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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
IN THE MATTER OF:

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
SUBCOMMITTEE ON RELIABILITY AND
PROBABILISTIC ASSESSMENT AND LIMERICK UNITS 1 AND 2

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Combined Subcommittee's

Limerick Units 1 & 2

and

Reliability and Probabilistic

Assessment

1717 H Street, Northwest
Washington, D. C.

October 10, 1984

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The Subcommittee's met, pursuant to Notice, at 8:35 a.m.

Subcommittee Members Present:		Consultants & Staff:
DAVID OKRENT	Chairman	DR. M. TRIFUNAC
WILLIAM KERR		DR. P. DAVIS
CARLYLE MICHELSON		MR. BENDER
JESSE EBERSOLE		DR. A. GARCIA
MAX W. CARBON		DR. POWERS
J. CARSON MARK		
CHESTER SIESS		DR. RICHARD SAVIC
DAVE WARD		MR. GLENN A. REED

AGENDA

PROCEEDINGS

(8:35 a.m.)

MR. OKRENT: Good morning. The meeting will now come to order.

This is a continuation of the Advisory Committee on Reactor Safeguard, Combined Subcommittee on Limerick Units 1 and 2, and on Reliability and Probabilistic Assessment. I am David Okrent, subcommittee chairman today.

We will proceed with the agenda in a moment. I see that Dr. Savio laid this out, he had an executive session and discussion of the subcommittee's objectives in the review of the PRA/SARA.

I guess from my own point of view, the letter that the ACRS wrote on October 18, 1983, to Chairman Palidino (phonetic) in which it provided an interim report had a paragraph which maybe it would be easiest to read, instead of trying to paraphrase it. It says, "In response to a request from the NRC staff, the applicant submitted a probabilistic risk assessment in March 1981. A supplement to this report was submitted in April 1983, in the form of a severe accident risk assessment, SARA report.

"In its meetings with the applicant the committee reviewed a number of plant features that had been identified during the PRA, and have been modified in order to reduce risks produced by certain hypothesized accidents. The NRC staff safety evaluation reports -- the Limerick station does not make direct use of the information contained in the PRA and the SARA, but rather follows the guidelines of the standard review plan. The manner in which the NRC staff reviews the PRA and SARA is described in the NRC staff letter to the ASLB, dated April 13 and May 24, 1983.

In these documents the NRC staff states that the PRA and the SARA will be used to compare the risks presented by the Limerick station with that of other nuclear power plant facilities. If this risk is found to be significantly greater than that associated with other such facilities, the NRC will consider the need to recommend compensatory features. The NRC's staff review of the PRA and SARA is continuing.

We expect to review the PRA and SARA with respect to the methodology, results and use in the Limerick licensing process. We believe that the demography of the site calls for careful considerations of the results of the PRA and the SARA.

The committee has several prior operating license reviews and noted the importance of assuring that the seismic contribution to risk is excessively low, with allowance for lower frequency more severe with seismic events than that considered as a safe shutdown earthquake. This issue is addressed in the SARA report, we intend to explore it further in our continuing review."

Then there are some other items mentioned. So, among other things, I assume that the committee plans to review what it says in this prior letter.

I don't have any other comments concerning the objectives. Do any of the members?

MR. KERR: As I explore it, especially the reviews, it seemed to me that the Brookhaven review would certainly indicate a rather thorough analysis of the PRA. And, indeed, in someplaces it almost represented a de novo PRA. Now, it was interesting that the insights gained were perhaps illuminating, but it in a sense represents a new approach to the PRA. And I am not sure I know how to compare the results of the Philadelphia Electric PRA with the results of the Brookhave PRA, because I think in a way one has almost two separate PRAs, so it is not surprising, perhaps, that the results should be somewhat different -- they are surprisingly different, I suppose.

Also, I think the review represents another example of the Davis Theorem, which is any review results in a higher predicted risk.

One of the conclusions, if I understood it correctly, that I felt somewhat puzzling was that the staff seemed to conclude that the risk associated with the ultimate operation of this plant would not be significantly greater than that associated with the operational design of Indian Point. I may have misunderstood, so somebody can correct me.

I would have thought that one would have been comparing the risk with something else, and I was a little curious as to why that particular comparison was made.

MR. OKRENT: By the way, I don't know who Davis is.

MR. KERR: That is Davis right over there.

MR. OKRENT: Oh, I see, pardon me. I thought it was someone hallowed.

MR. KERR: I thought so, too.

MR. OKRENT: But I have little doubt that I can go through Keith's history in matters, other than nuclear and find you examples where reviews dated more recent in time gave lower numbers than the prior analyses of risk. If there is a Davis Theorem, I don't think it hold universally.

MR. KERR: I was not defending the theorem, I was just calling attention to it.

MR. OKRENT: I think you only have to look in some of the proceedings that have gone on with regard to OSHA proceedings, things of this sort, to see when some companies feel really challenged they hired experts who come in with much lower risk numbers.

MR. SIESS: But does the theorem hold true in either plant PRAs?

MR. OKRENT: I am sure there are examples.

MR. KERR: The staff's own history on Indian Point goes against the example.

DR. DAVIS: If it would help, I will withdraw that theory.

MR. KERR: The theorem is no longer your property, it belongs to the agency.

MR. ORKENT: Okay, why don't we begin the review. I am assuming that we have all read and devoured and digested, and summarized, no doubt fully taken apart and put back together all of the paper received on Limerick. I am assuming that this is going to be the first meeting on Limerick where, in effect, we are learning about Limerick, and that there may, indeed, need to be one or more concerning PRA and SARA.

But let's see how it goes in any event.

MR. EBERSOLE: I threw a question out yesterday and got an unsatisfactory answer, so I want to repeat it. I had the good fortune to be out at the old Humbolt Bay plant a couple of weeks ago, and discovered in its design a feature I had not noticed in BWRs, wherein each rod drive had an individualized discharge valve, thus retaining the individuality of each rod to insert it without the potential blocking effect of all rods, due to a common dump volume.

I have asked for the historical evolution of the disappearance of that worthy feature, and the staff's part in allowing it to disappear. I suspect it disappeared in the context of it being a nuisance level leaking point, and that was obliterated, but at the price of failure of all of the rods.

I will repeat that request, I want to know how this happened, and what are the basic arguments that we allowed the individuality of the rods to be destroyed.

MR. OKRENT: Let me perhaps state your question, or substitute in another fashion. It has become the custom these days when anyone proposes a new feature that might improve safety, say let's review it to see how it might have a negative effect. Well, it seems to me it is fair to ask that about the design changes in the plans, and you just asked one and it ought to be answered in that light.

MR. EBERSOLE: Right. Thank you.

MR. KERR: Do you know about which plant are we asking, about design changes, Humbolt or Limerick?

MR. EBERSOLE: The transition is from the Humbolt design to the one represented by Limerick and all other BWRs, Subsequent to Humbolt I guess.

MR. KERR: But Limerick does not represent a drastic departure from other plants.

MR. EBERSOLE: No, it represents a drastic departure from Humbolt, which is 25 years old.

MR. KERR: I just wanted to be sure of the history.

MR. OKRENT: By the way, there are a large number of BWRs that are all the same, but they differ from Yankee in that they have small presurizers. And if you read here and there you will see that the trend goes back.

MR. EBERSOLE: It is the influence of the masters of business administration from the Ivy League schools.

DR. MICHELSON: Let me point out something, and this is as good a time as any to point it out. There is a feature of the Limerick mach two which I found to satisfy a number of concerns, and that feature is that they have highly compartmentalized the plant.

I would like to caution the people who use the Limerick as an example of how to treat other PRAs, it might be a potential error. Other mach twos do not have this highly compartmentalized arrangement, and therefore, are more vulnerable to common environmental disturbances, things of that sort.

So, one has to be very careful, in the case of Limerick it helped; in the case of other plants with mach two containments, they had better look carefully at their PRAs, because there are some real interesting questions that can be asked, that I think can be answered on Limerick, but not necessarily on others.

So this is a caution.

MR. OKRENT: Thank you.

Any other comments?

MR. BENDER: Just one point about the review that the staff, I guess, is going to tell us something about, as far as their uses of the PRA. I sort of agree with the point that Dr. Kerr developed about the relationship between Limerick and other stations developing PRAs. But my understanding of the approach was that WASH 1400 would be used as a benchmark.

And I think it would be particularly useful to find out in what way WASH 1400 is being used, because in looking at, for example, the containment assessment that Brookhaven attempted to make -- I think it was Brookhaven -- there was difficulty in deciding what methodology applied and deciding what kind of containment criteria went with the methodology, and even in my mind, what accident was being examined.

And I think it is so important that we have a good benchmark, that that matter ought to be explored pretty carefully.

MR. OKRENT: Any other comments at this time?

(No response)

MR. OKRENT: If not, we will go into the agenda items, NRC data and summary review, et cetera.

MR. SCHWENHER: Dr. Rowsome from the staff will make the presentation.

DR. ROWSOME: My name, as you all know, is Frank Rowsome,and I intend to talk to you only for about three minutes, and then turn it over to people who know a good deal more about Limerick and the technical details, than I do.

I want to set for you the stage for the effort, the inquiry into risk at Limerick. This effort was picked up by a letter signed by Harold Denton in the spring of 1980, requesting Philadelphia Electric that they perform a PRA and compare it with the reactor safety study treatment at Peach Bottom. The climate at that time was one in which we had six months before launched a task action plan to study the desirability of mitigation features at Indian Point and Zion, and issued a confirmatory order to both Indian Point and Zion to take special actions known as the "director's orders" in the interim, until a thorough study could be done.

The concern arose from a combination of our awareness that plants in high population densities, might, everything else being equal, pose a disproportionate share of societal risk. And the feeling that emerging from the accident at Three Mile Island, that we needed to take special care, to look into whether the margins in containment design were adequate to provide adequate mitigation of accidents at the severe end of the spectrum of core melt accidents.

At that time we were intensely aware of the hydrogen burn that took place at Three Mile Island and intensely aware of the fact that containments were not being designed for more than the large LOCA, and there was a question of how effective they would prove to be when challenged by core melt down accidents.

The feeling was that though we had a generic standards development enterprise underway in the form of what was then called the degraded core cooling rulemaking and minimum engineered safety features rulemaking, that both the urgency and the standard of improvement, should improvement be necessary, at the high population density sites might be higher than that which was applied generically. And, therefore, we instituted programs to study whether mitigation or other risk reduction features ought to be instituted, plants in high population density.

And it was in this spirit that Harold Denton wrote his letter in the Spring of 1980.

At that time, however, we have matured a little bit from our feeling in the fall of '79, and did not specify mitigation studies with quite the pointedness that they were threaded in to the task action plan and Indian Point design, because we were recognizing at that time that we were being a little presumptuous about what a technical inquiry into containment performance would actually show, and we wanted the facts to speak for themselves.

At that time and to this very day, the intention of ordering a PRA was to provide a divergent redundant form of safety analysis which would probe, as the regulations do not clearly probe, the ability of the plant systems to render inoperable or well mitigated severe accidents that extend into the domain of core melt down.

At the prodding of the ASLB, we committed ourselves to four particular uses of the PRA, those four are as follows: first, we would use the PRA to search for evidences of non-compliance with the regulations. At the risk of foreshadowing what is to come, let me give you one sentence which responds to what we, in fact, found. We found no violations of the single failure criterian in the PRA. There was some evidence that Appendix R of the fire protection rules would require a little bit more than originally envisioned, but no more than the deterministic standards of fire safety analysis were revealing at about the same time.

MR. EBERSOLE: Frank, may I ask a question about your single figure criteria, there are several.

DR. ROWSOME: Yes, you have a good point there. There are singles that proved to be important in the risk profile of the station as the vacuum entry reports indicate, none of them constitute legal violations in the single failure criteria.

MR. EBERSOLE: Would you express what that single failure criteria is that is not breached, I would like to hear it. I presume it doesn't contain any requirement about triple E-279, which says that having had an accident, and having perhaps had some residual damage to the mitigating systems, there still must be a redundant system to execute the function which permit a random failure of neither. Is that the single failure criteria that you say is not breached?

DR. ROWSOME: I am not as expert on the interpretation of the single failure criteria as you clearly want.

Jack Rosenthal is expressing a willingness to answer from the gallery.

MR. ROSENTHAL: Jack Rosenthal, reactors systems branch. There is an executive paper written by Dick Ireland about three or four years ago which describes the staff applications of the single failure criteria, deriving from originally the electrical requirements, things like 279, and then going on and seeking how it will be applied to fluid systems by reactor safety branch or auxillary systems branch.

And it is that exec paper which describes this, to include conformance to 279. And it is believed that this plan conforms to those requirements of a single failure. And that describes where you assume active and passive failures of fluid systems, as well as simple electrical --

MR. EBERSOLE: Well, does it require the prerogative of suffering a single random failure after having degraded a mitigating system as a direct result of an accident?

MR. ROSENTHAL: We take an initiating event, we take all consequential failures as a result of that initiating event, we then take the worst single failure of the mitigating system --

MR. EBERSOLE: In a random context?

MR. ROSENTHAL: Well, you search for the worst, and then you say is the remaining equipment appropriately sized to cope with the accident.

Now, for electrical systems like I-EEE-279, you include things like passive failures of wires. When you get to fluid systems, we don't take passive failures of pipes. So, there are differences in the application when you extent it from a simple electrical context to the broader systems context.

MR. EBERSOLE: What was that exec paper, again? I think we all need to review that again, at least I know I do.

DR. MICHELSON: Apparently that is still a document that you are abiding by, is that correct?

MR. ROSENTHAL: Yes, and that is embodied in the SRPs. I can get you a copy.

MR. EBERSOLE: I would appreciate that. I would like to get a copy, also.

DR. ROWSOME: Another use of the PRA in the licensing of this station has been in the severe accident considerations under NEPA. It has been the Commission's practice, since 1978, to include in environmental stations an assessment of severe accident risk, and this has generally been done with a generic model of accident frequency and release severity, but done with a plant-specific, site-specific consquence analysis.

However, having in hand a plant-specific PRA, it was used to fill this nitch in the environmental analysis under NEPA.

A third use, and I think by far the richest use we have had todate, has been in the intra-plant comparative risk arena. It is described in the written materials, such as new Reg. 1068, as being a search for unique design vulnerability, but what it in fact has been in practice has been close attention focused on what the PRA suggested might be among the principle or dominant contributors to risk. This process has lead to many rounds with the licensees, and the licensees have been singularly forthcoming and constructive in their cooperation with us in their review, and in their use of the PRA as a design review tool, as a design tool, rather than merely as a source of high technology propaganda about low bottom line risk.

And in so doing, we have found a number of instances in which the reliability of prevention or mitigation systems has looked a little thin from a PRA point of view, and design alterations have been developed to deal with that. This I think is an example of a particularly constructive use of PRAs.

MR. EBERSOLE: Frank, is it your opinion -- I have recently heard there has, in fact, materialized an actual instance where the sewer system became an important element of the PRA, in that it could damage certain reactivity control systems.

Is it your opinion that we have gone this far in identifying initiators in the plant?

DR. ROWSOME: I wouldn't say that we have gone to that level for every hypothetical scenario, no.

The fourth use is one that is just beginning, and that doesn't bear on the licensing of the station, per se, at all, but in the use of the PRA as a tool in generic standards development. As you know, we are working up six reference models of reactor safety as part of the severe accident research program, to undergear the evolution of severe accident policy in the staff. And Limerick is to be one of those referenced PRAs, one of those reference risk models.

And we anticipate extensive use over the coming years of the Limerick safety profile model embedded in our own critique of the licensee's PRA, as a test bed for studying generic issues, mitigation improvements, prevention improvements, things of that nature.

That, however, we take some care to point out is kept quite distinct from the process of licensing Limerick. We don't believe that use ought to interfere in anyway with the licensing of the station.

So, with that, I would like to turn the podium over to Frank Coffman, who will give you a more technical detailed account of the study.

MR. BENDER: I want to ask a couple of questions about these points, if the committee would allow me.

MR. OKRENT: Go ahead.

MR. BENDER: First, when you characterize this inter-plant kind of relationship, I reacted somewhat along the thought lines that what we may be looking now for is a one-horse shay. And I would like to know whether that is really what the PRA is intending to do, to get some uniform level of capability across the board, so that you can't decide that anyone thing deserves more attention than another. That might be one interpretation.

The second point I wanted to ask was, to what degree does sensitivity evaluation enter into the judgments? It seems to me that so much hinges on whether you have made the right subjective judgment about something like the reliability emergency power system, that that might be more important in determining which of the dominant sequences, then whether you have gotten some uniformity of risk.

Can you comment on either, or both of these?

DR. ROWSOME: The latter point, let me say I quite agree that I believe the larger source of uncertainty lies in modeling approximations, than in the statistics that one more commonly sees propagated as a source of uncertainty distributions, and that we have recommended in an attempt to discipline ourselves, to take great care to provide the kinds of sensitivity studies and the kinds of willingness to challenge our own premises, as well as the licensee's premises, to verify that we have our hands on real problems, and the right problems, and haven't missed ones that are staring us in the face.

The former point, I didn't quite catch what you meant by the one-horse shay, but I think I can comment about the concept of homogizing the contributions -- I think any form of safety analysis, be it classical, deterministic safety analysis, or PRA as we know it today, tends to invalidate itself as a means of actually predicting risk. As it becomes used in safety design and safety operations, you solve the problems that are correctly displayed by the safety analysis, and the problems to which it is blind remain there and remain controlling. That was true of deterministic regulation, and it would probably become true of PRAs as well. It has become self-invalidating, once it gets used for design decisions and operations decisions.

That's all to the good, that's the way it should be. We have not got a perfect safety analysis tool and we don't need to pretend we do.

What we do with our early ventures in PRA as a design tool is some cherry picking. We are venturing into a domain of safety analysis that deals with multiple failures and common cause failures, and severe accident phemonenology that has not been touched by safety analysis before. And to the extent that it shows some prominent vulnerabilities and those are eliminated, they will have the effect of homoogenizing and leveling out the contributions of risks from the many different scenarios. But that rather than being either particularly sought, or particularly regretted, is a natural consequence of doing what the PRA does best, which is picking out a handful of circumstances and situations where we think that more resources ought to be focused on better safety design and identifying many, many more where we have, perhaps, over-regulated in the past, and less allocation of resources might well prove fruitful in the long run.

MR. BENDER: Well, I like the tone of what you are saying, but as an experienced cherry picker, I know you don't get many cherries by climbing the tree. And it does better sometimes to shake it.

But it seems to me that in trying to establish usefulness for this methodology, it is more important to find out what the stages are in the actions and what can be done at each stage, than it is to go looking around for bits and pieces where something might not happen -- even this reliability that compares to something else within the plant. I don't find that particular exercise of great importance, but that is my perception.

DR. ROWSOME: One of the principal benefits and one of the principal tools by which we hope to harvest the value of this exercise for improved reactor safety you will hear about more today, and that is the safety assurance program, the continuing use of the PRA as an engineering and operations management tool.

What you suggest might well be a feature of that use. I would challenge you all to think about that concept of the continuing role of PRAs in safety design and safety operations, and bring your imagination to bear on how this can be done effectively.

The Commission, as you know, is very interested in tackling the problem of setting regulatory standards for conduct of operations. You have heard about general operating criteria, you have heard about the staff's interest in a maintenance plan, to study regulation, maintenance and the like. There are some tricky problems involved here, it is very easy to fall into the tramp into which QA has falled, in which in the hopes of improving the reliability of the equipment, we have so diluted system responsibility that we may have actually lost ground.

There is a danger when we move into regulation of conduct of operations of usurping the responsibility that properly belongs with licensee's management and must belong there.

So that it is very difficult to imagine and it takes restraint and great artistry to come up with the kind of regulation that is parsomistic, objective, impersonal, sets adequate standards, but does not intrude in what is properly the prerequisites of licensee management.

And I think the concept of a safety assurance program, the intelligent use of reliability engineering tools and methodology may well supply us the discipline we need to solve this particular problem.

And I would like to challenge you all to give it some hard thought and to contribute to the development of this program.

DR. KERR: It seemed to me, as I listened to you and Mike, that you were talking about different things, both important.

Mike, if I understood him correctly, referred to the possibility that one could follow the course of a serious accident and that there might be points at which intervention could be made, that would make the ultimate consequences less serious. And I remember, I believe, a Brookhaven comment in their review, which said that from their examination of this PRA, that the course of progression was not modeled accurately enough that one could depend on this PRA to do that. The Brookhaven people should correct me, if I misinterpret that.

I believe that I saw that statement.

What you are talking about, I think, is a different thing, of perhaps equal, or greater importance, and that is to do with reliability of operation, I think. But I don't think that is what Mike was talking about.

MR. BENDER: I think Dr. Kerr's interpretation of my comment is correct. I am thinking in terms of going through the PRA to see at various stages of accident progression where the emphasis of the operating program needs to be placed. Are the operating procedures attacking the right features at the right time? Are the signals that are being provided for the plant the right ones for diagnosis?

Those kinds of things enable you to find out whether you understand the accident, when it occurs. I don't find enough of that in these analyses to make the PRA very useful for the kinds of emergencies we are worried about.

MR. ROSENTHAL: I recognize your point about the limitations of the existing PRA. I believe we were talking to the same subject in the sense that the kind of follow-up application of PRA, or PRA improvement, if you will, to fill the vacuum you have described is the kind of thing I think of when I think of a safety assurance program.

MR. BENDER: Well, I don't know enough about the safety assurance program to know about it, but I know a little bit about reliability analysis. And that is largely a matter of going through and seeing what the historical record is of hardware.

So, I need to know if there is something different than that, what it is you are aiming at.

DR. ROWSOME: What I was aiming at is a little closer to what you were suggesting, although I think you had some contribution that we, at staff, had not anticipated, that helps to give it shape.

MR. BENDER: I am using up part of the meeting that is not mine. Maybe somebody could get closer together on the thoughts.

MR. OKRENT: Let me try a few comments that arose out of the previous discussion, in no particular order. Mike mentioned that you might use the PRA to get a signal and I think in some cases you can, but I think the recent Susquehanna event where they lost all AC power wasn't in the PRA, per se. They claimed, though, in fact, had they followed maintenance more in detail, and so forth, it would have been there, but it wasn't.

Mentioning Susquehanna brings a point to mind, it is a reference, and it leads to one of the PRAs I am now reviewing, I can't recall which one -- I don't have a copy of the Susquehanna PRA. I don't understand why the ACRS hasn't received them, but if I don't get --

DR. ROWSOME: The staff hasn't received it, it has not been submitted by the licensee, to my knowledge, nobody on the staff has one. I certainly don't.

MR. OKRENT: Well, all I can say is very soon I am going to stop looking at that particular PRA, because it references Susquehanna. And if we don't get the Susquehanna PRA, we will have a problem. So, the staff is alerted.

I am looking at G-Star (phonetic) and Limerick right now, and the two run together in my mind. But I am just making a statement that there is strong reference to the Susquehanna PRA and in the NRC contractor review of the document, among other places.

DR. ROWSOME: It is news to me, I can't place your reference. And I am quite confident --

MR. OKRENT: I will find it during the day.

DR. ROWSOME: I am quite confident that the NRC has not received a copy of the Susquehanna --

MR. OKRENT: Somebody must have seen it.

MR. EBERSOLE: I can't help but go back to Mike's comment about the beautiful one-horse shay. I hope we are not using that as a model, because whoever designed it designed the three-cent item with the same reliability as a three dollar item. And I hope that we can spend more in the three cent area to obliterate the unreliability there, than we would in the three dollar area. And thus have uninformed design --

DR. KERR: Jesse, what we were using the one-horse shay for was to delinate the age of the people who comment on it.

(Laughter)

MR. OKRENT: If I could bring up another thought that is raised by the discussion of reliability assurance. And I guess you have been an opponent of it, and assessed the hope that it would work -- I must confess, to me the end scope and requirement reliability assurance is a vague concept, I don't know what the staff itself plans to require along those lines.

DR. ROWSOME: Let me suggest that I think it has not gone anywhere near far enough to have identified that. That's why I invited you to participate in the thought process.

MR. OKRENT: Well, I assume you are inviting the utilities to participate as well.

DR. ROWSOME: We are.

MR. OKRENT: It seems to me it is not at all impossible that you could have a nominal reliability assurance program that occupied a considerable amount of effort, but missed the big thing. It is not too easy to envision just that.

The other kind of comment about how -- I don't know whether this arose in this discussion, or not, but that using the PRA and experience, one can improve things by this on going reliability assurance program.

I recently had the occasion to read somebody's cynical discussion of how safety of one of our leading planes, it happened to be the one that flew me in last night, was treated by the industry and the FAA, and you could call it an example of people trying to accomplish reliability assurance, I think. In fact, they weren't talking about little things, they were talking about substantive items.

In the end it seems that most of the changes occurred after the fatal accidents, when the warnings were there suggesting one could occur.

So, again, I think when you are developing reliability assurance program, you are going to have to ask yourself how do I distinguish between the gnats and the elephants, and how do I make sure I catch the elephants before they trample on people.

I will leave it at that.

DR. MICHELSON: I have one short question. You allude to the safety assurance program, I think it is sometimes called the reliability assurance program, and so forth. I have heard a number of names for it, but I have yet to read about the program.

When can we see something on this?

DR. ROWSOME: Well, the staff at the moment is not actually working on any description of the program and has not prepared one. We have prepared about a four-page summary of objectives and features we would like to see for the Indian Point hearing, which will be using subsequently in discussions with other licensees. That has been around for sometime and I think you have seen it, if not, I can certainly get you a copy.

The staff did deliberately avoid being descriptive about it on the grounds that if it were to be effective, it needs to be very well integrated and home-grown by a licensee, and this was one instance where we felt the need and desirability of making it home-grown, and overrode our desire to turn away from an excess of "show me a rock regulation in the past".

So many people have been asking about it, that I think we are going to have to write more. At the moment I have to write for Commissioner Zack, a very brief, one or two page account of what the minimum requirements that we propose be placed on Indian Point, what they would turn into in terms of actual things the licensee would have to do.

DR. MICHELSON: Well, my vague recollection -- I don't have the letter in front of me at the moment -- was that in the Limerick letter from the staff, that alluded to the fact that we would have to see some kind of safety assurance program. And I just wanted to find out what that statement was about. And you are telling me, I guess, that it really hasn't been worked out yet.

DR. ROWSOME: Well, the staff recommended to the Indian Point hearing board that Indian Point be required to institute one.

Harold Denton has written a letter in this case to Philadelphia Electric, recommending that they think about and volunteer to implement such a program, but has not threatened regulatory enforcement as a way of getting it. They do not intend to order anything of Limerick.

DR. MICHELSON: Well, if you are suggesting that there be such a program, how do I know what you are talking about, unless you have written it down somewhere, or can -- how do you communicate to Philadelphia Electric what you are talking about, when you talk about safety assurance programs?

DR. ROWSOME: We used the material that was developed during the Indian Point testimony to get the idea across, and that is about three or four pages. And I can get you copies of that.

DR. MICHELSON: I will have to see it, because that is apparently the only existing document dealing with the subject. Is that the case?

MR. MARTIN: One comment, please.

Bob Martin of the staff. The letter that we sent to Philadelphia Electric on the safety assurance program is included as Appendix B to the risk evaluation report, NUREG 1068.

We have received a response from the applicant, we didn't have it at the time we put the report out.

DR. ROWSOME: The attachment is an abstract from the Indian Point testimony. There is a little more than was in the Indian Point testimony, but not much -- this will give you an indication. We will, however, send you the rest of the Indian Point testimony.

DR. MICHELSON: Yes, I certainly want to hear a little more about it than what is in Appendix B here, which is one and -- two pages, which deals with a lot of other things.

DR. ROWSOME: I understand that Philadelphia Electric may be intending to summarize for you their intentions in this meeting. They may be better able to tell you what they intend to do, than we can tell you what we would have them do, since we don't plan to order anything of them in this arena, but merely encourage them to make constructive use of what they have already done with the PRA.

DR. MICHELSON: Is there going to be a staff paper on safety assurance, or is it going to be left in this vague way, and leave it up to each utility to suggest what it thinks it means?

DR. ROWSOME: How the concept is going to evolve is not clear at this point. We are talking to the Commission about the recommendation that it be ordered at Indian Point. They have made some recommendations back to us as to how to communicate with them further.

We are thinking about more extensive use of PRAs for operating plants in at least two or three arenas, the ISAP program, the further severe accident safety analysis called for in operating plants in the severe accident policy statement.

In the Commission meeting yesterday, in which we discussed with the Commission the severe accident policy, there was brief mention of the possibility that the resolution of this issue for operating plants might entail some kind of abbreviated PRA, safety assurance program to make that PRA come true. But we are far from having codified these concepts, or having a clear cut transaction of how this program would take shape and what kind of regulatory tools might be used to bring it about, or what relationship it might bear with the Commission's desire to formulate general operating criteria and the like.

So, I believe many of your questions seem to imply that we are much further down the path of planning these things than, in fact, we are.

DR. MICHELSON: Yes, I think for practical purposes, you are talking about years off, then, aren't you?

DR. ROWSOME: Possibly.

DR. MICHELSON: It really has little bearing on the immediate safety of the Limerick.

DR. ROWSOME: What Philadelphia Electric plans to do is all that has a direct bearing on the safety of Limerick.

DR. DAVIS: A quick question here. If I understood you correctly, and please correct me, if I am wrong. You indicated that the main objective of the Limerick PRA was to determine if the plant imposes an undue societal risk with its operation.

But in the documentation we have, and there is plenty of it, it is my impression that the comparison was not with societal risk as such, but with other nuclear facilities. And there is a large distinction there, because the other nuclear facility implication was that you were going to compare it with WASH 1400 results, which are very low in terms of overall societal risk.

Could you clarify that, and keep in mind --

DR. ROWSOME: Let me distinguish between the modivation that led us to order a PRA at Limerick in the first place, and the way we ultimately wound up using it.

The initial motivation was the feeling that plants in high population density sites, that both the standards and the urgency that is attached to addressing undue risk, should undue risk be an attribute of the station, would be at plants with high population density. So, we started with those.

When we got the PRA, when we started to study it, as we began to develop much more thorough, a more much mechanistic analysis of containment performance and the like, the safety problem took a different shape than we had envisioned it would at the outset.

We found at this plant, and at all the other high population density sites, very low societal risk, low enough that bottom line comparisons ceased to be particularly interesting. And at that point we were more interested in satisfying ourselves that the risk was, in fact, small in measuring how small it was, or making comparisons intra-plant.

And in availing ourselves of the opportunity to use this study as a design refinement tool and a procedure refinement tool. So, the ultimate use turned out not to be to make comparisons with WASH 1400, or comparisons with other plants -- we did a few of those along the way, because we promised to at the outset, but that was not the definitive or rich use of the study.

DR. DAVIS: That is not what the documentation says, in fact, it is very explicit on that matter. It says that the WASH 1400 is sort of the benchmark and decisions would be made on the Limerick based on this comparison with WASH 1400.

So, I understand the distinction.

MR. OKRENT: Just one piece of information, I mentioned the Susquehanna as having been referenced in either G-star or Limerick, well at least one document in which

Susquehanna is referened is the NUREG CR 3493, the review of Limerick generating station severe accident risk assessment, I have located it. And you will find on page 2-30, 2-43 -- a couple of pages I picked out in a hurry -- that data from Susquehanna to use in the Limerick analysis.

DR. ROWSOME: I will look into it. Thank you.

Now, I think I will turn the podium over to Frank Coffman, unless there are further questions for me.

MR. COFFMAN: My name is Frank Coffman, of the reliability risk assessment branch. I would like to continue the summary of the review of the Limerick PRA. And the review involved the attention of some 38 individuals among the staff and consultants. And I may be calling frequently upon some of the selected individuals who are here this morning to address specific areas.

I will be following this agenda, and there are some copies of the handout. You will find that other than this agenda, the rest of the handouts are the first five tables, NUREG 1068. I will not be covering all of the information on each of those tables, but in using those tables to keep us oriented and focused as we go through. And I will be picking on selected information out of those.

The PRA was submitted in March of '81, and SARA, the external events assessment was submitted in April of '83, with five revisions to the PRA and two to the SARA.

MR. CARBON: We are having difficulty hearing you.

MR. COFFMAN: Is that any better?

The results from the PRA had large uncertainties associated with them. I think we all recognize that. And the more important use of the PRA and the review are in the non-numerical insights gained, and I would like for us to remember that as we proceed through here.

MR. OKRENT: Excuse me, I have to sort of ask about that statement. In examining the potential usefulness of improvements, those analyses are quantitative, they don't reflect just qualitative insight. And in fact, there are ratios obtained and numbers bigger or smaller than one, and decisions are made based on ratios.

Now, what do you mean when you suggest that the quantitative analysis doesn't play an important -- relatively important role?

MR. COFFMAN: Well, to try and characterize what I mean, I think I would say that decisions are not based upon the numbers. The decisions are based upon considerations of the ratios and the sensitivity of the different value of that ratio to some of the assumptions that are made in obtaining the ratio, and factors which are, in fact, outside the assumptions.

So, the point was trying to emphasize that not a single numerical value or a set of single numerical values went into decisions, but that other more engineering considerations, I guess would be a way to characterize it, were made.

MR. OKRENT: Well, then if that is the case, I, for one, would like to see on each potentially important improvement a written analysis, which not only gives the cost-benefit result, but gives the other attributes, or whatever you want to call them, that you believe are important to the decision, including the uncertainties, et cetera, et cetera, and just how the conclusion was drawn. Because right now the only thing I am left with in reading this, reading the Indian Point testimony by the staff, and reading almost every opinion by the staff on an unresolved safety issue, or an issue like this, is a cost-benefit ratio,usually pointless. And I must say sometimes of doubtful quality.

MR. COFFMAN: I am not sure that we can put the work that we did in the review of the Limerick PRA into the same category as some of the decisions that have been documented in safety evaluation reports. In fact, that is why we have tended to refer to this report as a risk evaluation report, because we are not totally -- we haven't progressed to the point where we can tie this directly into licensing.

MR. OKRENT: When you go to CRGR you bring in only a fair risk assessment, cost-benefit analysis, or do you bring in other factors?

MR. COFFMAN: I think you are asking a question that is broader than was addressed in the Limerick PRA review.

Maybe I should ask Dr. Rowsome if he would like to address that point.

DR. ROWSOME: It is quite common that the numerical treatment of cost-benefit analysis brought to Cougar is a point estimate, though it would never survive Cougar's scrutiny without a qualitative verbal analysis of sensitivity and uncertainties attached to it.

MR. OKRENT: And that's all they ask is a qualitative verbal discussion?

DR. ROWSOME: They recognize, as we do, that the principal sources of uncertainty are not quantifiable, and understand that playing games with distributions on statistics is largely an empty exercise.

MR. OKRENT: If the uncertainties are not quantifiable, what meaning does your point estimate have?

DR. ROWSOME: It is simply one figure of merit that has modest probative value, but not a great deal, whose probative value is illuminated by the sensitivity -- discussions of sensitivity and the "what if" discussions that address the circumstances in which the premises and the calculation might be wrong.

MR. OKRENT: Well, I can envision a stratified case in which you have a decision and you illuminate it holding a candle and there is another chamber which is brightly lit, but you are just not getting into that chamber. So, I don't know what it means to be illuminated, frankly, and I don't know what your point estimates mean, and how you justify using them, in view of the fact that you just said that the uncertainties are so big, it really doesn't pay to quantify them and try to develop a rather well documented discussion.

DR. ROWSOME: Well, I think you are quite right, Professor Okrent, that there is plenty of room for improvement. We are doing these things better everyday, and I welcome your constructive criticism in the way we do such things.

DR. KERR: I don't want to make this too long, and drawn out, but the statement was made, I think, by Mr. Coffman, that, indeed, the numbers and considerations are such that one cannot use them in licensing, did I misunderstand?

MR. COFFMAN: No, sir, I would not exclude them from licensing, as much as they are, in fact, an attempt at an orthogonal perspective, and you use numbers to measure degrees. So the conclusions you gain from that analysis, then give you a starting point to address the licensing considerations.

DR. KERR: Now, when we get to the licensing of standard plants, and I don't want a long discussion, because we aren't doing that here -- but is my understanding incorrect, I had thought that in the licensing of standard plants that the severe accident issue was to be dealt with by giving a considerable weight to PRA, including, presumably, quantitative parts of it. Are we still going to be faced with the situation in which one can't use results of PRAs in licensing decisions, or will we somehow be able to shift perspective there, so that we can use results of PRAs in licensing decisions?

MR. COFFMAN: Well, rather than give you my impression of what is going on with the rest of the staff, I think that Jack Rosenthal maybe addressing issues related to that in --

DR. KERR: Or is one talking about a completely different kind of PRA than the one we are addressing here? Maybe that is the answer.

MR. LEWIS: Bill, if I may proceed on this same line for one moment --

DR. KERR: We can't hear you, Hal.

MR. LEWIS: I will shout -- have we moved backwards then from where we were in 1975, with WASH 1400? Because in WASH 1400, however badly the statistics were done, and I yield to a few in saying how badly it was. At least they defined their numbers by saying that the numbers they gave were medians, not media. That the error of bounds they were giving were 5 percent and 95 percent error bounds on a log form of distribution. And I am not a great advocate of log normal distributions, but at least they said what they were doing.

Are we backing off from that?

DR. ROWSOME: We are backing off from it to an extent, we have become increasingly aware that modeling approximations and completeness problems drive bigger differences in bottom line risk than one gets by propagating uncertainties originating statistics on fault event frequency, or probability, which was the sole source of uncertainty distributions in the reactor safety study.

One can still go through that exercise and from time to time we do, to get a lower bound on how big the uncertainties might be, but it is certainly no better than that, the lower bound. And it is rarely anymore illuminating than simply judging through sensitivity studies, how many decades of uncertainty are within plausible reach and getting a feel of just how many decades one is dealing with. Greater precision beyond that seems to be an exercise in self-delusion.

MR. LEWIS: I see, but of course possibility is in the mind of the beholder. So, to ask how many decades are within plausible reach depends on who is plausing. And I worry about the fact that we are taking the meaning away from the numbers, or the need at the time -- in 1975 it was to put more need into the numbers. I am not sure that we need to throw up our hands on this, but that is my view.

MR. COFFMAN: As we get to the third item on this agenda, we may want to explore it from a different perspective.

Table Five in NUREG 10.68 lists some more of the more significant voluntary improvements that were made by PECO to the Limerick facility, and that were influenced by the performance of the PRA, as identified by them. This is simply to itemize those in somewhat a decreasing order. The Atlas 3-A fixes. In fact, there is a little more there than just the Atlas 3-A fix, the ADS air supply system improvement, RHR service water pump discharge cross-over valves, the added fire barriers --

MR. OKRENT: Excuse me, you skipped a line. Would you mind telling me about that?

MR. COFFMAN: That line, the containment over-pressure relief system was not included as an improvement, and that is why I skipped it. It was early in their assessment that the use of the feature right above that, the cross-over valves in the RHR service water discharge headers, that enhanced the ability to cool the containment, that feature compensated for any benefit that containment over-pressure relief system would have offered.

MR. OKRENT: This is from plant one to two, which cross-over are we talking about?

MR. COFFMAN: This is the cross-over valve in the discharge headers from the heat exchangers, service water for both units, one and two, so that --

MR. OKRENT: This improvement involves both plants being there?

MR. COFFMAN: No, this improvement involves both service water facilities being there, which they are.

DR. MARK: I also wanted to ask about that one that was skipped. It doesn't seem to have anything whatever to do with the cross-over valves and why was it taken out of the -- you say it was considered and the system is removed. Did the staff remove it because of a fear of letting radioactivity out early, even though in a small amount, and for a good cause?

DR. ROWSOME: Excuse me, let me interrupt at this stage. This is scheduled for discussion in some detail in the next presentation by Jack Rosenthal. I think it would be more timely to take it up then.

DR. MARK: Very good.

MR. COFFMAN: This is an attempt to summarize first those voluntary improvements made by PECO and the staff did not -- they reviewed this, but they did not order it.

And the final one, some procedures to reset electrical equipment, after seismic event. These estimates in system unavailability are just estimates, and in essence, in reviewing these voluntary fixes or improvements, the staff concluded that they, in fact, were in the direction of reducing risks and that this, in fact, corroborated the more deterministic analyses to evaluate these improvements, and that some of these improvements contained features that are beyond those required to meet the staff's standard review plan criteria.

DR. KERR: Excuse me, what was it that corroborated the more deterministic analyses?

MR. COFFMAN: The benefits that we saw from adding the ATWS features to reducing the frequency of ATWS events, was independently supportive of the other considerations that were going on at the time.

DR. KERR: I thought I heard you say that something the staff did corroborated the conclusions that one drew on the basis of quantitative or deterministic analyses. And I was trying to -- I didn't understand what the staff did that corroborated this deterministic analyses.

MR. COFFMAN: The staff reviewed these improvements and corroborated, or independently concluded that, yes, they were improvements.

DR. KERR: I thought you were going to describe a process that gave an independent evaluation of the deterministic evaluation, some other process. I must have misunderstood.

What you are telling me now is that you looked over you -- you agreed with the applicants' analyses that they were improvements, is that it?

MR. COFFMAN: Yes, sir. They made these changes motivated by the PRA --

DR. KERR: No, I misunderstood. I thought you were giving me an alternate approach to analyses that gave you some confidence that the deterministic analyses was valid.

MR. COFFMAN: No, there are really only the two analyses, the deterministic review and the PRA.

MR. EBERSOLE: May I ask two questions? The item there on HRH service order pump discharge cross-over valve is in the general context of considering transfer devices, electrical, mechanical or whatever. If one is going to put in a transfer device, and make available to a given subcomplex in an equivalent system, such as to double the resources, the hypothetical improvement in reliability is merely a factor of two.

Evidently something has happened here that certainly I don't understand to get this vast improvement, and I would like to ask you were a transfer device is considered at large, and is there a set of arguments where you did consider them, and rejected them, or did not -- that is you actually incorporated them, and for what reasons?

MR. COFFMAN: Well --

MR. EBERSOLE: I want to get the perspective view of the picture.

MR. COFFMAN: Right, I interpret your question to be somewhat akin to the perfect switch syndrome.

MR. EBERSOLE: It is a controversial matter, because in doing this you incur risks, which you can compensate for by introducing features which prevent transfer under undesirable conditions. So, it is not just a simple matter, like that one line up there says.

MR. COFFMAN: I didn't mean to indicate that it was a simple matter. I take your question to be through to what degree did we look at transfer devices.

MR. EBERSOLE: And which did you incorporate, and which did you not, and for what reasons in each case?

MR. COFFMAN: Let me see if I can -- do I have any volunteers?

MR. CHELLIAH: Yes --

MR. EBERSOLE: I expect this is going to be too long to take up --

MR. CHELLIAH: What we have done, basically the applicant has performed this particular improvement and he has taken in the RHR system on a team and this has been given some improvement. The older version of the PRA did not have this particular fix, the latest version which is (inaudible) for PRA has this and it has the improved the RHR reliability. The systems frequency, that is one of the reasons that the removal of the containment water pressure which was in there previously to reduce the TW sequences and the major concern of the WASH 1400 in the PRA.

MR. COFFMAN: Can you indicate the rule for Dr. Ebersole, the extent to which we looked at the procedures for switching over to relying upon unit two's service water pump?

MR. CHELLIAH: All this transfer mechanism has to be modeled in the (inaudible), and also, there are some negative benefits, also. For example, pipe breakage can cause some system failure, some negative benefits, that is also quantified in the fault -- so the net benefit is really a positive benefit.

MR. EBERSOLE: How you got a factor of 11 is a mystery to me, when apparently all you are doing is invoking a system of equivalent reliability.

MR. CHELLIAH: No, here basically what we are doing we are giving credit to one of the systems in unit two, of course, the unit one operation time, this portion of the unit two is available. The applicant has agreed to install these systems.

MR. EBERSOLE: Is there a sub-computation someplace that I could look at, as to how you got this factor, or is it just -- do I have to deduce it from the PRA?

MR. CHELLIAH: Dr. Ebersole, this has been summarized by the applicant in one of the handouts, as I recall. The meeting was held at the King of Prussia. We have given the information to Dr. Savio, by the way.

MR. EBERSOLE: We will get our hands on this sub-computation that shows that, because it is still a mystery to me.

The second thing is do I understand that you have removed this ultra-simple way of cooling this core by venting the containment and providing low pressure water to keep the core covered?

MR. CHELLIAH: I guess --

MR. ROSENTHAL: They removed the dry well then and they do have procedures and identified valves for a wet well vent which we call a clean steam vent. The licensee has procedures for a wet well vent.

MR. EBERSOLE: And a low pressure water supply to flood the core compatible with whatever pressure you use to vent the wet well, right?

VOICE: No.

MR. HELWIG: Dave Helwig, Philadelphia Electric. I talked about this a bit at our last ACRS meeting. We deleted from the PRA credit for a containment over pressure release system because we judged it was not the wise thing to do at the time. We did not want Limerick licensing to hinge on the use of this system, we had included in the original PRA and discovered on closer scrutiny that in the modeling there were considerable numbers of conservativisms in the model, not only the RHR system, but also the frontal configuration of the RHR service water system which includes all four pumps, rather than distinguish them as being unitized with the HRH service water system. I would characterize as being common systems, common systems to both units. We made it fully available, which gave us a much larger complement.

MR. EBERSOLE: Is the complement essentially the same as in Unit 1?

MR. HELWIG: R-4 as opposed to R-2 would be a little more modest -- with a factor of about four sensitivity. But anyhow the containment of pressure relief, we never had a dry well, per se. We designed -- it was originally envisioned, --

MR. EBERSOLE: By dry well, you mean on the volume, on top of the suppression pool?

MR. HELWIG: Well, all we ever intended was whatever air space above the wetness --

MR. EBERSOLE: The back side?

MR. HELWIG: We have done extensive work, we do have the capability, there are a large number of things in our procedure that are in accordance with the emergency procedure guidelines and included in our plant-specific orientation procedures. A very large number of water sources that are consistent with that.

MR. EBERSOLE: What lowest pressure do you anticipate reaching? I am trying to find out where water might be available.

MR. HELWIG: At the last ACRS meeting I said we were almost done our design evaluation to support the implementation procedures, at that point I believe I said the pressure at which we actually vented might be as high as 100 and some pounds. There was some discussion whether that was too high.

I described it at the time we were completing the analyses to optimize that vent pressure -- was including some concern on the operability of the power solenoid valves on the (inaudible) -- our optimum value is 70 psi.

MR. EBERSOLE: Don't the standard SARs have some sort of a lock up at about 100 pounds, they will reclose at that pressure, and don't you really need some good valves, instead of those SRVs that you can open with assurance?

MR. HELWIG: The SRVs are pilot operated with air and they require differential pneumatic pressure.

MR. EBERSOLE: They are a Goldberg design valve.

MR. HELWIG: I wouldn't characterize it quite that way, but that was one of the considerations to selecting vent pressure at 70 pounds. We are well below that being a concern.

MR. EBERSOLE: They actually hold up at 70 pounds, don't they tend to close?

MR. HELWIG: 70 pounds dry well pressure.

MR. EBERSOLE: I am talking about primary pressure.

MR. HELWIG: You need 50 pounds differential.

MR. EBERSOLE: So that means --

MR. HELWIG: We are talking at cross-purposes --

MR. EBERSOLE: No, I am talking about the primary system to the dry well pressure -- coming to the wet well pressure.

MR. HELWIG: You just need a specified line pressure.

MR. EBERSOLE: That is air line pressure?

MR. HELWIG: No, water line pressure.

MR. EBERSOLE: You can hold them open at 50 pounds?

MR. OKRENT: There must be a delta somehow involved.

MR. EBERSOLE: I am getting a confused picture of the DPs and the air pressure, et cetera. All I really want to hear you say is you can open the primary valve, period.

MR. HELWIG: At this pressure?

MR. EBERSOLE: I would like to hear you say you can open it at any low pressure. There is some low limit on it, and I don't know what it is.

DR. MICHELSON: I think that is not quite the case, is it? Keeping in mind now your tailpipe is premanently pressurized to containment pressure, and you have to have a Delta P on that to keep the pilot open, at its minimum operating point.

I think that 50 pounds, as I recollect, is based on no downstream pressure on the pilot.

MR. EBERSOLE: And do you see why I am calling it a Goldberg, because it is not motor operated valve.

MR. HELWIG: I understand.

MR. MICHELSON: You have to add whatever containment pressure you have got to your minimum set point pressure, to find out what it would take to open it. When the containment is already pressurized, as opposed to when it is not pressurized.

MR. EBERSOLE: I think it is a worldly objective you are going at here, but the method by which you are going at it, and the equipment you are using, is not exactly compatible with --

MR. OKRENT: Before we go further on this point, I thought I heard someone say there would be a discussion of this specific matter, as part of the agenda. Did I hear wrong?

MR. ROSENTHAL: We will discuss it some more, yes.

MR. OKRENT: Why don't we hold further questions, if it is on this, until the staff picks it up --

MR. BENDER: I want to go back to the tables up here for a moment. It is interesting to see the multipliers up there, but I need to know what you are multiplying by, in order to have any judgment as to whether these numbers mean anything.

It seems to me that regardless of what we do, we wind up somewhere along the way with some kind of reference set of basic reliability numbers that we are starting from.

And if the judgment about the initial reliability is too conservative, the importance of the improvement becomes relatively unimportant, or vice versa.

Can you say something about what you are multiplying by what, in order to make a judgment about the improvement factor?

MR. COFFMAN: Yes, I am going to ask Mr. Chelliah to address that, address the mechanics of that.

MR. BENDER: I don't care what the mechanics are.

MR. COFFMAN: The basic logic is that they are all positive.

MR. BENDER: Well, 20 times 0 is 0. So, it is important to know what you are multiplying by what, to come to some answer, and that is what I am trying to get at right now.

MR. COFFMAN: Do you want to explain the numbers that were used?

MR. CHELLIAH: The system reliability is basically computed by the (inaudible) approach, so what do you do? You quantify as it is, then you get the one system and this is a point estimate, the best estimate. And then you add the planned fix to the system modeling, up date the -- and then requantify it. A reliability, so you take the ratio, that is what has been done. We have shown the extreme reliability factor.

DR. KERR: Okay, suppose that the system reliability improvement factor had been one, what would be the initial reliability number?

MR. CHELLIAH: Well, I can't answer the question, Dr. Ebersole, all I am saying in the base case, you --

DR. KERR: I understand how to calculate ratios, but believe me I am just trying to find out what the denominator is. If you don't know, you don't know. Say so.

MR. CHELLIAH: I don't know.

MR. COFFMAN: I am not sure I understood the question, but I would like to address the question because I think that all you are asking is did he show that by the fix, that the changing of faultry, that he came up with the same --

DR. KERR: No, I am asking, a ratio to me means you divide a numerator by a denominator. I am trying to find out what was in the numerator.

MR. BOYER: It was the actual number that was divided by?

DR. KERR: Yes, just the number, which I assume one had to start with.

MR. COFFMAN: We started with the system unavailabilities.

DR. KERR: What was it?

MR. COFFMAN: For the RHR system?

DR. KERR: For any of these, take the ATWS, the ATWS you have a system reliability improvement factor of 20. What was the original reliability before you improved it?

MR. COFFMAN: Do you have that number with you?

DR. KERR: If you don't have it readily available, --

MR. COFFMAN: We can get it during the break.

MR. EBERSOLE: I want to get it for the RHR, because all I can see is in essence you have brought into the picture the availability of the Unit 2 services to help Unit 1. I like to do it, and I used to do it regularly, and get a lot of criticism for it. But you buy a few risks when you do it, which is the pipe breaks, you are talking about. So, you have to weigh one against the other.

But by and large, Unit 2 generally is just like Unit 1, in its service availability. So, I have no more than two diesels, compared to one diesel, and I get a reliability ratio or availability ratio of an improvement by a factor of two, and that's all I get.

MR. COFFMAN: Well, if the system were simply --

MR. EBERSOLE: I would like to see how you get this large number, if you have the data to do it.

MR. BENDER: I want to go back to the basic question I asked again, because it is being diffused somewhat by side issues. Whether it is important to take advantage of the reliability improvement or not hinges on what the base number is. If you don't understand the base number and what its uncertainties are, then you can be deluded about the value of that reliability improvement. Ebersole is hitting on one aspect of it, the RHR system. And I think every element that you have up there needs to be thought about in that context.

I don't know that I am a big proponent of venting, but I see some aspects of venting that are somewhat different than this avenue. The venting concept is a diverse approach, it doesn't depend on the hardware that is in the sequence of events right now, it doesn't depend on the same system. And because of that it has a different kind of risk value than this business of adding some more hardware of the same type.

And I just want to make sure that point is understood.

MR. EBERSOLE: It is very simple by any other method.

MR. OKRENT: We are going to come back to the venting question.

MR. BENDER: I am not trying to promote it, I am only trying to clarify it.

MR. OKRENT: I am going to suggest that we take our scheduled break a little early. This will give the staff, if they wish, a chance to review issues of whether the numbers in which a factor of improvement is claimed.

Let's take 10 minutes, be back at 10:25 on the clock on the wall opposite the chairman.

(Whereupon, a short recess was taken)

MR. OKRENT: Let's continue where we left off.

Go ahead.

MR. COFFMAN: Just a couple of comments to hopefully keep this oriented. That some of the features in the staff review came out of the PRA and some of them were activities parallel to the PRA. The numbers that we have used for the unavailability of the HRH service water before the fix was in revision three of the PRA which we can try and locate that number and tell you what it was. It was on the order of 10 -6, in that range. That's the best we can do.

There are summary topics to be discussed, and I would like to go ahead and move to the next viewgraph, if I could.

The next one is the last one -- let me go back to the agenda for just a minute.

The next item was additional improvements, and what I had summarized were some of the more important fixes made by PECO that were influenced by the PRA. Then in doing the staff review, there were some additional items which we felt were in the direction of improving risk, they were not in the sense of violating any regulatory criteria. In fact, we looked at the dominant sequences identified in the PRA, and only the dominant sequences, to see if we could determine any violation of the regulatory single failure criteria.

And in those sequences we did not determine any. That was not a look across the entire plant, but it was just a focused look, an independent look at the dominant sequences. The improvements that appeared to be prudent and reasonable had to do with an upgrading of the procedures for manual depressurization, procedures for mitigating HPCI and RCCI room heat up and some emphasis in the training of operators on the extended possible use of the containment spray that was outside the consideration of the PRA.

So the staff suggested these to PECO and they, in fact, had already taken some action on these, and some action was still being completed.

As far as the last of the qualitative insight that came out of the review, there was the identification of the safety assurance program, on going use of the Limerick PRA which Dr. Rowsome has already mentioned.

The potential benefit that the staff had considered in a safety assurance program are also-- coincide with possible motivation, some have already been addressed by the committee, some of the more important elements might be -- and I say might, because at this point it is in the sense of not making it a requirement -- is to calculate importance to risk measures that will, in fact, allow emphasis to be put on some tech specs, more than others, and some features of the plant.

DR. KERR: I am curious as to what that phrase means, I encountered it in the 10.68 in a number of places. What is meant by something being important to risk?

MR. COFFMAN: You mean as far as the parameter used?

DR. KERR: In the context that you don't quantify risk because you don't believe in numbers. How do you know what is important to risk and what is not?

MR. COFFMAN: I'm notsure we can characterize or quantify risk because we don't believe in numbers. What I am saying is there are parameters used to measure importance to risk. They are, in fact, numeric.

DR. KERR: Okay, so the importance to risk is synonymous with a large change in numerically calculated risk, is that -- I am not trying to disagree with you.

MR. COFFMAN: Let me try and answer your question by saying what our consultants have done, and see if that will give you more insight.

DR. KERR: I am much more interested in what the staff means by this, than what the consultants mean by it. The staff must have something which it is describing when it says something is important to risk.

MR. COFFMAN: Yes, sir, these are things done for us by our consultants that have to do with the use of the importance, rankings factor identified as the (inaudible) importance factor reported in NUREG CR 3028, wherein the parameter can be calculated in two ways, --

DR. KERR: Mr. Coffman, surely one wouldn't have to do this -- in saying what is meant by importance to risk, does one?

MR. COFFMAN: How sensitive is risk to whatever feature we are looking at, be it an initiating event frequency, or a system unavailability.

DR. KERR: Is this risk measured in dollars, feet, inches, frequency, core melt probability, or what?

MR. COFFMAN: Core damage frequency was the parameter used.

DR. KERR: Okay, so it is a numerical estimate of the change in core damage frequency as a function of whatever is being done, is that --

MR. COFFMAN: Yes, sir.

DR. KERR: Okay. Thank you.

MR. COFFMAN: Another possible feature of the safety assurance program -- the use of importance to measure risk, the importance to risk measured would be to allow where there are limited resources, the opportunity those resources where they would give a bigger payoff, particularly, for example, in the area of operations or maintenance, quality assurance audits, and those types of areas. So that is a possible benefit that the staff would look to.

Another one being --

MR. OKRENT: Excuse me, I am a little lost. Why are you talking about importance to risk now?

MR. COFFMAN: I was identifying importance to risk as a possible ingredient to the safety assurance program, and then I was moving on to the next ingredient, which I was going to identify the possible use of the PRA to train --

MR. OKRENT: Well, I would like to suggest that this is not the meeting at which we are going to resolve what a safety assurance program is, because the staff doesn't have it defined.

Why don't we talk about your views on certainties and limitations, and how they affect decisionmaking? That is a subject I find interesting.

MR. COFFMAN: Okay,you would like to skip to the third item on the agenda?

MR. OKRENT: Well --

MR. COFFMAN: I had planned to address that --

MR. OKRENT: We are running a little bit late on the time allocated for the staff, and I think that that is a topic of particular relevance.

MR. COFFMAN: Okay. Table four in NUREG 10.68 is an itemization that addresses the subjects of uncertainty, but I think we need to -- it has been characterized already, we need to identify these as simply gross indications of uncertainties, obviously they are sources of uncertainties that in the operation -- or the assessment of Limerick that would contribute and increase these numbers, but were excluded, so they are obviously not in here.

MR. OKRENT: What does it mean then to have you define a median, a high and a low, and then to say there are things which could change these markedly, if I could put words in your mouth?

MR. COFFMAN: It means that as you try to compare the degree of different contributors to risk, -- I'm sorry, different contributors to the uncertainty of the risk that you are calculating, that you would then focus your attention, if you want to deduce that uncertainty, you would focus your attention on those sources.

Let me paraphrase that another way, the leading uncertainties for those sources which seem to contribute the most to the uncertainty are subject to more precise study. And one of the insights that you gain from reviewing the PRA is the identification of what needs more precision.

MR. OKRENT: Let me interrupt you a minute.

Presumably this is a viewgraph that you might want to show to the commissioners in a discussion of Limerick if you ever talk to them about Limerick. And then on top of this, if I understood you correctly, you say well, these display the uncertainties. On the other hand, we have not included all the uncertainties in here, so there is a lower bound, but nevertheless the numbers we are left with are these. And there is no careful statement of what is not in there and how much more the uncertainty might be, if you put it in there.

and so forth and so on.

MR. COFFMAN: What is not in there are those items of completeness in modeling the dependencies within the system that are beneath the level of detail that was, in fact, addressed in the PRA and its review.

MR. OKRENT: Excuse me, that's a nice general statement, but it doesn't tell me what those items are and how much they might contribute.

MR. COFFMAN: Some of the items that were included -- I don't know, I can't itemize all of the dependencies that were not in that. I can give you a feel for what was in there. And, for example, one of the reasons for the ADS air supply improvement was the fact that there was the potential for a location dependence for the gas supply to the ADS actuation, the fire special dependence which required the change for the fire barriers was in there. The dependence of HPCI and RCCI, pump cooling -- several that were noteworthy items of dependency done in the details of an evaluation of the plant.

So they were in the review, Brookhaven identified some of these dependencies, and it made some differences in the results. In fact, it is one of the major contributors to the differences between the core damage frequency estimated by Brookhaven and those by PECO. But they were not dramatic, those dependencies that were identified by Brookhaven.

So, it led us to conclude that, yes, if you looked closer at what Brookhaven did, you might be able to identify more dependencies, but it didn't appear that they discovered any dramatic ones. Therefore, the degree of dependency analysis that is represented by the PRA appears reasonable. That is not to say that it isn't complete.

And if we looked at this plant, or in fact, any plant, at the dependencies in more detail, that something might not be discovered. But I can't itemize what wasn't in there.

Another thing that wasn't in there was aging, aging is not in the PRA. Sabotage is not in there; design construction QA errors is not in there, but there are some things that are not in there that were, in fact, beneficial to safety, that weren't assessed.

But these are items that have been excluded, they are sources of uncertainty that have been excluded.

DR. GARCIA: Excuse me, I didn't understand your statement about there were some items of safety that were not assessed -- that were related to safety and were not assessed.

Could you explain that, please?

MR. COFFMAN: I make the general statement in the sense of addressing uncertainties, and what I was referring to is the credit for core spray system.

DR. DAVIS: Containment spray?

MR. COFFMAN: Containment spray.

DR. GARCIA: Are you saying that uncertainty in the credit for containment spray was not considered, or that the whole thing was not considered?

MR. COFFMAN: I am saying that among the sources of uncertainty, that contributed to the estimate of the magnitude of the uncertainty, that I listed several items, and I would expect those items to possibly increase the magnitude of the uncertainty significantly.

When one looks at completeness, one needs to not just go around searching for those items which would increase uncertainty, but would also contribute to safety. So I brought in this other example to say that, in fact, the model will always be incomplete in some areas. And if you are going to look at completeness, you have to look at both sides. That was the point.

MR. LEWIS: Could I pursue that for a moment. I apologize because I missed the beginning of this part of the thing. But uncertainty is being used in a couple of different ways here in the question of completeness, like the omission of sabotage could never reduce the risk. That is to say that is an uncertainty, but at least it defines signs, so in that sense it is not uncertain. Unless, I suppose the saboteur was so incompetent that he were to fix something that was originally wrong with the plant, but I think we can we can assign very low probability to that, at least on first principles. But other than that, I am not at all clear what these numbers mean. These are not log normal distributions one sees that and one sees the fact that the ratios between high, low to medium are not the same. And yet to give a mean you have to know the entire distribution, unless you fit it with some kind of curve, for which the traditional one is log normal.

What do these numbers mean? Maybe you said it before I walked in.

MR. COFFMAN: No, sir. Particularly on the internal events, the item there listed as I in that second column. Those represent what is closest to the more classical assessment of uncertainty wherein error factors were placed on log normal distributions. There may be some cases where there were not log normal distributions, but in general, it was log normal distributions.

MR. LEWIS: The first one on the list is clearly not log normal because the log normal normally has the same ratio to the median.

MR. COFFMAN: Then our understanding is different, and maybe --

MR. SHIU: Kelvin Shiu from Brookhaven.

The inputs evaluate the various parameters, that are assumed to be normally distributed with certain error factors. However, after you have evaluated the various sequences, the results you obtain is not necessarily a log normal distribution. That is what you see there.

So, the result does not necessarily have to be log normal.

MR. LEWIS: I understand that perfectly. If you multiply log normal probabilities, you get a log normal.

What has been done here is to use log normal input to add them presumably with a Monte Carlo or computer program of some kind, find the final distribution that you actually get, characterize it by 5 percent to 9 percent, take the mean and that is what I see up there. That answers the question.

I won't ask you why you did it that way, but that answers the question.

MR. COFFMAN: Thank you.

DR. DAVIS: Could you give us some hint as to which class is the most significant in terms of off-site risk? Is it Class S?

MR. COFFMAN: In terms of --

DR. DAVIS: Health effects?

MR. COFFMAN: Right, health effects.

MR. ROSENTHAL: Frank, I have a slide which will show that the class one sequences dominate latent health effects and class four sequences dominate early health effects, and generalization for internal sequences and seismic would tend to increase the early health effects of the Class S.

DR. DAVIS: Okay, I just wanted to point out that on the seismic contribution to Class S, the seismic contribution is the main contribution there, in terms of the mean value. But I notice that you have a 15 order of magnitude uncertainty. That is not a misprint?

MR. COFFMAN: No, sir, that is not a misprint.

MR. OKRENT: Neither is it 10 to the -21.

MR. COFFMAN: I don't think it is a misprint. Do you have a specific question about that --

DR. DAVIS: I just wanted to verify that there were 15 orders of magnitude between the low and the high, and that that is a dominant contributor to Class S.

MR. COFFMAN: Yes.

MR. BENDER: To get a more precise understanding of the significance of those numbers, suppose I just ignored everything except the high values, would I have to judge that all of those high values are intolerable, or should I judge that they are all okay, or should I look to see which ones are acceptable and which ones are not acceptable?

Has that been done?

MR. COFFMAN: That has not been done.

MR. BENDER: -- if the high values are acceptable.

MR. COFFMAN: There is no decision criteria that I am aware of that would say it is acceptable or unacceptable. This is just an estimate. It is a policy question as to whether or not there exists an acceptable or unacceptable value.

We did the PRA review all under the umbrella that all licensing would be done based upon the deterministic regulatory criteria.

MR. BENDER: Let me go back to the question that Jack Rosenthal tried to answer a minute ago when he said there is a table somewhere which characterizes Class 1 accidents with having the biggest impact on human health. And I suppose I have to say, well, there must be a reason why, it is either because the frequency is high and the consequences that go with the frequency are very serious, or it is some material quantity out there that gives you an answer.

MR. COFFMAN: It was not just health, that was latent.

DR. ROWSOME: Let me step in, if I may. I see a pattern, I think, in the kind of criticism we have been receiving. It falls into two bins, one is essentially journalistic. We did a lousy job in NUREG 10.68 in capturing the balance of qualitative and deterministic perspectives, the qualitative perspectives and the like.

The other goes to your concern that the actual way this is being used within the staff may reflect a primative or naive, or problematic decision logic.

In practice the way this has affected licensing is really twofold, first of all, from time to time, the management of NRR has queried those who have been directly working with the PRA review, division directors, Harold Denton and the like, to say "How is it going? Have you found any serious problems?"

And the answer has been "No, we haven't found any serious problems, we have found a few windows of opportunity for improvement on dominant contributors to risk and in each instance the licensee has been at least as quick as we, and sometimes quicker than we, to identify it, think about ways he could desensitize the plant to the kinds of vulnerabilities found in the PRA, and so we have been sending back reassuring messages."

There has been no formal decision logic used by Harold Denton or division directors, or myself, for that matter, in making recommendations to them.

It has been of the character I have just described, nothing more formal than that.

DR. KERR: Frank, apropos of that, and this is not meant to be critical, but an inquiry. What we seem to be hearing is that an unacceptable risk is one that is dominant, unacceptable in the sense that you and the applicant both think that something should be done about it.

I could follow from there that if one had a set of sequences, none of which was dominant, and one would conclude that nothing needed to be done, which was an earlier question.

Or, alternatively, one could conclude that no matter how small the dominant risk is, one would want to reduce it.

I doubt if either of those is true, but one could get this impression, at least from the discussion.

DR. ROWSOME: Yes, you are quite right that there are no formally agreed upon thresholds of remedial action, in terms of absolute bottom line risk. There are a couple of figures of merit that we keep in the back of our heads, one of them, which is not really a threshold of action, but is a threshold of really the onset of a de minimis attitude are those proposed by the Commission in their safety goal.

Another is a threshold that Harold Denton has expoused, for changing staff priorities. If he finds a 10 to -3 core melt sequence, he will give top priority within NRR to study the problem and identify whether it is real and whether some remedial action needs to be done. For lessor degrees of risk, along the lines that you have heard described in NUREG 0933 and their prioritization and generic safety issues, we have a scale of progressively lower levels of staff resources to be dedicated to problems according to the projected risk estimations attached to the vulnerability.

So, we do have thresholds identified, not for accepting the plant, but for allocating staff resources to study these problems, and we do use these thresholds that way.

DR. GARCIA: May I ask a question?

Dr. Rowsome, I wonder if you could explain what you mean when you describe the informal process involving Harold Denton, occasionally asking the question of have any important problems been identified? The answer always being no. What would constitute an important problem, a real problem?

DR. ROWSOME: Well, I was being rather off-hand about it. From time to time memoranda of the kind we just distributed to you have been solicited. You will find a memorandum dated February 29th, 1984, subject: Limerick PRA from Sammy Spease (phonetic) to Harold Denton, which was a progress report on findings and what we took to be messages for the licensing of the station.

I was, perhaps, a little too cavalier in saying that. However, it is widely understood that were we to find any indication of high societal risk, we would be obligated to pass the word on, up the chain of command as soon as the evidence appeared.

I can give you one historical example of the Indian Point case, no such example arose at Limerick, in which our contractor review of Indian Point suggested the core melt frequency of Unit 2 might be as high as 10 to the -3 per unit year, and that a substantial portion of that might be attached to a fairly serious, not mostly serious, but fairly serious release category.

That resulted in pulling people away from what would otherwise have been top priority NRR enterprises in licensing plants. It got the highest priority one can get. It got immediate attention without regard to what other work people were working on, to identify in a qualitative engineering judgment sense whether these vulnerabilities were real; what could be done about them in the short-term and in the long-term; what the options were.

And engineering specialists in the respective disciplines that dealt with the particular vulnerabilities -- one was fire, one was seismic, one was storm -- were sent to the plant to study whether these vulnerabilities were qualitatively as serious as the PRA review suggested they were, and to lay out opportunities for NRR to take action using orders, if necessary, to deal with these vulnerabilities.

So, there we have one historical data point in which we triggered top priority action. No such thing occurred on Limerick because in every instance all our indications were that the societal risk was quite small, the core melt frequency numbers were not very small, but not alarming, and as we looked into the leading contributors, we did not have any difficulty in getting Limerick -- the licensees, to give some serious thought to what could be done to reduce those vulnerabilities, and we did not need to use regulatory authority as a prod to get that kind of action.

MR. OKRENT: It seems to me the hard questions arise for that group of issues which lie just below the line that you set up for attention or the applicant itself sets up for attention, those which using your point estimates, or mean values, or whatever they are and using various kinds of measures of costs and benefits, come into some kind of a ban which regard to their ratio, usually some costs being larger than the benefits of fixing, but that ratio frequently differing from, let's say, one by a number substantially less than the uncertainties in the whole thing.

Those tend to not be dealt with, in my experience, except by a paragraph. And the reason for why they are not dealt with, I find incomplete, it certainly doesn't meet in its detail what the CRGR asks when you are trying to justify doing or not doing some new proposed fix.

It doesn't mean that those issues are less important than what you are bringing to the CRGR, but my observation of how this thing works is that these things are rather short-shirt, sometimes no attention at all in a particular study. And, as you well know, that is where I have a problem with what the staff is doing. And that's why I -- one of the reasons why I ask what do these uncertainties mean, and do they give the right impression even?

If the last set of numbers presented, do they give the right impression? And I will just leave it at that for now. It is not a subject I will forget.

MR. COFFMAN: In the interest of expediency, let me try and just address one item out of what I planned to say, which I think answers the question that was raised earlier, and then summarize. The question had to do with comparison of Limerick to other plants, it was in fact that they are different degrees of knowledge within the staff coming from the plant PRA. And the most knowledge concerns those plants which are in high population sites, so that was the bases of those plants -- we made the comparison to those plants, and they were somewhat closer to the charter for the conduct of the Limerick PRA.

The comparison was fraught with many difficulties because of differences in scope and methods, data selection, level of detail, basic quality assurance of the analytical methods here. So, the comparison is more just a simple indicator, but in essence the result of the comparison that Limerick is within that spectrum of the risks from these other high population density sites.

We are not sure that that would have been the conclusion, if it hadn't been for the PECO improvements that they had made.

MR. OKRENT: Where do the seismic issues stand in that conclusion you just drew?

MR. COFFMAN: Leon Reiter, would you like to address that question?

MR. OKRENT: Let me state the conclusion you just drew and then you can tell me whether the seismic issue in anyway qualifies it.

MR. COFFMAN: The statement was that the risks at Limerick were within the spectrum of the calculated risks for the other high population density sites, and that we are not sure that that conclusion could have been made without the PECO improvements that were made. And the focus was on seismic -- the sensitivity of that conclusion to the seismic analysis.

MR. REITER: I really cannot speak to a comparison, I mean, the core melt and fatality numbers at Limerick, I cannot speak to that. But the size of uncertainties associated, we had a Limerick present in the Zion and Indian Point assessments also. I can't do that.

MR. ROSENTHAL: The bottom line risk numbers include the seismic contribution and they are shown in the FES, and they are also shown in the risk evaluation report, and the comparisons between Limerick and Indian Point and Zion, and the numbers for the high population density sites are similar. So, Frank Coffman's statement stands.

Those statements are based on -- if you look at the slide that is up there now -- the IS frequency is -- the medium frequency is 7.6 E-9, and that is a seismic event in which the RHR lines are ruptured and the pool partially drains. I'm sorry, we placed a mean value of 1.2 minus 6.

If you drive that number up to the high number, then one would surely be more concerned over early fatalities.

MR. OKRENT: Before you hang up, your consultants listed a rather lengthy series of questions concerning the adequacy of the seismic review at Limerick and also the assumptions, and furthermore, their list is incomplete. One can add other things to the list to be considered.

So, I am trying to understand what is the quality of your answer when you say the seismic is in good shape, if I can paraphrase what you just told us?

VOICE: Dr. Okrent, again, in a comparative status, if we compare these to Indian Point or to Zion, the same kind of uncertainties that drive Limerick, indeed, driving these numbers, these are not meant to represent upper or lower bounds, they are a representative range. The same kind of uncertainty is driving the other numbers.

So, if you are going to compare -- we want to make sure that we are comparing the same thing.

MR. OKRENT: Well, I don't know that they are the same kind of uncertainties. You are making a statement which I believe you cannot back up in detail, that you would have to go back and look at just what the questions are from the seismic point of view, not only the seismic hazard curve, but the response and how the containment might fail, or lose integrity, et cetera.

And that kind of comparison from one plant to the other does not exist, there are different kinds of containment, and so forth.

Whether or not you get a by-pass on one due to seismic and not on the other, for example, could have a big effect.

And so I am bothered by the staff giving what I consider to be a loosely justified comparative statement.

VOICE: I was just referring to the often-stated statement --

MR. OKRENT: Not so much from you.

MR. COFFMAN: I think the staff would be in error to make anymore percise statements than the review justified.

MR. OKRENT: But if you said I don't know what the comparative seismic risk is, and that is open, I understand that.

MR. COFFMAN: But the magnitudes of the uncertainties were an attempt to -- in a relative fashion, to indicate the degree to which we know or do not know. And there is a large degree of unknowing. And seismic is certainly the significant contributor to the range, but it is not necessarily -- it may not necessarily be the biggest contributor.

MR. OKRENT: It is the staff's considered opinion that what is quote high to seismic, and those are numbers like 10 to the -6 or 10 to -7, at the high range, these include all of the uncertainties in the seismic, or is there a family of things that may not even have been looked at, by either Brookhaven, or Limerick, that could effect this?

