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Agency: U.S. Nuclear Regulatory Commission
Advisory Committee On Reactor Safeguards

Title: Subcommittee On Thermal Hydraulic Phenomena
NRC Program In Interfacing Systems Loca

Docket No.

LOCATION: Bethesda, Maryland

DATE: Wednesday, December 12, 1990 **PAGES:** 1 - 262

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

DATE: Wednesday, December 12, 1990

The contents of this transcript of the proceedings of the United States Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards, (date) Wednesday, December 12, 1990, as reported herein, are a record of the discussions recorded at the meeting held on the above date.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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SUBCOMMITTEE ON THERMAL HYDRAULIC PHENOMENA

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Meeting On
NRC PROGRAM IN INTERFACING SYSTEMS LOCA

Holiday Inn - Bethesda
The Delaware Room
Wisconsin Avenue
Bethesda, Maryland

Wednesday, December 12, 1990

The Subcommittee met, pursuant to notice, at 8:34 o'clock a.m., the Honorable Ivan Catton, Chairman of the Subcommittee, presiding.

PARTICIPANTS:

I. CATTON,	ACRS Subcommittee Chairman
W. KERR	ACRS Member
C. MICHELSON	ACRS Member
E. WILKINS	ACRS Member
C. WYLIE	ACRS Member
H. SULLIVAN	ACRS Consultant
P. BOEHNERT	ACRS Staff Member
W. BECKNER	NRC/NRR
G. BURDICK	NRC/RES
D. HANSON	INEL
D. WESLEY	INEL
W. GALYEAN	INEL
H. BLACKMAN	INEL
D. KELLY	INEL
D. GERTMAN	INEL

PROCEEDINGS

[8:34 a.m.]

MR. CATTON: The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Thermal Hydraulic Phenomena.

I am Ivan Catton, Subcommittee Chairman.

The ACRS members in attendance are Bill Kerr, Carl Michelson, Ernest Wilkins, Charlie Wylie, and ACRS Consultant, Harold Sullivan.

The purpose of this meeting is to discuss the status of the NRC staff's program on interfacing systems LOCA.

Paul Boehnert is the cognizant ACRS staff member for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on November 27, 1990.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice. It is requested that each speaker first identify himself, or herself, and speak with sufficient clarity and volume so that he or she can be readily heard.

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

I have a couple of comments but I think I'll just wait. One in particular, I ran into a new Code while reading through the documentation.

RELAP5/MOD 2.5/V3d3 -- maybe at the appropriate time somebody can tell me what it is.

Do any of the other members have any comments?

[No response.]

MR. CATTON: Seeing none, the first speaker is Bill Beckner.

[Slide]

MR. BECKNER: Good morning. I'm Bill Beckner. I'm the Chief of the Risk and Applications branch at NRR, and I'm going to give a brief introduction before we get to the bulk of the presentation which will be presented by Research.

[Slide]

MR. BECKNER: By way of background I'd like to briefly recap of how we got from, or, got to this current point. First of all there has been a generic issue associated with interfacing system LOCA for quite some time.

However, several years ago, why, NRR became concerned about it -- specifically Tom Murley -- came from concerned and from absorbing a number of events that were happening out in operating the reactor. Specifically, we're seeing a lot of events that look like precursors to interfacing system LOCA.

And we started becoming very concerned that the risk from ISLOCA might be a lot greater than a lot greater than what we had perceived at that time, and what the current PRAs were telling us. Because of that, NRR initiated an accelerated effort to take a look and try to evaluate ISLOCA risk faster than the current GI 105 program at that point in time.

So, we initiated a couple of things. First of all, AEOD did a review of operating experience, and NRR conducted a number of inspections at plants, and also did some limited route cause analyses to see what was the root cause of these various events we were seeing.

In addition, there was some engineering and PRA analyses conducted, or started, at that time by a Research. In effect, it was part of the continuing GI 105 effort, but that effort was significantly expanded at that point in time. So this is basically how we got to where we are now.

Let me tell you a little bit about what we plan to talk about today.

[Slide]

MR. BECKNER: I'm going to start out and try to provide a brief Regulatory perspective. Or, in other words, what NRR's current views are regarding this program. Then we'll go into a more of a status type report

Sammy Diab, whom I don't see yet -- I hope he gets here. We may have to postpone it -- is going to briefly talk about some of the inspection findings. Then we will get into the research results which will be really the bulk of what you're going to hear today.

After that, Gary Burdick is going to talk about what our schedules and future milestones are. And, of course, the bottom line -- and we'll try to provide a summary of what our initial findings are.

But one thing I want to point out is that we're not finished the GI 105 program at this point in time, so we're not really ready to provide an indication of specific recommendations that we might provide.

[Slide]

MR. BECKNER: We have gotten some preliminary information. We've taken a look at the work that research has done at this point in time, and we have come to some preliminary conclusions, based on the work that has been conducted to date.

What the initial findings seem to suggest is that, in spite of the large number of precursors that we're seeing out there, why the risk from ISLOCA might not be as great as what we perceived when we first saw these operating events. I believe the research effort will provide a lot of detail as to why that is true.

So basically, at this point in time, NRR does not see any basis to try to take any accelerated actions. And what our plan is right now is to continue to go ahead and monitor the GI 105 program, and not take any Regulatory actions until we get recommendations from that program.

However, we still are concerned, even though we think that the risk may not be quite as high as we initially perceived, we're still concerned about the large number of precursors that we're seeing out at the operating plants.

And we also feel that the research program and inspections that they have produce some useful information. So, we would like to go ahead and try to get that information out to the operating reactors ahead of any resolution to 105.

So, along that line, we have started to draft an information notice. This would not be any type of Regulatory requirement, but it would just be an information notice, to provide licensees with some of the indications of, first of all, what's happening out there as far as operating events. Also, provide an indication of some of our initial findings.

We probably will try to issue that information notice some time early next year, but we'd like to talk to some of the industry before that happens because we're aware that NUMARC and EPRI have also been ding some work on this.

So our plan is to try to initiate some discussions early next year with industry, see what they're coming up with, and then provide an information notice to just to give the licensees a heads up prior to any resolution to 105 on some of the problems that are being encountered out there, and some of the potential solutions.

That's really the Regulatory perspective and what NRR plans to do. As I indicated, our plan is to wait the resolution of 105 for any formal Regulatory actions, if that is recommended, but to try to get an information notice out earlier.

MR. KERR: May I ask a question?

MR. BECKNER: Yes.

MR. KERR: You indicated that, in spite of a generic issue resolution process, that NRR decided that this needed some special attention?

MR. BECKNER: That's correct.

MR. KERR: And so you started on this. Is that, perhaps, characteristic of any generic issues, with the resolutions proceeding more slowly than it should be? Has NRR looked at the picture generally?

MR. BECKNER: Okay. I'm not aware of any. There are a couple high priority things that we are looking at.

Shut down risk is one thing that's come up. NRR is working very heavily. We've also looked at some MOV problems. But I think we are working closely with Research on all those issues.

This was one in which I believe, again, I'm coming into this fairly recently, but from my time back in Research, that it was going along in a relatively low effort. I think what we did is, we just simply accelerated at both NRR efforts and also the research side.

But to answer your question, I'm not aware of any major things right now that are hanging out.

MR. KERR: Well, what I really was asking was whether NRR had decided perhaps they should take a systematic look at the resolution process to see if there might be other issues that needed to be accelerated?

MR. BECKNER: I think the answer is no. To my knowledge, we have not.

MR. KERR: Second --

MR. MINNERS: Could I make a comment on that, Dr. Kerr? On Issue 105, although --

MR. BECKNER: You'll have to identify yourself.

MR. MINNERS: Oh, pardon me. Warren Minners, Research.

Issue 105 was going slowly in its resolution, but I think the thing that NRR picked up that Research didn't was they saw human factors element that we were not concentrating on. So, they saw a different problem than we did. I think the direction of the issue was changed more than the schedule.

MR. KERR: I didn't mean to be critical about the process. It seems to me that it's not a bad idea for NRR to occasionally look and see what Research is doing, see if it's, in their view, maybe some different emphasis is needed. And I just was curious to know wether that was being done any more broadly than on this particular issue, and I guess the answer is no.

Second, you indicated that, although the preliminary work seems to indicate that the risk is not as great as you had expected, you're still concerned about the number of precursors.

Now, on what basis are you concerned if it's not -- if the risk is not very great? Is it that you're still skeptical of the numbers that you're seeing, or what?

MR. BECKNER: Okay.

As Warren Minners just indicated, we're seeing human factors playing a major role, both in the potential precursor and also in the potential recovery. While the net numbers are very low, we recognize that there's large uncertainty in the human factor element, so, yes, we recognize that PRA has its limitations.

As a minimum, even if the risk from these precursors is not high, it's causing operational problems out at the plants. They're having shutdowns, people are being injured and potentially things like that. We are concerned, primarily because PRA is not a perfect science and, particularly, this is very heavy into one of the areas of large uncertainty, and that's human factors.

MR. KERR: Thank you.

[Slide.]

MR. BECKNER: The only other thing I want to do is; I was asked to comment on the ACRS letter. I believe it was in January of this year, so I have briefly tried to summarize the letter.

My overall comment really is that I don't think I can disagree too much with the conclusions of this letter. Yes, I think that we've done a limited number of plants under the research program and we have seen tremendous variations in those plants, so, yes, we think that the causes and the ways to mitigate ISLOCA risks are going to be highly plant-specific.

Like I said, human actions is a problem as far as the state of the art in PRA and obviously, this problem has not been adequately treated in the past in PRAs. It's been treated primarily as a hardware problem and not a people issue. The IPE may not give us the answer we need in this area.

In general, I think we agree with the ACRS comments. As far as possible resolutions, again, there were three possible ways to resolve this, suggested by the ACRS, with pros and cons. I think, again, with the first order comment, I don't disagree with it.

I don't think, if we tried to -- of course, the IPE process is already underway. Everything we load on it is going to be another excuse or another reason to delay the IPE process, so including it directly in the IPEs really isn't an optimal situation.

That's already underway. Some type of separate resolution may be unnecessarily burdensome; we agree with that. I think what the ACRS ultimately recommended in the letter was some type of a hybrid approach where ISLOCA is not explicitly included in the PRA, but it is dealt with as part of the IPE process.

I guess I can't comment on what type of resolution will ultimately be recommended. Again, Research has to complete their program and see just what type of requirement, if any, they would recommend. I think, in general, we do agree with what the ACRS comments are. I think we'll keep this under consideration when Research and NRR work together on what the ultimate resolution will be.

That's really all I had to say. In summary, I think we generally agree with what the ACRS letter provided. Yes?

MR. MICHELSON: Section 3.6 of the Standard Review Plan requires that the licensees look at certain types of pipe breaks outside of containment and doing appropriate analysis. Are all of the ISLOCAs that you've looked at also covered by the licensee analyses, perhaps inadequately, but nevertheless covered?

MR. BECKNER: I think that they're covered inadequately.

MR. MICHELSON: But they are covered? Every ISLOCA you have looked at, you could find a particular licensee's analysis of?

MR. BECKNER: I think the primary thing, for instance, the one plant that we've completed the analysis of, there were procedures and it had been looked at as far as a leak outside the containment, but this tended to be a small leak and not a large LOCA.

MR. MICHELSON: You realize that Section 3.6 calls for particular size leaks and so forth. You don't decide how big the leak is.

MR. BECKNER: Right.

MR. MICHELSON: You use the Standard Review Plan. Did they do that type of analysis?

MR. BECKNER: Well, again, I'm just commenting on the one plant with which I am familiar. In general, their analysis of breaks outside the containment were small leaks and not larger ones.

MR. MICHELSON: How did they get by the Standard Review Plan requirement then?

MR. BECKNER: I guess I can't specifically answer that, but I think that, in general, the licensees were not and probably NRC was not really up to speed or aware of this potential problem at that point in time. We viewed it more as a hardware problem, like I said, with basically problems with check valves failing.

I don't think that we really looked at it from the aspect of the real problem which is basically opening and closing of pressure isolation valves in the wrong sequence, this type of thing.

MR. MICHELSON: Section 3.3 and 3.6 has rather explicit requirements for what you do look at and the size break you have to postulate and so forth. Was that kind of analysis, though, done? It didn't have to be called an interfacing systems LOCA; just, did they do what Section 3.6 required to begin with?

MR. BECKNER: I think they obviously did it in an inadequate manner. I think the reason for it is that they were primarily looking simply at check valves and that type of thing.

MR. MICHELSON: Well, 3.6 has nothing to do, necessarily, with check valves. It has to do with postulated pipe breaks.

MR. BECKNER: That might prevent a postulated break. In other words, you might say that that break is not credible because you've got two check valves.

MR. MICHELSON: No, there's no rules in 3.6 about using valves to eliminate breaks. The rules have to do with how fast the break might be isolated, once the break occurs, but not having to do with whether you even have to postulate it. It would be interesting to go back on the case you've looked at to see how it escaped the 3.6.

MR. BECKNER: Okay.

MR. MICHELSON: This gentleman, I know, is well acquainted with it and maybe he has a better answer.

MR. BECKNER: John, do you have anything you want to add?

MR. O'BRIEN: John O'Brien, Office of Research. The issue is SRP 3.6.2 as it affects environmental requirements for equipment outside the containment.

MR. MICHELSON: Well, 3.6.1 is the one I want to address. 3.6.2 and 3.6.3 just give you further instructions on how to do it.

MR. O'BRIEN: Right. As Idaho will tell you very shortly, they have determined that any ISLOCA does not create safety problems for environmental qualification because there are redundant trains. You've always got one train that can execute the safety function.

MR. MICHELSON: But the question was, did the -- there's nothing in 3.6.1 that says you start out by saying, if you've got redundant trains, you don't look. It starts out by telling you what you have to look at and then how you analyze your way out of it. Did they actually look at it in the plants that you looked at?

MR. O'BRIEN: Did they actually look at it? Do you mean; did Idaho actually look to see?

MR. MICHELSON: Did you ever determine that they at least met the requirements of SRP 3.6.1?

MR. O'BRIEN: I don't know that.

MR. BECKNER: I think for the answers, we're going to have to get back to you.

MR. MICHELSON: Maybe Idaho, when they give us their presentation, can include that in their presentation. If it escaped it, I'd like a better answer. I'd like to know how it escaped the system?

MR. BECKNER: I think we've got to look at that and get back to you.

MR. CATTON: Bill, at the last meeting, I was under the impression that there was going to be some experimental determination of the fragility of piping. Is the lesser role of hardware the reason that that's not being done or was I mistaken?

MR. BECKNER: Okay, I can't answer that specifically; I wasn't here. There has been a lot of analytical work done on fragilities that I think will be presented today. Experimentally, I don't know. Gary Burdich would know.

MR. BURDICH: This is Gary Burdich. We do have some things to show you on the way we calculated the fragilities. I think --

MR. CATTON: I read your report, so I know what you do to calculate it, but I thought you had said that there was going to be some experimental work.

MR. BURDICH: There is ongoing experimental work that the program is aware of and is --

MR. CATTON: Maybe at the right time, you can tell us about that.

MR. BURDICK: Sammy.

MR. CATTON: On the other hand, I may have just misheard what we were told.

MR. DIAB: This is Sammy Diab. I'd like to respond to a few questions.

I was -- at the beginning of the program it was thought that this may be something that we can do within this program and we had some reservations from various groups and we decided not to actually pursue this testing, as a part of this program, anyway, of the ISLOCA Program.

MR. CATTON: Well, if the hardware plays as small a role as your reports indicate, maybe you don't need it at all.

MR. DIAB: We believe -- we thought that this fragility analysis was sufficient for the purpose.

MR. KERR: I don't see that the hardware plays a small part, if you include the piping and the hardware. Because whether or not one gets this break depends very much on the piping, I would think.

MR. CATTON: I would think so too.

MR. BECKNER: John.

MR. O'BRIEN: With respect to the question about experimentation, we hired a consultant, Everett Rodabaugh, to compare the analytical results with experimental data he had available. He confirmed that those analytical results were consistent with the information available. We did not, however, conduct new tests.

MR. CATTON: I would be nice if that were a part of your report.

MR. O'BRIEN: That statement, yes.

MR. CATTON: Well, or at least maybe even show a couple of comparisons so that one walks away convinced that the analysis is good.

MR. O'BRIEN: I could do that because I have the comparisons in my files. I could -- if you wish, I will see that you get a copy.

MR. CATTON: Well, I would like to see it in your -- in your report on the pipe fragilities, because then your analysis has some meaning.

MR. O'BRIEN: We could do that too, but the report has been published already.

MR. BECKNER: No, no. I see Gary Burdick nodding his head, so I assume that that can be done.

MR. BURDICK: The -- the work on the fragility estimation, by IMPEL, that has been published. But we can, in the final report on this B&W plant ISLOCA study, add an appendix that will do exactly what you want.

MR. CATTON: All too often we have analytical results that don't have much basis. Here you have an opportunity to use analytical results and you do have a basis, so you ought to state it.

MR. BURDICK: We'll do that.

MR. SULLIVAN: Bill, through the slight imperfections in the LER rule, do you think that -- that precursors are not being recorded?

MR. BECKNER: I'm not sure, Harold. We're seeing quite a few come through. Yes, certainly that could happen, but we're seeing enough of them and they tend to -- when they tend to, typically, overpressurize a pipe or cause a leak -- just recently we had some where someone got a small burn, those types of things readily come to the surface. But, yes, it's always a question of LERs, or are people reporting things where they almost -- almost pressurized a pipe, there are probably not. So there is a potential that we're seeing -- not seeing a complete set.

MR. SULLIVAN: So, you have some indication that it may be an even higher precursor rate?

MR. BECKNER: It could be higher, yes. I think, certainly, if someone almost does something, but they catch themselves, there would be a tendency not to want to report that.

MR. KERR: In that connection -- maybe I'm getting ahead of you, if so, I'll wait. But under the -- in the report, itself, under "Approach," it said: "This review included an identification." Then, among the things that were identified was "for those events that indicated an ISLOCA had occurred."

Have ISLOCAs occurred fairly frequently?

MR. BECKNER: I think what we're seeing is a lot of small precursors -- that we didn't get the ISLOCA, but we did overpressurize piping, that type of thing.

MR. KERR: Okay. So to say that an ISLOCA had occurred means that a precursor --

MR. BECKNER: I think that's -- yes. That's what we're seeing -- a lot of precursors, where piping is overpressurized or inadvertently almost overpressurized.

MR. KERR: It seems to me that such people who aren't familiar with the way you're using language might misinterpret that.

MR. BECKNER: Now, we have had incidents, we have had a couple instances where there was a large amount of water that was, for instance, discharged outside the containment. There have been 1 or 2 of those, I'm not sure of the exact number.

So, you might call those ISLOCAs. Obviously they were recovered very quickly. So there have been several what you might want to go ahead and call them that.

MR. KERR: I just didn't realize before that one characterized a leak as a small break LOCA, but I'm willing to use that description if everybody else.

MR. BECKNER: Right. I think the main thing is where water has just been inadvertently discharged outside the containment; where you've -- you've opened up your high or low pressure interfaces. That's the events that have actually occurred.

MR. SULLIVAN: Is NRR generally happy with the accident management or the operating procedures that concern interfacing system LOCAs?

MR. BECKNER: I think that's what you'll hear today is that that's one of our concerns, that we're not --

we're not basically happy with them. They tend -- they tend to be varied; but, again, that's the primary concern.

MR. CATTON: So that the treatment of the ISLOCA, in part, is accident management?

MR. BECKNER: Yes, or procedures to prevent an accident, if view accident management as prevention.

MR. CATTON: But, within the IPE, I thought a lot of that's where accident management was going to be exercised? How can you split a piece of it off then?

MR. BECKNER: No. Accident management sort of follows the IPE. Accident -- accident management -- we'll make use of your IPE results to implement accident management.

MR. CATTON: Then you'll make use of a separate set of results of ISLOCA accident management. Why don't you just put them together?

MR. BECKNER: Well, I think, it's a historical thing -- it's that this is only being recently being coming up to speed. But right -- but most of the concerns, we're talking about procedures here, are not typically in full power, which is what the IPE covers. Most of the concerns, as far as procedures are when you're involving going up to power or -- or coming down. You know, that's when a lot of these valves are being opened and closed and that type of thing. So, in that sense, it's really outside of the scope of the IPE, that IPE is limited to full power operation.

