	-	-	-
1-T-L3	2	22	0.6	3	1	1	0.6	0.5	2	0.5
1-SB-E1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
II-T-B3	20	20	2	2	20	20	2	2	2	2
ATWS	18	18	18	18	18	18	18	18	18	18
Total	131	59	33	23	76	68	31	25	22	25

*See Table 15.15 for a description of the release categories.

Table 15.10 Estimated frequency of release categories resulting from seismic events for GESSAR II base case and with design modifications

Release category*	Base case	Base case and perfect hydrogen control	UPPS	UPPS and seismic upgrade	10-hour battery capacity	DC charger generator	UPPS and generator and seismic upgrade	UPPS and seismic upgrade and perfect hydrogen control
1-SB-E1	1.2(-6)**	-	1.2(-6)	1.2(-6)	Same as base case		Same as UPPS and Seismic	-
1-T-L3	3.5(-7)	5.8(-5)	3.2(-7)	1.9(-7)	"	"	"	3.8(-5)
1-S2(max)	6.9(-8)	6.9(-8)	6.9(-8)	6.9(-8)	"	"	"	6.9(-8)
ATWS	5.9(-6)	5.9(-6)	5.9(-6)	5.9(-6)	"	"	"	5.9(-6)
1-T-I2	5.6(-5)	-	4.9(-5)	3.6(-5)	"	"	"	2.3(-7)
V-event	2.3(-7)	2.3(-7)	2.3(-7)	2.3(-7)	"	"	"	2.2(-6)
RHR pipe break	2.9(-6)	2.9(-6)	2.7(-6)	2.1(-6)	"	"	"	1.4(-7)
Massive failure	1.4(-7)	1.4(-7)	1.4(-7)	1.4(-7)	"	"	"	
TOTAL	6.7(-5)	6.7(-5)	5.9(-5)	4.6(-5)	6.7(-5)	6.7(-5)	4.6(-5)	4.6(-5)

*See Table 15.15 for a descripton of the release categories.
**1.2(-6) = 1.2×10^{-6}.

Table 15.11 Seismic risk, person-rems per unit year

Release category†	Base case	Base case and perfect hydrogen control	UPPS	UPPS and igniters	UPPS and seismic upgrade	UPPS and perfect hydrogen control	10-hour battery capability	DC charger generator	UPPS and seismic upgrade and generators	UPPS and seismic upgrade and perfect hydrogen control	UPPS and seismic upgrade with igniter
I-SB-E1	13	--	13	--	13	--	Same as base case		Same as UPPS	--	--
I-T-L3	0.3	52	0.3	0.3	0.2	45	"	"	"	45	0.2
I-S2(max)	0.5	0.5	0.5	0.5	0.5	0.5	"	"	"	0.5	0.5
ATWS	43	43	43	43	43	43	"	"	"	43	43
I-T-I2	526	--	456	--	342		"	"	"	--	--
I-T-E3	--	--	--	170	--	--	"	"	"	--	130
V-event*	12	12	12	12	12	12	"	"	"	12	12
RHR pipe break**	31	31	30	30	24	30	"	"	"	24	24
Massive failure	7	7	7	7	7	7	"	"	"	7	7
Total	632	145	562	260	44	137	633	633	440	131	212

†See Table 15.15 for a description of the various release categories listed.
*Based on estimated person-rem values, from Limerick for Event V.
**RHR pipe break assumed to have person-rem impact equal to that of 1-SB-E1.

Table 15.12 Core-melt frequency probabilities (per year) for GESSAR II base case and with design modifications

Cause of core melt	Base case	UPPS	UPPS and seismic upgrade	UPPS and DC charger
Internal event	3.8(-5)*	8.2(-6)	8.2(-6)	5.7(-6)
Seismic event	6.7(-5)	5.9(-5)	4.6(-5)	4.6(-5)
Total	1.1(-4)	6.7(-5)**	5.4(-5)	5.2(-5)

*3.8(-5) = 3.8 x 10^{-5}.
**Core-melt estimate includes large contribution from relay chatter. Resolution of this issue could reduce core-melt contribution to approximately 2 x 10^{-5}.

Table 15.13 Estimated accidental releases to the public (person-rems per year) for GESSAR II base case and with modifications

Risk	Base case	UPPS	UPPS seismic	UPPS and igniters	UPPS and perfect hydrogen control	UPPS and seismic upgrade and perfect hydrogen control	UPPS and seismic upgrade with igniters
Internal event risk	130	30	30	30	20	20	30
Seismic risk	630	560	440	260	140	130	210
Total	760	590	470	290	160	150	240

Table 15.14 Containment failure classes

Class	Event tree name	Description
I_L	CT1-L	Core damage initiated by a drywell LOCA
I_T	CT1-P	Core damage initiated by loss of ac power
I_T	CT1-T	Core damage initiated by transients other than loss of ac power
II_A	CT2-A	No containment heat removal and an earlier potential for loss of containment integrity compared to II_L and II_T
II_L	CT2-L	No containment heat removal following a LOCA
II_T	CT2-T	No containment heat removal following transient event
III	CT3	An ATWS event with boron injection but without core cooling
IV	CT4	An ATWS event with core cooling but without boron injection
V	CT5**	Core damage caused by containment or ex-containment LOCAs
VI	CT6**	A loss of containment integrity caused by a containment LOCA

*The frequency associated with this event is relatively small and does not justify an individual tree. These sequences were processed by other trees.