MR. COFFMAN: No, there is no attempt to indicate that these values in Table 4 include all sorts of uncertainties. The purpose for looking at the uncertainties, if you look at the leading contributor to uncertainty, and that tells you where you need to study, where you need to put emphasis and study more, if you are going to refine the analysis.

And you look at the magnitudes, those features within the design or insults to the design by external events, that contribute most to the risk measure, so that you have a feel for where you might want to start looking at the plant, to make modifications. And that's about the best that -- that characterizes the review.

And it would seem that a natural follow on, and I think that is what you were putting some emphasis on the safety assurance program, is that one would want to continue to use the PRA to guide, to look for parts of the plant, or insults to the plant, where more emphasis should be put for safety -- for risk, rather. And also you have to continually try and update the analysis, to eliminate the inprecision in the analysis, and you have to go to the plant and get the specifics from that plant.

MR. OKRENT: But if I were a commissioner looking at that table, I would look at the median and I am told that down below "S" means seismic, so I would look past one "S", to something times 10 to the -9, something of 10 to the -8, something like 10 to the -11 -- I would ask myself why we were talking about seismic, apparently everything is out of the range of interest. Well, is that the conclusion I should draw?

MR. COFFMAN: To give you a personal opinion, I wouldn't start with seismic personally, The largest contributor -- the item which has, it seems to me, the biggest potential to change the results, the numerical results, would be something more associated with the internal events in Class 1, and maybe things like the radio nuclei source term would be something that I would look at maybe first, not to exclude seismic, but I wouldn't go there first. That's what the numbers there would tell me.

I would look first at those items which have the biggest potential to change the results. Seismic has the biggest range --

DR. POWERS: How does the source term interfere in this?

MR. COFFMAN: I was saying the source term is a --

DR. POWERS: It is just a frequency --

MR. COFFMAN: Yes, that's true, but the initiating events -- yes, that's true, but the initating -- I'm sorry, the internal events are the ones that are contributing most to the core damage frequency, which is the prerequisite for the consequences.

These are just indications, and that is how we were using the PRA.

DR. POWERS: Can I ask you for another personal opinion, at least when I look at the PRA, comparing the design at Indian Point and the PRA I came away with the conclusion that the people at Limerick more strictly interpreted the WASH 1400 methodology than the people at Indian Point. It seems like the Zion and Indian Point PRAs introduced new descriptions in accident progressions, rather normal interpretations, and Limerick had avoided that.

Is that also your impression?

MR. COFFMAN: Well, my impression is that Limerick did a better job, the Limerick PRA did a better job than WASH 1400 in identifying the transient initiators, you know, like on the order of 20.

DR. POWERS: I think I would agree with you if you were more careful about implementing the WASH 1400 methodology, but once they made the analysis, they followed very closely the phenomenological descriptions in WASH 1400 much more closely than did Zion or Indian Point, and both those PRAs seem to be willing to take advantage of research.

MR. COFFMAN: Not being that familiar with the Zion and Indian Point, I might --

MR. ROSENTHAL: At the time that the Limerick PRA was done, and then again at the time that the Limerick SARA was done, I think that the applicant used reasonable state-of-the -- what they perceived as state-of-the-art calculations at the time that they did the calculations.

Now, obviously, these are massive undertakings and you have to periodically freeze your methodology. But that is not to say that -- it is my impression that they did push forward the state of knowledge, and did use state-of-the-art source terms as they appeared.

Now it is the staff, embargoed by the EDO, who tell us to use more of the of the RSS methodology in our case work. And I will go into that more in a little while.

DR. POWERS: My question is simply in reading the document to understand what the bounds were --

MR. COFFMAN: An example is that they used NUREG 772 release fractions, which was the state-of-the-art in SARA, which was the state-of-the-art at the time they did SARA.

Maybe it would be appropriate at this time to have Jack come up and take over on this summary. I might mention that the staff has allocated -- or the time allocated to the staff in the afternoon, and at that point we were going to take a more -- have the people available to address issues as they come up.

MR. OKRENT: Are we going to hear this morning about the venting system?

MR. ROSENTHAL: Yes.

I have six slides, I thought I would start with the backup slides -- the backup slides start with a picture. This is design pressure 55 psi and the core value is four times 10 -- the zone pressure is comparable to a large containment, although its free volume is about one-sixth that of large drop.

In response to questions how could we distinguish in terms of the methodology between those sequences, the answer is yes. We can draw a lot of distinctions, we can look at the Class 1 sequence transient in which the fission product see the core and containment, something like the Class Four sequence in which containment is failed prior to core melt and the vapprization released. So trace the differences in health effects to the phenomenological behavior -- let me speak to the so-called IS sequence.

It was postulated that the RHR lines fail and those lines would drain and we would now have a full scrubbing factor of roughly 100. The downcomers, if you are using our assessment methodology which today would be conservative, one believes that from a constant standpoint, you would down at least the consequences by that sort of sequence. It is just plain hard to imagine a sequence in which containment is failed and you drain the pool, submergence is low and the communication between the bottom of the downcomers which are then uncovered and the dry well space above -- it is hard to imagine a worse scenario.

I would like to talk about the relative contribution of internal events and then add a little about external events, and then talk about bottom line. Here I am talking about internal events only, and I just want to make the point that for early health effects from internal events only, we see them dominated by trends, by the ATWS contribution and then the whole risk.

In comparison latent health effects, and note that the so-called Class 1 sequence dominate, the Class 2 sequences are farther down. Let me interject that the Class 2 sequence is called TW and they constitute about 80 percent of the core melt sequence on this plan, transients are more common, TW is suppressed and TC is suppressed, relative to the RSS.

If you take advantage of the emergency procedure guidelines which were not in effect at the time that the PRA was done, but the applicant has committed to implement them prior to operation. I understand that is almost completed now. I believe that the Class 2 sequences would be further suppressed and Class 1 sequences would then stand out as even larger fractional contributions to latent cancer. These are all assessed methodology. We are embargoed from using the Bechtel new source end products, but that is not to say in the case of the nuclear we believe that there is conservative in this analysis, things like the time of containment failure and the amount of (inaudible) that will happen prior to containment failure.

Taking that insight and looking at the numbers, we then say that in one sequence in which the core fails -- containment -- are the vary sequences in which one would expect larger production in source terms, than in the ATWS sequence, the Class 4 sequence in which you have a failed containment, and we don't have the time for the conglomeration settling.

So the conclusion that the Class 1s dominate the latent and the Class 4s dominate the early, I would believe it would only be strengthened by the factor on a relative basis, by including some of the new information. That is not to say that the absolute values of these quantities would not go down.

MR. BENDER: Excuse me, Jack, just to understand these tables a little better. Obviously, these numbers are very low, if you are talking about these kinds of fatalities for a very rare accident. It is hard to believe that they represent any risk at all, that's measurable. Why not lay a

-- what are they a reference for? What am I supposed to judge in seeing these latent fatalities, that these accidents are serious, not serious, or what?

VOICE: I think the judgments are yours. I will show you numbers for risk and numbers for consequences, and they are on a conditional consequence standpoint, you still have to believe that a Class 1 sequence would have a total person rem on the order of 10 million person rem and they are reported in the FES and slightly less than the order of magnitude -- depending on the sequence.

So if you are abhorrent of conditional consequence, in terms of person rem are there.

MR. BENDER: I was talking about the number of people, but I am trying to understand really -- well, maybe I am premature, but I can't understand where I am going to take advantage of this information, in trying to judge what the relevant significance of the risk is in Limerick to what it was in this reference evaluation that you are working from. I won't say reference plan, because I don't think that WASH 1400 really represented any plan.

MR. ROSENTHAL: Just a couple more slides, and then let me just talk about when one adds the internal -- external events. When you add external events you would still find that internal events would still dominate latent fatalities with external events being rougly 14 percent and internal being roughly 18 -- don't take those numbers too seriously, and you will still find that the Class 1 sequence is dominated.

So, in terms of long-term health effects, the conclusion is still that the Class 1 sequence dominate latent effects and that is important when you get to mitigation.

In terms of early effect, one has a different view and that is that a rare seismic event, when you add in external events, that 90 percent of the early fatalities would be due to external events, and roughly 10 percent due to internal events.

Now, let me go to my second set of three slides --

DR. POWERS: Jack, before we go to that, I wonder if we could pursue the question raised yesterday when you were not here, concerning evacuation plans, and how they were treated in coming up with these consequences. The problem essentially arose in yesterday's discussion that it appeared particularly for Class 4 events, that we were going to get the most extensive part of these right in the middle of the evacuation -- we were told that the evacuation would take like five hours.

And based on the efficiency -- like core melting would start like two hours --

MR. ROSENTHAL: Containment fails prior to the event taking place, and then the core melts and by the time you recognize it, you are in trouble, but the frequency is low.

DR. POWERS: I guess the question came up the evacuation plans that are being developed now, is there some realism about those evacuation plans, taking into account developing these consequence analyses, and now sensitive are the consequences and conclusions to the changes, of an hour here and there in the evacuation time?

MR. ROSENTHAL: Well --

VOICE: The assumptions that went to the risk analysis that are described in the APS in details, and I brought a few slides, if some of you would like to see them -- essentially we did not use -- in our parameters we tried to stay somewhat close to what could be the site-specific parameters, but the site-specific parameters are not yet finalized. So we had some experience as to what kind of parameters were dealt with at Indian Point and at Limerick -- the low population density.

So, before the evacuation -- it was similar to Indian Point, and 5 percent -- there is another parameter that goes to modeling -- that was somewhat based on one of the earlier evacuation time estimates that was prepared for the government. And the numbers on that were not too different from what was assessed for Indian Point.

So, we took that evacuation speed. We also did perform some sensitivity as to if this type of thing could go around or take place. There was some alternative response to that, the response was initiated by various earthquakes, different category of response. Only the people from the hot spots, the highly contaminated areas will be relocated, at some later time.

So the details of this are described in ATS and if you would be interested, we have some slides here to show the elements of this.

DR. POWERS: I would be, but should I conclude from those comments that you did not use the results of the HMM Study that were reported by the applicant?

VOICE: I don't recall what that study is -- HMM study? We looked at that, but we did not take --

DR. KERR: You did not use their results in your consequence estimates?

VOICE: That might have come up later, after we did the analysis, I am not sure.

DR. KERR: Okay, thank you.

MR. ROSENTHAL: I believe you have several copies of NUREG 3028 on the table and if you look at Table 8.15, on page 8-22, it will show you some sensitivity in terms of evacuation, scheme one and scheme three, to the ATWS sequence, and you see about an order of magnitude difference in the early fatalities due to the difference of those two evacuation schemes.

DR. POWERS: That is the answer to the question of yesterday, they are indeed sensitive.

DR. KERR: The results we have have not taken into account a site-specific study, which exists.

MR. ROSENTHAL: Okay, but --

DR. KERR: I am not trying to be critical, I just wanted to know if that was a fact.

MR. ROSENTHAL: When one does risk estimates, you have the mean probability times -- what I believe are conservative consequence models, in terms of containment phenomenology and built into that some of those seismic sequences include a disaster model which is a very pessimistic evacuation.

When one does do the summing, one still ends up with an estimated early fatality within one mile of the plant of 5E-3, per reactor year.

DR. KERR: Well, Mr. Rosenthal, it appears to me that since on a number of occasions I have heard the comment that one would like to be able to use the results of the PRA in planning and in operations. It is not obvious to me that conservative results have great virtue.

It seems to me that one wants results that are as near to what one might expect to happen as it is feasible, rather than conservative results.

MR. ROSENTHAL: Well, for the purposes of the DES and the FES, I think we would rather err on the conservative side in informing the public.

For the purposes of performing the PRA, yes, of course one does best estimates.

DR. KERR: The only way they would rather err on the conservative side, and to try to get as close to the actual results as feasible.

MR. ROSENTHAL: I can't argue with that.

At Limerick there was a decision to use the RSS methodology in assessing the plant, from the --

DR. GARCIA: Could I ask a question related to the results? There have been a couple of comments made this morning having to do with a comparison of the final results for Limerick with Indian Point and Zion. And we have now heard the statement that the evacuation model was for Limerick, was essentially based on that for Indian Point and Zion. I think that is what I heard.

Also we are aware from some of the questions raised yesterday, it appears a lot of sensitivity in the results to that model. So, I guess I am a bit puzzled as to how we could conclude that they are all alike, if we don't have any real site-specific evacuation model for Limerick?

Could you explain --

VOICE: -- somewhat similar to Indian Point. There are two elements to the evacuation model, two parameters. Now, the delay time before you act which is two hours, later for Limerick, which happens to be the same as for Indian Point, and when they are assumed with this number it is not likely that this number would be too much larger than this.

The elements that go to build up the two hour delay that is given (inaudible) and a large release is impending, time for a decision by the authorities in charge of deciding what to do. That's the difference in time, and then there is another 15 minutes that given the decision to evacuate, 15 minutes of time for notifying the people, plus given the reason to evacuate the people also take certain time to prepare, visit the house and pick up the children -- and allow the family to get there -- you are looking at 90 minutes for these people sometimes.

So that leads to two hours, and the Indian Point site, the site of the similar population density and that is the basis for this two-hour time here, also. The emergency planning should be shooting for compliance with this, because these results are (inaudible) in time, one hour and a half, that is 90 minutes, it seems like a very reasonable time for that.

DR. GARCIA: Can I follow that up? Was the model that was used for Indian Point and Zion also a general model, along these same lines, or a specific model?

VOICE: There is no general model for Indian Point or Zion, as far as the staff analysis is concerned. 1 the staff analysis the parameters for the site-specific studies that were made on Indian Point, one was for the utility and the other was on behalf of NEPA. And the parameters derived frcm those two studies are very similar to those.

MR. ROSENTHAL: Can I try to bring this around a little bit, and that is for the more probable transient sequence, you believe you have time to evacuate for the Class 4 sequence, the ones with the early core melt, you worry about the evacuation plan, and you worry about the sensitivity of the plan, these are for the less probable events.

Where do they come from? They came from ATWS, or at least as far as internal initiators go. And you say what do you do about it? Well, they have the ATWS 3-A mitigation system at the plant and with three pumps for stand-by liquid control.

One just can't ring your hands and say is that the right evacuation model and what do we do about it. You just don't know.

DR. KERR: Mr. Rosenthal, there is another part of NRC that looks at -- or maybe it is FEMA, that looks at evacuation plans. Now, somebody has to make th. ' evacuation plan. Perhaps, they completely disregard what the NRC has done in evacuation models, I don't know. But if they don't completely disregard it, then it seems to me that if that evacuation model is in error, the evacuation plans might be in error, too.

Now, if you can tell me that there is no communication at all between FEMA and NRC, then I will feel okay and know that this information is not being promulgated. But it strikes me that it is possible there is some crack through which this sort of thing might be seeping.

MR. OKRENT: I think we'd better move along. I have a question of clarity on the estimated latent cancer fatalities within 50 miles per plant year of operation. What is the number then, 5E-2. Is that the total number of fatalities that you integrate over all time after the accident out the 50 miles from the plant, or is it per year for 30 years, or what is it?

MR. ACHARYA: The latent cancer fatality within 50 miles, that is 5 times E to the minus 2 cases per reactor year for the lifetime of the people so exposed. It is not per year per year.

MR. OKRENT: I think we'd better move along or we are going to be late on our agenda.

MR. ROSENTHAL: Points to be made and considering mitigation features were, one, the plant is or will be in conformance with the regulations at the time the plant is licensed. It was a foremost consideration.

The next thing from a risk perspective, the contribution of the plant to the background, risk from the plant compared to a background seems low, as this slide shows. I'd like to point out that 5 E-2 is to be compared to 14,000 latent cancers, and the 7 million population within 50 miles of the plant.

MR. OKRENT: Excuse me. You've made a statement that that is to be compared with, and I really am not sure that the NRC wants to say that they think their risk from the plant should be compared with that 14,000. Let me leave it at that.

MR. ROSENTHAL: The next question was an initiator perspective. If you look at the sequences, you find that station blackout still dominates the transient sequences, even with the additional -- even with the 4 diesels at the plant. We find loss of decay heat removal and that brought a sense of being thins like transients with failure of high pressure injections as well as the TW sequence dominate the Class I sequences. Also ATWS are still shown in terms of early fatalities being important. That was not surprising. For those three classes, there are regulatory initiatives, generic regulatory initiatives underway. And so one would have to question why should one do something special at Limerick rather than taking the generic approach which would be ultimately applicable at Limerick which addresses the issues which we believe --

MR. OKRENT: I'm sorry. You have now touched a point that is a little bit of interest. You suggested that since there are generic studies on station blackout and heat removal ant ATWS, that one need not review that separately at Limerick?

MR. ROSENTHAL: In trying to decide whether Limerick needed separate and unique mitagative features, one should

3

bear in mind that 844 and 845 were underway, and that those three areas address the initiators at Limerick. That is just another facet.

MR. OKRENT: Let me switch to another approach that's possible, without prejudging the outcome here. Back around 1971, when Nubolt Island was being looked at, the staff was supposedly looking at ATWS and resolving it.

The committee nevertheless recommended that certain features related to ATWS, not a full compliment but certain features, be part of Nubolt if it were built. So I would just like to note that one doesn't always -- and it may not be always be wise to say this is a generic issue, we don't have to deal on this plant in any way, and I will leave it at that.

MR. ROSENTHAL: Another facet is to consider conditional consequences. The coremelt frequency is believed to be of the order of 10 to the minus 4, not remarkably low, or high. If you look at things like the SES, you will see a total person-rem of the order of 10 to the 7, which are substantive.

So from that facet, one could say one should look further. Given that, we should have a cost-benefit perspective. There is an estimate of total person-rem to 50 miles about 700 person-rem per year per plant, per year of operation.

With a value of $1000 person-rem out to a distance of infinity essentially, 700 to 1,000. You can pick your number, and that's the number that one would use in deriving mitigative features.

If you will remember I pointed out at the Class I sequences in which -- that dominate the latent health effects. So one would want to suppress the more probable Class I sequences.

At 700 person-rem, if you simply take $1,000 per person-rem, that was $700,000 a year. You multiply it by 30 years, it's 21 million. It's a number. At 1,000, it would be 30 million. If you present worth at 8 percent, you end up 8 million instead of 21 million. If you present worth it at 4 percent, you end up with 11 or 12 million versus 21 million. I don't know what is the right number to use, but the range of dollars at that person-rem translate --

MR. OKRENT: When you present worth those annual health costs, you are adopting the philosophy, am I right, that a death 50 years from now is not as important as a death next year? Is that what you are doing, at 4 percent or 8 percent or whatever present -- am I incorrect?

MR. ROWSOME: I believe you are incorrect. I believe it reflects the opportunity cost of money, and that it is appropriate to discount because our understanding of reactor safety is changing from time to time, and we can be more discriminating in identifying what needs fixing a few years from now than we can be today, and in light of the overwhelming evidence that we will know very much more about reactor safety 5, 10, 15 years from now than we know today.

It seems silly on the basis of things like the use of WASH-1400 source terms and the like, to estimate a 30- or 40 year budget for backfits on the basis of today's calculations.

MR. OKRENT: I'm sorry, but if I understand correctly, one is estimating health effects that might occur in the future, trying to estimate discounting the future health effects from present worth of the price you might put in today. I think that is the procedure that was followed. It is a possible procedure. I think it is nevertheless discounting future health effects.

Now, among the philosophers, as you well know, there are differences of opinion. You will find some who say you should not discount health effects into the future, and one of those regulatory agencies seem to have either agreed or adopted or espoused the idea of not discounting regulatory effects in the future if the Nuclear Regulatory Commission, as they understand it, because when it looks at geologic disposal of high level waste, a health effect 10,000 years in the future is of importance where you could discount it to an infinitessimal amount obviously, with discount rates much smaller than you are using.

So, I don't really know where the NRC stands on this question of discounting future health effects. I would appreciate learning what NRC policy really is, and if you could somehow get the people who look at long-term geologic disposal and we look at this sort of thing, talk to the commissioners and say, look, we are doing this on the one hand and, in effect, zero discounting on the other. Are we both right? Why?

MR. ROWSOME: Let me make two statements on that subject. First of all, the use of a discount rate in assessing the value of long-term risk reduction does not in any sense necessarily imply discounting the value of future casualties.

One can easily envision mathematical models that have half a dozen different terms that either escalate or deflate future values. We could be escalating the value of human life with one term, plus counting opportunity costs of money with another, plus accounting projections of uncertainty reduction and greater information from a third, and so forth, and get very complicated formulas.

One does not automatically imply that this agency is discounting the value of human life merely because a discount factor appears in such algebra. Now, as to the commission position, as you know, there is no formal commission decision on this subject, although there is an inclination on the part of most people not to discount human life. In fact, I can think of no individual memer of the staff or the commission who personally advocates discounting future casualties, but we recognize that there are many different factors that influence whether or not it is appropriate to treat future risk on the same monetary basis as today's risk.

MR. OKRENT: I must say, when you are all done, I really thought you were talking about something else than that line which present worth of ideal mitigation ranges from $8 million to $21 million.

MR. ROWSOME: What that tells you is clearly that the variance in the present worth of projected losses originating from one's choice of discount factor is very small compared with the variance originating from uncertainties in the PRA, so that at least for this pupose it is moot to irrelevant what discount --

MR. OKRENT: What it tells me is that staff considering is discounting future health effects, I'm sorry, in this application. And whether that happens not to be the largest factor that goes into the cost-benefit balance, I can't say, but nevertheless it seems to be doing this. As I say, I find a rather different approach on long-term geologic disposal, and I am trying to understand why does the difference --

DR. BENDER: I'd like to ask a couple of questions.

Right now, I don't know that a person-rem is actually a measure of health effects. So there remains a question of what the significance of the number is. And I understand the regulations may have been written around that at one time, but I don't know that they presently exist in that form. They are used for certain kinds of environmental impact analysis, but not for this particular purpose yet.

The second point, and probably more important, is the question of if the computation procedures that you are using, the ones that were used perhaps at Zion instead of the ones that were developed for reactor safety studies, give you orders of magnitude differences in the exposure. How is that addressed in the usefulness of this? That's a question that was asked a little while ago, and I hope you will answer it now.

MR. ROSENTHAL: I was trying to come up with some sort of upper bound on the kinds of dollars that one would want to spend on mitigation feature, and point out that those dollars would be spent on mitigating (inaudible) and they would have pressure relief from the ATWS. Relating to your question, you should bear in mind that we are talking about 10 to the 7 person-rem, 10 to the 6 some odd people, so we are still talking about a sensible amount of rem per individual. And with respect to the new methodology, please bear in mind that we are embargoed from using the new source term material.

We did not count on the primary system retention. The calculation are based on analyses done with our core gone show that the time of containment failure would be extended and instead of five hours, maybe we are talking about --

MR. BENDER: I know that there are a lot of things that weren't covered. Right now I'm just asking the question that has to do with whether the embargo is getting us in trouble. Is it creating something that is meaningless or more meaningful than if you didn't have the embargo because if you are going to use this methodology, it can't just be because the EDO said don't do something. He's just another guy out there. He's not even a lawyer.

How about explaining what would happen if the computation could predict something larger or smaller than those numbers? What would happen?

MR. ROSENTHAL: I think I'm trying to say that the -- what I perceive as the sum of knowledge, there hasn't been any specific effort, extra effort. Rather just the total of information that's come out of $200 million worth of researc would say thatClass I sequence, the transient differences with an intact containment, are significantly overestimated, using our assessment methodology, and in fairness to you I am pointing out I don't look to that sort of insight for an ATWS type sequence because it just isn't there. Now, is it getting us into trouble, somewhat -- I'm squirming here --

but we're slowly getting out of our problem.

MR. POWERS: I guess I'm surprised since you automatically say the interval knowledge, especially for BWRs, is the result of short production of the source terms at least as possible in the ASTPO worth. I think that in terms of things that ASTPO is still wrestling, things like boric acid reaction versus a lot of the mitigation available to BWRs, very high releases of fracture materials predicted for most BWR sequences because of the low level of oxidation --

MR. ROSENTHAL: That's right that's why the core con in time of failure become so important, because of a concern -- and, remember, that we are going now -- it's mostly in terms of refracter because the iodine in the Class I sequence is down about 1 percent rather than the BWR two numbers. The question is, how much further would you want to press down the 1 percent.

MR. POWERS: At that point, I bring up the argument of the primary system retention neglected, containment failure time underestimated, aglomeration and settling underestimated, especially in a small plant like this. I guess the bottom line is which direction --

MR. ROSENTHAL: I think that it's a reason -- there's a reasonable assessment of where we are going with the Class I transients and -- core melt into an untight vessel, that the time to failure of that containment is believed to be --

MR. POWERS: In the high risk sequences, the four that seemed to just dominate everything, three of those are sequences where the core melt takes place under pressure and presumably the vessel could fail under pressure. Was there a different analysis of the acts of progression when you had the core melt penetrate the vessel under pressure than when you did not?

MR. ROSENTHAL: Trevor Pratt?

MR. PRATT: Could you speak up a little bit?

MR. POWERS: Essentially, I'm asking, in the reactor safety study, vessel failure at pressure is not treated at all. Three of your four risk actions seem to have pressurized vessels at least part of the time.

MR. PRATT: You're talking Class I sequences and the subset of --

MR. POWERS: The subset in which there is failure to depressurize, and I'm wondering, in your assessments, or anybody's assessments, has there been an analysis of the acts of progression that distinguishes between having a pressurized vessel and an unpressurized vessel as far as subsequent behavior of the core and things like that?

MR. PRATT: No. I'm sure what you are referring to is the recent work that's been going on in terms of the containments modes working group where we have been looking directly at direct containment heating and the effects of that. No, explicitly not.

What we did do, though, in looking at the uncertainty study was to assume that the containment build did fail right at vessel failure, as being an upper bound calculation, and that was about as bad as we could do.

Again, because we were constrained to use WASH-1400 methdology, the releases that we calculated even when we broke it up for a long time, were relatively large so that the sensitivity to the early failure mode wasn't great. And that's why we concluded in NUREG 3028 that our, if you like, best estimate calculations WASH-1400 methods were very close to the upper bound estimates that we came up with.

So, in answer to your question, there was no direct calculation for direct heating, but we did assume that the thing fell immediately.

MR. ROSENTHAL: Let me just point out that the geometry here is very different. Where that diaphragm flaw is believed to exist at the time of vessel failure, that surely looks a lot different than the Zion cavity, and there's a lot of stuff down there, and it is relatively constrictive.

MR. OKRENT: Your numbers there, whatever they mean, presume they are in terms of point estimates, mean values, or something.

MR. ROSENTHAL: The core melt frequency is a mean value, and I just got through saying that at least for the Class I sequences, I believe that the consequences are subjective upper estimates because of all the considerations which are independent of whether ASTPO --

MR. OKRENT: Whatever numbers you have there, they would then end up being lower, but they would be some kind of a mean value. They might be lower when you were done, but they would be some kind of mean value, around which ther would be large uncertainties. Fair enough?

MR. ROSENTHAL: Ideally, yes, that's the one would go.

MR. OKRENT: What do you mean, ideally?

MR. ROSENTHAL: Ideally, one would come out with a good uncertainty estimate on the back end of the PRAs, and you'd have mean value distributions and you would propagate them through. So, ideally, you would have means with distributions that --

MR. OKRENT: There would be uncertainties whether you have identified them or not, is my point. Now, when one goes through the decisionmaking process, I'm interested in knowing how the uncertainties should influence that decisionmaking process in your opinion, or in the staff's opinion, or in the commission's opinion, or in someone in the NRC's opinion, or even Mr. Rowsome's opinion.

MR. ROSENTHAL: Let me point out that what you are doing is, you are soliciting the opinions of various members of the staff rather than managers --

MR. OKRENT: Is there a document you can refer me to which will tell me how these uncertainties should be brought into the decisionmaking?

MR. ROSENTHAL: I know of no one document. I know that, for instance, in the seismic task force work there was haggling of how one should consider uncertainties. I believe that what I'm doing is consistent with the general philosophy, and that is that I am trying to relate my numbers to the dominant causes. In this case, I think I'd be able to distinguish between ATWS and Class Is, will stand the test of uncertainty analysis, and, hence, bottom line conclusions on where you put your effort reflect the agonizing with the details.

MR. OKRENT: I don't understand that last sentence. What I see when I read something is a list of possible steps that might be taken, and then numbers like the point estimates point costs. To me, it's questionable merit frequently, and a ratio. And no presentation of the uncertainties, and certainly no philosophy on how the uncertainties should affect the decisionmaking.

Now, if there is a document that I should have read that will answer all this, I really would love to have it.

MR. ROSENTHAL: I know of no document. Surely, we presented a range of possible costs. We are not shying away from it. I think we have spoken frankly to the consequences, and -- I believe --

MR. REITER: Dr. Okrent, in seismic error we're really wrestling with this I think in Appendix D-2 we try an address a little bit as to what we may do. We may not have been very successful in doing it, but giving some thought as to how we could avoid this overreliance on point estimates, and there are some suggested techniques. I don't know if it will help you or not. Appendix D.

MR. ROSENTHAL: What kinds of decisions are being made? We have shown you that the early fatalities expected at the plant seem small. We have said that the health effects we would want to mitigate is the total person-rem. I hear no one challenging that. We've tried to get some upper bound of time and cost that would be used. If you believe that the discount factor should be zero, in terms of zero, then take the 21 million number, or 30 million --

MR. OKRENT: My point is if you said in view of the large uncertainty -- I will give you an example rather than taking the point estimate, I will be prudent and take whatever I can estimate at the 90 percent confidence value, or 95 percent confidence value, those dollars would go up maybe by a factor of 10.

MR. ROSENTHAL: No, they wouldn't because those dollars are -- well, there are several aspects. First of all, if you don't like the discounting, take the 21 million, zero interest. Then you take the consequence. We believe that that consequence model for the sequences that we are talking about here is a conservative model.

MR. OKRENT: But the frequency of your initiating event is off by a factor of 10.

MR. ROSENTHAL: If the frequency of the initiating event is off by a factor of 10, then I would argue that one should put one's money into convention to drag down that core melt frequency.

MR. OKRENT: At the moment, what I am trying to say is that there are generally large uncertainties. I have seen the staff inviting estimatations being larger than a factor of 10. I have seen some of the staff contractors on specific estimates giving confidences larger than a factor of 10, and yet they do not enter into decisionmaking because they see it. I'm trying to find out how they do. But, anyway, we'd better -- Mr. Kerr is going to answer the question for us.

MR. KERR: I just want to say, you asked what decisions are being made, or are they being challenged, and it appears to me from what I've seen that a decision is being made that this plant is probably okay. That's a fairly important decision. I do not disagree with the decision necessarily, but it does seem to me it is legitimate to ask what part the uncertainties played in reaching that decision.

Furthermore, we have been told that Limerick is going to be one of the six or seven generic plants which will be used as a basis for decision for some larger population of plants. The same uncertainties will enter, presumably, and some added uncertainties, and decisions will be made on what to do about a larger population. So it does appear to me that fairly important decisions may be influenced by the results of this study.

And since the results do include the uncertainties, some way of taking them into account appears to be a fairly important part of the decisionmaking process.

MR. OKRENT: Let me give you another small example from another area of life, as to how uncertainties really can be important. There are some people that live near a hazardous chemical waste dump. They find something in the building. They don't know exactly how much. They don't know how long it's been there. It is buried. They certainly don't know the health effects of the particular thing, probably better than a factor of 1,000. The officials have a large body of uncertainties but, nevertheless, there might be more than certainly the occupational limits that they did measure over some period of time. And then they come in to face the people, and the people want to know if it is safe, or a week later they say now it is safe to go back.

If you think that uncertainties in just what the risk is as compared to somebody's mean value, you think uncertainties are not important, you are just not in touch with the real world.

MR. ROSENTHAL: I did not mean to imply -- we are mutually groping with the state of the art here on what we can do. There are studies of mitigation features underway at RDA and BNL under contract by NRR. This is the severe action risk reduction program, SARRP at Sandia, it is under contract to RES. RDA has amongst their other suggestions recommended some form of how to clean steam vents and they have some quantitative studies going on at Brookhaven now of the merits of venting. The venting procedures are really oriented to the so-called -- if asked today, we would recommend that those should be symptom oriented procedures rather than vent oriented procedures. If asked today, we would say that that venting should be done --

MR. OKRENT: Excuse me, but could I ask about a paper by Popazaglu (phonetic), Carroll, Hughes and Barry, risk evaluations contained in overpressure release system in nuclear power plants, which they gave at an ANS meeting November 4, 1983, in which they concluded, as I understand it, that the net effect is negative on this of this containment overpressure release thing. Did I read this wrong?

It's correct, I read it wrong?

MR. CHELLIAH: No, Mr. Okrent, that is correct, and also there has been -- what we did, basically, we performed some kind of sensitivity analysis of having this containment overpressure release and without having this, they quantified the risk reduction, and this also has been reported in the NUREG 0328. They are talking about what is the effect of removing this containment overpressure release, which, in fact, are told that you will be better off to remove the system. That is the conclusion, basically.

MR. ROSENTHAL: Let's talk about apples and oranges. We have vents of the drywell and vents of the wetwell. Wetwell vents would include scrubbing the fission product in the pool. A drywell vent would not end up in scrubbing of the degradation release by the pool. Kevin is one of the co-authors of that paper.

MR. OKRENT: I'm confused by your statement because I thought I heard someone say today it was never considered except one which would be from the wetwell, so why was a drywell analyzed and, anyway, which one was analyzed in this abbreviated paper.

MR. ROSENTHAL: Why don't we have the author answer the paper.

MR. SHIU: The paper -- I think you have in your hand part of a paper that has been presented in an AS meeting.

The full paper was presented in the Boston meeting, which includes the effect of COR, and if we took away the automatic actuation, of the SLC.

What we have looked at, as far as being presented in the earlier versions of the Limerick PRA, we did not have a detailed information on the configuration and the system information on the COR, and I think subsequent to that an effort has been made to take out the COR. So the analysis that you see reported in that paper assumes a venting that in my recollection is a drywell venting.

Now I heard earlier that there was some disagreement that it was said it was a wetwell, but what we have done was essentially to base on a cursory look based on event tree and containment bridge tree that has been developed in the Limerick PRA and come up with some assessments on the effectiveness of the COR.

And you are correct that we identified the benefit is not large. We also identified a possibility that one may inadvertently open the COR or the COR could fail in open state, but these are some of the questions that we have identified.

MR. ROSENTHAL: Wasn't that primarily with respect to the TW sequence?

MR. SHIU: That's correct.

MR. ROSENTHAL: And now we are thinking about the event in a more global sense for all sequences.

MR. SHIU: I think there is a distinction in what has been done in this effort, and what is going on right now with regard to venting.

MR. ROSENTHAL: Kevin, can you tell us the page numbers?

MR. SHIU: It's in Chapter 5.

MR. OKRENT: Well, I must say this conception which has a BNL NUREG number, I can't tell in looking through it that you are talking about overpressure relief on the drywell, and I must confess I have little basis for knowing where the numbers you used came from, so that also seems like it was a fairly important matter to have perceived a rather deviated treatment with an unqualified conclusion. I should read more on it, I guess. I will let that go for now.

MR. KERR: You realize that another paper could be got out of correcting this one.

MR. ROSENTHAL: Would PECO like to respond?

MR. HELWIG: The Philadelphia Electric's intent in defining the containment overpressure release system, the first version of the PRA, was never that it be a drywell vent. It was very undefined. It was a conceptual statement, and it was only a statement meant to convey the concept, the conclusion of the containment overpressure release system.

As we considered the design of that, it was never any question in anybody's mind that that vent would come off the wetwell airspace, never contemplated it. The present way of incorporating venting into the procedures, we have an ordered preference of venting. It includes all the capability of venting, and it starts, of course, with the small lines from the wetwell airspace and procedures to the larger lines of the wetwell airspace.

MR. ROSENTHAL: So now that we are clearly talking about a wetwell vent, because we have a system oriented rather than a vent oriented procedures, the staff, in writing its SER on PECO's submittal for venting and approving that venting, asks them to look into the risk for venting for other sequences.

MR. OKRENT: What is the staff's position on the pressure at which venting should be initiated?

MR. ROSENTHAL: The proposal was roughly one and a half times design. I will remind you that design is 55 psig, and it seemed a reasonable proposal to us.

MR. HELWIG: Precisely it was 70 poungs, 1.3 times design.

MR. OKRENT: At one time, in discussion of someone's reactor, I heard numbers that were a much larger fraction of design.

MR. ROSENTHAL: At one time, the submittal was for venting 128 psig, some number like that.

MR. HELWIG: The original emergency procedure guideline, when it was first being developed and put into the BWR emergency procedures generically, the concept was originally identified as purely for a structural protection at approximately two times design. Further optimization of that -- it does require a plant specific analysis, but ends up being around 1.15 to 1.5 times design.

MR. OKRENT: And the utility's position, if I understand correctly, that the net effect on risk is favorable.

MR. HELWIG: Absolutely.

MR. ROSENTHAL: It's a process of TW sequence, which was its original intent,, and the ATWS 20 to 30 percent power in which you have -- and containment fails and possibly you lose injection due to failing of containment, if you could vent, you would need a large vent for the ATWS to puff out under the same power, you can avoid melting the core.

The agony of the ones you go through is a system oriented procedure. Once these things are in place, I don't think you should ask the operator to figure out what's going on, but rather he should watch the pressure in containment and ultimately go to watch radiation containment, and then take action. So one had to agonize over what happens if one has a more probable Class I sequence and follow other procedures in venting.

MR. MICHELSON: A quick question of PECO. Your

70 pounds is gauge, I assume?

MR. HELWIG: Yes.

MR. MICHELSON: And what is the saturation temperature corresponding to 70 pounds gauge? That will be essentially the temperature of the entire containment when you start venting.

MR. HELWIG: Yes, it is less than 300 degrees.

MR. MICHELSON: And you have taken that into account in your analysis?

MR. HELWIG: Yes. We've had a number of meetings with the staff on the subject of how one selects the pressure temperature and optimizes it, and equipment that is going to be experiencing those temperatures is one of the factors of risk assessment.

MR. MICHELSON: And essentially entire containment will be at your saturation temperature because you've got to drive the steam out of the system, and it's going to drive back through the vacuum breakers that maintain pressure equilibrium with the upper portion of the containment that you vent through the lower portion of the containment.

MR. HELWIG: That's absolutely correct. There is minimum equipment in the drywell, and it's required in such --

MR. MICHELSON: I understand that. It's mainly the containment itself. And you have actually gone through the stress analysis for this differential expansion of the metals and all the other things that will occur?

MR. HELWIG: It is well below design.

MR. POWERS: In looking at the depressurization, you also look at things like cool flashing?

MR. HELWIG: Yes. I started to say we've had a number of meetings to discuss this in detail with the staff, and we have made two submittals in response to questions on all these subjects, and we've proceeded with a systems review. That is essentially what this is --

MR. MICHELSON: Could you give us an idea of at least one vent path from the wetwell space?

MR. HELWIG: Sure. We have containment -- I have a slide on that.

MR. MICHELSON: Are you going to cover that later today?

MR. HELWIG: We hadn't especially --

MR. MICHELSON: Well, maybe now is the time to do it.

MR. OKRENT: Well, I'm going to suggest, if I can, that we are about at lunchtime, and this is quite leading up to it. We will pick up on the remaining issues on the core event and containment vent issue right after lunch, and whoever has a contribution would do it, without spending, I hope, more than 15 minutes or so, and that will get us to 10:00 on the agenda, and we will begin hearing from -- is that okay? -- because we are about at lunchtime now. Is that all right with you?

MR. ROSENTHAL: At your service. I only have one more slide. I can show it now, or later, it's up to you.

MR. OKRENT: Well, we will come back to that also right after lunch. So, don't forget whatever it was.

We will come back at 25 to 2:00.

(Whereupon, at 12:35 p.m., the lunch recess was taken.)

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

MR. ROSENTHAL: The mitigation just finished showing your last viewgraph. And I have an errata that I'd like to point out. I extracted the estimated early fatalities from page --

(Tape Inaudible.)

What I used was the -- of the agenda for the entire region and the more proper numbers shown on the label that I have shown on page 5-100 of the Limerick. And that -- with various -- within one mile of the plant, 6E minus 4 rather than 5E minus three. Before I do my last slide, if at all, erase them. Go ahead, do whatever you want to do.

We can look in our mitigation studies to find some objectives which could be functional objectives to solve criteria such as this desire to be AC independent or BC dependent. Ultimately you can get upper pressure control over temperature control -- temperature control may be desirable and the last has something to do with that atlas. And -- of the system would accomplish these objectives. But just when we -- this with the Limerick plant it would be in terms of upper pressure control they now have.

We have oil venting procedure -- trip guidelines which should accomplish the upper pressure control. They have containment sprays, wetwell and drywell sprays, credit in the PRA was not taken for those sprays, but they exists and they have committed to monthly testing of those sprays and the sprays are in our procedures. Both of these features have AC dependencies.

There in the procedures and they have monthly testing, those sprays will one, provide a temperature control of the temperature control for the container atmosphere, which is not necessarily very pretty. They would provide -- pressure control and -- treatment products. The -- control, the plant is -- when it is inerted and the PRA is assuming that the Plan B inerted 99 percent of the time if the actual experience is significantly different from that --

(Tape Inaudible.)

MR. EBERSOLE: Your mike is not triggering for some reason. Evidently you're not holding it close enough to your face or something.

MR. ROSENTHAL: Okay.

With respect to the decay heat removal there are generic issues 844 and 845. You may or may not come up with something. There is nothing unique about the Limerick there.

With respect to core debris and mass energy control we'll know one can design something to funnel corium from one place to another and bring it into proximity with water or take it away from water. I believe that -- we need to make a decision on that a decision on that and --

(Tape Inaudible.)

Although that issue is from a less significant standpoint would be less than the other --

(Tape Inaudible.)

In the last atlas, the plant has the out list creating --

(Tape Inaudible.)

MR. KERR: Our next agenda item is for the licensee or the applicant to talk to you. He merely rised for one quick procedural comment. And that is, this morning we got into a discussion of matters that really go to -- by the staff on this PRA and in long-term generic standards development. I think it might be a way of trying to get back on our original schedule to try to constrain ourselves to the PRA insofar as it might effect your letter of full power operation of the station.

The staff for it's point of view is found not in the shadow of the problem in the PRA that would warrant the delay on full power operation. If anything we find such good intention to problem such as atlas with the 3A fix that we feel much more confident than we frequently do in coming to a recommendation for full power operation.

If you gentlemen don't share that view it might be a good way to focus our discussion for the afternoon on that dimension. We can be back with you and will in fact be back with you for the foreseeable future on the question of severe accident policy in the role of this PRA and other PRA's to illuminate generic standards development. So I don't think we need to earmark a large chunk of today's time to that broader subject.

MR. OKRENT: Well then, I think the applicant was going to give a little bit on that 3A containment relief.

MR. BOYER: Right. We'll do that right now.

MR. HELWIG: This is a little cartoon of the Limerick containment showing the various vent paths that have been identified to exist. You should appreciate in writing the generic emergency procedure guidelines --

(Tape inaudible.)

MR. EBERSOLE: Pardon me just a minute. That mike system is failing to work. I don't know for what reason but it's --

MR. HELWIG: I noticed that --

(Tape Inaudible.)

When we set out to write the BWR emergency procedure guidelines on the generic basis we had as an objective to optimize the use of existing plant equipment. Similarly in adapting those emergency procedure guidelines to the emergency operating procedures, which is what we call our trick procedures for remembering, we are attempting to optimize the use of the existing equipment.

It's in concept just to imply directly in addressing the continued bedding capability that we have. To identify a number of potential lines in the event the primary containment at Limerick.

They range in size from 2 inch to 24 inch and a couple inch -- on each one of them has varying levels of desirability. The approach that has been taken is a staged use of these valves, these venting paths, from smallest to largest, of course, wanting to minimize the release, not vent in a larger way than is needed. And also to favor the most -- vent.

For instance, the first two, the small lines, the two inch lines, theirs comes off the suppression pool air space so everything that goes through this vent is in the suppression pool. It also goes through our standby gas filters. The mass flow going through the two inch line will not -- standby gas performance.

(Tape Inaudible.)

-- down here, it's the current system, the lines off the supression pool -- first. In general, the trend is from the small slides to the larger slides. There are a number of factors to be considered that we had to address. We determined that it does require plant unique evaluation to determine at what pressure and how one would implement containing the vent to their plant.

And we've been communicating with the staff on a genetic basis about that. The sort of factors that come into play will be outlined to the staff in an August letter with responses and procedures in systems with new branch of questions. In fact, some of those lines pipe all the way out through the reactor building, some of them have a higher likelihood of causing adverse environmental conditions in the reactor. This is our --

MR. OKRENT: Excuse me, before you take that off. Are all of the vent lines shown there free of single failure to close?

MR. HELWIG: Free of single failure to close, yes.

MR. OKRENT: And we were earlier talking about drywell vents, yet we see a drywell vent here. Did you want to comment on that?

MR. HELWIG: Sure, the two inch line that I described is a very small line it goes against the gas flow with the end --

MR. OKRENT: So no matter how hot the drywell was, I mean radioactively, suppose the first one couldn't open and you opened the second one, wouldn't you open any of these if there was radioactivity?

MR. HELWIG: Right now, the way the procedures are structured, they would open NC plants on a symptom basis which is pressure.

MR. OKRENT: But, with no radioactivity, or could they be opened if there was some radioactivity?

MR. HELWIG: They could and would be according to our procedures. But, of course, if there was radiation present in any number of significance it would be done with the knowledge and cognizance of the state.

MR. OKRENT: All right.

But, it's not to be included, then, in the procedures to open these, given that there's radiation in the drywell or wetwell.

MR. BOYER: That is correct.

MR. OKRENT: This is really a back up to eventually -- it's really for a better mechanism for containment of --

MR. EBERSOLE: I'm trying to understand now. There was a time when, I think, the first proposal said it would only function given no anomylous radiation in the container.

MR. OKRENT: There's been a lot of thought that's gone into these things since that first --.

MR. EBERSOLE: Yes.

MR. HELWIG: When I said there were no -- that we did not contemplate a vent in the drywell. I believe we're contemplating the single and dedicated mind that would be the containment of the pressure relief line.

(Tape Inaudible.)

MR. OKRENT: Okay.

Isn't it true that almost all of these valves, or whatever they are or these vents are subject to common mode closure from the isolation system? And they are, in fact, anxious to close and not open -- you have few, if any, bypasses to get to most of them?

MR. HELWIG: Yes, sir, we do have to operate some bypasses to get most of them --

MR. EBERSOLE: Are those bypasses hard to come by, are they reliable in case you have to --

MR. HELWIG: They are proceduralized, and are relatively straight forward. In some cases, some jumpers are required to be used. In those cases, we have identified the many procedures for exactly how the jumper of this contact to this contact.

MR. EBERSOLE: The higher you let the pressure rise, the less likely you'll be successful in your endeavor to prevent core damage. Do you have any nominal values for when you're going invoke this if you've lost sufficient cooling?

MR. HELWIG: We symptom based procedures, which I think we use and are to be used is 70 pounds drywell.

MR. EBERSOLE: 70 pounds?

MR. HELWIG: That's correct.

And that pressure --

MR. EBERSOLE: Well, now, you're well above 200 degrees in the suppression pool. Right?

MR. HELWIG: It's more of a saturation pool

MR. EBERSOLE: Yeah, you're way up.

MR. HELWIG: Yes, sir.

MR. EBERSOLE: Is that not too late?

MR. HELWIG: No, we don't believe that that's too late at all. We put that in, I guess, the best perspective I could use and that is, we've looked to the whole thing as a defense in depth that occupies with the needs of our equipment. There are some means of injection, I presume that's what we're referring to. There are some means of injection that would be somewhat adversely effected by higher spreading core temperatures. Not all of them would be. Our low pressure injection are -- saturated with it.

MR. EBERSOLE: Wouldn't you be wanting to look at other sources of water, like domestic water, which is not that high, or whatever?

MR. HELWIG: Procedural-wize, and I don't believe I have a slide on it. Maintenance capability is reverse and redundant, we have the motor driven, turbine driven multiple section locations all on the conjecture sources. We can take -- with HPCI and RCIC we can check for the condensated storage tanks for the pressure -- if we so desire. Then the low pressure pumps are able to handle -- see I could pump saturated fluid and some pressure fuel. The condensate pumps, of course, are outside of the reactor and so effectively everything -- sooner or later we'd already charged to service and the CRD pumps, diesel fire pumps, everything' outside.

MR. EBERSOLE: Is there an action that will put out of core service water into the core pumper?

MR. HELWIG: Yes, sir.

MR. EBERSOLE: How do you implement these, do you just put in --?

MR. HELWIG: It's particularized, yes, it's a matter of opening them.

MR. EBERSOLE: So, you can pour the river into the core?

MR. HELWIG: In our case, not the river directly but the spray pond.

MR. EBERSOLE: Well, okay, whatever.

MR. HELWIG: Theion

is working or nct or reliable. The next step is to -- the core name and have it go down the steamline.

MR. [illegible] ld you run that by again, please?

MR. HELWIG: Which one is that, core draining.

MR. OKRENT: Yes. Except for the first two, how many of those vent to the same place or how many different vent places are being vented to. The first two go through the STGS, correct?

MR. HELWIG: Yes, sir. The next one that's directly to outside the reactor. It's the lines used to hook up the big to air compressors that have been used to pressurize the containments ready for testing.

MR. OKRENT: Yeah.

MR. HELWIG: It's a hard type system all the way outside the reactor that connects the outdoors.

MR. OKRENT: What level is it on?

MR. HELWIG: Ground level.

MR. BENDER: Ground level?

MR. HELWIG: Yes, sir. It's at the location -- well, the external connection into the reactor -- is at ground level.

MR. OKRENT: And what's on the ground there?

MR. HELWIG: Parking lot, bathing, you know, it's an open -- between these -- room compressors, oilless screw compressors that are on --

(Tape inaudible.)

MR. OKRENT: Okay.

What device do you use, which is free of all the disturbances of power failure, et cetera, to determine what the level above the core is of the water cover?

We've looked at that.

MR. OKRENT: I'd say normal instrumentation, if that isn't effective and there is a procedure which covers the evaluation of whether the instrumentation is working or not or reliable, the next step is to flood the core and have it go down the steamline.

MR. HELWIG: In the events for whatever situations, again a symptomatic procedural approach, when we cannot be counting the active water level the procedural directions, obviously, institute two diverse sources.

MR. OKRENT: Well, you're just going to fire up the line into the core, then, like the PWR's.?

MR. HELWIG: If we have to. If it came to that certainly we would.

MR. OKRENT: And you say you're going to fill the steamlines?

MR. BOYER: Well, that play -- --

MR. EBERSOLE: Once you fill them up, though, how do you know since -- because of the configuration that your core level that isn't -- come down, but the steamlines remain cold?

MR. BOYER: I think -- and I'm not up, but my recollection is that we pump enough in to be sure that we're overflowing with the steamlines.

MR. EBERSOLE: Yeah, the rationale that PWR's supposedly --

MR. BOYER: And whether it's -- I guess it's down to relief valves into the suppression pool?

MR. HELWIG: Yes.

MR. EBERSOLE: You don't condensate --

MR. BOYER: Acoustic monitors on the relief valves, which would give some indication of flow moving through there.

MR. EBERSOLE: I thought you were contemplating a really independent diverse level measuring system that would be free of the common low disturbances of the standard devices.

MR. HELWIG: No, sir, we've taken steps to improve the level of monitoring systems that we have.

MR. EBERSOLE: Well, I know, that's going on all the time because of the deviations you experience.

MR. HELWIG: We have made substantial improvements in the reliability because we've got a monitoring system.

MR. EBERSOLE: Yes.

I believe they require inverted power, don't they?

MR. HELWIG: We're -- yes.

MR. EBERSOLE: So, therefore, they're

subject to issued power failures, which is the real crux of failure, wherein, you lose containment cooling?

MR. HELWIG: No, I don't believe that that's one of the cases where you would lose cooling. Certainly I don't know that that's the crux of the matter. I don't know that that's -- it's one of the cases. We've looked at that within the capability that we had here, both for injection and then we have more than enough -- we have a diverse capability to be stable in such a state for a long period of time.

MR. EBERSOLE: I saw the diesel fire system awhile ago, which is the only one I noticed that was AC independent.

MR. BENDER: Yes, sir, diesels are AC independent. And anything that we hooked up to our -- for instace also would work.

MR. EBERSOLE: Uh-huh.

MR. BENDER: Would the four temperature agent monitors tell you anything about whether there's water up there or not?

MR. HELWIG: Well, it's -- do we even have those?

MR. EBERSOLE: They don't have them. This a phase change machine.

MR. KERR: We got something that measures the actual level.

MR. EBERSOLE: What?

MR. KERR: It has the power.

MR. EBERSOLE: Not on a boiler.

MR. OKRENT: That's a great idea.

MR. EBERSOLE: Oh, yeah.

MR. OKRENT: You probably wouldn't believe the level indicator if you had it anyway. You've got to start doing more --, you've got to start putting water in the thing.

Are you going to stop when you reach the level indicator?

MR. EBERSOLE: I doubt it.

MR. HELWIG: One -- point is make up the -- I'm just wondering, is the differential, the pressure that we're talking about here. In order to hold -- what we're doing here is injecting water into the vessel and the safety relief valve's open so that the water that's going in or the steam can get out in the supression pool and preventing the steaming off of this pressure pool. So that we're either steaming twice or flowing through --. In order to do that, we require a system pressure, a primary system pressure routing aimed at about nine --

(Tape Inaudible)

All of our injection sources up to and including the RHR service water pumps --

(Tape Inaudible.)

MR. EBERSOLE: Let me ask you this, where is the material balance? I understood that this is an open cycle system, you might evaporate out of the core and have a mass full of steam. And that would be precisely the same as mass full of steam out of the suppression pool or something is going to get full. And you can't tolerate a complete and continuing fill up.

MR. HELWIG: Yes. If we were in a situation where we had knowledge of the water level in the vessel, then, we would have a mass balance, probably it would be to eventually remove water from this suppression pool which has also been procedurally -- the suppression pool water level control. We have the same problem if you sit there -- we won't call it a problem. We have the same issue to address if we sit here and steam the suppression pool -- you have to eventually make it up.

MR. EBERSOLE: But, if you invoke that, you're back to dependency on AC power.

MR. HELWIG: Not necessarily.

MR. EBERSOLE: You mean, you can get water out of the suppression pool without AC power?

MR. HELWIG: I'm sure in the timeframes you're talking about we could.

MR. EBERSOLE: I guess what we need to see is a complete description of this open cycle process which I -- it's not laid out on paper yet is it?

MR. HELWIG: It's the --

MR. EBERSOLE: I have the offer.

MR. HELWIG: It's defying a procedural --.

MR. EBERSOLE: I have that, yes. But, then, the design as well?

MR. HELWIG: Well, appreciate it's not a design per se. It's a probable communications communications -- asking for the design documentation on the containment venting system. What it is is a composite of the capabilities that exist in the plant.

MR. EBERSOLE: So, it's then presented only in a procedural context?

MR. HELWIG: Yeah, and -- also --.

MR. EBERSOLE: And that's then tested or checked, then approved, and it's supposed to be a competent procedure?

MR. HELWIG: Yes, sir.

MR. EBERSOLE: Well, that characterizes it, so we got it in our hands, I guess we have to look at it.

MR. OKRENT: Don't those system where they have two valves, have one inside and one outside?

MR. HELWIG: No, sir, not in the vent cooling. These valves are all outside shelter, outside the primary containment.

MR. OKRENT: And that applies, also, for the wetwell?

MR. BENDER: Yes, that is a standard approach to these finds --. The valves are very close to the containment, but they don't put pressure on it.

MR. OKRENT: But, they outside. Okay.

So if you don't have AC power, you can indeed get at them manually?

MR. HELWIG: Yes.

MR. OKRENT: That's what I was trying to find out.

Okay.

MR. EBERSOLE: This philosophy about level, we've been developing level, I think, ever since about 1840 on the steam engines. And I hope we learn how to read level. And my view is, we're committed to ascertain level. Am I wrong?

MR. HELWIG: We certainly are committed to ascertaining level. We have --

MR. BOYER: We also have provisions for -- if we can't, if we cannot ascertain level.

MR. EBERSOLE: What about in filling up the container? If you fill it up too far, it will burst like a paper bag.

MR. SPROAT: Well then, there has to be some -- adjustment on here. And I'm not sure that we'd lose all of the instrumentation -- some of our instrumentations are --

(Tape Inaudible.)

MR. HELWIG: Could you elaborate on that Ward.

MR. SPROAT: Ward Sproat, Philadelphia Electric. The level of instrumentation that we have is both vent from AC and DC, normally -- off with the AC diesel buses. If we lose that, it throws over automatically to DC, which powers it through. So, we do have both AC and DC supplies to the level instrumentation.

In addition, something we've done with Limerick, which is, I think, a little unique, at least for BWRs', is that we've added thermal couples on the reference legs. So, we will know what the temperatures are on the reference legs as we go through a drywell heat up. And that will give us a very good indication as to whether or not we can believe the local indication that we're getting in the control room.

MR. OKRENT: I'm going to suggest the need to complete this for about three hours, the time being -- of according to my estimates. I don't intend to run three hours late and I -- that. So, maybe, we better at least move along. I wonder -- let me ask the Applicant, as I look at the agenda, there are a couple of places where the name -- appears. And in connection with that, it's seismic things are there. Would it blow your presentation far out of joint if we manage to have Mr. Schmidt make his presentations by 4:00 on today -- on this time. Now, that would --

MR. BOYER: No, it won't, in fact, I might raise a question whether you want our -- you have the slides -- whether you want to skip over some of the general introductions. I think you know how these PRAs' have been conducted and maybe get into some of the meat of the issues. If you want further explanations on what we did in the entire thing, we can come back to it.

MR. OKRENT: All right.

Why don't we try that.

MR. BOYER: Why don't we start with the internal events, then? I'll skip past George. I know he's been chapping at the bit here to give you the overview of it. But, I'll see that Bob Schmidt gets on and the seizmic area is covered shortly after that.

MR. OKRENT: Okay.

MR. BOYER: This is Gene Hughes who was at the time the PRA was in charge of the internal event analysis work that was performed by them. This has since come from SAI and has often owned them.

MR. HUGHES: I believe this is the quickest I ever moved from the audience to the podium. What I'm going to describe, let me first add I'm going to speak without the microphone provided I can be heard. If that's a problem, I'll be glad to try and use it.

COURT REPORTER: You've got to use it.

MR. HUGHES: I've got to use it. Can I be heard.

MR. BOYER: Keep speaking and then we'll find out.

MR. HUGHES: Okay.

Let me proceed with the presentation. What I wanted to discuss is the methodology applied to the Intro assessment of fore damaged frequency. A subsequent presentation will address itself to uncertainly in detail and so I will not discuss the uncertainly as I go through this presentation except for an occasional reference to it.

In addition, a subsequent presentation will address itself to external events. So I will cover these only briefly and defer that to Mr. Schmidt. The analysis that was begun began in 1980 was undertaken to perform an analysis of risks associated with Limerick plan in a method similar to Wash-1400 method. The methodology that was applied was, in fact, very similar with the event trees, fault trees, similar ground trees and light.

There were a number of sensations in the performance of the assessment to try to make it a plant specific analysis with plant specific details applicable to the liberty plant. First, it was a full scope analysis looking at all the various systems associated with plants and taking advantage of the capabilities we were able to define it.

As mentioned, the methodology was similar to Wash-1400. We looked for risks associated with damage from events taken from power for the most part or out of the events we did include the events from lower power as a separate subplant. We looked for data associated with fit life of the plant recognizing that such things as transient frequency tend to be higher during the first year.

We used the Limerick design itself, exclusively. We used all of the information that we could obtain from General Electric from Bechtel Power Corporation to design the balance of the plant and it was reviewed by Philadelphia Electric engineer, by GE systems engineers and the like.

Procedures and specifications were taken to be as close to those that would be applied to Limerick as possible, to Peach Bottom and Susquehanna were used as reference plants to obtain information along those lines. We sought to respond to some of the lessons learned in Wash-1400 and some of the comments subsequent to the publishing of Wash-1400. In particular transient initiators appeared to be imported, in deed, they proved to be in our assessment so we expanded the treatment of transients. We included five transient initiators.

We then included specific treatment through event trees for atlas events for four of those different transient initiators. The line I would love to claim as a typo having read the transcript of the Millstone discussion before the ACRS and Dr. Okrent's appropriate comments on best estimates.

The appropriate words here I think are realistic success criteria. We went back to General Electric. They undertook to perform some unique analyses taking credit for decay heat as it would be expected to occur, taking credit for heat transfer to try and see what the real capability was and, in deed, it was more capable of responding to some of these events than Wash-1400 had given it credit for.

New data available was primarily through data gathering efforts at the NRC and at EPRI. We had the benefit of this data and used it where ever it was appropriate. In a few moments I'll show you the hierarchy of data use that we used. We had a formalism for the choice that we went through. The uncertainly analysis was as comprehensive as we could try to make it and, again, that will be covered by Garrett Parry shortly.

If you're following along, by the way, I am going to skip some of these charts. I think I mentioned the types of events that were treated. What I'd like to cover from this chart is the basis on which events were selected. The top two items under the 40 types of events evaluated identify the philosophy that we adopted.

We basically looked to define the subsequent effects of a particular transient or a particular occurrence at the plant. For example, if a condenser vacumn failure led to an MSIV closure and that incurred rapidly then we felt we should combine those together and treat it as just an increase frequency of MSIV closure.

The second ground rule was to look at the effect of the particular initiating event on subsequent systems in this case, for example, isolation would cause loss of feedwater, loss of off side power would effect the condenser availability, et cetera.

The actual internal events that were analyzed or shown as indicated there were five different types of transients -- manual shutdowns, loss of cooling action axioms were divided into large, medium and small. And for the first four transients shown there was a specific treatment of the anticipated transient without scram included.

I'm sure you're all familiar with event trees so I won't dwell on it. These are included in the PRA for each of the transients, each of the transients without scram due to the loss of cooling accidents. As indicated the methodology is very similar to Wash-1400, the nomenclature for naming events and for tracking them through. The process of developing them involved some considerable air action which mean the utility personnel, the people performing the various steps and trying the sequences and also General Electric engineers who have been involved in actual analyses for some time.

One these were done and the various functions were identified and coming across the top of the event tree it became necessary to develop the fault trees associated with those various functions. I've skipped ahead here to try to depict some of the information needed for the development of those fault trees.

Obviously, the systems design, the drawings, the information in the detail is the most important first step and that was obtained through the various engineering organizations as identified. In addition, the technical specifications and procedures were required. The chart that I've shown here relates to dependency interfaces that were included in the attachment.

I've been moving rather rapidly so let me recap and then pause a moment at this chart. Basically what we did was identify over 40 different types of events that challenge land safety. We group those into five different transients three different loss of cooling accidents. We expanded the five transients into nine by treating four, and that was by scenarios.

We then proceeded to develop the sequence of events, identified the functions and then for those functions preceeded to quantify and develop fault trees. The fault trees got into the system design detail and, in addition, various things such as dependency interfaces.

The types of interfaces that are included as shown on this chart are of several different types. First, the support systems, the support systems included such things as electric power, the biases both AC and DC are identified in the fault trees themselves. Where we had fault trees it appeared to have significant interties potential between the various bus supplies. These were run together in the final analysis of the numbers for the event tree.

The systems of logic, the relays, et cetera, et cetera were included, again, in the specific fault tree. And if you look at the fault tree volume or in a moment I have excerpts from that, you can see some of these types of failures. Suction discharge lines association with support of these items were included as potential failures. Suction, primarily the suppression pool which is a common source of water for many of the systems, the discharge lines such things as a high pressured powered injection that seeps through other lines into the four.

Water sources, again, the suppression pool condensate storage tank and the like, not on this chart but included in the fault trees was service water another dependent. The next type shown are spatial dependencies. These are such things as room cooling containment leads -- and the like.

And example, the room cooling was HPCI, RCIC, share room cooling and for off well site power it was -- excuse me, share off site power support for room cooling and so forth. Situations with no off site power would be mutually affected. This was included directly in the trees and the common most failure of off site power, leading to the common most failure of cooling.

The containment leak to reactor building relates to the transient of loss indicating removal, transient to the failure to -- where injection was called upon where we had containment leaks in the reactor building. This was thought to run a significant potential of receiving the capability of the equipment to the extent it would not give us for the equipment to inject.

The local environment related primarily to RHR pump repair after a large loss of coolant -- which was given to reduce the ability. Given factors, primarily -- calibration, errors -- would come immediately with more detail in a subsequent chart. Functional dependencies are ultimately tied by measures earlier, such things as isolation failure, loss of lee water, loss of off site power coming off the lee water, intercomponent dependencies, primarily the DC generators.

The next chart shows an example of some of the effects --

MR. OKRENT: Before you to the next chart, are you prepared to identify the principle, either dependencies or initiators or modes of failure or modes of degregetion that were not included in the internal events analysis? Is that some -- is there a slide like that?

MR. HUGHES: No, there's no slide like that.

MR OKRENT: I'm aware earlier as to the nuclear sabatoge. That one's covered.

MR. HUGHES: In terms of the systematic

approach to identifying nuclear reactions or attempting to identify dependencies that include them, what we did was use a series of analysts who had experience in plant design and licensing try to identify them. They attempted to identify them through the reactor -- they attempted to identify them through the ability systems engineers. Where we could identify them, if they appear to be significant they were included.

There is certainly the possibility that there may be some that are not included but we do not have a list of those that were not included except in the treatment of uncertainties where we attempted to identify potential conservatisms and non-conservatisms. The potential to some of them was not included. It's certainly a potential non-conservative.

I think the comment was appropriately made this morning that there was sort of a self-fulfiling prophecy here. We know it was significant when we identified it. By definition then those things that are not there don't --

MR. OKRENT: I don't think that -- an accurate representation of the state of the art even when one tries to live up to the words you have just used. Of course there may be some things you don't know how to -- even though you know that an odd amount exists, design errors.

MR. HUGHES: You are certainly confident in one area that I will cover in a subsequent part. So maybe human errors are traditional but the possibility that the operator may take any correction.

MR. OKRENT: The model that --

MR. HUGHES: In cases, where procedures were followed and procedure were failed to be followed. I certainly can't claim that they included the -- some were included through human errors --

(Tape inaudible.)

MR. HUGHES: Others may have been included in the transient frequencies but again in completeness of an article that I have obtained --

MR. OKRENT: It seems to me it would have been helpful even at the time this report was first done which now two years ago. Certainly at this stage which is a couple of years later and there's been interaction with some groups and so forth to have a clear identification of those things which have not included or which have been included in a foundary way if I can use that term.

I mean I've seen somebody in some -- that BRA -- and I have allowed for incompleteness. I've put an epsilon -- or something to cover it. But that's not quite the --

MR. HUGHES: There is a mathematical niceness --

(Tape inaudible.)

MR. HUGHES: I don't know how to qualify it on a -- decision. That is to include what you can, include it as well as you can, identify the uncertainties, attempt to identify what we've left out. That's about it.

MR. OKRENT: Okay.

I was looking for this rather carefully thought out list of what was not included. A different question. At one point in time I think the fault trees for the internal events were proprietary or something. Is that still the case?

MR. HUGHES: Yes, it is.

MR. OKRENT: Is there some good reason why?

MR. HUGHES: I believe it's the opinion of General Electric Company that they represent a commercial advantage for that and for that reason they request that they remain proprietary -- Larry, do you know which --

(Tape inaudible.)

MR. FREDERICK: Just what you said. They

very definitely have commercial value.

MR. OKRENT: Now, I'm just trying to understand, we do get fault trees for fairly important ERA's done by other groups -- Larry could have done a series which they give fault trees.

Other groups may have -- what is the -- I'm trying to understand why it is that all of these should be called proprietary. Maybe the whole PRA should be called proprietary. After all, the Zion GRA, there were lots of new ideas which have had a big impact, in fact, on thinking among the NRC and so forth -- and Heneley might have said this is proprietary. Anybody who wants to think about it has to pay us or whatever. I don't know.

I'm trying to understand what plausible argument for why one group should call it proprietary and another group not when it seems sort of central to the whole safety of review process.

MR. FREDERICK: I'm Larry Frederick, General Electric.

I can't speak for the others but I know in our case that there was an awful lot of work that went into those fault trees other than the work that was done on the -- PRA. There's a lot of background effort in there and there's a lot of General Electric effort in money in collecting data, analyzing data. That's at the basis of a quite a bit of the fault trees.

Also the trees themselves represent the analysis of the BWR and we feel that there is a great deal of commercial value in that. I can't speak for anyone else.

MR. OKRENT: Well, do you feel there's some value in having the essence of the arguments to what makes for the safety of a plant available for what I'll call peer review just by the scientific and engineering community?

MR. FREDERICK: The fault trees have been reviewed. They're available to the staff and to you and to the interveners that have had a need for them. They're available to anyone that has a legitimate need for them but they're not available to the general public or our competitors.

MR. BOYER: Yes.

I think the one difference speaking just as a somewhat uninterested bystander in this particular aspect of the thing, Bigelow and Garrett did their work for a customer. Actually the customer ought to decide whether that is proprietary or not. It isn't Bigelow and Garrett's.

General Electric did a lot of this work back on their own in the development of the BWR and they therefore really have a reason to make some of the proprietary and not give it to the world to be used as a starting point for making money on whatever they want to do with it. The staff and everybody else that's needed it has had it available to them. So I don't see why it should be an issue.

MR. OKRENT: Well, I guess I'm not quite sure I understand what you mean by "one of them did it for a customer and the other one didn't."

MR. BOYER: Well, we paid GE for the work they did for us but they were using as a starting point allow the information that they had developed in doing the generic development -- with the reactors which they want to keep proprietary. Bigelow and Garrett didn't do any of that.

They were starting off with their expertise and somebody hired them, hired their expertise, to do a job for them and to develop some fault trees, whether it was the NRC or whether it was the utility or who it was. Now, that work that was done by them or had belonged to the customer.

If the customer wants to make it proprietary then he should be the one to make it propietary and most customers -- most utilities or customers don't really look at it that way and it would make it available to the world but the manufacturers are in a little different position from what we are in that respect.

MR. OKRENT: I'm not -- there is something that's different about Philadelphia Electric or if they were a customer and saw Data Edison or Commonwealth Edison but --

MR. BOYER: But we didn't make it proprietary. It was General Electric who did the work, who was making it or asked that it be retained or took the position that it be proprietary. I can see why they might to that and and I'm was just trying to point out the difference between them and us or Bigelow and Garrett or some of the other consultancy used. We started out from scratch and did work.

MR. OKRENT: Well, I'm just trying to think now. Let me -- I talked about airplanes before. Suppose it were that Lockheed or McDonnell Douglass or whoever it is, everything about, you know, our plan has to be proprietary or we can't discuss any of the safety laws that --

(Tape inaudible.)

MR. OKRENT: -- find out that other than

that it must all be a proprietary -- just to sort of be done incommunicado or whatever laws there might be at some other point.

MR. BOYER: But the FAA would know it, wouldn't they?

MR. OKRENT: Well, but the public -- I'll tell you something. Let me say two things. First, as a member of the public I wouldn't and secondly, from what I've read there is recently about the operations of the FAA. I'm not satisfied that the FAA alone should know it and I'll say that point blank.

MR. EBERSOLE: You said the FAA alone and that's the key word, "alone."

MR. OKRENT: In other words, that the public -- there are members of the public who understand claims and don't work for the FAA, don't work for that particular -- who could look and offer very sophisticated, meaningful comments. They're not interveners or anything. I'm just saying it's true for nuclear power. I'm a little troubled, more than a little troubled, when the essential information that isn't moving -- to how do you put this tube jigger in, you know, a very hard job --

MR. EBERSOLE: Yes.

MR. OKRENT: -- and sell a patent in mind as it were. It just seems to me that if you --

MR. EBERSOLE: The public was left in ignorance on the DC-10 design over years and years and years and fully in jeopardy through all those years and FAA was not at all cooperative in advising the public under what conditions they were flying.

MR. FREDERICK: I might say that the first two volumes of the PRA are not proprietary. The fault trees if they weren't complete with all the quantification and all of the data probably wouldn't be proprietary either. But in the form they are in they have definite commercial value to General Electric and that's the way they were presented.

MR. SCHWENHER: Al Schwenher from the staff.

They met the legal test of being proprietary. So we're bound by our regulations and one of those is that proprietary interest is a legitimate basis for making it proprietary.

MR. OKRENT: Well, again I was making the point that the principle, this could make much of most of the PRA proprietary --

(Tape inaudible.)

MR. KERR: Dr. Okrent is trying to save the General Electric Company from itself. He knows that the -- would be made much improved if they had brought a -- in. He's trying to convince GE that there was a case.

MR. EBERSOLE: May I try to shout in the dark? Does this plan have a diesel driven high pressure course priority?

MR. KERR: What is this turbine -- Okay. I'll stop there.

MR. OKRENT: Okay.

Well, let's go on with wherever you were before I --

(Tape inaudible.)

MR. HUGHES: Let me recap where I was.

The Board through the internal initiator discussed the various events that were created -- entries developed, functions identified. Fault trees being developed at this stage had not yet touched that quantification. The first step is to develop -- relationships, the second phase is to develop the data.

EXAMINATION

BY MR. DAVIS:

Q A question related to the completeness argument. I believe one of B and L's criticisms of the study was that you did not consider DC power failure as an initiator; is that correct?

A DC power as it initiated was not considered --

Q Why not?

A It was considered at the time that PRA was done to be not a significant contributor in terms of the --

(Tape inaudible.)

Q That's still your position?

A I'd like to refer if I could to Dr. Ed Burns who might be able to make some oberservations on that at this time.

DR. BURNS: By the time we did the analysis, -- was not --

MR. KERR: Excuse me, Dr. Burns, you're probably very well known to everybody here but me. But you're with whom?

DR. BURNS: He was SAI at the time. This was work that was being done.

MR. KERR: Okay. Thank you.

DR. BURNS: At the time that the original internal events were done, DC powered initiators were not assessed to be a contributor to BWR's in general.

Subsequently, we've identified some low frequency initiators. DC power has been specifically looked for Limerick and the frequency is because of the four separate divisions at Limerick, is significantly below any of the other dominant sequences that we're talking about and has the character of sequences of class one.

So, phenomenology wise, it's not different and frequency wise, it's below the other dominant sequences.

MR. EBERSOLE: May I ask a question?

You used four channels -- did you say that there are four channels in DC?

DR. BURNS: Four electrical divisions, yes sir.

MR. EBERSOLE: Buried sometimes in this large number of channels of supply is a hidden dependency on just two systems. So although you have four, if I evoke a failure of two, in any worse chosen pair, can I come out of this in a safe manner?