MR. KERR: Since the IPE was designed, presumably, to look at outliers, I never did realize it was restricted to operation at power, I thought it was looking for risks that might not have been recognized. Why should they be 2 separate programs to look at these things?

MR. BECKNER: Yes. I think it's -- it's primarily historical is that the state of the art in PRA is primarily involved with full power operation. We're just starting to have PRA work done that is applicable to other than full power.

MR. SULLIVAN: Bill, is it a general lack of -- what is the problem with the procedures? Is it not enough instrumentation, training or --

MR. BECKNER: Again, I'm getting in a little bit -- preempting what Idaho would say, but yes, there may be a procedure, for example, that says "close valve A before you open valve B," but there is not a caution and, in addition, there's not an understanding as to why you have to do that. So, yes, the procedure tends to be correct, but the operator is not aware that the reason you close them -- open or close them in that sequence is because you're dealing with a high pressure, low pressure interface, and the procedure lacks a caution and the operator, also, probably does not understand the importance of doing it in that sequence. That's an example.

MR. SULLIVAN: So, it may be a combination of training, instrumentation to telling it that the pipe is really pressurized and --

MR. BECKNER: Yes. Again, I think we're getting into this type of stuff that -- that Idaho is going to present here.

MR. CATTON: I don't see any further questions, and we're already starting to get a little bit behind.

MR. BECKNER: Okay. The next speaker is going to be Sammy Diab, who's going to give a short overview of the inspection results.

MR. CATTON: Sammy, did you bring any slides?

MR. DIAB: I brought some slides. I didn't bring enough with me. I apologize for this. We'll be able to provide this later on in the day.

[Slide.]

MR. DIAB: My name is Sammy Diab. I work in applications branch, NRR.

You probably have seen some of this material before. I would like to recap and give you some kind of a status of the program at this point and also I would like to set the stage for Idaho and the Office of Research to talk to you about the analysis that was done for the B&W plant.

[Slide.]

MR. DIAB: Again, this is some kind of a progression from about where we come from as far as this issue is concerned. PRAs estimate that there is ISLOCA, is a --

MR. KERR: Excuse me, Mr. Diab. I understand that the Commission has asked presenters to the Commission not to read transparencies.

MR. DIAB: Okay. I am not trying to read it.

MR. KERR: It sounded to me as if you were reading from the first bullet and I was going to suggest that we could speed things up by just letting us read.

MR. DIAB: Fine. Basically we are coming from a background that said the intersystem LOCAS are low contributors to risk and then we looked around and we see that operating experience, operating occurrences seem to indicate, suggest that if our concerns are justified, we are seeing too many of ISLOCA-like events, things that we call ISLOCA precursors.

That is a different issue. I think you asked the question earlier about what is a leak and what is a precursor and what is an ISLOCA.

We consider events that lead to overpressurizations or spillages of low pressure system, though low pressure systems, to be useful to us as ISLOCA precursors.

That is what we define by ISLOCA precursor.

There has been, when you say leaks, a leak seems to indicate a small leak. A leak is a leak but a spillage we have seen events that provided 14,000 gallons or 68,000 gallons of primary water going outside the containment, several thousand gallons, several hundred gallons. We call these significant ISLOCA precursors or ISLOCA-like events.

[Slide.]

MR. DIAB: We thought we might learn something if we look carefully into these events.

That is the reason for NRC embarking into this program, focused program to look at the ISLOCA risk, a fresh look at the ISLOCA risk to see if we can uncover something or if we can understand why we are seeing so many precursors.

This basically included a three-pronged approach or attack there -- assessment of operational events, and then from that we go into audit, fuel plants, hopefully varied different kinds of plants to see if we can learn something, and then we go into a detailed analysis of each one of the plants -- PRA, HRA and the rest.

[Slide.]

MR. DIAB: I will just describe briefly here the first two parts of this program and then the third part will be described later on by Research & Idaho.

The assessment of operational data, we looked at several events, ISLOCA-like events or precursors if you will, to understand how the events came about, how did we end up overpressurizing low pressure system or we end up spilling a significant amount of primary coolant outside and maybe even running the risk of uncovering the core.

We tried to understand the root causes for these events. That provided us with a good size laundry list of things one can look at when we go and audit a plant to see if that plant has something, you know, a vulnerability like this or this particular vulnerability. Can this plant have an event like that one we looked at?

Again, this was used to provide guidance for the inspectors when we sent them out to the plants.

Now comes after this the audit program. Within the guidance that we sent with the inspectors basically how one can prevent an ISLOCA from occurring, likelihood of early isolation of an ISLOCA, if one takes place how does an operation can stop or delay core damage and/or minimize the offsite consequences.

MR. KERR: Is what you are describing something that was done by NRR or something that was done by INEL or none of the above?

MR. DIAB: The guidance for the plant inspections was done by both NRR and INEL because they were an integral part of the inspection teams so this guidance was handed out to all the teams.

MR. MICHELSON: Excuse me? When doing the inspection and looking to see what the problems might be, did they make, did the people doing the work make any kind of assumptions about possible single failures that might be incurred in the process of addressing the IS LOCA?

MR. DIAB: I am not really sure I understand the question.

MR. MICHELSON: I assume that you did an analysis of some sort when you went out and looked at the plant, which I gather was the process?

MR. DIAB: Right.

MR. MICHELSON: In doing the analysis, do you make any assumptions about the possible single failures such as a valve being -- that is supposed to be closed might be open, things of that sort?

MR. DIAB: Yes.

MR. MICHELSON: Was a single failure included in the analysis?

MR. DIAB: This is in the PRA analysis and Idaho will be able to address this.

MR. MICHELSON: PRAs don't have to make single failure analyses. They make probability predictions about the likelihood of the valve being closed and that is in the

PRA but if you are doing a deterministic, which I gather this must have been, and it is an inspection of some sort, then you have to make an assumption about whether the valve is open or closed.

MR. DIAB: If you are addressing the inspection themselves, I don't think that that was made, that assumption.

MR. MICHELSON: What did the inspection do or what was the purpose then, if it wasn't to try to verify some kind of --

MR. BURDICK: Gary Burdick from Research.

The inspection teams were armed with preliminary event trees which were drawn from P&IDs before the teams went to the plants so they did have a pretty good idea of what to look for.

MR. MICHELSON: In an event tree you can make some assumptions about, you know, whether the valve is open or closed along the way, and there is a branch in the tree according to which way it might be.

How many of those branches did they go down the adverse directions? Just one? Any or --

MR. BURDICK: Well, we have made a number of inspections and I can't speak to that exactly right here but they were armed -- I can say they were armed as well as they could be with qualitative information what to look for.

This does not mean that there is something there that they may not have missed.

MR. MICHELSON: No, it wasn't addressing what they might have missed. I am asking a real straightforward question. We talked extensively in the past in doing deterministic analyses as to whether or not you make an assumption of a single failure -- arbitrary, singular, active component failure.

In this case do you make such an assumption?

MR. BURDICK: Single active components?

MR. MICHELSON: Yes.

MR. DIAB: Let me try to answer this.

MR. BURDICK: Go ahead.

MR. MICHELSON: Isn't that kind of fundamental?

MR. DIAB: Thank you, Gary. The answer to your question is, Mr. Michelson, did we make an assumption, a deterministic assumption that one of the trains is not going to be available?

MR. MICHELSON: No, that wasn't my question.

A single active component such as you go into a certain operational sequence and then it turns out the motor operated valve you thought was closed was actually open. Now I can make that assumption and if it were, what trouble did I get in?

Was that included? Did you look at that kind of an event or did you assume that everything was correct as you went along?

MR. BURDICK: I think we looked at more than single failures.

MR. MICHELSON: So you looked at multiple failures?

MR. BURDICK: Multiple failures, yes.

MR. MICHELSON: Okay. That is even more conservative, of course, to look for more than one possible failure. You must have found plenty of interfacing system LOCAs, then, if you made an assumption of more than one. Because in many cases, one is all that keeps you out of trouble.

MR. DIAB: The inter-system failures, or the systems that have, are exposed to high pressures, are limited. You have about four or five low-pressure systems.

MR. MICHELSON: That's right. Yes. But they are usually isolated by two isolation valves, and depending on where you're making your assumption of the break, it may even be between them, depending on the plant.

MR. DIAB: During the inspection, the question and answer, the inspectors looked at all possible ways of violating that high-to-low-pressure boundary.

MR. MICHELSON: Including single or even multiple random failures?

MR. DIAB: Including all types of failures. You ask, well, if that goes wrong, what if that opens or doesn't open. Assigning some values to the failures, individual failures, only took place in the PRA space.

MR. SULLIVAN: Gary, I guess the question is, did you find a single failure that would lead to an interfacing system LOCA?

MR. BURDICK: With respect to the B&W plant, I believe it's written into the inspection report that there was no single failure found at that plant.

MR. MICHELSON: Did you take interfacing system LOCAs to occur between the isolation valves at all or was that a no-break area in the B&W plant you looked at?

MR. BURDICK: Well, in the B&W plant we looked at, that's pretty hard to occur, because some of the valves are in fact welded, the check valves are welded together.

MR. MICHELSON: Well, these generally, although in a couple of systems they are check valves, in other systems they are motor-operated valves.

MR. BURDICK: In other scenarios, there are valves which do have piping. But no, we did not, in the inspection program, look at piping breaks between --

MR. MICHELSON: Between the isolation valves.

MR. BURDICK: Between valves, no.

MR. MICHELSON: Even though there are some cases of fair long distance.

MR. DIAB: The isolation valves, in general, are both located inside the containment.

MR. MICHELSON: No, no, no, no. Isolation valves, you know GDC requires one inside and one outside. They aren't generally both inside.

MR. DIAB: Well, whatever is outside is very, very close to the containment.

MR. MICHELSON: Oh, yes. Yes. But outside.

MR. DIAB: And the mechanical engineering people will tell us that they have what they call safe, and are applied so strong that the break, if it is designed for 2,500 pounds, then we're really not that interested in that part of the pipe.

MR. MICHELSON: So you really looked outside of the outboard isolation valve to even postulate your breaks; is that what you're saying?

MR. DIAB: In general, that's true.

MR. MICHELSON: Okay.

MR. DIAB: So that we can speed things up here, we have selected a few plants, PWRs. The idea was to get as much information about those plants that we can, and see what lessons we can learn from these plants.

And this was also considered as a very useful tool for the analysts, analysis teams, to get all information they needed, especially about the human reliability analysis part, which includes interviews and assessments of certain performance shipping factors, which will be considered, will be discussed later on.

All the inspection reports are completed and out.

[Pause.]

MR. MICHELSON: Paul, while you're looking there, did you look at any boiling water reactors yet, from this particular viewpoint, or just the pressurized water --

MR. BURDICK: No boilers at this point.

MR. MICHELSON: So your conclusions, whatever conclusions you're stating today are PWR-type conclusions?

MR. BURDICK: That is correct.

MR. MICHELSON: Right. Okay.

MR. WILKINS: Let me pursue that a little further, because I was going to ask, how did you pick the three PWRs you did pick. Are they intended to cover the spectrum of all possible PWRs, or be representative at least?

MR. BURDICK: It was just one each: B&W, Westinghouse, and CE.

MR. DIAB: Let me try to answer that.

[Laughter.]

MR. WILKINS: I thought I had it answered.

MR. CATTON: The other answer was okay.

MR. WILKINS: You know, a Judge would tell you to quit while you're ahead.

MR. DIAB: I thank you for volunteering to answer.

There was a set of criteria that we went after in order to pick a plant. Basically, the vendor type was very important. There were a couple of other important considerations. One of them is the performance of the plant.

And of course, we couldn't get the plants that we thought we would like to because of unavailability. So that was probably the most important criterion after the vendor type.

Well, there are a few --

MR. MICHELSON: If you're finished with that answer, let me ask just a follow-up question.

I guess you must have made some kind of a determination that you thought that PWRs were going to be worse off than the BWRs; is that right? And therefore, I mean if you had to make a choice and only look at one, you picked the PWR?

MR. DIAB: The idea of going after the PWRs first was basically the delta-P margin for the Ps is about twice as large as the margin for the boilers.

MR. MICHELSON: It depends on what system you're looking at as to whether that's true.

MR. DIAB: And the low-pressure systems are in general about the same design pressure anyway. So, considering the low-pressure systems are 400 to 600 pounds at the design pressure, and the primary is 1,000 or 1,100 in one case and 2,200 in another case, we thought if we look at the Ps first, that's one consideration.

MR. MICHELSON: Do you think the piping on a boiler is just as heavy as the piping on the PWR? Yes, it's twice the pressure all right, but it's also much heavier piping on the primary side. So there's no problem there. It should be the boiler in that case. And on the secondary side, you better look at all the secondary systems that interface on a boiler. Some of them are relatively low pressure.

MR. DIAB: True.

MR. MICHELSON: Very low pressure in a couple cases.

MR. DIAB: We also have limited resources. We couldn't really attack both types of plants at once.

MR. MICHELSON: Okay. But your gut feeling was the PWRs were probably worse off.

MR. DIAB: Well, our gut feeling is, if we needed to start in one place, we picked the PWRs. And we're finding that there are probably some useful lessons that may very well be applicable to boilers as well.

[Slide.]

MR. DIAB: I have only the remaining viewgraph here, which is a preamble to the research. Extensive analysis, focused analysis here, looking at the human reliability analysis, fragility analysis of low-pressure systems, and the thermohydraulics to determine what pressures are at what points at the low-pressure system, as well as the timing that's involved for the scenario for the system LOCA. The timing I think becomes very important when one looks at the human reliability analysis.

That concludes my presentation to you this morning.

MR. KERR: I have a couple of questions.

First, I certainly agree that human performance is important, and has not been very well treated in a good many PRAs, not through any fault of the analyst. But it appeared to me as I read what happened here that a good bit of emphasis was put on human performance that might increase risk.

I didn't see a similar effort given to human performance that might decrease it.

Is my perception incorrect?

MR. DIAB: Respectfully so. And the reason is, when Idaho discussed an analysis, the recovery is a very important part of this. There is so much initiation, but there is also so much recovery. And the recovery of course, is what saves it, in some cases.

MR. BECKNER: Bill, that was one of our concerns about the PRA results, is that it affected both sides, is that there was a large human contribution to the initiator and there was also a large human contribution to recovery.

So that's one reason we were still concerned, is that you've got uncertainties in the human element coming from both aspects. And so that's why we were still a little bit concerned about the precursors.

MR. KERR: My second question is about the concern expressed in the report that operators at Davis-Besse did not understand ISLOCA and its implications.

It appears also from the comments that at least the people who wrote the report felt that they should.

It's my feeling and correct me if I'm wrong that much of the emergency procedures that exist are based on what are called symptom-based LOCAs, which is interpreted by a good many people I think to say an operator doesn't really need to know what's going on. All he needs to do is to have some instrument readings and from that he can tell what he should be doing.

Indeed, I heard one of the staff members from Davis-Besse at a meeting recently who was discussing the Davis-Besse inspection and he said that we were criticized for the fact that the operators didn't understand small break LOCA or didn't understand ISLOCAs but he said that really doesn't matter because we use symptom-based procedures and they don't have to understand what is going on.

Now is it -- is the staff after this exercise going to have another look at symptom-based procedures and maybe decide that that is not the way to go?

MR. DIAB: Well, let me comment on this.

The B&W plants do not have under emergency operating procedures sections that deal with intersystem LOCA as a large break outside containment.

MR. KERR: I guess I didn't make my question clear.

MR. DIAB: I am coming to the symptom-based procedures. The symptom-based procedures may in a B&W plant may lead you to a leak or a small break outside containment.

A small break outside containment will not be able to handle, our procedure will not be able to handle an intersystem, full-scale intersystem LOCA like the ones that we're concerned with in this analysis.

MR. KERR: How do you know?

MR. DIAB: Because that is the assessment of the people who reviewed the procedures.

MR. KERR: Well, then, it seems to me if that is the case and if this is a very significant LOCA then one needs to have a look at the validity of symptom-based procedures generally.

MR. DIAB: Well, the symptom-based procedure is a valid concept. What seems to be missing here --

MR. KERR: Here is a very important place in which it turns out apparently not to be a valid concept.

MR. DIAB: Well, let me just comment to this.

You can have a concept but if you don't make provisions to use that concept efficiently then one can get into a point where the operators may in fact know or understand after some time into the event that they do have a large break outside containment but they don't know what to do with it.

MR. KERR: No, but you see, again maybe I am wrong in my interpretation of symptom-based LOCAs but I thought the philosophy was that an operator wasn't even supposed to worry about what the accident was; the symptoms would lead him to the correct procedures.

MR. DIAB: Well, I am not really sure that the operator is not supposed to worry. I think the operator needs to understand the events that are in general the background for the UPs. The symptom-based will help him.

MR. KERR: I have asked licensees on a number of occasions because I must say I am personally skeptical of symptom-based procedures, I have asked them suppose an experienced operator gets into a situation in which his intuition and experience tells him that the procedures are wrong. What would you want the operator to do?

In all cases but one the answer has been follow the procedures.

Now what this says to me is that the people, most of the people who are developing and using symptom-based procedures do not depend on the operator's understanding and indeed they don't want to depend on the operator's understanding of what the accident may be.

MR. DIAB: Whoever puts the procedure together it's a collective effort.

MR. KERR: Mr. Diab, I know that and I respect it. I am simply saying that if the philosophy of symptom-based procedures seems to me to be don't worry about understanding what is going on, operator, follow the symptom-based procedures, and this seems to me to be a situation which is developing which says an operator does need to understand the significance of the actions he takes and to recognize the accident when he has an ISLOCA.

I may be misreading what I --

MR. BECKNER: Bill, I'm no expert in procedures so I don't know if the issue is symptom-based versus some other type of thing but what I am told by our EPG people that are working with us is that it goes back to the EPGs, is that some vendor EPGs deal with ISLOCA events to a greater degree than others.

Presumably that means that some vendors then have dealt with ISLOCA within a symptom-based arena.

MR. KERR: No, but Bill, if they do they don't deal with it by saying you have an ISLOCA. They deal with it by not worrying about whether you have an ISLOCA or not.

As I read this report, the people who wrote the report felt it was very important that the operators understand the basis for an ISLOCA and understand when they had that specific accident.

MR. BECKNER: I think that comes through. Idaho came through with that, yes.

MR. KERR: I am not disagreeing with this. In fact, I tend to think it's sounder than the symptom-based procedures, but if it does turn out that that is a valid conclusion it seems to me one ought to re-look and maybe re-think the use of symptom-based procedures.

MR. DIAB: Dr. Kerr, this is only one plant that we're discussing. There are more than one plant. The second plant, for instance, does have procedures that may very well prove that the symptom-based procedure for intersystem LOCA are working.

MR. CATTON: I think you have completely missed the thrust of the dialogue that has gone by.

MR. DIAB: I'm sorry, I didn't hear it.

MR. CATTON: I think you have missed the thrust of the dialogue. Maybe we should just continue.

MR. DIAB: This basically concludes my presentation.

The analysis part will be discussed by Gary Burdick from the Office of Research.

[Slide.]

MR. BURDICK: That is who I am.

[Laughter.]

[Slide.]

MR. BURDICK: I want to give you a little introduction here.

Late last Winter or early in the Spring we met, had the first meeting with the ACRS on this program, and we promised to come back when we neared completion on the first plant study.

We're here. And as promised, you received a draft of that study, which is now a couple of months old. And some things have changed, and will change, I think, before the final draft is out. We do not want to have the draft that you have reviewed externally except by perhaps some other contractors. We do want to put the final draft, however, out for review by, in particular, the licensee, to give him a fair opportunity to examine the bases for our analyses.

The final draft will differ significantly in, I think, the three areas indicated here, from what you have now in the draft.

MR. KERR: What is meant by saying it will differ in plant identification?

MR. BURDICK: We plan to keep the names of the plants off all three documents, because this is in fact a hybrid approach to analyzing these plants, as you will see. We are following an approach that, in fact, was recently recommended to the Commission by the ACRS. And that is, we try to analyze towards some average plant. And we've tried, as you will see in this study, to normalize our risk calculations to a quote unquote "average" plant.

We thought that this would enable us, from the meager information we had, that is, only three plant studies, to perhaps get some clearer idea of impacts of actions taken with regard to ISLOCA on the industry as a whole.

You'll see more of this as Idaho gets into their presentation.

[Slide.]

MR. BURDICK: There has been some mention of this already. There were past ISLOCA analyses and PRAs, and they have been weighed in the balance, and they were found wanting in a number of areas, as indicated here.