Source: Table C.16.3, GESSAR II PRA.

Table 15.15 Release categories

Release category	Description
1-T-L3	Class 1 core-melt transient (e.g., station blackout) with late containment failure as a result of overpressurization from gases generated during core-concrete interaction.
1-T-E3	Core-melt transient as above with early containment failure resulting from local or global hydrogen detonation. However, the drywell is assumed to remain intact and pool scrubbing is maintained.
1-T-I2Q	Core-melt transient. Station blackout with power restored after 1 hour. Global hydrogen detonation with drywell failure and potential pool bypass; however most fission products are assumed to be released before the vessel fails and so are retained in the pool. Also, core debris is assumed to be quenched.
1-T-I2	Same as 1-T-I2Q but without quench.
1-T-E2 1-T-E2Q 1-T-I3 1-T-L2	Variations of above core-melt transients where "E" represents early containment failure, "I" intermediate time, and "L" late. The "1", "2", and "3" refer to partial, intermediate, and continuous scrubbing as defined in Table 15.11 of SSER 2. "Q" refers to quenched ex-vessel core debris.
1-SB-E1	Small-break core-melt transient with early containment failure (drywell) from hydrogen detonation and bypass of suppression pool.
1-SB-E1Q	Same as above but with quench of ex-vessel core debris.
1-SB-E3	Same as above but drywell remains intact and there is no pool bypass.
1-SB-L1	Small-break core-melt transient with late overpressurization failure of containment and partial bypass of the pool.
1-SB-L3	Same as 1-SB-L1 but with no bypass.
II-T-B3	Class 2 core-melt transient with initial failure of containment heat removal causing overpressurization and failure of containment. Core melt and vessel failure follow the containment failure. No pool bypass.
ATWS	Anticipated transient without scram and core melt.
S_2E_m	Core-melt accident caused by a very severe earthquake. Early containment and drywell failure with suppression pool bypass. Analysis values were approximated using BMI-2104 information (Battelle, 1984).

GESSAR II SLIDING STABILITY

A PRESENTATION TO THE ACRS
SUBCOMMITTEE ON GESSAR II,
RELIABILITY AND PROBABILISTIC
ASSESSMENT AND SAFEGUARDS
AND SECURITY

WASHINGTON, D.C.

GENERAL ELECTRIC COMPANY

AUGUST 7, 1985

TABLE OF CONTENTS

FOUNDATIONS

SLIDING STABILITY

- o BACKGROUND

  - FSAR SHOWED AUXILIARY BUILDING HAD LOWEST FACTOR OF SAFETY AGAINST SLIDING.

  - BASIS OF ANALYSIS WERE CONSERVATIVE STATIC CALCULATIONS ENVELOPING SITE CONDITIONS

- o INVESTIGATIONS

  - TO SHOW HIGHER MARGINS, A DYNAMIC APPROACH WAS CONSIDERED IN SER 1. ANALYTICAL COSTS AND PLANT CANCELLATIONS INDICATED OTHER ALTERNATIVES.

  - STATIC ANALYSIS ALTERNATIVES INVESTIGATED DID NOT SIGNIFICANTLY INCREASE MARGINS

FOUNDATIONS

SLIDING STABILITY

- o STATUS

  - COMPARABLE DYNAMIC ANALYSIS IN THE PAST RESULTED IN REALISTICALLY LARGER MARGINS. ASCE MANUAL NO. 58 "STRUCTURAL ANALYSIS AND DESIGN OF NUCLEAR PLANT FACILITIES," PAGE 451, STATES THAT DISPLACEMENTS DUE TO SLIDING AND DISTORTION OF THESE MASSIVE STRUCTURES CAN BE NEGLECTED.

  - SITE UNIQUE ANALYSIS AGAINST SLIDING BY FUTURE APPLICANTS SHOULD DEMONSTRATE AMPLE COMPLIANCE WITH STAFF ACCEPTANCE CRITERIA.