DR. BURNS: The PRA says you can't.

MR. EBERSOLE: On just two residual systems if I choose them in the worse possible way.

DR. BURNS: Yes, sir.

MR. EBERSOLE: I'm a little surprised.

MR. SPROAT: Ward Sproat, Philadelphia Electric.

We talk about this at the subcommittee meeting in Pottstown and at that time I had a viewgraph which showed the four safety related divisions. We have a non-safety related division of DC also. And how the ECSS loads were distributed among the four divisions.

Our analyses show that we can fail, in case of our safe shut down analysis for fire, depending what transients or scenarios you want to postulate, we can safely shut down the plant with just one DC division.

MR. EBERSOLE: One DC division. Thank you.

MR. OKRENT: Any one?

MR. SPROAT: Any one.

MR. DAVIS: A second quick question.

On the room cooling dependency with RCIC and HPCI, the last thing I read about that with respect to Limerick was that you did not feel that active room cooling was required if you could open doors or something. But that you wanted to take another look at that and revise the -- or review the calculation.

Has a final conclusion been reached on that?

MR. HUGHES: I think your mixing some of the things that have been said about the NRC and some of the things that were said of ERA.

MR. DAVIS: I'll admit that, yes.

MR. HUGHES: ERA addressed itself to the

capabilities felt to exist, not capability --, capability to open the doors to achieve cooling and some analyses have been done to show that that would be effective.

In terms of current activities and current considerations, I'd like to turn to Tom Shannon, I think he can address that.

MR. SHANNON: I'm Tom Shannon of Philadelphia Electric.

In response to your question that an analysis has been complete and it has shown that forced cooling in not required for --

MR. DAVIS: Not for indefinite time or --

MR. SHANNON: We carried the analysis out to four hours but the curve for the RCIC room is very flat and we could easily extrapolate well beyond that.

MR. DAVIS: Is it possible we could take a look at that sometime? Is that included as part of the PRA or --

MR. SHANNON: No, it's a recent analysis that was just recently completed.

MR. DAVIS: This issue has come up on several other PRA's.

MR. KERR: Does someone have to hold on the door and move back and forth --

MR. SHANNON: No, sir.

Matter of fact, the analysis is very conservative and even with conservative analysis more than adequate cooling is achieved.

MR. BOYER: It does matter to have it operate lower level? -- getting some ventilation. through the ground rather than just it's lower level.

MR. SHANNON: Yes. Yes.

MR. BOYER: I think it's the physical arrangement helps in giving the natural ventilation.

MR. OKRENT: I don't consider four hours particularly a long time if after that time we might not be able to recover.

As things are going on station blackout and loss of all AC power and so forth, I would say the trend is going well beyond four -- I think the French, for example are trying for 20.

MR. FREDERICK: Larry Frederick, General Electric. If it takes you four hours to loss of DC becomes a factor, so you're only really interested in maintaining the cooling for up to four hours.

At the end of four hours, you don't have DC at --

MR. OKRENT: Well, if that doesn't really make me jump with joy either. Are you sure that you don't have -- you can't have DC after four hours because --

MR. HUGHES: May I comment here, then let's continue with the discussion of design.

Let me first address what was concluded in the ERA. ERA was done on the basis of four hours of capacity batteries and on the basis of HBCI, RCIC requiring some room cooling and enhancement of about two hours.

The enhancement was opening doors and that believed to be successful based on analyses.

The thing that was not included that I wanted to mention was the possibility of reducing BC loads such that when DC load might be expanded beyond in four hours. And it's my belief based on various discoveries that that may be a conservative number.

Let me know refer to --

MR. SPROAT: As far as the DC in concerned, with our five divisions of the DC power, our station blackout precedure, which is in the final stages of development at this time, specifically call out that if it appears that the station blackout event is going to go on for any period of time, that we do have the capability built into our system physically to cross connect DC systems.

Now there -- it's not there -- we don't have a permanently installed switch where we can close the switch and tie the two together. We found that to be a negative contributer to system reliability.

However, we do have bus bar taps available and we do have receptacles built into some of the DC distribution panels. Such that, after four hours, we can cross connect to some of the other DC divisions which would not be heavily loaded and extend the availability of DC to, say for example, the RCIC system control for an extended period of time in excess of probably eight hours. So four hours is true on a per division basis, but the actual availability of DC power of Limerick would be substantially longer than that. The power of the RCIC and some of the other DC powered systems.

MR. EBERSOLE: May I ask this question.

Is it possible as we get a better knowledge of the fallability of AC power, and thus the secondary fallability of DC, then we are simply taking in stride a given, which is just batteries, without internal energy charges, and what we should really visualize is we need some one wung chargers, the batteries to fit in to the -- a new realization of the unreliability of AC power.

MR. OKRENT: Would you tell me what you mean by a wung?

MR. EBERSOLE: An engine driven DC charger.

MR. OKRENT: I see.

With a gas turbine sitting there?

MR. EBERSOLE: No, no.

A cheap continental engine.

I hate to think that we could just stay locked into a given philosophical configuration.

MR. OKRENT: I'm proving to put a -- just a gas turbine on the site.

MR. EBERSOLE: Well it doesn't need to be that big, Dave. Your not talking about more than, what, fifty horsepower?

MR. OKRENT: I guess they felt they could get from AC --.

MR. EBERSOLE: I hate that they locked into a given -- to design, when we have a rising realization that AC power is not as good as we used to think it was.

MR. HUGHES: I think -- look forward with the presentation of the DC assessment --. It's reasonably not large, but it's certainly there. That's given a plan that has -- I think there may be some conservatism in that assessment and if there's any sort of enhancement that -- procedure or design change it or -- certainly it could be looked at in the context of where the actual risk is located in the particular scenario.

MR. EBERSOLE: Let me ask another question since it was said a while ago and you had turbine driven --

MR. HUGHES: Yes, turbine -- from RCIC.

MR. EBERSOLE: In the PRA context, could you tell me how you get steam to these HPCI turbines?

MR. HUGHES: Steam is taken from the steam line and compared to the turbine and turned --.

MR. EBERSOLE: Is that steam line fully charged with steam, it's pressure right up to the turbine stop valve at all times?

MR. HUGHES: Yes, looking at Tom Shannon's --, yes.

MR. SHANNON: Yes, that's correct.

MR. EBERSOLE: Well, then I'd like to see the PRA analysis that looks into the hypothesis that the steam line fails. You know, the classic pipe failure. And you can tell me how quickly you will intercept the flow from 1100 psi system through a 10 inch main, I guess that's the size of it. And what happens if you don't intercept it? And you have to give me the reliability of the valves under full emergency flow through a 2 inch line, their ability to close under the --, forces, and stresses.

That will be part of the PRA picture. To show me -- to show us that they will close in fact against these excessive flows. Against this, perhaps you could give us what you consider the end point of the accident in the event you don't close these 10 inch --.

MR. SHANNON: We, go ahead Gene, you want to start?

MR. HUGHES: I was going to start it by saying I believe you asked more questions in a brief period than I'm accustomed to hearing. Let me suggest that perhaps we could count on a -- from the design capability as it exists, and then after we've covered that capability, I can come back to ERA. Is that acceptable?

MR. BOYER: By the way, at 3:00 we're going to switch to size make and then we'll come back to this if that's relevant. Okay?

And there will be at least one other meeting at which we can pick up some questions, if it's more convenient to defer it. Keep that in mind always, okay?

MR. HUGHES: Would you like to defer it or
do you want to take it now?

MR. SHANNON: Well, I can perhaps provide a
brief response. I think we discussed this subject
with you at the last meeting.

MR. EBERSOLE: It's an old and dear subject.

MR. SHANNON: Yes, and what we said at that
time and I'll repeat again is as far as the valves are
concerned, okay, those valves are specified and
designed to close against the full flow conditions for
a steam line break outside containment.

MR. EBERSOLE: Have they ever been tested
against those flows?

MR. SHANNON: No, sir, they have not.

MR. EBERSOLE: And so it's a paper validated
capacity to close?

MR. SHANNON: Well, they have been tested for
normal flow conditions, if you would --

MR. EBERSOLE: Oh, yes, of course.

MR. SHANNON: -- but not for the break flow.

MR. EBERSOLE: What is the ratio of normal
to break flows?

MR. MICHELSON: Where are your --

MR. EBERSOLE: Just outboard of the valve.

MR. HUGHES: While they're responding why don't we -- less likely it is.

MR. EBERSOLE: Of course. Well, he just asked me. I defined the point. And if you want to pick another point, that's all right. Do you want to pick --

MR. HUGHES: The reason I -- the valves are straight. -- break right at the valve.

MR. EBERSOLE: Yeah, I've reminded also that the valve insight containment is installed in the reverse direction such that the flow will tend to close the valve and provide further assurance of closing. And I think that's an important point in these valves.

MR. MICHELSON: Are you saying it's a closed valve.

MR. EBERSOLE: Yes, we have just recently found that the outboard valve is likely to be a victim of the very acts that we're talking about because of environmental considerations.

MR. SHANNON: Okay.

MR. EBERSOLE: So it may -- you can scratch it because of inability to close for -- reasons one of them being environmental inability to resist the conditions associated with this failure.

MR. SHANNON: We have looked at the break outside containment and we've looked at the environment for that break and we've evaluated and qualified the valves for that environment, but that qualification does consider the fact that the valves will close.

MR. EBERSOLE: Well, shall I guess -- how does that turn out in your PRA study and what's the composite?

MR. SHANNON: Well, I'll pass that one back to Gene.

MR. HUGHES: Okay.

If you look in the PRA at the various initiating events, the possibility of pipe break outside containment was not included in -- PRA.

MR. EBERSOLE: Was not included?

MR. HUGHES: Not included.

MR. EBERSOLE: As a generic matter?

MR. HUGHES: As a generic matter.

MR. EBERSOLE: Oh, for heaven's sake. How did you not have that --

MR. HUGHES: At the time we performed the PRA, we felt that the wide -- such a break given the design and the design details, then the potential -- should be isolated -- that it would not be --

MR. EBERSOLE: So the PRA doesn't have any pipe breaks outside of containment?

MR. HUGHES: That's correct.

MR. EBERSOLE: And that would -- in '72, I think, as a kind of a thunderbolt in our business.

MR. HUGHES: Well, don't mistake the possibility of pipe break outside of containment as recognized. The possibility of pipe break is addressed by any deterministic activities of Philadelphia Electric. The question here is whether or not it should have been treated as a separate -- in the -- assessment. And it was our view that we had adequate coverage with the events that you were considered. Certainly there's been subsequent bylaws that suggest that possibly that would not divide essentially at the time. But I think the results of analyses that the Board of -- conclusion has been an -- major decision. A -- feeling is not an assessment that I can report to.

MR. EBERSOLE: Well, just yesterday we were learning a few things about pipes, for instance, a 20 inch pipe's turned into -- tubes because of -- flow of hot and cold fluids at the top and bottom. And they're pulling out anchors all over the business now. We hadn't before realized that 20 inch pipe mains could become -- tubes.

MR. HUGHES: There is a link between -- assessment and any contacts with what you know or believe to be important which you subsequently discovered based on the formalistic adoptive studies. There's certainly the possibility and it's concluded at least qualitatively as to the large -- quantitative -- to making those assessments -- One of the ways of finding -- is to offer the experience. And there are processees in place to evaluate the offered experience and to assess that. That doesn't necessarily wrap it back into the PRA however.

MR. MICHELSON: The failure though that I'm a little concerned about that you didn't include was the failure of the RHR valve on the suppression pool. There's a single valve where it enters the suppression pool. And you're using a number like one times ten to the minus eight there's a probability of rupture. And since that's exposed to hold design conditions -- I mean the design conditions of the system for full year is always pressurized, it looks like it's got a probability by your numbers of about eight or nine times ten to the minus five. Now, if that valve ruptures, there's no way to isolate this. The suppression pool dumps into the basement.

So you have to start chasing that dump

around to see what happens when you uncover the dump to see what happens when you build up hydrostatic heads at 20 or 30 feet into rooms. And I couldn't find any of this in the severe accident assessment.

MR. HUGHES: Okay.

I think the discussion of the severe accident assessment might be a possible place to cover it. But let me burst -- make sure.

MR. MICHELSON: Well, it's got to either be there or the PRA. I couldn't find it either place but maybe you could tell me where it is.

MR. HUGHES: Before we find it, let me make sure we understand it. Can you -- which valve heads are you talking about?

MR. MICHELSON: -- system has to take suction from this suppression pool. And it takes an isolation valve to keep that suction line normally isolated and particularly in the case -- it's not normally isolated but it's isolated in case of a break of the RHR pipes somewhere. However, the valve itself could also fail according to your PRA who's using a number of one times ten to the minus eight for probability of valve rupture.

So I just take that number and multiply it by 8,760 hours a year to guide me up with the ten to the minus five range -- yeah, about ten minus five -- close to ten minus eight -- and then I assume this is a core melt since you lose all engineered safety features unless you prove to me otherwise. It has a core melt without containment and without suppression also. There's no suppression -

MR. SHANNON: Can I comment on that a second.

The valves that you're talking about, I believe, are the suction valves off the suppression pool to the RHR pumps. Those pumps are contained in watertight compartments, okay. So that even given a failure of that piping, the water level would equalize into the compartments. We looked at it and there is still adequate MPSH for the balance of the ECSS pumps.

MR. MICHELSON: You have to show me now that when it equalizes -- I think it equalizes apparently around 27 feet of hydrostatic heads.

MR. SHANNON: I don't recall --

MR. MICHELSON: Your walls must be pretty good walls to take that much water head.

MR. SHANNON: That's all been considered in the analysis.

MR. MICHELSON: Ventilation ducts had better not be -- there better not be any up in that elevation.

MR. SHANNON: It's all been considered in the analysis.

MR. MICHELSON: Okay.

Then how about the uncovering of the down comers?

MR. SHANNON: That --

MR. MICHELSON: Because you've got to take -- you know, you're going to have the possibility of isolation or whatever.

MR. SHANNON: The exquenchers would still be submerged even though the down covers were --

MR. MICHELSON: The relief valve covers would still be submerged, that's right.

MR. SHANNON: And I guess the response to that would be that we're not into a local situation.

MR. MICHELSON: Well, it's not real clear to me that this has been -- I mean it should have been discussed somewhere in the SAR. I think it's a fairly significant thing.

MR. BOYER: Let Bob Schmidt comment.

MR. SCHMIDT: Bob Schmidt, NUS, Corporation.

SARA addressed this in flooding.

MR. MICHELSON: I didn't address that particular kind of ploy. It just says an RHR pipe failure would flood the room. And I admit that because I thought you were taking credit for exposing the isolation valve.

MR. SCHMIDT: No.

MR. MICHELSON: Then I wouldn't have a problem.

MR. SCHMIDT: We failed everything in the room. We checked from the design basis whether the design included that flooding. It did. You fail everything in that room, take a transient to what would be caused in the contribution to the core melt was less than one percent.

MR. MICHELSON: So your walls are designed for roughly 15 pounds of pressure then, roughly. I think it's around 30 feet of water more or less it could get. That's assuming no containment pressure -- if there's any containment pressure it would force even more water in. If it forces enough water in then you have to look at your floor slabs as well. So it depends very critically on what the containment pressure is at the same time. That's why I was worried about the down comers.

Even with the suppression feature remaining for the relief valves, you better check carefully the containment pressure because if it starts rising, of course, that's going to push the water out of the suppression pool right into the building until something finally empties. So I think it's a scenario that's worthy of -- you know, at least addressing it. And I couldn't find -- I found only the flooding. No mention of the fact that it was un-isolatable and so forth. In fact, in the flooding discussion seemed to lead me to believe that it was isolatable. That's why I thought you were still taking credit for the valves. So, okay -- I'd like to -- I really think that ought to be analyzed somewhere.

The other one that bothers me a little bit yet is a reactor water clean-up. That elevation well up in the building, the rooms for the pumps are very small cubicles. They're apparently vented to a steam chaise which is apparently the venting process. And so my question is did you take -- assume a double ended rupture of the pipe when you did the analysis of the pressure in the pump room? That's a mighty small room.

MR. SHANNON: As you mentioned, the room is vented. And it's vented out through one of the stacks, I believe. I don't recall which stacks but they are the isolation valve compartment. So in looking at the pressure, you know, it's not a concern for that compartment.

MR. MICHELSON: You did assume the full rupture of the pipe, unobstructive blow down of the reactor.

MR. SHANNON: Reactor water clean-up is what we would categorize as a high energy line and yes --

MR. MICHELSON: If there's no time for isolation as far as the pressurization of the room, I'm sure you reach equilibrium in a second.

MR. SHANNON: The -- on the suction side we have fast closing isolation valves. And on the return to -- there are check valves which isolate this --

MR. MICHELSON: Yeah, but the fast closing isolation valves are how fast?

MR. SHANNON: That I don't recall.

MR. HELWIG: Ten seconds.

MR. MICHELSON: Yeah, and that's trivial compared with the size of the room that those pumps are in. You'd have to relieve the pressure flow --

MR. SHANNON: Right, but again, the pressurization is not a concern because of the --

MR. MICHELSON: My question was and you answered it, you are using double -- full rupture of the pipe unobstructive pool.

MR. SHANNON: Yes, sir.

MR. MICHELSON: Okay, thank you.

MR. BOYER: We have seven more minutes.

MR. MICHELSON: Let me ask you another question. You've got a number here for the pipe failure of three times ten to the minus of ten per section. What is this section of pipe to your case?

MR. HUGHES: I didn't catch the question upright.

MR. MICHELSON: What is the -- what do you mean by a section of pipe?

MR. HUGHES: It means the analysis that was performed for the pipe rupture frequency was based on a combination of data and methods. And I'd like Dr. Burns to take a moment and describe how that was done. I believe it's described in one of the --

MR. MICHELSON: Well, I think I understand how it was done. I just wondered about the number. I wanted to make sure I understood what you meant by a section of pipe.

DR. BURNS: That's always a bit of confusion. Usually in WASH-1400 it can be either 1,000 or from component to component.

MR. MICHELSON: Well, I don't think you're using 1,000 feet here.

DR. BURNS: No.

MR. MICHELSON: What are you using for section pipe because it seems to be a common denominator, so to speak. Do you always talk about one section, two section, six section? And what is a section?

DR. BURNS: From T to component.

MR. MICHELSON: So it could be anything from one foot to 1,000 feet? That's strange. You're using the same probability and failure number for either a foot or 1,000 feet. That's interesting. I also notice with your probability of failure for pipe -- valves is about 33 times that of pipe per section of pipe. Does that seem reasonable with valves to have that high of a probability compared with eight, three times seven to the minus ten versus ten minus eight for rupture. That seemed a little illogical, but --

DR. BURNS: There's now a lot of data on these things.

MR. MICHELSON: Well, yeah, but you're using all this data in a rather sacred way. So I have to kind of assume that a foot of pipe from what you told me earlier, a foot pipe is -- valve is 33 times more likely to fail than a foot of pipe.

DR. BURNS: That's the way we did it, yes, sir.

MR. MICHELSON: The rupture?

DR. BURNS: Yes, sir.

MR. MICHELSON: That's interesting because that's where I begin to get concerned about the valve on the suppression pool for instance. And there's several of those.

DR. BURNS: Well, they're WASH-1400 numbers.

MR. MICHELSON: Well, you shouldn't use those unless you believe them, of course. I assume you believe them.

MR. KERR: Well, keep in my mind that initially they were asked to do a WASH-1400 type analysis to compare. I don't know what --

MR. MICHELSON: But did you use the data?

MR. KERR: I don't know. I have wondered what that meant in view of the way it was done.

MR. HUGHES: In a moment I'll show a chart and you get that data. It'll be after the break so it would rather a long -- But the WASH-1400 data was used as the fourth of four data sets. And it was used primarily for those places where other or reliable data was not found --

MR. MICHELSON: So this was the best data --

MR. HUGHES: -- that we were able to use.

MR. MICHELSON: You're thinking this was the best data available then, okay. Are we going to discuss fire later today.

MR. BOYER: Yes, five minutes.

MR. MICHELSON: Okay.

That's takes cares of my questions then for the moment.

MR. HUGHES: Okay.

I am almost to the point at getting through a portion of this. So let me attempt to cover two more charts if I may. The next chart addresses itself to human factors in the PRA. Four different types of human action were modeled. The first indicated is the initiation of systems. An example of a manual system initiated as RHH cooling and in this case the possibility of failure to perform such initiation was included in the fault trees.

The back up of automatic systems through manual initiation particularly HPCI, RCIC and other systems was included in case there was a failure of the automatic initiation signal through whatever means could be identified.

In terms of maintenance in tests, the data that was used for maintenance errors tends to show up or the data rather that was used for component failures includes those failures that were induced through undetected maintenance errors on components and subsequently tested or found to exist through subsequent tests. So we felt some comfort that the possibility of undetected maintenance error was included in the data base that we were using for component failure rates. And I think that's accurate.

Secondly, the maintenance error possibility of initiating a transient would tend to show up in the transient data which we used which was an EPRI NP 801, summary of transient experience in the industry over a number of years.

The next item --

MR. OKRENT: Excuse me, let me understand. You did not separately include maintenance errors; is that what you were saying?

MR. HUGHES: The possibility that the maintenance error that's identified exclusively as an action to be taken in response to a procedure is included. But the possibility of a maintenance error leading to taking something or failing something is -- felt to be included in the failure weight for components. If you look in the PRA for components, I'm not talking about something being out of service for me. That's a --

MR. OKRENT: No, neither am I.

So therefore --

MR. HUGHES: Let me go just a step forward. Did you look in the PRA for various components? There is the fault tree drawn to show various ways in which components could fail. That's included in the PRA as a way of identifying those various beams but they were not individually quantified because they data didn't exist for what they were. Rather we had a more global data set that was adopted for the failure of those various components from any of those causes.

MR. OKRENT: All right.

Again, then -- so if maintenance there is -- were reflected in your data they were there and if not, they weren't?

MR. HUGHES: Correct.

MR. OKRENT: Okay.

MR. HUGHES: The repair of failed systems, there are two examples shown. Repair was included where we felt there was adequate time to perform it. In the case of RHR, we have a rather long time available for performing repair. So an exponential repair model was developed. In the case of recovery of AC power, it was not a model, it was data. And that data was applied to the probability or frequency rather loss sight power loss of increasing durations.

The last items shown are operator intervention some of which are sometimes called errors of commission. Here again there are some possible errors of commission that are implicit in failure rates, implicit in initiating events or in some of the maintenance errors that might have led to the types of things that are in the data.

We can't claim that we have a complete treatment of errors of commission. We did include the possibility of operator error wherever a procedure was being followed or wherever the likelihood of an action was felt to be sufficient that it'd be included. The particular one that's not included is the likelihood of the operator just completely misses the boat and heads down the wrong path taking wrong actions. And I think this is fairly common.

MR. OKRENT: Well, you know --

MR. HUGHES: It's fairly common treatment in PRA's.

MR. BOYER: The newer ones are trying to deal with this.

MR. HUGHES: The next chart shows some examples of operator actions that were explicitly modeled. The first two, recovery of feedwater and reopening MSIV's have rather clear procedures. And these are steps that would be taken. The next item, the manual control of HPCI and RCIC is to reduce the cycling which would occur. They systems would come on on low level, build a vessel to high level trip off and recycle. So we included the possibility that manual control would be taken. And this would then alleviate the need for restart. Manual depressurization with many backup valves and the other items that are shown on the chart were included.

I'm looking to the back of the room and to the right. And I appear to be at exactly 3:00. I'll put this chart back up when I return. And at this point, I'll turn to Bob Schmidt who will discuss the external events.

MR. MICHELSON: Could I ask you a couple of questions before you do that?

MR. OKRENT: Only if they take less than one minute.

MR. MICHELSON: The questions will take less than one minute.

MR. OKRENT: Go ahead.

MR. MICHELSON: Well, the first thing, I was very surprised that you said you didn't handle pipe breaks outside of containment because I thought I read a quite bit about pipe breaks outside of containment. And the particular one that I read that I had -- wanted to ask you a couple of questions was about the steam system pipe work and -- as you call it on page 5-33.

You discounted this particular event on the basis that GE had done a PRA on the event and came up with a very low number. And if you go back and look at the NETO document that's documented this event, I think you'll find that GE took credit for the environmental qualification of all the equipment outside of containment for atmospheric pressure at 212 degrees, 100 percent humidity. And I'm wondering, is that what Limerick is going to qualify their equipment for since that's the document you cited as the basis for your discounting the event?

MR. SHANNON: I believe the resolution to that for Limerick was that based on the GE document that the probability of that occurrence was so low that it was outside the design basis.

MR. MICHELSON: Yeah, but that's on the assumption that the equipment is qualified for 100 percent humidity, 212 degrees condensing atmosphere, atmospheric pressure. And are those the qualifications that you have on your equipment? If they are, then the NETO document applies. If they're not, then some other argument applies.

MR. SHANNON: Okay.

You're saying more than I'm aware of.

MR. MICHELSON: Well, it's in the document.

MR. BOYER: Yes, he's talking about the equipment for qualification, what was the specification on this Illinois valves and other things there -- down there --

MR. MICHELSON: All equipment, switchgear, whatever that gets fumigated by the affluent from this break.

MR. OKRENT: I'm going to suggest that that be the first thing we come back to when we leave external events, okay. So keep it in mind. And -- will give you time to look up whatever you want -- start with size length.

MR. BOYER: Right.

MR. OKRENT: And start with size length.

MR. BOYER: You're -- up to hear size length first.

MR. SCHMIDT: Are you getting something for this?

MR. MICHELSON: While you're getting ready, are you using a handout? The book you gave us is a part of your presentation? I'd like to know where to find my way into the book.

MR. SCHMIDT: Yeah, I didn't bring any cover and external events.

MR. OKRENT: Fire away.

MR. SCHMIDT: One brief word before I get into seismic. These are the events that were covered in SARA and I will talk more about finders later. Seems the directions are switch directly to seismic and I'll have to find my new address.

MR. OKRENT: Page 10

MR. SCHMIDT: First of all, let me indicate the first part of the presentation, the part showing in the agenda under external events was to discuss what we did in SARA. Later on in the presentation in response to a question to discuss seismic margins, we had inserted some analysis of seismic margins. Those are being lumped together now. And so the view graphs are in two different parts of the notebook.

The first part is really to discuss the methodology and results of the seismic risk assessment work done in SARA? The overall approach first included a hazard analysis of frequency exceeds of flective peak acceleration.

Fragility analysis, which is the probability of failure given for a acceleration system analysis where we put the model of the plant together as impacted by the seismic event, and then quantify that to come up with an overall frequency of more damage of various types to input into the overall core damage frequency and into the off site consequences.

The overall methodology used in the seismic hazard analysis was to first divide the region of the country where the plant is located into a number of seismic -- zones are representation of the region as they -- might effect the plant is, the different representations of how earthquakes really effects the plant and their sources. It is therefore a source region which may encompass the side or may not.

The -- based on -- this is based on basically expert opinion. Our consultant developed these. Based on this information and then for each donation then, historical data was used to obtain a magnitude versus frequency relationships of that zone. In each zone, the likelihood of earthquakes of a given magnitude presume to be uniform in that region.

Next step is to get -- convert the magnitude to acceleration at the plant concerning the distance from the site, and these will be done for various magnitude of earthquakes of a distance. These then are combined to produce the acceleration versus frequency curve, which is the basic input into the analysis. There will be result for each one of the potential hypothesis that will be incurred.

MR. OKRENT: Excuse me, does any of your zones include magnitude eight?

MR. SCHMIDT: Any of the zones include magnitude eight? No.

MR. OKRENT: Because your prior view graph suggested that. Okay.

MR. SCHMIDT: This is the result of the analysis that was done approximately two and a half years ago in the frequency of exceeds on various accelerations. They have six curves on here. There were four representations, four different zonations of the region. Two of those, they were alternative maximum magnitude earthquakes considered and one that was six curve.

Each of these curves represents a -- they're given a weighting factor, and these weighting factor represents a judgment as to the likelihood of that representation. So we have a very large spread of likelihoods. The very large earthquake, what's called the Coleman Dome, the height or the potential for large magnitude, high frequency and high acceleration earthquakes. The others don't give that.

The -- to get into the -- analysis, these weights represent basically a distribution on belief of the uncertainty that the frequency of various accelerations.

MR. BOYER: Excuse me.

MR. SCHMIDT: As you observed in an earlier part of the presentation, there's a very wide frequency on the likelihood of more damage due to earthquakes. And the reason is because of this very large magnitude.

MR. TRIFUNIAC: Before you take this up, can I ask a question. Curve six and I believe five continue to grow in the continuous manner -- while the rest of the curves like four and three and one and two lead to constant level. And I wonder if you could state why that is the case? Like for example, take six. It just comes to point eight. It stops right there.

MR. SCHMIDT: I'm going to ask one of my associates in the middle of the road. I'm sure you're familiar with will address this is Bob Kennedy or Robin McGuire.

MR. KENNEDY: Bob Kennedy, SMA. Basically, the reason for upper bound truncations on effective ground acceleration are based upon in each of these zones, an upper bound has been placed on the modified mercallian intensity. I'll let Robin McGuire discuss the upper bounds on modified mercallian intensity.

But if you start with an upper bound on modified mercallian intensity, the intensity scale is a damaged scale. It's an indicator of damage. These effective ground accelerations are being used in the PRA as damaged indicators. These are the accelerations to which we anchor our damage predictions or our fragilities.

Therefore, there has to be a correlation between the modified mercallian intensity and the effective ground motion because they both are damaged indicators. And what has been used here is for any given intensity zone is to do side analytical studies of what ground motion would predict the kind of dampen. For what ground motion would you predict the kind of damage that that intensity is defined in terms of.

And then to take the highest ground motion that might lead to that little of damage. For instance, in an intensity nine, what was done was to predict the damage associated with intensity 10 on the intensity scale, and take the upper level of ground accelerations that would be consistent with intensity 10 and use those as an upper bound on intensity nine.

Similarly for eight, predict the highest ground motion that would be consistent with the damaged scale for intensity nine, and use that as a upper bound on eight. And that was done consistently to arrive at these upper truncations on effective ground motion to keep these curves consistent with their use.

Robin, do you want to answer anything on the intensities?

MR. MC GUIRE: I'll just -- Robin McGuire, consultant to Philadelphia Electric.

The upper bounds on magnitudes and the consistent upper bounds on intensity were judged at the time to be reasonable upper bounds for the zones conditional, and the zones being the proper explanation of techtonics in the eastern U.S. And that represents an estimate on the upper bound, the earthquakes which can occur which are then translated to an upper bound on effective ground motion as Dr. Kennedy discussed.

DR. MARK: There are half a dozen zones --

MR. OKRENT: Well, wait, of course if you let Mike --

DR. MARK: I'm sorry, Mike.

MR. TRIFUNIAC: If I don't question the intensities -- if I accept the intensities as an absolute -- well, I'll just do that. I expect a various distribution -- given that intensity. Are you plancating that distribution, because maybe this is just a drafting thing, but these lines get to be hurting on these bounds.

MR. KENNEDY: Bob Kennedy, SMA, again.

Basically, for a given intensity there is a distribution on acceleration. These cut-offs on a acceleration are an upper bound truncation of that distribution. Now, in more recent PRA's, you won't see these almost vertical line drop-offs because it's done more sophisticated at this time than back at the time where the Limerick occurs.

But they still would -- they would drop off -- actually, in fact, these curves would tend to be somewhat on the conservative side because they allow you to go up to that truncation level as if there was no effect of an upper bound, and then tend to truncade over.

So that what we're saying, for an intensity nine earthquake, if it's truly an intensity nine earthquake at the site, the effective ground acceleration would not be in excess of .8G.

MR. TRIFUNIAC: And the probability of .81G is zero.

MR. KENNEDY: The truncations are a determistic truncation, yes. But they're considerably above any kind of expected ground acceleration for that intensity range.

MR. TRIFUNIAC: Thank you.

MR. OKRENT: Paul?

DR. MARK: You mentioned have a dozen seismic zones. They have a geographical boundary, I presume or at least one was assigned to them. Could you just say a word about the range of opinion that might go with the assignment of those boundaries?

MR. MC GUIRE: At the time we did the study, we thought they represented a reasonable range of opinion on seismic zones for the purpose of calculating seismic hazard at Limerick in that they represented very small zones in some cases and one big large zone in another case.

And since that time, many more hypotheses have been proposed in seismic zonation in the eastern U.S. And of course, they don't consider those hypothesis.

DR. MARK: Okay.

So someone else doing this could really make a different composed curve by having drawn those boundaries differently?

MR. MC GUIRE: Yes, sir.

MR. OKRENT: Robin, some years ago I think when you were with the USDS yet, you did studies of intensity versus frequency for the eastern U.S. taking various plausible zonation stands. Do you recall that work?

MR. MC GUIRE: Yes, sir.

MR. OKRENT: What has yielded results that were about the same on the average as what was used in this report for this site.

MR. MC GUIRE: I think the major difference is that that study was done on the basis of frequencies of an exceedance of an intensity rather than ground acceleration and would not reflect any truncation of ground motion.

With that proviso though, I think they would be reasonably similar.

MR. TRIFUNIAC: Would you explain that what you just said a little more precisely? I thought you used the word frequency of occurence of intensities.

MR. MC GUIRE: Frequencies of exceedance of intensities at a given sight. In no way were those truncated in the intensity study. If we in some way tried to account for that and make a translation between intensities and accelerations with this study, we might find similar results I would expect.

MR. TRIFUNIAC: If you use any relation to the -- wouldn't that distribution of -- curves over because it would be a long zero probability of whatever you told the largest -- so you would have to involve that with explanation.

MR. MC GUIRE: I'm sorry, I don't understand the question.

MR. TRIFUNIAC: Well, I understood you to answer that there would be no difference, much difference, significantly between the way things were conduct here and if it will be used in previous results. Did understand that correctly?

MR. MC GUIRE: With the previso that you understand that there is a truncation in one case and no truncation in another.

MR. TRIFUNIAC: Right. Well these are just the one truncation and this back up for this truncations.

MR. MC GUIRE: That's correct.

MR. TRIFUNIAC: So if you were to use your distribution results with intensities and what were those accellerations?

MR. MC GUIRE: If I put a truncation in that conversion I expect they would bend over, yes.

MR. TRIFUNIAC: But I thought that you said that there would be no difference if you did not do that.

MR. MC GUIRE: If I did not put truncation in these curves, I'd expect there to be not much difference also, yes.

MR. OKRENT: Could I ask, are you the author of the truncation for this or is this something that you were given?

MR. MC GUIRE: Bob Kennedy and I worked on the truncation together and tried to come up with some reasonably way to estimate that truncation.

MR. OKRENT: Why is it that when you did that earlier study, you felt it plausible not to truncate and now you do. Is there some physics that you have good knowledge of regarding the stresses and the sizes and breaks and so forth that can occur that say truncation and in fact is clear there, or you just can't get a larger earthquake or what is it?

MR. MC GUIRE: I think the issue in the original study was to estimate frequencies of exceedance at an intensity with no specific application.

MR. TRIFUNIAC: Isn't that the same objective that you have here?

MR. MC GUIRE: No, we're estimating effect to frequency of exceedance of effective peak acceleration with specific application.

MR. TRIFUNIAC: What is the physical difference?

MR. MC GUIRE: In one case, you're estimating intensities and in other cases you're estimating effective peak accelerations.

MR. TRIFUNIAC: Yeah, but why truncate just because in one case you do in one and not the other? I'm trying to understand the reason for the truncation and not the other.

MR. MC GUIRE: My understanding and my recollection is that the reason we examine truncation for this study was in the application of the curves to estimate structural response for the PRA.

MR. TRIFUNIAC: But that's the same thing that the previous --

MR. KENNEDY: Bob Kennedy of SMA. I think a wide number of people involved in the review and evaluation of structures and equipments' performance in past earthquakes believe rather strongly that there is no indication that the damage of structures and equipment keep going up as you get closer and closer to the epicenter without truncation. I think that a wide body of evidence is that damage levels tend to reach a certain level and do not continue to go up as you get closer and closer to the epicenters, which instrumental accelerations do seem to go up.

So there's a strong belief that there tends to be upper levels to the damage effective ground motion as opposed to instrumental ground motion. And this was an attempt to take that into account. It is based on making upper bound estimates on intensity, and if you belief that those upper bound estimates on intensity of the ground motion could be exceeded, if those upper bound intensities could be exceeded, then these truncations of acceleration could be as exceeded as well.

So the question really boils down to whether you do or do not believe these represents upper bounds on intensity for these zonations. If they do, I think there is upper bounds on damage effective ground motion.

MR. OKRENT: I guess that I understand something you said, Dr. Kennedy, if -- I'm saying if in the vicinity of an epicenter, you indeed did get repetitive larger acceleration. In other words, suppose you got 10 cycles at 1G instead of 10 cycles at .4G, would you not as an engineer expect greater damage?

MR. KENNEDY: I would certainly expect greater damage from 10 cycles of 1G gramotion than from 10 cycles of .4G gramotion.

MR. OKRENT: You're not telling me that that's what's been observed. What is it that's been observed?

MR. KENNEDY: It's been observed that from the earthquakes that we've observed, it's been observed that the damage at half -- the damage from shaking a half kilometer from the epicenter really is no worse than the damage for a five kilometers from the epicenter. That the damage doesn't seem to increase.

We see hicher instrumental peak accelerations close, but we see not as many repeatable peaks.

MR. OKRENT: Well, all right.

It's a different phenomena to which you're referring. I think it really gets around. I don't consider your comment a direct response to the question of on what basis does one truncate, because if you didn't truncate you would have either higher intensities or higher magnitudes or whatever. And these would led you to the possibility of larger effective accelerations and therefore greater damage.

MR. KENNEDY: If you did not truncate the intensity as is shown on this field graph, you would have a potential for higher effective accelerations than is shown on this view graph. The effective acceleration is a direct result of truncation of intensities. So if there is a belief that these zones could produce higher intensity earthquakes than these upper bounds, then you'd have to also say that they could produce higher effective ground acceleration than these bounds.

MR. OKRENT: By the way, you have a chance, I assume, to review the comment that Professor Kafka who was a consultant at BNL. Do you have any comments on those? They're given in Nureg CR 3493 at the back.

MR. KENNEDY: Those are really seismological comments so that Robin should answer that.

MR. OKRENT: I agree.

I'm just wondering that if he were in Professor Kafka's shoes, he might not have made the same comments really.

MR. MC GUIRE: Well, I think some of

Professor Kafka's comments are well taken. I think in substance, there's not a lot of argument as to the work we've done. There's some argument as to the style in which it's presented.

MR. OKRENT: Well, I wouldn't put it quite so innocently if I'd been you. Use an adjective. He says some things about the choice of waiting for your different hypotheses, for example. And in other words, I would hardly say he supports a choice of waiting where 60 percent weight is given to marvels that lead to less than magnitude six, for example. I wouldn't lead that in a comment.

I wouldn't -- Professor -- Dr. Pomeroy has given us some comments which I would say reflect similar tenure, and a little more expert again, as similar results that tend to predict more motion at the same frequency or however you want to say it than the study and the Limerick TRA is predicting now.

This is clearly not a science, and so it's not surprising that different experts differ. In fact, a little more study will show that the different experts differ. But the weight of their experts and the comments that one has here all lie on one side of what is proposed in the Limerick PRA which sort of makes, suggests that it's near a lower end of what experts might predict for this sight.

Am I wrong?

MR. MC GUIRE: Well, I think that we should recognize two things. One, there is a difference in methodology in some aspects between the Larsmore Study and this one. In particular, on the philosophy where ground motion truncation should be put into the process.

Second, some of the comments by Dr. Kafka and Dr. Pomeroy and the staff are in conflict. Some of the issues raised by Dr. Kafka are not raised by the staff. In fact, the opposite view is supported by the staff. So there's some inconsistencies in those statements. That, as you say, is part of the argument of the science.

MR. OKRENT: Again, you know, if the staff has more than one result and it will be impossible for them to all agree, right?

MR. KENNEDY: Bob Kennedy, SMA. I'd like to make a comment on the comment that these intended to be that these for Limerick tended to be on the low side of what some other experts might produce. Having participated in quite a few different PRA's, I can assure you that it's very easy to find experts in the seismic hazard area who predict substantially lower hazard curves than Robin McGuire does.

In fact, people who've been involved in these PRA's, Robin McGuire has tended to predict higher than many others. So you can find experts who will give you higher hazard curves but you can find an equal number of experts who will give you substantially lower hazard curves.

MR. OKRENT: Without taking an involvement of McGuire, I don't know which Robin McGuire we're talking today.

No, I think he has given different predictions sort of at different times under different circumstances for similar areas. And they all are clausible. It's hard to say that one is right.

MR. MC GUIRE: Let me point out that these curves were produced about three years ago. The state of the art is evolving rapidly. So is my experience. And given the task again, I would not privy these same curves.

MR. TRIFUNIAC: Are they larger or smaller?

MR. MC GUIRE: They would probably tend to be a bit higher.

MR. OKRENT: Any cther questions?

MR. TRIFUNIAC: I have a question that follows this question. Before you get these two fragilities, you have to take some spectra to multiple those with. Now, --

MR. KERR: Dr. Trifuniac, I can barely hear you. I don't know if it's the mike or what.

MR. TRIFUNIAC: I was just asking is what spectra these approximations are multiplied into to go into the next stage of the analysis.

MR. KENNEDY: Bob Kennedy, SMA. At the time Limerick was done, what we used, we used these effective peak acceleration hazard curves as an acre to a medium spectra for rock site as generated by Newmark. The medium spectra for rock sites has spectral amplifications less than ray guide 1.6. O because ray guide 1.60 is intended to be an 84 percent nonexceedance probability spectra.

Now, in addition to taking the medium spectra for rock sites, we do take uncertainties in spectra amplifications into account. And so we took into account the fact that amplifications could -- had a 50 percent probability of being higher than those mediums and a 50 percent probability of being lower. We established logrithmic standard deviation on spectra amplification.

But the 50 percent spectra were Newmark rock sites medium spectrum.

MR. TRIFUNIAC: Those Newmark 50 percent rock medium spectra, were those developed by using whatever you consider to be the meaning of effective -- or would they develop something else.

MR. KENNEDY: Newmark in his original development of his spectra used earthquake records that had several significant peaks. So that for the records that Newmark used, I would believe that effective peak acceleration and instrumental peak acceleration would tend to be the same.

In fact, our definition at Limerick for effective peak acceleration was 1.32 times sustained peak acceleration using Nutley's definition of sustained peak acceleration. But a 1.23 factor was arrived at from reviewing a number of record earthquakes with Richter magnitudes from about six to seven, and finding that with that magnitude range on Richter magnitudes, that the average ratio between instrumental acceleration and Nutley's sustained acceleration was approximately 1.23.

So for earthquakes with the Richter magnitude range, sustained peak -- sustained based peak of 1.23 times Nutley sustained and instrumental are essentially the same. As you get to lower magnitudes, the difference widens.

So we believe that the Newmark medium spectra are appropriately anchored to these sustained based peak values. In fact, in some very more recent effective ground motion work that I have done, I have found that you could considerably lower the uncertainties in spectra if the spectra had been -- in the original place, had been anchored to a sustained based peak rather than an instrumental peak.

You get must better correlation on spectra shape when you anchor spectra to sustain base peaks, than when you anchor it to instrumental. And I think that this was done consistently.

MR. TRIFUNIAC: I understand the question. Can you answer my question?

My question was again the Newmark specs were the development of this type of finish for the peak scaling.

MR. KENNEDY: The Newmark specs were developed anchored to instrumental acceleration but they were developed for earthquake magnitudes which are somewhat larger than these magnitudes and we've gone back and shown that you can take the 1.23 times the sustained base peaks or the sustained peak accelerations and they are essentially equivalent to instrumental accelerations. Peaks that Robin developed here developed on that basis.

They are 1.23 times -- sustained acceleration.

MR. SCHMIDT: The next step in the analysis is to develop fragility curves or to basically represent the conditional failure probability due to earthquakes. Structures and components in the plant vary sizably -- modes of failure.

Based on design analysis for -- considering the margins of failure, consider margins of strength, -- , structural and equipment response which results in a set of lognormal curves which include the randomness carrier probability and the uncertainty in the exact value. It occurs like this and you add acceleration, conditional probability failure given the acceleration represented by median fragility or the possibility of failure is 25 and this is a term of value to quote. The shape of the curve, the randomness is the shape here and then the certainty which gives us a breadth across here.

Some of the fragility results from Limerick that are -- are important in the analysis are shown here with their median fragility. First, the loss of offsite power, which is failure of ceramic insulators at approximately .2 g. This is important because it results in loss of offsite power at a very low acceleration.

The next one, and really he's talking about these, because these are the ones that seems to dominate the contribution formula or the risk. They're significant ones that we looked at, aside looking at all of them, these are ones that stand out. Reactor internals where the potential here is for binding of the control rods due to shroud support failure.

So there's potential here for loss -- but when -- .167 g. The shear wall of the reactor to the control enclosure which leads to failure of all the equipment in the building, and that's an assumption, that there's failure because the heat exchanger is supported from the wall, RHR heat exchanger, if it falls we assume that the RHR suction piping, which is connected to the suppression pool, fails. The pool is then drained and now you have a direct connection from the containment to the building into the atmosphere.

It occurs at approximately 1g. Had a lot of PD failure --

MR. MICHELSON: I thought a few moments ago, though, I was assured that that's a still "I know, never mind," because it won't be in more than one room. Are you postulating here more than one heat exchanger falling?

MR. SCHMIDT: We have taken both of them falling in this case. The feeling was that these would both have a high life but if given one would fail, the other one would. It's more than a "No, never mind" here because the building failure also caused a loss of all make up to the reactors. So we have an accident. In the other case there's no accident. The leaking in the RHR line does not create a transient all by itself.

MR. OKRENT: This was analyzed specifically for Limerick? Item 3?

MR. SCHMIDT: The shear wall?

MR. OKRENT: Yeah. In detail?

MR. SCHMIDT: Yes. The design analysis was looked at by SMA and came to the conclusion as to the fragility. And that review was indeed commented on by Brookhaven.

Bob, do you have a comment?

MR. KENNEDY: Bob Kennedy, SMA.

This is a plant-specific fragility estimate. Yes, it is based upon a detailed review of the deterministic design analyses and an estimate for each of the parameters that go into that analysis of the factor of conservatism associated with that parameter and the uncertainty associated with that parameter.

This is a ground motion level that we believe would correspond to substantial distress in this building. I don't believe it corresponds to collapse of the building but I don't think that we could estimate what this building would do beyond this point. So I'd call it substantial distress or substantial structural degradation.

And it's a conversatism on PRA's that that failure is then assumed to result in failure of all equipment located within the building.

MR. SCHMIDT: When I get to the systems analysis part we'll see that the ventry which would highlight that assumption.

MR. KENNEDY: And on this particular fragility SMA estimated that the fragility was 1.05 g. The reviewer estimated that the fragility was .95 g. In my judgment, in the ability to estimate fragilities, those are the same numbers and that's why the viewgraph shows it as 1.0 g.

MR. SCHMIDT: The next one on the list is RPV failure where failure of the upper vessel supports the curve, and the vessel starts moving. This was assumed, looking at the design, to lead to failure of the steam lines because of their restraints up to this area and the -- 1.25 g. This is based on the Limerick specific analysis as is these three in the middle. They are all Limerick specific analysis.

The last item on the list here, onsite AC/DC power. These are failure of various electrical components. AC and DC buses can switch gear with several of them, 1.46DB is the capacity, however.

This is based, in SARA, on a generic fragility, generic analysis, are in some cases based on Susquehanna information. You mentioned that Limerick, the RER cited Susquehanna. It did not cite, to my knowledge, Susquehanna PRA. It cited Susquehanna information. It so happens that our consultants had some of the Susquehanna information. The support packages of seismic qualification data for Susquehanna was completed at the time that this work was going on.

However, from Limerick it was not. The plans designed by the same AE, or assembly area, we use this kind of information to develop the generic -- or to help support the fragilities where there was not specific Limerick information available because of the time of the project.

Later on we'll talk about the updating of that.

MR. OKRENT: Before you leave that viewgraph, in the new reg VRF 3493 is, I'm sure you're well aware, Brookhaven goes through a variety of components up 'til then and in some cases is in close agreement as you just indicated, the .9 to 1.05.

In other cases they have open questions. Have you reviewed all of this in some way or written a technical response which in your opinion deals with each of these matters or where do those matters stand? The date of the document is July, '84. It's fairly recent. I just have not followed -- it may have been submitted since.

MR. KENNEDY: Bob Kennedy, SMA.

We've reviewed that document very carefully. We have not submitted any written responses. But as you'll see later today when we get to the seismic margin issue we have updated a number of these fragilities that Brookhaven discussed on electrical equipment.

Primarily the reason they're open items is most of those fragilities on Limerick electrical equipment were based upon either generic data or Susquehanna SPURT package data. Because the data simply didn't exist for Limerick at the time the seismic PRA was done. The data does exist now for Limerick.

And in the seismic margin review we have updated fragility estimates for many of those electrical inactive equipment but we have not responded in writing. It turns out that the updated fragilities in most cases are higher than the generic ones. There are a few exceptions to that to where they are lower than the previous generic ones.

There is no case that the updated fragilities are significantly lower. There are cases where the updated fragilities are significantly higher.

MR. OKRENT: Let's say with regard to switchgear you show a rather substantial fragility. Are they vulnerable to -- or is the action of switchgear vulnerable to relay action?

MR. KENNEDY: This value that is shown is a median value. And the value that is shown is associated with relay chatter. That is the failure mode in the SPURT packages on Susquehanna. It is a median value and in the case of AC/DC power, median values, I think, are somewhat misleading. There is very large uncertainties on these median values to where the high confidence of low probability values can be substantially lower than that.

And when we get into the margins issue I'll show you relay chatter associated with -- fragilities associated with relay chatter data and fragilities associated with nonrecoverable failure modes, i.e., would make this equipment nonfunctional even after the earthquake ended.

And so I think maybe you can answer that question a lot better when we get to the margins issue.

MR. OKRENT: Okay.

I must confess it's not clear to me that median value for equipment which is used, or tentatively in the plant in an acceptable way to go because if, for example, you had 20 components and 17 of them failed at the fragility of 5 and 3 of them which happened to be in a cutback failed at .5, okay? The median would be very large indeed but the vulnerability would be large, the effective fragility would be small. So I'm not willing to buy at face value a median value in that situation.

One last question in this area, you don't have to answer it today, but sometime before we finish this review of the TRA I would like to know just which components or subcomponents or sub-subcomponents of interest have not been modeled in what's been done so that they're really an out and out assumption as to what their fragility is. I mean, for example, if a diesel were vulnerable to lubrication as it would be and this had not been included in what you did, you looked at the basic structure and so forth, then you would say we've looked at the diesel but there are some parts here which if they failed could lose a diesel if they're not included in what we've done.

Right now I've not seen anything that resembles even a partial list so that one has a feel for what is covered in here, in this analysis, and what is really left out.

MR. KENNEDY: Well, in our detailed fragility reports, which get quite long, unfortunately, we don't have enough detail in on any individual item of equipment because there's so many items of equipment, in those reports we try to describe exactly how we arrived at each individual fragility: whether it's generic data, whether it's past earthquake experience data, or whether it's plant-specific data.

Now, in each of the failure modes you've talked about we have given fragility data. We have certainly given fragility data associated with --

Coolers on diesel generators. That's often one of the governing things for diesel generators.

MR. OKRENT: Well, I cited it because I knew one failed in tests in Japan, so it was a good example.

MR. KENNEDY: We give fragility data on relay chatter. The fragility data that we give on relay chatter is almost always generic. The exception to that being Limerick Seismic Margin Review, we do have plant-specific relay chatter data on a few components, a few.

Relay chatter is a tough area for seismic PRA's. The big question is can you survive relay chatter or not? Does relay chatter really lead to circuit breaker trip or not? There is fragility data for relay chatter. It is generally assumed in seismic PRA's that you're recoverable from relay chatter.

Obviously, as I've indicated before, current seismic PRA's do not account for the effect of gross or large construction errors. And gross and large construction errors could change the results.

There's conservatisms and unconservatisms scattered throughout a seismic PRA. The biggest conservatism being assuming that when a building reaches strong structural distress every piece of equipment fails in it. Another conversatism being that if you have five pumps that are redundant pumps located approximately at the same location and roughly the same manufacturer, you assume all five pumps fail concurrently. You take no advantage of the seismic PRA of redundancy.

So those are some conservatisms and unconservatisms, probably the biggest one being relay chatter and construction errors.

MR. OKRENT: Well, again, I would find it of some interest when next we met, if that's possible, a note is included in the current fragility.

MR. SCHMIDT: Let me maybe point out that in the giving the SMA a list of equipment to consider we took the PRA that existed and went through all of the fault trees and identified equipment that were considered in there, added additional equipment that was in certain failures were not considered in the PRA provided, that SMA through either Limerick's specific analysis, through generic analysis, or some surrogate plan, developed fragilities for all these components.

These are what was at the end of systems analysis. There was a lot of components. Now you get into the question of boundaries and does the diesel generator fragility include some of the supporting systems on it or not? And these are detailed.

Let me turn then to the plant modeling, the systems analysis. The plant model, a seismic event tree was developed based on loss of starting using loss of offsite power tree with a front end modification. We'll see it in a minute. And fault trees were developed where the seismic failures were added as appropriate. And I have examples of each of those and I think they're important.

Certainly the seismic event tree showing some of the conservatism throughout the seismic event and the first question, the first issue, is where the vessel fails. The vessel is considered to fail when you get a large LOCA beyond capability, many emergency core cooling systems leading directly to core damage.

If it doesn't fail we go to the reactor building and have basically the same assumption with a split here for whether the rods go in or not. It was our concern at the beginning of the analysis does the failure to scram or not make the accident more severe from a consequence standpoint. These two both lead to core damage.

And then we go into an offsite power question where both of these then go to if it fails, the question of lost offsite power and we use the loss of offsite power tree developed for the internal PRA's. And you conclude all the rigor of the internal advance PRA in loss of offsite power assessment for that with the exception of recovery of offsite power which we do not assume is possible in a seismic event.

We recognize on here we have not events that this is RPD detailing here, this branch is that RPD does not fail and those are included in the analysis. So we don't wind up double counting.

The failures of systems, once we get in past the initial failures of the vessel and the reactor building, we input failures of a system using the internal event fault tree modified for seismic events, piping failures. This is an example of an -- system simplified to the degree where we have random failures, combination of random and seismic -- failures and seismic failures. Carry that down to varying steps throughout the whole thing.

This leads us to write a failure probability equation or Boolean equation which combine random failure and seismic induced failure which you then combine the overall analysis with the event tree to do the quantification. So you do have the same formalism of the definition of sequences including the Boolean expression, seismic failures are written as a function of acceleration, combined with random failures which are independent of acceleration and integrating over the entire acceleration range to get the overall frequency of seismic -- damages.

MR. POWERS: In doing these analyses do you take into account things that might be important for the source term? Like enhanced leakage between the drywell and the wetwell that bypasses this suppression pool?

MR. SCHMIDT: That particular one is not included except that, for example, the building failure did lead to containment failure. So that's a certain one. The other things that cause similar things like that is the increased leakage to the diaphragm floor in particular was not considered to be a structural failure. Or the lining pulling away from it, that kind of detail was not --

The results, if they you'd rather look at pie charts, are numbers and they're not in focus. This is the mean result for Limerick seismic contribution to core damage was approximately six minus six. The major contribution was loss of offsite all AC, which is the TsEsUX sequence in which Ts is a seismic amount; Es is loss of offsite power due to the ceramic failure which occurs at a median of .2g; UX, then, is failure of the electrical components in a plant due to seismic events which leads to a nonrecoverable loss of power and no makeup to the reactor and therefore a core melt. Called also a Class 1 accident.

The next contributor is called TsRb which is a seismic event caused by failure of the reactor building leading to core damage, vessel failure, and many Class 4 type accidents -- where we have the failure of the rods to insert in -- control system. It's at the overall -- is six times ten to the minus six.

Now, you'll see a little bit later -- in fact, pretty soon now as we go on with this, there has been some re-analysis done, not to revise SARA but looking at some of the explicit fragilities which were based on generic information -- some changes in these numbers of these contributions.

That basically concludes the main part of the presentation on seismic -- .

MR. DIEDERICH: Okay.

I suggest we take a break at this time then we'll go on with your margins and then fire and then, in order to make sure that we get to it today, I'd like to make up a containment analysis and how the containment behaves as you see it in various degrees of core accidents. I'd like to make sure we talked about it today, okay?

And then other things as we have time, all right?

MR. SCHMIDT: All right. Fine.

MR. KENNEDY: My name is Bob Kennedy -- Mechanic Associates. Both myself and Bob Schmidt will be discussing this seismic margins issue.

Essentially the seismic PRA results have been revisited to see what comments could be made concerning the seismic margin of Limerick. The purpose of this revisitation of the seismic PRA results and the seismic margin review were to address using the seismic PRA techniques to attempt to quantify the capability of Limerick to withstand seismic events greater that the SSE level.

Three different types of quantification were considered. First of all, to try to quantify what ground motion levels corresponded to high confidence of low probability of failure of structures and equipment.

Secondly, to determine the ground motion level which corresponds to high confidence of low probability of floor damage and activity releases.

And third, to try to quantify the ground motion level which presents a small contribution to seismic -- damage and seismic induced public risk.

Now all three of these goals do depend on the development of seismic fragilities. The development of seismic fragilities is a fairly new area. The method that was used on Limerick is that which is consistent with the techniques described in NUREG CR 2300, this PRA guide, consistent with the techniques that have been used on five other PRA's which have undergone NRC review. And the techniques are described in a large number of different technical papers presented at various technical conferences, NRC workshops and in technical journals.

For Limerick, the fragilities that were generated for Limerick were a combination of plant-specific fragilities using plant-specific data together with generic data.

In the original Limerick PRA there was quite a bit of generic data because of the time the PRA occurred relative to the time that some of the equipment qualification work was done.

The Limerick PRA has been reviewed by the NRC staff in the seismic portion by Brookhaven and by Jack Benjamin and Associates.

Since the Limerick PRA was seismic PRA was completed and in addressing the seismic margin issue, there's been an effort to go back and update some of the fragilities in the original Limerick seismic PRA, update them basically to use more plant-specific data and less generic data.

Now as part of this seismic margin review, there have been sensitivity studies conducted to see how sensitive the end risk numbers are to various areas of uncertainly and controversy. In particular, sensitivity studies have been conducted to incorporate most of the more significant review comments from the various review bodies to see what influence those changes might make to those ultimate risk numbers.

Now, I want to understand what has tried to be displayed when we talked about seismic fragilities. This happens to be the fragility curve for the reactor enclosure and control structure. It is basically a shear wall failure. This happens to be the structure fragility curve that most contributes to risk, seismic risk.

So this is the -- as far as civil structures are concerned this is the most critical of the civil structure fragility curves. In the handout packets there are also fragility curves associated with a critical piece of passive equipment and fragility curves associate with a critical piece of active equipment.

The type of information that is trying to be displayed here is first of all, what is the median capacity of the equipment? Now in this case that corresponds to about 1-G. Now that number is supposed to represent the number whereby if you're making the estimate, you should be thinking in terms of going out, making the estimate, such as you had to make the estimate, and then some other expert could decide which side he wished to be on the estimate, and you had to be on the other side of it and take an even bet.

That's what we're trying to do. Now, some conservativisms, in my mind, creep in. For, quite frankly, in my judgment I would much prefer to be on the side of saying that we would not fail at 1-G, than being on the side that said we would fail at 1-G. I think at some extent these are conservatively biased even though they are attempted to be median estimate.

But that's the one piece of information being displayed. An equally important piece being displayed in what is our ignorance in this fragility number? And basically we are estimating that our ignorance in this case ranges that this median number rather than being 1-G might be anywhere from about

MR. KERR: Could you comment a little bit on why it is you think you're being conservative in your estimate?

MR. KENNEDY: Why I think we're being conservative is we try to place design engineers --

MR. KERR: Is it a deliberate effort?

MR. KENNEDY: -- to making these estimates. The design engineers always try to sneak in some conservatism. Managers then try to get them to get it out again, but it always -- some sneaks through.

When you dig into the details of the estimates, I think in those places where there's controversy, is somewhat than lower than median value is selected in most cases.

The attempt is to have a median estimate. The attempt is not to have this conservatism.

Other information displayed is what ground motion level corresponds to a relatively low probability of failure? In this case it corresponds to a five percent frequency of failure.

Again, if I had to make a bet that it was a twenty to one odds and I didn't know which side of the bet I was on, this was be the ground motion estimate that would be made, .6g, and then let another expert choose the side to be on and then I would have to take the other side.

The last number on here is the number that corresponds to high confidence of a low probability of failure. And in a lot of checks we've done, that number tends to correspond to the ground motion level that you would estimate using conservative, deterministic techniques.

So it's a ground motion level where every one of the parameters has been conservatively selected but not excessively so and would correspond to deterministic analysis. We call that the high confidence, low probability number. In this case, it's about .4 g.

It corresponds to approximately 95 percent confidence of approximately 5 percent frequency of failure. But that simply expresses far more precision than I think any of the estimators would want to express. I think the words high confidence, low probability express it better than trying to say it exactly what confidence or exactly what probability.

Anyway, using these fragility curves, these represent margins that we have estimated for some of the more critical structures and passive equipment at Limerick. These are structures and equipment which were significant in the risk study.

Median values or confidence bounds on these median values are high confidence, low probability and failure numbers. You see the values of the structure that I showed you the fragility curve on.

Some other important values are the reactor internals, that happens to be one of the lower fragility estimates. Reactor internals in this case is the lower support skirt inside the reactor and it's excessive deformation of that skirt which leads to the possibility of not being able to insert the control rods. It corresponds in this case of a margin of about -- a seismic level of about .2-5 g's, high confidence, low probability of excessive defamations.

Another critical item is the reactor pressure vessel support for which there is median of about 1.25 g, high confidence, low probability of about .5 g, .49 g. That failure modes consist of failure of the support skirt of the reactor pressure vessel and excessive deformation of the upper support stablizers such that the upper stablizers move -- fail such as the reactor pressure vessel is simply capable of shaking back and forth in its cavity.

It undergoes movements before hitting walls of about seven and a half inches and in our estimate those movements are too large to have any assurance whatsoever that the main steam lines will not break.

So this fragility has been assumed to correspond to breaking to all four main steam lines and thus the consequences of this failure won't be very large. So that's what -- why that comes out to be a significant contributor even though its got a rather high ground motion level associated with high confidence, low probability of failure.

DR. POWERS: Have you looked at the kind of motion that is necessary to make penetrations through the -- damaged penetrations through the drywell?

MR. KERR: Dr. Powers, I'm sorry. I can't hear you.

DR. POWERS: I asked if he had looked at the kinds of damage motion the vessel might make with penetrations through the drywell walls.

MR. KERR: Thank you.

MR. KENNEDY: Well, the penetrations of piping that are attached to the -- piping that its attached to the vessel is primarily restricted but -- from moving -- type restraints that are close to that piping. And the piping that appeared to be most critical and most vulnerable to the large movements of the vessel were the main steam lines when they are in their hot condition. Because the main steam lines have a -- when they are in their hot condition have a relatively small gap between the steam line and restraints.

And in our judgment the steam lines are not stiff enough to prevent the vessel from moving and the steam lines are not forgiving enough that they would not rupture if that vessel did move. And so we thought that the main steam lines were the critical element. We did not look at other elements.

SPEAKER: I guess my question is because it's a relatively new field how -- penetrations and things like that are becoming unique concerns in lots of -- analyses for nonseismic considerations. Perhaps we can realize that seismic considerations as well -- as state of the art.

MR. KENNEDY: I think it's within the state of the art to estimate the seismic performance of penetrations. But it would take considerable effort and it has not been done on seismic PRAs that I am aware of. But I think it could be done but it's a very extensive effort because you would really have to dig into the details of each penetration.

But there's a lot of data available on how penetrations, leak type penetrations have behaved in ground motion events. There's an awful lot of data associated with the containment of underground nuclear detonation at Nevada test site and how those penetrations behave through such containments, behave under very high ground motion levels, much higher than seismic. And their behavior is very sensitive to the details of the penetration. But with good details penetrations are not vulnerable to seismic events, with good details.

So you'd have to look at that very very carefully. And it has not been done to the best of my knowledge in seismic PRAs.

SPEAKER: So that would be one of the things on the list I asked for.

MR. KENNEDY: Yes. But it would be a very extensive effort.

SPEAKER: I'm just at the moment trying to understand what's --

MR. KENNEDY: Yes, that would be one of the things on the list, yes. One that I had not thought of but yes, it would be on the list.

SPEAKER: Well, we've talked about it at prior meetings, in fact, but it was helpful of Doctor

Powers to bring it up.

MR. KENNEDY: Now in some other -- these are margin estimates for active and electrical components and in many cases these are different than were used in the seismic -- the SARA because these are now plant-specific where before they were generic and primarily from Susquehanna SPURT packages.

These estimates have been broken down into two categories. What we've called recoverable functional failure and what we've called nonrecoverable functional failure. And basically the separation in our mind, this fragility correspond to the performance of the equipment after strong shaking has ended.

This corresponds to the performance of the equipment during strong shaking. And primarily this corresponds to fragilities associated with relay chatter and circuit breaker trip. This corresponds to fragilities ignoring relay chatter and circuit breaker trip.

Now some of the list, the hydraulic control units for the scram mechanisms were estimated to have some of the lower high use for high confidence low frequency of failure numbers, around .3g. The 4160 switch gear had rather high fragilities associated with relay chatter because it's -- there's data, Limerick specific data to indicate that those relays are not particularly vulnerable to relay chatter. And there are others that have relatively low fragilities associated with relay chatter, the 250 volt DC motor control set. In all cases the fragilities associated with nonrecoverable failures are substantially higher.

MR. MICHELSON: On these cases what is the threshold for chatter, what g values does it start to chatter?

MR. KENNEDY: For these two particular items of equipment where we have good Limerick data I would say we have high confidence that the threshold for relay chatter is in excess of a ground motion of .4 g. And in the case of 4160 volt switch gear it is in excess of .27 g for the 200 -- 50 volt motor control center.

Now where we've looked at Corps of Engineers gen --

MR. OKRENT: Excuse me --

MR. KENNEDY: -- generated fragility data we find that if you go out and you obtain off the shelf relays the fragility data varies all over the ballpark. And that a lot of relays out there are in this kind of a level, the lower level here.

MR. MICHELSON: But you're dealing now with, I assume, so-called seismically qualified relays.

MR. KENNEDY: Yes, these are all --

MR. MICHELSON: It would seem --

MR. KENNEDY: -- have been seismically qualified to a conservative floor spector for a .15 g earth plane and that's, in fact, what drives these numbers up.

MR. MICHELSON: And in the process of that level of qualification there was no relay chatter.

MR. KENNEDY: That's right.

MR. MICHELSON: And this is chatter that starts to be induced somewhere above that point and these are the thresholds that they have, hopefully.

MR. KENNEDY: Yes.

MR. MICHELSON: Thank you.

MR. KENNEDY: Yes.

For other than these relays that were looked at specifically, generic relay chatter data was used. And the generic relay chatter data tends to correspond more with these lower numbers than with the higher. And, in fact, is somewhat lower than these lower numbers.

SPEAKER: It would appear to me that if I were trying to do this sort of thing to see what these larger earthquakes would do, I might be interested in knowing the -- relief valves open, for instance, so I'm a little surprised you don't have some numbers on that one just as a boundary to show that you don't get a fairly substantial LOCA during the earthquake.

MR. KENNEDY: We have numbers associated with fragility of relief valves. They are very very high --

SPEAKER: Well, what --

MR. KENNEDY: -- proportionality of relief valves though depend I think to a large extent on the electronics mechanisms, relay chatter, et cetera.

SPEAKER: Do you --

MR. KENNEDY: And I simply --

SPEAKER: -- cold circuit.

MR. KENNEDY: -- don't know those fragilities other than from test data and other from relay data.

SPEAKER: Wouldn't that be kind of interesting and important to know though if you're trying to explore this area. It seems intuitively obvious.

MR. KENNEDY: I think that as a research effort there are areas of functional failures of active equipment that is extremely interesting to explore in the fragility area.

MR. OKRENT: A moment ago you mentioned seismically qualified relays were tested at a purely high g value and that they were not to chatter at that point. But if I understand correctly these are relays which are high up in the building and which are moving with greater acceleration than the foundation or what?

MR. KENNEDY: Well, relays are mounted in modern control centers and other pieces of equipment throughout the building. Some are low in buildings, some are high in buildings. Relays high in buildings will see more motion than the ground motion. That is included in their qualifications. And that is also included in our estimate of fragilities.

In other words, we have taken motions that wherever the estimated motions that wherever the relays are at and -- those back to ground motions. So these slide -- that viewgraph was in terms of the ground motion.

MR. OKRENT: All right.

MR. KENNEDY: Now in review -- I've shown you viewgraphs on all of the components that dominated the risk numbers. If we look at all of the components for which we generated fragility data which is a very much larger list, in fact, it occupies about 10 or 12 pages of very small type.

What are the components in my mind which are vulnerable to earthquakes less than .25 g? In other words, what are the ground motions for which we do not have high confidence of a low probability of failure of below .25 g?

There are the off site power, there are the block walls, -- carrying block walls. There are the refueling water storage tank, the condenscent storage tank and the whole question of relay chatter and that's it. With the exception of those items it is my judgment we have high confidence of a low probability of failure of any of the structural or mechanical components up to ground motion levels in the .25 to .3 g range.

MR. MICHELSON: Are all the block walls at Limerick cored and rodded?

MR. KENNEDY: Yes, all of the block walls at least that we reviewed. And we, I think, reviewed the critical ones. All that we reviewed do have reinforcing steel and they are fully grounded.

MR. MICHELSON: How does their strength compare with the poured concrete and reinforced poured concrete?

MR. KENNEDY: In my judgment fragility

levels for block walls with reinforcing steel is still significantly lower than fragility levels for pouring concrete with reasonable levels of reinforcing steel. On the other hand block walls with reinforcing steel are quite a bit better than block walls without it.

Now in other meetings there's been considerable concern on battery sets. The high confidence, low probability of failure numbers associated with the battery sets associated with the diesels for Limerick is a 0.7 g level and it's based upon failure of the battery case.

That concludes the material I wanted to present on seismic margin and Bob Schmidt will then take this and carry it forward from the structures and components to the risk levels.

MR. SCHMIDT: As I described a little while ago the fragilities for the various components, structures and pieces of equipment are combined using models which represent the logic of the plant, the logic resulting from the event trees and fault trees and lead to core damage or the various classes of core damage.

If we do this combination using the fragilities that Bob described and I'll get into in more detail here, conditional in having earthquake --

acceleration. This is not a core damage frequency, this is a conditional failure probability -- fragilities that Bob Kennedy talked about combined with the logic --

I do this to get here a plot of informational fragility, overall plant core damage fragility, look and see here this burst of distribution and I find the median, the mean and -- the median, the mean, a five percentile. And you can see that the median -- core damage fragility about .5 is about -- .6, about .7 g.

On the other hand the high confidence level in using this distributions, in the fragility analysis, we get a five percent chance of failure and approximately two times SSE. These are combined using a Monte Carlo program just like any of the other uncertainties. I take into it a detailed rule and expression for the logic --

The contributions to this -- I think it is interesting to look at the various details because you could say well, what's controlling this and what's the weak point -- look at each -- the various classes. I guess since we changed the presentation around we haven't had too much of a definition of classes. This, again, is the overall core damage. This is a mean plotted here.

The Class S, we will talk about in a little more detail later, is essentially the vessel failure to the seismic events. There's a high fragility and it comes out to be very important.

Remember, the seismic event tree sequence is just TSRVV. So that's the fragility of vessel failure combined with some containment failure modes which we'll talk about in a minute. These are basically the least categories, the least in the atmosphere.

The Class I is a core melt in an container. Class IS is the sequence where the vessel has not failed, the cracked vessel has not failed, but we do have core melt but the containment fails because the building has failed -- bypass containment. So at low accelerations the number of the sequence is --the process certainly is not very -- we say we got a Class IS, Class I, Class -- Class F.

We'll talk about several of these in a little more detail. The one that -- Class I is not certainly a large contributor to the -- but it is of interest because of the electrical equipment associated with it. We'll talk about it. The sequence is basically as I said earlier a TsEsUX which is loss of off site power and loss of on site AC power and therefore, resulting in loss of makeup to the reactor.

Considered in this the fragility of this TsEsUX is it's failure of the -- insulators which is in this loss of off site power. That's the Es term. That and this, or any one of these failures which leads to loss of the on site AC or DC power, therefore, the loss of ability to makeup to the reactor, we get the failure of AC to the seismic regions -- in the motor control center -- there are actually four components included in this chain when you look from the diesels to the loads, there are four active components.

The DC, there are three DC components. The main purpose of DC is to provide power to get -- short-term. There are three major DC where there are relay -- that could fail. Failure of the diesel to generate HBAC are random common caused failure of the diesel generator, allow for the random failure and that is important as we monitor this aspect as we see a little bit later.

In addition to this we got nonvessel -- if we look at the fragility curve for this sequence; this is the mean Class I, this is the 95 percent confidence value and the reason it goes up and down is because we do -- higher probability of occurring at higher accelerations. The point really from this is is that this contribution -- a very small probability of failure using the high -- curve somewhere above the SSE and there is some contribution in this -- you see this again later. It's a random failure.

The Class IS which I described before --

MR. OKRENT: I'm sorry, would you say again why it turned down on that last viewgraph.

MR. SCHMIDT: Why this turned down?

MR. OKRENT: First, what exactly is being plotted on that curve and then why it turns down.

MR. SCHMIDT: This is a conditional failure probability of Class I sequences which are a combination of failures given by our event trees and our fault trees. It is a conditional failure viewed in certain way. And -- and the other curves are not folded into this. This is strictly for the fragility, combining fragility, probability at each acceleration with combining --

Here is a lost of off site power which has a median fragility of 0.2 g. Fifty percent chance of failure or .2 g.

MR. OKRENT: I see.

MR. SCHMIDT: The electrical equipment, all the various AC and DC electrical equipment, when you combine those you get a fragility that looks like this. But this has to be combined with this and combined with not failing the reactor vessel or not failing the reactor buildings because they are handled separately. They are handled in different classes.

You combine those, you get this curve here, right here. And basically this is the mean or the difference between this curve -- since this goes along very quickly that's -- combine it with this, the reason for the difference between the equipment failure and the results is the -- not failing the other components which don't start to become until you get to the higher acceleration.

MR. OKRENT: So you're saying if you feel one of those other components, it doesn't fall in class one so you've removed it.

MR. SCHMIDT: That's right.

It falls in another class.

MR. OKRENT: Yes.