In particular, these past PRAs did not account for the human contribution that we've been seeing in the operational events. And as was mentioned previously, this is what raised some new concern about the ISLOCA issue and the speed with which the issue was being addressed.

Was, in fact, the program properly focused to handle the human error content?

The program had previously a narrow hardware focus, simply on the testing of the PIVs, the thought being that if you got the pressure isolation valves not to leak, that that would solve the problem. However, that again ignored the human content, the possibility of humans activating valves, when they shouldn't.

[Slide.]

MR. BURDICK: So about a year and a half ago, research, that is Eric Beckjord, received a user request from Tom Murley, asking us to get involved in the five activities listed here, and to put the other four of these activities in a PRA framework which, after considering all of these activities in the formulation of a program, in response to that request, we decided that this was in fact how the GI-105 research program should be reorganized.

MR. MICHELSON: Let me ask, on the previous slide, you said there was little or no modeling beyond the PIV.

That suggests that there was modeling of the PIVs. Is that correct? When you did your PRAs, you put in probability that check valves would close tightly and so forth? You used a set of numbers for all of that?

[Slide.]

MR. BURDICK: Yes. But here I'm talking about past ISLOCA --

MR. MICHELSON: Yes. I understand --

MR. BURDICK: -- PRAs.

MR. MICHELSON: -- Yes. And you also at that time put in probability of isolation motor-operated valves being closed at the time, as a number?

MR. BURDICK: Yes.

MR. MICHELSON: Okay. So there was some accounting of human error in there to the extent that, indeed, the valve wasn't closed, but you put in a probability of that in there?

MR. BURDICK: There is a spectrum of ways that this problem was dealt with in the past. I don't think you can make one hard and fast --

MR. MICHELSON: But it was modeled, you think?

MR. BURDICK: In some cases, there was some modeling done; in other cases, no.

MR. MICHELSON: Well, this suggests that in all the cases, the modeling was done for the PIVs; it's just that the deficiencies were beyond that.

MR. BURDICK: That's right. The modeling of the low-pressure systems is where the deficiencies --

MR. MICHELSON: But the PIVs were included in your models previously and you were satisfied. Maybe the numbers weren't good, but you did have them properly modeled?

MR. BURDICK: Not my models, but whoever did the analysis.

MR. MICHELSON: Whoever did the analysis.

MR. BURDICK: Right.

MR. MICHELSON: Certainly.

MR. BURDICK: There have been industry analyses as well as agency.

MR. MICHELSON: I wonder if that's the case. But I'll have to go back and refresh my memory.

MR. CATTON: In coming to your conclusion that hardware wasn't very important to the risk, did you use the more current thinking about MOVs, the reliability numbers, or did you use the 1150 numbers?

MR. BURDICK: Well, first of all, that's not my conclusion. Hardware plays a very important role here, in a number of --

MR. CATTON: Lesser role than the human factors.

MR. BURDICK: Oh, as far as --

MR. CATTON: You ranked the things that played a role, and hardware was the bottom.

MR. BURDICK: As far as initiating the ISLOCAs?

MR. CATTON: Well, on both ends. As far as the initiation, the valve is open and you can't get it closed or the operator opens it, then can't get it closed. There's some reliability associated with the functioning of the isolation valves. What numbers did you use? Last time we discussed this, you were going to use the 1150 numbers, and not the more current thinking about MOVs. Which did you use in your study?

MR. BURDICK: That's going to be covered. We used a number of data sources to get reliability, failure information on --

MR. CATTON: That could shift the weighting a bit, if you used the 1150 numbers. But I'll wait.

MR. MICHELSON: The real problem, of course, is making sure the numbers reflect the conditions that exist at the time you are required to close the valve under the ISLOCA. And most of your data doesn't relate to a large delta-P and so forth, which is a rarity out in the world, but it's an actuality in this case.

MR. CATTON: That's just a part of it, Carl, it's both.

MR. MICHELSON: That's part of it; and they don't have numbers for that. They may say they do. They pull something out. But we just don't know. The tests so far indicate highly likely they won't work.

MR. BURDICK: We will have a discussion of the engineering approach taken to calculating the likelihood of failure of these valves with various delta-Ps.

MR. CATTON: We're going to hear about this from Duane, I guess, Duane Hanson. Is that right? Background and approach?

MR. BURDICK: No, you are going to hear about that from Bill Galyean.

MR. CATTON: Oh. Okay. It says "interfacing system rupture probabilities."

MR. KERR: Be patient.

[Laughter.]

MR. BURDICK: Duane Hansen will give an overview, and touch upon each particular area, and then turn the program over to people who will talk about each of these areas in more depth.

MR. WILKINS: And we'll lock the door, if, at the end of the day, we still haven't got an answer to this question, and ask it again.

[Laughter.]

[Slide.]

MR. BURDICK: Our Generic Issue 105 resolution approach is to first assess the ISLOCA risk from PWRs.

And we're starting first with the ex-containment ISLOCAs because those are the riskiest. These have been indicated in past PRAs as, with all the warts they have, that, for Ps, the ex-containment ISLOCA is significant to dominant in its risk profile.

We plan to go on and add, as you see here, cover the rest of these bases, the external events; inside containment ISLOCAs; and finally do a cost benefit analysis to look at the reasonableness of potential fixes, hardware and perhaps human.

And then we're going to move on and look at the boilers. And Idaho has just recently started thinking about an exploratory study to do on the boilers, with an eye to using what we've now learned, in particular, with respect to the component fragilities, to perhaps get some idea of plant invulnerability or perhaps immunity to human actions. It may be that there are sufficient margins there, that for at least some of these systems, they may not overpressurize.

We're first taking a look at that, and we're taking that approach to be prudent, frugal. We have a limited amount of money, and, as you can see here, competing priorities.

MR. MICHELSON: Excuse me, before you go on. You talked, in the first bullet, about internal events analysis, and in your next bullet you talk about external events.

Now, relative to pipe breaks, some of which might be ISLOCAs, some of which might not, is that where you're drawing the line, that if it's an ISLOCA, it's an internal event; if it's any other pipe break outside of containment it's an external event? Is that where you're breaking this?

MR. BURDICK: No, no. The externals --

MR. MICHELSON: Where are you breaking it? Because you know, depending on which group I talk to, external events means something very different than internal events, and pipe breaks are thought to be external events when they're outside of containment. And you apparently don't, at least for ISLOCA.

MR. BURDICK: By external events, here, I mean the seismic, flood, fire --

MR. MICHELSON: Flood from external flooding coming into the building?

MR. BURDICK: We're even looking at the flooding caused by the LOCA itself.

MR. MICHELSON: Oh, you're separating, when you have an internal event you may also have an external event; is that what you're saying? Is that the way you're dividing it out?

MR. BURDICK: You're going to cover that, Bill? Are you going to talk to that?

MR. MICHELSON: If you can clear it up later, fine.

MR. BURDICK: Okay.

MR. MICHELSON: It depends on who you talk to.

MR. GALYEAN: This is Bill Galyean. The distinction, I think, we're looking at ISLOCA specific events. Now, they can be caused by, in our terminology, internal events which are basically hardware failures, operator errors, that type of thing. But the bottom line is, things that, errors that violate the pressure isolation boundary, things that open the valves.

When we talk about external events, we use the same focus. However, we look at different causes. We look at earthquakes, fires, floods. Floods internal to the plant, due to pipe breaks, for example, abandoned pipe breaks.

MR. MICHELSON: That's a pressure-boundary failure, isn't it?

MR. GALYEAN: No, no. It can be like a process water line, just a service-water line.

MR. MICHELSON: That's a pressure boundary also. Anything that holds fluid is a pressure boundary.

MR. GALYEAN: Right. But in the ISLOCA terminology, when we refer to pressure boundary, we're referring to the pressure boundary for the primary system, okay, the primary coolant system pressure boundary.

MR. MICHELSON: Only up to the first isolation valve outside of containment.

MR. GALYEAN: Well, if your first one fails, then you have the second one, and that is then the pressure boundary.

MR. MICHELSON: If a pipe breaks beyond the second isolation valve, it's an external event?

MR. GALYEAN: No. Well, only in the sense that if that pipe break, okay, then causes the pressure boundary for the primary system to be violated. For example, you have a flood that gets into an electrical cabinet, affects some relays; the relays cause a motor-operated valve to open, and allow primary --

MR. MICHELSON: If I have a service-water failure, that's always an external event, even though the pipe ruptured?

MR. BURDICK: Not as --

MR. MICHELSON: Didn't lose any reactor fluid.

MR. BURDICK: Right.

MR. MICHELSON: But it's service-water --

MR. BURDICK: I think there's confusion here between the terms ex-containment and external, external event.

MR. MICHELSON: Well, yes, there's a great deal of confusion. That's why I was trying to clarify how you are using the term, so I could understand the rest of the morning. And I'm not quite sure it's clear to me yet where you separate internal event water pressure boundary ruptures from external event pressure boundary ruptures. It's not clear to me. But apparently, a service-water outside of containment is --

MR. GALYEAN: We're talking about the cause of the primary system pressure boundary violation.

MR. MICHELSON: Okay. Clearly it won't be violated with a service-water.

MR. GALYEAN: Right.

MR. MICHELSON: Let's assume that it isn't.

MR. GALYEAN: Right.

MR. MICHELSON: That's an external event.

MR. GALYEAN: Well, it is in the sense -- it is; that's right. That is an external event.

MR. MICHELSON: Okay.

MR. GALYEAN: Because it's external to the system we are looking at.

MR. MICHELSON: But if somehow you lost reactor coolant in the process of the event, then it becomes an internal event?

MR. GALYEAN: No. It just becomes an external cause to an ISLOCA.

MR. MICHELSON: I'll give up at this point. I try to get it more simplistic than apparently it's possible to state it. But other people have given me very simplistic answers that I can understand. This one I don't, to be perfectly frank.

MR. BURDICK: I have a schedule here that I'd like to come back at the end of the presentation by Idaho and talk about.

[Slide.]

MR. BURDICK: But I want to prepare you for their presentation in a couple of ways here.

I want you to bear in mind as they are going through their discussion that what they are talking about are outside containment ISLOCAs. Every time you see an ISLOCA in their presentation, that will refer to outside containment ISLOCAs.

Now, we'll talk about the approach, and we'll give you what we consider now to be pretty final results on the B&W plant. And I want you to bear in mind that the results that we're going to give you on the Westinghouse plant are at this point preliminary.

That concludes what I have to say except to introduce the Idaho team, led by Duane Hansen in the middle of the front row; Dana Kelly, to his left; Bill Galyean to his right; directly behind Dave Gertman.

Duane Hansen will lead off the Idaho presentation.

MR. KERR: One short question.

In reading the report, in a number of places, I got the impression that conservatisms were used in the PRA analysis.

Were the analysts instructed to be conservative when they had a choice?

MR. BURDICK: Bill, the analysts were repeatedly cautioned not to be conservative, but to be as realistic as they could, and this is in keeping with the severe accident policy statement, where the staff has been cautioned not to be conservative. And I agree with that philosophy. It's a double whammy when the staff makes, injects conservatisms into their studies, and then you may have some conservative approach taken by the regulator. We tried to avoid that.

MR. KERR: They should instruct their word processor to go through and remove those cases which conservatism appears in.

MR. SULLIVAN: Gary, can I ask you a question?

MR. BURDICK: Sure.

MR. SULLIVAN: I think Sammy, when he was doing his presentation, said that the risk was too high for interfacing, or they thought it was larger than the ERA.

Well, that means two things to me. Either they missed the consequences, or the probability is wrong. And I assumed that he meant the probabilities.

And then, the LERs are the only way that I know that they know that -- in fact, that seems to be the concern, the precursors from the LERs. But I never saw anybody take that and estimate, well, you know, they're twice too large or three times too large, factor of 10 too large. And then in the report it says, it gets into human factors. And it says, well, we are concerned because there are human factors involved, and we know that that's probably -- but I couldn't get a clear understanding of what the problem, what are they really concerned about, and are the LERs, the database and the LERs, saying that the precursors are way too large?

MR. BURDICK: There are a number of things to respond to in your comments there.

First of all, as Bill Kerr pointed out, there is a -- the word "precursor" means a lot of different things to different people. It's bandied about. And I believe AEOD has a precursor program still ongoing that defines what they mean within that program by precursor. IAEA has another definition. For the purposes of this program, we have a definition.

But before this program got started, there was a perception that there were perhaps more of these events occurring than should be. And that was one of the things about this program going.

But you're going to see a little later on that I think our analysis enables us to understand what we are seeing, why we are seeing it, and that a lot of these events that we call precursors are not really precursors in the AEOD sense. They are things that happen because it's not a perfect world we live in. And these things are in fact benign events in a lot of cases.

MR. CATTON: So you've reduced the probabilities?

MR. BURDICK: Pardon me?

MR. CATTON: The bottom line is you've reduced the probability side of the product?

MR. BURDICK: No. We have not reduced the probabilities. The core damage frequency that we're coming out with is about what it has been in past studies, even though those studies did have warts and ignored the human content. But we also have a handle now on the frequency of the kinds of events we're seeing, and understand why we're seeing them. And actually, what we're seeing in the operational occurrences in the real-world events is pretty much in line with what we're coming out with in our studies here.

MR. CATTON: Do you understand that?

MR. SULLIVAN: Yes, I think I do.

MR. CATTON: Could you explain it?

MR. KERR: Ivan, you aren't supposed to understand

PRAs. Harold and I understand it.

MR. CATTON: I thought Harold asked a good question. Reduced risk, where did it come from, probability or consequences? I didn't understand the answer.

MR. KERR: I'll explain it to you.

MR. CATTON: Okay.

MR. SULLIVAN: So what you're saying is that the database that you have is consistent with the LER database, and the probabilities are roughly correct?

MR. BURDICK: They're in agreement.

MR. SULLIVAN: Okay. I'll accept that.

MR. BURDICK: Anything else?

[No response.]

MR. CATTON: I understand now.

[Laughter.]

MR. CATTON: I think, rather than have Duane start right now, we might take a break before that. I have five of, so we'll come back at ten after.

[Brief recess.]

MR. CATTON: The meeting will come to order. The next speaker is Duane Hanson, Idaho.

MR. HANSON: All right. This morning I'm going to be briefly introducing to you the ISLOCA program by discussing the background and approach.

The approach was developed and intended to meet the objectives that were discussed by Dr. Burdick in the previous presentation.

The program was basically structured around three steps. First, developing a methodology for assessing potential just for an ISLOCA. Then applying this methodology and refining it, based on the application. And then, finally, to generalize the findings in the form of an evaluation process.

I'm only going to be covering, briefly, the first step. In subsequent presentations we'll give you more detail on some of the unique aspects of this methodology and also on the applications.

[Slide]

MR. HANSON: Now, at the onset of this program we performed a review of some of the historical plant operating data in the form of the LERs. And this review as to identify the LERs and help us to better understand potential events at nuclear power plants.

We looked in several areas. We looked at the pressure isolation valve failures that could occur based on hardware, human causes.

We looked at misalignment of motor operated valves. Not necessarily only involved in low pressure systems, but those which would be involved and would have safety implications.

We also looked at what we called the occurrence of ISLOCA precursors. Here, when we speak of precursors, we're speaking of cases where a low pressure system was -- the pressure was increased as a result of incongruent communication with the RCS. Of course, speaking of cases where there were valves switch had problems, either maintenance or could fail, and also leaks from high pressure systems to the low pressure systems.

Now the results helped us to do several things. They helped us to identify potential types of human errors or hardware failures that could be important for an ISLOCA. They also provided us with some information in a limited number of cases as to failure rates on some types of pressure isolation valves.

We didn't find the information adequate to help us to develop human error failure probabilities, because of differences in the types of things being done, the context that they were being done under, and that timing, and these sorts of things.

Now, the insights that we gained from this review helped us to work out some of the details to put together an approach and a framework.

[Slide]

MR. HANSON: What I have shown here is an eight step process, which I would like to just briefly run through with you and then come back, talk about each one of the steps in a little more detail. Then, as I indicated, as we go through the remaining presentations will provide significantly more detail on several of the steps.

MR. MICHELSON: Excuse me. Before you go on.

MR. HANSON: Yes?

MR. MICHELSON: In a case that you might experience an ISLOCA, one of the first mitigating steps might very well be to try to isolate this LOCA if it just opened up.

MR. HANSON: Yes.

MR. MICHELSON: To do that, you have to now go back and use, for instance, a motor operated valve.

MR. HANSON: Yes.

MR. MICHELSON: And are you including that in this previous slide? You've gone back and looked at the probability that the motor operated valve would close under the conditions now existing in the system, as opposed to any other data that you might have about how it works when there's no load on it?

MR. HANSON: No, we didn't. In our LER reviews we didn't look at the capability of valves to open and close.

MR. MICHELSON: No. I was thinking beyond LER, because LER didn't experience the LOCA, therefore, it didn't experience a probability -- I mean, it didn't experience a data point for operation of the valve.

MR. HANSON: Yes. In the --

MR. MICHELSON: How do you do this for the case of -- you're doing an analysis. Now, what you do have indeed an ISLOCA to develop and how do you determine the probability litigation?

MR. HANSON: In our analysis of at least the B&W plant, we did look in detail at the sizing of the motor operators on valves that could be used to isolate the systems, and in that analysis, we used data that's come from testing that's going on, on valves, under the auspices of the NRC, and used that analysis to make a determination of whether the valves would open and close.

MR. MICHELSON: Now, how did you adjust the probability of failure from the numbers you might otherwise have used in order to do your PRA. What probability of failure do you now use, because you're -- this program doesn't develop numbers for the probability of failure.

It develops an understanding of why valves do fail under excessive flow or differential pressure. But that doesn't give you a probability number.

MR. HANSON: Now, we didn't, I guess, didn't estimate then the probability of failure of the valve itself.

MR. MICHELSON: Well, how do you do a PRA without including that number?

MR. HANSON: Well, we do look at the probability the operator would close that valve. I don't really --

MR. MICHELSON: Well, that's the operator action, I will assume a probability of one that he did what he was supposed to. Now what's the probability the valve will close after having been instructed to close.

MR. GALYEAN: This is Bill Galyean. The short answer to your question is we didn't adjust the probability.

MR. MICHELSON: So when I'm looking at your --

MR. GALYEAN: It was a two step process. Okay? First, we checked to see if the valve operator was strong enough to operate under the delta P that it's experienced.

MR. MICHELSON: Um-hum.

MR. GALYEAN: And if it was strong enough to operate under that delta P, then we just used regular generic failure rate probability

MR. MICHELSON: In summary, since it was strong enough that it would behave just as well this day as any other day?

MR. GALYEAN: Right.

MR. MICHELSON: Which is not very good assumption since you know the friction factors have increased significantly. Now, maybe the motor is big enough, but maybe your friction factor estimate's not too good either.

Particularly if it's starting to get in severe galling, and the friction kind of goes out the window.

So, your probability clearly -- your probability of success clearly decreases. How much, I don't know. I was trying to find out if you knew, or how you even approached the question.

And the answer is, well, as long as the motor is big enough I'll assume it works just as good as if they were unloaded.

MR. GALYEAN: Okay.

MR. HANSON: The first step in our process here was to assess the potential for ISLOCA and that we did this by obtaining such information as P&IDs, procedures, and used these then to help us develop some preliminary eventiaries prior to gathering detailed information.

In the next step we gathered, we used these peliminary eventiaries to help us gather the information and we accomplished by an extended visit to the plant as part of the inspection team itself.

Information then was used to develop this -- detailed information was used then to develop detailed eventiaries which included all the plant specific data that we had obtained.

The information then was used in two areas, and these two areas contain some probably some fairly unique approaches and will be discussed in more detail in subsequent presentations.

We estimated the rupture potential for the plants, for the hardware that's involved in the plants, and also performed human reliability analysis and included in this errors of commission.

This information then all fed into the quantification of eventiaries which led, then, to consequence evaluations and, finally, a performance of sensitivity analysis to examine areas where additional insights, we felt, would be important.

Now that you have a kind of a general picture of the steps in the process, let me go back and talk --

MR. MICHELSON: Well, before you leave the general picture. If an ISLOCA worked or occurred, it's going to expose the area of the plant in the vicinity of the LOCA to a very harsh environment. And, depending on high quickly you get the valve closed and so forth, that will determine how harsh the environment is.