- o INTERFACE SPECIFICATION

  - SEE SER 4, TABLE 1.2

FOUNDATIONS

SLIDING STABILITY

o CONSECUENCES OF SLIDING

- PREVIOUS TESTIMONY SHOWED THAT SIX INCH MOVEMENT CAN BE TOLERATED BY INTERCONNECTING STRAIGHT PIPING

- ACTUAL FOUNDATION SEPARATION IS THREE INCHES. EMBEDMENT OF STRUCTURE IS ABOUT FORTY FEET. BOTTOM OF FOUNDATIONS ARE AT DIFFERENT ELEVATIONS.

- TRANSLATION OCCURS WITH TORSION WHICH EFFECTIVELY LIMITS DISPLACEMENTS.

- CALCULATED SSE DISPLACEMENTS ARE SMALL. DIFFERENTIAL SETTLEMENTS USED IN DETERMINISTIC DESIGN ARE IN THE RANGE OF FIVE INCHES. ROTATIONS AT THE BOTTOM ARE SMALL.

PIPING

DESIGN BASIS (DETERMINISTIC)

- DESIGN IS DONE TO ASME SEC. III REQUIREMENTS
- FSAR SEC. 3.7 AND 3.9 DESCRIBE DESIGN DETAILS:

  LINEAR ELASTIC ANALYSIS.

  DYNAMIC ANALYSIS DONE FOR OBE AND RESULTS DOUBLED FOR SSE.

  ANALYSIS FOR BUILDING DISPLACEMENTS SHOWN IN FSAR SEC. 3.7.3.8.1.8.

CONCLUSIONS

- PIPING DOES NOT GENERALLY FAIL
- MAXIMUM EXPECTED DISPLACEMENT IS THREE INCHES NEGLECTING EMBEDMENT EFFECTS. CALCULATIONS FOR SIX INCHES INDICATE NO PIPING DISTRESS.