MR. SCHMIDT: For example building failure because they're more risk significant. That's why we separate them out. If there were more damaged, we wouldn't have to separates them.

In fact, the overall core damage has to be done jointly, all of the -- combined to get the right and proper distribution on --

Class 1S is one of the classes such as a building failure PSRV as a potentially more risk significant, consider it separately. Again that is a seismic event and fragility is reactability -- RV but not RPV.

That has a potentially more greater concentrates.

MR. OKRENT: By the way, do those fail by hitting together or do they fail separately because in those restraints --

MR. SCHMIDT: The building?

MR. OKRENT: The reactor building and control building.

MR. SCHMIDT: There -- is that one structure or the --

MR. KENNEDY: That's one structure and it's failed because of failures of sheer walls.

MR. OKRENT: Okay.

MR. SCHMIDT: This is the virgility of the class 1S in the 95 percentile in mean value here we happen to have plotted the RPV attack and not RPV and indeed this value reaches the maximum on this -- starting with the effects, but the key thing is that the major contribution from this class is out in high acceleration and -- twice SSE in very small contribution to this class.

Only one more of these which is class S represents a vessel failure, reactor vessel failure -- there are three different contributors each having a RVP failing in it. There is an entry if you will, a symbol of entry which shows this combination. We have three different failure modes. One which is a different class, class 3.

If you don't fail the building you don't have this -- support fail you got -- then you assume there is due to the impact itself there is a chance of failing the building, failing the payment by needs, this is what is class S.

It is a composit of a number of different containment failure modes associated with this class. The largest contributor consists of this branch here. The -- again for that are significant or important because they're, this class is the one that controls the early risk and here we have the earned 5 percent file value including value -- here we don't get up out of the dirt until we get up around .60.

So in some rate on this part of the analysis where we combine the individual fragility into the various - classes and oral --. If we say what is the, where do we have high confidence, no probability of failure, 5 percent chance of failure. For damage the value is .3 and for the various classes it's higher than that.

Class S which in risk report, early risk report is way up around .16. Again these are independent to the hazard system. If we go the next step and take these fragilities and combine them with the hazard curve and using this one which we saw a little while ago. If you use this hazard curve you'd wind up with a -- as follows: where this is the percent contribution of total -- frequencies as opposed to acceleration.

This is now frequency and this is -- here percent of the poll, the poll here being 1856. This number is -- in the -- number because of the changed fragilities that Bob Kennedy presented, all valued, Sara value is 5.7, and 10 to minus 6.

Really I'm talking about advising Sara and -- sensitivity study for March was the impact of these changes and so 5.7 to 3.8 minus 6. Really not a very significant change.

The percent contribution, now there are two curves on here. This curve is the seismic, the non-seismic failure. I need random failure included in this value, while in this one is strictly the seismic implant failure. This -- event is still the seismic loss and loss power but it excluded from this the random contribution in the bars down here, which is the percent of each of these instruments you get, we have a similar result.

What you see is that below about .2g's there is only, essentially the only contribution probably -- small percentages of relatively small numbers is due to the random failure. It's a seismic loss of offside power that random failure --. That's the major contributor in this small region.

Now as you go up higher in accelerations and start getting more and more seismic failures, the random failure contribution is essentially constant, there is a constant so you start getting this constant delta here.

For this curve we start picking up some other random -- as we get out here and other components. What you see from this is that if you don't get up to the 5 percent of our total value amount until we get out around -- consider only seismic implant failures around 10 times SSE.

When this random acceleration is in seismic failures is really not this --.

MR. OKRENT: When you've done this seismic PRA what do you assume the non-seismic equipment is doing?

MR. SCHMIDT: The equipment not that I -- me.

We basically ignore it. We do not say that it -- it's unsafeties or the plan is reviewed from that standpoint. Anything that is important for safety is designed in class one, the seismic category one standard.

We do not take credit for power conversion systems and our procedures for example those -- building failings, seismic event does not impact the safety of the plant.

MR. OKRENT: But you haven't fault treed, if I can use that term, the failure modes of the non-seismic equipment to see whether there are failure combination that could impact adversely on your ability to accomplish --, we just assume that it's not there.

MR. SCHMIDT: That's right. Based on the support for all the various -- analysis or not.

MR. OKRENT: Well, if they're --

MR. DIEDERICH: Dick Diederich, Philadelphia electric. The non PRA design of the plant is such that under the seismic design the seismic safety grade stuff is all seismicly designed and the non-safety grade stuff is designed so that should there be an earthquake it will not fail in a manner which affects the safety grade equipment.

If there is a pipe that goes over a motor control center it is designed to withstand the seismic event or it is rerouted.

MR. OKRENT: Which seismic event is it designed to withstand?

MR. DIEDERICH: The SSE.

MR. OKRENT: Yes, but we're looking beyond the SSE here. So I would say you don't know mechanically what may happen and furthermore, I would suggest you may not really know electrically what may happen. It may not be bad but I figure you just don't know at this stage.

MR. MICHELSON: Believe me I don't believe I know at even at lower "g" values for the non-qualified equipment because that's what really is suscepitible to seismic even more so than mechanical components.

You look a little puzzled. Do you have a problem?

MR. DIEDERICH: Would you say that again

please?

MR. MICHELSON: The non-qualified switchgear, electronic components, instruments controlling equipment of various sorts that has never been shaken, you have no knowledge of it what thresholds you get relay chatter and things of that sort, for instance, if you've never tested it.

Now, in some cases you have some knowledge because you've tested comparable equipment and that helps a little bit. But I think as a generic clash you're, you have no knowledge of the failure modes and effects of non-qualified equipment unless you have done the analysis and the testing if necessary.

MR. SCHMIDT: The impact on the safety systems is considered in the analysis of the --

MR. MICHELSON: Not in the electrical area. Only in the mechanical area. I don't think you've gone through and done an electrical analysis of all non-qualified equipment to make sure that it doesn't have an adverse interaction.

MR. SPROAT: Ward Sproat, Philadelphia electric. We have done that from an environmental qualification standpoint. It's not seismic but we did look at environmental, adverse environmental affects on non-qualified instrumentation and control circuits.

Now, the failure modes are going to be essentially the same. We looked at instrumentation and transmitters, bistable devices and we assumed either failure to operate or spurious operation, and we did look at on an area by area basis, what happens when those -- when the systems associated with those insruments spuriously operate.

MR. MICHELSON: Yes, but --

MR. SPROAT: And we took with that, and we took with that a coincident single failure of safety systems needed to mitigate any events that may be caused by that spurious operation.

MR. MICHELSON: The problem is an area by area environmental examination is being made on the assumption of one area at a time being involved. Whereas, a seismic is a common cause challenge to everything in sight.

MR. SPROAT: That's true. I just wanted -- afterall we have looked at players of non-qualified devices.

MR. MICHELSON: And I think in the process of your pipe break analysis and so forth even outside of containment, you should look a such matters.

MR. SPROAT: Yes, we have.

MR. MICHELSON: But only on a point by point basis and not a common cause challenge to all equipment.

MR. SPROAT: That's correct.

MR. MICHELSON: And that makes a big difference in your answers.

MR. OKRENT: Mr. Michelson raises a question in my mind. Are there any failures in your PRA due to the equipment that was nominally environmentally qualified malfunctioning or did you assume if it was environmentally qualified it never failed due to environment.

MR. HUGHES: Gene Hughes. We use the random failure rate for components that were environmentally qualified with the exception of those few events that clearly would exceed the capability and then we took the failure rate to 1.0.

MR. OKRENT: Yes. So the answer is you did not, you assumed if it was environmentally qualified it didn't fail under those conditions. I think the experience sandia and elsewhere suggests that may not be a good assumption because in fact the equipment may not be in its original state and therefore, even though it was once qualified it may not be that way or -- well or the equivalent let me say in other ways.

So that in a sense, I don't if it's an

important -- it could be an important admission because of the common cause potential.

MR. HUGHES: Can I interject? If you're talking about large seismic events then the --

MR. OKRENT: Just a moment, excuse me. It was not necessarily a seismic event in this case although seismic is one of the things you're qualified.

MR. HUGHES: Okay.

But here for large seismic events that are postulating horrendous results the plant in calculating, at least the consequences from failing containment and failing -- trial lines and a pulling water out of pools. I mean it's very hard to imagine where the consequences would be worse given that it's a non -- fail for the large seismic event.

MR. OKRENT: Oh no, no.

MR. HUGHES: But on the end for the small seismic events, which postulated here is that it is you have the LOP followed by random failure. Again we have to -- in that case be postulating with most of the equipment in the plant available that the concern over the non-seismic equipment would perturb the risk enough that you'd see it. And I just don't see where you can only get a different picture of the seismic risk as a function of acceleration from going down to that --.

MR. OKRENT: Well, again I was raising the question in terms of qualification including seismic qualification. I don't think you've made the case what you said that it lesser accelerations there may not be problems that arise due to failure of non-seismically qualified equipment doing a variety of things qualification wise. Okay?

In other words, -- well let me just leave it at that. I think it's an area that I haven't noticed, although I don't read the PRA, word for word. I try to catch what the people think of the highlights or the new points that they've covered and so forth.

MR. MICHELSON: Yeah, it might be worthy to note that although I don't think Limerick necessarily has this problem it's always -- to watch the power protection systems and their common cause actuation as a consequence of an earthquake. Particularly if they use -- systems actuated on smoke detectors, for instance, which see the dust and the building created by the earthquake and pick it up as potential smoke signal and the actuate the fire protection systems.

Now, this has been happening in a localized basis then you see it in LAR's where dust is generated and the get it -- to water. Well in the case of an earthquake you're going to get quite a bit of dust in all parts of the building.

If you have that kind of a system, which I'm not saying you do, because I think you've taken care of it, then there's a real problem with earthquakes as an example.

MR. OKRENT: I have one -- point. My, the smoke detector in my house will go off if I'm roasting the chicken at too high a temperature. It creates enough aerosols.

MR. SCHMIDT: The point we're at is looking what is the acceleration in a small contribution to -- for damage or to frequency the various -- here again that we're talking about acceleration filed twice SSE or higher in the case of the --.

The table before was the additional failure probability --. Perhaps the last part of this is what happened to risk -- a similar analysis here instead of core damage frequency. This is early fatality expressed in the area under a -- and you got really nothing significant in the range of --. This is because the -- contribution are merely due to the very severe class S where we have a vessel failure and early containment failure.

Remember in our class 1S, which is the

building failure, while the containment is bypassed the SRB discharge patterns nozzeled onto the water.

MR. OKRENT: Now what we need now is someone to faultry as it were how people are doing the seismic PRA part to see that it doesn't have important omissions. You know what I mean?

I think it's a bit -- it showed an important contribution to do it. I don't want you to misunderstand me but I think we're at a point now where we have to look to see that its robust, let me put it that way.

MR. SCHMIDT: One issue that was -- or commented on about -- chatter. As Bob presented was a -- not a sensitivity study. If we take the pieces of equipment where we could identify based on Limerick qualification there is a potential for chatter. And we've taken, and this is in the switchgear both the work for DC and AC, and we take the what we call the generic relay chatter, which accounts for the fact that there are a number of other relays out there which could cause adverse impact.

Then we combine that with a -- analysis, which combines those chatters with a probability of not recovering the operators of .2 instead of an estimate of a typical value. We get change in --

frequency which is about in the range 50 to 60 to 75 percent.

Not a factor of 3 or 4 or 5 or 10, a something less than doubling. Some of the features of Limerick, there is time delays in the -- circuits which would prevent them from relay chatter from sealing out the -- system.

There are question of automatic ADS initiation because of relay chatter, remember there is a two minute delay in that circuit. So a lot of things like this have to occur. Relay chatter is certainly an issue which needs to be further looked at. No doubt about that.

We haven't solved it. This is not an analysis which says that's the answer, but it does show it's not extremely sensitive. Part of it is because we have to build some of these -- failures also. If we change that then --. The conclusion on this very quickly unless there's other questions is that using these techniques to describe is shown on various categories of livelihood considering the -- if we have any analysis, which we'll probably get it now.

We don't get any significant either conditional failure problems or total or contradiction to actual frequency according to -- to SSE moderate risks involve about 4 -- before the plant really knows considerable margin based on the design basis as designed --SSE.

That takes care of the seismic margin unless there are some questions.

MR. GARCIA: Just one question.

MR. OKRENT: Okay, Mr. Garcia.

MR. GARCIA: Why did choose the word risk in this statement of conclusions for early where I saw only early -- fatalities in previous slides? Is there a significance to that?

MR. SCHMIDT: No, I think generally my and Jeff check me on this, if you find some contradiction. The same sequences contribute to early fatalities and contribute to early injuries. Talk early risk being fatalities or injuries.

MR. GARCIA: That was my point. Is this inclusive of something other than the early fatalities mentioned early?

MR. SCHMIDT: Only analysis we did and the margin was early fataly and I think the conclusion was -- for early injuries as for talking about similar sequences causing both modifications and major contribution to early injury would be class S, and that's what controls this number.

MR. OKRENT: Mr. Davis?

MR. DAVIS: Dr. Okrent, I think mentioned earlier that there were still some issues on seismic risks that appeared to be unresolved based on the Brookhaven review and I came to the same conclusion in reading the documents and I can give you a few of those. Pipe failure between the containment and the enclosure, embedment effects, soil amplification, fragilities. There was also an interesting one about how you account for evacuation -- from an earthquake and I'm wondering how many of these are important and which ones are still unresolved?

MR. SCHMIDT: I haven't gone through the analysis on all of those items. Certainly seismic evacuation and -- acceleration shouldn't be a major issue --. It gets to -- of what's happening to the point -- range. This is a result of a sensitivity study, which some of the Brookhaven comments mainly having to do with -- but also having to do with some of the seismisity structural impact interfate. There's no change in the -- curve -- curves on any of those basis then your assumption is rational.

You see the first is no damage reduction facts for large magnitude earthquakes. This was a comment this 1.23 factor that Bob talked about. If you don't apply that to the coleman zone there's some argument whether you do that or not. If you -- that has potential change in the 60 percent range -- are the 95 percent components.

It doesn't change the margin values but this is the impact on the -- experiment. If you use the first one and change the building to the .9 value, the 1G value into -- and a vessel fare, which is -- comment the probability of failure is grand, exceeds the amount.

You change those you see got similar type of values if you combine this whole set and this of, which I'm talking about, you may get a doubling of the -- possibly in this range so it's preconsistent to the comments that these are individually small maybe a little more than a class 1 and 2 when you combine them. But still this doesn't necessarily mean agree of the overall impact is relatively small.

One issue was the waiting of the coleman zone. We assigned it a weight of .1. If we come on arbitrarily increase it to .25 reduce the other weight so that the four major opposite are weighted equally. There were curves but two of those were subdivided. The others we got about a -- 6 percent in the -- in fact, Brookhaven did an analysis that the whole thing is do to the Colman Zone.

Their analysis is that you went up a factor in full in --. Some of the sensitivity were done in this whole area of hazard -- hav not done any re-analysis. Robin has not gone back and redone the analysis based on the fact there is so much individual work going on -- that if the status would be premature really to go by -- and other analysis right now.

(Meeting adjourned.)

DR. BENDER: I may be missing something, but it seems to me that none of these controversial areas really make a large difference, and yet your results have huge differences of from 5 to 95 percent confidence. What's driving that big range?

MR. SCHMIDT: That's a hazard curve.

DR. BENDER: That's where mostly all of that is coming from.

MR. SCHMIDT: Certainly in the fragilities areas there is uncertainty, but I think most of it is in the hazard curve. Also at the higher acceleration -- I don't see it there particularly, but if you look at some of the other results that are dominated by the vessel failure, and you look at the median, for example -- this is the mean -- look at the median in 95, and you get a wider range of uncertainty of Class S because of the vessel failure which primarily occurs at high acceleration.

DR. BENDER: Thank you.

MR. OKRENT: Piping between buildings is not an issue?

MR. SCHMIDT: Piping between buildings is not an issue. I don't believe so. I think there was one question of the small piping in the vicinity of the reactor enclosure and containment structure and potential restraint. The large pipe was looked at. The small one, there was no pipe by pipe review to see whether there were any restraints, because of the proximeter of the restraints, that would cause failure of small piping.

MR. OKRENT: I don't know what you are telling me.

MR. SCHMIDT: One comment of the review was the potential for relative motion which means the reactor building, reactor enclosure, and the containment. They are separate structures. There is a gap of a number of inches to allow for relative motion.

The question was raised about impact. At a certain acceleration, you start getting impact at that joint, and could this lead to a number of potential damages either to spalling due to vibrations and due to small pipe failure. That's the only issue that I know of that is open.

Large pipes were looked at for that by the review and in the peer review of small pipes. We don't think it's a problem, but there's been no going back and looking at every small pipe that bridges that gap.

DR. GARCIA: Did you also look at buried piping?

MR. SCHMIDT: Bob? Everything is pretty much on bedrock.

MR. KENNEDY: This is essentially a rock site. There has never been a welded duct of steel buried pipe that has ever failed in an earthquake, that I'm aware of, purely due to the inertia shaking effects or the wave passage effects.

The failure cause for walled or ductile or steel buried pipe is either due to gross soil failures, crossing active faults, crossing zones of substantial slope instability, substantial seismic induced settlements or liquefaction zones, or the entering of buildings and tanks where there is substantial vibration of the building or tank.

Now, these buildings are founded on rock, and there simply isn't going to be any significant uplift or substantial relative motions of the lower portion of the buildings relative to the ground surrounding it, so I can't conceive of a buried pipe failure at Limerick due to any reasonable earthquake level, and I guess I will classify reasonable as being up to about 1g, so I don't think there is a possibility of such failure at Limerick.

DR. GARCIA: Thank you.

MR. SCHMIDT: That ends the comments we have on seismic margins. Do you want to turn right now to fires?

MR. BOYER: Or do you want to go to in-containment analysis? Your choice.

MR. OKRENT: I will give you my master plan. The original agenda said that we were scheduled to go until 7:00 p.m. I would propose to go till 7:00 p.m. and, in that time, which is an hour and a half, to cover both fires and in-containment analysis, with more on the second question. Okay?

MR. BOYER: Fine.

MR. OKRENT: Now, in which order we do it, I don't know it, but if there is a chance that fires will try to eat up more than half of the time, then we should start with the in-containment. Those are the two topics I'd like to cover in the remaining hour and a half.

Well, let's start with the fires while Bob is up there.

MR. SCHMIDT: It will take me just a second to get the Vu-graphs. This is in the main part of the presentation.

In-plant fire initiated accidents were considered in a two-stage analysis. The first stage is a conservative analysis where there was no mitigation. Each fire zone is let burn, and look at the impact on the plant for core damage.

Stage 2, this is analytic. Stage 2 is a realistic analysis of the fire progression where fire progression and mitigation for the significant fire error is found in the first analysis.

Another feature of the analysis is random failures as well as fire induced failures were considered, and the success criteria, i.e., what happens when various systems are not available, the same as the PRA which -- I don't know if we described them earlier, but the intent would be realistic success criteria.

MR. MICHELSON: Does your fire analysis now include the effects of smoke in the building, heat, loss of ventilation, things of that sort, that might be caused by the particular fire you are postulating?

MR. SCHMIDT: I don't think that smoke was explicitly considered. Paul? We made the assumption about -- I'm sure they are consistent with the fire protection report and the isolation of the various fire zones.

MR. GUYMER: Paul Guymer. In the initial screening analysis, we assumed that all equipment within a fire zone would be damaged due to the fire. Now, whether that be due to the effects of heat, smoke, humidity, whatever.

MR. MICHELSON: But your fire zone would soon rapidly narrow down to several feet and not necessarily several hundred feet where smoke goes long distances in a building, even though -- I'm not worried about the consequences of the smoke damaging something, I'm worried about actuation of other fire protection systems by smoke and so forth.

I think you are pretty well off, but I want to emphasize that one has to chase that carefully.

MR. GUYMER: We did not explicitly address the impact of smoke traveling through the building. However, in terms of smoke actuating automatic protection systems, I think we looked at that and we found that really it had no impact on the systems.

MR. MICHELSON: Certainly, it actuated the system, but I think you are running drive pipe systems with thermal linkages of the nozzle. And if you verified that was the case, then you could write it off on that basis.

MR. GUYMER: Activation of fire suppression systems, in itself, will not cause equipment damage.

MR. MICHELSON: If you use thermal links at each nozzle. If you don't, if you use a deluge system, you are going to wet down equipment, and then you have to argue that it is okay to wet down equipment without it being damaged, and then you tell me it's qualified for that application.

MR. GUYMER: I'd like to say that it is qualified, but I think Ward Sproat, Philadelphia Electric --

MR. MICHELSON: Your equipment here, for instance, is qualified to be sprayed on by a sprinkler head?

MR. SPROAT: At Philadelphia Electric Company, we do have fusal head links, and generally they are pre-action systems throughout the plant where we have a critical problem, and they are all actuated by heat detectors.

MR. MICHELSON: You are not using smoke detectors then?

MR. SPROAT: Only for early warning throughout the plant.

MR. MICHELSON: But you are actuating on heat?

MR. SPROAT: Yes.

MR. MICHELSON: Well, that's a good answer. It's one way to do it, but not everybody does it that way, unfortunately.

MR. SCHMIDT: The important steps in the fire analysis were, first, the identification of the fire areas; then what is in those areas in terms of equipment, cables, other pieces or things that could affect the plant safety; plus, what is the frequency of fire in each area; evaluate the effects of each fire in two respects, what is the initiating event that could be caused by a fire, what is the damage that could occur by the fire, and then combine these two evaluating core damage frequency.

MR. MICHELSON: Did you also evaluate the effects of fire mitigation in those ares where two trains of equipment are located in the same room, for instance, and I think the auxiliary equipment room was one example where you cited since the equipment was 13 feet apart you were okay, and then you said you brought a fire hose in to fight the fire, and I kind of get uneasy about two trains of equipment that close together and using fire hose to fight the fire in one of the trains.

So, I just wondered, did you look at that carefully?

MR. SCHMIDT: It was considered the detail -- we did not go through and assign a likelihood of additional damage due to the action of the fire prevention system. The auxiliary equipment room, for example, is protected by a CO-2 system, which is the initial attempt to put out a fire --

MR. MICHELSON: Maybe my information is wrong. My information, that I read right out of your report, says it was a water hose. You used Halon in the floor, but not in the cabinets.

MR. SPROAT: Let me try to address that. Ward Sproat, PECO. You have to make a distinction here between the deterministic analysis, which we did, to -- as far as safe shutdown capability, to satisfy Appendix R requirements, and the analysis which we are talking about here for PRA.

In the auxiliary equipment room, specifically, we are designed at Limerick that we can take a total failure of all equipment in that room due to fire, and also due to any water from suppression.

As part of our safe shutdown analysis, we looked at short circuits, shorts to ground and open circuits that could be caused by the fire or by the suppression. When we define a fiew area, that area is defined by three-hour fire barriers around its perimeter, top and bottom.

So, in the example that we're talking about here, in the auxiliary equipment room, deterministically, we have -- the plant is designed to take a total failure of all equipment in that room due to the fire and the suppression activities, and we are still able to get to cold shutdown with the remaining equipment we have available, with control from other locations.

MR. MICHELSON: Maybe the story has changed since the report was written. I'm looking at location A in the auxiliary equipment room --

MR. BOYER: Which report are you reading?

MR. MICHELSON: This one here was the SARA, yes, and it was page 4-27.

MR. SCHMIDT: There is Supplement 2.

MR. MICHELSON: Yes, but I looked at that supplement and I found no change to it. I don't know if that was Supplement 2 or 1. Yes, Supplement 2. Supplement 2 revised the fire analysis, but not in that area, unless I missed it. And the problem was that you were into redundant systems.

Now, if the answer was that even if you got into the redundant system and was, no, never mind, that was fine, but that's not what it said in the report. It said that since it's 13.2 feet from one system to the other, which is more than twice the cabinet damage range of most severe transient combustible fires, it was no, never mind, and that was fine from the heat viewpoint, but not from the fire mitigation.

MR. SPROAT: I think what we have to remember here is what the SARA is addressing is on a probablistic basis. If we would have a small exposure fire in the room that was near one of the relay cabinets which control one of the safe shutdown trains, that what was the probability of that fire affecting the redundant cabinet which was X-number of feet apart, and they are looking at that from a probablistic standpoint but, from a deterministic standpoint, we don't care. We can burn out the entire room.

We have designed our remote shutdown system that we do not need any components in that room.

MR. MICHELSON: Unfortunately, I did not bring the pages along from SARA that explained to me that I couldn't burn off that room and that, therefore, this was the justification for that location, but maybe that's changed.

If you can assure me that I can burn out the entire auxiliary room, no problem, then, sure --

MR. SPROAT: I would suggest instead of looking at SARA for the place to document that analysis, the proper place is the fire protection evaluation report for Limerick.

MR. MICHELSON: I don't have, unfortunately, the fire protection report at the time.

MR. SPROAT: In that report, we went fire area by fire area through the plant, and looked specifically at what equipment was in there, what cabling was in there, and our basic assumption was that everything in the fire area was destroyed.

MR. MICHELSON: So, I guess the fire report superseded the SARA?

MR. SPROAT: Yes. As a matter of fact, the initial

SARA was done, I think, to Rev 2 or Rev 3 of the fire protection report, and we are now up to Rev 6.

MR. EBERSOLE: May I make a comment, Mr. Chairman. My impression of that plant was that you found yourself putting in that auxiliary control room as an afterthought, not an original design thought. You were following the ancient old criteria, GGC-19, which admits you could extend extension cords to some distant point, and then you got caught in the act of doing that, and you put this in afterward, and you put it into a place that was congested, in the presence of relay rooms and switchboards and other things, and I think if you think that it is, in fact, impervious to common influence from fire and smoke, you'd better get out some smoke bombs and validate your thoughts very carefully because I certainly wasn't impressed that you were distant, or removed, or in anyway, in a hard line sense, segregated from common mode fire influence.

MR. MICHELSON: Jesse, you may want to know that it it that room that I'm talking about.

MR. BOYER: At the time you visited, the walls had not been installed around that facility and it wasn't complete.

MR. MICHELSON: I realize that, but I also wondered when it was complete, do you have to walk through the auxiliary equipment room to get to it?

MR. BOYER: No, you don't.

MR. MICHELSON: You now have a separate entrance.

MR. SPROAT: Yes.

MR. EBERSOLE: But a smoke bomb test is not expensive or tough or anything, and they let you visualize lots of things you don't really believe until you see them. I think that would be worth your while to look at.

MR. SPROAT: we have looked specifically at the HVAC aspects of that remote shutdown room which we built there, and I'd like to have Gary address that since he is our mechanical man.

MR. EBERSOLE: Before you do that, let me say this. I think in the whole business of this fire protection engineer context, that the utilization of tracers, such as smoke or whatever, has a visible and measurable exhibit of confidence in this isolation feature is probably a mandate to confirm that you have that fire protection that you think you have.

MR. REED: For that particular area, we did isolate the remote shutdown cabinets from the balance of the room, and we have -- first of all, we are capable of putting the entire HVAC system in a purge mode, and we have also balanced the room to keep the remote panel room pressurized to the aux equipment room.

MR. EBERSOLE: That sounds good, if you can do that. Relative pressurization, overpressure.

MR. REED: Yes, sir.

MR. OKRENT: By the way, I'm perfectly willing for this discussion on these points to go on as long as you want. At 6:15 and no later we are switching to containment. I just wanted you all to know.

MR. EBERSOLE: Well, on this matter, did I hear, was it this plant -- I've been to several -- that you really have no really firm constraints on the transportable fire source, that you might, in fact, be rolling 55-gallon drums of acetone around.

MR. BOYER: Say that again?

MR. EBERSOLE: I said you didn't have any administrative tight controls over --

MR. BOYER: We do have administrative controls, and we have a fire protection engineer on the plant staff.

MR. EBERSOLE: Do you have a running inventory of where the combustibles are?

MR. BOYER: We will be monitoring that and limiting combustibles to reasonable values, and both from issuance to maintenance people and -- that would be one of the assignments for this fire protection engineer to verify that the procedures are being complied with.

MR. EBERSOLE: You would be able to ask him at any point in time, to tell you where the combustible inventories were.

MR. BOYER: Yes, I would expect to be able to do that.

MR. MICHELSON: The thing I was kind of concerned with was the addressing of fires in local areas and, as a consequence, the water or whatever you are using gets out of hand. Apparently, you are using water rather widespread and the cooling effect that you are using a lot of firehoses and not too many sprinklers, but I couldn't tell because I didn't have the fire report.

MR. BOYER: I wouldn't say that. I think we use more of the sprinklers.

MR. MICHELSON: Let me ask, in the auxiliary instrument room, are you using firehoses as the report suggests, or have you changed that, other than in the floor.

MR. BOYER: As a hang-on system --

MR. MICHELSON: In the floor it has, yes.

MR. BOYER: -- and we have CO-2 overhead in that room.

MR. REED: We have Halon on the floor, we are all aware. We do have portable extinguishers outside the room, but as our fire procedures are written now, the first point of attack is with a firehose for the aux equipment room.

MR. MICHELSON: So you are going to use firehoses on these two trains of electronic equipment, and you are kind of satisfied that whatever it causes is going to be all right as far as safe plant shutdown?

MR. REED: Yes.

MR. MICHELSON: I realize you have analyzed the whole thing and you said, yes, I can wipe it out, but have you looked at what happens in the process of wiping it out?

MR. REED: It's not as if we are going to just go in there and spray water all over the room. We have some, I would guess, 50 fire procedures for each area, and where we have particular concerns and where we have installed mechanical means to separate these cabinets is definitively outlined in each fire protection procedure, in each fire fighting strategy.

MR. MICHELSON: Well, I'm sure it is all well defined, but I was looking in the PRA, of course, then for the probability of human error where you sprayed the wrong cabinet or things of this sort, in the process. In the exciting situation of a fire, human error kind of goes up a little bit, and I just could find nothing in the report to address the human aspects of mistakes made during fire mitigation and, since it's manual fire mitigation, I can expect some human error, and I'd like to know the consequences and if you are going to show it's a no-consequence situation, that's great, but I didn't find it in there anywhere, however, I found words that said don't worry about it, the cabinets are far enough apart, which was --

MR. REED: One thing to keep in mind, too, throughout the plant -- and I will use the aux equipment room as an example. We have some 57 smoke detectors in the ceiling, or 6,000 square foot area, and we also have on the Unit 1 side alone, upwards of 175 smoke and heat detectors. So, we feel we are in a fine position to identify a fire very early and get to it, and we had minute panels in the room so we can go in and see exactly where the fire is and, hopefully, put it out with a portable extinguisher, before we have to drag out hose.

MR. MICHELSON: I understood that the kind of numbers you have to talk about, though, are 5 to 10 minutes from the time of the alarm until the time the fire brigade is there to do something about it.

MR. REED: That's probably accurate.

MR. MICHELSON: And 5 to 10 minutes is quite a bit of time. By that time, it could get fairly exciting.

MR. BOYER: I wouldn't expect it to, not with the cabling we have and the combustible --

MR. MICHELSON: The next question I'm going to ask, when does the cabling go in the cabinets? Not off in the cable trays, but in the cabinets, in the vendors. Are those IEEE383 cabling?

MR. BOYER: Yes.

MR. MICHELSON: In the cabinets?

MR. SCHMIDT: In the cabinets.

MR. SPROAT: Throughout the entire plant, we hav specified, regardless of Class IE, non-Class IE wiring and cabling, we've specified all IEEE383 qualified fire retardant cables, both cable and single conductors.

MR. MICHELSON: How about the penetration of the floor, since the control room is directly beneath. Are those all sealed against water since water is your mitigating proposal?

MR. SPROAT: I don't believe -- we don't have any penetrations directly from -- through the floor slab down into the control room. The way the cabling is routed is actually out through the side, then down and back up through the spreading room, but to answer your question, those seals are three-hour silicone foam seals, and they are designed not only for a certain amount -- for a fire, but also for differential air pressure and some water static pressure. Exactly what in that area, I can't answer.

MR. BOYER: They have to be sealed for us to meet our Halon requirements.

MR. MICHELSON: That's a little different propagation than I had in mind. You say you don't need the essential chillers -- pardon me, I should say it different. You say that your chillwater system is not essential. What do you use for chill for cooling the control room then, in an emergency? The fire report says they are non-essential -- not the fire report, pardon me -- the SARA.

MR. SPROAT: In terms of control structure HVAC, we have looked at the need for control structure chillers, which would provide cooling to the control room and the auxiliary equipment room.

Our feeling there was, we have, in one area -- we have redundant fans for that system. They are located in a common fire area right next to each other, up on the top of the control structure.

There is no way we could segregate those fans from each other. We did segregate the cabling to them and the controls to them, but we don't have a 100 percent assurance that we can prevent damage to both of those fans if we had a fire in that area, even though they are covered by sprinkles.

Our feeling was that in that case, that if we did lose all cooling -- if we lost the chillers, the control room doors do open up out into the turbine deck, which there are large hatches which go right down through the turbine building and out the side of the turbine building.

If we got ourselves into a situation where we lost cooling and heat was building up in the control room, we felt that through opening the doors, we could establish some natural circulation to the outside through the turbine building.

MR. MICHELSON: Now, this is with a fire, say, in the chiller area which is underneath th e control room?

MR. SPROAT: That's correct, or in the fan room above.

MR. MICHELSON: You won't have a problem with smoke when you open your stairway doors, and that sort of thing?

MR. SPROAT: The stairway doors all have fire doors on them --

MR. MICHELSON: I just wanted to establish, you are climing, though, that you do not need chilled water in this plant, that you have emergency means of handling the situation.

MR. SPROAT: I just want to say that chilled water, as far as control structure HVAC is concerned. As far as cooling water for emergency service water for room unit coolers, we do use those.

MR. MICHELSON: Now, I notice the switchgear room has an emergency cooler in it. Apparently you use service water there then, and not chilled water?

MR. SPROAT: In the 13K switchgear room?

MR. MICHELSON: Yes. A so-called emergency chiller, and I assumed that that meant it had to be somehow protected.

MR. SPROAT: That's not used to cool that specific room. That's where the chillers are located.

MR. MICHELSON: No, the chillers are the next floor below. Your chilled water system is the next floor below. These chillers are in the 13KV room.

MR. BOYER: Is that a SARA reference?

MR. MICHELSON: No, this is not a SARA. These drawings are out of the SFAR report, but the discussion in there -- the chiller is -- I can't read -- the SARA has that drawing in there. The chiller is at elevation 200. The switchgear room cooler is the next elevation up, and then quite a way up from there at 229, and I just wonder, what is the emergency auxiliary switchgear room cooler, as opposed to the control room chiller.

MR. SPROAT: The control room chiller provides cooling to the cooling water, which circulates through the coolers that are located in the various rooms. So, if you lose the chillers, you still might have the capability to circulate water through the individual fan units in the rooms, but you wouldn't be able to remove the heat from it.

MR. MICHELSON: Well, the chiller pumps are also lost when you have a fire in the chiller room, so we can't circulate water, so that was my question. Are you using service water then, or what?

MR. SPROAT: No. In that case, we would be without cooling water in the control structure.

MR. MICHELSON: You mean even this 13KV switchgear room doesn't need cooling?

MR. BOYER: No.

MR. MICHELSON: It's way below grade.

MR. SPROAT: No, the 13KV switchgear room is at-grade. It's on elevation 217. That has a large door from it directly through the turbine room which also leads outside, so we could establish cooling that way.

MR. BOYER: It's a large open area.

MR. MICHELSON: You can open doors there, too, and keep cool?

MR. SPROAT: Yes.

MR. BOYER: Yes, that's no problem.

MR. MICHELSON: I believe that takes care of my questions on that.

MR. SCHMIDT: Perhaps at this point, the best thing to do is skip right to the results.

MR. OKRENT: Sounds like a good idea to me.

MR. SCHMIDT: The results of the fire analysis, the 13KV switchgear room, fire is a dominant contributor. These are all potential fires. It's not a particular fire sequence, it's a summation of them all. That's 38 percent of the total fire initiating events, and this should be compared with the internal initiated core damage frequency of about 1.5 times 10 to the minus 5, so we're down to a fairly small number at this point, about 5 percent.

For an access area which is in the reactor building, is the next highest figure. Most of the accidents, 75 percent of the accidents equals loss of makeup. These are Class I accident sequences as opposed to Class II, which is loss of heat removal, and it has impact on risk associated with these.

Another assessment, 80 percent, the majority due to fire in across stage 2 -- that's part of the presentation I didn't give, but this is where the fire is propagated to the minimum separation distance because before it propagates what's called protected equipment, both protected by insulation or fire barriers and things like this.

That basically covers unless there is any question on fires.

MR. OKRENT: What's the chance that cabling or system 1 of your, let's say, your RHR is run by accident through the same tray as cabling for train 2 of the RHR, or some other equivalent thing -- like happened at Brown's Ferry, if I recall it correctly, and has happened at at least one other plant in my memory. How does one know whether or not this is a zero possibility for your plant?

MR. SPROAT: Let me try to answer that. We had two parts of the program to erode the fire, to try and minimize that possibility or reduce it to zero. One is the quality assurance program, or quality control program when we were installing the cables initially.

We color code the cables as they are pulled off the reel. They are color coded and we make sure that they are going in to a raceway of the same color. After they are terminated, QC verifies that the ends of the cables are terminated at the proper devices so that they are in the proper division. That's what we do with all cables.

For the cabling that's associated with the fire protection safe shutdown systems, what we did as part of our safe shutdown analysis, we identified, first of all, what components we would use to safely shutdown the plant in the event of a fire.

We then identified all of the cables associated with those devices. We then identified what raceways those cables are run in, and then what fire areas those raceways are located in.

So, we had really two separate programs to check proper cable routing. I cannot tell you that we went out and did a wringout of every cable in the plant. Nobody does that, and I wouldn't suggest that we did that or need to do it, but essentially that's how we did our safe shutdown analysis, with an independent verification of on a component by component basis, what raceways that the cabling associated with that component were routed in, and then what fire areas those raceways were in, and then how -- what kind of separation we had from raceways carrying cables for redundant components.

MR. BOYER: And when it wasn't adequate separation, then we put the three-hour fire barriers in, new insulation or other devices, or rerouted cables.

MR. MICHELSON: Wasn't that a one-hour fire barrier?

MR. SPROAT: It was. What we did was we either used one-hour fire barriers with automatic suppression and detection, or we used three-hour fire barriers in other locations. We did, really, an area by area analysis and did the most cost-effective route in each fire area. Our total bill for complying with Appendix R shutdown requirements, we don't have the final numbers in, but as an order of magnitude, it was about $20 million, and we have finished -- we just finished about a month ago our NRC and Brookhaven audit of our Appendix R shutdown analysis, and we came through with no major findings, minor procedural things.

So we are one of the few plants in the country right now that is in compliance with Appendix R requirements.

MR. MICHELSON: Somehow I was under the impression that only one plant has been accepted by the NRC so far.

MR. SPROAT: Calvert Cliffs was the first, that's right.

MR. MICHELSON: You haven't actually been accepted yet then?

MR. SPROAT: Well, when they got accepted, they had their audit, and when their audit was done and they resolved their individual small findings, they were termed accepted. Our audit only took place four weeks ago, and we haven't even gotten the formal audit report yet, but all of the findings from that were relatively minor, procedural in nature, and those procedures have been fixed and essentially we are in total compliance at this point.

MR. MICHELSON: As far as you know at least, there are no surprises?

MR. SPROAT: That's right.

MR. MICHELSON: Thank you.

MR. OKRENT: Are the diesels protected from trouble due to fire protection?

MR. BOYER: What do you mean by that?

MR. OKRENT: Is there water deluge in the diesel building that could hurt the diesels?

MR. SPROAT: Yes, there is. The diesel cells are four individual cells with three-hour firewall in between them. We have a pre-action sprinkler system in each diesel cell.

Now, the way that is set up is that we have three flow switches on each -- in each diesel compartment that monitors flow through the sprinkler system over that diesel. We have a two out of three logic on the flow switches, that if two out of three flowswitches sense flow, it will trip the diesel, only if the diesel has either started manually or if it was started in response to a loss of offsite power signal. That trip is automatically bypassed on receipt of an accident signal.

MR. OKRENT: That relates to tripping the diesel.

MR. SPROAT: That's right.

MR. OKRENT: But a water deluge itself shouldn't hurt the diesel?

MR. EBERSOLE: Pardon me, won't hurt the diesels? The water deluge won't --

MR. OKRENT: Yes.

MR. REED: I'd going to try and say it. We have shrouds over the generator to protect the generator, and we also have shrouds over the control cabinets to protect the cabinets, and it's not a deluge system, again, it's a pre-action system. The localized heat have to fuse the head and have an application of water where the fire is. It's not as it if it's going to rain on the pumping compartment.

MR. MICHELSON: All the fancy two out of three is just to charge the system, and not necessarily to spray the water. It still takes heat and the melting of the --

MR. REED: Well, the two out of three is a safety feature to shut it down. Two out of three on flow.

MR. MICHELSON: Oh, that's the interruption, not to alert the fire protection.

MR. REED: That's right.

MR. MICHELSON: It is just a pre-action system.

MR. REED: Yes.

MR. MICHELSON: So then they don't have the problem of spraying. I think you are doing it right.

MR. OKRENT: Are the seismic parts --

MR. REED: Piping?

MR. OKRENT: Piping.

MR. REED: We call it Class II-A, which is the same thing as seismic 1, but it is not safety related. It is installed, the seismic Class I requirements, yes.

MR. OKRENT: What's the fragility, has someone estimated it?

MR. MICHELSON: David, if you want to worry a little more, reactor water cleanup is non-seismic, for instance, and all that high pressure, high temperature, is the SFAR wrong then? It says that all except the isolation valve is category II, not II-A. Maybe I read it wrong. I didn't bring that sheet with me either, but it said Category II.

MR. SPROAT: That must be a mistake in reading, it's II-A.

MR. MICHELSON: I'll show it to you in a minute.

MR. SPROAT: Maybe it's a typo.

MR. SCHMIDT: The next item on the agenda, and it happens to be the one that follows me, is in-plant accident progression.

MR. OKRENT: What I'd like to emphasize, if you would, is the progress of a severely damaged core from various accident scenarios, and how this affects containment failure modes. I think we lack enough time for serious questioning today, to go into the entire topic, so if you would somehow single out that matter -- perhaps by taking one or two scenarios and talking about them in detail, one or two that are different.

MR. HUGHES: If I can, I'd like to start with about four minutes for one question that was left over from before. in the interest of symmetry it's not kosher.

MR. OKRENT: Okay. I'll time you.

MR. HUGHES: There were several questions that were raised regarding break outside containment, and what I wanted to reiterate was some information that I covered before, and provide some additional information that I did not cover.

First of all, in the performance of the original PRA, the possibility of break outside containment was not explicitly analyzed. The basis for this was an evaluation that looked at the significance of the break outside containment, the fact that there are isolation devices in place to preclude the break from continuing to release fluent without some probability of these isolation devices failing.

The low frequency of break in the first place in these areas, and the fact that there is substantial compartmentalization in the plant, that was the basis on which the original PRA did not include it.

The SARA included the possibility of pipe break outside containment from a flooding standpoint. So you will see discussion of flooding included in SARA.

Subsequent to that, we have reviewed the subject and it still appears to us that the frequency was low, and it would not be a substantial increment to the risk that is quoted in the books.

Other PRAs were reflected in this evaluation. Let me mention a couple of them. HPCI, for example; reactor water cleanup, for example. There are diverse capability for isolution based on flow of pressure. There is one valve outside, one valve inside. The compartments isolate. They are vented. So the likelihood of something of the type we were talking about is felt to be relatively small.

The other item that was mentioned was scram discharge volume. The initial work on scram discharge volume failure was done by GE in a rather rapid response to some inquiries, I think, that originated with Mr. Michelson. The frequency was found to be, or assessed to be, less then 3 times 10 to the minus 5 per year, on a generic basis.

The conditional core melt probability given that break was approximately 1 times 10 to the minus 4, but that did take credit for qualified equipment. So the comment that that included qualified equipment is correct.

The equipment for this plant is not fully qualified to this environmental condition for a continuing break. That comment was also correct.

Later, the BWR owners group did some additional work. They looked at fracture mechanics, performed several evaluations, included in-service instruction, and concluded that the frequency was something in the neighborhod of 3 times 10 to the minus 7 per year, or less. This is documented in NEDO 2209.

There is some conditional probability of core melt that should then be applied to that. The numbers vary, of course, from the previous 1 times 10 to the minus 4 to as high as 1.0, but the 1.0 we feel is very conservative and it is significantly less than that, although probably not as low as 1 times 10 to the minus 4.

On the basis that this was a generic analysis, a specific plant analysis would be needed to get an actual number, but since the value was 3 times 7 to the minus 7, that has not been generated for Limerick.

So that, I think, at least encompasses some of the information on that subject.

MR. MICHELSON: This is a clarification then. Are you qualifying your equipment for the environment, or are you simply claiming the break won't hurt, just to be sure I understood yiur answer since there are a lot of numbers and words. Which way is it?

MR. SHANNON: We are not qualifying the equipment for the environment for the scram discharge, discharge volume break. It is qualified for slightly lesser environments, however.

MR. MICHELSON: Yes, I realize that. So your position is it seems credible for that break point.

MR. SHANNON: Yes, sir.

MR. MICHELSON: I think that's a position that should have been essentially stated in there somewhere.

MR. OKRENT: I don't recall. Does Mr. Kennedy specifically look at the fragility of all of the piping associated with the scram discharge piping and other components, and I don't mean generically.

MR. BOYER: I can't answer that, and Mr. Kennedy has gone, I believe.

MR. OKRENT: Well, you might look at that one, and let's find out if seismically the probability is less than 2 times 10 to the minus 7 for the break. And you quoted, I think, the probability for events not seismic in nature, so let's just check to see.

MR. EBERSOLE: In order to run an analysis of the risk of this pipe break -- if I just pick one outside containment, the HPCI break. One has to have an understanding of the degree of the terminal consequence.

Let's say that I take a prolonged uninhibited flow from 1100 pound steam system out into the auxiliary building from a broken HPCI supply line, and my valves, in fact, didn't work since they were never tested that way anyway, and now they are 30 years old and they have been idled from open to shut for the last 30 years, so they were degraded and you didn't know it, because you make no performance test even though you had even physically qualified them in the beginning.

So what is the consequence if we have this uninhibited flow from this line? Have you got a picture of that?

MR. HUGHES: I believe in the process of doing the high energy line break evaluation, there has been some consideration of the effects of these various rooms. Let me give the first level answer and then defer to some of the people that have been involved in that analysis.

The first level answer is, I believe the room would become pressurized, the dampers would close, there is a venting associated with the room, so we would have an adverse environment that would be largely isolated to the region in which the pipe break occurred.

So I think the question then becomes one of what equipment is affected by that and is, in fact, that assumption that I just made accurate?

MR. EBERSOLE: That's a rather prodigious flow, isn't it, 1100 pounds from a 10-inch main?

MR. HUGHES: I would think that it would be reasonably significantly, but I'm not sure what that means in that context.

MR. MICHELSON: You are undoubtedly in good shape because as I tried to point out at the very beginning of our meeting, you have compartmentalized the plant, and as a consequence, I think you can handle the HPCI and RCIC since the lines are brought directly into the compartment and from the compartment directly into the atmosphere. Not everyone is quite so fortunate and, therefore, I think the question has to be reraised each time.

Your answer is only a plant-specific answer, and it's a good one for your case, but it's not good --

MR. EBERSOLE: Is that the answer then, that the damage is restricted to the compartment?

MR. HUGHES: Let me see if Tom Shannon from Philadelphia Electric, would like to add anything.

MR. SHANNON: Yes. As we mentioned previously, each of the compartments that has a high energy risk steam line is vented to the outside atmosphere, so there is no overpressure concern on those compartments.

MR. EBERSOLE: You treated these then pretty much like the turbine hall is treated. You may lose the roof, but so what?

MR. SHANNON: Yes.

MR. EBERSOLE: Fine. Okay.

MR. MICHELSON: Before we leave this, though, I think there is one more that I really think was inadequately answered this morning, and that's your reactor water cleanup.

I admit that you are venting the steam to atmosphere, but you really haven't told me yet what happens to the water, and it is predominantly a water blowdown that is occurring. Later on in the blowdown, it is 60 or 70 percent of the flash.

You didn't really explain to me what happened to the water, and keep in mind that the pressure capability of those rooms may be limited since they are the rodded concrete block rooms and with poured walls.

MR. SHANNON: I believe those rooms are vented also, so like the HPCI compartment, they were not --

MR. MICHELSON: Well, what happened to the water?

MR. SHANNON: First of all, the break would be isolated. On a design basis, the break isolates because it would take redundant -- multiple failures not to isolate.

MR. MICHELSON: It didn't even take one failure not to isolate. The break is just downstream of the valve, the output isolation valve, which is in a compartment which is vented all right, but you have to protect the valve against the break. Do you put a shroud around the valve?

MR. SHANNON: There are redundant valves, in series. There are pipe break restraints provided upstream in the inboard valve and downstream of the outboard valve, so in order to have an unisolated break, you'd have to have failure of both valves.

MR. MICHELSON: No, you only happen to have the break interfere with the electrical power to the valve that has got to close. These are not fail closed valves, I don't believe. They appear on the drawing to be powered valves and motor operators and, therefore, you've got to have 10-15 seconds of power.

MR. SHANNON: The valves are powered by separate divisions, by different divisions, so you're talking --

MR. MICHELSON: Oh, yes. The wiring is in the room where the break is for the valve that's outboard, it has to be. So I think you can see that only one valve stands between you and a non-interrupted blowdown, and that's the single failure that you told me you took care of somewhere else.

MR. SHANNON: To reiterate a point from this morning also, all the equipment that's in those compartments that are required to mitigate the high energy line break, i.e., the closure of the valves, is qualified for the environment that it will see in that area.

MR. MICHELSON: So the valve is qualified and the electrical wiring is protected.

MR. SHANNON: Yes, sir.

MR. MICHELSON: So you claim you can take the break in the compartment.

MR. SHANNON: Yes, sir.

MR. MICHELSON: Thank you. That's a good answer.

MR. OKRENT: Let's go.

MR. HUGHES: Okay. Let me proceed. I think I understand the question you raised. I'm not sure I have all the information to respond to it, so let me at least serve as a lightning rod for the question and get to it as quickly as possible.

What I have here are a couple of observations I need to make before we get into the actual analyses that were performed. I would like to take a minute and discuss binning. We looked at six different types of accidents, but I can keep that very brief.

The sequences modeled were --

MR. OKRENT: Excuse me. I'd really rather look at a couple of accidents, phenomenologically in detail, than the binning and the subsequent consequence calculation and so forth.

MR. HUGHES: The information that I think you seek --

MR. OKRENT: In other words, there were certain pictures of how Mark I behanved or misbehaved in WASH 1400, given a core melt factor for that. I would like to go through the same, but presumably modified kind of phenomenological process for the Mark II, your Mark II.

MR. HUGHES: This is Mark II.

MR. OKRENT: But they are not all necessarily identical.

MR. HUGHES: I have limited information with which we will address what you are seeking. Let me take five minutes and see how much I can get to.

What I've put up is a very simplistic Class I-IS. It looks at the time to containment failure. What was done in the analysis was to take the ray-cap containment analysis package -- and I can pick a couple of sequences in a moment -- take the sequence, develop a model for it, perform the analysis using the computer code package, and determine for an intact containment what the response would be.

This response in an intact fashion was then overlaid with containment capability to determine when and how the containment might fail and what the progression would then be in term of the source term. So the source term we then calculated using the CORRAL computer code.

The raycap package is different from March in that it uses the contempt LT rather than mace to keep track of what the fission product release is doing in terms of pressure and temperature, but it is very similar in other regards. It has boil, PV melt and Inter associated with it.

I do not have any calculations or results curves to show today, for what the various aspects are of that analysis in the different subroutines and what's going on, but I can characterize the general time at which things happen, and also discuss the containment failure paths associated with that and the containment analysis that led to that.

My fear is your question is aimed more at the physics of core slumping and how things occur, which I am not really prepared to discuss.

MR. OKRENT: Yes, it is, and now let me ask the question of power. If we have a followup subcommittee meeting on October 20, are you free then? It's a Saturday.

MR. POWERS: I think we talked about it and I found it was open.

MR. OKRENT: Okay. Well, if you are not prepared to discuss the physics of it in detail, then I don't know that it pays to --

MR. POWERS: It would be helpful to give him an outline of the kind of things we want to go over.

MR. OKRENT: Why don't you do that. What you'd like to have discussed in detail next time.

MR. POWERS: I think if we are going into detail, the things I expressed, it would be very interesting to go through the Class I action because they seem to figure very highly in the analysis that they've done to-date.

It would be very interesting to go through a detail of the Class I accident because they figure very highly in the analyses that have been done to-date, and a Class IV accident because they seem to be going down in importance, so we understand that phenomenologically there is a basis for going down and not some surprise omission or inclusion in those analyses that might cause them to come back up again.

And I think what we'd be interested in, from my point, is that if you did use the boil code, PV code and especially INTER, did you do anything outside of that code package to convince yourselves that the answers were physically real for your plant?

Did you look at anything that those codes, when they were built, did not consider? In particular, I'd be very interested in the effects of internal circulation within -- during the core meltdown and the possibility of overheating piping systems that would give you a bypass of the suppression pool, the effects of a high pressure scenario for the vessel, the melt comes down and penetrates the vessel at high pressure and perhaps gets sprayed around on the floor area rather than be confined in the cavity just below the vessel, perhaps the possibility of the diaphragm floor failing as a result of that high pressure and getting a very sudden steam spike in the wetwell. Those things are things that do not appear in any of those codes that you are citing. That's a quick summary of my list.

MR. OKRENT: I think if you have any others to add to it, this is a good time to do it, so that they have a chance to develop what information they can.

MR. POWERS: All I can say is that I'm looking very intensely at things that will change the risk associated with a given frequency because of the possibility of bypassing the suppression pool or failing containment earlier than anticipated. In the source term area, that would probably include vaporization and whatnot, but that becomes kind of a touchy area because of the directions used for WASH-1400 falls. They quickly go beyond the bounds of their study, I think.

MR. OKRENT: For purposes of what we are talking about, there is nothing that says one should or should not use the WASH-1400 formula, or any formula. We are trying to understand as best we can the situation.

MR. BOYER: Aren't you getting into areas where -- I'm trying to understand.

MR. OKRENT: Well, if you think someone from INCOR has answers worked out on the physical behavior for various postulated accidents in a Mark II like Limerick, and you want to bring them here to discuss this, that would be fine from my point of view.

I'm interested -- I haven't seen or heard the equivalent of what I've been able to read, let's say, concerning a PWR like Indian Point or Zion, and I'd like to feel that I've seen --

MR. BOYER: The progress of the core to the core melt, core damage or core melt, and the regression?

MR. OKRENT: And the progression to containment failure.

MR. BOYER: The likelihood of some earlier containment failure.

MR. OKRENT: Or just in general. In some cases, do you get no containment failure, or if you get containment failure, in what way is it most likely to be via what I will call a moderate leakage rather than a really gross leakage.

The next thing I'd like to hear about -- I wasn't proposing it for today -- I'd like to go into, again, as well as we can, the physics of how the containment behaves when it is taken well beyond the design point, temperature or pressurewise, why you think it will fail, if it fails in certain ways, so that we have a better feel, for example, if the position is most of the time you expect it to fail well above the wetwell, what is the basis for this and so forth; what would it take for that, and so forth.

I want to be sure that some of these key assumptions are really quite robust, and not likely to be overturned in the next paper given at the next scientific meeting, assuming that somebody is able to read this because it's not proprietary.

MR. HUGHES: Let me make an observation and then ask a couple of questions to further clarify what is desired here. First of all, I think the observation has to be made that when Zion was performed, the PRA, there was a significant question from the NRC staff relative to the capability of containment phenomenology improvement features, design features that might enhance based on containment phenomenology.

As a result of that, there was a significant effort to look at sensitivities and look at different sorts of things that was included there. When we did the Limerick risk assessment, we were not asked to look at the same sorts of things, so we performed an analysis based a little bit simpler on the design that exists, without a lot of assessment of design features that might be added.

So, we do not have in the PRA sensitivity studies or design feature evaluations. We do have a discussion by Bob Henry, of Henry-Fowski Associates (phonetic), that talks about the phenomena. So that's included in the PRA, and I think we can go through some of that.

MR. OKRENT: Well, what I discussed up to now, in fact, is the phenomena involved in meltdown and containment failure. You haven't heard me, up to now, mention the possible merits or disadvantages of, for example, mitigation features, not that I'm uninterested in them, but I'd like, first, to understand better in my own mind how the containment is thought to behave for a range of core melt scenarios, and also to have a better feel for, let's say, the likely "range" of offsite consequences and where the uncertainties are, and if you had studies on possible mitigation features, I'd be happy, in fact, to hear about them.

It may be -- I can't say -- as a result of hearing the discussion of how you think the containment behaved and the resulting source terms and so forth, I will tend to feel like you do, that the low numbers are for real, or I may think that the uncertainties are pretty big in it, at which point, I might ask, are there any steps that one can take that even if you are not sure that they will necessarily reduce the numbers because they are small, at least they will reduce the uncertainties that the numbers, and whatever. But right now, at least, I'd like to develop a good understanding of, as I say, the physics of those situations.

MR. HUGHES: Would I be going too far if I attempted to characterize it as a discussion of the physics area, what was done, how it was done, and what the results indicate in terms of our knowledge of the containment and how it performs?

MR. OKRENT: Yes.

MR. HUGHES: What that would leave out is a discussion of substantial -- there's a great deal of effort going on today to evaluate new computer codes, new methods, new things that might be used in these areas, and I don't think we would be prepared to discuss all of those various methods and what they might mean. Indeed, I'm not sure anyone would, but can I exclude that from the discussion and talk primarily about what we've done and what the results indicate and what we think they mean?

MR. OKRENT: Well, the problem with saying yes to what you propose is if the thinking since the SARA was written could change markedly concerning the way some of the scenarios behave in either direction, to make them less likely, or to have a lower source, or the other way, it's relevant to know about that, and at least to know what are the key phenomena that are thought to be doing that.

What if something wasn't included, or something now quenches where you didn't think it would quench, or whatever? I'm not wild to have reams and reams of computer paper brought into the room, but I would like to have understanding as it exists today, of what is thought to be the behavior. Is that fair enough?

MR. ROSENTHAL: Before you answer, since we will have to support your meeting also, I am hardpressed to still understand the objectives. The applicant's work was done with computer codes which surely the ACRS and its consultants are familiar with -- boil, INTER, contempt, CORRAL.

The phenomenology, asking Henry phenomenology, I think you understand and I'm not quite sure what would be gained by your listening to that material again.

There is the newer codes, new insights, simply are not available to the applicant, at least on the short-run, to do independent analysis.

MR. OKRENT: I don't know what you mean by the newer insights.

MR. ROSENTHAL: Of course, we always have public meetings, people can come to it, but there is just no -- I don't see how it would be feasible for the applicant to run a COR confinessa (phonetic) and compare that to source terms which he got from the older series of codes. They just physically can't do it. The information isn't there to be had. And, alternately, if they can't do it, what would you want from the staff?

MR. OKRENT: I am, at the moment, more interested in understanding the robustness of our own understanding of the progression from core melt to containment, when and what magnitude of failure.

MR. BOYER: I would respectfully submit that this is what INCOR is spending $15 million doing, and has been doing over a three-year period.

MR. OKRENT: And they were supposed to have done by now.

MR. BOYER: Well, it's pretty well along, and it is much further along than anything we have. So there's nothing we can do between now and October 20th to generate new data relative to what we did in response to the NRC's request that we make this evaluation. We could tell you what we did. If somebody isn't happy with that, I'm sorry, that's what we did and in accordance with the directions and what was known at the time.

The thing that you seem to be seeking as a result of INCOR, which I happen to be involved in through some steering committees, and I know the extent of the work that's been done on that, and the number of people that have been involved, and the reason it isn't done is because of new information becoming available, additional information and going still further. So it's not a thing that is completed even yet, and so it's a moving target and fast approaching some resolution point for at least issuance of a report which can summarize the work done to-date and the state of the knowledge to-date, but it is beyond what we have in our house, or what we did.

MR. OKRENT: Let me talk to the staff for a minute. As the staff knows, on occasion, I have indicated that I, for one, and I thought the ACRS in general, have not seen a thorough examination of the physics of core melt through containment failure for all of the containment types commonly in use, and that I thought that was important information, for example, consideration in adopting some statement on severe accident policy.

If the staff really doesn't know how a Mark II containment will behave under these circumstances, they should rush up to the commission and say, "We are withdrawing all prior copies of Spec 82-1 and 1(a), (b) and (c) and all the succeeding numbers because, in it, you make statements like you know that the risk is acceptable, and to do that you have to have some idea as to what the containment does, given an accident that melts the core.

Either you have a hand on this which enables you to repeatedly make that statement, and it was made as recently as last week, or you don't. If you do, you can come in here and tell us what the Mark II does.

MR. ROSENTHAL: Yes. I think both the staff and the applicant have models of the Mark II containment. Let me point out that INCOR's four reference plans does not include a Mark II. Then available to the staff by virtue of the work of the containment load ten performance working groups, is information on a Mark II and, in fact, the dimensions are for Limerick.

We can bring forward that information. And we can for you. I just wanted to alert you that I don't think that the applicant has available that information. And, furthermore, we are doing Limerick-specific calculations for the full ASTPO product for three reference sequences, but that information is not available today.

MR. OKRENT: I'm interested at the moment more in getting up to the point of containment failure, when and what form. I'm willing to accept that you are still manipulating your best knowledge as to how much of what fission product gets out, given that.

MR. ROSENTHAL: Now you have to decide on -- we can do that -- now you have to decide on what is the proper form that, who do you wish to be there, and what is Limerick's participation, PECO.

MR. OKRENT: Well, let me say, I had thought, in fact, it was one of the agenda items for today, as I read the agenda that was made out, that we would naturally lead into the topic by whatever presentation was made.

I should have remembered that INCOR did not include a Mark II. I don't know how Boyer let them get away with that if he's on the steering committee but, in any event, unless they have something that they think applies based on other things they've done, that they are not a likely source there. and so it sounds like the thing that would lead to the best flow of information on October 20, which is when we are next scheduled, lest we defer it, is for the utility to review what they have done and to have their consultants present what they think is the physics of the situation, because whether INCOR has done something or not, Bowski and Associates because they are the consultants, have thought in this area, and then the staff tell us their best thoughts on both the phenomenology of what I will call core melt behavior and then containment behavior in these circumstances, and we should have a fairly good picture a the end of that. Is that fair enough?

MR. ROSENTHAL: Yes, sir. Just pressing it a little bit more. This morning when I stood up there and said that I thought there was conservatism in the time to containment failure, that was based on roughly five hours to containment failure as calculated by INTER versus numbers of more like the order of 10 hours for core con Mark II, so there were factual underpinnings for the statements.

I would appreciate it if we could schedule -- we'll bring in our consultants for that -- a coherent two-three hour presentations in order to explore the thing in sufficient depth to warrant it.

MR. OKRENT: That sounds like about the right time.

MR. BOYER: We would certainly need to bring Bob Henry, who did some of the work on Limerick.

MR. OKRENT: Well, we will have to go back and see if there are other topics in the PRA and SARA we should cover, but that's one we have not looked at or talked about at all, so it should receive a considerable share of the time at the next meeting. There will be some other topics on the agenda.

MR. ROWSOME: I certainly agree with you that these subjects weren't careful and thorough addressed. I wonder, though, whether we are not confusing what needs to be done to support the writing of a full power letter on Limerick, with what we would like to do in support of the severe accident research program and severe accident policy.

I don't want to find ourselves in a bind in which we have inadvertently made the Limerick license hostage to generic standards development policy, evolution and the like. If we can abbreviate -- if we can segregate what we need to support your letter from what you would like to hear more thoroughly at a more relaxed pace in support of generic standards development, I think it would be in everybody's interest.

MR. OKRENT: Well, for whatever reason, when the ACRS wrote an interim letter, it said it would look at the PRA and the severe accident risk assessment for Limerick, and if we are going to look at it, we have to look at that source material.

It seems to me for your severe accident policy, there are lots of reactors around, there are future reactors. I mean, it's a broad --

MR. ROSENTHAL: It's a much broader topic.

MR. OKRENT: -- a much broader question. This is one piece that fits into the other and not sort of vice versa.

MR. BOYER: Well, in connection with the Limerick PRA and SARA, we can tell you what we did and how we went about it. The people who have been involved in that work have also been involved in '78 work and would have some relationship to the past work to the present work as to its applicability, and have increased knowledge or whatever changes might ensue. That's what we can tell you.

MR. ROWSOME: Perhaps the key to a common understanding, as you raise physics as distinct perhaps from physical chemistry or behavior and the like, if you want to kick the tires of the safety analysis by challenging whether or not the staff and/or the licensee has perhaps failed to consider penetration failures or some physical phenomenon, which containment fails in a more gross serious way than the -- than were reflected in the models, in terms of broad outline, qualitative serious omissions, that would certainly be appropriate to your work to support the letter. It would certainly be appropriate to the meeting on the 20th.

MR. OKRENT: I thought that was what I was saying, and I was trying to --

MR. ROWSOME: Just wanted to make sure we have a common understanding.

MR. OKRENT: I was trying to indicate that I wasn't looking for your -- the last word on your source term calculation and so forth, for part of that meeting.

MR. ROSENTHAL: I'm still hard pressed to see where we are going. For instance, the assumed steam explosion probability here is small compared to the early failure mode by failure to inert the containment such that the exact number on the steam explosion probability will change the total risk number, and really how much should we discuss that farther.

The pool DFs, in the staff's analysis were 1 in 100. The applicant has used 10 in 100. Nobody is talking about values of 6,000 where a reduction from 6,000 to 60 could change the nature of the risk of the plant.

MR. OKRENT: Excuse me. The DF probably should be discussed, and what the applicant and the staff's thinking is on this because that is something that is part of Limerick. It certainly -- if it were 1, you would look differently on a variety of scenarios than if it were --

MR. ROSENTHAL: But having assumed pessimistic values of pool DFs, one could be reasonable comfortable that the values -- that the source term is only going to come down, not go up, that somehow -- that what you have to do is say that the new technology will change the risk profile as well as the absolute values. Having changed the profile as well as the absolute values, that decisions will be different than the decisions were now made.

And I just don't see, coming from the values that were used in things like the FES, where we are going to get such a remarkably different picture of the profile of the plant, that the decisions would be different.

It would be very different if you had a very small numbers for source terms as may be emerging from the BMI work and then were questioning how big would the variations be. When you are talking about small source terms, the uncertainties in those small numbers are very high, but when the source terms are large and the containment modeling was somewhat pessimistic, I don't see where one is going to get a remarkably different picture.

MR. OKRENT: If the source terms are small enough, you don't mind having big uncertainties. The whole range falls in a low enough band -- I'm not sure what your question is.

MR. ROSENTHAL: Having attended the containment performance group meetings, having attended the containment load working group meetings and the INCOR meetings, as some of your consultants have and occasionally an ACRS member, I don't think there's that much more to be learned by the subsequent meeting, and at least based on my perception, don't believe that the risk profile for Limerick, as far as down to the point of basic conclusions, is going to change. But we will have the meeting. I'm just trying to get the right people and understand it.

MR. BOYER: Really what I see we'd be doing is saying what we did in the Limerick PRA and SARA, and then compare it to what we think we know today, what the current state of the knowledge is, and to indicate that we're conservative, in containment failure, in steam explosion and hydrogen effects, in source term and so forth.

MR. OKRENT: I think that would be good if that's the way the new information since you wrote the report comes out. That would be useful.

MR. HUGHES: I think we can do that. I have a fear that I think maybe the same fear that the NRC is expressing, and that is in the process of doing it in the time frame we're dealing with, there are certain to be areas where we have DFs, for example, or we have other things that we've included, and we may not be able to go to the extreme that was referenced here from Dr. Powers in terms of the phenomena that aren't even treated by some of the codes, I think, is probably unlikely we will be able to touch on. And to the extent that we can address the questions of Dr. Okrent and others, I think that's fine. We can try to do it, but I'm not sure that we will be able to address everything.

MR. OKRENT: If the questions -- there weren't very many -- that Dr. Powers raised are among those for which you haven't sought -- you don't have answers as to whether or not this changes containment failure likelihood or release fractions or anything, it seems to me your program has been deficient. Somebody must have thought about it. I can't believe those have not been thought on, whether they are written in the Limerick document or not.

MR. HUGHES: My only point is we have essentially an analysis that was done based on what we thought were the best codes and reasonable assumptions to perform that analysis , and I think the thing for us to do is to present that and see where we come out.

MR. OKRENT: Well, I've tried to indicate what I thought would be an area of interest that we could cover in less than a day, that I think is important for the committee to have a grasp of if, indeed, it is reviewing the severe accident risk analysis, and I'm really not sure I understand what all the problem is about. Somebody ought to tell me.

MR. PARRY: I think the problem is the state of the art at the point in time that the Limerick PRA was performed, it's different than it is today and it is still evolving. The codes that were utilized were codes that were recognized then as representing the best information available. We certainly explained what was done in those codes, we can explain why it was done at that point in time.

To compare it with the present state of the art situation, however, being so fluid and not completely having all that information available to us, we can't do much more than that.

MR. OKRENT: We will leave it to the staff then, to present what they think is the current state of the art and the extent to which it alters what you have in your report and so forth.

Are there --

MR. BOYER: You will have another meeting at which that is discussed, what else do you want? You didn't get through all the program today. We had a few things like relative use, how we view PRA in the future, et cetera.

MR. OKRENT: I think what we will have to do is prepare an agenda for the next meeting. I think we will have to go back and look at what we covered, and we didn't cover. I will ask the consultants for their suggestions for things that we should hear about at the next meeting besides what I will call the progression of core melt through containment failure, and we will try to get an agenda, tentative agenda I'd better call it, out to you as soon as we possibly can.

DIEDERICH: That's only about a week away.

MR. OKRENT: I realize that. We could defer the meeting if you prefer, but I don't particularly like the situation of leaving my family on a Saturday either.

MR. BOYER: The things we would be able to talk about is how we addressed those concerns or parameters or conditions in the Limerick PRA and SARA, and try to show it in the context of what we believe is the current trend or what information has become available to INCOR or other sources since that time.

MR. OKRENT: That sounds fair enough.

MR. SCHWENHER: Dr. Okrent, could I suggest perhaps that the staff could make input to Dr. Savio in terms of the things that we would commit to for the meeting, perhaps the applicant could do the same thing, and do that over the next couple of days.

MR. OKRENT: I would suggest you try to do it tomorrow if you are going to, so that maybe by Friday we have an agenda agreed on.

MR. SCHWENHER: And perhaps there could be a feed-back exchange between the committee's consultants so that these things could happen about the same time.

MR. OKRENT: Okay.

MR. BOYER: We could do it now, as a matter of fact.

MR. OKRENT: But we don't have to do it as part of the meeting per se, so let me ask, are there any other points anyone wants to raise at this late hour?

If not, I will thank you all for a group of interesting presentations, and I will assume we will be getting together again in the not too distant future.

The meeting is adjourned.

(Whereupon, at 7:00 p.m., the meeting of the ACRS subcommittee was adjourned.)

CERTIFICATE OF PROCEEDINGS

This is to certify that the attached proceedings,

IN THE MATTER OF:

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
SUBCOMMITTEE ON RELIABILITY AND PROBABILISTIC ASSESSMENT
AND LIMERICK UNITS 1 AND 2

DATE: OCTOBER 10, 1984

PLACE: WASHINGTON, D.C.

were held as herein appears and that this is the origina; transcript for the file of the Commission.