How did you determine the degree of harshness to the environment and whether or not the equipment would even be qualified to -- it needs to function -- would even be qualified to function under the conditions existing in the plant at the time.

Did you do that at all, or did you just assume it was okay.

MR. HANSON: Well, we walked down the systems that had the potential to fail and looked at the redundancy and separation of the systems.

MR. MICHELSON: Well, the first thing you had to do, I think is to determine what the environment was that you would have to withstand so that when we did our walk down, you can make a judgment as to whether the equipment would even handle it or not.

Also, how far does the environment? Depending on how quickly it closes the valves in, environment may spread throughout the building.

MR. GALYEAN: What we did when we walked through the plant we looked at the areas where the ruptures were likely to occur. Then we said everything in that room, that area, would fail. We assumed that equipment is not qualified for 600 degrees fahrenheit that would result from the RCS. So, we just assumed everything in that room would fail.

It turns out that there is good separation of parallel of trains and there are redundant systems.

MR. MICHELSON: By good, do you mean the environment of this LOCA does not ever get into the same --

MR. GALYEAN: Well, I'm not going to say that. At the plant we looked at, everything with strong concrete walls --

MR. MICHELSON: Well, what --

MR. GALYEAN: However, the doors, most of the doors are security doors and not water-tight doors. So --

MR. MICHELSON: They'll withstand the pressurization that you're going to get.

First of all, unless you can tell me you've made a determination of this environment, it's very difficult for me to believe what these barriers will have to withstand. And, if you haven't done your first piece of work, how can you make these judgments about the validity of barriers.

If you could tell me, yes, I've determined the environment and it's so many pounds pressure in that area, and so much temperature, so much water content, so many inches on the floor or whatever, if you've done that, fine. Then I could look at that and I can say, yeah, that should be okay. But, if you haven't done that, how can you make all these other determinations.

MR. GALYEAN: Well, we just took the expedient approach and just said everything failed in that area.

MR. MICHELSON: But that isn't the question. The question is how far does the environment go so I know how big the area is. And the are is more than this room and maybe the hallway out there, and maybe the next room, depending on how big the break is and how long it takes you to isolate it. It may be the whole basement of the building, depending on what your analysis shows the environment to be. But if you haven't done the environmental analysis, how can you do all this other analysis?

MR. GALYEAN: Well, there's obviously an uncertainty. For example, how big is the leak, how long does it go on before it's detected and isolated. We're just compounding --

MR. MICHELSON: But that's a part of your PRA, isn't it?

MR. GALYEAN: Well, we do what we think is most prudent within the constraints that we have, obviously. And this is the approach we took.

MR. MICHELSON: I find it to be rather -- the staff apparently accepts this as an acceptable approach and has all the good answers as to why you don't need to determine what the environment is in order to determine things are all right.

MR. O'BRIEN: May I make a statement?

MR. MICHELSON: Certainly, anybody who can answer will be quite welcomed.

MR. O'BRIEN: The equipment that we're thinking about is inside the containment.

MR. MICHELSON: Well, outside of containment, now.

I'm not going to talk about inside the containment. I'm not even worried about inside the containment from this viewpoint. Only outside a containment.

MR. O'BRIEN: Oh.

MR. MICHELSON: No, I have no problem. I wouldn't want to raise it inside, because I don't think it's valid there.

MR. WILKINS: Carl, it seems to me --

MR. MICHELSON: Sure.

MR. WILKINS: Let me try to see if I can sharpen up this question. Because I'm not sure that they understand what you're driving at. I've heard you ask this question before.

MR. MICHELSON: Well, it's been asked so many times --

MR. WILKINS: So many times.

You know, you've got this thing in a room. It's all very well to say that we'll just forget about all the equipment in that room. But how do you know that you can confine the effects to that room, if you don't know that the pressure is below the pressure that it would take to break the barrier between that room and the next room, or between that room and the hallway?

MR. MICHELSON: A pound per square inch might be all it takes for doors like that to open the doors which are normally doors.

MR. O'BRIEN: Our attempt again. For outside a containment it's true that we don't have assurance that the environment will spread to adjoining rooms --

MR. MICHELSON: Or will not spread.

MR. O'BRIEN: However, if there is any piping in adjoining rooms, they're normally postulated to rupture, and there would be some kind of protection against the environment.

I would also venture a plant, that if it's outside the containment, the building leaks. It's very hard to build up a substantial environment in adjoining areas because you will get leakage of the environment outside. Even in the steam tunnel, for instance, we have blow out panels to limit the pressure.

So, I don't feel -- I understand your concern, but I don't think it's a major concern, although we have not qualified it. But you have to understand the expense involved in qualifying that

MR. MICHELSON: I don't know that money has anything to do with safety. If there's a safety issue, you have to address it. If it costs more to do it you spend the money.

If it's an important enough safety issue, and that's what you have to determine. You have to make a judgment. There has to be more than just talk off the top of the head. There has to be some calculation, some estimation of the pressure and the temperature in the room and so forth.

Then a judgment might be made as to whether the rooms, the doors -- the ventilation penetration's usually the one that gets you. The darn ventilation system will just transmit the steam to the next room anyway because it's on a common ventilation system, even though the door is good.

So you have to do some of this. First of all, though, you have to understand what environment we're going to expose equipment to. Then we determine how far that environment can extend. There may be an inverter right outside the door that can't stand water droplets, or can't stand over 150 degrees in the room, or whatever. And those conditions might easily be reached.

Now, if you do your analysis for the adjacent room, that's fine. But when you did that analysis did you assume that whatever happened there came back into the first room? You do -- unfortunately, you do these analyses a room at a time and you don't look to see how far the environment goes, and you just write off what's in the room. You can't.

You've got to write off whatever the zone of influence of the environment is, you've got to look at all the equipment in that zone. And if you want to write it off as a simplistic approach, that's fine. But you've got to know the zone. And the zone is not the room in which the equipment is located necessarily.

MR. HOUSE: Well, we appreciate the comment. But this was really a judgment call, and we had to bound the analysis somewhere to live within the funding we had, and we did the best thing we could under the circumstances.

MR. MICHELSON: Now, the problem of bounding it even within the room gets into the next question. Is it a correct assumption just to assume all the equipment quits? Is that considered conservative? The answer may be no.

It may be worse when the equipment is exposed to the degraded environment and it misbehaves. It creates unwanted actions that you have to consider.

And this happens when you read LERs, a water system leaks through the floor and it gets to the equipment you hadn't even dreamed of here.

MR. HOUSE: Again, if we had world enough and time, you know, we could --

MR. MICHELSON: I'm not going to raise that issue other than to point out we aren't necessarily being conservative even in assuming the loss of equipment in the room.

Clearly, we're not conservative in not looking at the environment if it extends beyond the room. We're quite non-conservative.

MR. SULLIVAN: Do I understand it correctly that you did not do a flooding common cause analysis? Is that what we're talking about?

MR. GALYEAN: That's correct.

MR. HOUSE: Yes.

MR. CATTON: If you have a line break in a small room and the type pressure, the high temperature, that can create chaos in the room you're in, as well as in the adjacent rooms. You can't ignore that.

All you have to do is visit the HDR containment in Germany. It does all sorts of neat things to adjacent rooms.

MR. O'BRIEN: That's inside the containment, though.

MR. CATTON: I'm talking about a room. If you have a break in one of the small rooms with equipment outside of the containment and it's got a door and it's got an adjacent room, the flow of steam and water and all that kind of stuff through those doorways just shreds things.

MR. MICHELSON: In fact, that's the only way you keep from blowing the walls out, is you blow the doors or the ventilation system out first. This relieves the pressure, but that relief thing goes into other parts of the building unless you've provided relief panels that always assure it goes outside to the outside right away. Some people have done that for certain rooms.

MR. CATTON: And you have the calculational tools to address this.

MR. O'BRIEN: I guess the judgment call is that there would probably be piping in adjoining rooms and that those pipes are postulated to rupture. And the environment for equipment in adjoining rooms is more likely to be controlled, is governed by the ruptures in that room rather than in a room where the ISLOCA is going on.

However, the ISLOCA presents a more serious environment. But it has to spread, and it may spread to several rooms, each of which is venting.

I am familiar with the tests that were done at HDR.

MR. CATTON: The point I'm trying to make is that it doesn't necessarily have to be a judgment call. You could have used one of the codes that you guys have spent years creating to calculate it, and they're not expensive codes to run.

MR. O'BRIEN: Right.

MR. MICHELSON: But I do -- maybe you missed my point. I'm sure you didn't.

Never the less, [illegible] like to repeat. You did the analysis one room at a time, and yes, you did the analysis in the next room, but when you did that analysis you didn't assume that this room had any environmental effects.

If you'd done the two together then you would have had the answer that you need. Maybe it's okay and maybe it's not. But you looked at one area at the time and if these could be well confined environmental areas so you're sure the environment didn't spread beyond that area, then it's a good analysis.

In these older plants it's not easy to do. And in newer plants, even, we're still fussing about how good the barriers are between the areas that might have an adverse environment.

[Slide.]

MR. HANSON: The first step in our process, as I indicated, was to obtain plant-specific information, such as hardware descriptions, P&IDs, schematic drawings, operating procedures, emergency procedures that pertained to LOCAs and ISLOCAs, and then to use this information to help identify the systems that interface with the RCS that have components that could fail under high RCS pressure conditions.

You asked a specific question earlier about the piping between the check valves. We didn't consider that piping to fail, because it's rated at the RCS system pressure. We looked at the low-pressure systems in particular.

We then determined the maximum interfacing system break size that would not result in what we judged to be core damage, and we screened the systems based on this break size.

We looked at the makeup systems, the rate which they could make up the amount of water available, and these sorts of things, to determine this break size. Breaks below that size, then, weren't considered in the analysis; and breaks above that size were considered as being potential risks for ISLOCA.

We then developed preliminary event trees for the ISLOCA, based on the initiators and sequences, in preparation for gathering more extensive plant information.

[Slide.]

MR. HANSON: The types of information that were gathered then, were gathered in our case in a plant visit as part of an inspection team, and we used the event trees to help us understand what things to look at in the procedures, what types of hardware to look at. And we specifically talked to those people who would be involved in the operations that looked like they have a potential to cause an ISLOCA, and also to look at the training that those people were given. And that would [illegible] both the procedures and in maintenance and [illegible] testing.

We also gathered information on factors that could influence the performance of the people, for either detection, prevention, or mitigation, and looked for such things as workload, stress loads, environmental conditions that might be detrimental, and the general practices.

MR. CATTON: Under the last bullet, did you look at what the symptoms are that the operator is supposed to react to and whether or not the symptoms were indeed of the ISLOCA or were represented properly to the operator, whoever had to make a decision?

MR. HANSON: What we did there was, we looked at the procedures to see how the procedures would address the symptoms and whether they might lead you to understand that you had a break outside of your containment and needed to do some things differently than you would under normal LOCA conditions where the break was inside the containment.

MR. CATTON: Do you have to look to see whether or not the symptoms --

MR. HANSON: Yes.

MR. CATTON: -- that he finds properly represent what's going on? Was that done?

MR. HANSON: I don't know that we looked at symptoms specifically.

MR. GALYEAN: Well, we looked at the indications that would be available to the operators.

MR. HANSON: Right.

MR. GALYEAN: We looked at which alarms, and which indicators and which instrumentation would be available in the control room for the operator to refer to.

MR. CATTON: Okay. And did you ascertain whether or not the symptoms available to the operator were reliable, that there was no opportunity for him to interpret it in another way?

MR. HANSON: I think in the human reliability analysis, we --

MR. CATTON: My recollection is, in the early 1980s, when the French decided to go to symptom-based procedures, this is one of the things they did. And they came to the conclusion that there was more instrumentation that was needed in order for the symptom-based procedures to do what they were supposed to do. As near as I can tell, that's never been done in this country, yet we have gone to the symptom-based procedures. The ISLOCA is kind of a step removed from what we usually think about, a symptom of something going wrong on the reactor itself.

I think you need to do that.

MR. HANSON: Okay. We did not look at the symptoms specifically. We did look at how you might detect the symptoms and look at how they interfaced in the procedures.

MR. SULLIVAN: Duane, I think you indicated that there is a problem in the procedures.

MR. HANSON: We believe, in the case of the B&W plant, that it would not adequately lead you to detection of your ISLOCA, at least in a very rapid manner.

MR. SULLIVAN: So the answer to Ivan's question is, there is a problem.

MR. HANSON: In the case of one particular plant. Yes.

MR. MICHELSON: Well, how severe the environment is is going to be determined by how long it takes you to find out where the ISLOCA is and get it isolated, so there is another uncertainty in even predicting the environment to begin with.

MR. HANSON: That's correct.

MR. MICHELSON: How long does it take until you figure out what to do? And we're not sure th instrumentation is too good, or some of it.

MR. KERR: In your evaluation of operator performance, did you determine whether one had roughly the same staff that was available in the earlier Davis-Besse incident?

MR. HANSON: The numbers of people; is that what you're speaking about?

MR. KERR: Well, the numbers or the same people.

I asked, because it seems to me that that group was rather ingenious in putting together a method for cooling the core under unusual circumstances, and I got the impression in reading this report that you felt that the staff that was there might not be very ingenious.

MR. HANSON: I'm not sure I would characterize it that way. I think we gave quite a bit of credit in the recovery for the plant for ingenious actions.

MR. KERR: Okay.

MR. MICHELSON: When you decided what they could do, did you take into account the environment existing where they might have to do their thing?

MR. HANSON: Yes.

MR. MICHELSON: Because clearly it's outside the control room.

MR. HANSON: That's right.

MR. MICHELSON: And how did you do that if you didn't calculate the environment from the ISLOCA? How did you determine people could get to where they needed to go and so forth?

MR. HANSON: In general, we didn't rely on people getting into areas in the aux. building that were anywhere near where the postulated rupture would be.

MR. MICHELSON: Yes, but how far the environment ha spread from the point of origination I don't know, and you, I don't think, know either. So how can you predict what parts the operators can get to?

Now, if it's clearly outside the aux. building, sure, there's rational reasons to believe that's fine. But once you enter the aux. building for an event occurring in the aux. building, unless you understand that event and know how long it took to isolate it, and so forth, I don't know how you can predict what operator actions you could perform.

MR. HANSON: As I recall, we didn't rely on the operator to take manual actions in the auxiliary building to isolate any of the ruptures.

MR. MICHELSON: That would be a conservative but correct way to do it, if you don't do the calculations of the environment.

MR. CATTON: Is this the incident where the operator really had to extend himself to get it done?

MR. HANSON: Extend himself in terms of --

MR. CATTON: Well, he got something done that was near impossible, and he really had to hustle.

MR. HANSON: I don't believe that was the case. We found there was quite a bit of time available, and in fact that's why we gave a lot of credit for recovery, is because there was a lot of time available for the operator to take action.

MR. CATTON: I must, I'm thinking about another incident.

I don't remember, but apparently there was an incident where the operator really had to hustle from one place to another.

MR. MICHELSON: He knew, he had instrumentation to tell him what had happened. In this case, I don't know that he even knows what's happened.

MR. CATTON: Didn't he violate the procedures somehow when he did that?

VOICE FROM THE FLOOR: Yes, he did.

MR. WILKINS: He probably ran through some doors that he was not supposed to.

MR. CATTON: That's what I thought that he did, and that he no longer works for the utility.

[Slide.]

MR. HANSON: We then combined the hardware faults and the human errors to look at the sequences, and we examined sequences that were not only involved in the normal power operating mode, but also in startup and shutdown, and in fact, in the case of one particular plant, it was in the startup and shutdown that it appeared that there was the potential for the increased human error in causing an ISLOCA.

We then developed event trees, detailed event trees, based on three possible phases: an initiation phase, where the breach would occur as a result of isolation boundary failures; and second then was events that would determine the rupture probability and location size, and this would be addressed in detail in step four, and in subsequent presentation; and then events that would involve detection and diagnosis and mitigation. And these events, of course, are related both to the human factors and to the capability, for instance, for valves to be able to close and isolate.

We then estimated the event thermal-hydraulic timing. These were quite simple calculations.

To be quite frank with you, Dr. Catton, I'm not sure what RELAP5/MOD2.5, whatever else it was --

MR. CATTON: Slash V3d3.

MR. HANSON: Yes. The calculation were really done in two different parts. The B&W plant was evaluated with MOD2.5 in the fairly simplified calculations that were made. The later plant, the Westinghouse plant, we used RELAP5/MOD3. The particular V3 whatever it is I don't think anybody here could answer that.

MR. CATTON: So in essence, what you did is some calculations with an undocumented code?

MR. HANSON: Well, in the case of MOD2.5, that was done when the MOD3 was being developed. So there was not a MOD3 available at that time.

MR. SULLIVAN: Ivan, that's close enough.

MR. CATTON: What?

MR. SULLIVAN: He's close enough.

MR. CATTON: You think so?

[Slide.]

MR. HANSON: Moving on, then. I don't want to spend very much time on this slide, because, as I indicated, there will be quite a bit more detail given in subsequent presentations, since this is a fairly unique feature.

To estimate the rupture potential, we relied on some work done by IMPEL to give us the median failure pressures and some distributions for the hardware.

We estimated the pressure drops in the lines in which the ISLOCA would occur, and there are pressure drops here because there are relief valves which open in these lines. They are not adequate to provide complete pressure protection, but they do cause significant pressure drops in the lines themselves.

We developed event trees. And these event trees are more along the lines of the NUREG 1150 event trees where we used a particular code that they had developed, to analyze them in a kind of a question and answer format, and then estimated the relative frequencies in a Monte Carlo approach of failure.

MR. KERR: Why did you use a log-normal

distribution for the failure probability of each piece of equipment, as the report indicates?

MR. HANSON: Do you want to address that, Bill?

MR. GALYEAN: Well, what we used was a log-normal distribution for the pressure capacity of each piece of equipment. And that's supported two ways.

One is that apparently material properties have been shown to be log-normal distributed random variables. And also, the pressure capacity turns out to be a function and a combination of products and quotients of a number of factors, which then also leads to a log-normal distribution.

Does that answer your question?

MR. KERR: Well, it's sort of the answer I expected to get, which is that you don't have data for this; it was just an assumption based on the fact that a log-normal distribution is easy to use.

MR. GALYEAN: Well, there is some support, at least analytical support, for the assumption. But, yes, it's basically an assumption.

MR. CATTON: Nothing wrong with that.

MR. KERR: Well, it may warp things in one direction or another if it isn't a correct assumption. I was just curious.

MR. O'BRIEN: John O'Brien from Research.

The limited data we have does suggest that the log-normal distribution is adequate. Moreover, if you get into PRA space, virtually everybody uses log-normal distributions for capacities.

We have a long historical precedent. If you challenge that, you challenge PRA in general. And there is data to support it.

[Laughter.]

MR. WILKINS: I'm not sure that's a very cogent argument.

MR. MICHELSON: John, does that argument pertain to tubing and so forth, or just to ASME-class piping?

MR O'BRIEN: Mostly it depends on piping.

MR. MICHELSON: Because tubing, you know, methods of determining wall thickness and everything, it's a whole different game. In fact, some of it is indeterminate, by the code, because it's a part of the supporting auxiliaries like the seal system on the pump and so forth.

How do I know, you know, where the rupture will be and so forth, unless you've analyzed each of these systems? I know you've analyzed the big piping, and that's how you drew some of your conclusions. But how about the small stuff? The instruments attached to the system, the tubing that takes the fluid and runs it through the seals and so forth, is all pressurized to whatever the suction of the system or the discharge is, depending on the pump.

MR. HANSON: When we looked at the minimum size break, it screamed out, the tubing.

MR. MICHELSON: In other words, you're not worried about one-inch tubing ruptures, you're only worried about bigger pipe breaks?

MR. HANSON: That's correct. We've found that, for instance, on a one-inch break, that there's adequate inventory in the BWST and adequate makeup to the BWST that you could extend the scenario --

MR. MICHELSON: I wouldn't worry about enough water around. I'd just worry about what it does to the room that it's flowing into and what it does to our safe shutdown capability. In other words, the environment that it creates, if you can show me a one-inch pipe doesn't create an adverse environment, then that's a good answer. Whether you have enough water to make up what it's doing is not a good answer, because that's not really the concern. The concern is what it's doing to equipment required for safe shutdown.

So you do, though, cut off at some certain size and have made some kind of a determination that those are not adverse environments from the viewpoint of the equipment; is that the way you do it?