GESSAR-II PRA REVIEW

EFFECT OF A CORE MELT ON VESSEL SUPPORT INTEGRITY

PRESENTED BY

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PRESENTED TO THE ACRS

AUGUST 7, 1985

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

TOPICS

- ABLATION OF SUPPORT

- SIGNIFICANCE OF LOSS OF CONTAINMENT INTEGRITY FOLLOWING SUPPORT FAILURE

- EFFECT OF CONTAINMENT VENTING

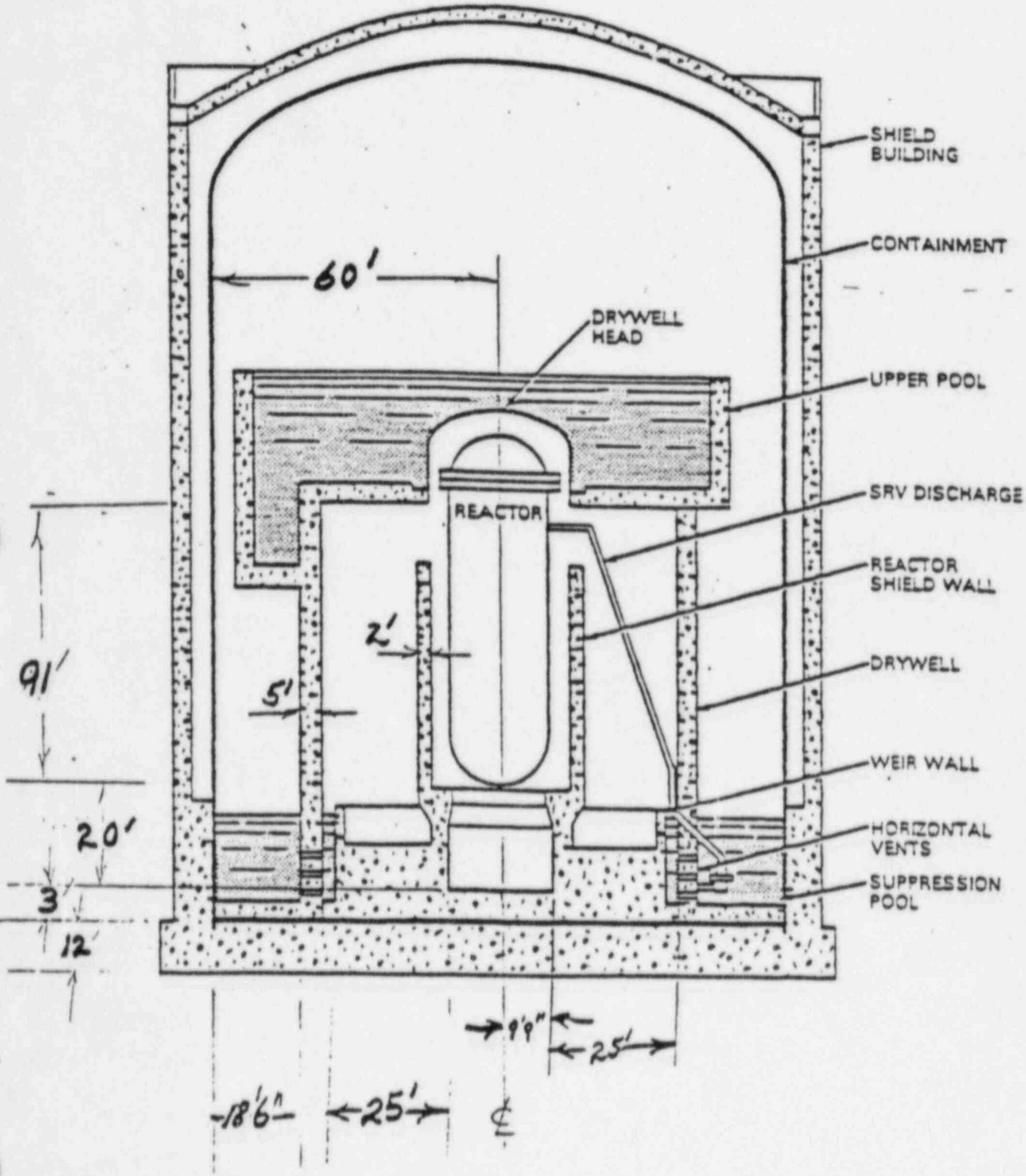
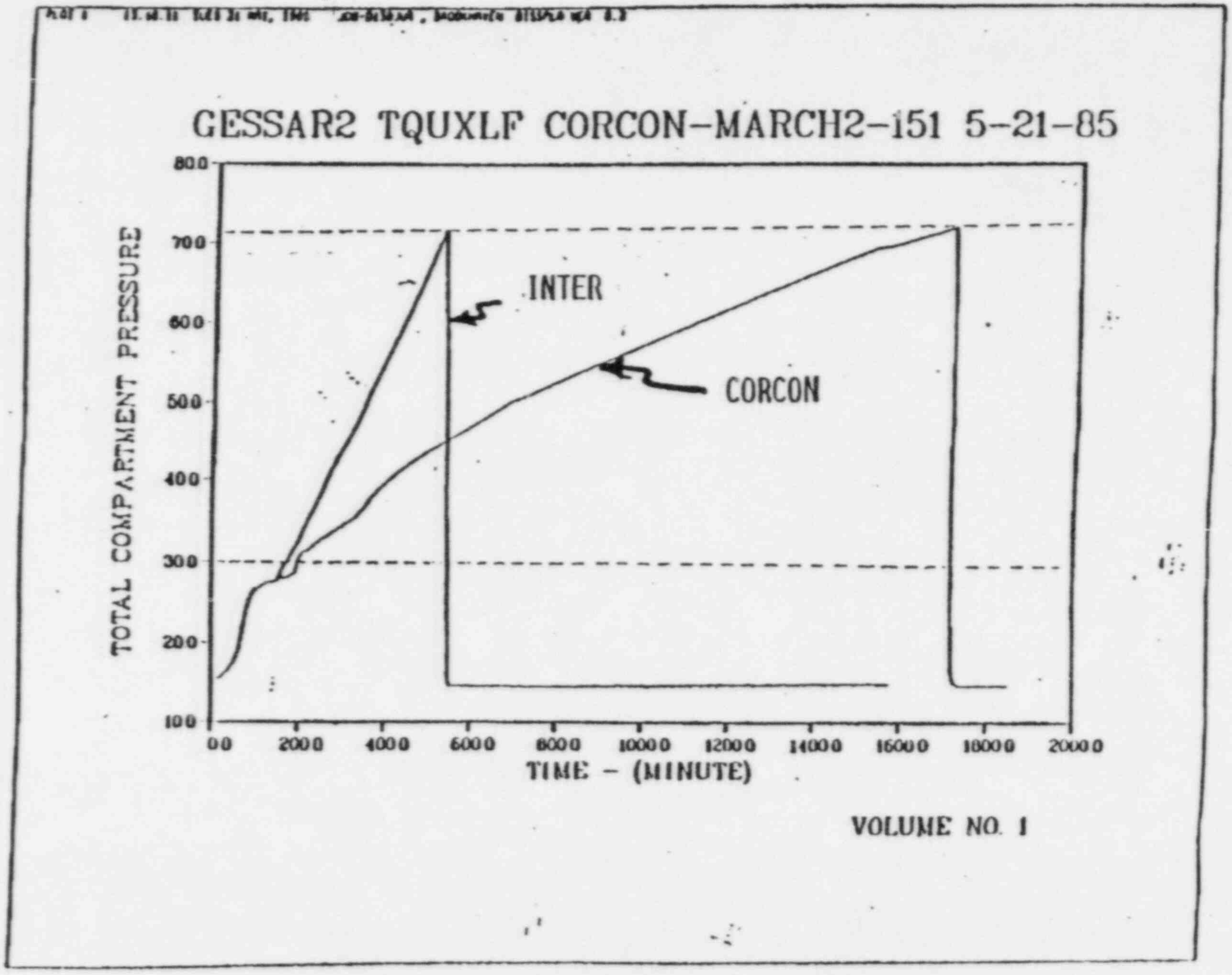
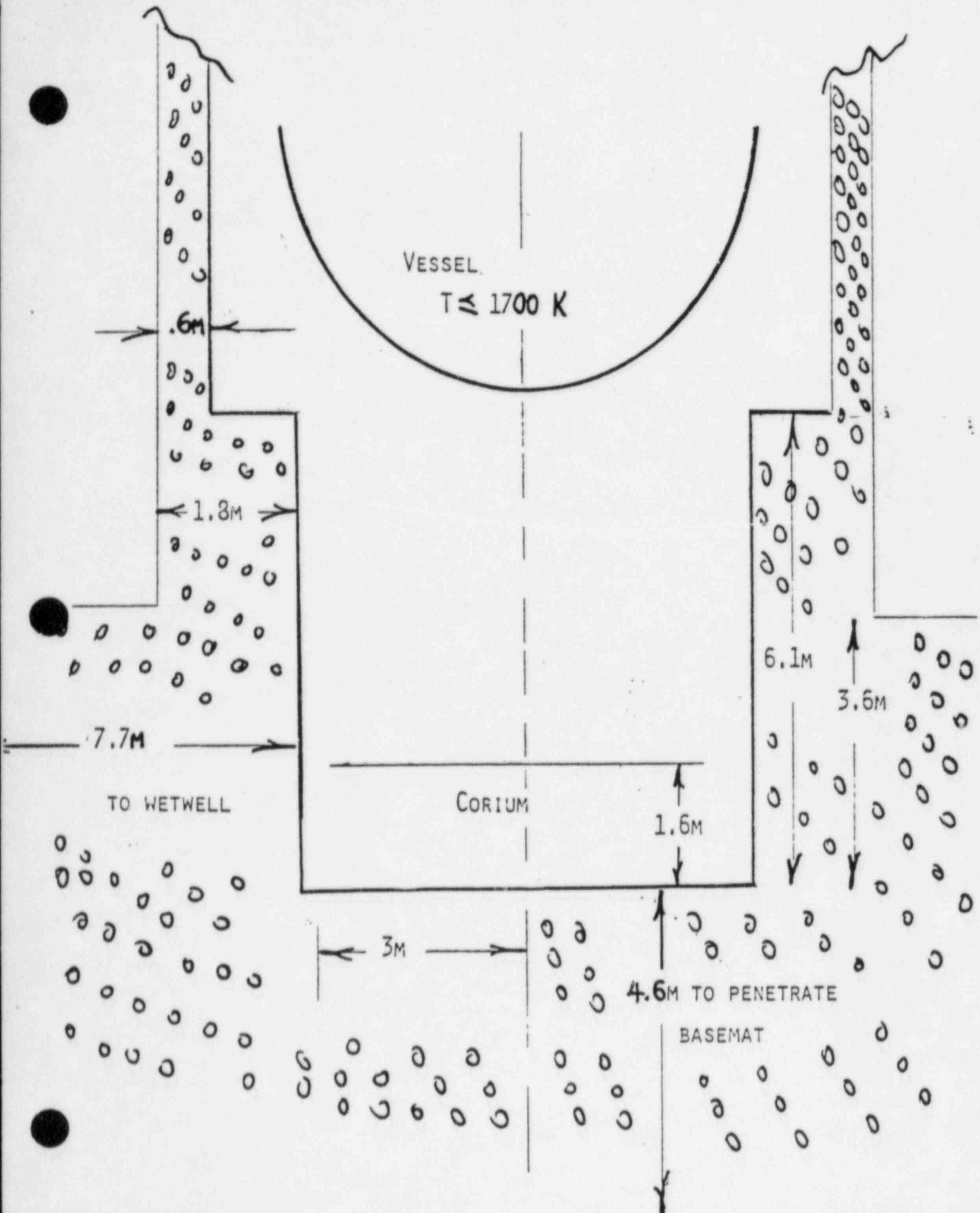