REPORTER: PHYLLIS YOUNG

SIGNED: Phyllis Young

TRANSCRIBER: NEAL R. GROSS

SIGNED: Neal R. Gross

LGS MITIGATION CONSIDERATIONS

MEETS DETERMINISTIC REGULATORY REQUIREMENTS

RISK PERSPECTIVE

ESTIMATED EARLY FATALITIES WITHIN 1 MILE (per plant year of operation)	5E- 3
ESTIMATED ACCIDENTAL DEATH TO 3000 PEOPLE WITHIN 1 MILE OF PLANT (per year)	2E- 0
ESTIMATED LATENT CANCER FATALITIES WITHIN 50 MILES (per plant year of operation)	5E- 2
ESTIMATED CANCER FATALITIES DUE TO ALL CAUSES TO 7E+6 POPULATION WITHIN 50 MILES (per year)	1.4E+4

INITIATOR PERSPECTIVE

STATION BLACKOUT, LOSS OF DECAY HEAT REMOVAL, ATWS ARE SHOWN IN LGS PRA TO BE IMPORTANT

GENERIC REGULATORY INITIATIVES UNDERWAY

CONSEQUENCE PERSPECTIVE

CORE MELT FREQUENCY ABOUT 1 E -4

CONDITIONAL CONSEQUENCES USING RSS METHODOLOGY
OF THE ORDER OF 1 E + 7 person -rem

COST/BENEFIT PERSPECTIVE

ESTIMATED TOTAL PERSON-REM TO 50 MILES ABOUT
700 PERSON-REM PER YEAR OF OPERATION

AT $1000/PERSON REM AN ANNUAL COST OF $ 700,000 WARRENTED

PRESENT WORTH OF IDEAL MITIGATION $ 8E6 to $21E6

MONEY TO BE SPENT ON CLASS 1 TRANSIENT MITIGATION

METHODOLOGY

ABOVE ESTIMATES BASED ON RSS METHODOLOGY

PRIMARY SYSTEM RETENTION NEGLECTED
CONTAINMENT FAILURE TIME UNDERESTIMATED
AGLOMERATION AND SETTLING UNDERESTIMATED
SECONDARY CONTAINMENT NEGLECTED

ASTPO PRODUCTS NOT TO BE USED PENDING REVIEW

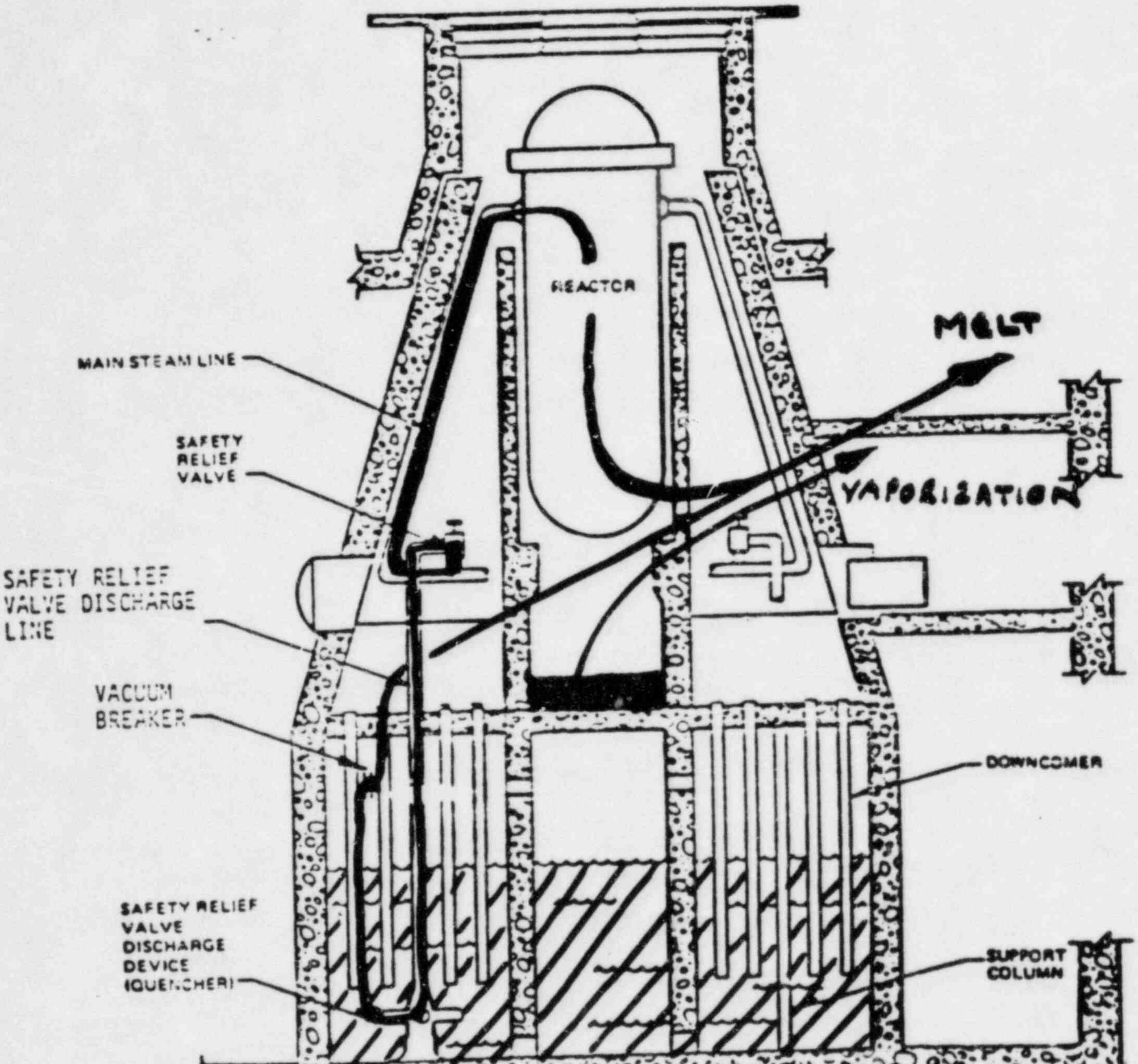
STUDIES UNDERWAY AT RDA AND BNL SPONSORED BY NRR
SNL SPONSORED BY RES

IDEAL MITIGATION

- OVERPRESSURE CONTROL
- OVERTEMPERATURE CONTROL
- HYDROGEN CONTROL
- DECAY HEAT REMOVAL
- CORE DEBRIS MASS AND ENERGY CONTROL
- ATWS

LIMERICK

VENTING	PROCEEDURES
SPRAYS	PROCEEDURES, MONTHLY TESTING
INERTED	99% OF TIME ??
A 44, A 45	
SARP	
ATWS 3A FIX	



CLASS IV ATWS, FAILURE IN DRYWELL

($C_4\gamma$, IV-T/DW)

AS MODELED IN LGS-PRA & NUREG/CR-3028

RELEASE CATEGORY CONTRIBUTION TO MEAN EARLY FATALITIES PER REACTOR-YEAR

(LGS-DES, NUREG-0974, SUPPLEMENT 1)

FAILURE MODE	EARLY FATALITIES	PERCENTAGE OF TOTAL
TRANSIENT INITIATED ATWS WITH COOLANT INJECTION		
- DRYWELL FAILURE	2.5(-4)	50
- WETWELL FAILURE ABOVE POOL	1.9(-4)	38
- WETWELL FAILURE BELOW POOL	1.9(-5)	4
LOCA INITIATED ATWS WITH COOLANT INJECTION (MODELED AS DRYWELL FAILURE)	1.3(-5)	3
CLASS I TRANSIENTS WITH LOSS-OF-COOLANT MAKE-UP, CONTAINMENT LEAKAGE, AND SGTS FAILURE	1.3(-5)	3
	TOTAL	98

RELEASE CATEGORY CONTRIBUTION TO MEAN LATENT FATALITIES PER REACTOR-YEAR

FAILURE MODE	LATENT FATALITIES	PERCENTAGE OF TOTAL
CLASS I TRANSIENTS WITH LOSS-OF-COOLANT MAKE-UP:		
- CONTAINMENT LEAKAGE WITH STANDBY GAS TREATMENT SYSTEM FAILURE	3.4(-2)	47
- DRYWELL FAILURE	1.4(-2)	19
CLASS II TRANSIENTS WITH LOSS OF CONTAINMENT HEAT REMOVAL SYSTEM	1.2(-2)	16
CLASS III ATWS WITH LOSS-OF-COOLANT INJECTION	6.9(-3)	9
CLASS IV ATWS WITH CONTINUED COOLANT INJECTION	1.2(-3)	2
	TOTAL	93

AGENDA

SUMMARY OF REVIEW INSIGHTS

1. VOLUNTARY IMPROVEMENTS INFLUENCED BY THE PRA
2. ADDITIONAL IMPROVEMENTS
3. ONGOING USE OF THE LGS PRA/SARA

SUMMARY OF RISKS .

1. FREQUENCY OF CORE DAMAGE
2. LEADING ACCIDENT SEQUENCES
3. OTHER RISK INDICES

VIEWS ON UNCERTAINTIES AND LIMITATIONS

1. ALLOCATION OF UNCERTAINTIES AMONG ACCIDENT SEQUENCES AND HAZARDS
2. SOURCES OF UNCERTAINTIES
3. LIMITATIONS

VIEWS ON THE LGS MARK-II CONTAINMENT

Table 5 Voluntary Plant Improvements Influenced by the PRA

Items	System Reliability Improvement Factor 3/ 5/	Sequence Frequency Reduction Factor 4/ 5/
ATWS Alternate 3A fixes. These include SLC pumps (129 gpm) improved automatic system initiation, on-line test capability, alternate rod insertion, recirculation pump trip, redundant and diverse scram volume instrument sensors and MSIV isolation setpoint change L2 to L1	20	10
ADS air supply system improvements (added redundant air solenoids, piping, and valves)	12	1.2
RHR SW pump discharge crossover valves added	11	11
Containment overpressure relief system	1/	1/
Added fire barriers for reactor building equipment hatches	7	7
Added procedure to reset selected electrical equipments after seismic events	2/	2/
MSIV air supply system improvements	2/	2/

1/ Previously considered and now system is removed.

2/ Estimate is not available.

3/ Reliability improvement factor is the ratio of the reliability estimate before the system modification to the reliability estimate after the system modification.

4/ Frequency reduction factor is the ratio of the sequence frequency estimate before the system modification to the sequence frequency estimate after the system modification.

5/ Estimates were provided by the applicant.

Table 1 Frequency of Core Damage at Limerick

Contributors	PECO	Review
Transients and LOCAS	1.5E-5	8.5E-5 1/
Fires	3.4E-6	2/
Seismic events	5.7E-6	6/
Flood	3/	3/
Tornado	3/	2/, 4/
Turbine missiles	3/	3/
Random vessel failure	2.7E-8	2/
Total	2.4E-5/RY 5/	9E-5/RY

1/Frequency increase is due to the added common mode failures and revised transient frequency.

2/Review indicates that PECO's frequency estimates seem reasonable. See Table 4 for uncertainties associated with these estimates.

3/Negligible (less than 1.0E-7 per reactor year).

4/PECO has submitted analyses to demonstrate that the ultimate heat sink piping can withstand tornado missiles with the criteria that the probability of exceeding 10 CFR 100 limits is less than 1.0E-7 per reactor year.

5/PECO performed ATWS, RHR, and fire-related fixes and reduced the total core damage frequency to 2.4E-5 per reactor year.

6/The staff's review did not provide a specific alternate estimate to that of PECO. See Table 4 for uncertainties associated with these estimates.

Table 2 Dominant Accident Sequences at Limerick

Sequence	PECO	REVIEW	Comment on Differences
A loss of offsite power with a common cause failure of all diesel generators no timely recovery of AC power, and loss of inventory makeup systems (T_EUV)	5.9E-6	1.8E-5	Higher initiator freuquency, higher HPCI unavailability 1/
Reactor isolation with failure to restore the feedwater and condensate system, failure of higher pressure injection, and failure of timely ADS actuation (T_FQUX)	3.6E-6	3.7E-5	High T_FQ dependency, higher HPCI unavailability, higher human failure probability to depressurize 1/ 2/
Turbine trip followed by loss of feedwater, failure of higher pressure injection, and failure to depressurize the reactor (T_TQUX)	7.7E-7	8.0E-6	High turbine trip frequency, higher HPCI unavailability, higher human failure probability to depressurize 1/ 2/
Loss of offsite power with loss of high pressure injection due either to failure to restore AC power or due to random failures followed by failure to initiate ADS (T_EUX)	6.9E-7	5.0E-6	Higher initiator frequency, higher HPCI unavailability, higher human failure probability to depressurize 1/ 2/
Inadvertent opening of a relief valve followed by a failure of high-pressure injection and failure to initiate ADS (T_IUX)	6.8E-7	4.0E-6	Higher initiator frequency, higher HPCI unavailability, higher human failure probability to depressurize 1/ 2/

1/BNL has quantified the effect of support system dependencies (AC, DC, SW) at the accident sequence level. This contributed to increase in sequence frequency.

2/These values were determined prior to the implementation of TMI Action Plan Item II.K.3.18 regarding modifications to the actuation logic for ADS and, therefore, may not be fully representative of the current plant design.

Table 3 Risk Review of Limerick

Risk Index	PECO1/6/	Review2/6/	Comment
Early fatalities (per plant year of operation)	3.3E-4	5.0E-3	3/, 4/
Latent cancer fatalities (per plant year of operation)	2.8E-2	5.0E-2	4/, 5/,
Person-rems (per plant year of operation)	295	700	

1/Estimates are obtained from Limerick SARA

2/Estimates are obtained from Limerick FES (Table L.1a). See the FES for the uncertainties associated with these estimates.

3/Estimates are based on supportive medical treatment.

4/Estimate are based on crediting those plant modifications which are dicussed in Section 5.

5/Estimates include thyroid cancers.

6/Estimates correspond to "population to 50 miles" case.

Table 4 Uncertainty Estimates on Various Classes on Accident Sequences at Limerick 1/

Sequence Class2/	Contributor3/	Frequency Range/RY			Mean Value7/
		Low	Median	High	
Class I	I	4.7E-6	3.3E-5	3.3E-4	7.7E-5
	S	1.3E-9	1.7E-7	1.7E-5	3.2E-6
	F	1.7E-7	1.4E-6	1.2E-5	3.4E-6
Class II	I	4.5E-7	2.3E-6	1.1E-5	4.1E-6
	S	4/	4/	4/	5.0E-8
	F	5/	5/	5/	5/
Class III	I	2.6E-7	1.6E-6	1.1E-5	3.3E-6
	S	2.7E-12	1.8E-8	4.9E-6	9.2E-7
	F	5/	5/	5/	5/
Class IV	I	1.7E-8	1.1E-7	1.1E-6	3.2E-7
	S	2.9E-13	2.1E-9	6.7E-7	1.3E-7
	F	5/	5/	5/	5/
Class IS	I	6/	6/	6/	6/
	S	8.0E-14	7.6E-9	7.0E-6	1.2E-6
	F	6/	6/	6/	6/
Class S	I	1.0E-9	1.0E-8	1.0E-7	2.7E-8
	S	1.9E-21	3.2E-11	2.5E-6	4.1E-7
	F	6/	6/	6/	6/

1/For source of uncertainty, refer to Section 2.3 and to Appendix C.

2/For sequence class description refer to Section 2.3.

3/I - Internal (see NUREG/CR-3028, Table 5.31 and SARA Supplement 2, Table 5);
S - Seismic events (see SARA Supplement 2, Table 5);
F - Fires (see SARA Supplement 2, Tables 4 and 5).

4/Estimate is not available.

5/Review indicates that fire does not contribute to these classes of sequences.

6/Not applicable.

7/SARA Supplement 2 Tables 4 and 5 are point estimate values.

WASHINGTON, D.C.

AGENDA FOR THE ACRS SUBCOMMITTEE
LIMERICK UNITS 1 AND 2
RELIABILITY AND PROBABILISTIC ASSESSMENT

OCTOBER 9-10, 1984

October 9, 1984

1.	Executive Session	ACRS	15 min.	1:00-1:15 pm
2.	NRC Staff Report - Status and schedule for NRC licensing activities on Limerick and discussion of response to comments made in the October 18, 1983 ACRS Interim Report on Limerick.	T. Novack R. E. Martin		
	a) NRC Staff Presentation		15 min.	1:15-1:30 pm
	b) Discussion		30 min.	1:30-2:00 pm
3.	Region 1 status report on significant plant experience and Region 1 assessment of the Limerick plant.	R. Starostecki	30 min.	2:00-2:30 pm
4.	Comments from Philadelphia Electric Company	G. M. Leitch	15 min.	2:30-2:45 pm
BREAK			15 min.	2:45-3:00 pm
5.	Discussion of Emergency Planning	R. A. Kankus/ Kantor, Sears, Matthews	90 min.	3:00-4:30 pm
6.	Discussion of Security Plan (Closed)	R. J. Weindorfer/ McCorcle, Skelton	30 min.	4:30-5:00 pm
7.	Summary, Conclusions, and discussion of future review activities.	ACRS	30 min.	5:00-5:30 pm

AGENDA
FOR THE ACRS SUBCOMMITTEE
LIMERICK UNITS 1 AND 2

OCTOBER 10, 1984

October 10, 1984

1.	Executive Session	ACRS	15 min	8:30-8:45 am
2.	Discussion of the Subcommittee's Objectives in the Review of the LGS PRA/SARA	ACRS	15 min	8:45-9:00 am
3.	NRC Status and Summary of Reviews and Views as to the Use of the LGS PRA/SARA by NRC	F. Rowsome F. Coffman E. Chelliah R. Martin	60 min	9:00-10:00 am
4.	A. General Overview of PRA/SARA effort	G. F. Daebeler	30 min	10:00-10:30 am
BREAK			15 min	10:30-10:45 am
	B. Discussion of Methodology for Internal Events.	E. A. Hughes	45 min	10:45-11:30 am
	C. Discussion of Methodology for External Events.	E. R. Schmidt		
	i. Fires		15 min	11:30-11:45 am
	ii. Other			
	iii. Seismic Analysis		45 min	11:45-12:30 pm
LUNCH			60 min	12:30-1:30 pm
	D. Discussion of In-Containment Analysis	E. A. Hughes	45 min	1:30-2:15 pm
	E. Discussion of Consequence Analysis	G. D. Kaiser	30 min	2:15 - 2:45 pm

October 10, 1984 (cont'd)

F.	Discussion of Uncertainty	G. W. Parry	45 min	2:45-3:30 pm
BREAK			15 min	3:30-3:45 pm
G.	Discussion of Seismic Design and Margin	E. R. Schmidt et.al.	45 min	3:45-4:30 pm
H.	Insights and uses in Evaluation of Plant Design	G. F. Daebeler	20 min	4:30-4:50 pm
I.	Future Use of LGS PRA	A. R. Diederich	10 min	4:50 - 5:00 pm
5.	NRC Comments on the LGS PRA/SARA	F. Rowsome F. Coffman E. Chelliah R. Martin	90 min	5:00 - 6:30 pm
6.	ACRS Comments and Discussion of Agenda for Future Subcommittee Meetings	ACRS	30 min	6:30 - 7:00 pm

LN/gra/10038404r

INTRODUCTION

LIMERICK PROBABILISTIC RISK ASSESSMENT

G. F. DAEBELER

AGENDA

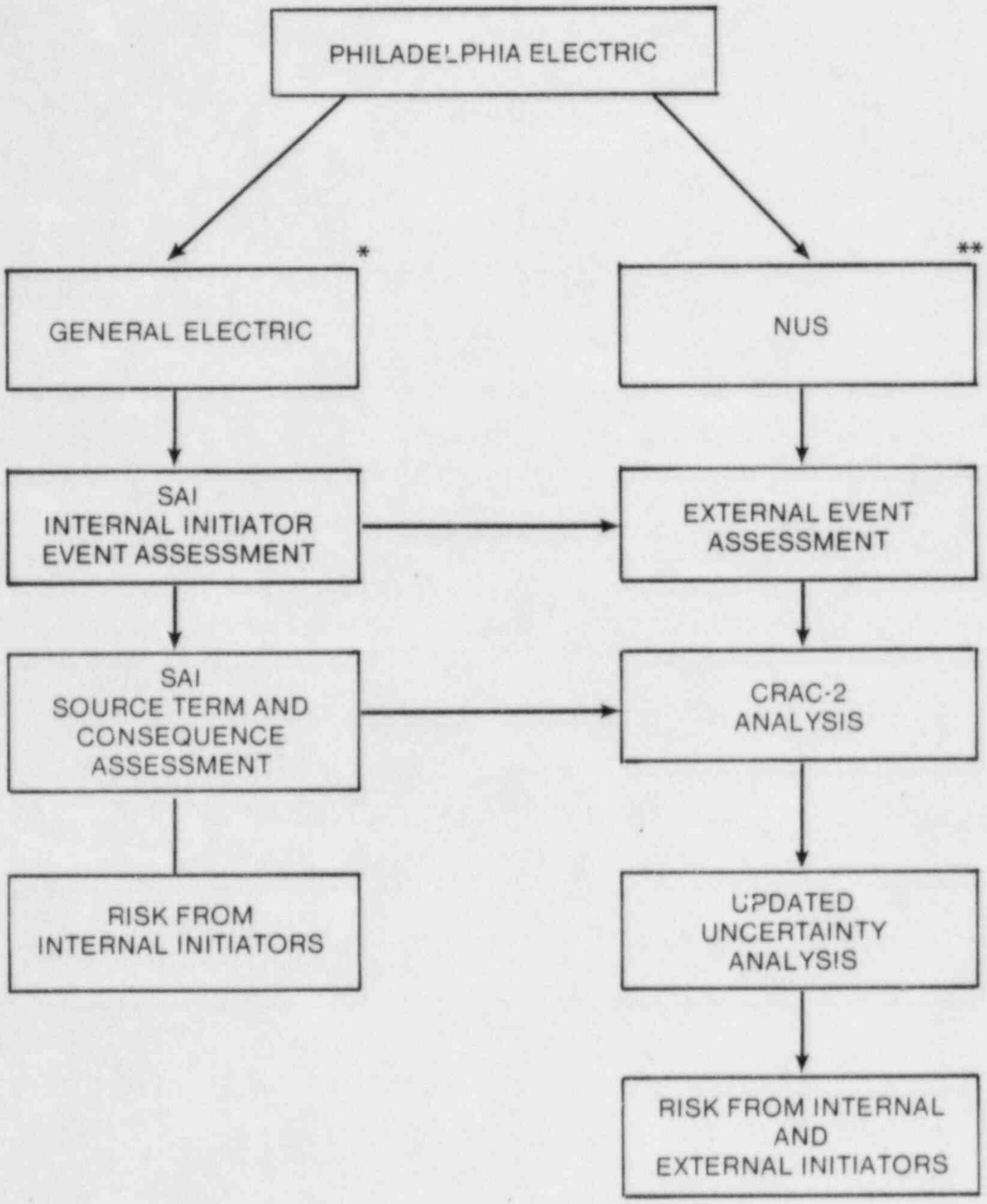
GENERAL OVERVIEW	G.F. DAEBELER
METHODOLOGY FOR INTERNAL EVENTS	E. A. HUGHES
METHODOLOGY FOR EXTERNAL EVENTS	E. R. SCHMIDT

* * * LUNCH * * *

IN-CONTAINMENT ANALYSIS	E. A. HUGHES
CONSEQUENCE ANALYSIS	G.D. KAISER
UNCERTAINTY	G. W. PARRY
DISCUSSION OF SEISMIC DESIGN AND MARGIN	R. P. KENNEDY E. R. SCHMIDT
CONCLUSIONS AND INSIGHTS	G. F. DAEBELER
FUTURE USE OF PRA	A. R. DIEDERICH

MILESTONES IN PRA/SARA

MAY, 1980	NRC LETTER REQUEST
DECEMBER, 1980	PRESENTATION OF RESULTS AT POTTSTOWN
MARCH, 1981	SUBMITTAL OF PRA
MARCH, 1982	REVISION 3 OF PRA
SEPT, 1982	REVISION 5 OF PRA
APRIL, 1983	SARA SUBMITTAL
APRIL, 1984	SUPPLEMENT 3 OF SARA



PHILADELPHIA ELECTRIC

GENERAL ELECTRIC *

NUS **

SAI
INTERNAL INITIATOR
EVENT ASSESSMENT

EXTERNAL EVENT
ASSESSMENT

SAI
SOURCE TERM AND
CONSEQUENCE
ASSESSMENT

CRAC-2
ANALYSIS

RISK FROM
INTERNAL INITIATORS

UPDATED
UNCERTAINTY
ANALYSIS

RISK FROM INTERNAL
AND
EXTERNAL INITIATORS

- PEER REVIEW
  *NUS
  **S. LEVY

LIMERICK PLANT SPECIFIC ANALYSIS

- FULL SCOPE ANALYSIS OF RISK (LEVEL 3)
    - INTERNAL INITIATED EVENTS
    - EXTERNAL INITIATED EVENTS
- LIMERICK SPECIFIC
    - SYSTEMS
    - PROCEDURES
    - MARK II
    - SITE
- PHILADELPHIA ELECTRIC DATA
    - OFFSITE POWER
    - DIESEL GENERATOR EXPERIENCE
    - MAINTENANCE

KEY ACTIVITIES

- INITIATING EVENTS
- FUNCTIONAL RESPONSE/EVENT AND FAULT TREES
- DATA/QUANTIFICATION
- CORE DAMAGE FREQUENCY
- ACCIDENT PROGRESSION ANALYSIS
- FISSION PRODUCT TRANSPORT
- OFFSITE EFFECTS
- UNCERTAINTY ANALYSIS
- RISK

INITIATING EVENTS

- OVER 40 CONSIDERED
- GROUPED INTO 15 FOR DETAILED SYSTEM RESPONSE ANALYSIS
    - 5 TRANSIENTS
    - 4 LOCAS
    - 6 EXTERNAL EVENTS

INTERNAL EVENTS ANALYZED

- MSIV CLOSURE/LOSS OF FEEDWATER
- TURBINE TRIP
- LOSS OF OFFSITE POWER
- INADVERTENT OPEN RELIEF VALVE
- MANUAL SHUTDOWNS
- LOCAS

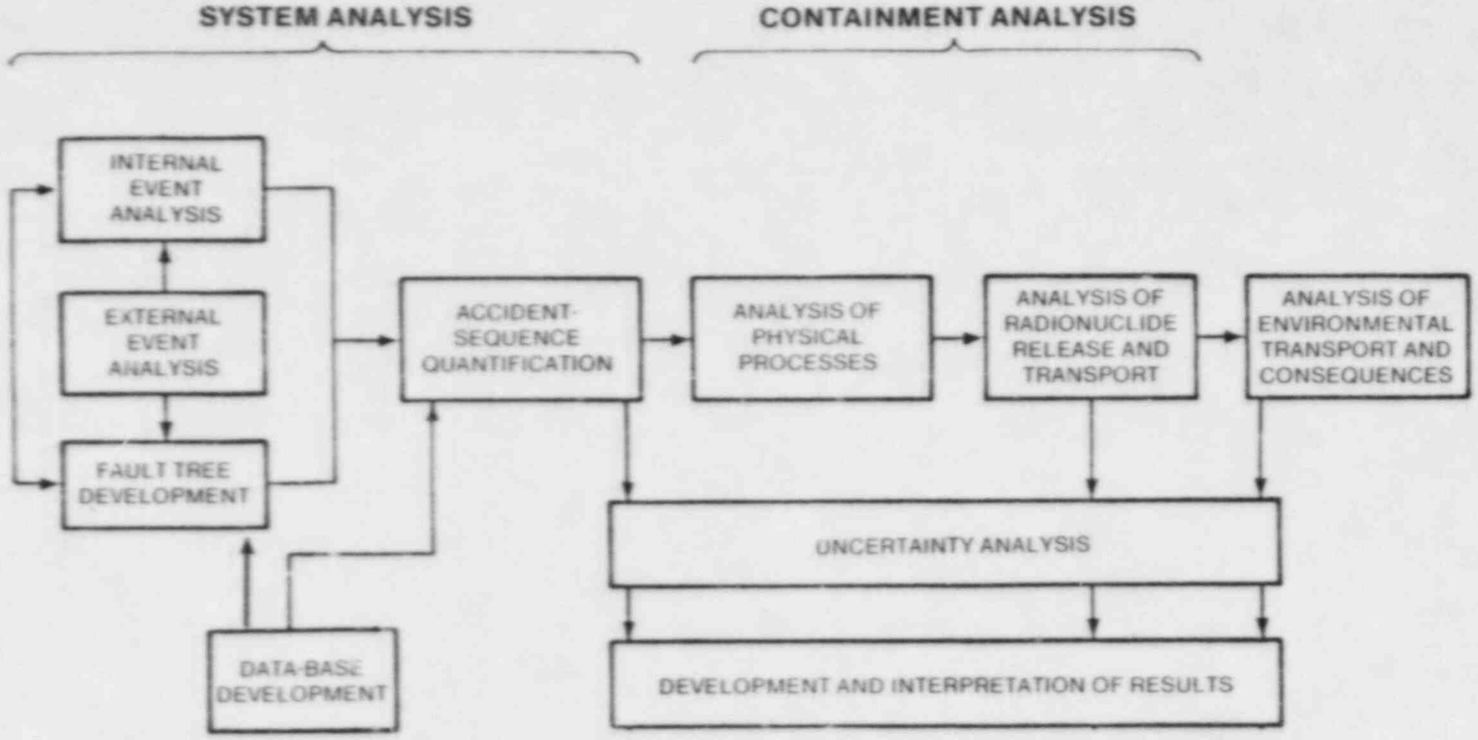
EXTERNAL EVENTS ANALYZED

- SEISMIC
- FIRE
- FLOODING
- TORNADOES
- OFFSITE HAZARDS
- TURBINE MISSILES

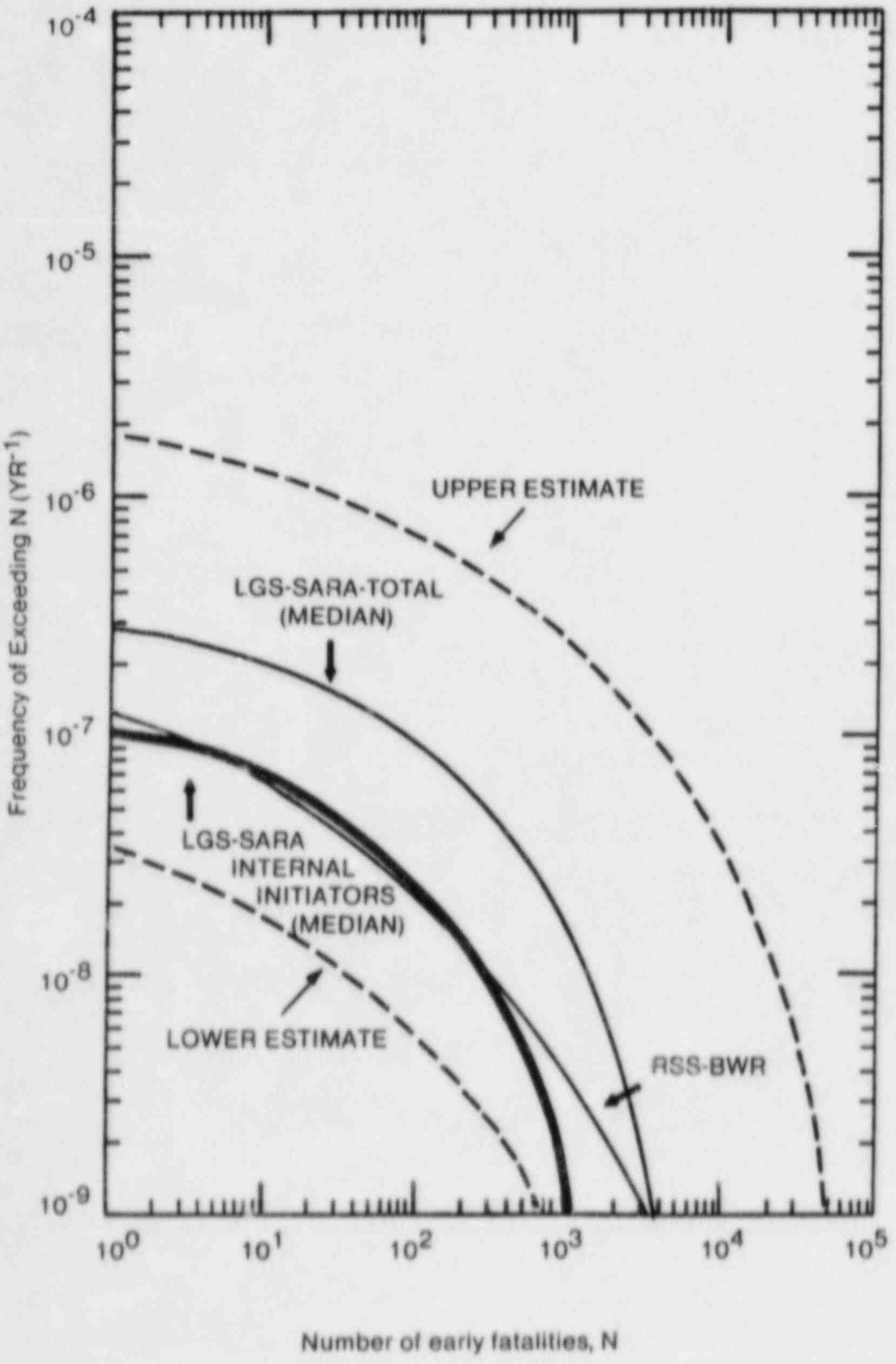
OVER 200 SEQUENCES QUANTIFIED.

CORE DAMAGE
RESULTS OF PRA/SARA
POINT ESTIMATES

	FREQUENCY OF CORE DAMAGE (PER REACTOR - YEAR)	% OF TOTAL CDF
INTERNAL EVENTS	1.5×10^{-5}	62
EARTHQUAKES	5.7×10^{-6}	24
FIRES	3.4×10^{-6}	14
OTHERS	NEGLIGIBLE	—
TOTAL	2.4×10^{-5}	



RISK ASSESSMENT PROCEDURE



CCDFs of acute fatalities-comparison with the Reactor Safety Study.

LIMERICK PRA/SARA
SIGNIFICANT CHARACTERISTICS

- ASSESSMENT OF PUBLIC RISK USING METHODS SIMILIAR TO WASH-1400
- MID LIFE PLANT AT POWER
- EVALUATION MODELS BASED ON LIMERICK DRAWINGS AND WALKDOWNS
- LIMITED CREDIT FOR REPAIR/RECOVERY OF EQUIPMENT
- REALISTIC SUCCESS CRITERIA
- EXTERNAL EVENTS AND UNCERTAINITY INCLUDED
- GENERIC AND PE SPECIFIC FAILURE RATE DATA
- REALISTIC ASSESSMENT OF CONTAINMENT INTEGRITY
- 1980-81 SOURCE TERM TECHNOLOGY
- SANDIA EVACUATION MODEL PLUS MODIFICATION FOR SEISMIC EVENTS
- NO CONSIDERATION OF SABOTAGE

SUMMARY

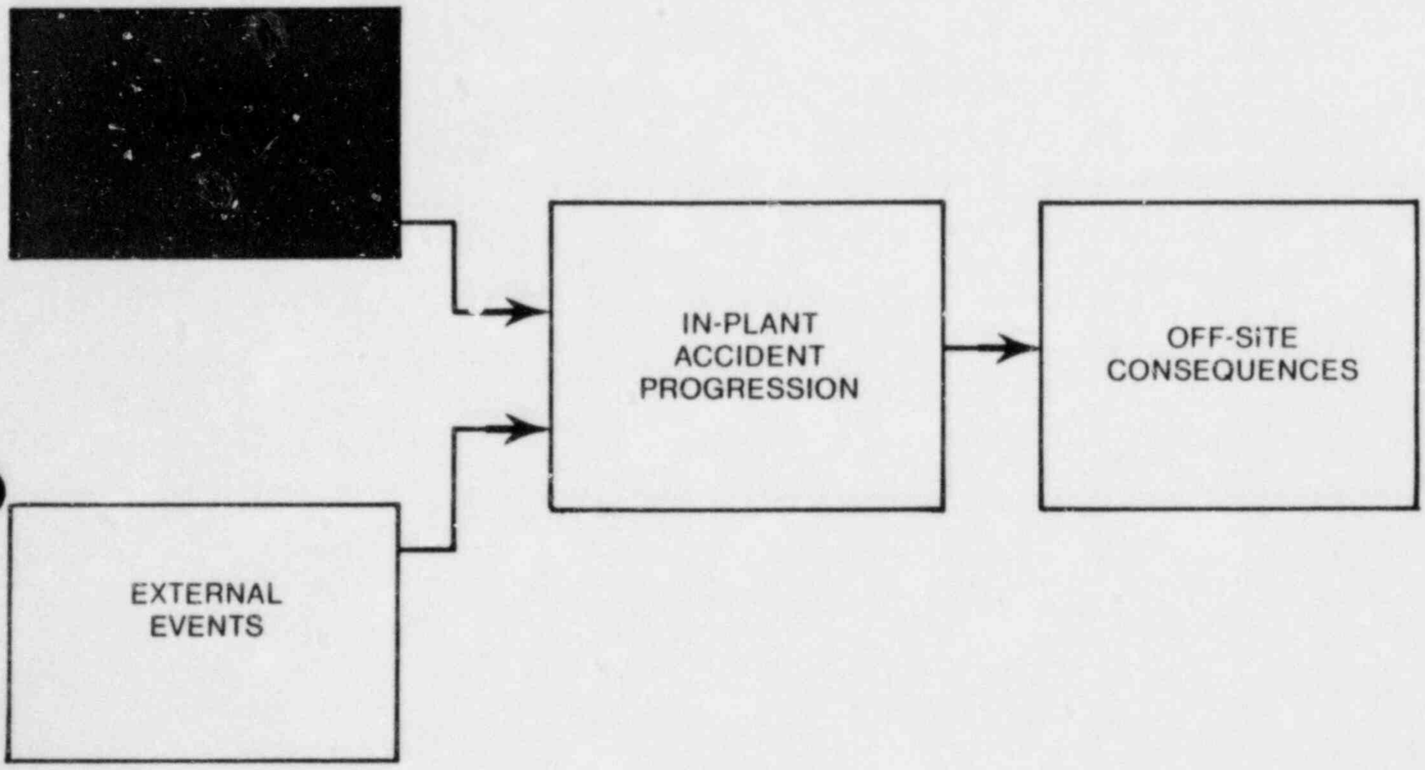
PURPOSE

- DEMONSTRATE THE POTENTIAL RISK CONTRIBUTION TO THE PUBLIC DUE TO LIMERICK OPERATION
- RESPOND TO NRC REQUEST

RESULTS

- RISK LESS THAN PROPOSED SAFETY GOAL AND COMPARABLE TO REACTOR SAFETY STUDY
- PRA/SARA RESULTS VERIFY THE ADEQUACY OF THE DESIGN OF THE LIMERICK PLANT

LIMERICK PRA/SARA



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EXTERNAL EVENTS

IN-PLANT ACCIDENT PROGRESSION

OFF-SITE CONSEQUENCES

INTERNAL EVENTS

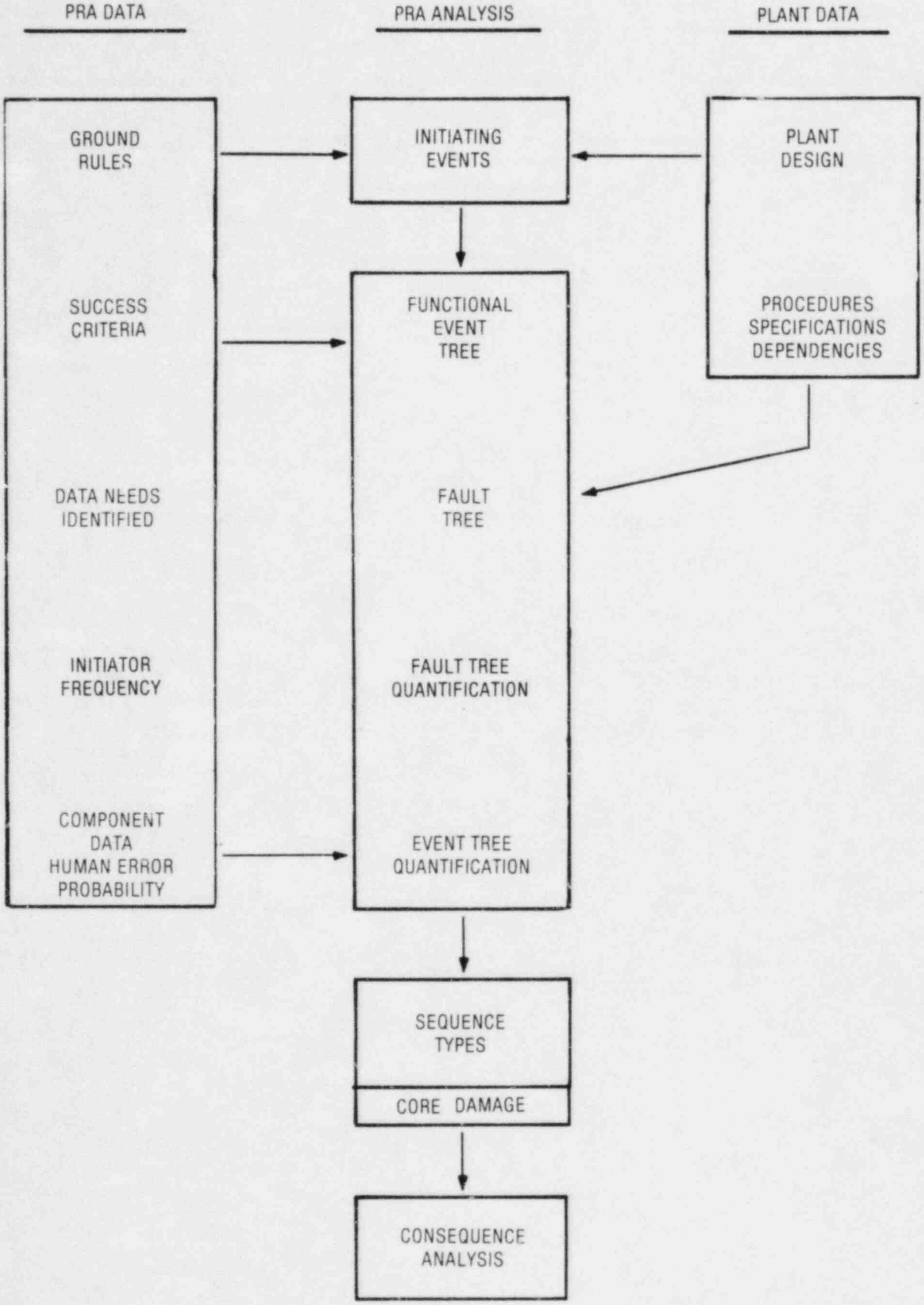
E. A. HUGHES

LIMERICK PRA
SUMMARY OF METHODOLOGY

- SIMILAR TO WASH-1400
    - EVENT TREES
    - FAULT TREES
    - GROUND RULES
- FULL SCOPE PLANT SPECIFIC ANALYSIS

LIMERICK PRA
KEY FEATURES

- FULL SCOPE PLANT SPECIFIC ANALYSIS
- METHODOLOGY SIMILAR TO WASH-1400
- RISK OF CORE DAMAGE FROM POWER
- MIDLIFE PLANT
- LIMERICK PLANT DESIGN AND SITE
- APPLICABLE PROCEDURES & SPECIFICATIONS
- EXPANDED TRANSIENT TREATMENT
- BEST ESTIMATE SUCCESS CRITERIA
- NEW DATA AVAILABLE
- UNCERTAINTY ANALYSIS


PRA DATA
PRA ANALYSIS
PLANT DATA
GROUND RULES
INITIATING EVENTS
PLANT DESIGN
SUCCESS CRITERIA
FUNCTIONAL EVENT TREE
PROCEDURES SPECIFICATIONS DEPENDENCIES
DATA NEEDS IDENTIFIED
FAULT TREE
INITIATOR FREQUENCY
FAULT TREE QUANTIFICATION
COMPONENT DATA HUMAN ERROR PROBABILITY
EVENT TREE QUANTIFICATION
SEQUENCE TYPES
CORE DAMAGE
CONSEQUENCE ANALYSIS

EVENT TREES

- OVER 40 TYPES OF EVENTS EVALUATED
    - SUBSEQUENT EFFECTS CONSIDERED
    - EFFECT ON PREVENTION AND MITIGATION DEFINED

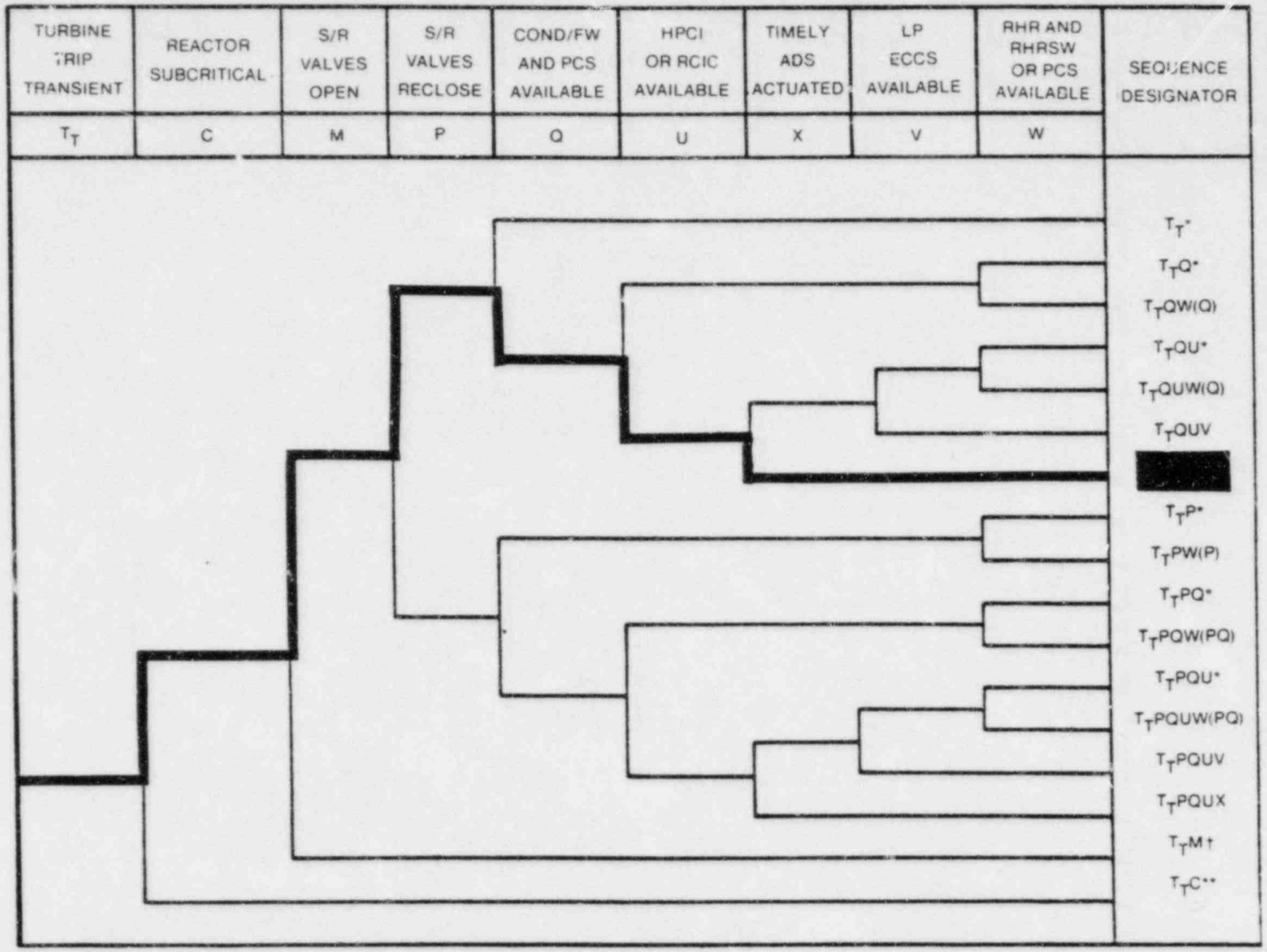
- DISCRETE REPRESENTATIVE SET CHOSEN
    - TRANSIENTS
    - LOCAS
    - ATWS
    - EXTERNAL EVENTS

INTERNAL EVENTS ANALYZED

- MSIV CLOSURE/LOSS OF FEEDWATER
- TURBINE TRIP
- LOSS OF OFFSITE POWER
- INADVERTENT OPEN RELIEF VALVE
- MANUAL SHUTDOWNS
- LOSS OF COOLANT ACCIDENTS

FOR EACH EVENT

- SEQUENCE OF EVENTS DEFINED
- FUNCTIONS EVALUATED
- TIME LINE OF EVENT ESTABLISHED
- TREE DRAWN - TYPICAL FUNCTIONS
    - SCRAM
    - PRESSURE CONTROL
    - HIGH PRESSURE MAKEUP
    - DEPRESSURIZATION
    - LOW PRESSURE MAKEUP
    - HEAT REMOVAL



* NOT CORE MELT SEQUENCE

** ATWS INITIATORS ARE TREATED IN A SEPARATE EVENT TREE

† TRANSFER TO LARGE LOCA EVENT TREE

INPUT TO LOGIC MODELS

- DESIGN INFORMATION
- SUCCESS CRITERIA
- TECHNICAL SPECIFICATIONS
- DEPENDENCIES
- OPERATOR ACTIONS & PROCEDURES

SUCCESS CRITERIA

- MINIMUM ACCEPTABLE CAPABILITY

- LGS SPECIFIC ANALYSIS
  - "REALISTIC" CODES
  - 2200 °F PEAK CLAD TEMPERATURE LIMIT

- EXAMPLE — TRANSIENT
  - INJECTION, ANY ONE OF
    - HPCI
    - RCIC
    - FEEDWATER/ CONDENSATE
    - CORE SPRAY TRAIN
    - RHR PUMP

    } REQUIRE DEPRESSURIZATION

  - HEAT REMOVAL, EITHER
    - RHR LOOP
    - CONDENSER

TECHNICAL SPECIFICATIONS

ADOPTED FROM

- SUSQUEHANNA AND PEACH BOTTOM

EXAMPLES

- IF RCIC IN MAINTENANCE

  — THEN —

- HPCI MUST BE DEMONSTRATED OPERABLE

- IF RCIC OUTAGE EXCEEDS 7 DAYS
- SHUTDOWN

DEPENDENCY/INTERFACES INCLUDED

- SUPPORT SYSTEMS, SUCH AS
  - ELECTRIC POWER
  - SENSORS AND LOGIC
  - SUCTION/DISCHARGE LINES
  - WATER SOURCES

- SPATIAL DEPENDENCIES, SUCH AS
  - ROOM COOLING
  - CONTAINMENT LEAK TO REACTOR BUILDING
  - LOCA ENVIRONMENT

- HUMAN FACTORS
- FUNCTIONAL DEPENDENCIES
- INTERCOMPONENT DEPENDENCIES

EXAMPLE

DIESEL DEPENDENCY MODEL:

	FAILURE OF ALL FOUR DIESELS		
FAILURE OF ONE DIESEL	INDEPENDENT	INCLUDING COMMON CAUSE	LIMERICK VALUE USED
.02	1.6×10^{-7}	1.08×10^{-3}	1.08×10^{-3}

HUMAN FACTORS IN THE PRA

FOUR TYPES OF HUMAN ACTION MODELED:

- INITIATION OF SYSTEMS
  - MANUAL SYSTEMS
  - BACKUP OF AUTOMATIC SYSTEMS
- MAINTENANCE & TEST
  - UNDETECTED MAINTENANCE ERROR
  - MAINTENANCE ERROR INITIATES ACCIDENT
- REPAIR OF FAILED SYSTEM
  - RHR
  - RECOVERY OF AC POWER
- OPERATOR INTERVENTION ("ERRORS OF COMMISSION")
  - IMPLICIT IN FAILURE RATES
  - IMPLICIT IN INITIATING EVENTS
  - EXPLICIT IN SOME MAINTENANCE ERRORS

EXAMPLES OF OPERATOR ACTIONS EXPLICITLY MODELED IN THE PRA

- RECOVERY OF FEEDWATER
- REOPENING OF MSIVs
- MANUAL CONTROL OF HPCI & RCIC
- MANUAL DEPRESSURIZATION OF REACTOR
- CONTROL OF REACTOR WATER LEVEL DURING ATWS
- INITIATION OF RHR/RHRSW
- PROVISION OF ALTERNATE ROOM COOLING
- RESTORATION OF OFFSITE POWER
- RESTORATION OF EMERGENCY POWER
- MISCALIBRATION OF INSTRUMENT SENSORS
- REPAIR OF RHR

SYSTEM FAULT TREES

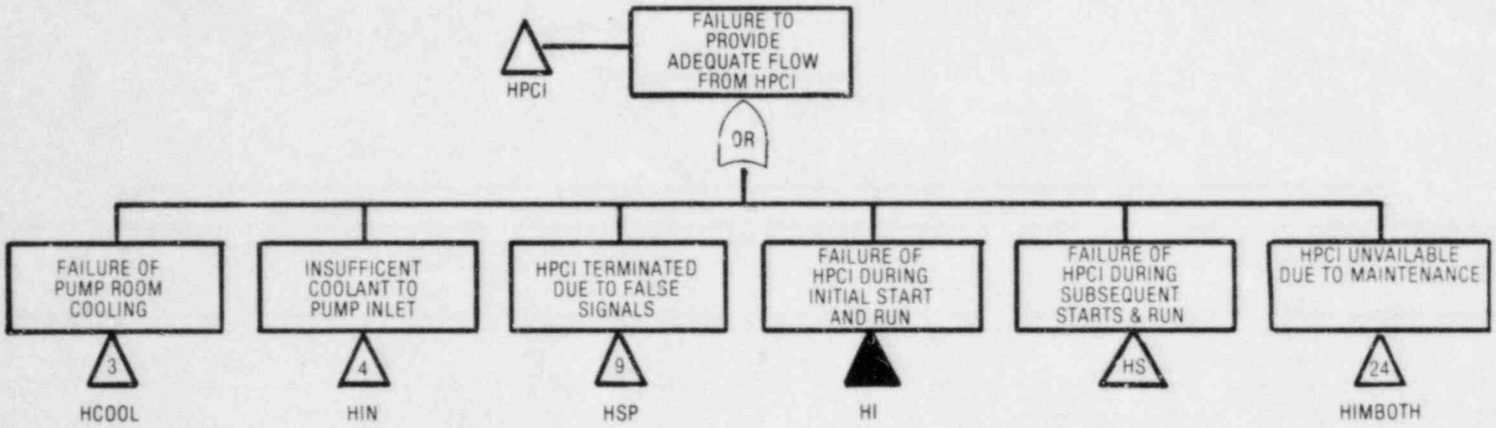
- HPCI
- RCIC
- FEEDWATER/ CONDENSATE
- DEPRESSURIZATION
- LPCI
- CS
- RHR
- SLC
- ESW + NSW
- RHRSW
- ELECTRIC POWER

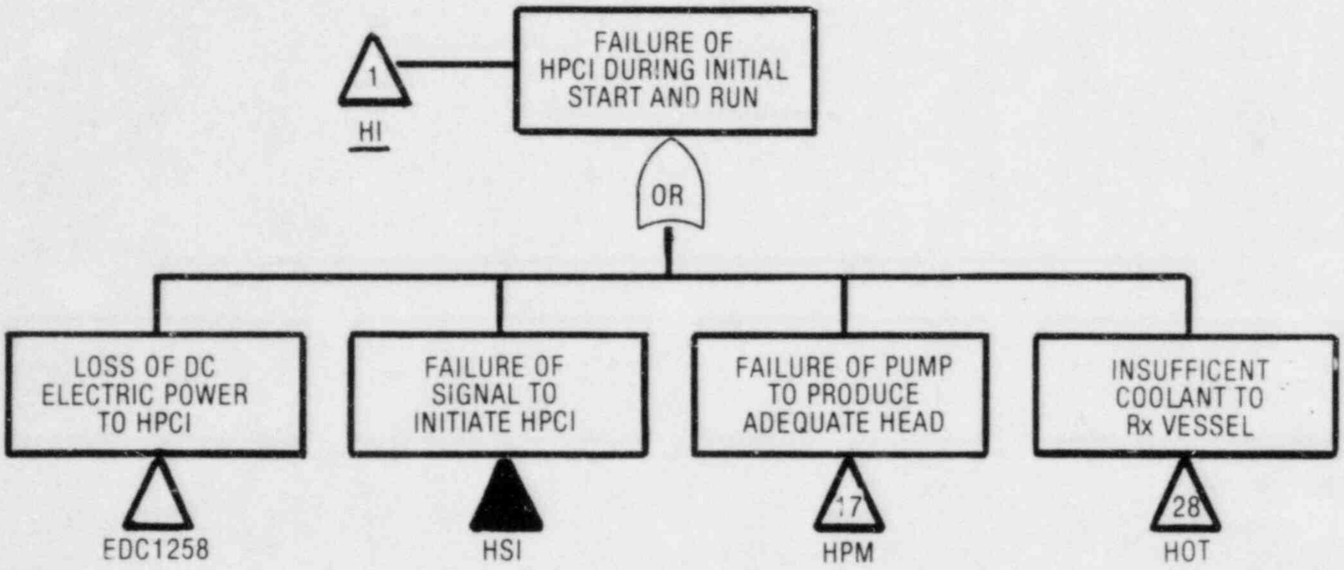
- COMPONENT LEVEL
- OVER 3000 GATES
- OVER 4000 COMPONENTS

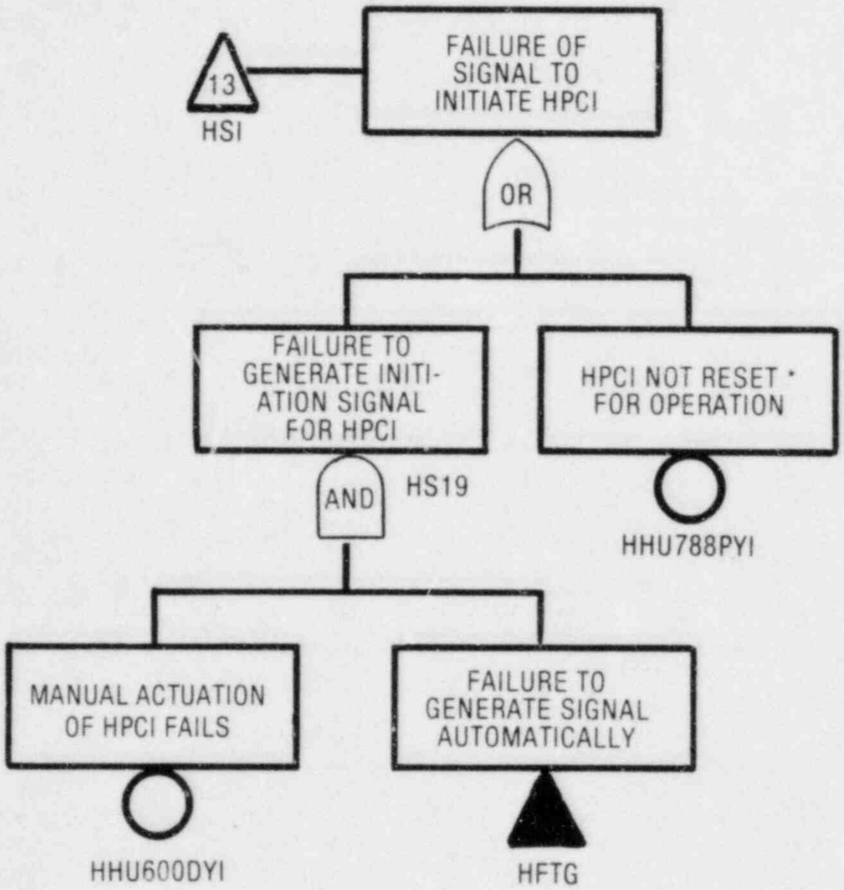
LOGIC MODELS INCLUDED CONSIDERATION OF:

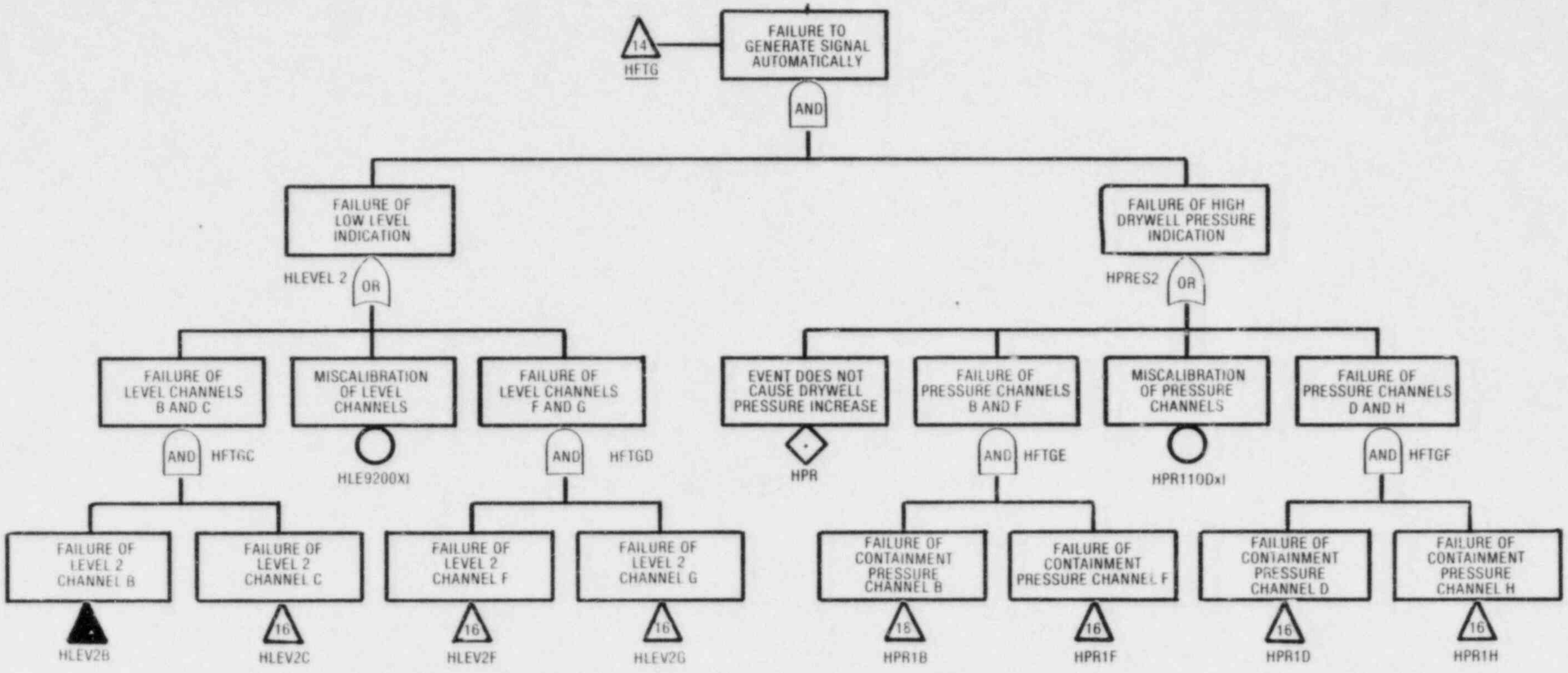
- COMPONENTS AND DESIGN DETAILS
- MAINTENANCE
- TECHNICAL SPECIFICATIONS
- SUPPORT SYSTEMS
- SUCCESS CRITERIA
- REPAIR
- MISSION TIME
- OPERATOR ERROR

HPCI FAULT TREE

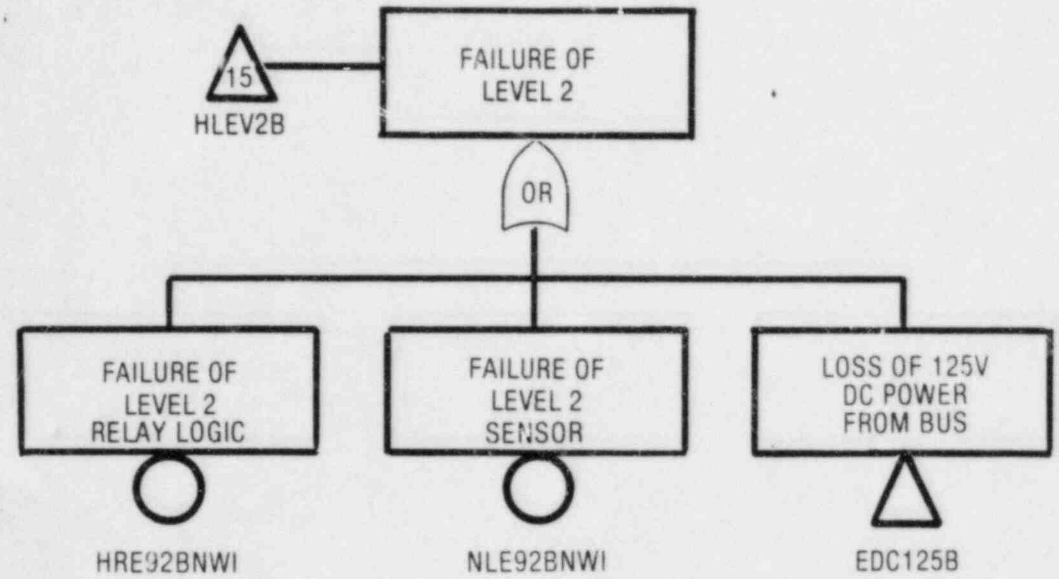



1
HI
FAILURE OF HPCI DURING INITIAL START AND RUN
OR
LOSS OF DC ELECTRIC POWER TO HPCI
EDC1258
FAILURE OF SIGNAL TO INITIATE HPCI
HSI
FAILURE OF PUMP TO PRODUCE ADEQUATE HEAD
17
HPM
INSUFFICENT COOLANT TO Rx VESSEL
28
HOT


13
HSI
FAILURE OF SIGNAL TO INITIATE HPCI
OR
FAILURE TO GENERATE INITIATION SIGNAL FOR HPCI
HPCI NOT RESET FOR OPERATION
AND
HS19
HHU788PYI
MANUAL ACTUATION OF HPCI FAILS
FAILURE TO GENERATE SIGNAL AUTOMATICALLY
HHU600DYI
HFTG



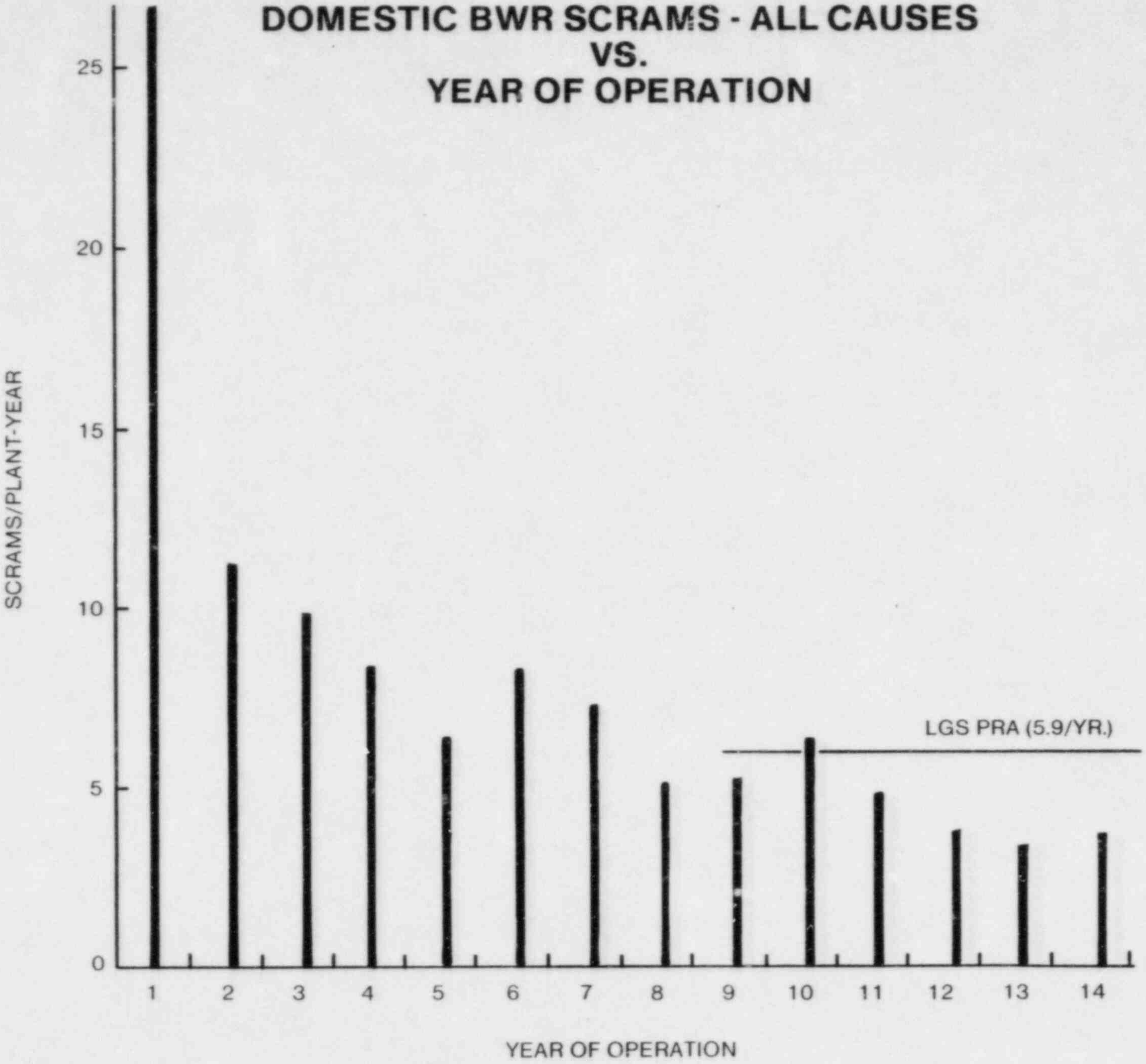
‡ NO DRYWELL PRESSURE INCREASE ON SOME EVENTS HPR = 1.0
OR
HPR = 0.0


15
HLEV2B
FAILURE OF LEVEL 2
OR
FAILURE OF LEVEL 2 RELAY LOGIC
HRE92BNWI
FAILURE OF LEVEL 2 SENSOR
NLE92BNWI
LOSS OF 125V DC POWER FROM BUS
EDC125B

QUANTIFICATION

- INITIATOR FREQUENCY
- FAILURE RATES AND UNAVAILABILITY
  - COMPONENTS AND SYSTEM EXPERIENCE
  - MAINTENANCE
  - HUMAN ERROR RATES
  - DIESELS
  - SCRAM
  - DEPENDENCIES
- WAM CODE ANALYSIS

DOMESTIC BWR SCRAMS - ALL CAUSES
VS.
YEAR OF OPERATION



FAULT TREE QUANTIFICATION

PRIORITY OF DATA USE

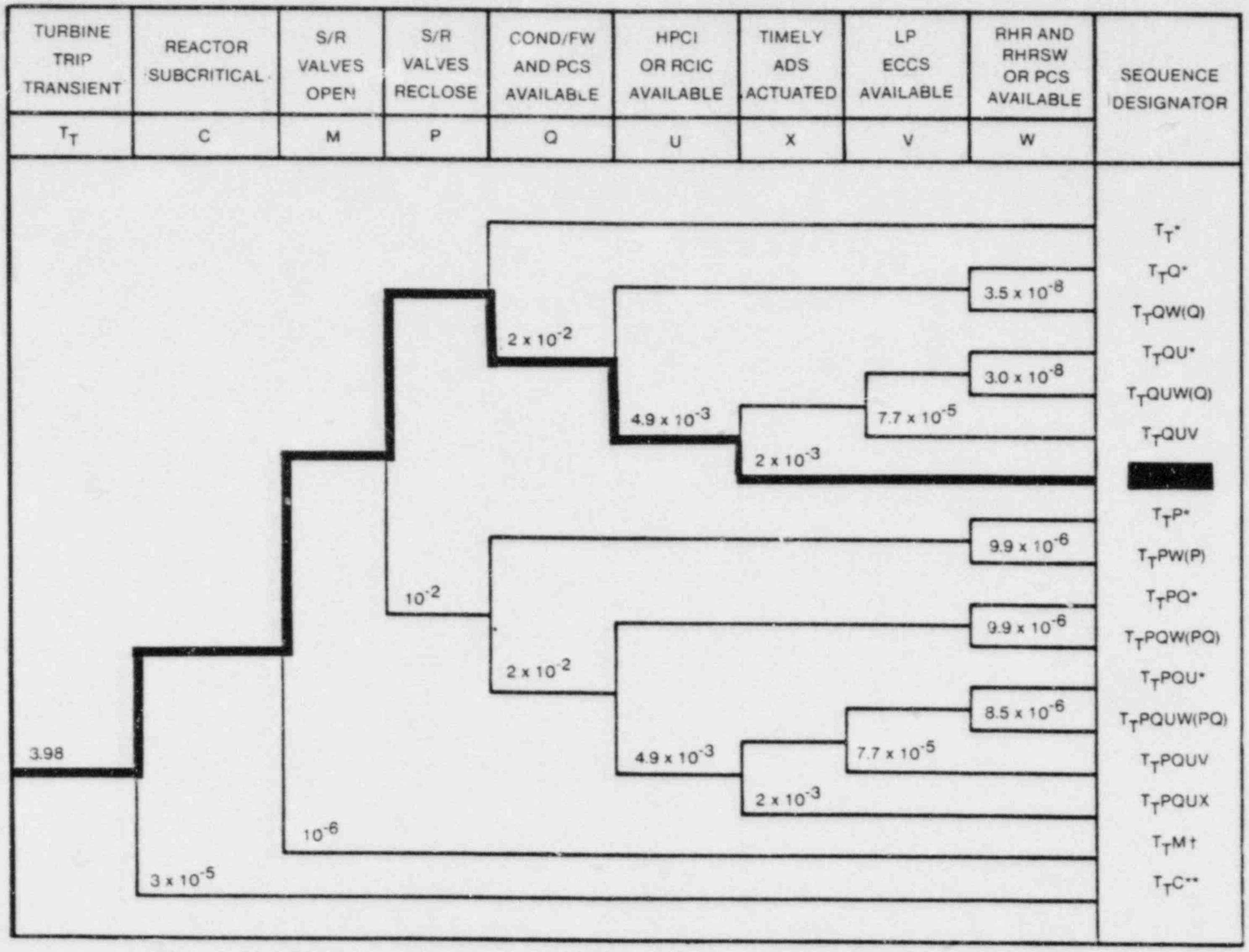
- PECO SPECIFIC
- NRC DATA
- GENERIC BWR DATA
- WASH-1400

SELECTED HUMAN ERROR PROBABILITIES USED IN THE LGS PRA

REQUIRED ACTION	HUMAN ERROR PROBABILITY	REF
OPENING REMOTE MANUAL VALVES	0.9	EST.
BACKUP MANUAL INITIATION OF AUTO. SAFETY SYSTEM (30 MIN. HPCI, RCIC, LPCI, CS)	0.1	WASH-1400
RHR INITIATION (15 MIN.) (ATWS SEQUENCES)	0.01	SWAIN
DEPRESSURIZATION (30 MIN.)	0.002	SWAIN
VALVE ALIGNMENT DURING MAINT.	0.0001	SWAIN
MISCALIBRATION	0.001	SWAIN

EVENT TREE QUANTIFICATION

- FAULT TREE VALUES DERIVED
- COMMONALITY CHECK
- DEPENDENT CASES IDENTIFIED
  - IF LARGE, LINKED
  - IF SMALL, ENCOMPASSED



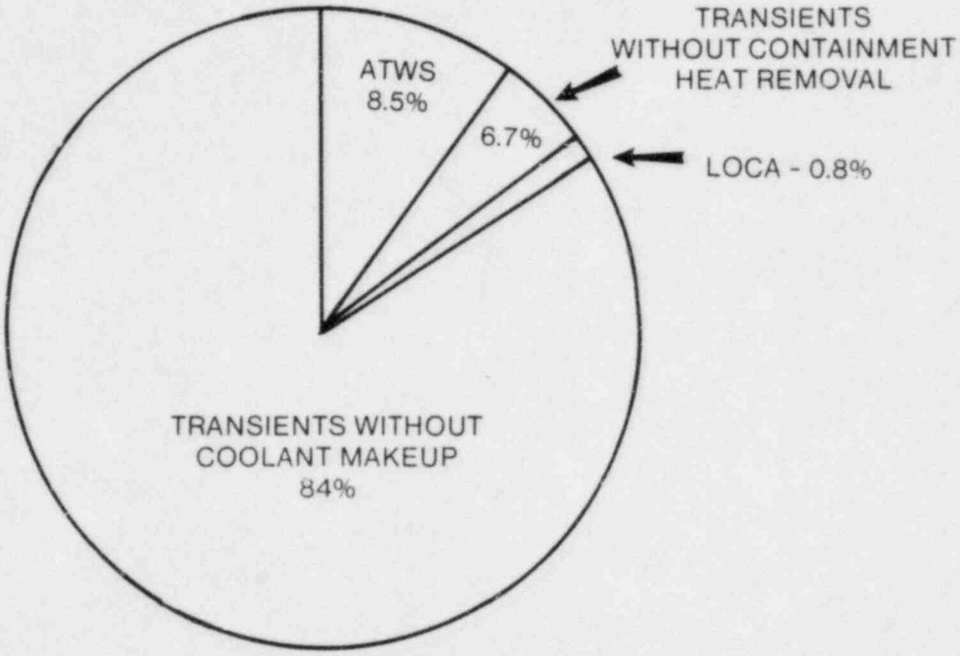
* NOT CORE MELT SEQUENCE
** ATWS INITIATORS ARE TREATED IN A SEPARATE EVENT TREE
† TRANSFER TO LARGE LOCA EVENT TREE