MR. HANSON: We didn't, in the determination of the size, we did not look particularly at the effect on the environment.

MR. GALYEAN: I think in most of these rooms, there are room sumps with sump pumps, which can pump approximately 150 gallons a minute total.

MR. MICHELSON: I wouldn't argue the one-inch system. I just was trying to figure out where your cutoff was.

MR. GALYEAN: On that basis, on the basis that the room sumps and sump pumps can handle these small leaks, we judge that --

MR. MICHELSON: How big is a leak from a seal on one of those pumps that you would have to contend with?

MR. GALYEAN: Well, basically, the criteria we used was if it was less than 200 GPM.

MR. MICHELSON: Maybe that's not an unreasonable number.

Now, you've determined, though, that a 200-GPM release of hot water, in fact reactor water is what we're talking about, at full temperature, and the source is at full pressure, that leak -- 200 gallons is all? Boy, that's not a very big leak being driven by 2,000 pounds pressure. I think a seal would give out bigger than that.

MR. GALYEAN: You have considerable --

MR. MICHELSON: These are not reactor coolant pump seals now by any means.

MR. GALYEAN: Right.

MR. MICHELSON: These are much, much less exotic seals. These are not designed for high pressure at all; these are 100-pound seals if it's 100-pound suction on the particular pump. And you're talking about putting 2,000 pounds on it. You're talking about a catastrophic blowout of this seal, and I just wonder, how big is that? Do you have some feel for it?

MR. GALYEAN: First of all, the analysis that IMPEL has done predicts that the seals will not fail catastrophically.

MR. MICHELSON: Even with 2,000 pounds?

MR. GALYEAN: That's right.

MR. MICHELSON: What pressure-rated seal did they look at?

MR. GALYEAN: They looked at the pumps. They looked at the high-pressure injection pumps, then the low-pressure injection pumps.

MR. MICHELSON: I was thinking more of things like RHR pumps.

MR. GALYEAN: Well, that's low-pressure; for this particular plant, low-pressure and RHR are the same.

MR. MICHELSON: And air-suction is how high a pressure?

MR. GALYEAN: 300.

MR. MICHELSON: 300 pounds suction size?

MR. GALYEAN: Right.

MR. MICHELSON: So the seals are rated at least 300 and presumably a little more. So a 300-pound seal gives how much flow with 2,000 pounds?

MR. GALYEAN: Well, I have to -- IMPEL's work has been published in a separate report. I don't have that --

MR. MICHELSON: Did they name a number, or do they just say it's a non-problem?

MR. GALYEAN: They name a number.

MR. MICHELSON: Okay. You don't recall what the number would be?

MR. GALYEAN: No, I don't recall what the number is.

MR. MICHELSON: That is really steaming up the room in a hurry, even 200 GPM, with that hot a water.

MR. SULLIVAN: Duane, how did you determine the time cutoff?

MR. HANSON: The time -- tell me what you mean by the time cutoff.

MR. SULLIVAN: If you assume that there is 200 GPM, eventually you run out of water, right? So there has to be a time.

MR. HANSON: No. In fact, you don't, you would run, take an extremely long time to run out of water, because of the size of the BWST and the capability to make up to the BWST. So they were approximately the same, the 200-GPM leakage and the makeup. I think the makeup to the BWST is like 150 GPM and there's on the order of 450,000 gallons of water in the BWST.

MR. SULLIVAN: But wasn't there a time cutoff in there that you said if you got past this time, you had enough time to correct the action?

MR. HANSON: I don't remember us giving the time cutoff.

MR. GALYEAN: Not explicitly.

MR. HANSON: No.

MR. GALYEAN: We assumed that it was on the order of days or weeks, that it was not a concern.

MR. MICHELSON: You mean 200 gallons a minute for weeks, into the reactor, into the auxiliary building? Is that what you're saying?

MR. GALYEAN: Right. Right.

MR. MICHELSON: And that was a non-problem for the redundant equipment needed to cool the core?

MR. GALYEAN: We assumed that, on the analysis that we did, we assumed that the break would be isolated long before that.

MR. MICHELSON: Oh. Wasn't that the question, how long before you isolate, stop this thing?

MR. GALYEAN: Right.

MR. MICHELSON: And what was the estimation of the isolation time?

MR. GALYEAN: For the high-pressure make-up sequences, it was four hours, and for the low-pressure DHR sequences, it was eight hours.

MR. MICHELSON: So, at the 400 gpm, 8-hour full, it was still a non-problem for the auxiliary building.

MR. GALYEAN: Two hundred gpm flow with a net -- with 150 gpm discharge due to the sump pumps. So, it's a net --

MR. MICHELSON: Sump pumps aren't taking much of this. You know what happens when you flash 2,000 pounds of water at 560-80 degrees. You don't worry about the sump pumps.

MR. GALYEAN: That's right.

MR. MICHELSON: You worry about the steam running through the building.

MR. GALYEAN: The area were the leak occurs -- as we said before, everything has failed.

MR. MICHELSON: Yes, I got that part. But now, that steam never got out of this room, apparently.

MR. GALYEAN: Well, that's the assumption we made.

MR. MICHELSON: In four hours?

MR. GALYEAN: Right.

MR. MICHELSON: At 200 gpm volumetric flow into the break.

MR. WILKINS: With leaky doors.

MR. MICHELSON: Yes, the leaky doors.

[Slide.]

MR. HANSON: Our next step, then, was to perform the human reliability analysis, and again, there will be a detailed presentation on this. I have just listed the steps here that will be reiterated by David Gertman, and there are some unique things that were done here, and in fact, as he discusses them, we'll talk about errors of commission, which were looked at in detail.

[Slide.]

MR. HANSON: Based on the rupture probabilities, then, the rupture information, the human reliability analysis, and data on the hardware, we used these inputs, then, to quantify the event trees, both in the sequence initiators, which could either be hardware or human error initiated.

The rupture probabilities, then, of course, came from the combination of the IMPEL and INEL analysis, and detection diagnosis, isolation, and mitigation from the HRA results from the capabilities of valves, for instance, to close under the ISLOCA condition and from the capabilities of systems to scrub the fission products, because in our case, when we're talking about mitigation, we're talking about mitigation of fission product release, and at least, in one of the particular plants we looked at, we didn't find a high likelihood that there would be mitigation of fission products.

MR. MICHELSON: How does your analysis now take account of -- you have a finite probability you weren't able to isolate the break. That's what your valve capability is involved.

Then, assuming that you went down the branch where you were unable to isolate the break and then your calculation went on to a new conclusion, but the new conclusion still said that the break was still confined to the one room in which the break occurred, even though you were unable to isolate this?

MR. GALYEAN: No, I wouldn't say that. I would say nothing else really matters. Once you start in the realm of core damage and releasing fission products to the environment, it doesn't matter whether the equipment in the next room fails.

MR. MICHELSON: Let's assume for the moment that your tree went down to the seal failure, so 200 gpm, and you said I can take 200 gpm forever, or for many hours. The analysis, though, says that I will just keep releasing this magnitude, and it still said the environment was confined.

MR. GALYEAN: Well, we say that during that time that the control room operators will get their act together and isolate the break.

MR. MICHELSON: If they can.

MR. GALYEAN: That's right.

MR. MICHELSON: Presumably, what they tried to do was isolate, and that's the valve that didn't work. Is that right?

MR. GALYEAN: No. I guess I don't follow that.

MR. MICHELSON: Well, you don't always have many, many valves back to the source. You may only have one inside the containment, maybe two, and those are the only ones protected, really, from this adverse environment, to begin with.

MR. GALYEAN: That's right. We assume those valves --

MR. MICHELSON: There was a finite probability they didn't work.

MR. GALYEAN: That's right.

MR. MICHELSON: That's what valve capability was all about.

MR. GALYEAN: That's right. And if the valve doesn't work, then you're going down to core damage and release to the environment.

MR. MICHELSON: You mean your tree just took you right down to core damage?

MR. GALYEAN: That's right.

MR. MICHELSON: Okay. It didn't try to understand further what you might do. Okay.

MR. CATTON: So, there is some question here as to what unreliability you use for those valves.

MR. GALYEAN: Typically, we use both a combination of human error -- you know, the operators not doing what they're supposed to do -- and also the hardware failure probability or the valve failing to close, and we combine those two, and that's the failure probability.

MR. CATTON: And you used, essentially, 1150 numbers.

MR. HANSON: No. We didn't use 1150 numbers. We used primarily generic data from a number of different sources. We didn't really draw any information from 1150. We probably used a number of the same sources 1150 used, although we haven't checked that to see if that were the case or not.

MR. CATTON: I would be interested in knowing what that unreliability number that you used was.

MR. HANSON: Reliability number for the closure of valves?

MR. CATTON: Right.

MR. HANSON: A particular valve?

MR. CATTON: Any of several valves which were key in redirecting the event.

MR. MICHELSON: I think you did tell me, though, earlier, that you looked at each of those key valves and determined the motor operator was more than adequate or at least adequate.

MR. HANSON: In the case of one plant, that's true.

MR. MICHELSON: Well, in the case of the one that we're going to get our numbers on, is that the case?

MR. HANSON: That's right.

MR. MICHELSON: Okay. However, you assumed that if the motor was big enough, then there was no effect on the probability of closure.

MR. CATTON: We know that's not right.

MR. MICHELSON: And we know that's not right. We went through that a little while ago. But that's the approach they used, I gather.

MR. HANSON: Did you not apply failure probabilities to those valves?

MR. GALYEAN: Right. The failure probability was then just a random hardware failure problem.

MR. HANSON: Generic.

MR. MICHELSON: Generic.

MR. HANSON: We didn't enhance that because they were under higher pressure.

MR. MICHELSON: It's probably 1 in 1,000 probability of failure. It's traditionally the one used.

MR. GALYEAN: That's approximate.

MR. MICHELSON: Well, we know that's maybe off a magnitude or two under these circumstances.

MR. KERR: Well, it depends on how many of these failures occurred at full power and how many may have occurred at start-up or shut-down. That would influence the valve performance to some extent.

MR. HANSON: That's correct, and it would also depend on the size of the break, because if it were a large break, the system would be at low pressure, and therefore, you might have enhanced flows, but the pressure may be down substantially.

MR. KERR: Did you use a source term for immediate shutdown after operating at full power in all cases? I notice you use an adjusted source term from the Oconee PRA, but was it a full power source term for all cases?

MR. HANSON: Yes, it was. What we tried to do was to be prudent in our analysis here. We didn't develop a source term for individual plants but used source terms from similar plants and then scaled them based on power, and we did use a full power source term.

[Slide.]

MR. CATTON: The MACCS code is a new code, isn't it?

MR. HANSON: It's one that was used in NUREG-1150. If that's new, I guess it's new.

FROM THE FLOOR: The old code was CRAC.

MR. HANSON: Yes.

MR. CATTON: This replaced it, as I understand.

MR. HANSON: That's correct.

We used a -- normalized to a site. We didn't use a site for the particular plant. The way we normalized to our site was to first identify an average site based on the -- in the United States, based on the weather-weighted population density that was published in the Sandia Siting Study.

This average site was then compared to those sites that had existing MACCS models and, in particular, those that were available from NUREG-1150, and selected a site based on a match, the closest to the average population density that we determined previously. This site was the Surry site, and therefore, the numbers you'll see on consequences are for the Surry site.

MR. SULLIVAN: Did you adjust the net data?

MR. HANSON: No.

MR. SULLIVAN: So, what you're saying is the Surry net data is like Davis-Besse.

MR. HANSON: No. We're saying we normalized to an average site. We're not saying how the consequences would relate to the plant at its site.

MR. SULLIVAN: I wouldn't exactly call that Davis-Besse from then on then.

MR. HANSON: I don't believe we have.

MR. SULLIVAN: In the report, it says that you selected those plants in the very front of it.

MR. HANSON: We selected those plants. We selected different sites.

[Slide.]

MR. HANSON: Our final step, then, is our sensitivity studies, and we used those to help us better understand the effects of what we determined to be important parameters.

We looked at the types of studies that should be considered, for instance, to help us evaluate the sensitivities to parameters that might have uncertainties that are large, uncertainties, for instance, in rupture probability of a component or piping that was determined to be very important, we examined.

We looked at estimating change in core-damage frequency to potential changes in the plant hardware operations, examined potential changes that might be made to enhance or to improve risk and, also, alternative methods of establishing probabilities.

So, we're using our sensitivity studies to help us examine important parameters.

Now, the sensitivity studies that we're going to be talking about with you today, there are some in the report you have. We have done others, and we'll be discussing some of those today.

Before I finish up, though, I'd like to talk to you about, or share with you, two important pieces of information that have come about; one of them, at least, which has come about since the report was issued.

[Slide.]

MR. HANSON: We have performed some additional analysis based on the comments that we received on this draft report which you have and have reviewed, and as a result of that, the results we'll be presenting today don't exactly reflect the results that are in that report, because we have done things to, we believe, improve the analysis, in several different areas.

We have looked at the thermal-hydraulic estimates for the large and small break timing, and I believe someone brought up the fact that, in some cases, the analysis is mentioned as being conservative in the report.

So, we looked at a better estimate, what we believe to be a better estimate of the timing for large and small breaks, and in fact, the timing, in most cases, was about a factor of two larger.

We also performed some additional HRA analysis to incorporate reviewers' comments and, also, to reflect the differences in timing that we obtained from the less conservative thermal hydraulic results.

We looked at, also, modifying our quantification approach to allow performance of uncertainty analysis. The original codes that we had used to perform the analysis were based primarily -- or were not capable of doing the types of uncertainty analysis that needed to be done here, and therefore, we changed the code and had to modify some of our quantification then.

MR. KERR: Your first bullet could be interpreted to mean that you are still using conservative estimates but just less conservative.

MR. HANSON: If you look at what can occur -- take an example of a small break. If you look at what can occur during a small break, you could probably get a range of time from what we published in the report you had, which was about four hours, probably out to infinity, just depending on what the operator would do and what he could do.

So, we tried to make best-estimate assumptions, but it's hard to -- you know, it's very difficult to say exactly what the operator will do, and so, you have to make assumptions on what he will do, and some people might interpret those assumptions to be conservative. We didn't.

MR. KERR: So, your assumptions are not deliberately conservative --

MR. HANSON: That's correct.

MR. KERR: -- although they might be interpreted by others as being deliberately conservative.

MR. HANSON: That's right. Yes.

MR. CATTON: Duane, in your report, Harold has pointed out to me where you refer to Davis-Besse risk. If you stuck that plant into a different kind of population, maybe you ought to reword that, wherever it occurs.

MR. HANSON: Okay.

MR. CATTON: And this is in your conclusions.

MR. BURDICK: Let me repeat: The names of the plants are going to disappear in the final. It's just not really the Davis-Besse plant. We have done a normalization to a "average" plant to get the risk.

MR. CATTON: I hear you, but I am learning that you have to be very careful about context.

MR. BURDICK: Certainly.

MR. HANSON: We agree with that.

MR. SULLIVAN: After this meeting, it is not going to be anything but publicly known.

MR. HANSON: We understand that.

MR. BURDICK: That's true, and we will try to deal with that. We are going to give the licensee, Davis-Besse, a copy of the report to examine the bases, but still, it is a hybrid analysis.

We will try to make that clear, and we're going to try to do that with all three of these analyses, and the reason is we don't have the money or the time to examine each one of these plants. We have to somehow try to get an assessment of the industry, and we're trying to do that by an average plant approach.

It's the one thing that -- again, the ACRS has recommended to the Commission that the staff try to do it.

MR. KERR: Mr. Hanson, on page 12 of the report, under sensitivity studies, there are two sentences.

"Each sensitivity case was performed on the models themselves, rather than through some type of estimation technique. This not only provides for an accurate estimate of the issue importance on risk and core damage frequency but also allows for an estimation of the importance of models and modeling assumptions."

What does that mean? I didn't understand what it meant.

MR. HANSON: Do you want to address that, Bill?

MR. GALYEAN: First of all, if you're familiar with what was done in 1150, they had a code. I think they call it RISKUE or something. That basically took the results of a number of different analytical codes, put it together, and then they used that to perform a number of sensitivity studies, where they sort of empirically varied the results to see what kind of final result they got.

When we do a sensitivity study, we start at step one and propagate that difference through the entire analysis. That's what's meant by the first part.

For the second part, because we're using all of our codes and all of the methods that we use, we can make some changes in, for example, the -- in some of the parameters, simply for the sake of testing that particular model's effect on the final results. We can exercise the models themselves to see what effect that has on the final results.

MR. KERR: By exercising a model, does that mean you change the model somewhat?

MR. GALYEAN: We can make some different assumptions, for example, on how we assume a different probability distribution for a certain parameter. We can change that probability distribution and see what effect tha that has on the final results.

We can try different -- well, that's basically the intent.

MR. KERR: Thank you.

MR. CATTON: And you're operating under the assumption, if it's RELAP 5, that 2, 2.5, and 3 are close enough that you don't have to worry about differences. Is that right? Right now, 2.5 just really bothers me.

MR. KERR: That's because he grew up in an age in which there were Roman numerals.

MR. CATTON: If it's not too important, that's one thing, but if it turned out that the thermal hydraulics calculations play an important part, then what were the changes between 2 and 2.5 and why did it go to 3?

MR. HANSON: In fact, the thermal hydraulics calculations were quite simple, and there were two types done.

One was basically a six-volume model of the entire reactor coolant system, including the interfacing system LOCA piping, and this was only to help us get a rough idea of what the break flow would be.

The other type of models were some fairly detailed models of the low-pressure piping, but the only intent here was to look at the pressure drop in that piping. If there had been enough time and the people available, a person could do that type of a calculation by hand. We felt, because of the variations we needed to look at, that it would be quicker to do it with the RELAP 5 code.

So, the calculations with the code are fairly simple, and if you got back and read the appendix on how we estimated timing, our estimates of timing were basically very close to hand calculations themselves. We just tried to match break flow and injection flow and look at how long it took to empty the BWST.

MR. CATTON: The only thing is that you make a point in the report of having used RELAP 5/Mod 2.5/Version 3d3.

MR. HANSON: I understand what you're saying.

MR. CATTON: I think, in a month, nobody is going to know what the hell that is.

MR. HANSON: I agree. And we will clarify that.

MR. CATTON: I think you should clarify that.

MR. HANSON: We will.

MR. CATTON: Either take it out or do something.

MR. HANSON: Right. I agree.

[Slide.]

MR. HANSON: The last thing I'd like to do is just to point out some important considerations to look for in the following presentations.

There are some things that -- I don't want to present the results at this time, but let me ask you, as w go through, to look at the effect of human actions as initiators for an ISLOCA -- this includes errors of commission -- and also to look at the relative contribution of human errors and hardware failures to ISLOCA, core-melt frequency, and risk, and I think what you're going to see here is a distinct difference between some plants

The first plant we'll be talking about the B&W plant, and it has some distribution of relative contribution, but when we look at the Westinghouse plant, you're going to see something quite different, and of course, the Westinghouse plant are preliminary results, but they are different.

MR. MICHELSON: When you talk about "hardware failures" in the second bullet, do you mean the failures of equipment that were adversely influenced by the environment or just the valves that were required to isolate the ISLOCA?

MR. HANSON: Primarily in the area of initiators, hardware that could fail to initiate an ISLOCA.

MR. MICHELSON: These are hardware initiators.

MR. HANSON: Yes, although there would be some in the mitigation, as well.

MR. MICHELSON: But not consequential failures. Was a valve failure during mitigation considered a hardware failure?

MR. HANSON: Yes, it would be.

MR. MICHELSON: But the devices in the room that were failed by the break were not considered hardware failures. Is that where you draw the line?

MR. GALYEAN: I guess I don't understand the point. I mean the equipment's failed, and in our analysis, we assumed the equipment's failed.

MR. MICHELSON: This second bullet talks about "hardware failures." My question is what hardware? Does that include the hardware in the room that was --

MR. GALYEAN: Yes.

MR. MICHELSON: -- that was destroyed? Okay. So, you -- okay. And you're saying that that is still a minor contributor, that the human factor was the major contributor.

MR. HANSON: Well, I don't think that -- the slide doesn't say that. What it says is you need to pay attention to the relative contribution of the two.

MR. MICHELSON: Yes. Yes, you certainly do.

MR. CATTON: Your Executive Summary said that.