Figure 15.1 Principal features of MARK III containment



GESSAR2 TQUXLF CORCON-MARCH2-151 5-21-85
TOTAL COMPARTMENT PRESSURE
800
700
600
500
400
300
200
100
0.0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
TIME - (MINUTE)
INTER
CORCON
VOLUME NO. 1



VESSEL
T ≲ 1700 K
.6M
1.8M
7.7M
TO WETWELL
CORIUM
1.6M
6.1M
3.6M
3M
4.6M TO PENETRATE
BASEMAT

Ablation Rates

$$\dot{q} = \rho\left[C_p(\text{concrete})(T\ \text{ablation} - T\ \text{initial}) + \lambda\ \text{ablation}\right]\dot{x}$$

$\dot{q}$ = 10 - 20 W/CM^2 (LOWER CAVITY)

$\dot{q}$ = 12 - 3 W/CM^2 (SURROUNDING)

ρ = 2.5 GM/CM^3, C = 1 J/GM/K, λ = 240 J/GM

$\dot{x}$ = ABLATION RATE = 10-20 CM/HR (LOWER CAVITY)
INITIAL

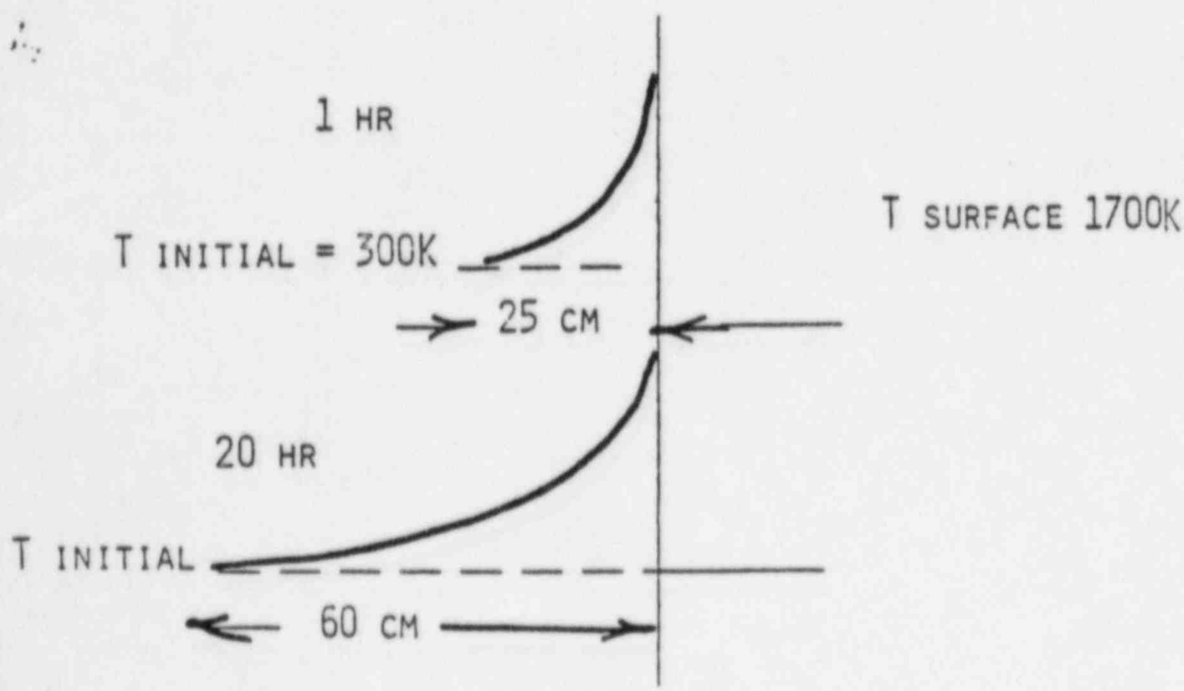
= 12-3 CM/HR (SURROUNDING)

x 10 HRS ≈ 120 CM AXIAL

≈ 140 CM RADIAL, PEDESTAL INTEGRITY DOUBTFUL

Thermal Gradient

$$\nabla^2 T = \alpha\, \partial T/\partial t$$



SIGNIFICANCE OF LOSS OF VESSEL SUPPORT

- MEASURE EFFECT RELATIVE TO RISK ESTIMATES IN TABLE 15.9 OF SUPPLEMENT 4 TO SER (NUREG-0979)

- EARLY LOSS OF CONTAINMENT INTEGRITY

  - LATE CONTAINMENT FAILURES (L2, L3) BECOME EARLY FAILURE (I2, I3)

- EARLY LOSS OF CONTAINMENT INTEGRITY PLUS LOSS OF DRYWELL INTEGRITY

  - COMPLETE POOL SCRUBBING SEQUENCES (E3, I3, L3, B3) BECOME PARTIAL POOL SCRUBBING SEQUENCES (E2, I2)

Table 15.1 Conditional consequences predicted by the staff for internally initiated events and probability of occurrence with and without UPPS, per reactor year

Release category*	Early fatality	Early injury	Latent fatality	Person-rems	Probability	
					w/o UPPS	w/UPPS
1-T-L3	0	0	40	7 x E5**	3 x E-6	9 x E-7
1-T-E3	0	0.0005	200	3 x E6	8 x E-6	1 x E-6
1-T-I2Q	0	3	200	3 x E6	1 x E-5	1 x E-6
2-T-B3	0	0	300	5 x E6	4 x E-6	4 x E-7
ATWS	0	1	400	6 x E6	3 x E-6	3 x E-6
1-T-I2	0	6	500	8 x E6	3 x E-6	3 x E-7
1-SB-E1	0.006	10	600	9 x E6	1 x E-9	1 x E-9

*See definitions in Table 15.15.
**7 x E5 = 7 x 10^5.