RESULTS

FREQUENCY OF CORE DAMAGE

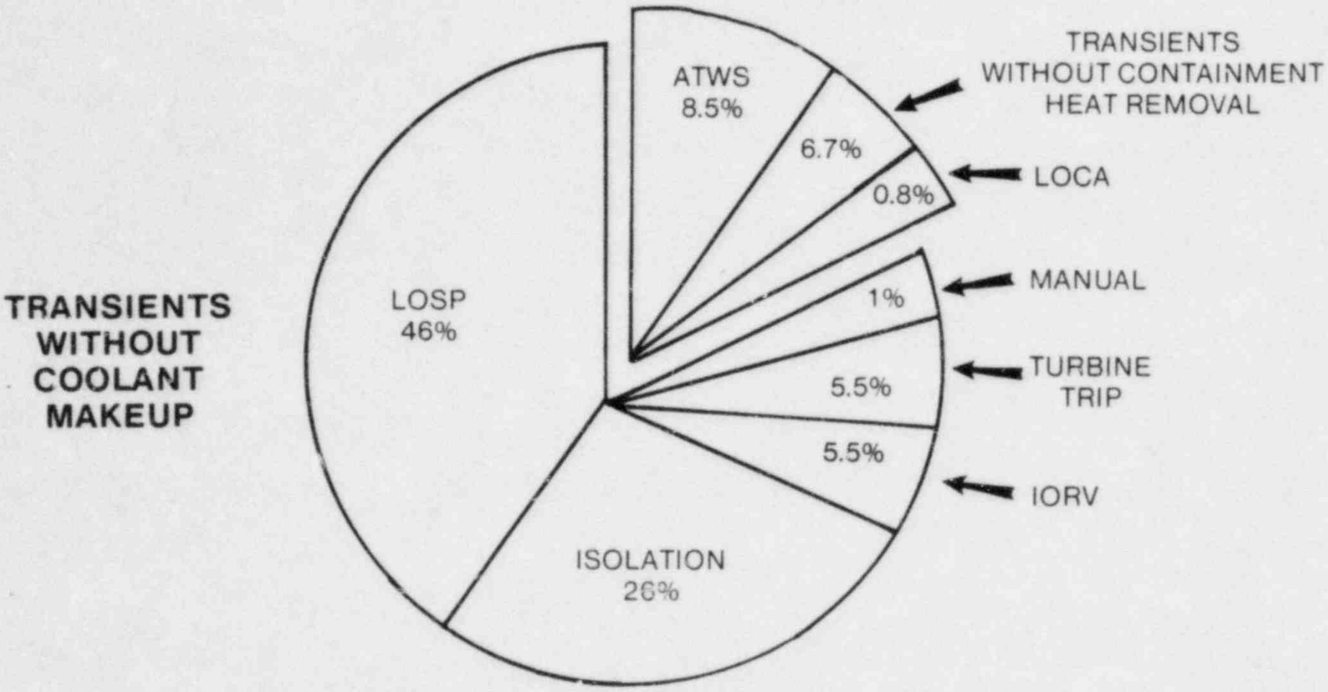
1.5×10^{-5} /year

INTERNALLY INITIATED CORE DAMAGE FREQUENCY BY INITIATOR



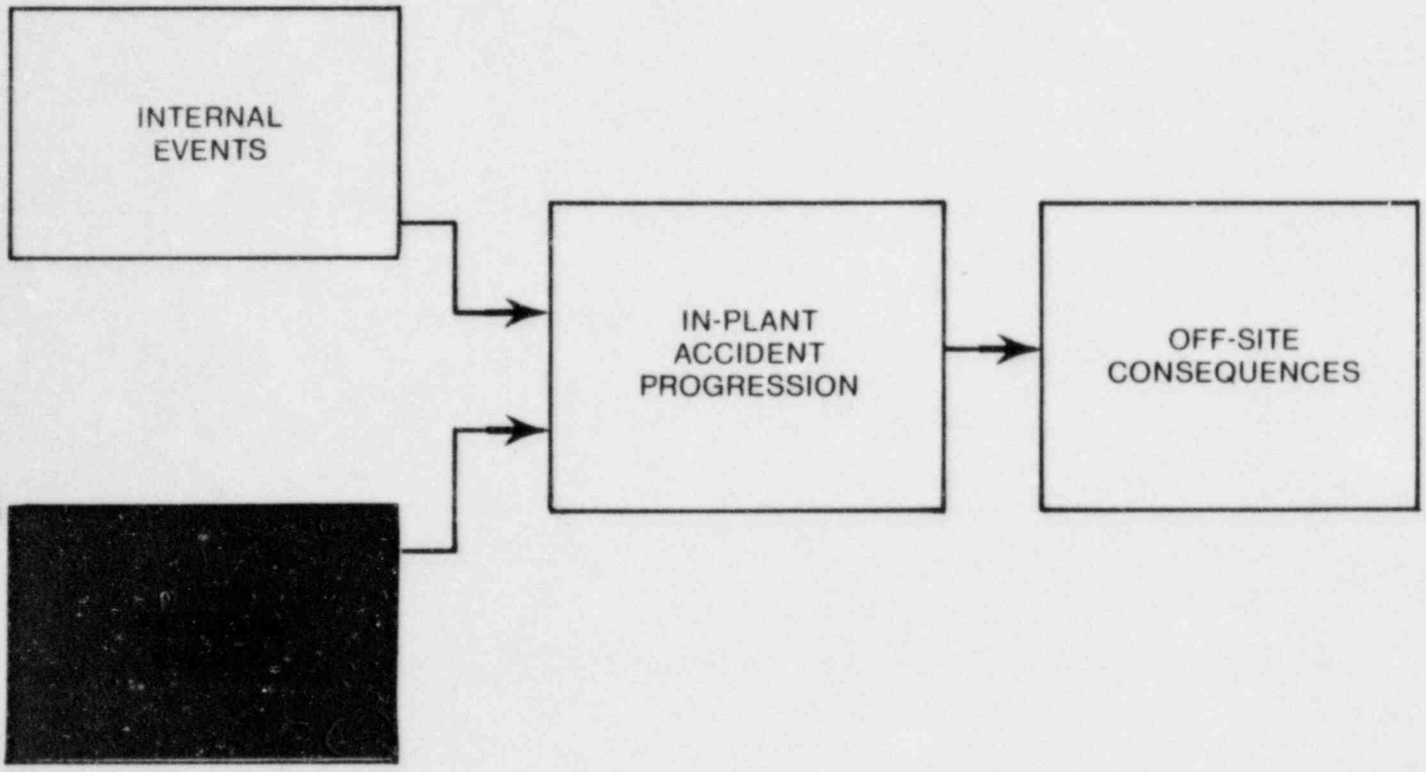
TYPE OF EVENT	CORE DAMAGE FREQUENCY
TRANSIENTS WITHOUT COOLANT MAKE-UP	1.2×10^{-5}
ATWS	1.2×10^{-6}
TRANSIENTS WITHOUT CONTAINMENT HEAT REMOVAL	9.6×10^{-7}
LOCA	1.1×10^{-7}
TOTAL	1.5×10^{-5}

INTERNALLY INITIATED CORE DAMAGE FREQUENCY BY INITIATOR



TYPE OF EVENT	CORE DAMAGE FREQUENCY
TRANSIENT WITHOUT COOLANT MAKEUP	
LOSP	6.6×10^{-6}
ISOLATION	3.8×10^{-6}
TURBINE TRIP	8.1×10^{-7}
IORV	8.5×10^{-7}
MANUAL	2.3×10^{-7}
ATWS	1.2×10^{-6}
TRANSIENTS WITHOUT CONTAINMENT HEAT REMOVAL	9.6×10^{-7}
LOCA	1.1×10^{-7}
TOTAL	1.5×10^{-5}

LIMERICK PRA/SARA



INTERNAL EVENTS

[redacted]

IN-PLANT ACCIDENT PROGRESSION

OFF-SITE CONSEQUENCES

EXTERNAL EVENTS METHODOLOGY AND RESULTS

E.R. SCHMIDT

EXTERNAL EVENTS CONSIDERED

- FLOODING
- TORNADOES
- TURBINE MISSILES
- TRANSPORTATION/ INDUSTRIAL ACCIDENTS
- FIRE
- SEISMIC

IN-PLANT FIRE INITIATED ACCIDENTS

- TWO STAGE ANALYSIS
  - STAGE 1 CONSERVATIVE ANALYSIS; NO MITIGATION
  - STAGE 2 REALISTIC ANALYSIS OF FIRE PROGRESSION AND MITIGATION FOR SIGNIFICANT FIRES AREAS
- RANDOM FAILURES AS WELL AS FIRE INDUCED FAILURES
- SUCCESS CRITERIA SAME AS PRA

IMPORTANT STEPS IN ANALYSIS

- IDENTIFICATION OF INDEPENDENT FIRE AREAS
- IDENTIFICATION OF EQUIPMENT, CABLES IN THOSE AREAS
- ESTIMATE FIRE FREQUENCIES IN EACH AREA
- EVALUATE EFFECTS OF FIRE
  - INITIATING EVENT
  - PLANT DAMAGE
- EVALUATE CORE DAMAGE FREQUENCY

FIRE FREQUENCIES

- BASED ON HISTORICAL DATA

  ~.05 SIGNIFICANT FIRES/YEAR

- ALLOCATED TO LGS FIRE AREAS BASED ON EQUIPMENT INVENTORY

  — CABLE
  — SWITCHGEAR

FIRE AREAS FOR STAGE 2 ANALYSIS

DESCRIPTION	
13 KV SWITCHGEAR ROOM STATIC INVERTER ROOM CABLE SPREADING ROOM CONTROL ROOM AUXILIARY EQUIPMENT ROOM	CONTROL STRUCTURE
SAFEGUARD ACCESS AREA CRD HYDRAULIC EQUIPMENT AREA GENERAL EQUIPMENT AREA	REACTOR BUILDING

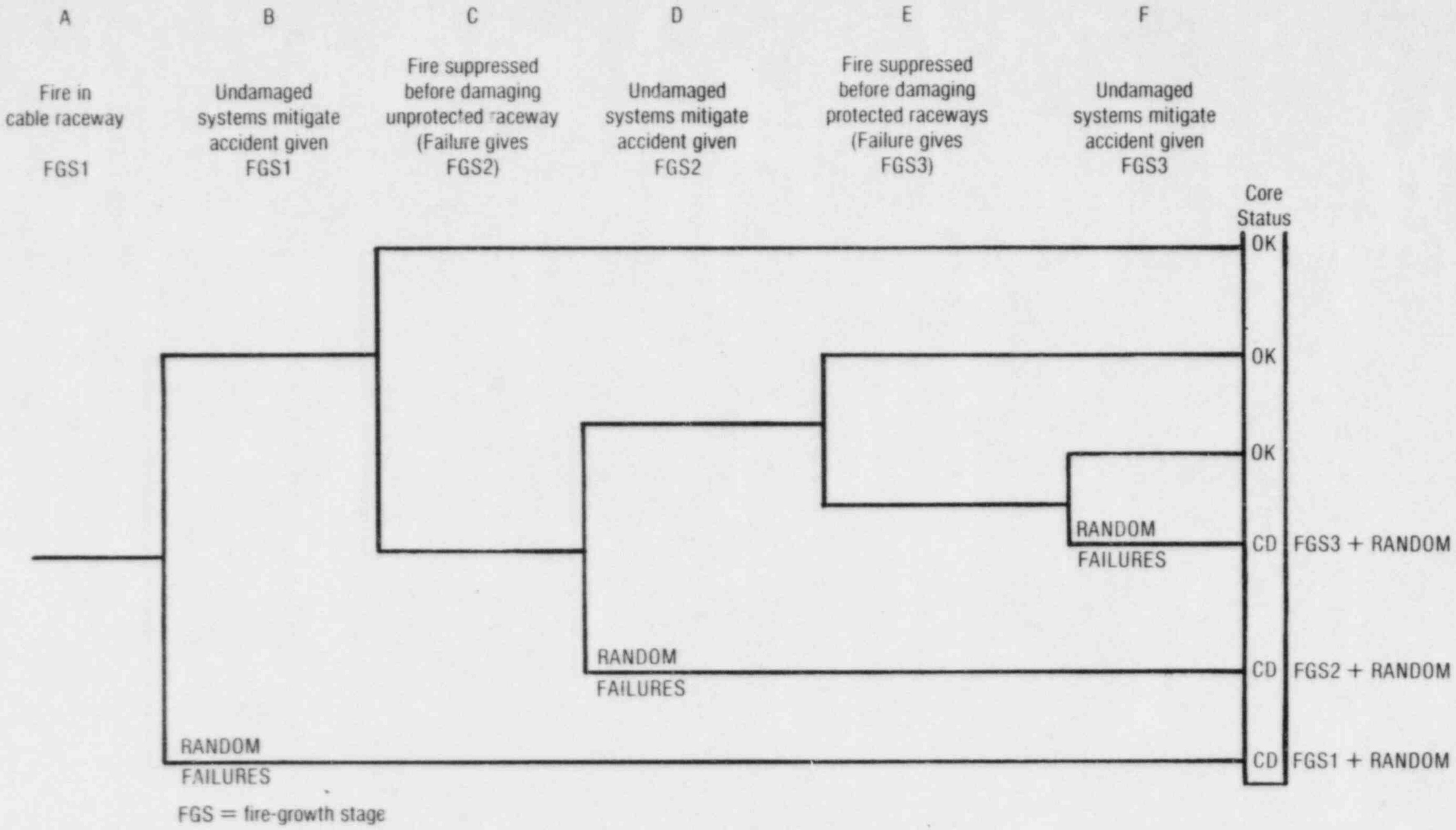
DETAILED ANALYSIS

- THREE FIRE TYPES
  - — SELF-IGNITED CABLE FIRES
  - — CABINET FIRES
  - — TRANSIENT COMBUSTIBLE FIRES
- FIRE GROWTH STAGES

  FGS1 — DAMAGE TO COMPONENTS IN THE VICINITY OF THE FIRE SOURCE

  FGS2 — DAMAGE TO ADJACENT EQUIPMENT SEPARATED BY THE MINIMUM SEPARATION CRITERION

  FGS3 — DAMAGE TO PROTECTED EQUIPMENT
- ESTIMATE PROBABILITY OF SUPPRESSION AT EACH FGS



FIRE-GROWTH EVENT TREE

RESULTS

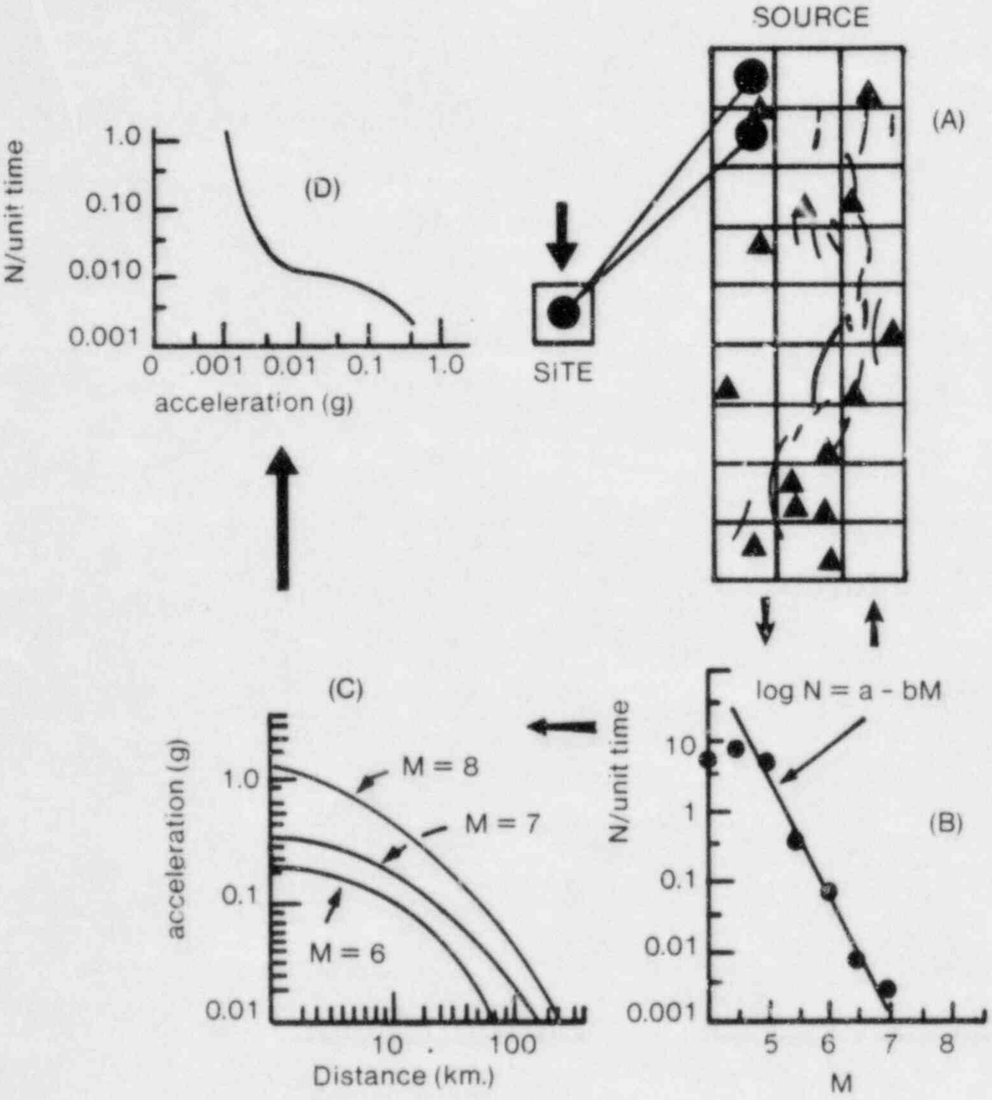
	CDF	
13 KV SWITCHGEAR ROOM	1.3×10^{-6}	38%
SAFEGUARD ACCESS AREA	6.9×10^{-7}	20%
TOTAL FIRE INITIATED EVENTS	3.4×10^{-6}	

~75% LOSS OF MAKE-UP

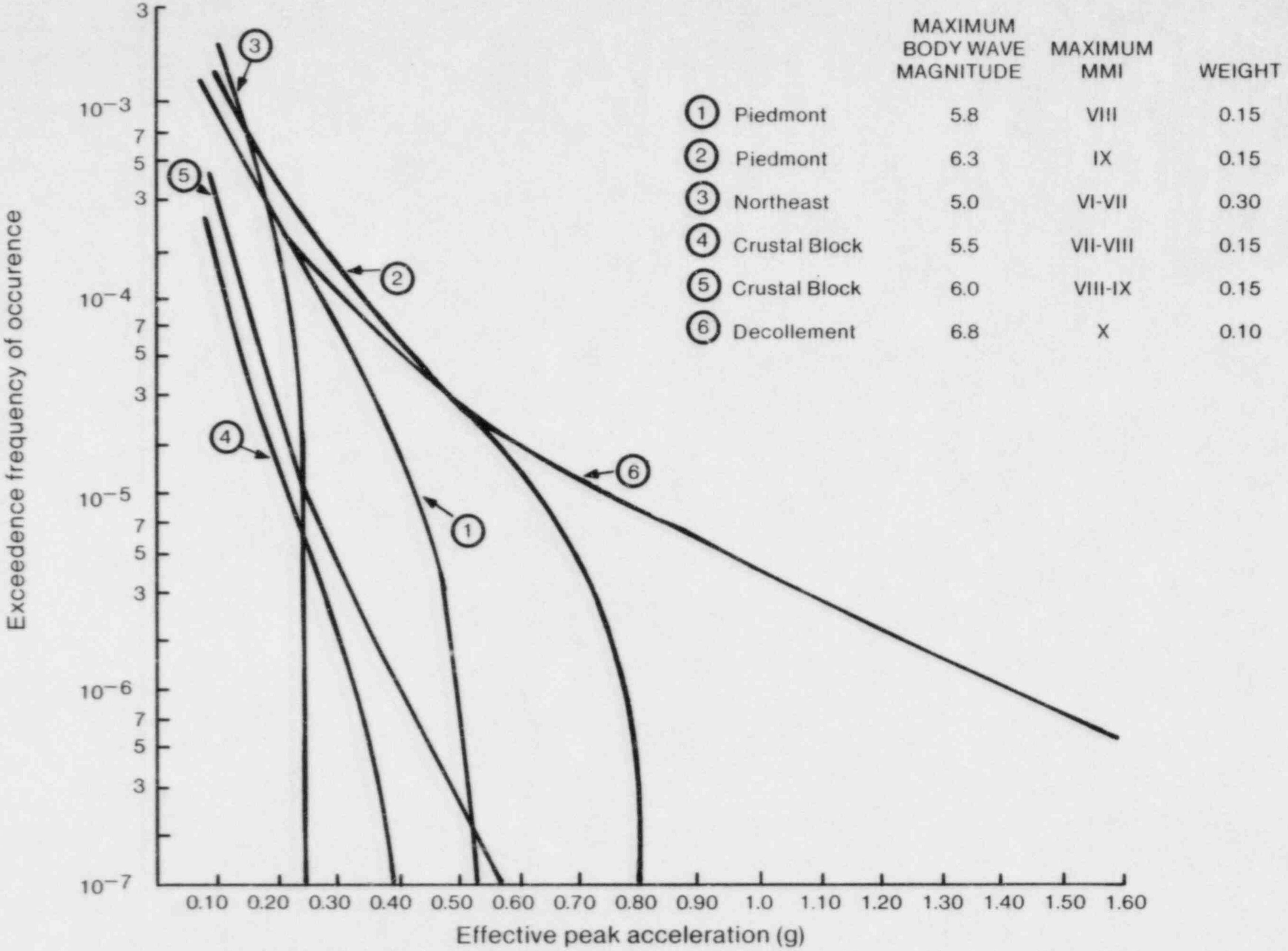
~80% DUE TO FGS 2

SEISMIC ANALYSIS — APPROACH

- HAZARD ANALYSIS
  - FREQUENCY OF EXCEEDANCE OF EFFECTIVE PEAK ACCELERATION
- FRAGILITY ANALYSIS
  - PROBABILITY OF FAILURE OF COMPONENTS OR STRUCTURES GIVEN AN ACCELERATION
- SYSTEMS ANALYSIS
  - LOGIC MODELS MODIFIED FOR SEISMICALLY INDUCED FAILURES
- SEQUENCES QUANTIFIED
  - INTEGRATE OVER ENTIRE RANGE OF ACCELERATIONS



THE STEPS INVOLVED IN THE EVALUATION OF SEISMIC HAZARDS.



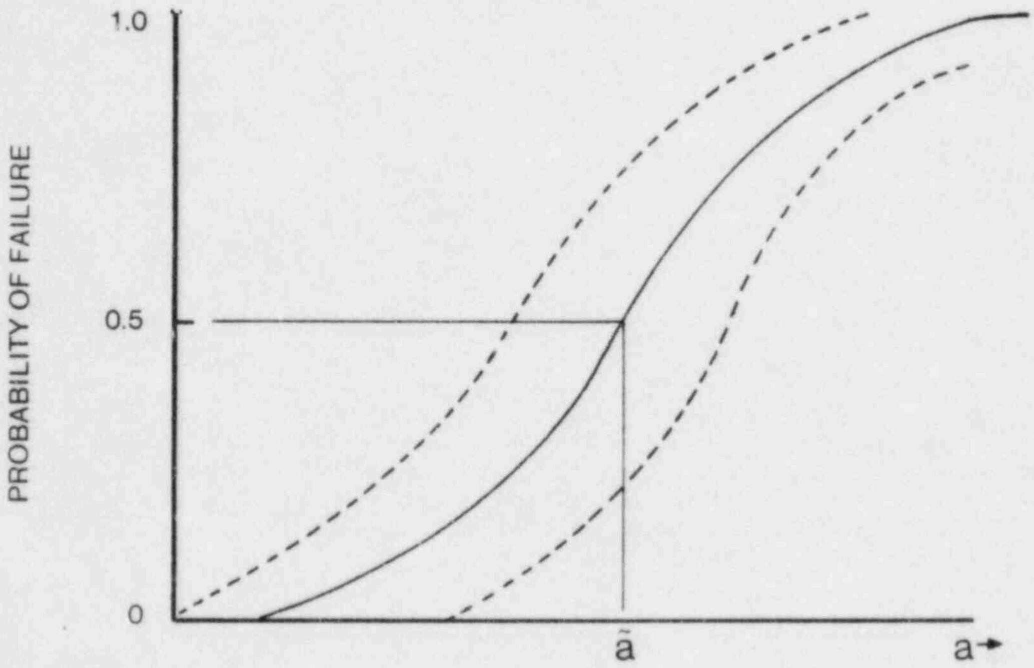
	MAXIMUM BODY WAVE MAGNITUDE	MAXIMUM MMI	WEIGHT
① Piedmont	5.8	VIII	0.15
② Piedmont	6.3	IX	0.15
③ Northeast	5.0	VI-VII	0.30
④ Crustal Block	5.5	VII-VIII	0.15
⑤ Crustal Block	6.0	VIII-IX	0.15
⑥ Decollement	6.8	X	0.10

Annual frequency of exceedence versus peak acceleration for all seismogenic zones.

FRAGILITY ANALYSIS

- SEISMICALLY INDUCED MODES OF FAILURE
- STRUCTURES AND COMPONENTS
- BASED ON DESIGN ANALYSIS CONSIDERING MARGINS TO FAILURE
  - STRENGTH
  - DUCTILITY
  - STRUCTURAL RESPONSE
  - EQUIPMENT RESPONSE
- FAMILY OF LOGNORMAL CURVES
  - RANDOMNESS IN FAILURE PROBABILITY (β_R)
  - UNCERTAINTY IN EXACT VALUE (β_U)

FRAGILITY CURVES



ã - MEDIAN GROUND ACCELERATION CAPACITY
β_R - GOVERNS SHAPE OF SOLID CURVE
β_U - GOVERNS WIDTH OF THE FAMILY OF CURVES (DOTTED LINES)

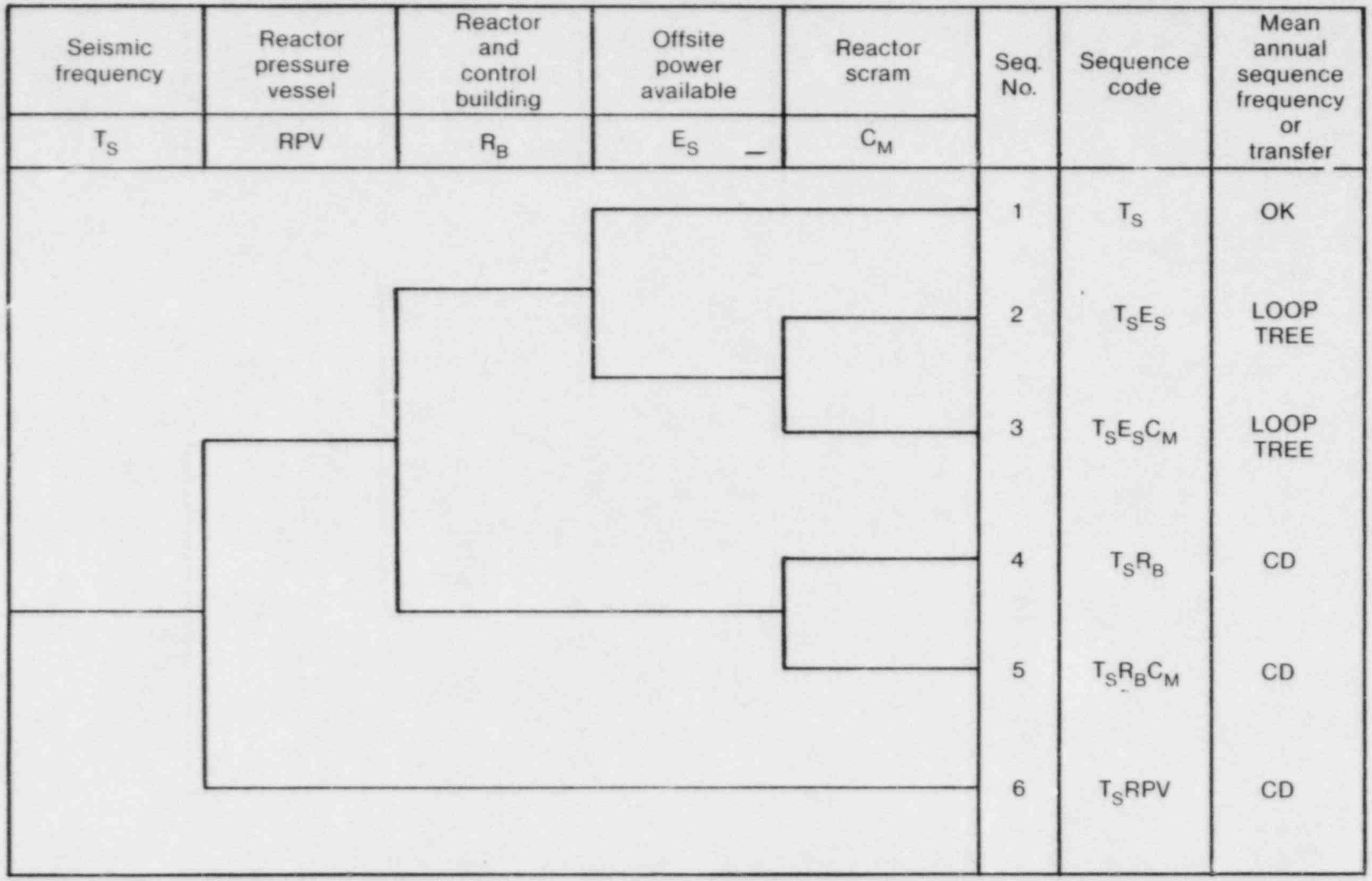
SIGNIFICANT COMPONENT FAILURES

- LOSS OF OFFSITE POWER - CERAMIC INSULATORS
  $\tilde{a} = 0.20\,g$
- REACTOR INTERNALS - SHROUD SUPPORT FAILURE
  - POTENTIAL FOR CONTROL RODS FAILING TO INSERT
  $\tilde{a} = 0.67\,g$
- FAILURE OF SHEAR WALLS IN REACTOR AND CONTROL ENCLOSURES
  - FAILS SYSTEMS OUTSIDE CONTAINEMENT INCLUDING LOSS OF SUPPRESSION POOL INTEGRITY
  $\tilde{a} = 1.0\,g$
- RPV FAILURE - FAILURE OF UPPER SUPPORT BRACKET
  $\tilde{a} = 1.25\,g$
- ONSITE AC/DC POWER - AC AND DC BUSES AND SWITCHGEAR
  $\tilde{a} = 1.46g$

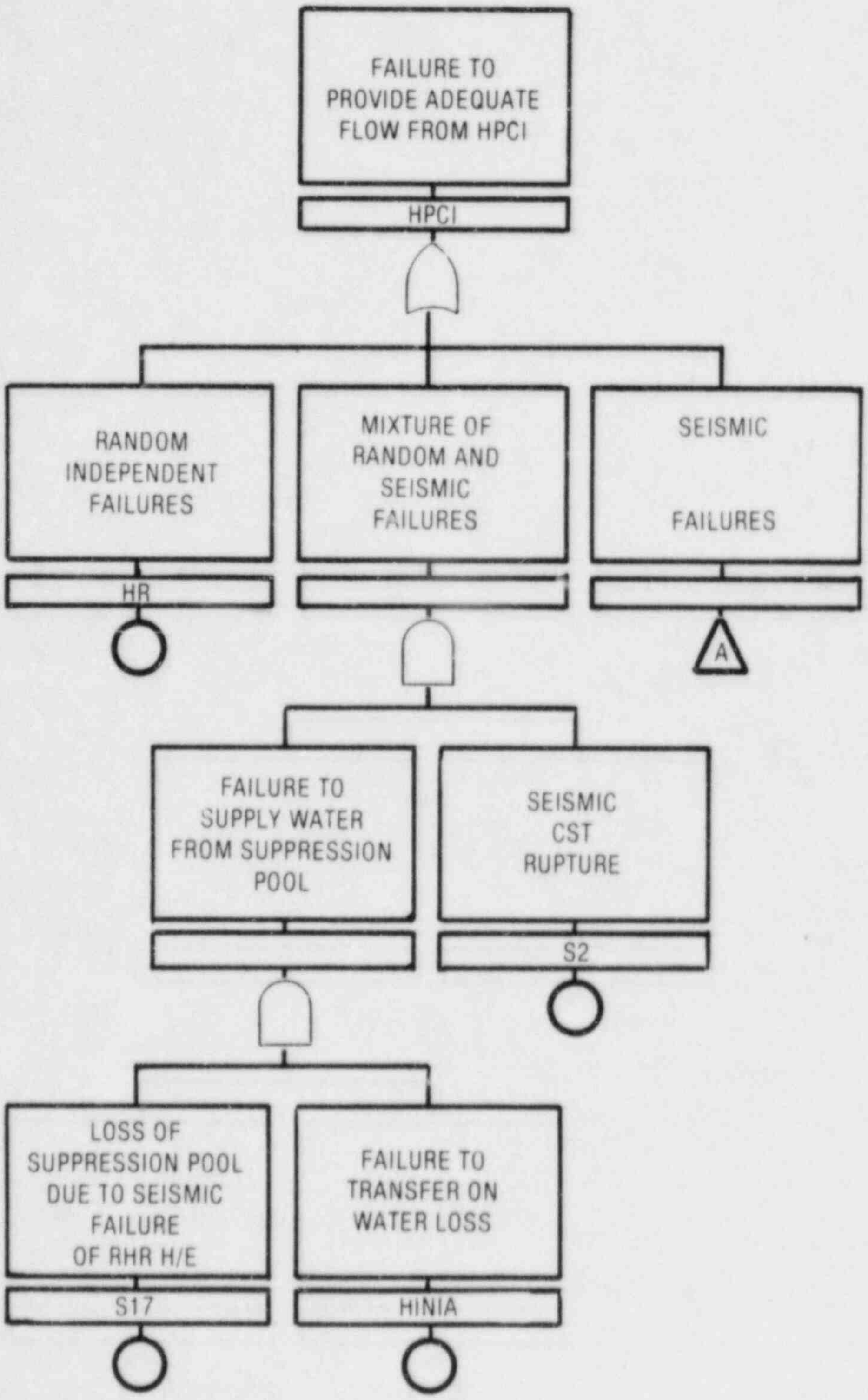
PLANT MODEL

- SEISMIC EVENT TREE
  - LOSS OF OFFSITE POWER TREE
  - FRONT END MODIFICATION FOR REACTOR VESSEL, REACTOR BUILDING FAILURES
- FAULT TREE
  - SEISMIC FAILURES ADDED AT APPROPRIATE LEVEL

SEISMIC EVENT TREE

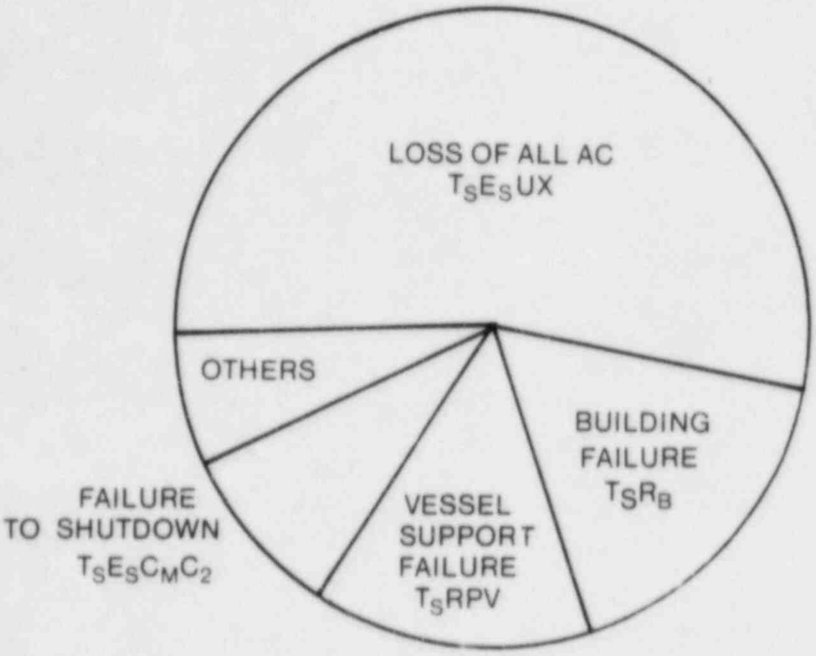


REDUCED SEISMIC FAULT TREE FOR THE HPCI SYSTEM



QUANTIFICATION

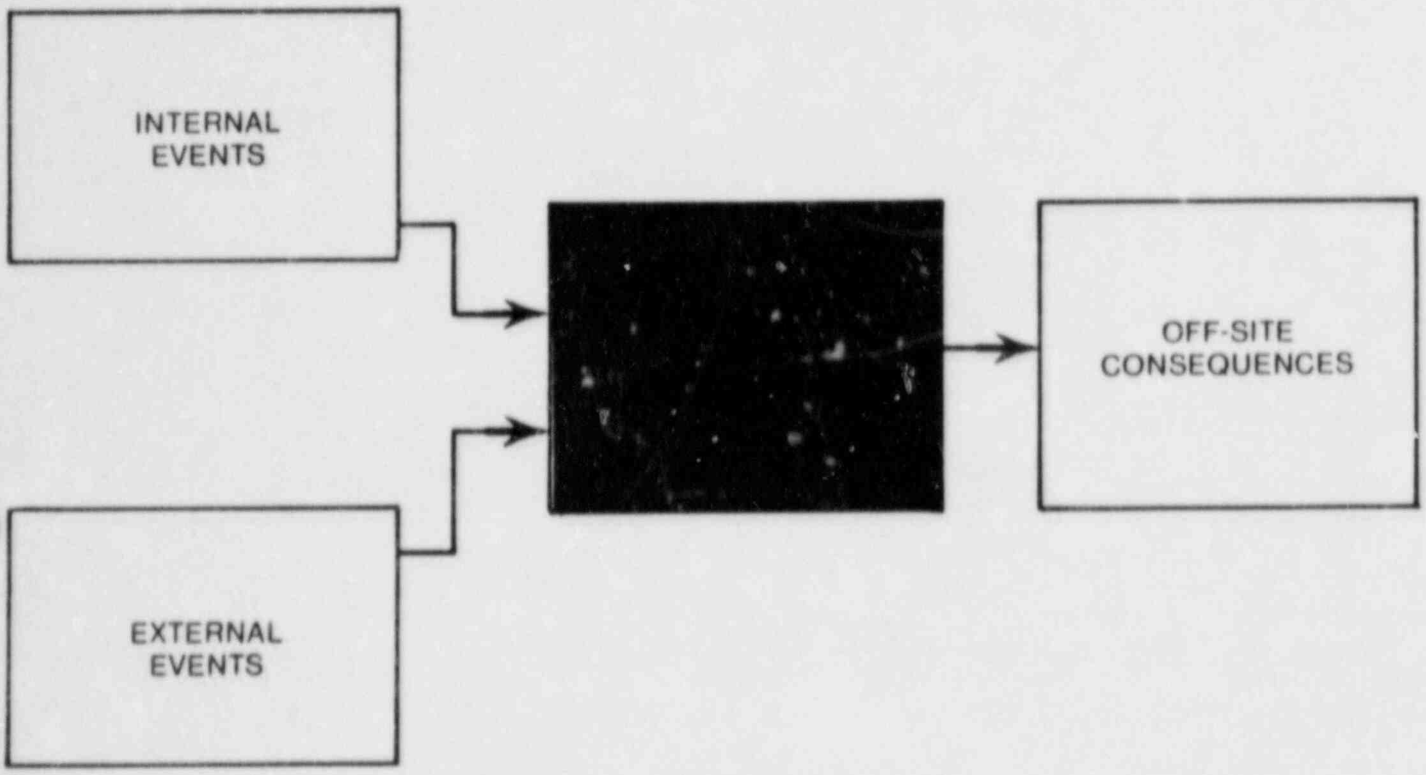
- FORMALISM OF INTERNAL EVENTS USED
  - BOOLEAN EXPRESSIONS
  - SEISMIC FAILURE AS FUNCTION OF ACCELERATION
  - RANDOM FAILURE
- RESULTING CONTINUOUS FUNCTION INTEGRATED OVER FULL RANGE OF ACCELERATIONS



LIMERICK
SEISMIC CONTRIBUTIONS TO CDF
MEAN – 5.7 x 10^{-6} /REACTOR YEAR

CHARACTERISTIC FAILURE	ANNUAL FREQUENCY	PERCENT CONTRIBUTION	SEQUENCE
LOSS OF ALL AC	3.1 x 10^{-6}	54	T_SE_SUX
ALL MAKE-UP LOSS DUE TO R. B. FAILURE	9.6 x 10^{-7}	17	$T_S R_B$
FAILURE OF UPPER SUPPORT BRACKETS	8.0 x 10^{-7}	14	T_SRPV
FAILURE OF ROD INSERTION AND SLC TEST TANK SUPPORT	5.4 x 10^{-7}	9	$T_SE_SC_MC_2$
TOTAL SEISMIC	5.7 x 10^{-6}		

LIMERICK PRA/SARA



INTERNAL EVENTS

EXTERNAL EVENTS

OFF-SITE CONSEQUENCES

IN-PLANT ACCIDENT PROGRESSION

E. A. HUGHES

IN-CONTAINMENT RADIONUCLIDE TRANSPORT AND RELEASE

ACCIDENT SEQUENCE CLASSES (BINNING)

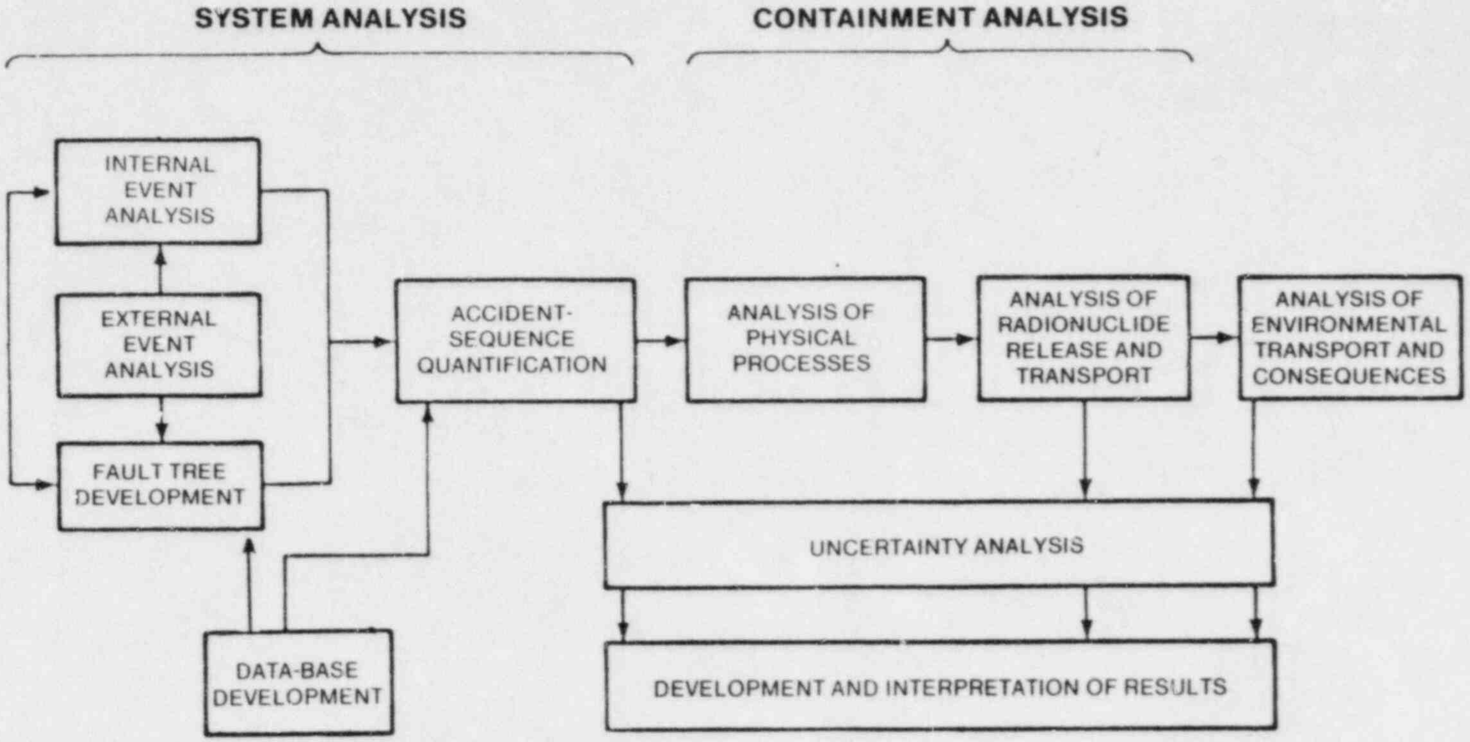
SEQUENCES MODELED — PHYSICAL PROCESSES

CONTAINMENT STRUCTURAL EVALUATION

CONTAINMENT EVENT TREE

FISSION PRODUCT TRANSPORT

SOURCE TERMS



RISK ASSESSMENT PROCEDURE

BINNING – ACCIDENT SEQUENCES

- TOO MANY SEQUENCES TO ANALYZE SEPARATELY
- TOO MUCH VARIATION TO PICK ONE

THEREFORE

- EVALUATE TIMING OF CORE DEGRADATION
- CONTAINMENT RESPONSE VARIATIONS
- SELECT REPRESENTATIVE GROUP

CONCLUSION

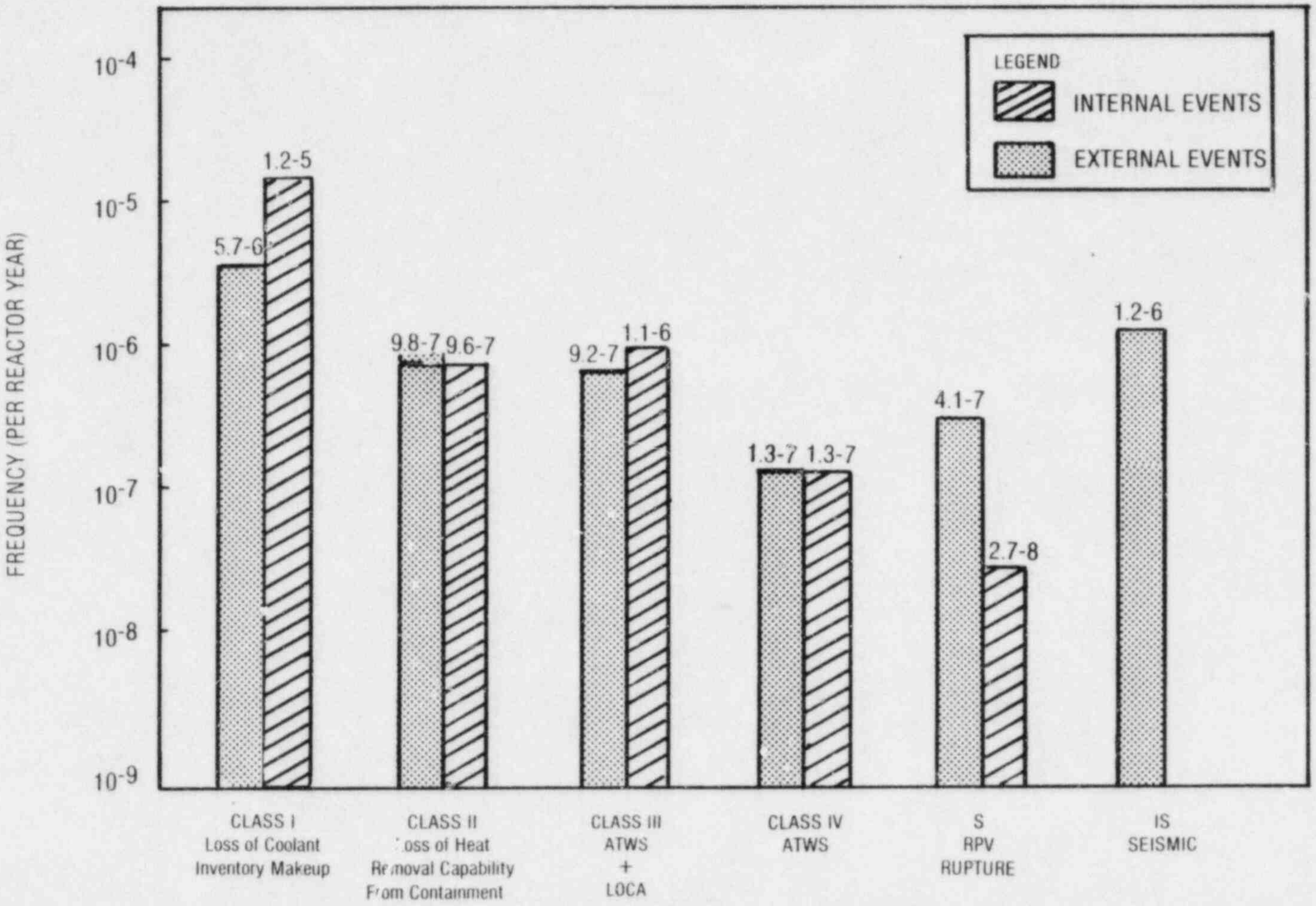
- SIX CLASSES DESIRABLE
    - CORE DAMAGE: EARLIER, LATER
    - CONTAINMENT FAILURE BEFORE AND AFTER CORE DAMAGE
    - TWO RAPID RELEASE SPECIAL CASES

ACCIDENT SEQUENCE BINS

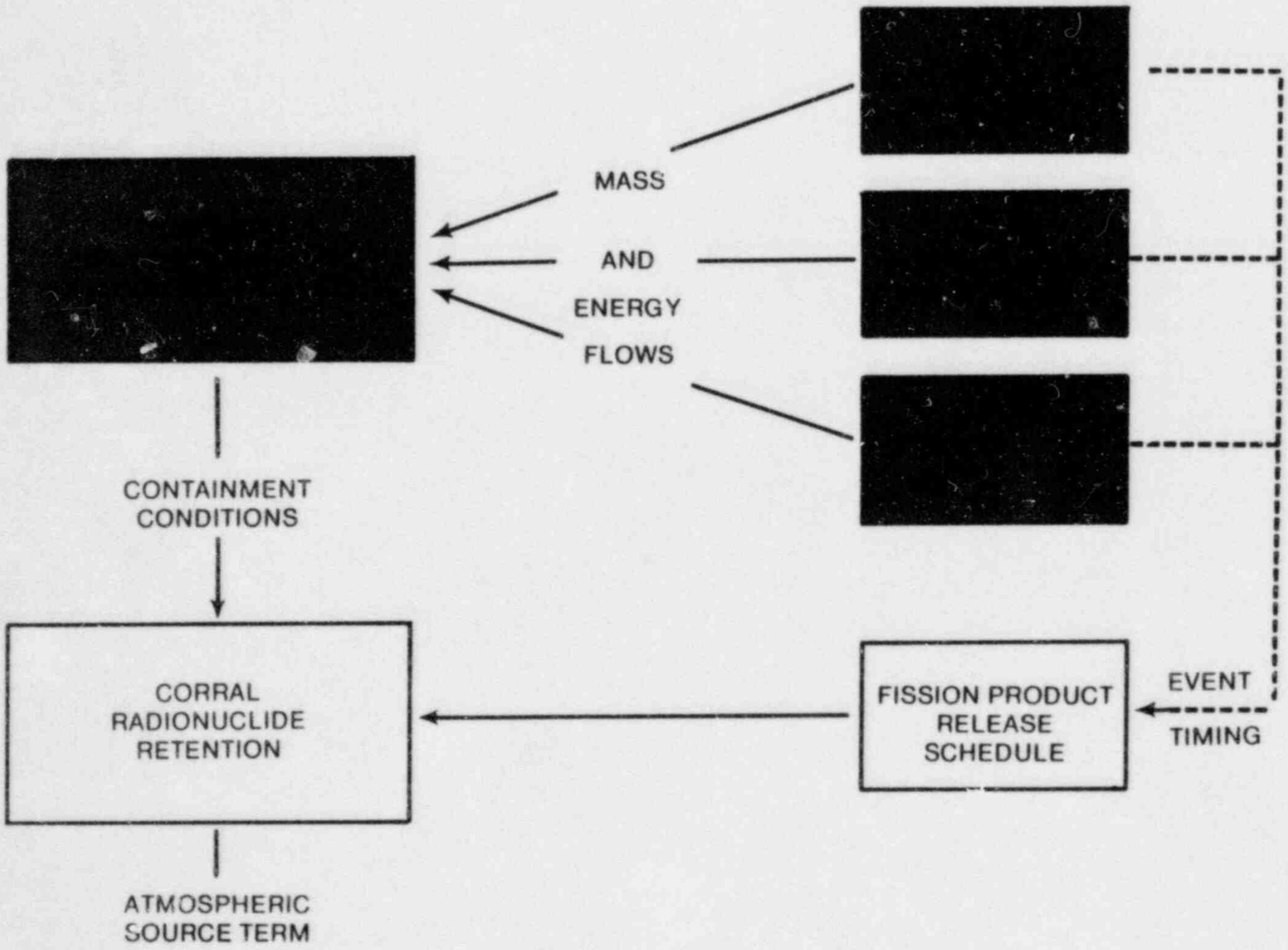
ACCIDENT CLASS (BIN)	CORE CONDITION	CONTAINMENT CONDITION AT CORE DAMAGE	EXAMPLE
I	• CONTROL RODS INSERTED • DECAY HEAT	INTACT AT LOW PRESSURE	TQUV
II	• CONTROL RODS INSERTED • LONG TERM DECAY HEAT	FAILED	TW
III	• ATWS; LOCA • 30% POWER	INTACT AT HIGH PRESSURE	$T_F C_M U$
IV	• ATWS • 30% POWER	FAILED	$T_F C_M C_2$
S	• IMMEDIATE CORE UNCOVERY • DECAY HEAT	FAILED	RPV RUPTURE; SEISMIC AND RANDOM
IS	• CONTROL RODS INSERTED • DECAY HEAT	FAILED	SEISMIC REACTOR BUILDING FAILURE

REPRESENTATIVE ACCIDENTS CHOSEN FOR EACH CLASS

- ALL SEQUENCES GROUPED INTO CLASSES
- REPRESENTATIVE SEQUENCES DEFINED
- PHYSICAL PROCESS ANALYSIS PERFORMED


LEGEND
INTERNAL EVENTS
EXTERNAL EVENTS
FREQUENCY (PER REACTOR YEAR)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
5.7-6
1.2-5
9.8-7
9.6-7
9.2-7
1.1-6
1.3-7
1.3-7
4.1-7
2.7-8
1.2-6
CLASS I
Loss of Coolant
Inventory Makeup
CLASS II
Loss of Heat
Removal Capability
From Containment
CLASS III
ATWS
+
LOCA
CLASS IV
ATWS
S
RPV
RUPTURE
IS
SEISMIC

ACCIDENT PROGRESSION ANALYSIS



MASS

AND

ENERGY

FLOWS

CONTAINMENT CONDITIONS

CORRAL RADIONUCLIDE RETENTION

FISSION PRODUCT RELEASE SCHEDULE

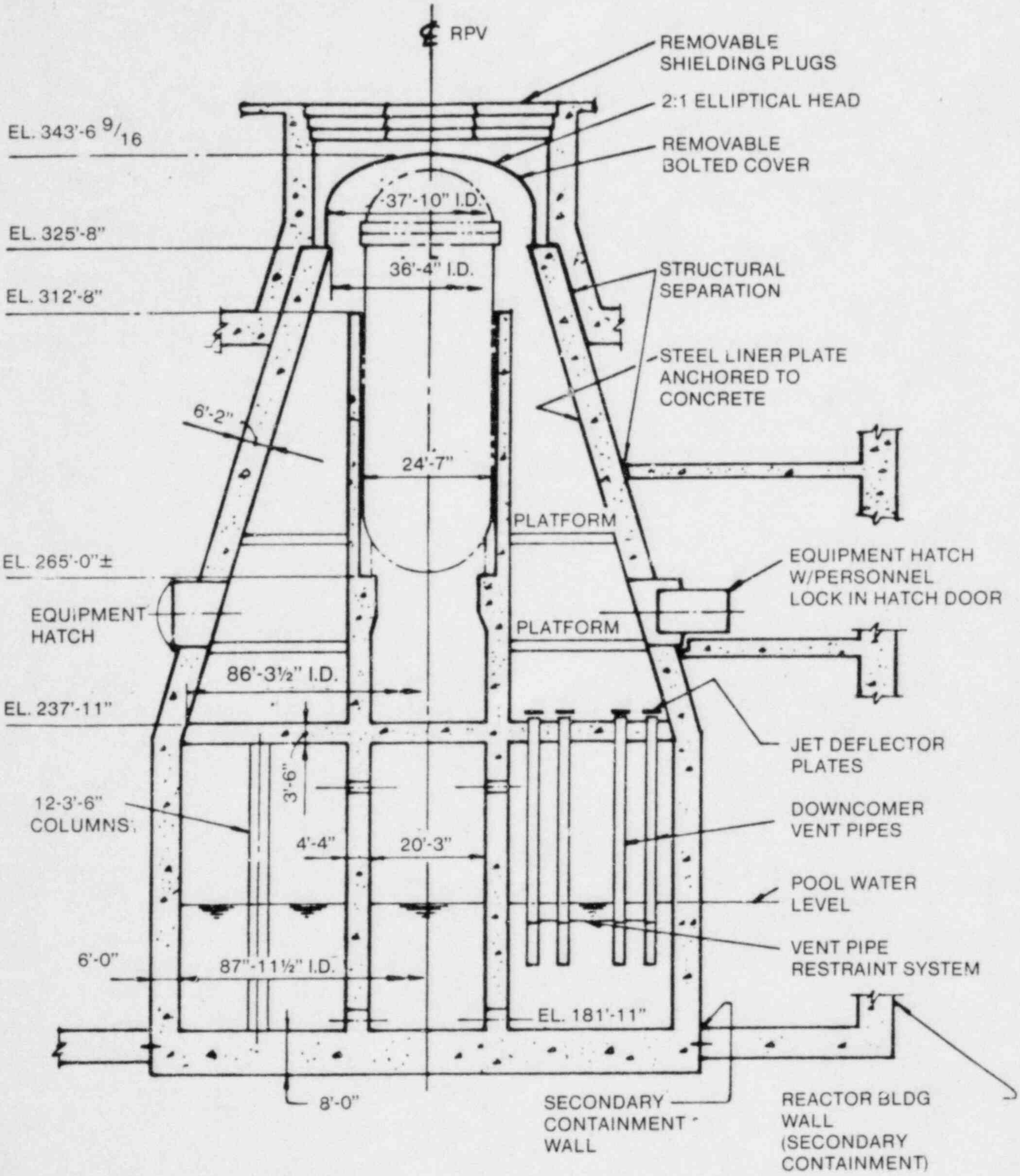
EVENT

TIMING

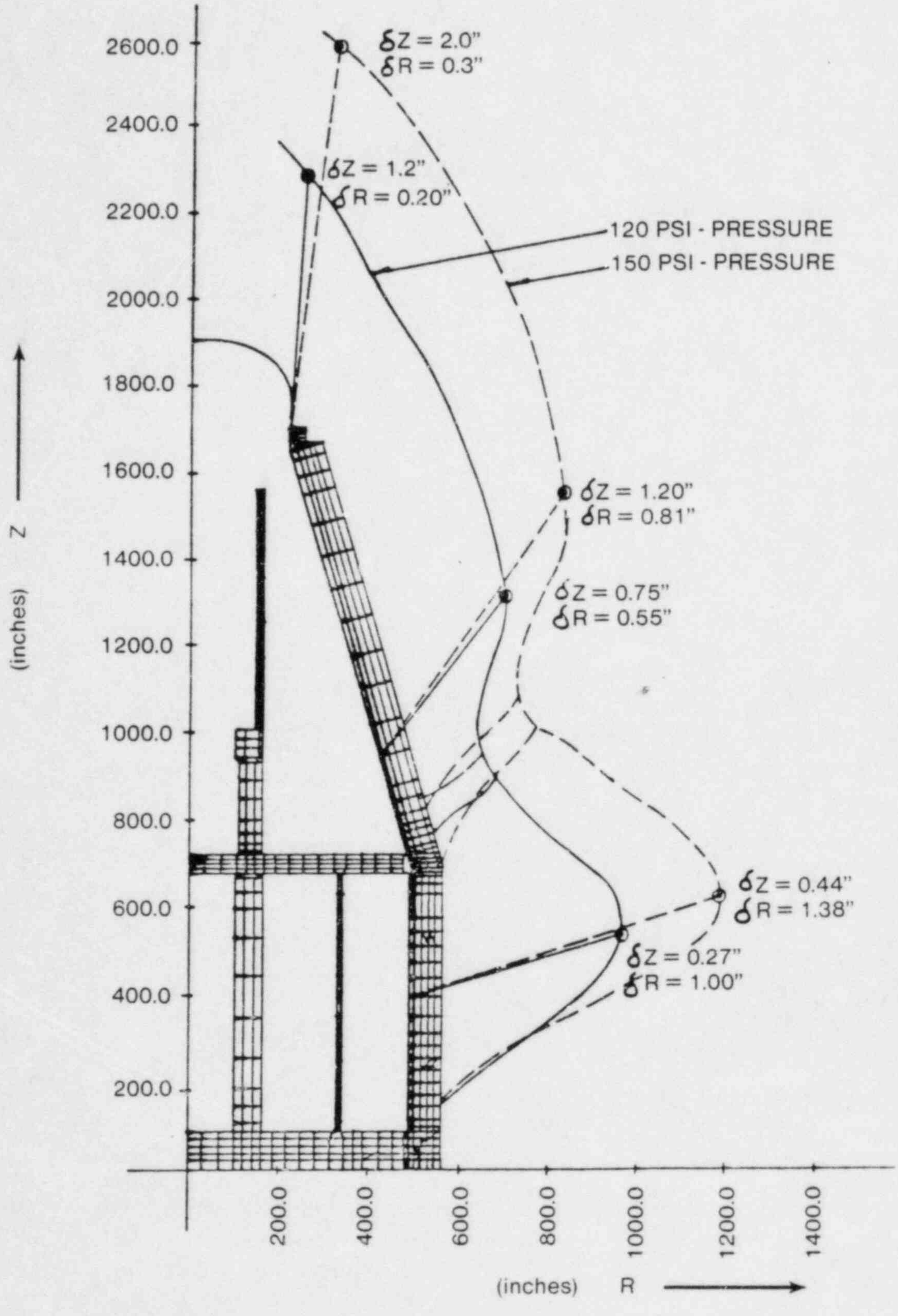
ATMOSPHERIC SOURCE TERM

SUMMARY OF CONTAINMENT CONDITIONS FOR REPRESENTATIVE ACCIDENT SEQUENCES

CLASS	PRINCIPAL ELEMENTS OF CONTAINMENT ANALYSIS				
	INITIAL PROBLEM	CORE POWER AT CORE UNCOVERY	CONTAINMENT PRESSURE AT MELT INITIATION	CONTAINMENT INTACT DURING VAPORIZATION	POOL TEMPERATURE
I (T QUV)	LOSS OF COOLANT INVENTORY	< 2%	17 PSIG	YES	SUBCOOLED
II (TW)	CONTAINMENT PRESSURE INCREASE	< 1%	140 PSIG ATMOSPHERIC	NO	SATURATION
III (LOCA ATWS)	LOSS OF COOLANT INVENTORY	30%	25-65 PSIG	YES	SATURATION
IV ATWS	CONTAINMENT PRESSURE INCREASE	30%	140 PSIG ATMOSPHERIC	NO	SATURATION
S $(T_S RPV\text{-}R\text{-}_B)$	RPV RUPTURE	< 2%	ATMOSPHERIC	NO	SUBCOOLED
IS $(T_S R_B)$	SEISMIC CHALLENGE	< 2%	ATMOSPHERIC	NO	SUBCOOLED



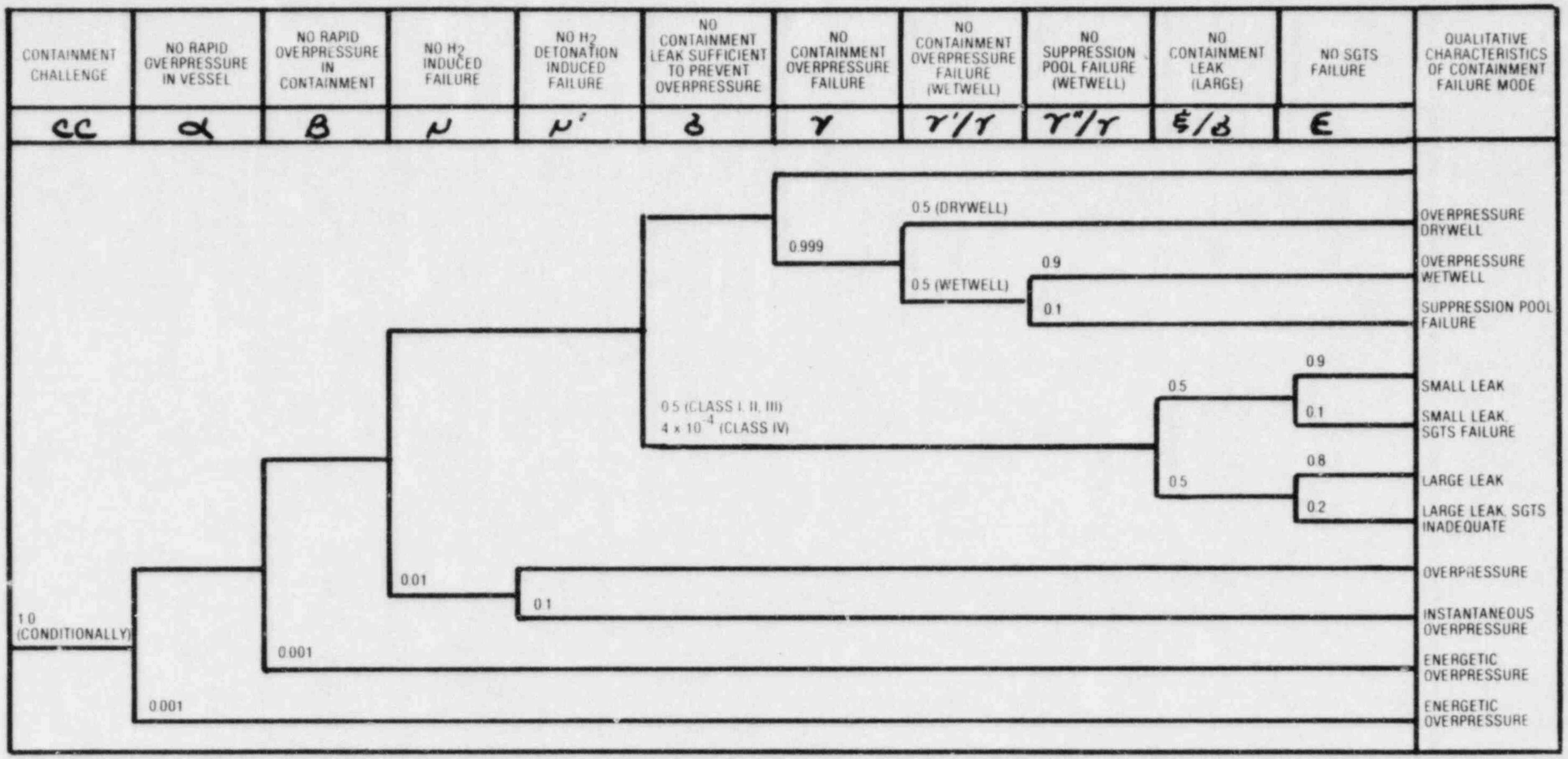
VERTICAL SECTION
CONTAINMENT GENERAL ARRANGEMENT



FINITE ELEMENT MODEL WITH DISPLACEMENTS AT 120 & 150 PSIG

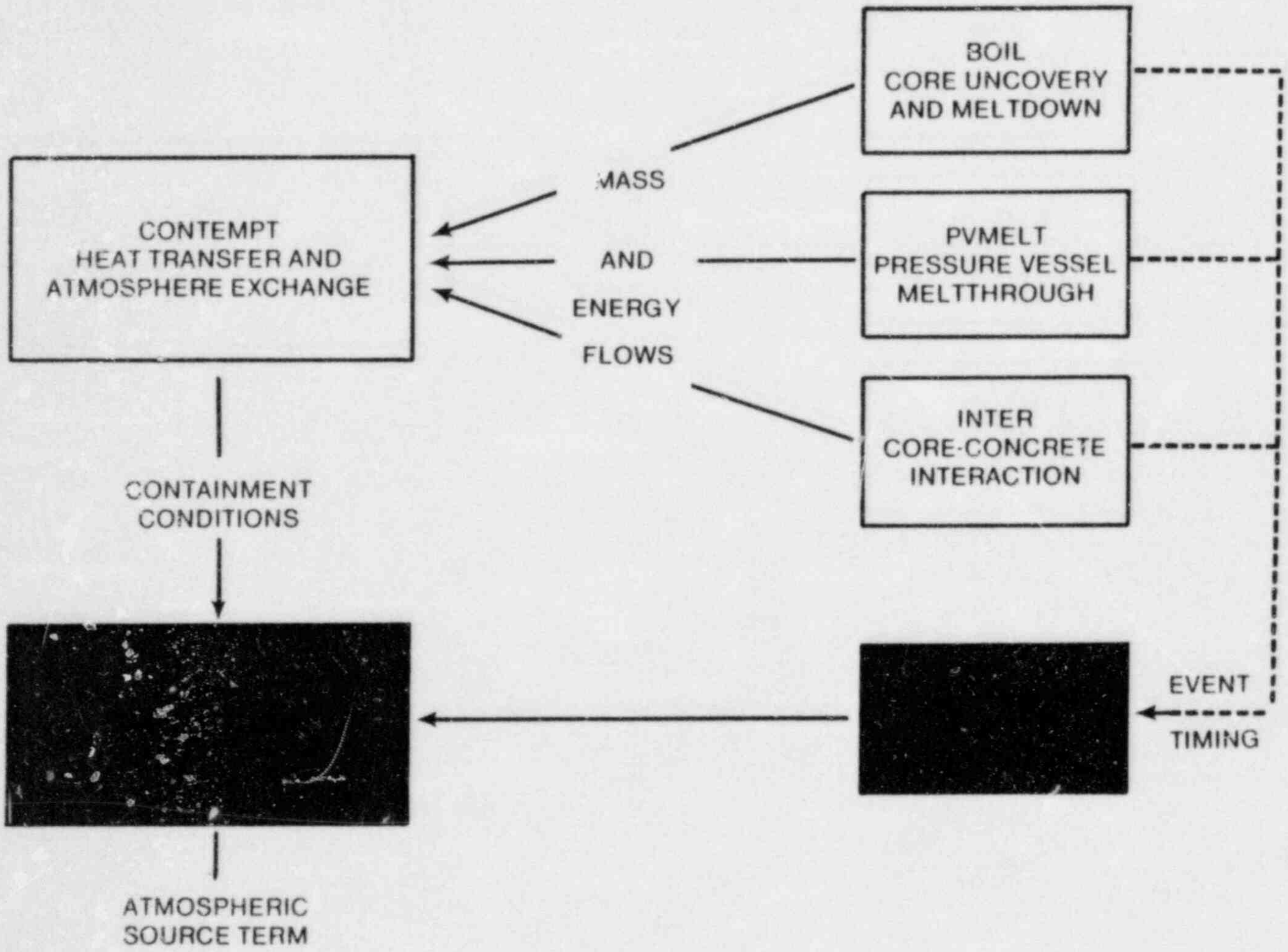
TIME TO CONTAINMENT FAILURE

CLASS	TYPICAL SEQUENCE	PRINCIPAL ELEMENTS OF CONTAINMENT ANALYSIS	
		INITIAL PROBLEM	TIME TO CONT FAIL (HRS)
I	T QUV	LOSS OF COOLANT INVENTORY	6.5
II	TW	CONTAINMENT PRESSURE INCREASE	30
III	ATWS LOCA	LOSS OF COOLANT INVENTORY	6.0
IV	ATWS	CONTAINMENT PRESSURE INCREASE	0.6
S	T_SRPV-R_B	RPV RUPTURE	0.0
IS	$T_S R_B$	SEISMIC CHALLENGE	0.0



CONTAINMENT EVENT TREE FOR THE MARK II CONTAINMENT

ACCIDENT PROGRESSION ANALYSIS



BOIL
CORE UNCOVERY
AND MELTDOWN

PVMELT
PRESSURE VESSEL
MELTTHROUGH

INTER
CORE-CONCRETE
INTERACTION

MASS
AND
ENERGY
FLOWS

CONTEMPT
HEAT TRANSFER AND
ATMOSPHERE EXCHANGE

CONTAINMENT
CONDITIONS

[redacted]

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EVENT
TIMING

ATMOSPHERIC
SOURCE TERM

FISSION PRODUCT RETENTION MECHANISMS CONSIDERED

- NATURAL DEPOSITION PLATEOUT AND GRAVITATIONAL SETTLING
  - IN CONTAINMENT STRUCTURE SURFACES
    - DRYWELL
    - WETWELL CHAMBER
  - REACTOR BUILDING SURFACES
- SUPPRESSION POOL SCRUBBING
- SGTS FILTRATION
- MOLTEN FUEL (QUENCHED OR FROZEN ON DIAPHRAGM FLOOR)

SUPPRESSION POOL SCRUBBING

POOL CONDITION	DECONTAMINATION FACTORS	
	IODINE & PARTICULATES	NOBLE GASES
SUBCOOLED	100.	1.0
SATURATED	10.	1.0
BYPASS	1.0	1.0

BINNING OF RELEASE PATHS

TYPE	ACCIDENT SEQUENCE CLASSES	RADIONUCLIDE SOURCE TERMS
INTERNAL	4	7 EACH
EXTERNAL	2	3 TOTAL

- TOTAL OF 31 RADIONUCLIDE SOURCE TERMS
  - RELEASE FRACTIONS COMPARED
  - SIMILAR SOURCE TERMS COMBINED
- RESULT: DISTINCT FEATURES MODELED BY FEWER CRAC 2 ANALYSES