MR. KERR: On page 37 of the report, under human reliability analysis, I find the following sentences:

"It's also important to recognize that the total ISLOCA risk is not only from any single event, such as the early entry into DHR shutdown cooling procedure identified in this report. Rather, the identified risk is a significant example of an error of commission resulting in ISLOCA but not necessarily the only error of commission which could lead to similar events at other commercial plants."

Then the sentence, "It is believed that this cognitive error is the most risk significant error." What "cognitive error"? There must be a sentence left out of the paragraph or something.

MR. HANSON: I think the Human Factors people are considering this error of commission to be an error of cognition.

MR. KERR: You mean all errors of commission are cognitive?

MR. HANSON: No, I don't believe so. The particular one we're talking about here turned out to be that type.

FROM THE FLOOR: What is the particular one you're talking about?

MR. HANSON: Early entry into the DHR shutdown. The sentence isn't clear.

MR. BURDICK: There is a little pronoun reference problem there. We can clear that up.

MR. KERR: Okay.

MR. BURDICK: This is going to be covered in detail shortly.

MR. KERR: Okay. Thank you.

MR. HANSON: We would encourage you, as we go through, to examine or to pay attention to the components that would fail when exposed to overpressure -- this, I think, is at least one of the first attempts to predict one of the components and their relative fragilities -- and the importance of detection, diagnosis and isolation and mitigation in reducing risk, and I think we find that, in the case of the B&W plant, at least, there was quite a bit of credit given for these things that helped to mitigate the effects of an ISLOCA, and finally, the influence of procedures, instrumentation, and training on the capabilities of plant personnel to reduce ISLOCA risk.

MR. KERR: In that connection, on the bottom of page 53, there is a statement: "At Davis-Besse" -- and I realize that's going to be taken out of the report -- "there are no ISLOCA procedures available, and it is assumed until data are discovered to the contrary that there is an inherent background error rate in the reading and execution of procedures."

The people at Davis-Besse would say, I think, from conversations that I had with them, that they don't need ISLOCA procedures, that they have symptom-based procedures, and so, from their point of view, they do have ISLOCA procedures, and I think that the report ought to make that clear, because I think it's an important part.

MR. HANSON: This point has come up a number of times over the past six months as to the adequacy of the existing procedures to handle an ISLOCA, and I guess it is our judgement that they wouldn't do that very well.

MR. KERR: I don't disagree with that, but I am saying I think, instead of making a statement that way -- because I think it's an important point -- you should say they have procedures. symptom-based procedures, which were considered to be capable of handling this, but we don't think they will.

If it's true -- and I have no reason to doubt it -- it's an extremely important point, I think.

MR. HANSON: All right.

MR. BURDICK: It is an important point, and again, when you see the word "ISLOCA," you should read "ex-containment ISLOCA," and in some cases, the licensees will have LOCA procedures, they'll have ISLOCA procedures, but the procedures may not get them to the point where they understand they have an ex-containment ISLOCA.

MR. KERR: I'm not disagreeing with the conclusion, Gary. I think, from what I have seen, the conclusion is probably valid.

I'm saying that these guys, and perhaps other people, think they have procedures which will handle this. You have concluded that they are wrong, and if that's the case, I think it's important that this view get into the public domain fairly soon, so that people will look at it.

MR. CATTON: If the symptoms don't tell them about ISLOCA, they're not going to do them any good.

MR. MICHELSON: Is it true that there are some systems whose interface between high and low pressure is inside of primary containment?

MR. BURDICK: [Yes.]

MR. HANSON: [Yes.]

MR. MICHELSON: There are some? Can you give me one example so I get a feel for the kinds we're talking about?

MR. BURDICK: Core flood tanks, check valves.

MR. MICHELSON: Okay. Yes, quite right. Yes. That's the kind you're talking about. Okay.

[Slide.]

MR. HANSON: Let me just finish up by indicating what's going to be coming down the pike here in the next few presentations.

On your agenda, we show two presentations that would summarize the estimation of rupture potential. In fact, we have combined those into one presentation, and that will be presented by Bill Galyean, and Dr. O'Brien has agreed to support him if there are any detailed questions in the area of materials analysis, stress analysis.

Following his presentation, David Gertman will talk about some of the unique aspects of the human reliability analyses. Then we'll have presentations on the overall results from the B&W plant, given by Bill Galyean again, then preliminary results from the Westinghouse evaluations, given by Dana Kelly, and then conclusions by Bill Galyean.

MR. CATTON: If you could keep the combined talk down to around 30 minutes, I would be in your debt.

MR. GALYEAN: I will do my best.

MR. CATTON: Thank you.

[Slide.]

MR. GALYEAN: Just to set the tone a little bit, we went into this analysis with the idea that we need to do accurate estimates or realistic estimates of the probability of ruptures in the interfacing systems. Specifically, we needed to identify which components are likely to rupture, what the likely rupture locations were, and also the size of the ruptures.

[Slide.]

MR. GALYEAN: The approach that we put together is basically a probabilistic approach. Because of the large uncertainties involved in this type of analysis, we didn't think a realistic, deterministic approach would be adequate.

Thereby, with this probabilistic approach, we can consider things such as preexisting flaws in equipment -- for example, piping -- and also, we can handle uncertainties with respect to variations in the expected pressures being seen by this equipment.

[Slide.]

MR. GALYEAN: I will just go through real quickly.

The calculation that we put together is basically a stress-strength calculation. The strength is based on the work done by IMPEL, who estimated the capacity, the pressure capacity of the interfacing system components. That work, by the way, has been published in a NUREG/CR. It came out about a month ago. It's just titled "Pressure-Dependent Fragilities for Piping Components," NUREG/CR-5603.

The stress on the system would then produce the -- is generated by the pressures inside the interfacing systems. In estimating the stress, we included effects such as relief valves and flow restrictions, such as orifices and small pipe size and things of that nature.

MR. MICHELSON: With that approach, how do you estimate the rupture size?

MR. GALYEAN: Well, the rupture size is done in the first step, when the pressure capacity is being estimated.

MR. MICHELSON: You think the rupture size is independent of the degree of overpressurization, for instance?

[Slide.]

MR. GALYEAN: No, we don't think that.

MR. MICHELSON: How do you determine the rupture size in proportion to the degree of overpressurization?

MR. GALYEAN: Well, the rupture size is a function of internal pressure.

MR. MICHELSON: Yes. But how do you determine how big it is? Do you do that calculation?

MR. GALYFAN: Yes, we do that.

MR. MICHELSON: Some kind of a stress calculation which will predict the propagation of the crack and how far the thing splits open?

MR. GALYEAN: Yes.

MR. MICHELSON: Is that in that -- I got that document.

MR. GALYEAN: Yes.

MR. MICHELSON: It's in there?

MR. GALYEAN: Yes. There are estimates. There are pressure-dependent estimates of leak sizes and leak areas in this report.

MR. MICHELSON: And it's wall-dependent and so forth or stress-dependent somehow. You've got to relate it back to stress somehow.

MR. GALYEAN: That's right. That's right.

MR. MICHELSON: And that's in there. Okay.

MR. GALYEAN: That's right.

MR. MICHELSON: Good.

Now, how does that affect the probability of failure, since probabilities are based on experience or something, aren't they? And if there is no experience with these--

MR. GALYEAN: I think I will cover --

MR. MICHELSON: -- this database for this degree for several times over design.

MR. GALYEAN: I think I am going to get to most of these questions in just a few minutes.

MR. MICHELSON: Okay. I'll listen. Thank you.

MR. GALYEAN: The pressure capacity valuation, as I mentioned, done by IMPEL and published in the NUREG/CR, had three major objectives: first, to develop a methodology to do this work; second, to determine median failure pressures and their associated uncertainty; and lastly, when failures are expected to occur, determined the expected leak rates or leak areas.

[Slide.]

MR. GALYEAN: IMPEL was chartered or tasked to look at the interfacing systems that were identified previously in the analysis. Specifically, they are the decay heat removal, low-pressure injection system, which are one and the same system; high-pressure injection and the makeup and purification systems which, at the plant we looked at, are two different systems.

All components in the systems were looked at; specifically, pipes, tanks, flanges, valves, and pumps.

MR. CATTON: If one wanted to track down how good the predictions were, how would you do it?

MR. GALYEAN: Well, for some pieces of equipment, there are test data available. Okay? Specifically, for like flanges, flange connectors, there have been tests run on flanges.

The pipes are probably -- there probably is no hard data available on pipes.

MR. HANSON: I think there are data available on pipes, some done by Oak Ridge.

MR. MICHELSON: Pipes are better at that.

Flanges, I am not aware of any where you use several times design pressure and saw what happened to the bolting. Are there data that tell you when a valve box is going to come flying off, at what pressure, because the bolting now yields and it all gives?

These have been done for over-design, but -- I mean overpressurizations, but not several times design.

MR. O'BRIEN: My name is John O'Brien.

In the case of valves, most of the information we have came from manufacturers. Those information were not analytically developed. The analytical stuff was for the piping and the flanges.

MR. MICHELSON: But you certainly can calculate the fracture of the bolting. There is a pressure internally at which the bolts will all fracture and the thing will come apart.

MR. O'BRIEN: We could have done it that way, except that we had manufacturers data.

MR. MICHELSON: I'd like to have a feel for whether we're talking about four times design that that occurs at or ten times design. I don't know.

Certainly, some bounding kind of examination would be far more meaningful, wouldn't it?

MR. O'BRIEN: Yes. As I recall -- and I'm talking from memory -- for the cases of pumps and valves, they had substantial margin, like maybe a factor of two, three, or four.

MR. MICHELSON: Like pipes. They have substantial margin, too.

MR. O'BRIEN: Right.

MR. MICHELSON: But that doesn't help me much if I am trying to determine the leak size. If a valve bonnet comes off, I know what the leak size is, there is no doubt, and it's extremely large. But I'd like to know.

Maybe the bonnet bolting fails before that pipe fails. I don't know. I don't have any feel for this. And

I don't know that I have seen the data that tells me what will happen.

MR. O'BRIEN: It's usually the seals that fail.

MR. MICHELSON: I'm not worried about leaks. The seals will start failing, but these degrees of overpressurization, that leak isn't going to relieve the pressure enough.

MR. HANSON: The relative -- what fails first, second, or third, I don't think we got into in detail, but there are -- in their data, there are indications of when a flange would fail versus, say, a pipe that would be next, based on pressure.

MR. MICHELSON: Now, "fail," by definition, was leak, or "fail" means the bolting breaks.

MR. HANSON: As I recall, in cases of flanges, there were a couple of different leak areas looked at. A small leak, your bolts would relax and cause some separation of the flange faces.

MR. MICHELSON: If that relieved the pressure, that's as far as it would go.

MR. HANSON: That's right. And then there was a larger leak where, as I recall, the valves themselves failed.

MR. MICHELSON: The bolting.

MR. HANSON: The bolts failed.

MR. MICHELSON: That's where you can't relieve quick enough, and the pressure stays up, and it pops the bonnet off.

MR. HANSON: Yes.

MR. MICHELSON: I think it's more important to know that, perhaps, than even how the pipe can stand, because pipes are a much more predictable, much more conservatively-designed than perhaps are the flange boltings, for instance. People have ruptured bolts, and then you've got to know where the torque is on the bolt when you start out. There are a whole lot of things you've got to know.

These bolts are not worked as lightly as some people believe. Some of them are heavily worked, with a lot of normal torqueing.

MR. GALYEAN: That's right. We collected and IMPEL utilized such information such as the material used in the bolts, how far they were torqued, the type of material used in the gaskets.

The put in a factor to consider bolt relaxation, and they looked at the pressures required where the bolts would stretch both elastically and then plastically. These were all taken into account in the IMPEL work. Okay?

The bottom line was that they were trying to do a realistic pressure estimate on the capacity of this equipment.

MR. MICHELSON: Well, assuming that you didn't get adequate relief from the leaks starting in the flange, did they predict at what point the flange bolting would fail, at what level of overpressure, four times design of the system?

MR. HANSON: Yes, they did.

MR. MICHELSON: So, it's about the same? Was that the answer they came up with?

MR. GALYEAN: It varies. It varies by the size of the flange. I mean when you start getting up into bigger and bigger flanges -- for example, a 150-pound flange and 300-pound flange may each use 6 bolts, but then when they go to a 600-pound flange, they may use 12 bolts. Okay? So, it's not a smooth relationship.

MR. MICHELSON: But you don't have any rules of thumb, then.

MR. GALYEAN: No.

MR. HANSON: We just haven't looked at the data to see if those rules of thumb are available.

MR. KERR: But you developed a normal distribution for these, didn't you? You didn't just use one number.

MR. GALYEAN: That's right. That's right.

MR. SULLIVAN: I think there are three cases in there that it could go to. There is a leak, and then the valve -- ended up valve failure.

MR. GALYEAN: Are you talking about the flanges?

MR. SULLIVAN: Yes.

MR. GALYEAN: Okay. Very minuscule leaks, on the order of milligrams per second, and then you get up into a portion where the valves start to stretch elastically, and then you get up into higher pressures and the valves start to stretch plastically. Is this what you're referring to?

MR. SULLIVAN: Yes.

MR. GALYEAN: Okay.

MR. SULLIVAN: I can't believe that -- I couldn't ever see a case that you would only have a leak in a gasket. It looks like it would go from one case to the other.

Was that an important parameter?

MR. GALYEAN: It turned out not to be important.

Flange leaks were not very important, because typically, when you get up into the plastic -- when the valves start to stretch plastically, you're above the pressures at which we're interested, and in that in-between regime, where you're talking about the bolts stretching elastically, you're still talking about very small leak rates.

It's only when you start getting up into the elastic range where you start to develop large leak areas.

MR. SULLIVAN: Well, you know what the pressure is. Right?

MR. GALYEAN: That's right.

MR. SULLIVAN: And you can't leak enough out of a seal leak to make any difference at all.

So, it looks like it goes from one case to another one almost instantaneously.

MR. GALYEAN: I guess I don't understand the question.

MR. SULLIVAN: I'm saying if it leaks -- if we're depending on it leaking to relieve the pressure so that it doesn't go someplace else, then it just isn't going to happen.

MR. GALYEAN: That's right. We agree.

Flange leaks did not figure significantly into the analysis. Okay? They don't develop large enough. They don't develop large enough leak areas to depressurize the systems.

MR. MICHELSON: And the reason?

MR. GALYEAN: Because they're strong enough to withstand.

MR. MICHELSON. Well, suction sides of pumps have gate valves on them. You just go back far enough. The next device at the suction side is a valve, and it's generally a gate valve, although it may be globe.

But at any rate, there is a gate valve, and it will be a 150-pound valve, but it will not be rated for 900 or whatever, because it’s all low-pressure piping. The suctions of the pumps are rated this way. They can’t take full pressure. And the piping is rated that way and so are the valves.

So, you’re talking a 150-pound valve on a -- it’s close to 2,000 pounds pressure if you’ve got the interspacing system LOCA developing.

MR. BURDICK: I think we’re very much in danger of getting very confused here, because we’re getting ahead of things. We don’t know. We don’t know that we are at full system pressure, because in this analysis, we analyzed sequences where you are coming down in pressure and you may be going up in pressure.

So, no, you do not know what pressure you’re at. You don’t know that you are at full 2,200 or 2,100.

MR. MICHELSON: You know the scenario you’re analyzing, and you’re saying there are no interfacing systems at scenarios at 2,200, then, I guess, that could affect this 150-pound valve. I think that’s the bounding condition. If you’re down in pressure, you’re not going to blow the bonnet.

MR. HANSON: I’d suggest that maybe we just proceed with the presentation, and he will get into and, in fact, show you a ranking of probabilities of different components in a particular system rupturing and the difference, whether they may be large leaks or small leaks and that sort of thing.

[Slide.]

MR. GALYEAN: To just finish up on this slide, as I mentioned, the pressure capacities are assumed to be log normal random variables, and the analysis assumed quasi-static pressure and temperature conditions, which was based on the simple RELAP 5 models that were developed and run.

[Slide.]

MR. GALYEAN: To just briefly touch on some of the results that were generated by IMPEL, as you can see, some -- all this equipment is from the DHR system at the B&W plant. There are 12-inch and 18-inch pipes on the DHR suction lines, and these are rated at 1,660 psi and 840 psi respectively.

Both of these are designed for 300 psi. Both of these, I think, are designed for 300 psi. The 300-psi-rated flange can take 2,250 psig, and also, the heat exchanger also turns out to be one of the weaklings in the system.

MR. MICHELSON: Now, you realize that valves are not designed with a particular rated bonnet flange. That's a part of the valve vendor's design.

MR. GALYEAN: Right.

MR. MICHELSON: It doesn't have a unique degree of conservatism. I don't know -- depending on how the valve vendor has cast his body. It's all an integral cast arrangement.

MR. GALYEAN: Right.

MR. MICHELSON: You've got to do the analysis on the particular valve --

MR. GALYEAN: That's right.

MR. MICHELSON: -- and its flange, and it may or may not be as good as a 300-pound flange. I just don't know.

MR. GALYEAN: That's right.

MR. MICHELSON: And the bolting is the same argument.

MR. GALYEAN: We collected specific information on specific valves at the plant we were looking at.

MR. CATTON: From the valve vendor?

MR. GALYEAN: We collected vendor packages from the utility.

MR. CATTON: Well, you all know how optimistic the manufacturers can be.

MR. MICHELSON: And you were actually able to get a dimension drawing of the valve?

MR. GALYEAN: Yes.

MR. MICHELSON: That's unusual, because they don't like to give you those.

MR. GALYEAN: It was very difficult, and we are forever in our debt to the utility for cooperating with us in this. We got vendor packages that had dimension design drawings and things for all the equipment we're looking at.

MR. HANSON: And in fact, the B&W plant is the only plant we have gotten that information on.

MR. GALYEAN: That's right.

MR. HANSON: We have not been able to obtain similar information from other plants.

MR. MICHELSON: One of the problems to be careful of on valve flanges is that they are cast, not forged, and there is a whole lot of difference in the homogeneity of the material. You just don't know how good it is.

MR. HANSON: I guess we did get that similar information from the Westinghouse plant, as well, on the valve bodies themselves, but not on the operators. It was the operator information we're missing.

[Slide.]

MR. GALYEAN: The local RELAP I alluded to before were developed using RELAP 5 models. We assumed -- these systems are -- all these systems are normally kept filled. The calculations assumed were simplified such that the calculations assumed a steady state RCS, which we believed is justified, that is, it's only very slightly conservative. Because the -- once the pressure isolation boundary is opened and the interfacing system is pressurized, it reaches equilibrium very quickly.

There are some cases where small relief valves, in combinations with flow restrictions, flow orifices or small pipes will protect certain portions of the interfacing systems.

[Slide.]

MR. GALYEAN: These 2 sets of data then, the -- the pressure capacities and the local system pressures were then combined in an event tree format, such that each -- each component in the system was represented by a series of questions in the event tree.

MR. MICHELSON: Just let me ask, in the case of the pumps, of course, the same problem was with the valves, you don't have drawings of the thicknesses of the nozzles on the suction side of pumps. Did the vendors give you the information with which to do the stress analysis?

MR. GALYEAN: Yes.

MR. MICHELSON: Thank you.

MR. GALYEAN: The approach, it was a Monte Carlo - - once the event tree was developed, a Monte Carlo approach was -- was taken, whereby we sampled a reactor coolant system pressure and scale it, based on our RELAP models, for the different portions of the interfacing system, then extracted or sampled from pressure fragility distribution for each component and compared the 2.

As I mentioned, the local system pressures were assumed to be a function of RCS pressure, which we, in turn, assumed was -- was log normally distribution, or normally distributed, rather.

[Slide.]

MR. GALYEAN: Let's go through a -- a very -- an example very quickly. As I mentioned, we used the NUREG-1150 event tree code to perform this calculation. The local system pressure or the -- actually the reactor coolant system pressure was sampled and then scaled for different portions of the interfacing system. At the same time, and then for each component in -- in the interfacing system, a failure pressure was sampled and the 2 compared.

MR. MICHELSON: Now, what is your standard deviation on your failure predictions? I mean, your -- you've tuned up very nicely the pressure -- the energetic source that's causing the potential failure, but how do you know how -- at what point a particular boundary fails? Did you have some kind of distribution on your calculation there too?

MR. GALYEAN: I guess I don't understand the question. The -- the local system pressure was assumed to be normally distributed, with a standard deviation.

MR. MICHELSON: How about the failure point now, to determine where the rupture was going to happen? How good are your calculations on the pump nozzle, on valve flange and so forth? How good do you think they were, I should say?