Notes:

(1) All conditional mean consequences were calculated using the upper range BNL source term values described in SSER 2.

(2) The calculations assumed the Shippingport site, with public evacuation within 10 miles and relocation 12 hours after plume passage.

(3) Mean consequences were computed over 91 different weather conditions.

Table 15.9 Public risk from internal events (person-rems per unit per year) for GESSAR II base case and with design modifications

Release*	GESSAR w/o UPSS	Perfect H_2 control	Base case with UPPS	UPPS and perfect hydrogen control	10-hour battery capacity	DC charger generator	UPPS and igniters	Unlimited generator and UPPS	Unlimited generator and UPPS and perfect hydrogen control	Unlimited generator and UPPS igniters
1-T-E2	3	-	0.5	-	1	1	-	0.3	-	-
1-T-E2Q	1	-	0.2	-	0.4	0.3	-	0.1	-	-
1-T-E3	23	-	4	-	10	8	9	2	-	4
1-T-I2	22	-	3	-	9	7	-	1	-	-
1-T-I2Q	31	-	4	-	12	10	-	1	-	-
1-T-I3	12	-	2	-	5	4	2	0.5	-	0.5
1-T-L2	-	-	-	-	-	-	-	-	-	-
1-T-L3	2	22	0.6	3	1	1	0.6	0.5	2	0.5
1-SB-E1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
II-T-B3	20	20	2	2	20	20	2	2	2	2
ATWS	18	18	18	18	18	18	18	18	18	18
Total	131	59	33	23	76	68	31	25	22	25

*See Table 15.15 for a description of the release categories.

SIGNIFICANCE OF LOSS OF VESSEL SUPPORT (CONT.)

- EARLY LOSS OF CONTAINMENT INTEGRITY:
  - GESSAR W/O UPPS: 131 PERSON-REM PER YEAR
  - WITH EARLY LOSS: 139 PERSON-REM PER YEAR

- EARLY LOSS OF CONTAINMENT INTEGRITY PLUS LOSS OF DRYWELL INTEGRITY:
  - GESSAR W/O UPPS: 131 PERSON-REM PER YEAR
  - WITH EARLY LOSS: 227 PERSON-REM PER YEAR

EFFECT OF CONTAINMENT VENTING

- "CLEAN" VENTING:
  - ATTEMPTS TO MITIGATE CLASS 2 AND ATWS SEQUENCES
  - MEASURE EFFECT RELATIVE TO RISK ESTIMATES IN SER
  - CLASS 2 SEQUENCES SIGNIFICANTLY REDUCED BY UPPS
  - ABILITY TO MITIGATE ATWS BY VENTING UNCERTAIN
- VENTING AFTER CORE DAMAGE:
  - MINIMAL IMPACT ON EARLY H_2 PHENOMENA
  - HENCE H_2 CONTROL NEEDED EVEN WITH VENTING

ULTIMATE PLANT PROTECTION SYSTEM

SYSTEM DESCRIPTION	PROVIDES FIRE PUMP INJECTION, RPV DEPRESSURIZATION AND CONTAINMENT VENTING CAPABILITY INDEPENDENT OF AC OR DC POWER
CHANGE FROM NEDE 30640 BASIS	SER 4 REQUIRES SEISMIC PROVISIONS TO PROTECT UPPS INJECTION CAPABILITY (NOT FULL SEISMIC CATEGORY 1)

UPPS RISK REDUCTION (MAN REM/YR)	INTERNAL	SEISMIC	TOTAL
WITHOUT IGNITERS			
BNL (W/O SEISMIC)	100	70	170
BNL (W/ SEISMIC)	100	190	290
WITH IGNITERS			
BNL (W/O SEISMIC)	100	65	165
BNL (W/ SEISMIC)	100	115	215
GE (W/O SIESMIC)	1	.015	1
GE (W/SEISMIC)	1	.02	1

COMMENTS:
- SEISMIC RISK IS 5% OF TOTAL RISK
- SEISMIC PROVISIONS INCREASE COST APPROX. 2 TIMES
- TOTAL RISK REDUCTION IS VERY SMALL
- NEVERTHELESS SEISMIC PROVISIONS WILL BE INCORPORATED