RESULTS OF BINNING:
ELEVEN RADIONUCLIDE RELEASE CATEGORIES

OXRE — ALL STEAM, H_2 EXPLOSIONS FOR ALL CLASSES

OPREL — CLASS 1, 2, 3 OVERPRESSURE
DRYWELL AND WETWELL FAILURE ABOVE POOL

C4δ — CLASS 4 DRYWELL FAILURE

C4δ' — CLASS 4 WETWELL AIRSPACE FAILURE

C4δ" — CLASS 4 POOL FAILURE

LEAKS — WITH OR WITHOUT FILTRATION

C123 δ" — OTHER EVENTS WITH POOL FAILURE

RB (IS) — POOL PARTIALLY DRAINED, SEISMIC FAILURE

VR — SEISMIC, VESSEL RUPTURE (DRY)

VRH20 — SEISMIC, VESSEL RUPTURE (WET)

RELEASE CATEGORY

RADIONUCLIDE RELEASE FRACTIONS

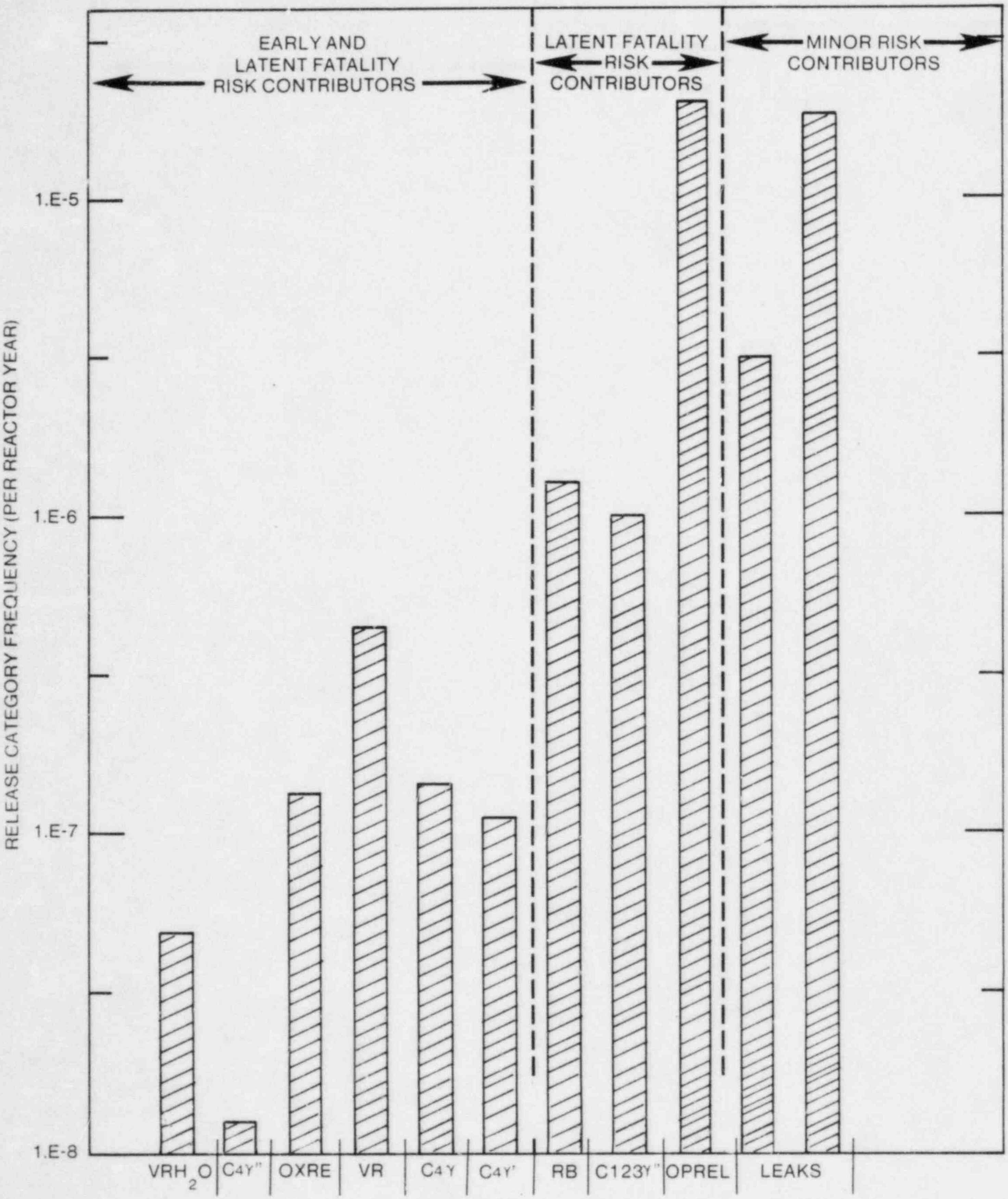
RADIONUCLIDE RELEASE FRACTION

Source Term	I	Cs	Te
OXRE	0.20	0.06	0.50
OPREL	0.11	0.09	0.016
C4-γ	0.261	0.202	0.434
C4-γ'	0.07	0.09	0.20
C4-γ"	0.73	0.70	0.55
C123-γ"	0.13	0.17	0.50
LEAK 1	0.019	0.0098	0.046
LEAK 2	0.0027	0.000098	0.00046
RB	0.05	0.09	0.09
VR	0.1	0.33	0.33
VRH2O	0.5	0.73	0.75

SOURCE-TERM RELEASE CATEGORY CHARACTERISTICS

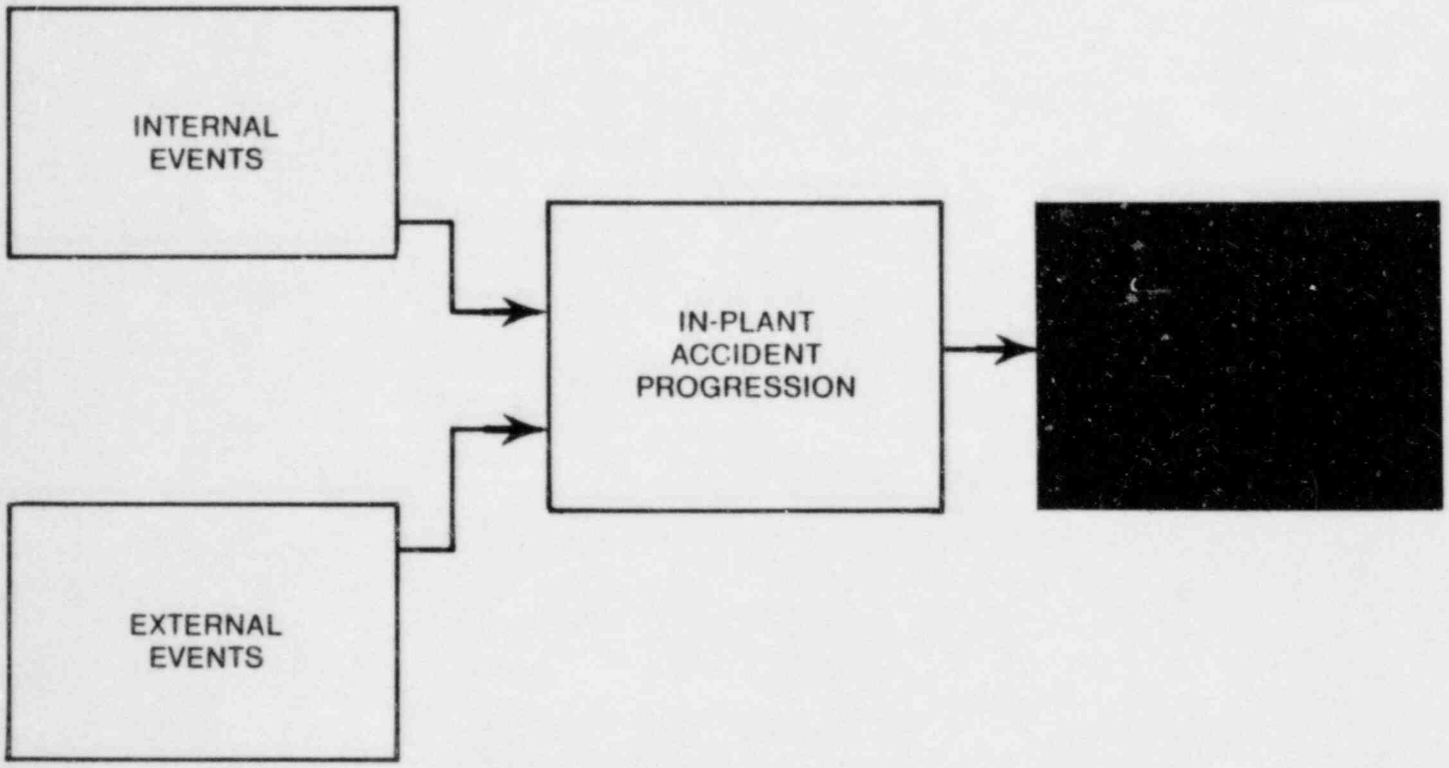
SOURCE TERM	T_r (hr)	T_d (hr)	T_w (hr)	h (m)	Q (cal/sec)
OXRE	4.0	0.5	3.0	27	8.4×10^6
OPREL	7.0	2.0	6.0	27	8.4×10^6
C4γ	1.5	2.0	1.0	27	7.0×10^4
C4γ'	1.5	2.0	1.0	27	7.0×10^4
C4γ"	1.5	2.0	1.0	10	7.0×10^4
C123γ"	7.0	2.0	6.0	10	7.0×10^4
LEAK 1	7.0	2.0	6.0	27	7.0×10^4
LEAK 2	7.0	2.0	6.0	27	7.0×10^4
RB	1.5	3.0	1.5	10	8.4×10^6
VR	0.25	3.5	0.25	10	1.4×10^4
VRH2O	0.34	0.65	0.34	10	2.0×10^6

T_r = Time of Release
T_d = Duration of Release
T_w = Warning Time
h = Height of Release
Q = Energy of Release



COMPARISON OF RADIONUCLIDE RELEASE CATEGORY FREQUENCY VERSUS CONSEQUENCE IMPACT

LIMERICK PRA/SARA



INTERNAL EVENTS

EXTERNAL EVENTS

IN-PLANT ACCIDENT PROGRESSION

[redacted]

CONSEQUENCE ANALYSIS

G.D. KAISER

LGS-SARA CONSEQUENCE MODEL

- CRAC2 CODE
- SITE SPECIFIC METEOROLOGY (5 YEARS), POPULATION AND ECONOMIC INPUT
- PLANT SPECIFIC SOURCE TERMS
- WASH-1400 DOSIMETRY AND HEALTH EFFECTS

EVACUATION MODEL

SEPARATE MODELS DEVELOPED:

- INTERNAL INITIATORS AND SMALL EARTHQUAKES
- LARGE EARTHQUAKES
- BASED ON CONSIDERATION OF EFFECT ON ROAD NETWORK

EVACUATION MODEL (CONT)

FOR INTERNAL INITIATORS AND SMALL EARTHQUAKES

SANDIA GENERIC MODEL

- DELAY TIMES OF 1, 3 AND 5 HOURS (PROBABILITIES 0.3, 0.4, 0.3)
- EVACUATION SPEED 10 MPH
- CONSISTENT WITH U.S. EVACUATION EXPERIENCE AND WITH RECENT SITE SPECIFIC EVACUATION STUDY

EVACUATION MODEL (CONT)

FOR LARGE EARTHQUAKES

- 3 HOUR DELAY AND 1 MPH EVACUATION SPEED

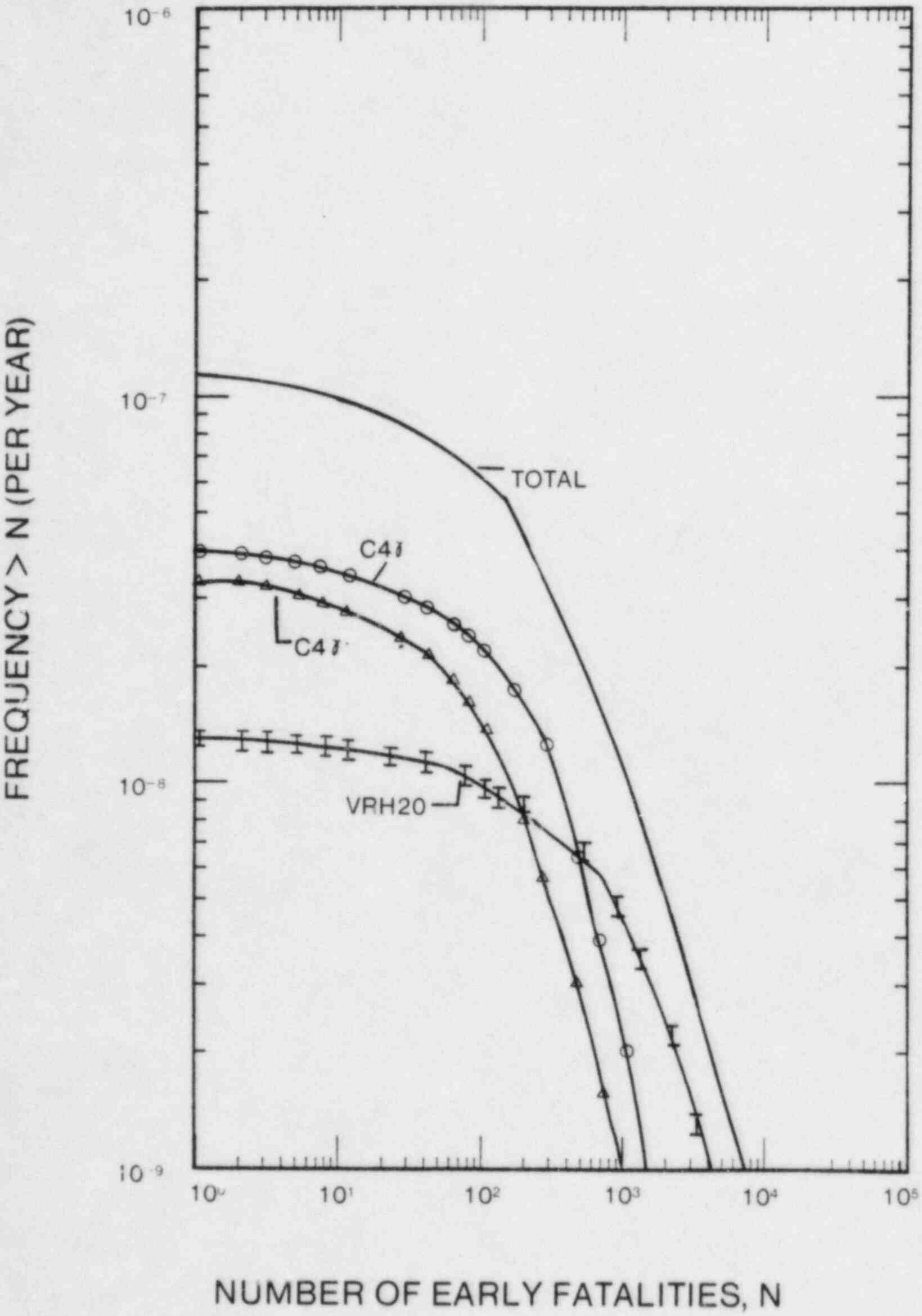
SHELTERING MODEL

BEYOND 10 AND WITHIN 25 MILES

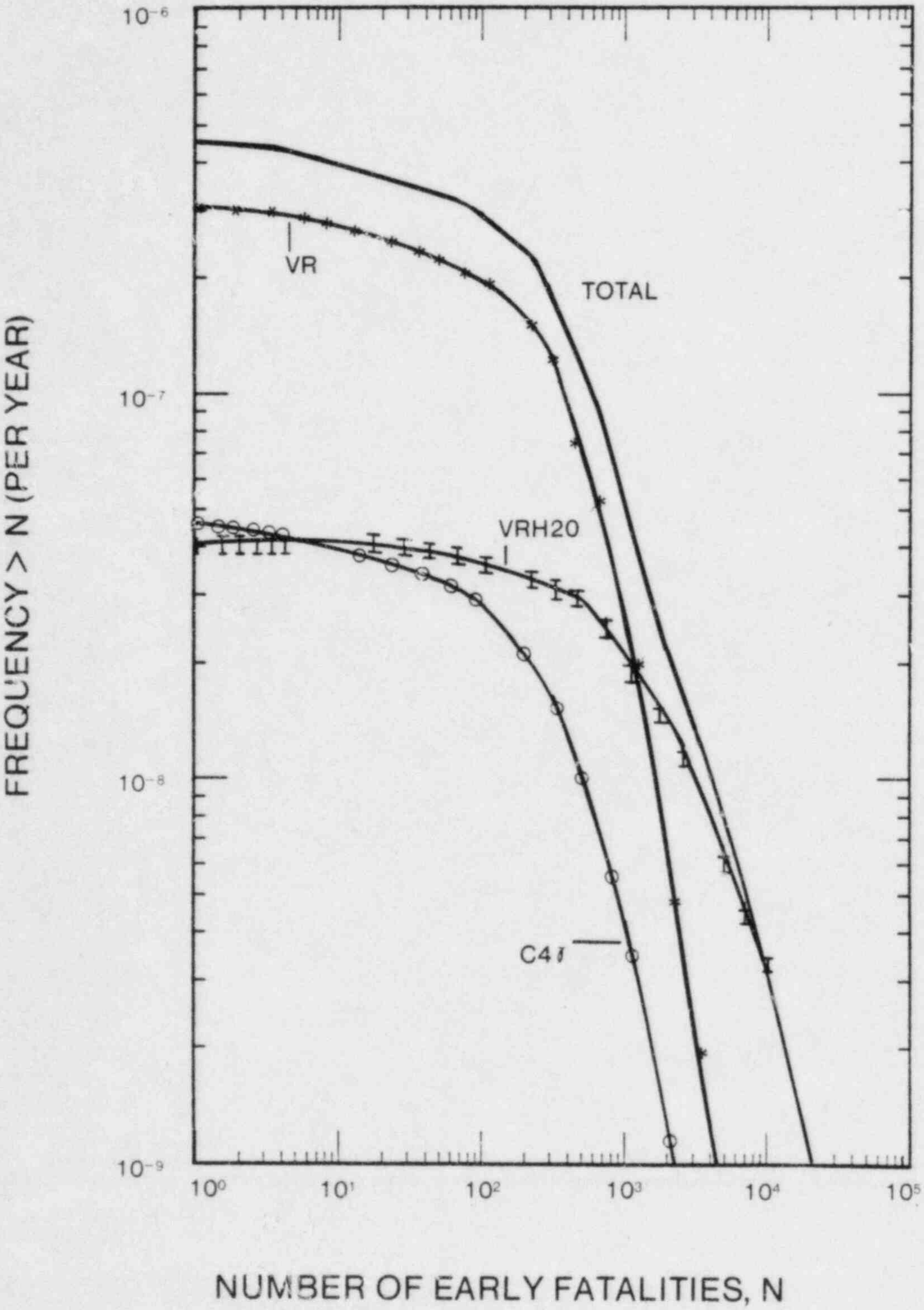
- 12 HOURS "NORMAL ACTIVITY" AFTER PLUME PASSAGE FOR INTERNAL INITIATORS AND SMALL EARTHQUAKES
- 24 HOURS "NORMAL ACTIVITY" FOR LARGE EARTHQUAKES

RESULTS

- CCDFS;
  - — EARLY FATALITIES
  - — LATENT CANCER FATALITIES
  - — THYROID CANCER FATALITIES
  - — WHOLE BODY POPULATION DOSE
  - — PEOPLE WITH BONE MARROW DOSE EXCEEDING 200 REM
  - — OFF-SITE COSTS



INTERNAL INITIATORS



SEISMIC INITIATORS

CHOICE OF SOURCE TERMS FOR SENSITIVITY AND UNCERTAINTY ANALYSIS – EARLY FATALITIES

- RANDOM VESSEL RUPTURE (VR, VRH20)
- SEISMIC VESSEL RUPTURE (VR, VRH20)
- ATWS CLASS 4 SEQUENCES, SEISMIC AND INTERNAL ($C4\gamma$, $C4\gamma'$)

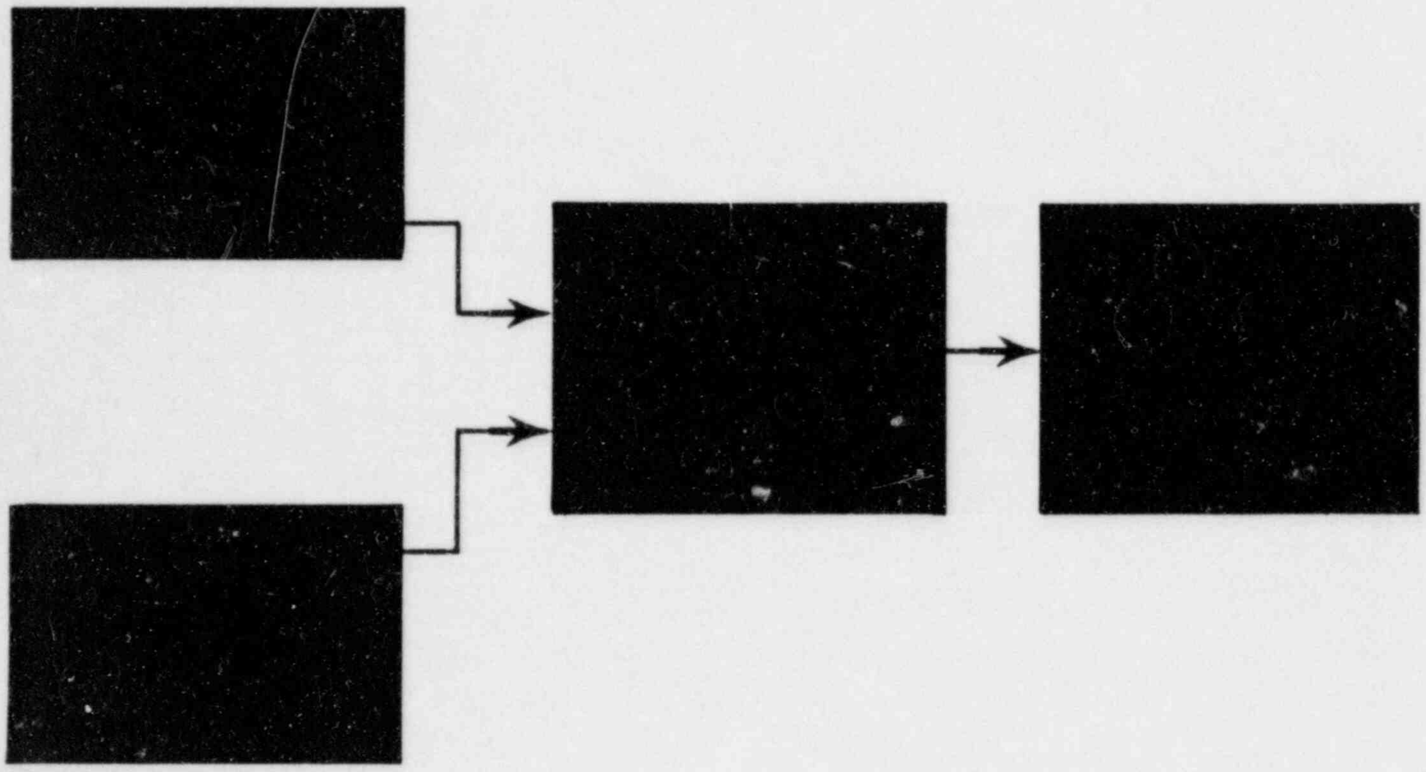
POINT ESTIMATE CONTRIBUTION TO RISK OF LATENT CANCER FATALITY (YR^{-1})

SOURCE TERM	INTERNAL	FIRE	SEISMIC	TOTAL
OPREL	1.4×10^{-2} 82%	3.1×10^{-3} 83%	3.9×10^{-3} 35%	2.1×10^{-2} 64%
RB	—	—	3.4×10^{-3} 31%	3.4×10^{-3} 10%
C4 γ, γ', γ''	7.0×10^{-4} 4%	—	6.9×10^{-4} 6%	1.4×10^{-3} 4%
VR, VRH2O	2.5×10^{-4} 1.5%	—	2.7×10^{-3} 25%	3.0×10^{-3} 9%
OTHERS	2.9×10^{-3} 13%	8.6×10^{-4} 18%	8.2×10^{-4} 3%	4.4×10^{-3} 13%
TOTAL	1.7×10^{-2}	3.8×10^{-3}	1.1×10^{-2}	3.3×10^{-2}

CHOICE OF SOURCE TERMS FOR SENSITIVITY STUDIES LATENT CANCER FATALITIES

- LATE OVERPRESSURE FAILURE (OPREL)
- VESSEL RUPTURE (VR AND VRH20)
- SEISMIC BUILDING FAILURE (RB)
- ATWS CLASS 4 SEQUENCES (C4 SEQUENCES)

LIMERICK PRA/SARA



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UNCERTAINTY ANALYSIS

G. W. PARRY

OVERVIEW

- POINT ESTIMATE RESULTS EVALUATED USING BEST ESTIMATES FOR ALL INPUTS.
- UNCERTAINTY ANALYSIS PROVIDES MEASURES OF THE RANGE OF POSSIBLE RESULTS.
- UNCERTAINTIES ARE THOSE IN PREDICTIONS OF THE GIVEN RISK MODEL.
- THEY DO NOT INCLUDE
  —ALL CONSERVATISMS IN THE MODEL.

  —OMISSIONS

OVERVIEW

- AIM IS TO CALCULATE THE UNCERTAINTY IN
  - CORE MELT FREQUENCY
  - RISK AS EXPRESSED BY CCDFs
- RESULTS PRESENTED AS
  - PROBABILITY DISTRIBUTION ON CORE MELT FREQUENCY
  - UPPER, MEDIAN, AND LOWER ESTIMATES OF CCDFs

PRA/SARA RISK MODEL

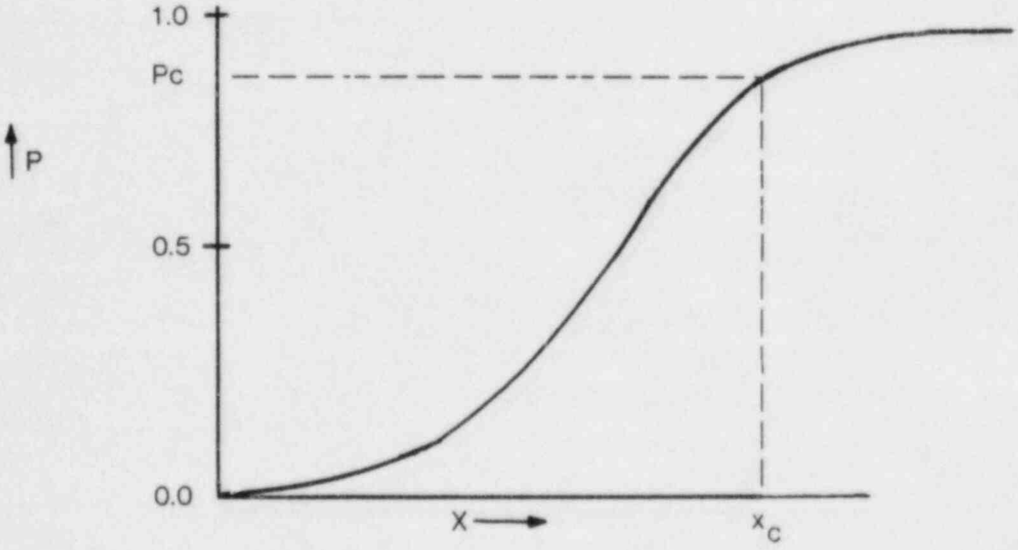
- EVENT TREES DEFINE ACCIDENT SEQUENCES
  - SEQUENCES GROUPED INTO SIX ACCIDENT CLASSES.
- FAULT TREES PROVIDE LOGIC MODELS FOR ESTIMATING SEQUENCE FREQUENCIES.
- CONTAINMENT EVENT TREES (CETs) DEFINE CONTAINMENT FAILURE MODES
- ACCIDENT CLASS, CET END POINT COMBINATIONS GROUPED INTO RELEASE CATEGORIES
- FREQUENCY OF EACH RELEASE CATEGORY AND ASSOCIATED SOURCE TERM DETERMINE OFFSITE CONSEQUENCES

UNCERTAINTY ANALYSIS

- PERFORMED ON MAJOR CONTRIBUTORS AS DETERMINED BY POINT ESTIMATES
- UNCERTAINTIES ON FREQUENCIES AND CONSEQUENCES EVALUATED DIFFERENTLY.
- SUBJECTIVIST APPROACH TO REPRESENTATION OF UNCERTAINTY

REPRESENTATION OF UNCERTAINTY

- UNCERTAINTY CHARACTERIZED IN TERMS OF PROBABILITY DISTRIBUTION



PROB $[x < x_c] = P_c$

UNCERTAINTY ANALYSIS – FREQUENCIES

- BINARY LOGIC MODELS LEAD TO FREQUENCIES EXPRESSED AS SIMPLE ALGEBRAIC FUNCTIONS OF PARAMETERS SUCH AS:
  - INITIATING EVENT FREQUENCIES
  - FAILURE RATES
  - CONTAINMENT EVENT TREE BRANCH POINT PROBABILITIES
- SOURCES OF UNCERTAINTY
  - PARAMETER VALUES
  - FAILURE MODELS
  - COMPLETENESS
  - ASSUMPTIONS
  - BIASES

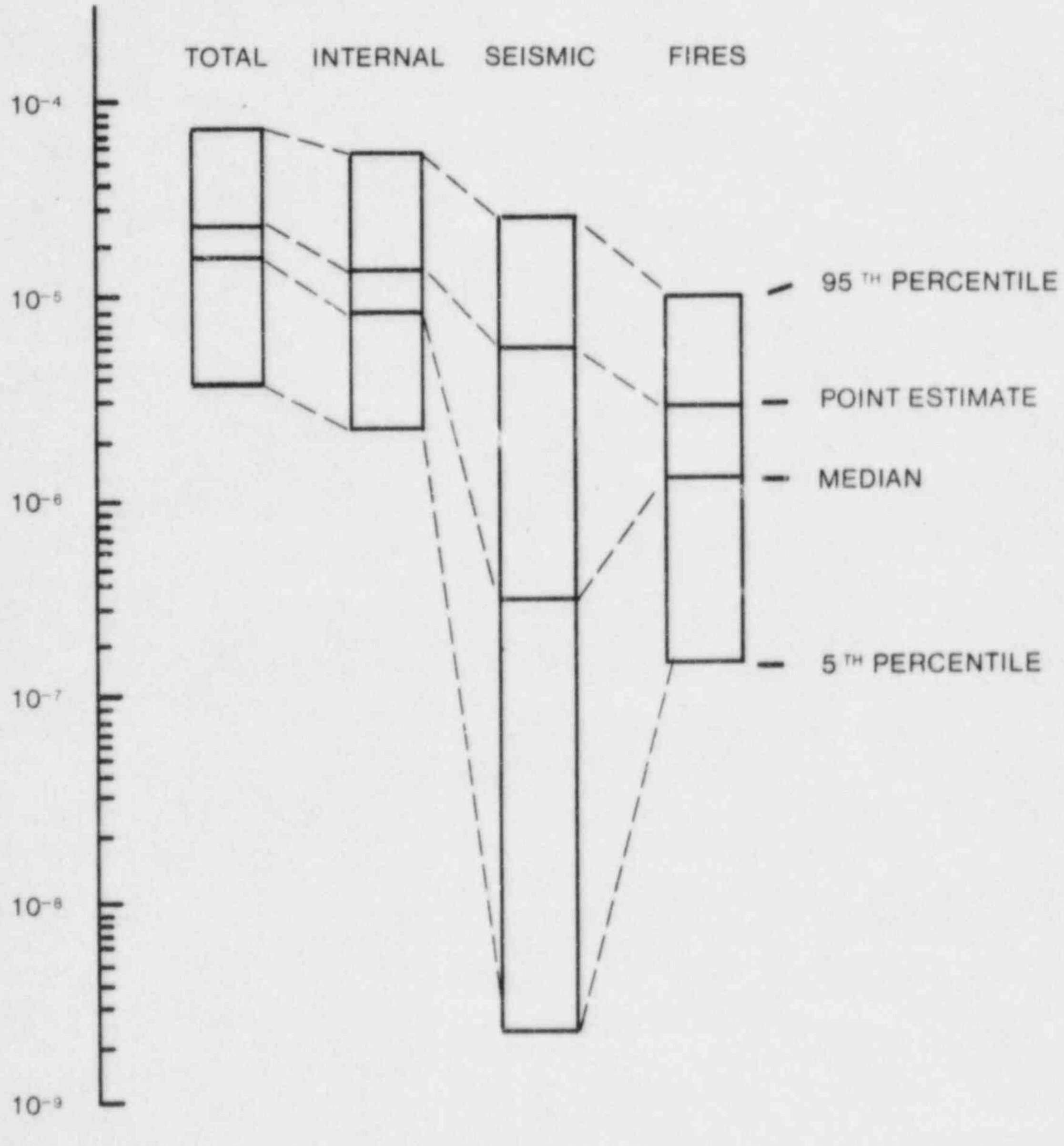
UNCERTAINTY ANALYSIS – FREQUENCIES
(CONTINUED)

- ONLY PARAMETER VALUE UNCERTAINTIES ADDRESSED FOLLOWING STANDARD PRACTICE
- CONSTRUCT ALGEBRAIC FUNCTION FOR DOMINANT CONTRIBUTORS
- DETERMINE APPROPRIATE PROBABILITY DISTRIBUTIONS ON INPUT PARAMETER VALUES
- CALCULATE PROBABILITY DISTRIBUTION ON FREQUENCIES USING MONTE CARLO SIMULATION

ANNUAL CORE MELT FREQUENCY

	5th Percentile	Median	95th Percentile	Point Estimate
Internal	2.4-6	9.2-6	6.0-5	1.5-5
External				
Seismic	2.2-9	3.3-7	2.7-5	5.7-6
Fire (revised study)	1.7-7	1.4-6	1.2-5	3.4-6
Other		NEGLIGIBLE		
Total	4.0-6	1.8-5	7.8-5	2.4-5

ANNUAL CORE MELT FREQUENCY



UNCERTAINTY ANALYSIS – CONSEQUENCES

SOURCES OF UNCERTAINTY

- CHAPTER 9 OF PRA PROCEDURES GUIDE-51 PARAMETERS OR MODELING ASSUMPTIONS CONTRIBUTE TO UNCERTAINTY
- ELEVEN CONSIDERED "MAJOR" CONTRIBUTORS
- FURTHER JUDGMENT, BASED ON EXPERIENCE WITH CRAC2, FOUR MOST IMPORTANT
    - SOURCE TERM FREQUENCY
    - SOURCE TERM MAGNITUDE AND TIMING
    - EVACUATION AND SHELTERING PARAMETERS
    - DOSE-RESPONSE RELATIONSHIPS

- OTHER MAJOR CONTRIBUTORS CONSIDERED
  - DRY DEPOSITION MODELING
  - WET DEPOSITION MODELING
  - STRAIGHT LINE VS. TRAJECTORY VS. MULTIPUFF MODEL
  - SAMPLING OF METEOROLOGICAL DATA
- OTHER POTENTIAL MAJOR CONTRIBUTORS NOT IMPORTANT FOR LGS
  - DIURNAL AND SEASONAL POPULATION VARIATIONS

UNCERTAINTIES ON RISK

- EVALUATION OF RISK - THE RISK EQUATION, EXAMPLE - EARLY FATALITIES

$$\begin{aligned} \mathrm{CCDF} = {} & F(VR)\cdot \mathrm{CCCDF}\,(VR) + \\ & F_S\,(VR)\cdot \mathrm{CCDF}_S\,(VR) + \\ & F\,(CIV)\cdot \mathrm{CCCDF}\,(CIV) + \\ & F_S\,(CIV)\cdot \mathrm{CCDF}_S\,(CIV) + \\ & F_S\,(T_S\,R_B)\cdot \mathrm{CCCDF}_S\,(T_S\,R_B) + \\ & \text{LOWER ORDER TERMS} \end{aligned}$$

F (X) - FREQUENCY OF RELEASE CATEGORY X
CCCDF (X) - CONDITIONAL CCDF FOR RELEASE CATEGORY X
SUBSCRIPT S INDICATES SEISMIC CONTRIBUTION

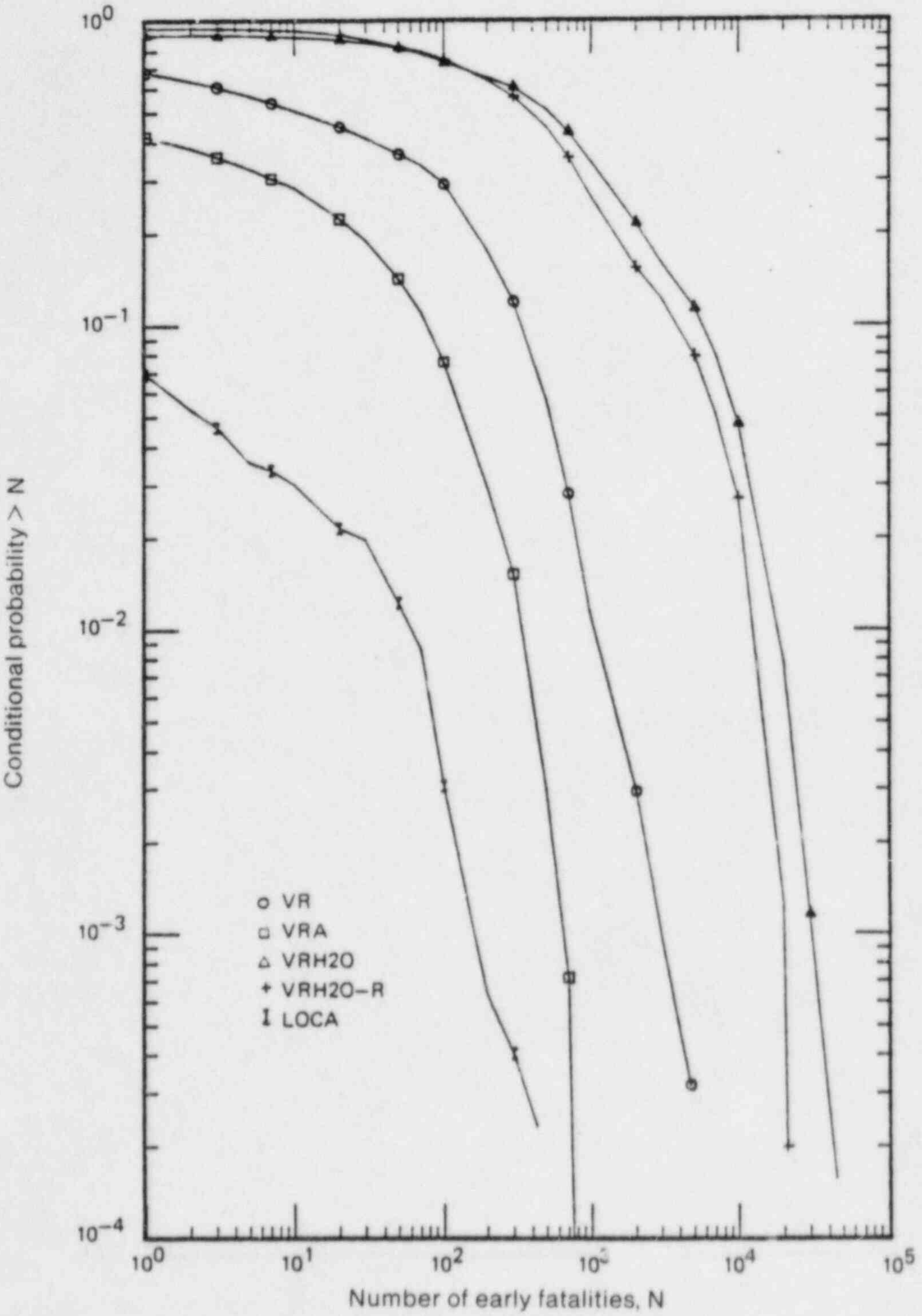
- DISTRIBUTION OF CCDF OBTAINED FROM DISTRIBUTIONS ON THE F(X)s AND THE CCCDF(X)s

UNCERTAINTY ON CCCDFs

- RESULTS NOT EXPRESSABLE AS SIMPLE FUNCTIONS OF INPUT PARAMETERS.
- MODELING UNCERTAINTIES NOT AMENDABLE TO REPRESENTATION AS CONTINUOUS DISTRIBUTIONS
- USE SENSITIVITY STUDIES TO DETERMINE RANGE OF POSSIBLE RESULTS

EXAMPLE – VESSEL RUPTURE, EARLY FATALITIES

- MANY SENSITIVITY STUDIES PERFORMED
- FIVE SOURCE TERMS
  - IMMEDIATE CONTAINMENT FAILURE, SOME WATER LEFT IN VESSEL,NUREG-0772 FUEL RELEASE FRACTIONS (VRH2O)
  - IMMEDIATE CONTAINMENT FAILURE, SOME WATER LEFT IN VESSEL, WASH-1400 FUEL RELEASE FRACTIONS (VRH20-R)
  - IMMEDIATE CONTAINMENT FAILURE, NO WATER IN VESSEL (VR)
  - IMMEDIATE CONTAINMENT FAILURE, NO WATER IN VESSEL, IN-CONTAINMENT RETENTION ENHANCED (I.E., SMALL SOURCE TERM, VR-A)
  - LATE CONTAINMENT FAILURE - LARGE LOCA



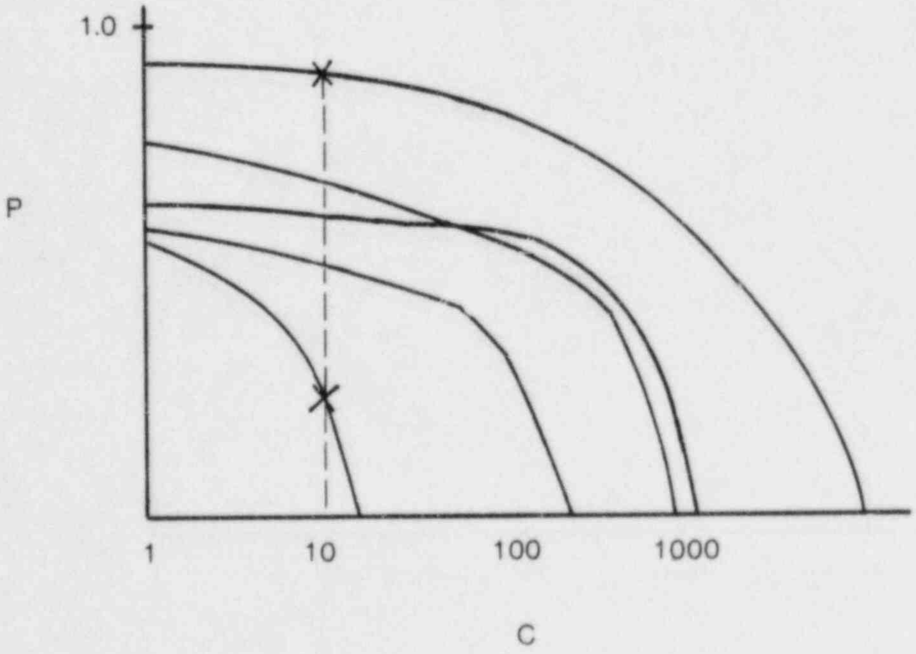
Example of effect on conditional CCDF for early fatalities-variation in vessel-failure source terms.

- FOR EACH OF THE 5 SOURCE TERMS, 6 VARIATIONS IN EVACUATION STRATEGY
  - 1 HOUR DELAY, 10 MPH
  - 3 HOUR DELAY, 10 MPH
  - 5 HOUR DELAY, 10 MPH
  - SANDIA GENERIC EVACUATION SCHEME (1 HR, 3 HR, 5 HR DELAY WITH PROBABILITIES 0.3, 0.4, 0.3)
  - WASH 1400 EVACUATION SCHEME (0 HR DELAY, 1.2 MPH)
  - SEISMIC EVACUATION SCHEME (3 HR DELAY, 1 MPH)
- IN ADDITION, FOR VR AND VRH2O, THE SANDIA GENERIC EVACUATION SCHEME AND ITS COMPONENTS WERE USED WITH A 2.5 MPH EVACUATION SPEED

- FOR VRH2O, VR AND LOCA
    - MINIMAL MEDICAL TREATMENT
    - HEROIC MEDICAL TREATMENT
- IN EACH CASE, THE 6 EVACUATION VARIATIONS WERE USED
- OVERALL, 74 VARIATIONS ON VESSEL RUPTURE SOURCE TERMS JUST BY VARYING THE THREE MAJOR PARAMETERS
- IN ADDITION, THE PROPORTION OF VRH2O TO VR WAS VARIED
- SOME EXAMPLES ARE TABULATED IN SARA TABLE G-4 (FOR RANDOM REACTOR VESSEL FAILURE, 11 CASES) AND TABLE G-5 (SEISMIC REACTOR VESSEL FAILURE, 7 CASES).

PROBABILITY DISTRIBUTIONS ON CCDFs

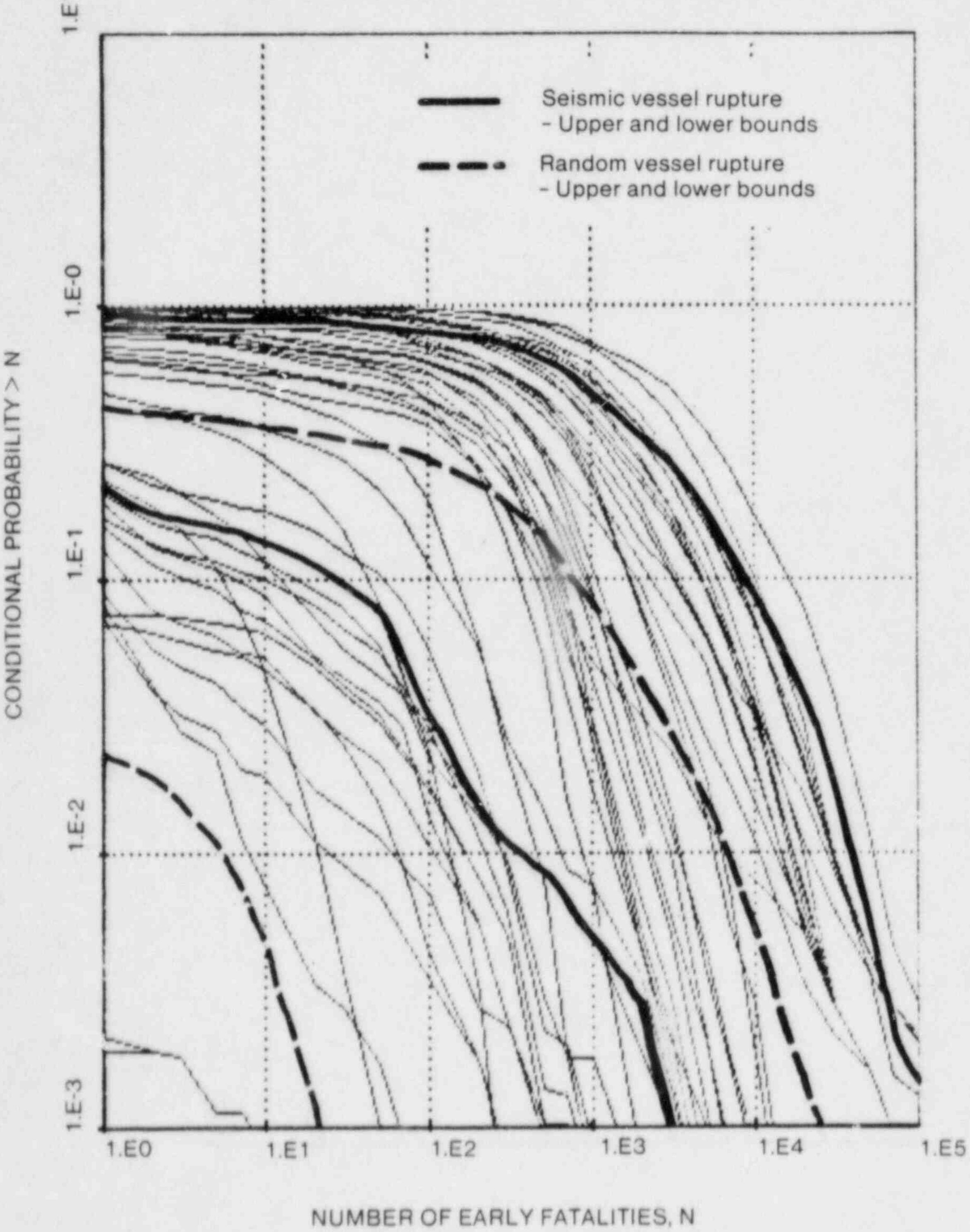
- DISTRIBUTIONS ON CCCDFs DETERMINED FROM SENSITIVITY STUDY RESULTS
- UPPER AND LOWER CURVE USED AS 95TH AND 5TH PERCENTILES OF A LOGNORMAL DISTRIBUTION AT FIXED CONSEQUENCE



EXAMPLE I

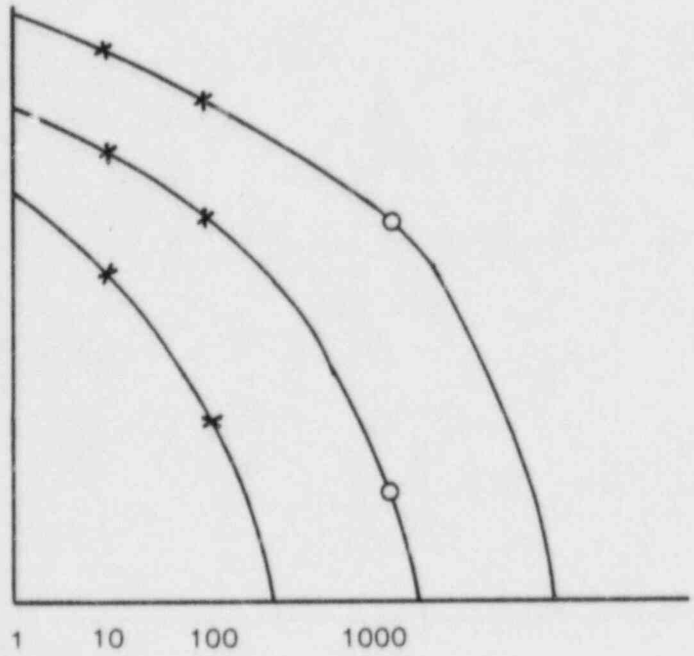
- SOURCE TERM FOR SEISMIC VESSEL FAILURE - A CONTRIBUTOR TO EARLY FATALITIES.
- UPPER ESTIMATE
  - — 50% TO VRH2O RATHER THAN 10%
  - — MINIMAL RATHER THAN SUPPORTIVE MEDICAL TREATMENT
- LOWER ESTIMATE
  - — SMALL SOURCE TERM (LIKE LARGE LOCA)
- ALL CASES USED EARTHQUAKE CONDITIONS FOR EVACUATION

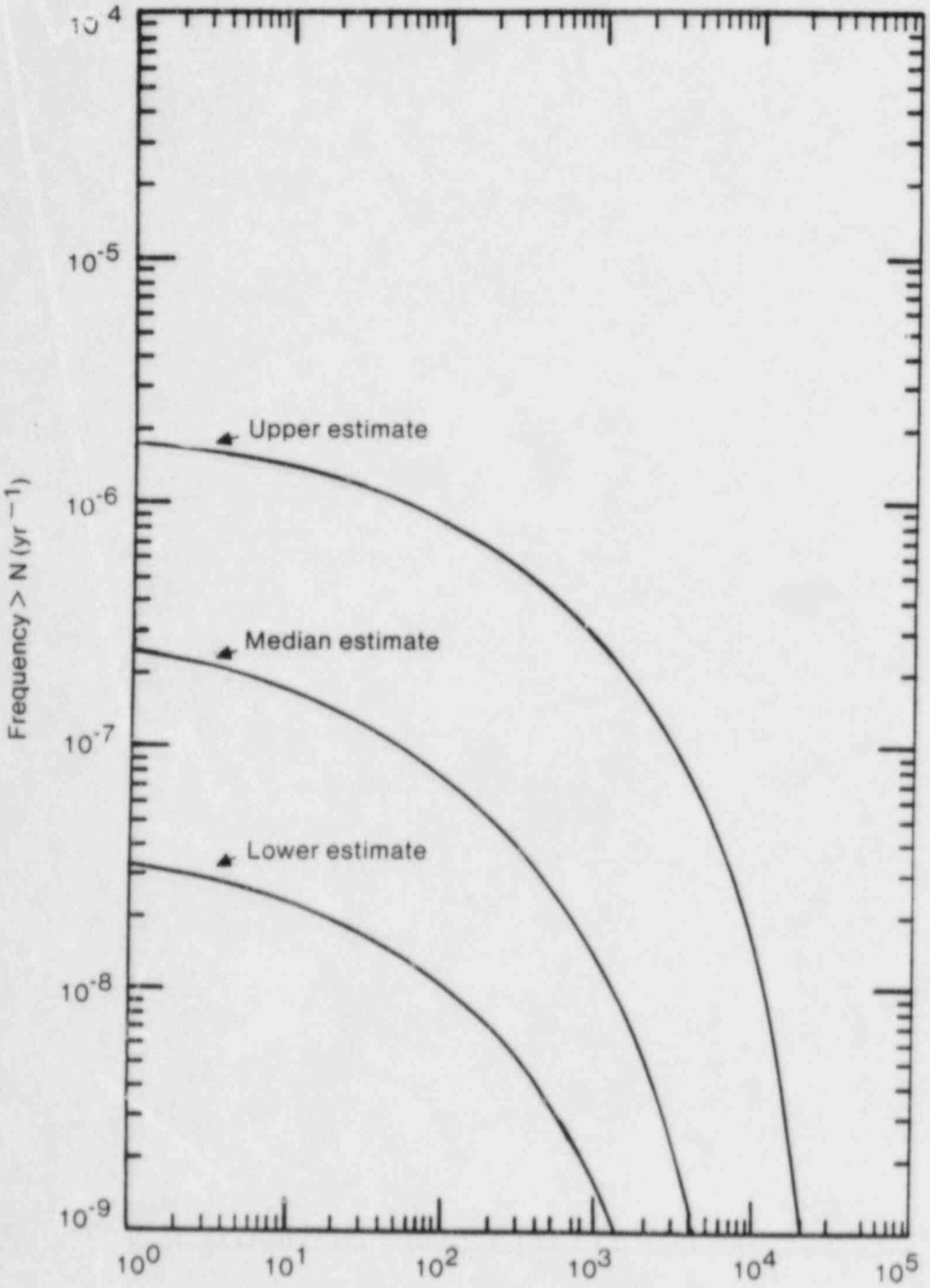
NUMBER OF EARLY FATALITIES FROM VARIOUS EVACUATIONS AND SOURCE TERMS



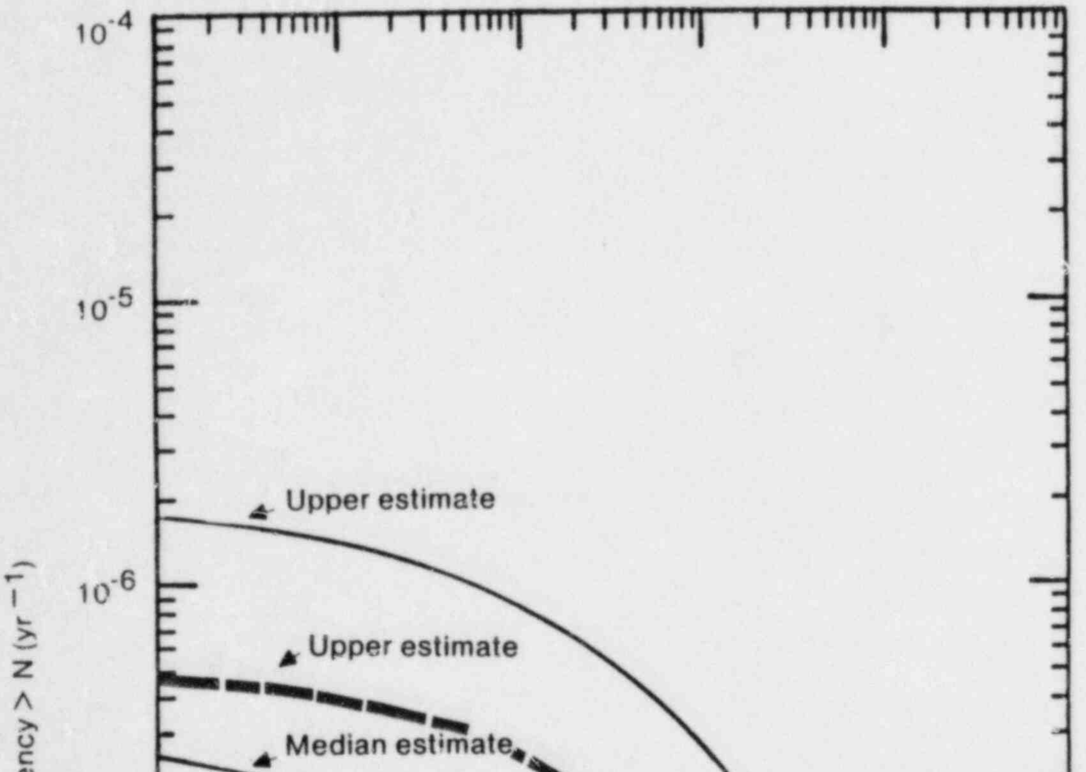
IMPLEMENTATION IN RISK EQUATION

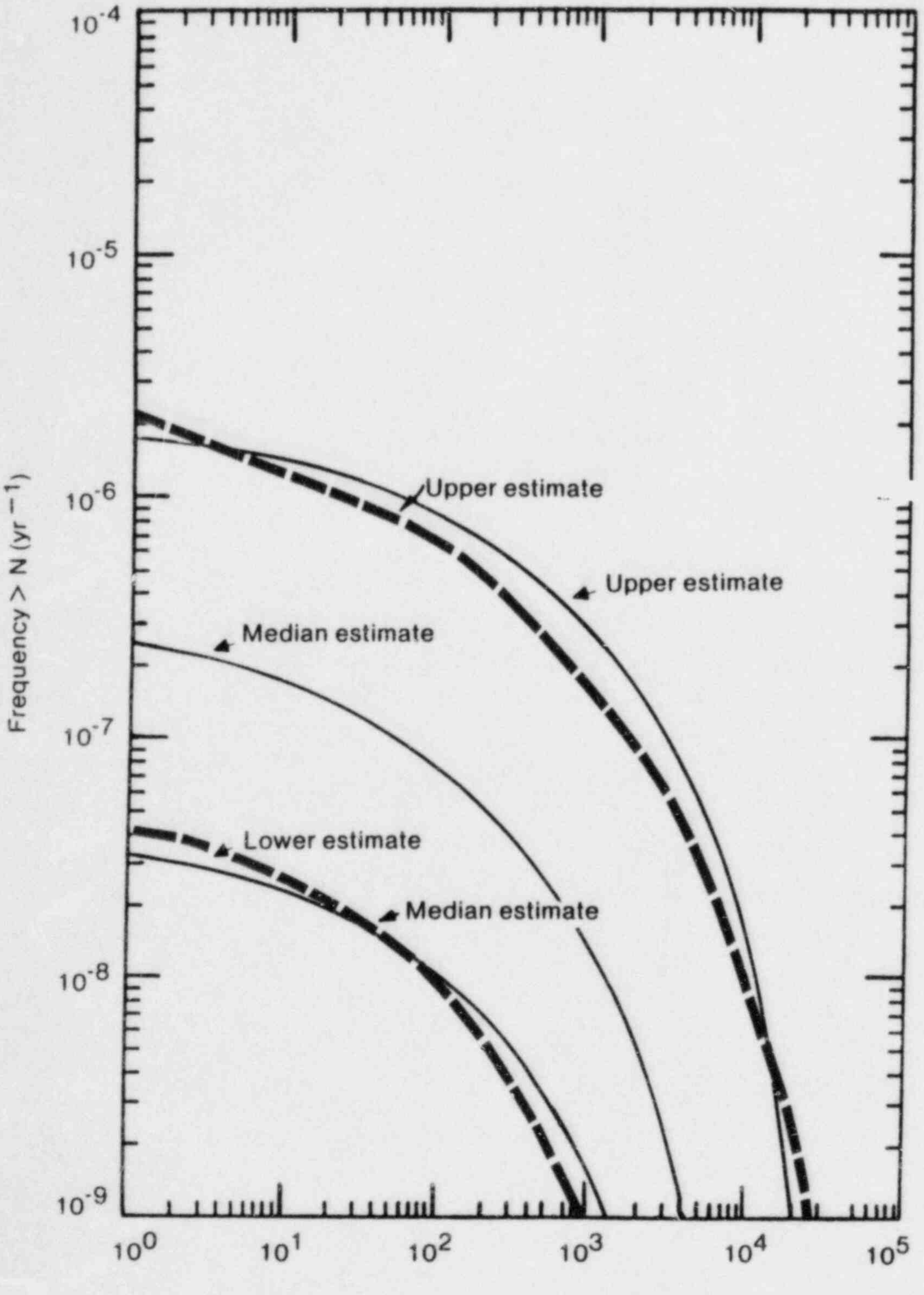
- SUBSTITUTE DISTRIBUTIONS FOR POINT ESTIMATES AND EVALUATE DISTRIBUTIONS ON CCDFs AT SEVERAL CONSEQUENCE VALUES



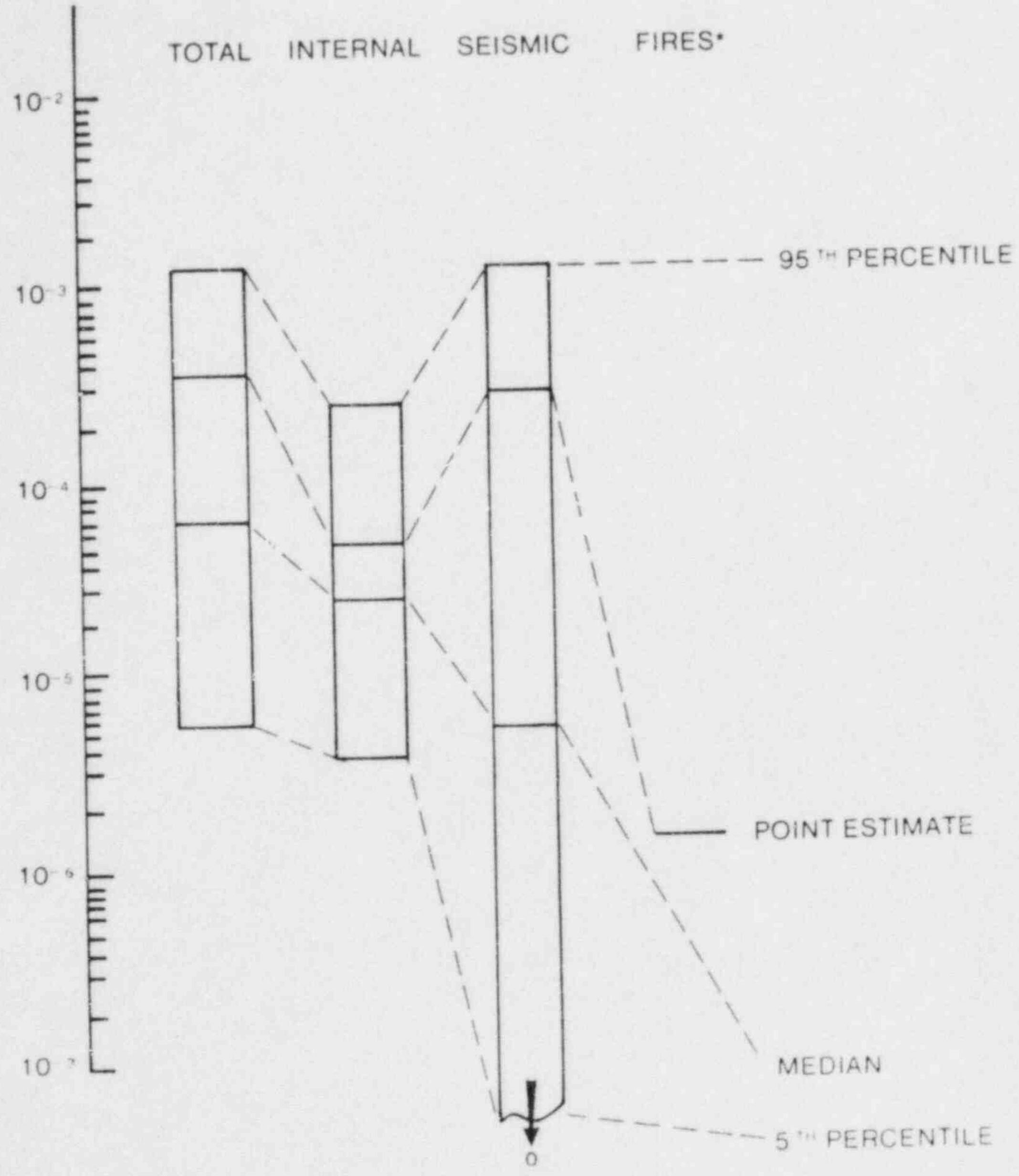


CCDFs for early fatalities from internal and external initiating events


10-4
10-5
10-6
10-7
10-8
10-9
Frequency > N (yr^{-1})
Upper estimate
Upper estimate
Median estimate
Median estimate
Lower estimate
Lower estimate
10^0
10^1
10^2
10^3
10^4
10^5

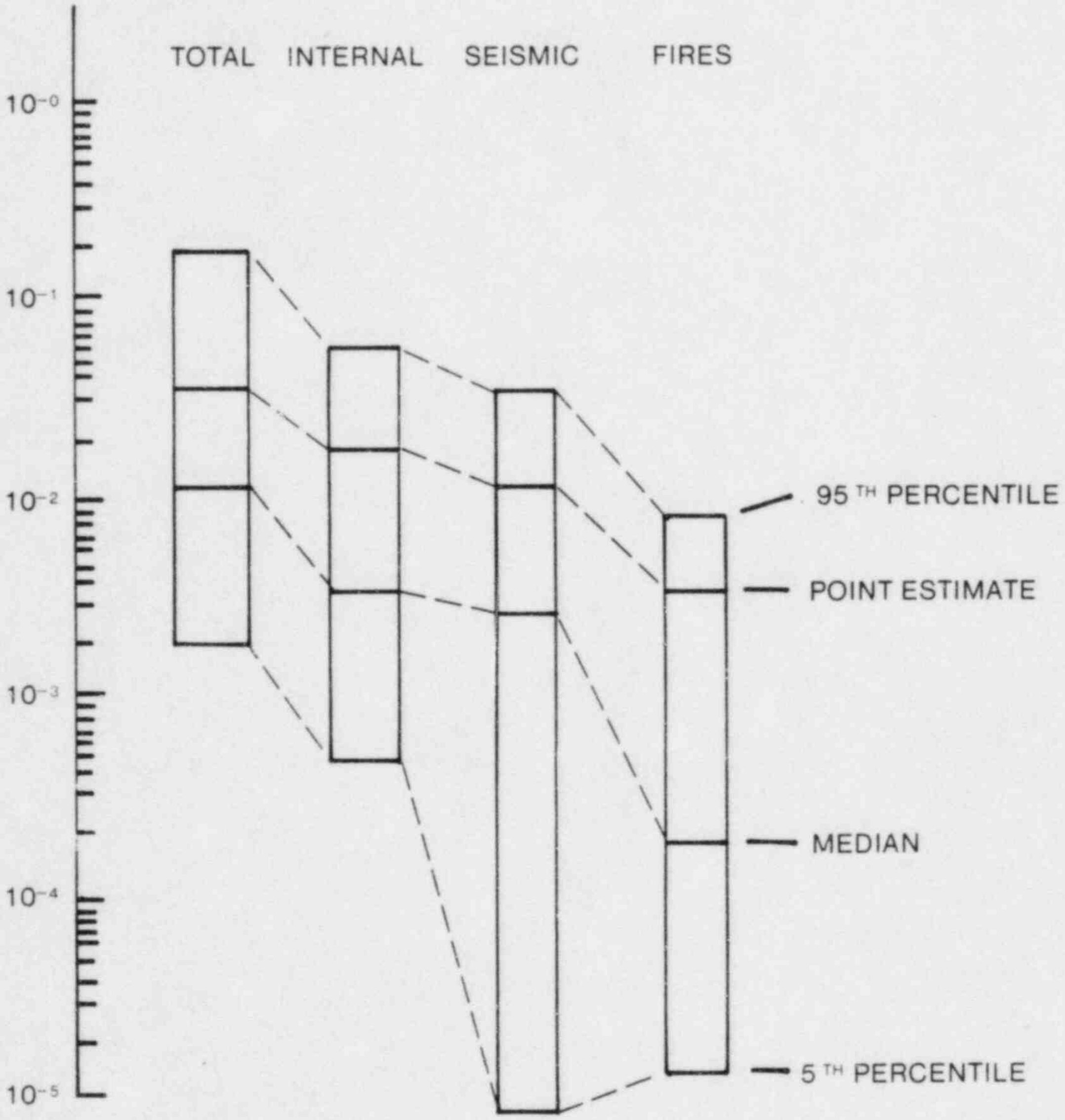

Frequency > N (yr^{-1})
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
Upper estimate
Upper estimate
Median estimate
Lower estimate
Median estimate

EARLY FATALITY RISK



* FIRES DO NOT CONTRIBUTE TO EARLY FATALITIES

LATENT FATALITY RISK



EXAMPLES OF CONSERVATISMS NOT INCLUDED IN UNCERTAINTY ANALYSIS

- NO CREDIT FOR CRD FLOW FOR INJECTION INTO VESSEL
- NO CREDIT FOR CONDENSATE PUMPS
- NO CREDIT FOR SERVICE WATER, FIRE PUMPS, FIRE TRUCKS AS INJECTION SOURCES
- SCRAM FAILURE ASSUMED TO BE ALWAYS COMPLETE FAILURE TO INSERT RODS
- CORE DAMAGE IS ASSUMED TO OCCUR AND TO LEAD TO CORE MELT WHEN SUCCESS CRITERIA ARE NOT MET.
- CORE DAMAGE ACCIDENTS ARE ALWAYS TAKEN TO FAIL CONTAINMENT.
- CONTAINMENT FAILURE ALWAYS LEADS TO CORE MELT IF NOT ALREADY MELTED

EXAMPLES OF CONSERVATISMS NOT INCLUDED IN UNCERTAINTY ANALYSIS (CONTINUED)

- NO CREDIT FOR ADS ON LOW LEVEL ONLY
- NO CREDIT FOR VENTING OF CONTAINMENT
- NO CREDIT IS TAKEN FOR PLATEOUT IN THE REACTOR BUILDING.
- NO CREDIT FOR "HEROIC" OPERATOR ACTIONS

EXAMPLES OF POTENTIAL NON-CONSERVATISMS

- MISSING ACCIDENT SEQUENCES
- MISSING DEPENDENT FAILURES
- NON-PROCEDURAL OPERATOR INTERVENTION ERRORS
- SABOTAGE

PROBABILITY DISTRIBUTIONS ON INPUT PARAMETERS TO SYSTEM ANALYSIS

- INITIATING EVENT FREQUENCIES

  T_T, T_F, T_M - DERIVED ON THE BASIS OF PLANT-TO-PLANT VARIATIONS (EPRI NP 2230, ALO-79)

  T_I, A, S_1, S_2 - JUDGMENTAL SINCE NOT IMPORTANT CONTRIBUTORS

  T_E - STATISTICAL, BASED ON PJM DATA USED IN LGS PRA

  SEISMIC INITIATING EVENT FREQUENCY EXPRESSED AS A PROBABILITY DISTRIBUTION ON THE FREQUENCY OF EXCEEDING A GIVEN ACCELERATION LEVEL

PROBABILITY DISTRIBUTIONS ON INPUT PARAMETERS TO SYSTEMS ANALYSIS

- COMPONENT FAILURE RATES (RANDOM), HUMAN ERROR PROBABILITIES, MAINTENANCE UNAVAILABILITY,
  - — LOGNORMAL DISTRIBUTIONS
  - — ORIGINAL PRA POINT ESTIMATES USED AS MEANS OF THE DISTRIBUTION, ERROR FACTOR OF 3 OR 10
- COMPONENT AND STRUCTURAL FAILURE RATES (SEISMIC)
  - — DERIVED FROM THE FRAGILITY ANALYSIS WHICH SPECIFICALLY ADDRESSES THE UNCERTAINTIES

SUMMARY

- UNCERTAINTY ON ACCIDENT SEQUENCE FREQUENCIES
  - PARAMETER VALUE UNCERTAINTIES ONLY
  - EXCEPTION: SEISMIC HAZARD CURVES - SIX PREDICTIVE MODES REPRESENTING A LARGE UNCERTAINTY IN FREQUENCY.
  - POTENTIAL CONSERVATISM OR NON-CONSERVATISMS NOT ADDRESSED

- UNCERTAINTY IN CONSEQUENCES BASED ON SENSITIVITY STUDIES
  - SOURCE TERM MAGNITUDE
  - EVACUATION PARAMETERS
  - MEDICAL TREATMENT

SEISMIC DESIGN AND MARGIN

R.P. KENNEDY
E. R. SCHMIDT

LIMERICK GENERATING STATION
SEISMIC MARGIN REVIEW

- USING SEISMIC PRA TECHNIQUES, QUANTIFY THE CAPABILITY OF LGS TO WITHSTAND SEISMIC EVENTS ABOVE THE SSE

  - HIGH CONFIDENCE OF LOW PROBABILITY OF FAILURE OF STRUCTURE AND EQUIPMENT

  - HIGH CONFIDENCE OF LOW PROBABILITY OF CORE DAMAGE AND ACTIVITY RELEASE

  - SMALL CONTRIBUTION TO SEISMIC CORE DAMAGE AND PUBLIC RISK

LGS SEISMIC DESIGN BASIS

- 0.15 g SSE
- SPECTRA DEVELOPED SPECIFICALLY FOR LIMERICK PLANT (PLANT DOCKETED FOR CONSTRUCTION PERMIT REVIEW IN MARCH, 1970, THREE YEARS BEFORE REG. GUIDE 1.60 WAS ISSUED)
- DAMPING 5% FOR REINFORCED CONCRETE STRUCTURES
- ABSOLUTE SUM MODAL COMBINATION
- CODE ALLOWABLE MATERIAL STRENGTHS
- LOAD COMBINATION INCLUDE LOCA + SSE

LIMERICK GENERATING STATION
SEISMIC DESIGN CONSERVATISMS

- STRUCTURAL DESIGN USED LOW DAMPING VALUE
- IN DESIGN OF CATEGORY 1 STRUCTURES L.G.S. USES A RESPONSE SPECTRUM TECHNIQUE WITH ABSOLUTE SUM COMBINATION OF ALL MODAL RESPONSES UP TO 33 HZ. WHEREAS REG. GUIDE 1.92, WHERE MODES ARE NOT CLOSELY SPACED, COMBINES MODAL RESPONSES BY SQUARE ROOT OF THE SUM OF THE SQUARES.
- STEEL DESIGN BASED UPON GUARANTEED MINIMUM YIELD STRESS OF STEEL.
- TESTS SHOW ACTUAL YIELD STRENGTHS GREATER THAN SPECIFIED
- DESIGN AND QUALIFICATION OF CATEGORY I SYSTEMS AND COMPONENTS BASED UPON STRUCTURAL DAMPING OF 5%.
  REG. GUIDE 1.61 RECOMMENDS STRUCTURAL DAMPING OF 7%.
- ANALYSIS OR PIPING SYSTEMS AND SUPPORTS IS BASED UPON LOWER DAMPING VALUES THAN RECOMMENDED IN REG. GUIDE 1.61.