MR. GALYEAN: The failure pressure, okay -- the work that IMPEL did, they generated a median failure pressure and a logarithmic standard deviation, okay, on --

MR. MICHELSON: That's the one you used here?

MR. GALYEAN: That's what we used. That's right.

MR. MICHELSON: So you depended on the goodness of those numbers?

MR. GALYEAN: That's right.

MR. MICHELSON: That's the one reported in the NUREG?

MR. GALYEAN: That's right.

MR. MICHELSON: Thank you.

[Slide.]

MR. GALYEAN: As I mentioned, the Monte Carlo simulation was run and, for those instances where failure was predicted to occur, it was binned in to a system failure category and where no failures occurred that was binned into a no failure category.

We did categorize the ruptures by largely small leaks and no failures. The probability of failure for a given situation then is just the number of Monte Carlo samples that -- that resulted in failure, divided by the total number of observations made.

MR. MICHELSON: Over what range was the Monte Carlo --

MR. GALYEAN: Generally, we use 10,000 samples.

MR. MICHELSON: Yes, but I mean this was just for full power operation though?

MR. GALYEAN: Well, it depended on the specific sequence we were looking at. We looked at each sequence individually.

MR. MICHELSON: Okay. So, for a given sequence then, you went through --

MR. ALYEAN: That's right.

MR. MICHELSON: -- a number of samples.

MR. CATTON: How did you do this? Did you just assume -- randomly select a pressure and ask if it would fail?

MR. GALYEAN: Yes. We assumed a distribution up front. For example, that the initial RCS pressure was 22 --

MR. CATTON: Did the distribution and pressure at the device that you think might fail?

MR. GALYEAN: Well, yes. Well, we only sampled from the -- the RCS pressure once, and then we take that sample and scale it for different -- as we move through the interfacing system to account for things like flow losses and such.

MR. CATTON: But you have to assume some kind of flow?

MR. GALYEAN: That's right.

MR. CATTON: So, what kind of flow did you assume?

MR. GALYEAN: Well, it depends on -- again, it depends on the specific system. In almost all cases there are some relief valves, okay.

MR. CATTON: Okay, so you're assuming they flow through the relief valves --

MR. GALYEAN: That's right.

MR. CATTON: -- and then you calculate the pressure?

MR. GALYEAN: That's right.

MR. KERR: This is where RELAP/mod 2.5 comes in.

MR. CATTON: Oh, that's right. But, I guess, if you did that and it works out, where's the Monte Carlo part of this?

MR. GALYEAN: Well, it comes in -- in doing the sampling. We sample from distributions, we sample from a distribution of RCS and --

MR. CATTON: You have a piping system, you have flow through the relief valves. It seems to me that pressure is deterministic. Were's the randomness?

MR. MICHELSON: Yes.

MR. GALYEAN: Okay, the -- the internal pressure may be deterministic, but the pressure capacities, the failure pressures are not.

MR. MICHELSON: Yes. But the uncertainties in those calculations are so large compared with the uncertainty in predicting pressure that it looks to me like you're wasting your time to start out by playing around with the source.

MR. KERR: What they're doing is logical.

MR. MICHELSON: Well, yes, it's logical, it's just a waste of time because you've got to recognize the uncertainty in the answer.

MR. GALYEAN: Well, it was must faster to do it this way than it was to do it by hand.

MR. CATTON: Well, it's always must faster to assume something probabilistically than to do the calculation.

MR. HANSON: There are some variations, not only just in calculating the pressure, but in, of course, the operating conditions of the plant. They don't operate always exactly at 2250; they operate 2250 plus or minus some value. So that was accounted for in the distributions.

MR. MICHELSON: But this rupture probability has got much bigger uncertainties than that on it.

MR. HANSON: That's correct.

MR. MICHELSON: It looks to me like you're playing, you know, it's impressive to just make all these words, but I don't think it had anything to do with the outcome. The real outcome is how well can you predict these ruptures.

MR. HANSON: That's probably true; however, if we hadn't done it that way, then somebody probably would have asked us why we didn't account variabilities in operations.

MR. MICHELSON: You did a good job.

[Slide.]

MR. GALYEAN: Just for comparison sake, the calculation -- you can do the calculation by hand, if you so choose. It's analogous to what's done in seismic analysis.

MR. CATTON: I wasn't suggesting that at all. But why don't you just move along.

[Slide.]

MR. GALYEAN: I am going to go through a quick example of one of the calculations that was done. This is a diagram of the DHR let down line which is the -- one of the interfaces that we were looking at.

This -- this right here is the containment boundary; this is inside containment and this is outside containment. The pressure isolation valves that we're looking at are DH-12 and DH-11. What we did -- we created a simple RELAP 5 model of this system and then opened these valves and we nodalized the model to take -- so that we --

it would calculate pressures at different portions of the system.

For example, DH-12, there was a calculation, a pressure calculation done at DH-12, at the base of this 4-inch relief valve, in this 2 and a half inch bypass line and then downstream where the line also opens up again into 12 inches. Then we opened up these valves and RELAP then calculated the pressure distribution in the interfacing system.

MR. MICHELSON: This was a 300-pound suction design?

MR. GALYEAN: That's right.

[Slide.]

MR. GALYEAN: This, then, is the RELAP output for those five pressure points, and you can notice here we're starting out at basically RCS pressures. This is the inboard pressure isolation valve. And then the three points that we looked at show a few hundred psi pressure drops as you move through the system, because of the effect of, primarily, the relief valves and various flow restrictions in the system.

You can also see that the equilibrium is reached very quickly. On the order of six or seven seconds, you reach equilibrium.

MR. MICHELSON: I don't know where these reds and blue are. Can you tell us?

MR. GALYEAN: Yes.

[Slide.]

MR GALYEAN: The uppermost graph is the DH12, which basically reflects the RCS pressure. The second graph or the second line is at the base of this relief valve.

MR. MICHELSON: That was that red one.

MR. GALYEAN: Yes, DH4849. The next one, which I think is green, was at this flow element up here, and this is a 2 1/2-inch bypass line, and this represents the third pressure calculation, and the last one, which I think is black, is in this -- opening up again into a 12-inch pipe, which is, I guess, about -- the label is 2733 or 2734.

MR. MICHELSON: Where is the flow beyond the relief valve?

MR. GALYEAN: There are more relief valves downstream, very small ones, but there are more relief valves downstream.

MR. MICHELSON: Now go to your chart and explain the large pressure valve beyond the relief valve, which is a steady-state one, not the instantaneous.

MR. GALYEAN: That's right.

MR. MICHELSON: You're dropping down beyond that relief valve to something on the order of 1,200 pounds?

MR. GALYEAN: That's right.

MR. MICHELSON: Because of these little reliefs?

MR. GALYEAN: There are flow restrictions.

MR. MICHELSON: If there is no flow, this pressure is gone.

MR. GALYEAN: That's right.

MR. MICHELSON: But there is flow, and that's the only thing that's attributing such a large pressure drop, and those are big pipes and little bleed points. I can't believe you've got --

MR. GALYEAN: There's a 2 1/2-inch pipe in between. This is in a 2 1/2-inch pipe, this pressure point right here. This is 12 inches. You're going down to 2 1/2 inches.

MR. MICHELSON: That's immaterial. What's flowing through the pipe at the time?

MR. GALYEAN: That's right.

MR. MICHELSON: -- relief?

MR. GALYEAN: That's right.

MR. HANSON: There are several 1/2-inch relief valves, if I recall.

MR. GALYEAN: That's right.

MR. MICHELSON: This is not real clear.

MR. GALYEAN: This is just an example of the results that we're working with, the kind of results that we have predicted using RELAP.

MR. MICHELSON: But this has a great deal to do with whether ruptures occur or not.

MR. GALYEAN: That's right.

MR. MICHELSON: Not all plants have this many relief valves.

MR. GALYEAN: That's right.

MR. MICHELSON: If any. Generally, there's one on the suction of the pump to take care of check valve leakage.

MR. GALYEAN: That's right. Based on the IMPEL predicting the pressure capacities and the local pressures predicting through the RELAP ru[illegible] [illegible]form on Monte Carlo simulation, and this is an example of a system failure probability.

This graph contains three mutually-exclusive events. Okay? That is the probability of having a large rupture, the probability of having no leak, and the probability of a small leak.

There is a precedence here. Whenever a large rupture occurred in a Monte Carlo example, it was binned into the large rupture category.

MR. MICHELSON: Now, the reason B&W has that large relief valve there, isn't that having to do with vessel overpressurization during shutdown?

MR. GALYEAN: That's right.

MR. MICHELSON: Other plants have tackled that problem in different ways, rather than with the big relief valve. Is that right?

MR. GALYEAN: That's right.

MR. MICHELSON: Or does everybody have a big relief valve?

MR. GALYEAN: No.

MR. MICHELSON: Okay. If you don't have the big relief valve, this answer changes significantly.

MR. GALYEAN: That's right.

MR. MICHELSON: Okay.

MR. CATTON: What about the flow through the relief valves? Is that an important parameter?

MR. GALYEAN: Well, it is in the sense that it keeps the pressure down in the area of that relief valve.

MR. CATTON: My recollection of the EPRI results presented at a meeting in Santa Barbara several years ago, you can get fluctuations of a factor of two in the mass flow through these valves because of their complicated internal geometries and a sonic plane.

What would that do if this thing started to -- mass flow started to fluctuate by a factor of two through the relief valve?

MR. GALYEAN: I guess we didn't consider that. We used the manufacturer's design rating for the capacity of the valve, how big it was.

MR. CATTON: If the relief valve flow rate is important, then you had better take a look at some of those EPRI studies.

MR. MICHELSON: You're also using the cold-water relief capacity on that suction side, I'm sure, and that's a lot different than the hot-water relief capability. It's a lot less.

MR. GALYEAN: Well, yes. We use it to estimate the relief size, the opening area.

MR. MICHELSON: But if it turns out that you didn't rupture, then it's saying those valves are big enough, and they are big enough for cold, but when the hot water starts getting to them, they're no longer big enough, and then the rupture occurs, and I don't think that's in your analysis, probably. That is a problem.

MR. CATTON: Do you understand the concern?

MR. GALYEAN: Yes, I understand.

MR. HANSON: As I recall, the EPRI relief valve testing, though, was more for code safety relief valves. These are much smaller relief valves. But I understand your point.

MR. CATTON: You still have to look at the reasons.

MR. HANSON: Yes. I understand your point.

MR. CATTON: It turns out it's where the critical flow is within the valve that determines the mass flow, and it bounces around inside the valve.

MR. HANSON: And if, in fact, the relief capacities were less than we were calculating, then the pressures in the downstream piping would be higher.

MR. CATTON: There is also the impact on the piping system of having it vary a factor of two. Just the vibrations that would be sent up might shred the system.

MR. GALYEAN: The failure probabilities that were predicted using this model, as I mentioned, are shown on the graph. The one item you might take note of is the median failure pressure for the system, which is the DHR system, and that is the point at which you have a 50-percent probability of getting a large rupture. That translates into about 1,100 psi. And this is RCS pressure on the bottom scale, not local pressure. Okay?

MR. MICHELSON: What does this mean again, tell me?

MR. GALYEAN: Well, this represents the system pressure capacity, the system as a whole, as an aggregate. We can model individual pieces of equipment, for example, like IMPEL did, but then how to do you combine those? And that's basically what the Monte Carlo simulation does.

It combines those individual components into a system, and we can get a system failure probability. And here the system pressure capacity, then, you can interpret this 50 percent as the median system failure pressure capacity, which translates into 1,100 psi RCS pressure.

MR. MICHELSON: Now, that means, then, that there is a 50/50 chance of the rupture of this pipe.

MR. GALYEAN: Of a large rupture. If the RCS pressure is at 1,100 psi and you open the pressure isolation boundary, there is a 50-percent chance that you will get a rupture in the DHR system.

MR. MICHELSON: That's fairly high.

MR. MINNERS: You confused me when you said "rupture," and maybe it confused other people. There's a 100-percent chance, at 1,100 pounds, of getting water out of the system. Okay? Fifty percent chance of a small leak, 50 percent chance of a big one.

MR. GALYEAN: Yes, that's right. That's right.

MR. MINNERS: I don't know what you mean by "rupture."

MR. GALYEAN: That's right, yes.

MR. MICHELSON: Well, it looks like the rupture occurred, but 50 percent is also crossing at 1,100 pounds.

MR. GALYEAN: That's right. I was saying there's a 50-percent chance of getting a large rupture, and the other 50 percent of the time, you will get a small leak or a small rupture, evidenced by the red line, which also is --

you see, the no-leak probability is at zero. Okay?

MR. MICHELSON: There's also a 50-percent chance of getting a small leak at that pressure, and I don't know which it is.

MR. GALYEAN: That's right. That's right.

MR. CATTON: Which of them do, according to the manufacturers' data?

MR. MICHELSON: All of them do. There's a great uncertainty in this answer. They're not showing any uncertainty bands.

MR. CATTON: We know, Carl, from what the manufacturer said it took to close the valves, how far it off it was. This was a more difficult thing to estimate.

MR. MICHELSON: But it's also very difficult to predict exactly where the rupture of some of these castings and so forth are going to occur, because they're non-homogeneous. It's not like a pipe, even, which is generally quite homogeneous.

Valve castings, valve flange castings are very un-homogeneous. That's why they make them thick.

[Slide.]

MR. GALYEAN: This table simply tabularizes the information presented on the previous page, on the graph. This shows the failure probabilities for each individual piece of equipment in the DHR system. Here is a brief description of that piece of equipment, the median failure pressure as estimated by IMPEL and then the failure probability, given this type of RCS.

This calculation was done simply to generate this table. We don't actually use this in the analysis. This just gives you a feel for -- you can go through and identify where the weak links are in the system, which we have identified with the stars.

The SMALL refers to the fact that if this piece of equipment fails, it will generate a small leak, rather than a catastrophic rupture.

MR. MICHELSON: Where are the valves on this list?

MR. GALYEAN: This is a motor-operated gate valve, a swing check valve. The P&ID on the next page of your handout shows a description of the system.

MR. MICHELSON: I'm not looking at the same list.

MR. GALYEAN: I believe so. As I said, the next page of the handout shows a P&ID, a simplified P&ID of the system, and if you want to go through, you can identify those components on the system. I'm not going to go through that right now.

[Slide.]

MR. GALYEAN: Just to quickly summarize this portion of the work, we come to the conclusion or the observation that ruptures are likely for most ISLOCA sequences. We expect that these ruptures will occur very quickly, on the order of a few seconds; that relief capacity is not adequate to protect the interfacing systems. Flange and seal leaks are possible, but not expected to be large enough to protect other pieces of equipment and that ruptures of the pipe and the heat exchangers are most likely the result of ISLOCA types of sequences.

MR. SULLIVAN: Carl, it is interesting, from that table, if you look at it, that the pipes break and the valves don't.

MR. MICHELSON: I was trying to determine and I was going to ask the question; on a given valve, is the valve body that's predicted here, or is this a prediction of the weakest point, wherever that might be, including the bolting?

MR. GALYEAN: That's right. Generally, the valve failures are predicted to occur in the bolted bonnet, not the valve body itself.

MR. MICHELSON: So this is saying here that this will occur at 1660 pounds -- I'm sorry, 1704 pounds. I'm reading from the table, the fourth item down.

MR. KERR: That's the median.

MR. MICHELSON: It's got a distribution on it already.

MR. HANSON: If you look at the size of the breaks on most of the valves, you'll see most of them have an SM, indicating a small break, which would be not the valve body failing but the bonnet.

MR. MICHELSON: A flange leak.

MR. GALYEAN: At this point, I think Dave Gertman is going to come up, or is it time for a break?

MR. CATTON: Since it's 12:00, I think we ought to each. Let's have lunch and come back at 1:00.

[Whereupon, at 12:00, the Committee recessed for luncheon, to be reconvened this same date at 1:00 p.m.]

AFTERNOON SESSION

[1:00 p.m.]

MR. CATTON: Why don't we get started. Mr. Gertman, go ahead.

[Slide.]

MR. GERTMAN: It's my pleasure to speak to you this afternoon on the human reliability analysis that was conducted in support of the evaluation of ISLOCA. As mentioned earlier by both Gary and Duane, we've gone back and done a more detailed HRA analysis and, as a result, some of the numbers have changed. Therefore, today's talk is mainly on the methods that we employed as part of our effort.

[Slide.]

MR. GERTMAN: What we have here is two dimensions which are key to understanding how human error occurs in power plants and other high technology systems. Basically, we have two dimensions here.

The first is the failure mode and we talk about omission and commission. Omission is skipping a step in a procedure or failing to take an action. Commission can be of a couple types. The first is the simpler and what you tend to see in PRAs, if it's represented at all, and that's your simple selection and execution errors.

That is when you go from a procedure and you try to take a control action, you simply select the wrong switch out of a panel of switches or you go ahead to try to change a position indicator and you switch it to the wrong position. That would be an execution error.

Likewise, in terms of an activity to mention, there are two subsets to that. One is latent. Those types of errors, either omission or commission which lay dormant until another plant evolution, at which point the impact of that error becomes manifest. An example of that would be an inadvertent valve lineup which doesn't cause a problem until a monthly jog test or a quarterly stroke test is administered.

Again, the active is the kind associated with; if you were to model the human as initiator of a sequence of events, that would be an activator or an error taken in attempting to isolate a series of valves in recovering and you were to select the wrong one or not close it all the way. That would represent the activity that I mentioned.

It's interesting to note that almost all of the date that show up in contemporary PRAs show up under omission and show up in the active cell here. What we tried to do in this research program here is to move over to this side of the equation, because in our review of the LERs and other activities of plants, it becomes apparent that people makes these types of mistakes as well.

The problem is that they're not too well represented and there are not great denominators for these. Part of this effort was to try to move out of this confined space over into this part of the system.

[Slide.]

MR. GERTMAN: We conducted a review of some LERs. It's in Appendix A of the report for the B&W plant. Likewise, a study was conducted by the AEOD, some of which has been synopsized elsewhere by Sammy Diab. These are the types of errors that have occurred in operating facilities here in this country and it gave us a key as to what we might look for, what might be possibilities when we conducted our analyses.

These include: a bad valve assembly, attempting to seat a check valve by opening a motor-operated valve on the low pressure side, improper wiring of an interlock and miscommunication between controller/operators and INC technicians. In fact, this latter one is sort of important because, again, no other PRA or HRA efforts have gone to the trouble to try to say; what coudl be the contribution from miscommunication. We know that between people, it's part of the background human error rate for individuals.

I should mention, too, that the error rates that one finds in HRA are a bit different than the ones that you typically see for hardware numbers for PRA. If I were to go ahead and get 7 telephones and line them down the length of this panel and have you all try to dial your home phone numbers a hundred times in quick succession, I can guarantee you pretty much that your error rate would be out there at E-1 or E-2.

A couple individuals may fail ten times, but almost all of you would fail at least two or three or four. This is the kind of numbers you see a lot of times in human factors. It is not what you are used to seeing with valves and pumps, so some of the error rates that we have in here may look a bit high to you, but in terms of human performance, when you see errors out at E-3 and E-4, that is a relatively low rate for human beings.

I think it's important to keep that in mind as we proceed. Now, what we tried to do was to use what I consider to be a unique, integrated approach to HRA. What was unique about it is that we used the Human Factors Team throughout the exercise. These were not just engineers that have been cross-trained in HRA or knew a little bit about human factors, but we had human factors involvement throughout.

The second thing is, we found a technique for identifying errors of commission.

MR. KERR: Excuse me, what is meant by "human factors involvement throughout?"

MR. GERTMAN: Starting with the identification of the preliminary event trees, going over the P&IDs, the operating procedures, actually being at the plant to walkdown some of these procedures, to perform task analysis, to conduct interviews --

MR. KERR: What sort of people did you have?

MR. GERTMAN: Human factors people. What were the degrees in?

MR. KERR: Human factors people can vary from psychologists to industrial engineers. I was just curious.

MR. GERTMAN: That's a fair question. My background is in experimental psychology. A Human Factors Engineer that we had from our group that went to Davis-Besse as part of the inspection team has been working in human factors for around 10 years, maybe 12. Orville Meyer, his degrees are in nuclear engineering and electrical engineering.

The group we had back in Idaho is comprised of 18 or 19 people now. I guess it's 18. It's about 40 percent who have industrial engineering as their course work and roughly the remaining 55 of 60 percent have experimental psychology as a background.