HYDROGEN IGNITER SYSTEM

SYSTEM DESCRIPTION — IGNITER SYSTEM BASED ON HCOG RESOLUTION OF HYDROGEN CONTROL ISSUES

CHANGE FROM NEDE 30640 BASIS — SER 4 REQUIRES DEDICATED POWER SUPPLY FOR IGNITERS WITH SEISMIC PROVISIONS

HYDROGEN CONTROL RISK REDUCTION (MAN REM/YR)	INTFRNAL	SEISMIC	TOTAL
BNL			
IGNITER (W/DED. POWER)	2	302	304
GE			
IGNITER (W/DED. POWER)	.7	.01	.7

COMMENTS

- DEDICATED POWER ASSUMED IN FVALUATIONS
- OVERALL COST IS APPROX. .0,000,000 INCL. HEAT REMOVAL SYSTEM
- COST/BENEFIT RATIO APPROX. 1 WITH BNL ASSUMPTIONS (NOT .02 STATED IN SER 4)
- BNL SEISMIC BENEFIT OVERESTIMATED
- GE HAS COMMITTED TO AN IGNITER SYSTEM EVEN THOUGH NOT COST EFFECTIVE. A DEDICATED POWER SUPPLY WILL BE INCLUDED.

TEN-HOUR STATION BATTERIES

SYSTEM DESCRIPTION	ASSURANCE THAT THE STATION BATTERIES SUPPLYING CONTROL ROOM INSTRUMENTATION REMAIN OPERATIONAL FOR TEN HOURS
CHANGE FROM NEDE 30640 BASIS	PART OF THE TEN-HOUR SBO PROVISIONS
RISK REDUCTION	NONE
COMMENTS	INTERFACE ITEM TO BE INCLUDED TO ASSESS THE FINAL AS-BUILT DC LOADS AND SPECIFY LOAD SHEDDING NEEDED TO ACHIEVE TEN-HOUR CAPABILITY

AC CROSS-TIE CAPABILITY

SYSTEM DESCRIPTION	CAPABILITY TO CROSS-TIE DIVISION 1 OR 2 TO THE HPCS DIESEL GENERATOR FOR INJECTION OR HEAT REMOVAL CAPABILITY
CHANGE FROM NEDE 30640 BASIS	GE DELETED RECOMMENDATION FOR INJECTION CAPABILITY DUE TO UNCERTAIN TIME AVAILABLE FOR CROSS-TIE. CAPABILITY FOR HEAT REMOVAL RETAINED.
RISK REDUCTION	INSIGNIFICANT
COMMENTS	MODIFICATION NOT REQUIRED BY SER 4

BASIS FOR ELIMINATION OF OTHER MODIFICATIONS

ADDITIONAL HP SYSTEM (DIVERSE POWER) OR LP BATTERY-DRIVEN SYSTEM	ALTERNATIVES TO UPPS; FEWER GENERIC ISSUES ADDRESSED
16-HOUR BATTERY DC BUS CROSS-TIES	NO IMPROVEMENT OVER 10-HOUR BATTERY CAPABILITY
RCIC STARTING IMPROVEMENT	IMPLEMENTED
COMPUTER-AIDED INSTRUMENTATION	PROPOSED TO UTILITIES; WILL IMPLEMENT IF SOLD
OTHER ITEMS	COST/BENEFIT TOO HIGH

SUMMARY OF POTENTIAL MODIFICATIONS
WITH COST/BENEFIT RATIOS <50

POTENTIAL MODIFICATION	NEDE 30640 SECTION	RISK RED.	C/B RATIO	
10 HR SBO PROVISIONS	3.10.a	2*	2.3	
UPPS (W/O SEISMIC PROV.)	3.2.e	10	3.1	
IMPROVED MAINT. PROC.	3.1.c	1.5	4.2	
UPPS (W/SEISMIC PROV.)	3.2.e	10	6.2*	
COMPUTER AIDED INST.	3.1.b	1.01	5.7	
ADD'L HP SYSTEM (POWER ONLY)	3.8.j	15	6	
LP BATTERY DRIVEN SYSTEM	3.10.c	10	6.2	
16 HOUR BATTERY*	3.10.a	2	11.4	
RCIC STARTING IMPROV.	3.2.a	1.05	11.4	IMPLEM.
DC BUS CROSS-TIES	3.10.d	1.08	14	

NEXT GROUP OF MODIFICATIONS

ADD'L HP SYSTEM	3.2.b	15	24
UNINTERRUPABLE PWR	3.9.b	2.2	31
LP FUEL CELL DRIVEN SYST	3.10.c	10	31
ADD'L DIESEL GENERATOR	3.9.a1	7.9	32
GAS TURB	3.9.d	7.9	32
STEAM DRIVEN T/G	3.9.f	5	35
ISOLATION CONDENSER	3.2.c	10	35
DIVISION 3 CROSS-TIE	3.9.c	1.01*	170*

*MODIFIED FROM NEDE-30640

NOTE: COST/BENEFIT VALUES DO NOT ACCOUNT FOR UPPS IMPLEMENTATION