SEISMIC FRAGILITY METHODOLOGY

- METHODOLOGY CONSISTENT WITH ACCEPTED TECHNIQUES (NUREG/CR-2300)
- METHODOLOGY USED IN 5 PRAs WHICH HAVE UNDERGONE EXTENSIVE NRC REVIEW
- APPROXIMATELY 20 TECHNICAL PAPERS PRESENTED TO DATE AT TECHNICAL MEETINGS, NRC WORKSHOPS, AND IN TECHNICAL JOURNALS

LGS SEISMIC PRA

- LGS SITE-SPECIFIC FRAGILITIES DEVELOPED, SUPPLEMENTED BY GENERIC DATA
- PEER REVIEW CONDUCTED BY NRC STAFF, BROOKHAVEN, AND J.R. BENJAMIN AND ASSOCIATES
- LGS FRAGILITIES UPDATED TO REFLECT CURRENT SEISMIC QUALIFICATION INFORMATION
- SENSITIVITY STUDIES CONDUCTED TO EVALUATE AREAS OF UNCERTAINTY (INCLUDING REVIEW COMMENTS)

EVALUATION OF SEISMIC GROUND ACCELERATION CAPACITY

STRUCTURE: REACTOR ENCLOSURE AND CONTROL STRUCTURE

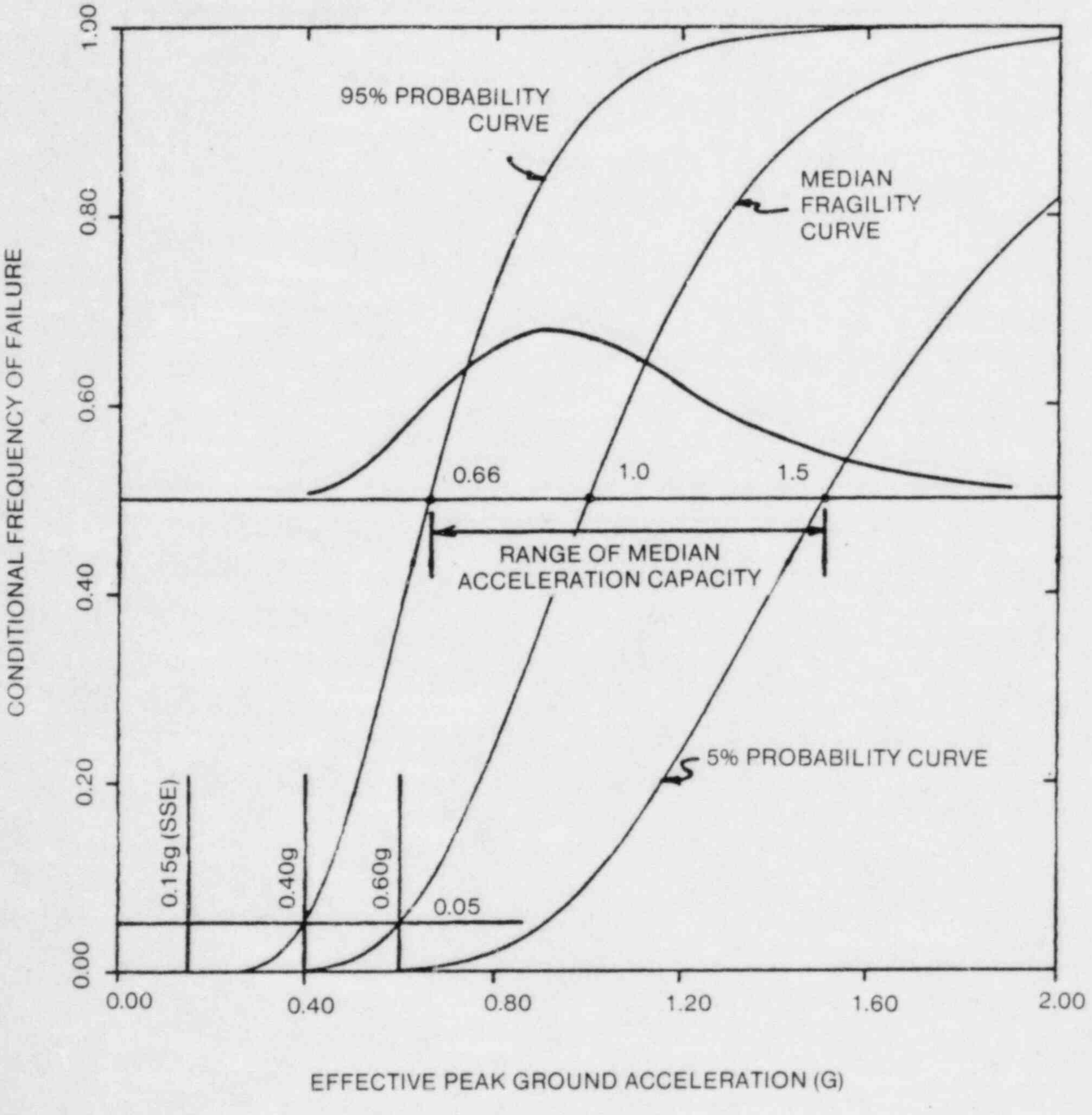
FAILURE MODE: FLEXURAL FAILURE OF SHEAR WALLS

ITEM	MEDIAN F.S	β_R	β_U	β_C
STRENGTH	1.58	0.13	0.15	0.20
INELASTIC ENERGY ABSORPTION	1.86	0.11	0.13	0.17
DURATION	1.4	0.12	0.08	0.14
SPECTRAL SHAPE	1.65	0.20	0	0.20
DAMPING	1.0	0.12	0.06	0.14
MODELING	1.0	0	0.10	0.10
MODAL COMBINATION	1.0	0.01	0	0.01
COMBINATION OF EARTHQUAKE COMPONENTS	0.98	0.02	0	0.02
SOIL-STRUCTURE INTERACTION	1.0	0	0.05	0.05
TOTAL	6.65	0.31	0.25	0.40

MEDIAN ACCELERATION CAPACITY = 6.65 (0.15g) = 1.0g

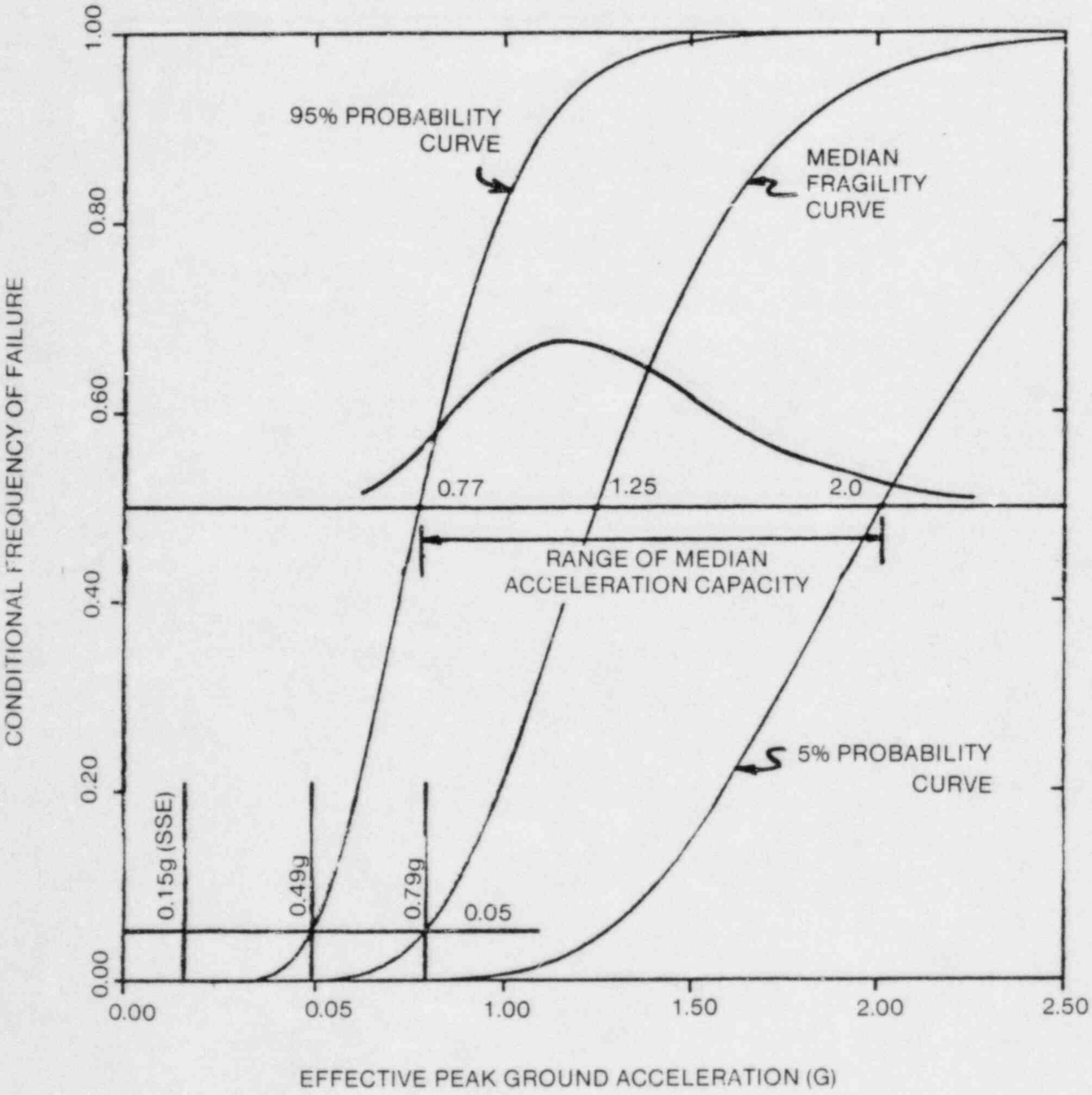
FRAGILITY CURVES FOR REACTOR ENCLOSURE AND CONTROL STRUCTURE

($\check{A}$ = 1.0G, β_R = 0.31, β_U = 0.25)



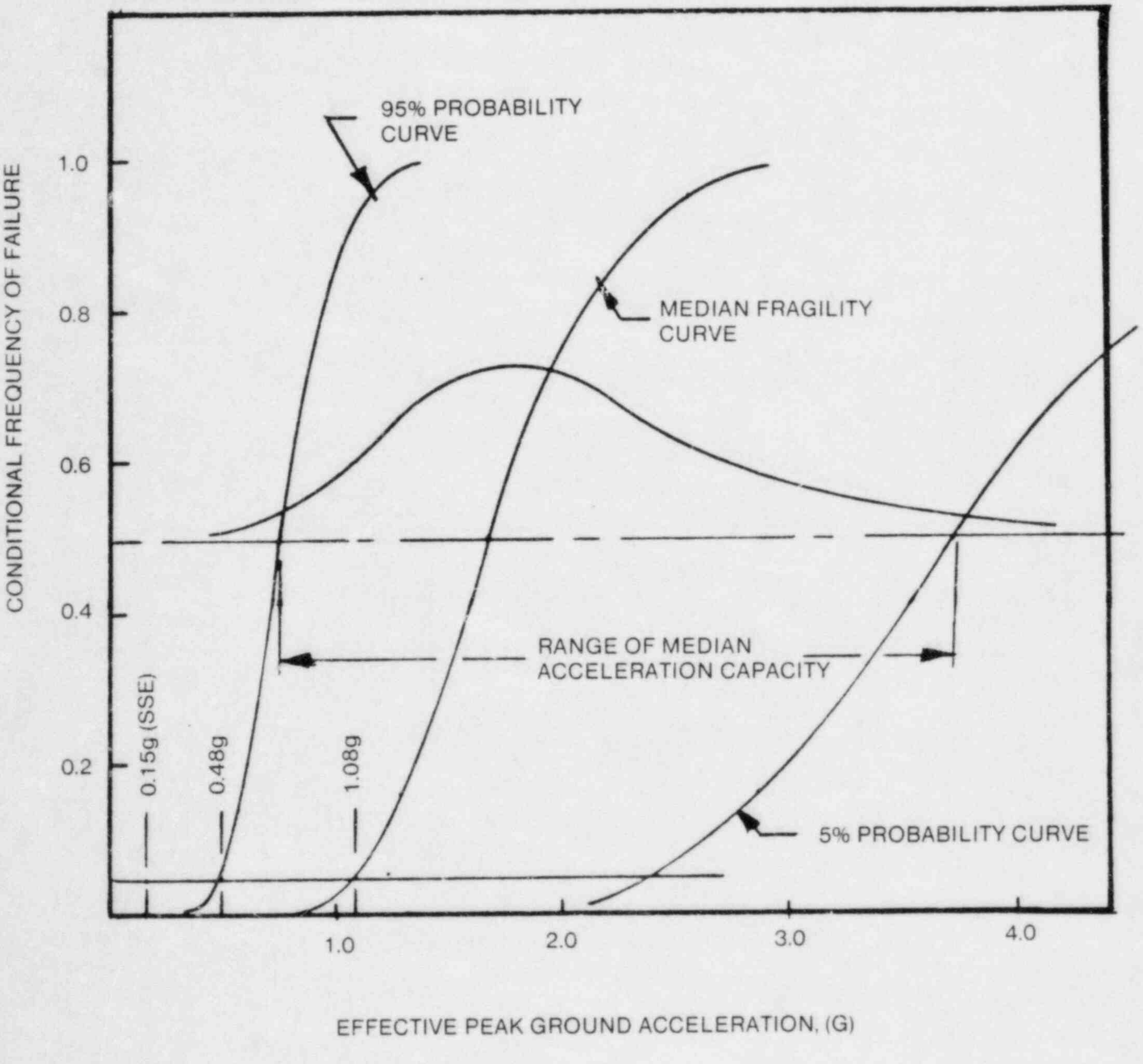
FRAGILITY CURVES FOR REACTOR PRESSURE VESSEL

($\check{A} = 1.25G, \beta_R = 0.28, \beta_U = 0.29$)



FRAGILITY CURVES FOR 4160/480 V TRANSFORMER

($\check{A} = 1.66G, \beta_R = 0.26, \beta_U = 0.49$)



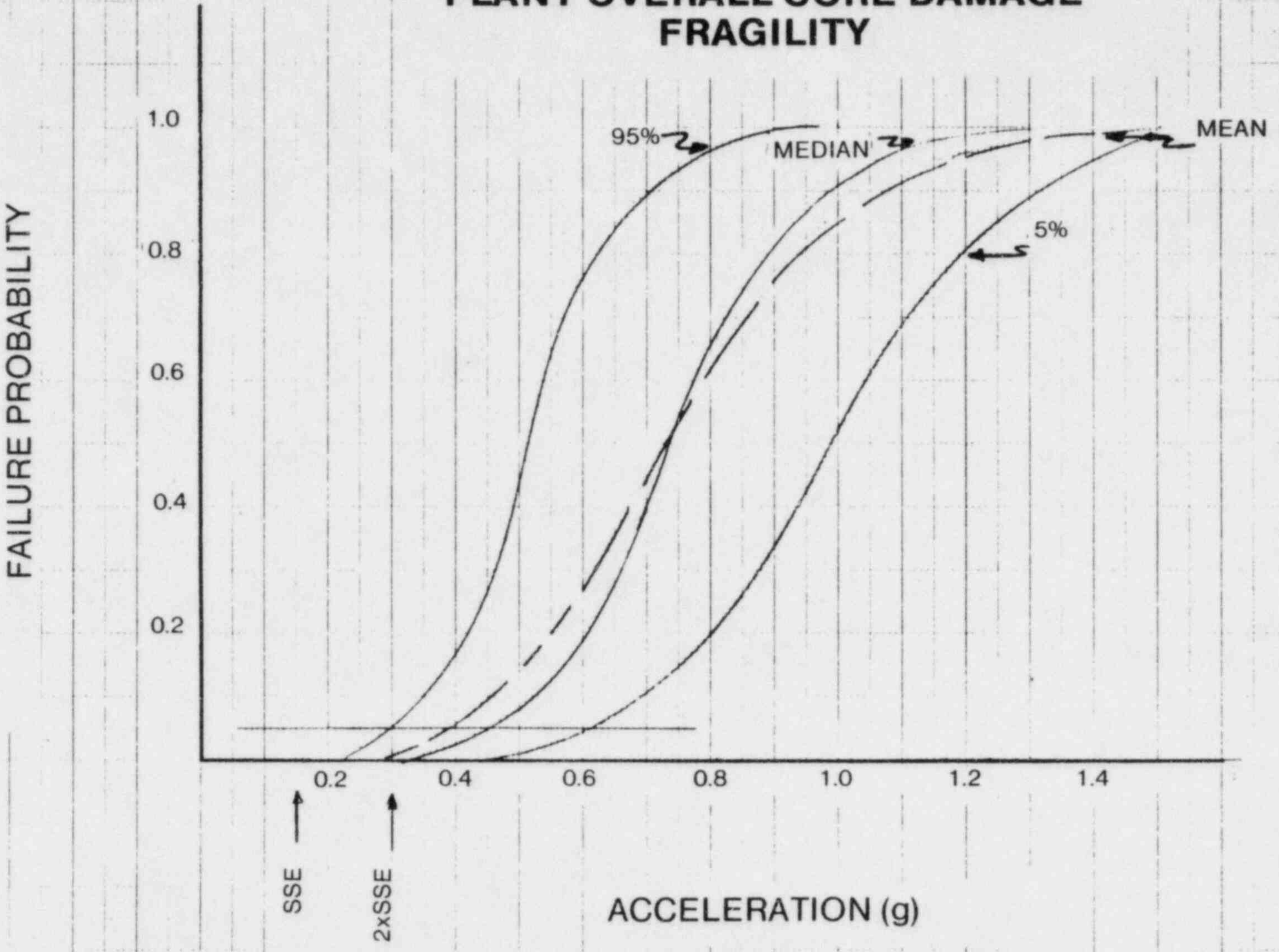
MEDIAN AND LOWER BOUND CAPACITIES FOR SIGNIFICANT CONTRIBUTORS TO EARTHQUAKE INDUCED RISK FOR LGS

COMPONENT	MEDIAN SEISMIC CAPACITY G's	90% CONFIDENCE BOUNDS G's	HIGH CONFIDENCE LOW PROBABILITY OF FUNCTIONAL FAILURE, G's
STRUCTURES			
REACTOR ENCLOSURE AND CONTROL STRUCTURE	1.0	0.66-1.51	0.40
PASSIVE EQUIPMENT			
REACTOR INTERNALS	0.67	0.40-1.14	0.25
CRD GUIDE TUBE	1.37	0.77-2.44	0.48
REACTOR PRESSURE VESSEL SUPPORTS	1.25	0.77-2.02	0.49
SLC TANK	1.33	0.97-1.82	0.62
DIESEL GENERATOR H & V DUCTING	1.55	0.76-3.15	0.48
RHR HEAT EXCHANGER	1.44	0.68-3.02	0.41

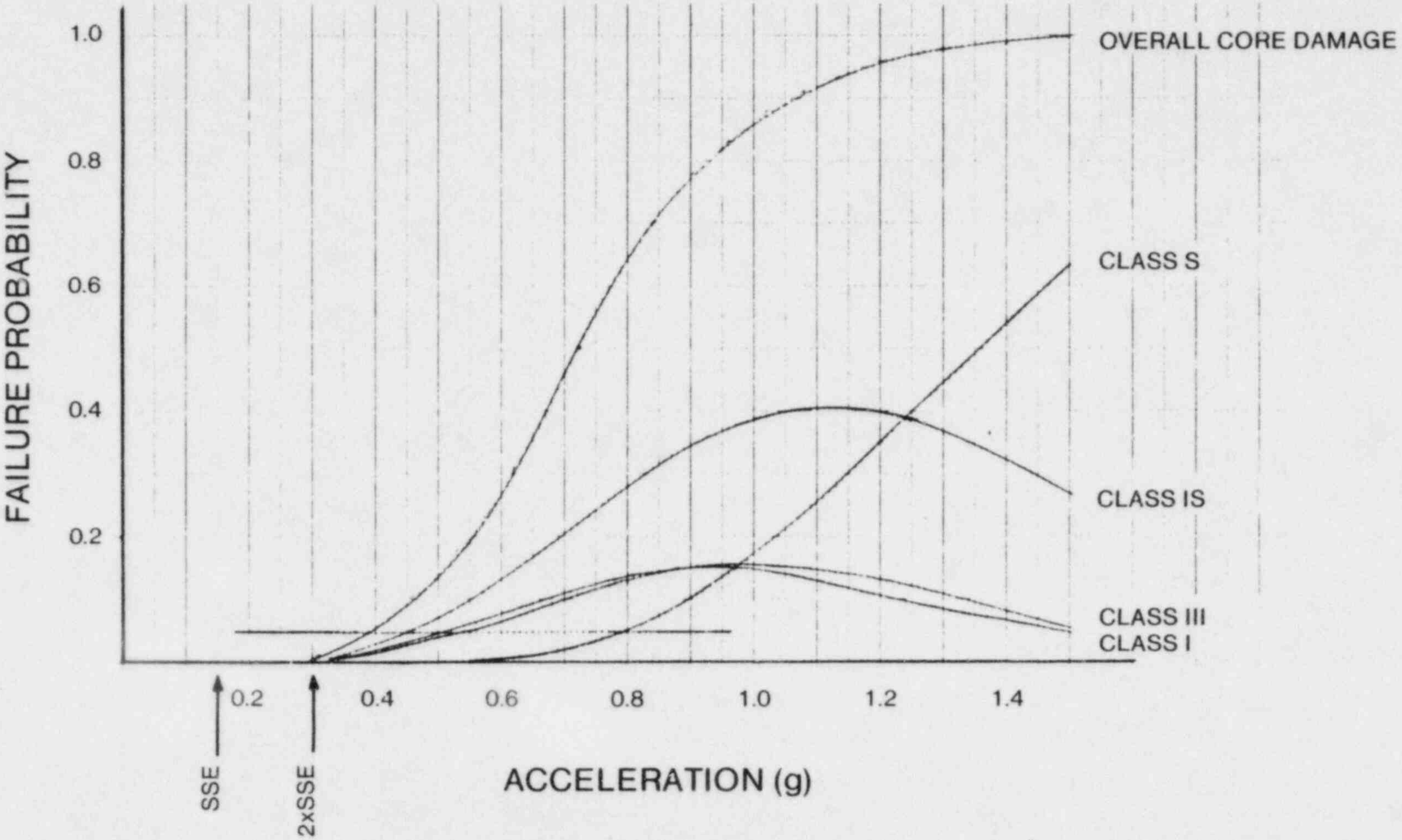
MEDIAN AND LOWER BOUND CAPACITIES FOR SIGNIFICANT CONTRIBUTORS TO EARTHQUAKE INDUCED RISK FOR LGS

	RECOVERABLE FUNCTIONAL FAILURE (CHATTER/TRIP)			NON-RECOVERABLE FUNCTIONAL FAILURE		
ELECTRICAL AND ACTIVE EQUIPMENT	MEDIAN SEISMIC CAPACITY G'S	90% CONFIDENCE BOUNDS G'S	HIGH CONF., LOW PROB. OF FAILURE G'S	MEDIAN SEISMIC CAPACITY G'S	90% CONFIDENCE BOUNDS G'S	HIGH CONF., LOW PROB. OF FAILURE G'S
HYDRAULIC CONTROL UNITS	NA	NA	NA	1.24	0.53-2.92	0.29
4160V SWITCHGEAR	1.33	0.71-2.49	0.40	2.6	1.30-5.20	0.73
480V SWITCHGEAR	1.50	0.72-3.10	0.41	3.95	1.54-10.1	0.86
250V DC MCC	0.83	0.41-1.69	0.27	4.3	1.19-15.6	0.77
4160-480V TRANSFORMER	NA	NA	NA	1.66	0.74-3.72	0.48
125V DC DISTRIBUTION PANEL	1.01	0.64-1.60	0.36	4.43	1.31-15.0	0.73
125V DC FUSE BOX	1.01	0.64-1.60	0.36	4.43	1.31-15.0	0.73

PLANT OVERALL CORE DAMAGE FRAGILITY



MEAN FRAGILITY CURVES FOR OVERALL CORE DAMAGE AND CLASSES



CLASS I

CORE MELT WITH DELAYED CONTAINMENT FAILURE

- DOMINATED BY $T_S E_S UX$
- $T_S E_S UX$ — SEISMIC LOOP WITH FAILURE TO MAKE UP
- FRAGILITY GIVEN BY

  — FAILURE OF CERAMIC INSULATORS

  AND

  — FAILURE OF AC

  OR

  — FAILURE OF DC

  OR

  — FAILURE OF DIESEL GENERATOR HVAC

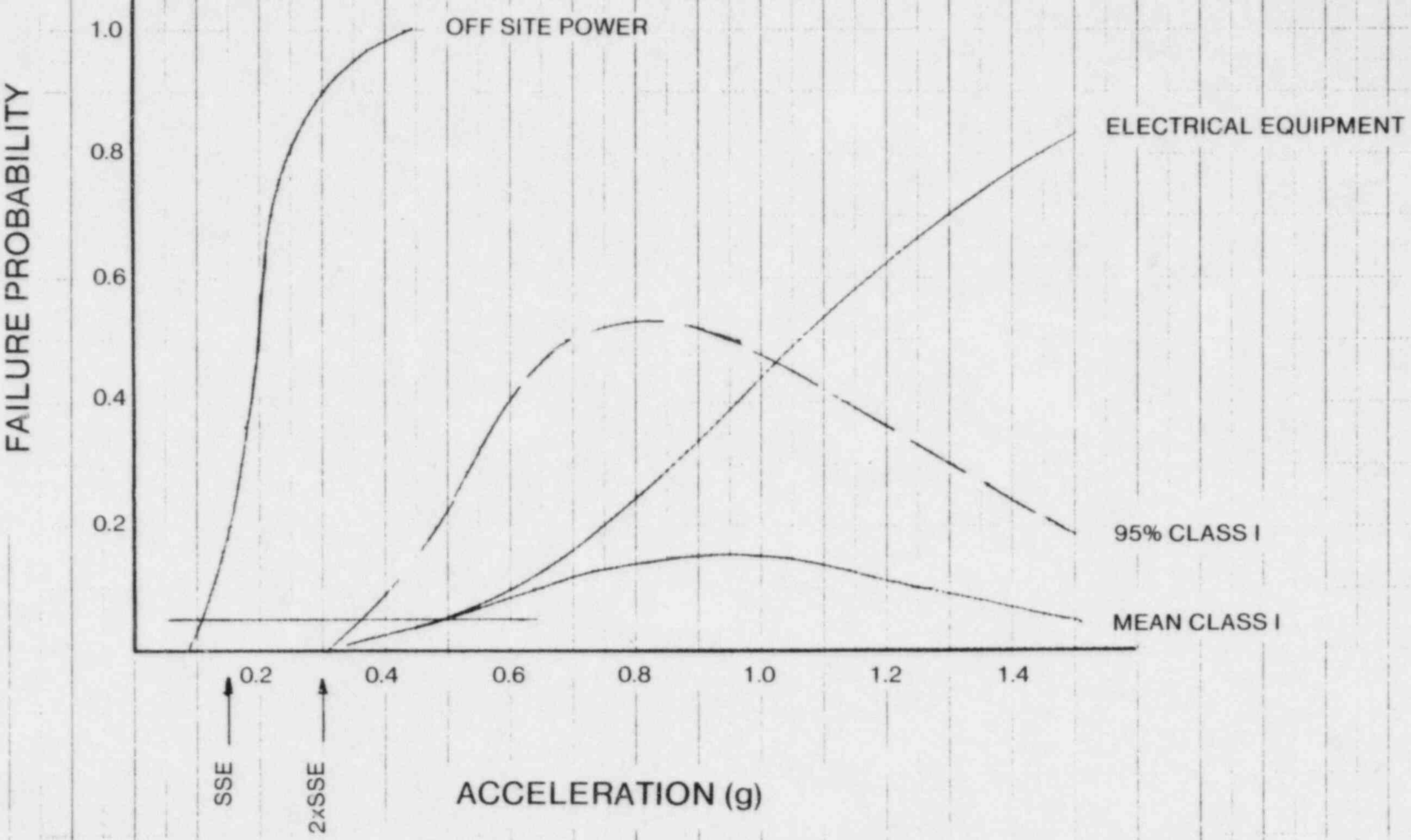
  OR

  — RANDOM COMMON CAUSE FAILURE OF DIESEL GENERATOR

  AND

  — NOT RPV, R_B, C_M

FRAGILITY CURVES
CLASS I



CLASS IS

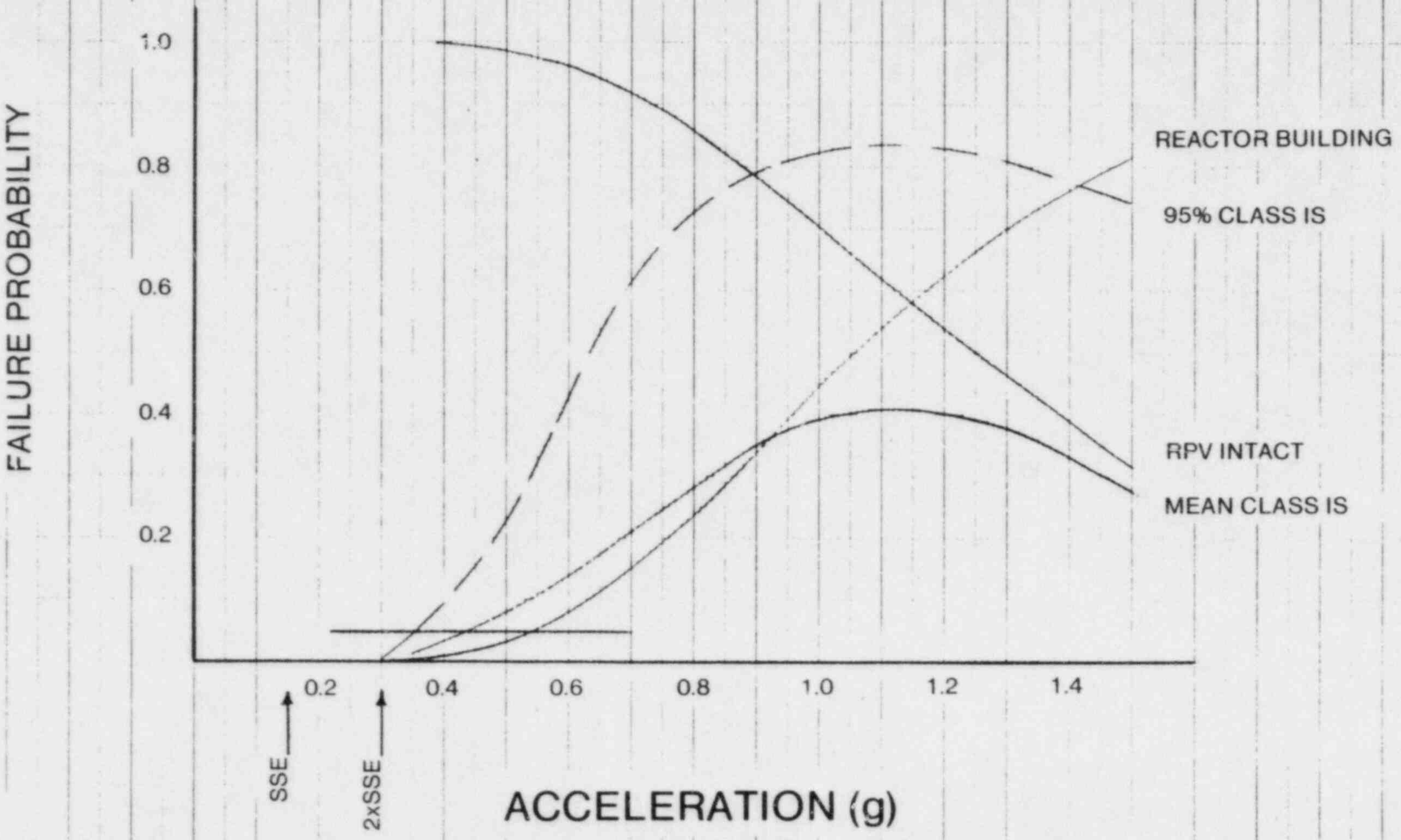
CORE MELT IN INTACT VESSEL
WITH EARLY CONTAINMENT FAILURE

- DOMINATED BY $T_S R_B$
- FRAGILITY GIVEN BY
  - REACTOR AND CONTROL BUILDING FAILURE (R_B)

    AND

  - NOT RPV

FRAGILITY CURVES
CLASS IS



CLASS S

VESSEL FAILURE WITH EARLY CONTAINMENT FAILURE

- CONTRIBUTORS

— T_SRPV Γ	RPV AND CONTAINMENT DIAPHRAM FAILURE
— T_SRPV R_B	RPV AND REACTOR BUILDING FAILURE
— T_SRPV H_E	RPV AND RHR HEAT EXCHANGER SUPPORT FAILURE

- FRAGILITY GIVEN BY:

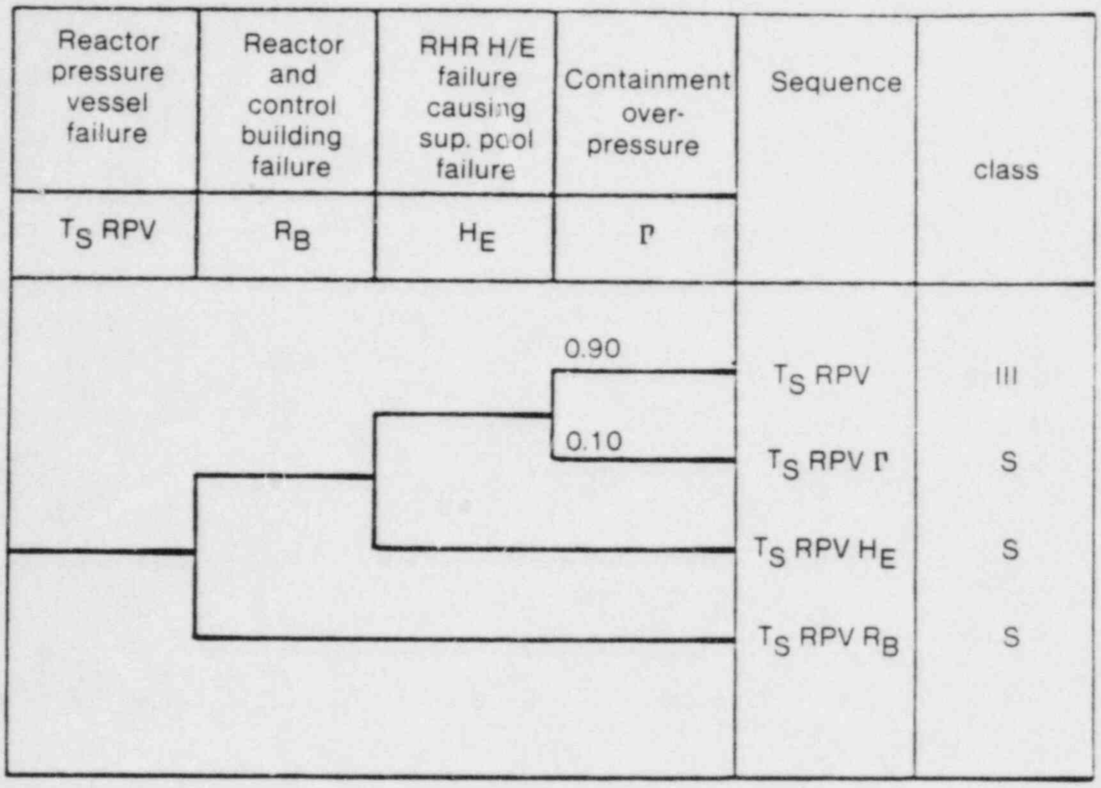
$$\text{RPV}\ \overline{R}_B\ \ \overline{H}_E\ \Gamma$$

OR

$$\text{RPV}\ \overline{R}_B\ \ H_E$$

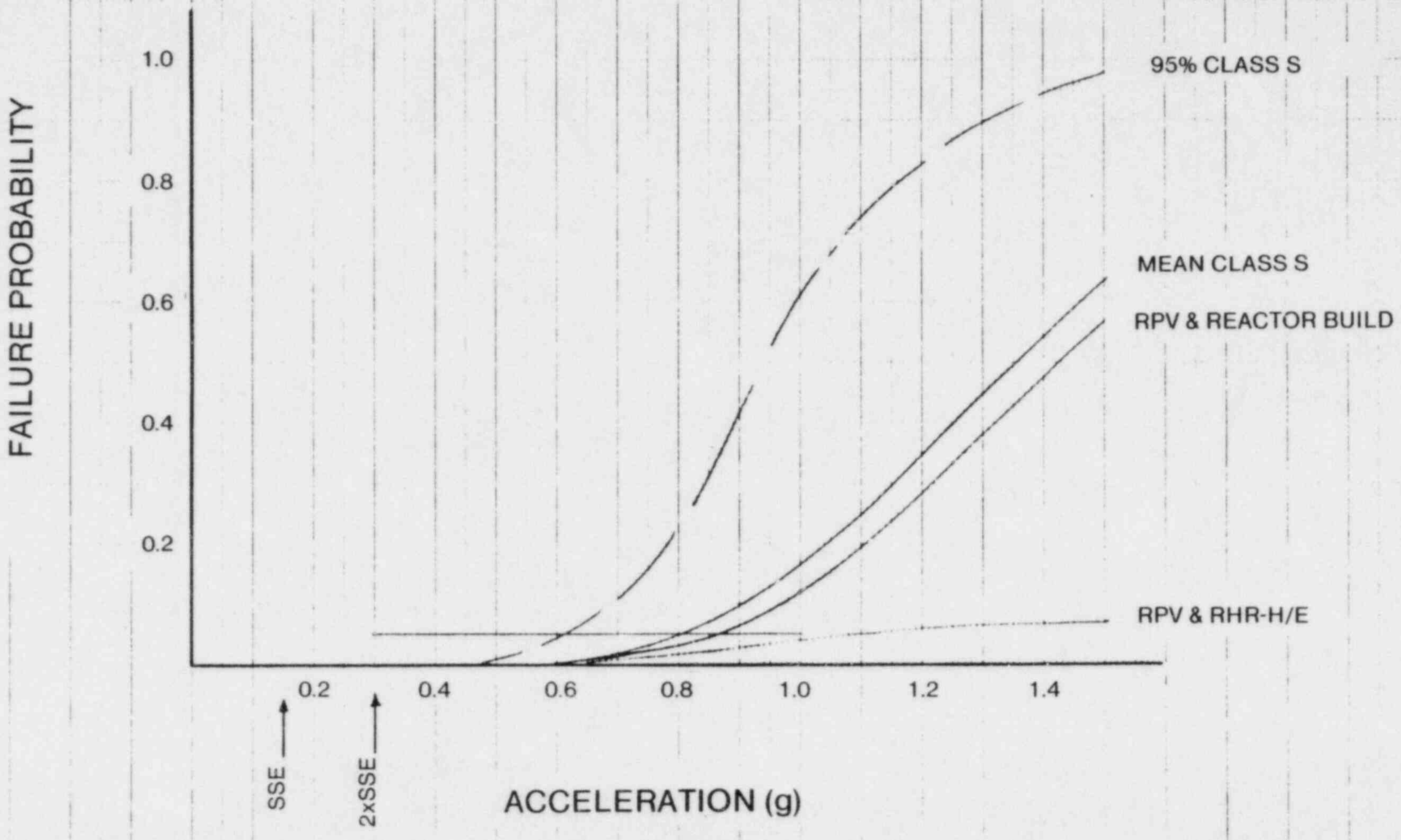
OR

$$\text{RPV}\ R_B$$

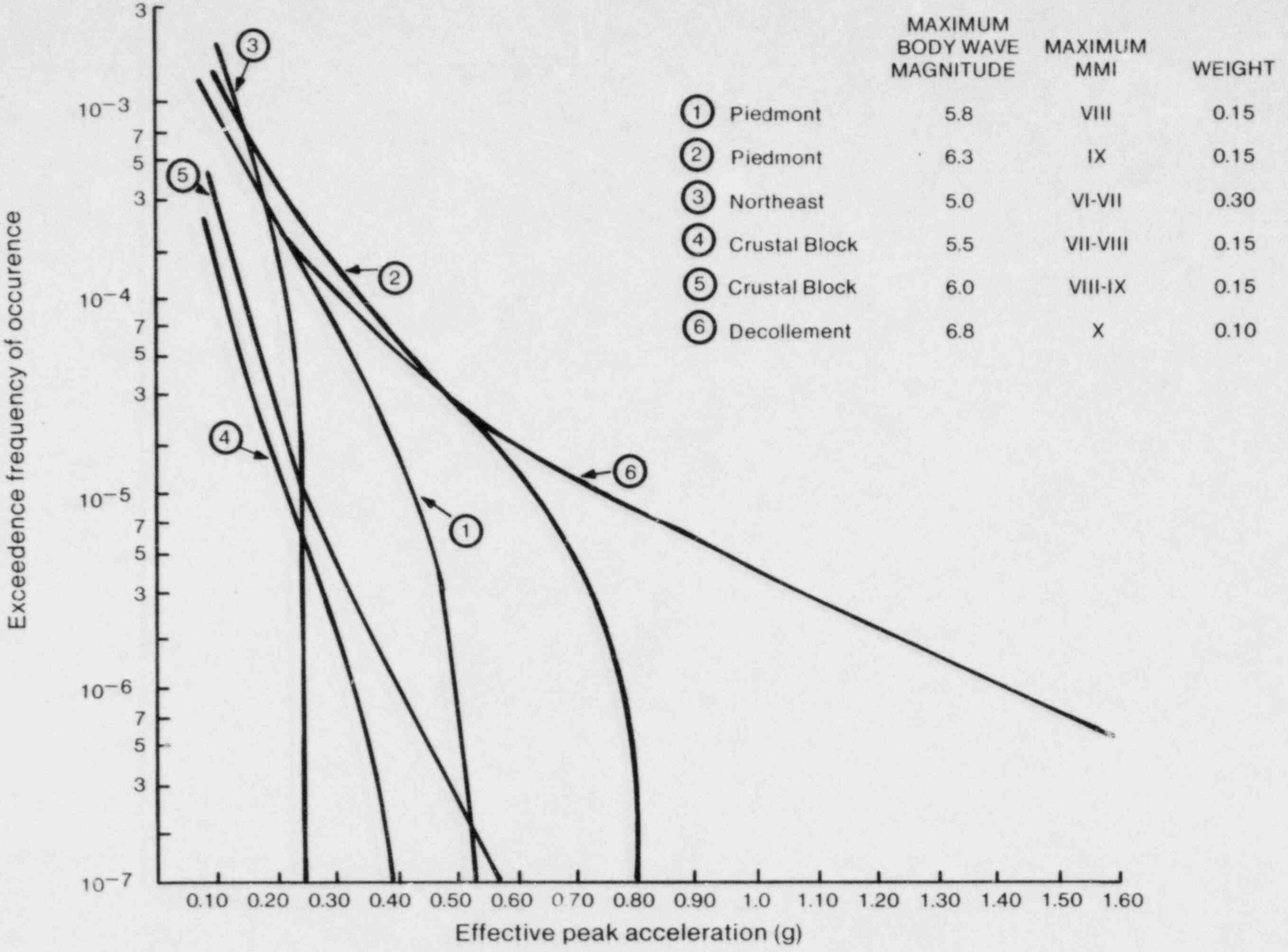


Containment event tree for class S (T_S RPV) sequences

FRAGILITY CURVES
CLASS S

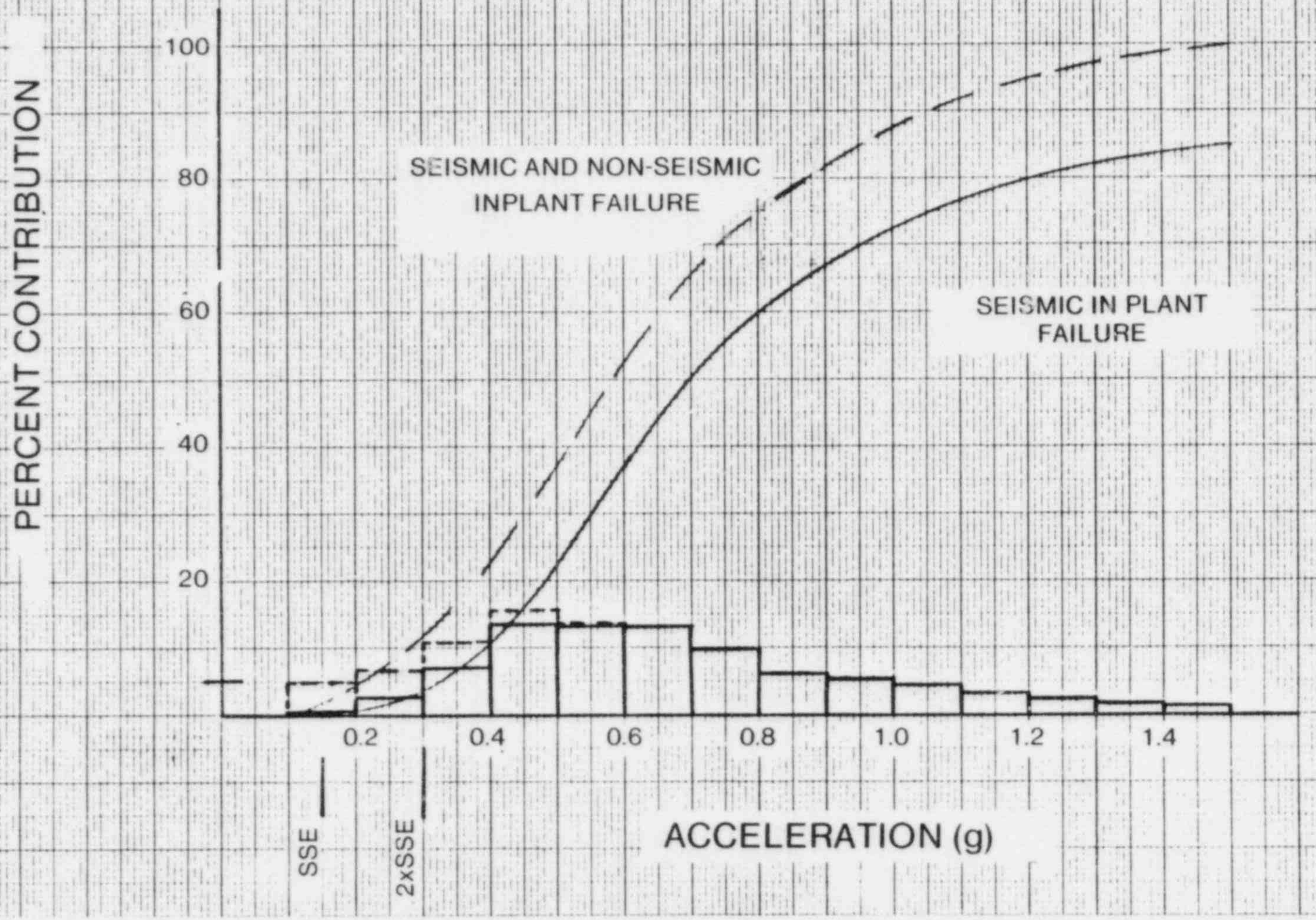


	HIGH CONFIDENCE LOW PROBABILITY OF FAILURE AT
CORE DAMAGE	0.30g
CLASS I — LOSS OF MAKE UP IN INTACT CONTAINMENT	0.38g
CLASS IS — LOSS OF MAKE UP IN FAILED CONTAINMENT	0.36g
CLASS S — VESSEL FAILURE WITH EARLY CONTAINMENT FAILURE	0.60g

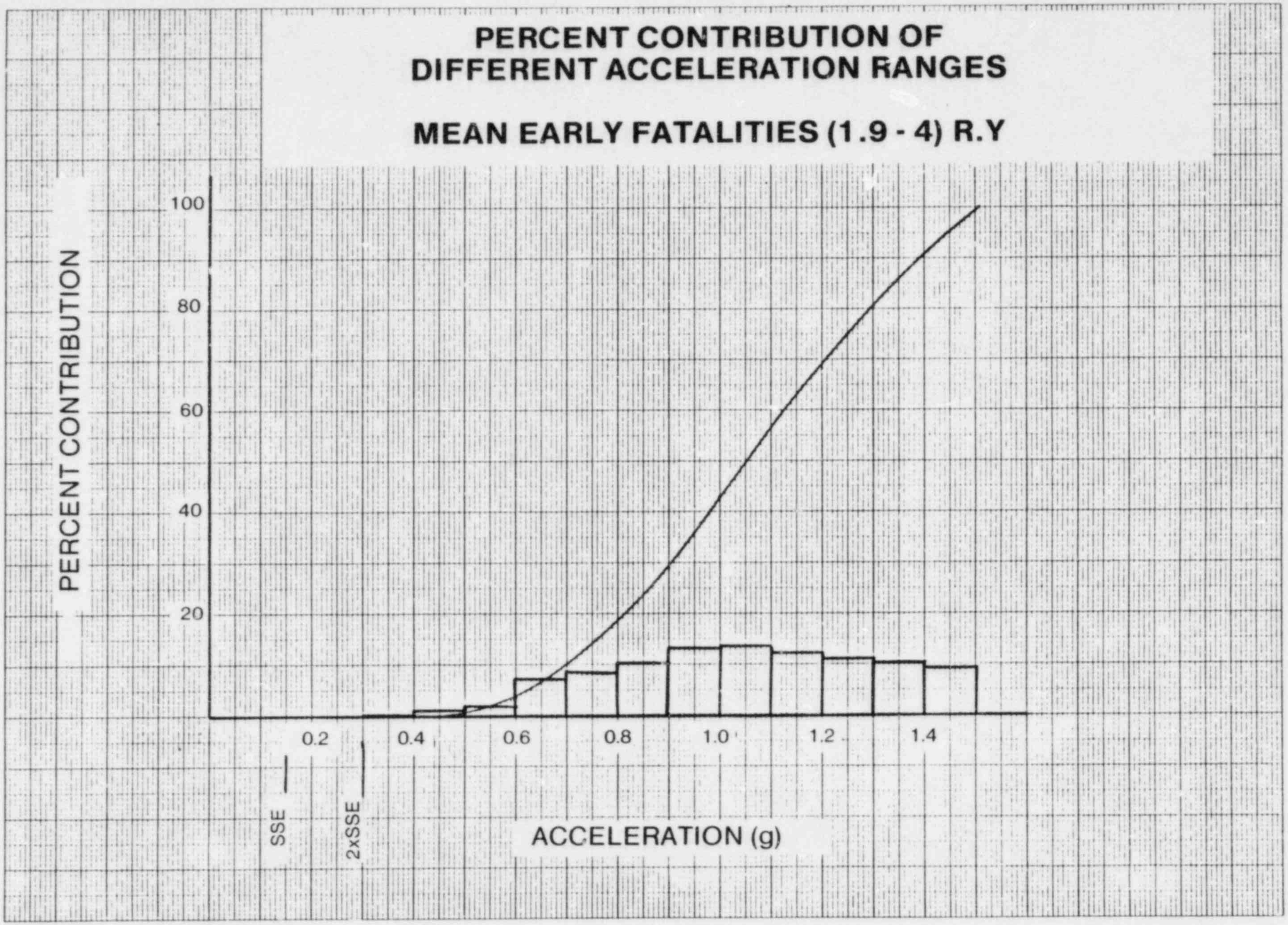


Annual frequency of exceedence versus peak acceleration for all seismogenic zones.

PERCENT CONTRIBUTION OF DIFFERENT ACCELERATION RANGES
OVERALL SEISMIC CORE DAMAGE (3.8 -6) /R-Y



		SMALL CONTRIBUTION TO FREQUENCY g'S (SEISMIC IN PLANT FAILURE)
CORE DAMAGE		0.33 g
I	— LOSS OF MAKE UP IN INTACT CONTAINMENT	0.30 g
IS	— LOSS OF MAKE UP IN FAILED CONTAINMENT	0.32 g
S	— VESSEL FAILURE WITH EARLY CONTAINMENT FAILURE	0.60 g
IV	— ATWS WITH FAILED CONTAINMENT	0.45 g



PERCENT CONTRIBUTION OF
DIFFERENT ACCELERATION RANGES

MEAN EARLY FATALITIES (1.9 - 4) R.Y

		SMALL CONTRIBUTION TO RISK, g'S	
		EARLY FATALITY	LATENT FATALITY
TOTAL		0.62	0.33
I	— LOSS OF MAKE UP IN INTACT CONTAINMENT	0.60	0.30
IS	— LOSS OF MAKE UP IN FAILED CONTAINMENT	0.60	0.34
S	— VESSEL FAILURE WITH EARLY CONTAINMENT FAILURE	0.65	0.58
IV	— ATWS WITH FAILED CONTAINMENT	0.45	0.45

CONCLUSIONS

- SEISMIC PRA TECHNIQUES WHICH INCLUDE ASSESSMENT OF UNCERTAINTY SHOW HIGH CONFIDENCE THAT:
  - SMALL LIKELIHOOD OF SEISMICALLY CAUSED PLANT FAILURE BELOW 2 x SSE
  - SMALL LIKELIHOOD SEISMICALLY CAUSED CORE DAMAGE BELOW 2 x SSE
  - SMALL LIKELIHOOD SEISMICALLY CAUSED RELEASES OF EARLY RISK SIGNIFICANCE BELOW 4 x SSE
  - SMALL CONTRIBUTION TO SEISMIC CORE DAMAGE FREQUENCY BELOW 2 x SSE
  - SMALL CONTRIBUTION TO SEISMIC EARLY RISK BELOW 4 x SSE

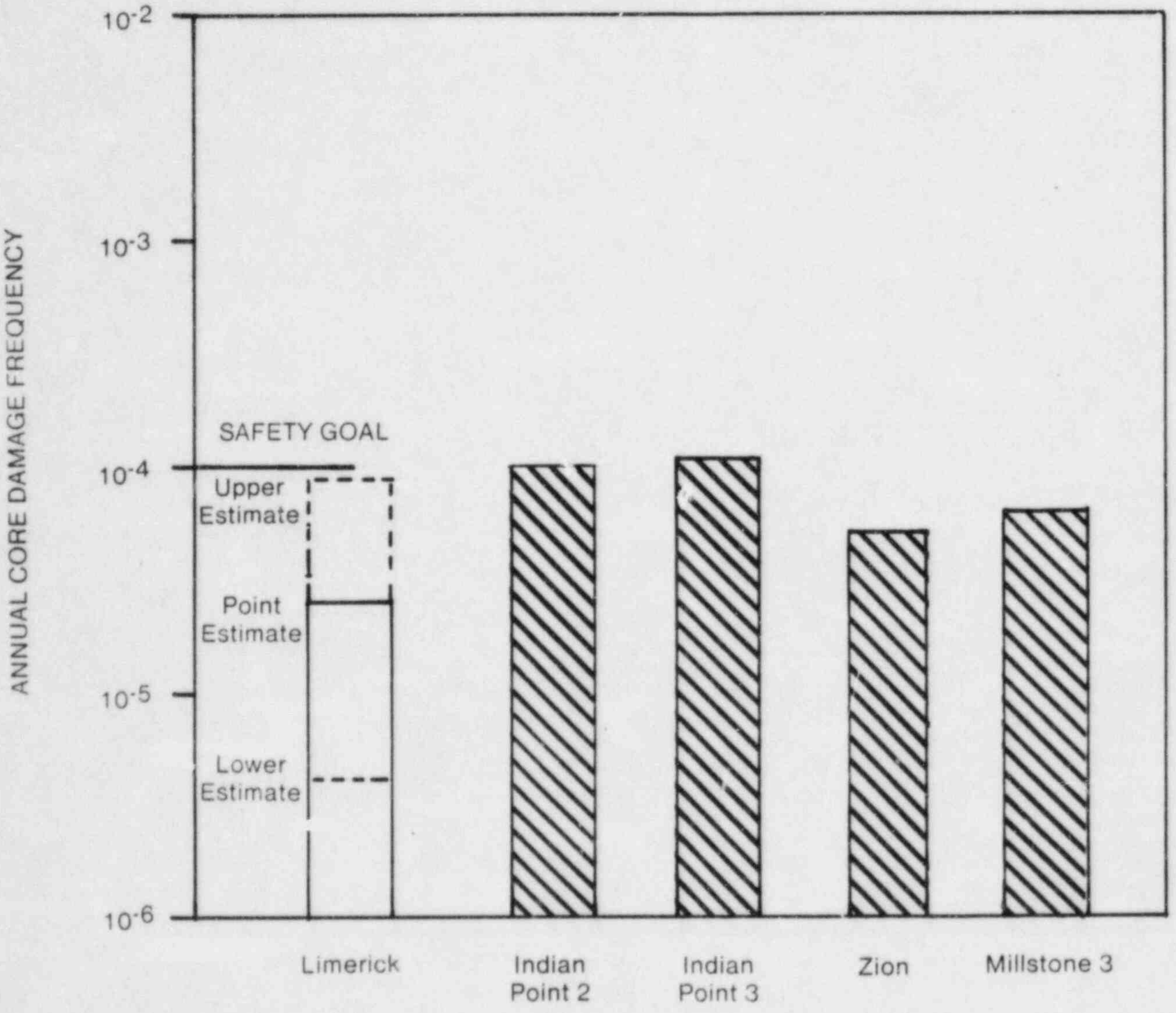
CONCLUSIONS
AND
INSIGHTS

G.F. DAEBELER

CONCLUSIONS AND INSIGHTS

- OVERALL RESULTS
- PLANT SPECIFIC CONCLUSIONS
- PROGRAMMATIC INSIGHTS

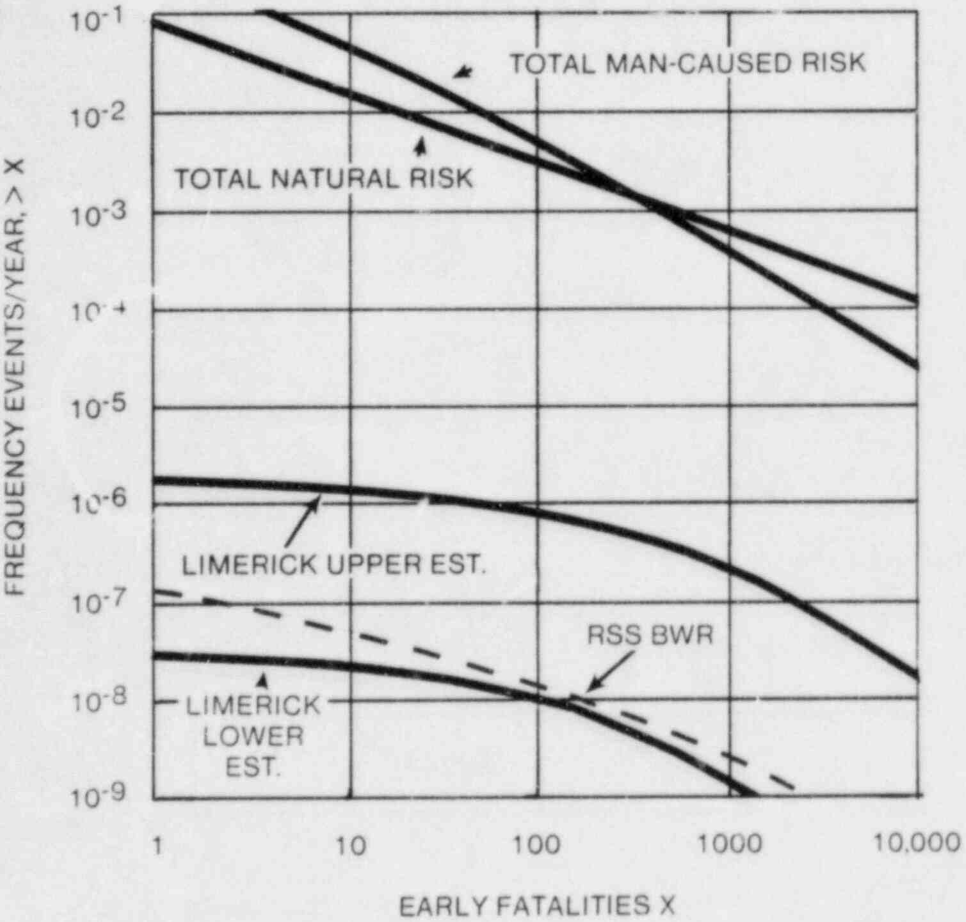
COMPARISON OF LIMERICK CDF WITH POINT ESTIMATES OF OTHER PLANTS



ESTIMATED CORE DAMAGE FREQUENCY AT LIMERICK

- SUBSTANTIALLY BELOW SAFETY GOAL
- SIMILAR TO OTHER PRA's

EARLY FATALITY RISK



ANNUAL INDIVIDUAL RISK

	EARLY FATALITY	LATENT CANCER FATALITY
U.S. Avg.	5×10^{-4} (1)	2×10^{-3}
Safety Goal	5×10^{-7} (2)	2×10^{-6} (3)
LGS Upper	7×10^{-8} (2)	1×10^{-8} (3)
LGS Lower	1×10^{-10} (2)	2×10^{-10} (3)

(1) Accidental Causes

(2) Avg. Within 1 Mile

(3) Avg. Within 50 Miles

RISK DUE TO OPERATION OF LIMERICK

- MUCH LESS THAN OTHER RISKS
- LESS THAN PROPOSED SAFETY GOAL
- COMPARABLE TO REACTOR SAFETY STUDY
- LIMERICK DOES NOT REPRESENT A DISPROPORTINATE RISK TO THE PUBLIC

PLANT SPECIFIC CONCLUSIONS

CORE DAMAGE FREQUENCY (CDF)

- DOMINATED BY INTERNAL INITIATED EVENTS
- EARTHQUAKES AND FIRES ARE LESSER CONTRIBUTORS
- NO SINGLE SEQUENCE SO DOMINATES CDF THAT A REDUCTION IN ITS FREQUENCY WOULD CAUSE A SUBSTANTIAL REDUCTION IN CDF
- NO SINGLE SYSTEM SO IMPORTANT THAT A REDUCTION IN ITS LIKELIHOOD OF FAILURE WOULD CAUSE A SUBSTNATIAL REDUCTIONN IN CDF.

ANNUAL CORE DAMAGE FREQUENCY

	LOWER ESTIMATE	MEDIAN	UPPER ESTIMATE	POINT ESTIMATE
INTERNAL	2.4×10^{-6}	9.2×10^{-6}	6.0×10^{-5}	1.5×10^{-5}
EXTERNAL				
SEISMIC	2.2×10^{-9}	3.3×10^{-7}	2.7×10^{-5}	5.7×10^{-6}
FIRES	1.7×10^{-7}	1.4×10^{-6}	1.2×10^{-5}	3.4×10^{-6}
OTHER		— NEGLIGIBLE —		
TOTAL	4.0×10^{-6}	1.8×10^{-5}	7.8×10^{-5}	2.4×10^{-5}

DOMINANT CORE DAMAGE SEQUENCES

DESCRIPTION	DESIGNATION	POINT ESTIMATE	PERCENT OF TOTAL
LOSS OF OFFSITE POWER COMMON CAUSE FAILURE OF ALL DIESELS FAILURE OF HPCI AND RCIC	T_EUV	5.9×10^{-6}	25
LOSS OF FEEDWATER FAILURE TO RESTORE FEEDWATER FAILURE OF HPCI AND RCIC FAILURE OF TIMELY DEPRESSURIZATION	T_FQUX	3.6×10^{-6}	15
SEISMIC LOSS OF OFFSITE POWER SEISMIC FAILURE OF AC/DC BUSES AND SWITCHGEAR	T_SE_SUX	3.2×10^{-6}	13

EARLY RISK

- SEISMIC INITIATED ACCIDENTS ARE A MAJOR CONTRIBUTION FOR THE HYPOTHESIS THAT A LARGE MAGNITUDE EARTHQUAKE OCCURS IN PLANT REGION.
- UPPER ESTIMATE LARGER THAN FOR INTERNAL INITIATED EVENTS
  - LOW ESTIMATE NEGLIGIBLE CONTRIBUTOR
- EXCEPT FOR SEISMIC CONSIDERATIONS, INTERNAL INITIATED EVENTS CAUSE THE MAJOR CONTRIBUTION

LATENT RISK

- INTERNAL INTIATED EVENTS ARE MAJOR CONTRIBUTOR
- SEISMIC ALSO CONTRIBUTES
  - UPPER ESTIMATE ABOUT EQUIVALENT TO INTERNAL
  - LOWER ESTIMATE LESSER CONTRIBUTOR
- FIRE IS A LESSER CONTRIBUTOR

EARLY RISK

- INTERNAL
  - DUE PRIMARILY TO ATWS SEQUENCES
  - LESSER CONTRIBUTION FROM VESSEL FAILURE
  - NO SINGLE SEQUENCE DOMINATES RISK CONTRIBUTION
- SEISMIC
  - DUE PRIMARLY TO VESSEL SUPPORT FAILURE AT HIGH ACCELERATIONS (> 1g)

LATENT RISK

- INTERNAL
  - SAME SEQUENCES AS THOSE AFFECTING CORE DAMAGE FREQUENCY
  - NO SINGLE SEQUENCE DOMINATES
- SEISMIC
  - DISTRIBUTED BETWEEN
    - LOOP AND FAILURE OF ONSITE POWER
    - REACTOR BUILDING FAILURE
    - VESSEL SUPPORT
  - NO SINGLE SEQUENCE DOMINATES

FUNCTIONS IMPORTANT TO CORE DAMAGE AND RISK

INTERNAL INITIATORS

- RECOVERY OF PCS
- DEPRESSURIZATION
- HPCI AND RCIC
- AVAILABILITY OF AC POWER
  - RECOVERY OF OFFSITE POWER
  - DIESEL RELIABILITY
  - BATTERY LIFE
  - HPCI/RCIC ROOM COOLING
- ATWS PREVENTION AND MITIGATION

SEISMIC INITIATORS

- AVAILABILITY OF AC POWER
- RPV SUPPORTS
- RESETTING OF CONTROL CIRCUITRY

FIRE INITIATORS

- TRAINING IN PREVENTION AND MITIGATION OF FIRES

LGS DESIGN FEATURES INFLUENCED BY PRA/SARA

- INSTALLATION OF ALL RHRSW AND ESW PUMPS BY UNIT 1 OPERATION
- STANDBY LIQUID CONTROL SYSTEM
  - ADDITION OF 3rd PUMP
  - ARRANGEMENT OF EQUIPMENT FOR ENHANCED TESTABILITY
  - USE OF REDUNDANT PENETRATIONS FOR INJECTION
  - INJECTION THROUGH CORE SPRAY SPARGER
- ADS AIR SUPPLY:
  - TYPE AND LOCATION OF BACKUP SUPPLIES
  - PHYSICAL ARRANGEMENT OF PIPING & VALVES
  - DESIGN OF SAFETY/NON-SAFETY INTERFACES
  - USE OF DUAL PILOT SOLENOID VALVES
- MSIV AIR SUPPLY IMPROVEMENTS
- FIRE PROPAGATION BARRIERS FOR REACTOR ENCLOSURE EQUIPMENT HATCHES

PRA/SARA CONFIRMS DESIRABILITY OF INCLUSION OF THE FOLLOWING FEATURES

- 4 DIESELS PER UNIT EACH WITH:
  - REDUNDANT AIR START SYSTEMS
  - REDUNDANT ESW SUPPLIES
- 4 SEPARATE ELECTRICAL DIVISIONS
- NUMBER AND ARRANGEMENT OF OFFSITE POWER SOURCES
- ASSIGNMENT OF REDUNDANT COOLING LOADS TO SEPARATE ESW LOOPS
- RHR PUMP DISCHARGE CROSS-TIES
- DESIGN OF ESW/SW INTERFACES
- AUXILIARY STEAM SUPPLIES TO SJAE's
- FLEXIBILITY IN USE OF SPRAY POND AND COOLING TOWERS
- REDUNDANT, SERIES SUPPRESSION POOL/DRYWELL VACUUM BREAKERS
- ESTABLISHMENT OF APPROPRIATE FIRE ZONES

PROCEDURES INFLUENCED

- HPCI/RCIC ROOM COOLING
- CONTAINMENT SPRAY
- VENTING
- REESTABLISH PCS
- RESETTING OF CONTROL CIRCUITRY

PROGRAMMATIC INSIGHTS

- THE PRA PROCESS ENHANCES UNDERSTANDING OF PLANT DESIGN AND OPERATION.
- DUE TO UNCERTAINTIES IN MODELING AND DATA PRA IS BEST USED TO COMPARE ALTERNATIVES.
- RECOGNIZING INHERENT UNCERTAINTIES IS CRITICAL IN EVALUATING POTENTIAL PLANT CHANGES. POTENTIAL FIXES MAY HAVE SIGNIFICANTLY MORE OR LESS BENEFIT THAN POINT ESTIMATES WOULD INDICATE.
- IN EVALUATING ALTERNATES, ESTIMATES OF CORE DAMAGE FREQUENCY RESULTING FROM INTERNAL INITIATORS CAN BE IMPORTANT INPUT.

FUTURE USE
OF
PRA

A. R. DIEDERICH

CONTINUING USE OF PRA

STUDY GOALS

- INTEGRATION WITH ORGANIZATION
- ESTABLISH TECHNICAL BASES
- PLAN IMPLEMENTATION

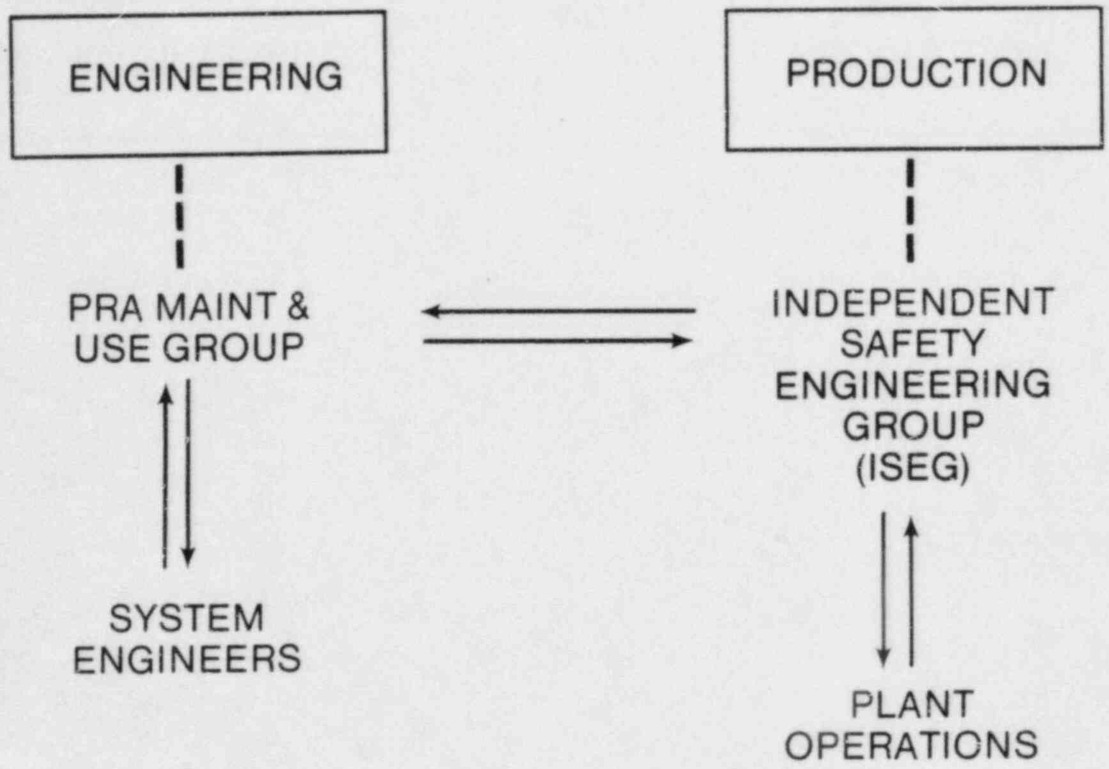
PRA MAINTENANCE & USE GROUP

- DOCUMENT ORIGINAL BASES
- UPDATE PRA
  - BASELINE
  - PERIODIC
- EVALUATE MODIFICATIONS
- EVALUATE TECH SPECS
- MAINTAIN/USE CODES
- DATA ANALYSIS
- PRA TRAINING
- STUDIES/ANALYSES

ISEG

- EVALUATE OPERATING EXPERIENCE
  - LIMERICK
  - OTHERS
- IDENTIFY/REQUEST PRA STUDY
- ASSURE PRA RESULTS REFLECTED IN
  - PROCEDURES
  - MAINTENANCE
  - TRAINING

ORGANIZATION



ENGINEERING

PRODUCTION

PRA MAINT & USE GROUP

INDEPENDENT SAFETY ENGINEERING GROUP (ISEG)

SYSTEM ENGINEERS

PLANT OPERATIONS

TECHNICAL BASES

- SCOPE
- MEASURE
- DETAIL

PRA SCOPE

INCLUDED:

- INTERNAL INITIATORS

NOT INCLUDED

- EXTERNAL INITIATORS
- ACCIDENT EFFECTS

PERIODIC EVALUATION
OF MAJOR STUDY UPDATE

MEASURE

GOAL: SIGNIFICANCE OF ITEM UNDER STUDY

CHOICE: CORE DAMAGE FREQUENCY

NOT: CONSEQUENCES

- POPULATION
- INDIVIDUAL
- PLANT RELEASE

DETAIL

- PRESENT PRA LEVEL
- EXPAND DETAIL AS NEEDED BY APPLICATION

IMPLEMENTATION

TRAINING INITIAL ORGANIZING/STAFFING
6 MOS.

BASELINE/DOCUMENT
18 MOS.

RESULT

- PRA INTEGRATED WITH ORGANIZATION
- RESULTS REFLECTED IN
  - MODIFICATIONS
  - OPERATIONS
  - MAINTENANCE
  - TRAINING
- PRA MAINTAINED UP-TO-DATE
- PERIODIC RE-EVALUATION OF BENEFITS