MR. KERR: Thank you.

MR. GERTMAN: In addition, what we did is, we borrowed, kind of by analogy, a technique from sneak circuit analysis which is called Sneak Analysis, to use as a method of determining an error pathway around what might be intended by a procedure within the system. I'll talk a little bit more about that later in some slides.

Also, in this study, we placed more emphasis on errors of commission like I showed you in that matrix. We modeled communication between people and for the first time in a PRA, unlike other contemporary efforts such as 1150, we considered the human as an initiator of events.

Finally, we evaluated performance shaping factors for errors of commission as well as omission. If you go to some of the sources, such as THERP, the Technique for Human Error Reliability Prediction by Swain and Gutman, which is NUREG 1278, it does allow for modification of failure rates for errors of omission and simple errors of commission such as execution and selection based on performance shaping factors.

What we tried to do here is take it over into the realm of decisionmaking as well.

[Slide.]

MR. GERTMAN: So taking the matrix that I showed you on the second slide, what we did was to go ahead and to apply it to five error categories, going from initiating events or initiating event errors all the way through mitigation.

I should say that, in our case here in terms of mitigation, we're saying isolation is taking those actions to stop the flow going to the right valves, whether they be in containment, primarily in containment here for the different sequences. But in terms of mitigation, since there were not hardware resources available to the personnel afterwards, we did not do extensive modeling in this area.

[Slide.]

MR. GERTMAN: It is reasonable to ask why errors of commission are not well-represented in contemporary PRA efforts. There's a few reasons for this.

First of all, methods for identifying and quantifying these errors are not well-developed. It's emerging. Methods for doing it for omission are well-developed. There are a number of data sources one can go to, and people tend to use, when performing HRA.

So again, what we tried to do was not only identify them and model them, but to go ahead and quantify them.

[Slide.]

MR. GERTMAN: In each of these areas, there were slight problems. The first was error identification, how you could go and find out where they might exist, aside from the routine task analysis you would do, and walk down of systems, and interviews witn personnel.

The error representation, generally what you do, if you don't go to a source like human cognitive reliability model, where you would pick up table values based on the time available and the average time taken by a crew to respond, would be to do your modeling either in fault trees or HRA event trees. And the technique for HRA event trees is pretty well documented in Swain's work.

We went ahead and built on the HRA event trees, and came up with a slight modification of that to account for modeling the action subsequent to a decision-based error. And I will talk to that a little bit later.

In air quantification, we used the following sources. We used THERP, we used HCR, we used a reliability data bank sponsored by the NRC, called NUCLARR. And we also went to a model for decision-based errors and a data set called INTENT.

MR. WILKINS: Is it important to us to know what any of those things are?

MR. GERTMAN: I would say except for the latter, which is rather new, INTENT, these are the types of models and quantification techniques ordinarily used in the conduct of HRA.

MR. KERR: What he is saying is that everybody knows --

[Laughter.]

MR. MINNERS: It's documented.

[Laughter.]

[Slide.]

MR. GERTMAN: Okay. Error identifications include probable errors of commission. You normally identify a series of errors through task analysis. We were at the plant, both as part of the inspection team, and again on a second visit to gather data. You go ahead, you do interviews with a determined sample of personnel, a couple representatives from the different types of positions that would be involved in the sequences. You review the existing control room instrumentation. And you do this with human factors personnel, hopefully. You likewise sit down with systems analysts and PRA analysts on going over the operating schematics in this case at this B&W plant, the operating procedures, and the P&IDs. And this forms a lot of your knowledge base.

MR. KERR: A determined sample is not the same as a sample of determined, is it?

MR. GERTMAN: Well, I'm not sure what the latter means. I can tell you what I mean by a determined sample, if you like. And basically, it wasn't a stratified random sample. We knew a couple of the key positions that would be involved, and we tried to speak to one or two people in each of those positions, time permitting.

The people that were there on the inspection team also did double duty as they were acting as inspection team members. So there is some overlap. They were able to bring information back, but they were also sharing that other task of being participants in the inspection.

Then, here again is, we went to a sneak circuit analysis, and by analogy, and said we have unwanted pathways around a system, generally where you get a short-circuit. The equivalent of that for us is how do people, how might people work around an intended pathway within the system to cause an unwanted response.

So, to sum, we believe we have the means for identification of potential errors of commission; through this combination, we have the technology.

And in here, this is just saying that we were knowledgeable about the requirements of the different modeling techniques and quantification techniques so that we collected the right information while we were there.

MR. CATTON: Did you look into plant instrumentation symptoms versus operator perception?

MR. GERTMAN: We looked to see what was available in the control room. We differentiated between things which were on computerized displays versus things which were enunciated. We also, as part of the sensitivity, if we noticed that some instrumentation, in part of a system, such like, well, let's say like a DHR system, was available only as a local indication in aux. building, and part of the sensitivity work that we're doing, we're saying suppose that information was brought into the control room, would that not be an aid?

So, in part of an ongoing study we're doing to decide now, we're looking at our base HEPs that we got from this first analysis and then going ahead and saying if we were to change things somewhat, what might be changed, what would be hypothesize would change, and what would happen to the error rate as a result of that. And we are looking at that question of bringing the information up.

MR. CATTON: I'm not sure I understood the answer. But when the operator is in the control room, and there is an intermediate system LOCA, what are the symptoms and how are they, how do they manifest themselves, the symptoms that he is supposed to respond to?

MR. GERTMAN: Well, in a lot of cases, you would have a makeup letdown mismatch. You might have that valve that was shown earlier in Bill's talk, the relief valve 4849 opening up. You'd have the sump level indications in containment. You might have some pressures and temperatures around that suction side of he pump, before it fell apart, or that line fractured. And we looked at those things as being available. And then we just said what percentage of that would be available to the person back in the control room. And then we tried to assess their ability to come to grips with that as a signature. And we, I should mention that we distinguished between the detection, the diagnosis, and the isolation in the following way. We sort of say that the detection is a detection that something is abnormal, in terms of the pressure, or that mismatch. We say the diagnosis is that we understand that we have this loss of RCS inventory and we're into a ISLOCA situation. And the isolation is the actions you take once you have the proper diagnosis.

MR. SULLIVAN: I can see why you got to where you are from the way that you started approaching this problem, is that there is a set of procedures that are symptom-oriented, and you wanted the guy to identify that he had an ISLOCA.

MR. GERTMAN: Well what we gave credit for was if the procedure, or going to different procedures, would take you specifically to the right combination of valves to isolate, then we gave credit.

If it would not direct you on that path, we didn't give credit for the isolation. What did help in the case is some of the timing information that Bill Galyean related, that indication was up for so many hours in the two cases he mentioned, four hours and eight hours, that we believed that if the crew that happened to be in there at the time wasn't the exemplary crew that Bill Kerr referred to, but a different crew, or a crew at 3:00 O'clock in the morning, that there would be sufficient time to bring other people in that could come to the right conclusion. That's why the failure rates for both the detection and the diagnosis are rather low in the HRA study. Even though we highlight a variety of errors, we've also modeled in the recovery, due to the time arising.

Have I answered the question?

MR. SULLIVAN: I don't think so. It's a different approach --

MR. GERTMAN: Yes.

MR. SULLIVAN: -- that we're trying to get to. You've assumed that he has to recognize, one method is just to follow the procedures. And did you ever look at that?

MR. GERTMAN: Yes. Yes, we did. And the procedures don't give much relief. There is an exception to an abnormal decay heat procedure. And when I look at a specific scenario, and I happen to go to that procedure, you know, I could call it the blue plague, or whatever, if I just follow that, that will take me to either the right pair of MOVs in the decay heat pit or it will take me to the right bypass valves. And in that case, in part of this reanalysis, we've gone back and given credit for that.

But again, we've indicated a low failure rate for the diagnosis as well as the function of the amount of time available. So the penalty, it's out there almost to a negligible, what is for us, a negligible human error probability, to begin with. And so there is quite a bit of credit given.

MR. SULLIVAN: Could you explain negligible human error probability?

MR. GERTMAN: Okay.

MR. SULLIVAN: In the context you used it, I didn't see the connection.

MR. GERTMAN: Okay. My opinion is, once you get past E minus 4, approaching 1E minus 5, in human error, you really are stretching the limits for people's performance. It's just not much better than that. You have to, you can put in recovery factors, but it's just not a credible number if you look at the error factors associated with guessing at numbers out to that extent.

People simply don't do much better than that. There's not much, there's no evidence I can think of to the contrary. If we were to switch industries for a second, I could tell you that the failure rate for seasoned pilots with crews approaching aircraft runway with their landing gear up and having to be called off on a vigil, is about 3 out of 10,000, which is a pretty significant error by a seasoned crew with years of experience, which you don't expect to happen. That is a very low frequency event. There's not much you can find out there out of 100,000 or certainly not out of a million, for people.

MR. MINNERS: So what error rate is the recovery here? I think that is the question.

MR. GERTMAN: Well, the recovery factor is in to raise the error rate to E minus 5 in a number of instances, which is about the best you would hope to do. And I wouldn't be comfortable putting down any number better than that for people.

MR. CATTON: That's E minus 5 core melt?

MR. GERTMAN: Oh, no. Just on the human error probability alone, which has to be factored in conjunction with the hardware and then propagated out.

MR. CATTON: Do you really believe that number?

MR. GERTMAN: I don't believe anything higher.

MR. WILKINS: That wasn't the question, I don't think. You're not going to push it any lower.

MR. CATTON: That, too. I was thinking more in terms of the other direction.

[Slide.]

MR. GERTMAN: Yes. Well, my personal belief is that it might be a little higher for people, in general, yes. One of the problems is that if you sign up to using a particular model or method, you're somewhat constrained to follow the rules and assumptions of the model.

MR. CATTON: Even if they don't look right?

MR. GERTMAN: Well, you have to pick from what's available and choose the one whose method best matches to the situation at hand. Decision-based errors have a higher failure rate than some of these other things.

Now, when we've had the preliminary event trees that were designed sitting in concert with the systems analysts and PRA analysts, we had some preliminary events that suggested possible errors on the human side, and what we did is we applied sneak analysis from the bottom up to see if there were potential pathways up to this type of an error.

When you do sneak, of course, you're talking about getting around barriers, whether they be physical barriers or administrative barriers.

[Slide.]

MR. GERTMAN: One finding which was kind of important for the study is that we found a possibility for entry into early DHR cooldown, and we said that this could come from a number of sources here.

We had procedurally sanctioned to jumper open on PIV in that series. You had a mindset, where you were allowed by procedure to jumper interlocks, and the administrative barriers were not identified, and I will get back to this point a little later on.

This suggested to us a sneak pathway for the error of commission related to early entry or to DHR cooldown in the opening of those valves.

[Slide.]

MR. GERTMAN: Once we had identified this, the next question to be dealt with is how could this be best represented?

There are some reasons for when you go ahead and model errors of commission somewhat differently than simple execution errors. Modeling intentional errors, you could use the word "decision-based," as well. They are quite different.

Once you make a decision which is less than optimal, you must conduct a series of actions in order to carry it out. You must look at these actions and see whether or not they have the potential to be successfully performed. You have to find out the errors rates for these.

In addition, we looked at kind of a unique aspect here, and this was that once you start on your pathway to complete this bad decision, if you have an error which precludes you continuing, that actually affords you some sort of recovery from your original decision error.

So, we wanted to be sure. We wanted to capture that, as well.

So, trees -- and this means HRA event trees -- must be made to model the performance after the decision error has been made. We came up with a term, calling it a commission of entry, in order that it might be separated from the human error event tree, which normally is used to model omission and simple commissions.

MR. CATTON: That's kind of a strong statement, isn't it? "Any additional error allows recovery"? Oh, "allows." You might recover.

MR. GERTMAN: Yes, but --

MR. WILKINS: It throws you off the wrong track. The probability is that it is onto another wrong track.

MR. GERTMAN: You could exacerbate the situation, and this would probably be better as "some additional errors allow recovery." I'd agree with that.

MR. CATTON: So, how did you incorporate that into your HRA tree? Did you look at all possible things the guy could do that surrounded what his intention was?

MR. GERTMAN: Yes. We looked at the series of actions that would have to be carried out. I have to say that we didn't do an analysis to see -- a separate analysis to see if we could exacerbate the situation in any way. We just said once you intended to do this, as you go down that pathway, if you make errors, can you continue in your decision, or do these errors give you some kind of recovery from your bad decision?

MR. CATTON: Don't you have to look at the symptoms and decide what he would do? Because that's the only thing that would make him change.

MR. GERTMAN: Well, this one is an initiator. So, there was a decision to enter into the situation.

MR. CATTON: He's just standing there watching everything go to hell, and he decides to do something and does the wrong thing.

MR. GERTMAN: Well, it's actually that decision and some of his actions that cause things to get bad.

MR. SULLIVAN: So, when he make an error, then that's an end event. You don't follow that anymore.

MR. GERTMAN: No. What we do is we say you have to combine the bad decision with the probability of executing that decision. So, you have to combine those. It's basically multiplied.

You need both the bad decision and the actions commensurate with executing the actions to support the decision.

MR. CATTON: Are most of the actions that are taken taken from the control room?

MR. GERTMAN: Some. Some involve sending personnel to other parts of the plant, which is an important point, because what happens is in the postulated scenario, an I&C technician is sent out to jumper a valve which is normally not jumpered, and what we did in there is we modeled the possibility for the I&C technician actually refusing to perform the jumpering, based on the fact that he or she had not performed a jumpering of that valve before.

MR. CATTON: Or maybe they think there's too much hot water around.

MR. GERTMAN: Possible, also.

MR. CATTON: The reason I ask is one of the utilities is actually generating data via a simulator for a range of different kinds of accidents, and there you can follow this whole chain, right or wrong, until he either remedies it or it falls apart on him.

If I had to guess, I'd say that's the only really reliable kind of data.

MR. GERTMAN: I would have two comments, I guess.

If what we did is simply stop some valves or created an off-normal condition and we're watching the response, the simulator is an excellent device for picking up good data. But since this was going to be a decision, we'd have to set a scenario so they would come to that decision and then decide to act upon it.

So, it's a little more difficult than that.

MR. CATTON: You can't do that with a simulator?

MR. GERTMAN: I don't think, in this instance, it would be easy to do.

The second issue that you bring to light and one of my interests is if you talk to people doing the conduct of simulator studies is the human error probability estimates that one gets are very high in comparison to what are used in other methods. It is a good source of data.

But if you were to go over and look at the percentage of failures on licensing requal using the simulators and say, for these safety-critical actions, that's representative of potential failure rates, and if you have a failure rate of higher than 10 percent with these exams, then our HEP should not be on the order of E minus 2 and E minus 3 and E minus 4; we've got a problem with a much higher error probability.

So, my sense is that it's someplace between those sort of data and something out there, E minus 5 and E minus 6. But I think that the failure rates --

MR. CATTON: In the simulator, he makes a mistake; he remedies it before it goes very far. So, he's done two things. He's made a mistake, and he's corrected it, and if he doesn't quite correct it, like in your third bullet, maybe he does something, a third action that brings it back, and you don't have any of this. You just sort of have a perception of a number to place on the whole thing.

MR. GERTMAN: Well, we do have aspects to the recovery model. I was also going to say, in running some simulator trials -- or being involved with them, because I didn't actually run them -- at some utilities, when we ran six and seven crews on three and four scenarios, we did end up with failure rates, where crews, within the time allotted, failed to discover the error and take the appropriate actions.

So, I would say that even if it's not 2 E minus 1, if it's down at 1 E minus 1, I still think there is a high failure rate from that, and I think that would make the complexion of the situation look worse than perhaps it is realistically.

Had we had a simulator available to us at the time we were there doing an inspection, it was our intention to use one, and I think it's a good point to raise. If we had it, we would have more data.

MR. CATTON: E minus 5 is just awful small.

MR. GERTMAN: I agree.

[Slide.]

MR. GERTMAN: Why is quantification of intentional or decision-based errors of commission somewhat difficult?

Part of it is a lack of sufficient operational data to help come up with these error rates. Part of this problem is that we have some excellent case studies and examples. We have a numerator, even if it's under-reported, in terms of near misses; but we simply don't have much in the literature in terms of denominators for decision-based errors.

We also know that decision-based errors are not as much time-driven as are other types of errors. Not to say that they're completely insensitive, but using a time estimate isn't a good way of either modeling or quantifying human errors in decision-making. You really can't tell much of the story of human performance that way. That's why time and motion studies out of the '40s and '50s just didn't do all of the job for industrial psychology that perhaps it could have.

We also know that if errors are cognitive in nature, they're influenced by performance shaping factors, such as quality of procedure, training and nebulous concepts, such as the awareness of a potential consequence to events, such as ISLOCA.

MR. CATTON: Or an ambiguity in the symptoms.

MR. GERTMAN: Yes.

MR. CATTON: That would enter on that number 3.

MR. GERTMAN: Yes, an ambiguity, I guess, from the -- either from the situation that the instrumentation might not be reliable or that the signature is not well defined or known.

MR. CATTON: Just that the signature could be one of several things.

MR. GERTMAN: So errors of their decision may occur -- what we're seeing is much in the thinking as in the doing. That's why we have that split between the decision and then what actions do you need to carry out the decision and that they're combined. Therefore, what the analyst does is go to some expert judgment techniques and employ those.

[Slide.]

MR. GERTMAN: That's kind of the omission/commission side of that matrix I presented to you in slide 2.

This slide deals with --

MR. CATTON: I thought you were going to tell us about the expert opinion process, expert judgment, like 1150?

MR. GERTMAN: 1150 did use some expert judgment, but we did also. We made use of a -- a model and a data set developed at the INEL called INTENT and what it is is a list, on table 1, of 20 decision-based errors for which there are upper and lower bounds and basically, you travel below those bounds based on ratings of performance shaping factors.

It's -- the formulas and equivalents that the probability of finding that performance shaping value, which is a composite of 11 factors is equivalent to the probability of picking a point between that other distribution with an upper and lower bound and a log normal assumption has been made in both cases. We use that technique for deriving rates for which there were not a good source of data anywhere else.

In terms of the latent dimension, the errors that surface involve inappropriate valve line-ups and most of these latent errors involve locally operated valves. I should also add that the status for a lot of these was not really available in the control room, other than through the locked verification log.

Additionally, there's a lack of procedural time to the potential for ISLOCA. They would give them a cue as to, if I had this type of a line-up, I could be at risk for some sort of ISLOCA consequence.

[Slide.]

MR. GERTMAN: What we're doing is we're conducting a sensitivity analysis now, which is going to evaluate the effects of the potential modifications. What we did is we hypothesized changes in a number of different areas. These included cautions, notes and warnings in different parts of procedures. We hypothesized the existence of an ISLOCA procedure. We precluded jumpering of interlocks as a way of doing business.

We went ahead, in terms of instrumentation, at the very minimum, we considered the addition of a valve status board, in the control room, which could go ahead and give you the status for some of these locally operated valves, which figured prominently in terms of ISLOCA.

Also, we said if there were more presentation of informational pressures, temperatures, levels and flows from parts of systems such as DHR available in the control room and not local to an aux building that we felt this would make an impact.

In training, we said, now there was a module, where none existed before, specific to ISLOCA and it was also in the alarms to be associated with an ISLOCA signature, so that the symptoms perhaps would be less confusing or ambiguous.

We also looked at recovery, that any kind of recovery, in this case, we don't mean mitigation because we consider that scrubbing of the release, but the isolation actions would be covered by procedures. These procedures would have check-offs and they would have independent verifications as well.

So the base case is the analyzed review, the task analysis, the documentation, the things that are the body of the report, therefore.

Then we went to standard quantification sources, saying, if these things were changed, what would the resultant value be? This is in progress right now. Then we're going to go ahead and look at that delta. The sensitivity from what is, versus what could be.

I think there's also -- there will be a cost benefit analysis conducted. But certainly there's different types of costs associated with some of these changes versus others.

MR. KERR: This cost benefit will evaluate the effect on total plant risk?

MR. BURDICK: ISLOCA plant risk. ISLOCA risk.

MR. KERR: Well, I'm not interested in ISLOCA risk, I'm interested in plant risk. I might have a situation in which I would reduce ISLOCA risk significantly, at the cost of increasing plant risk, generally.

I mention that because one of the conclusions, after TMI, I think, was that control boards were confusing because of the amount of information that an operator had to assimilate. What I'm seeing here could be interpreted as asking an operator to assimilate additional information. This may be a wise thing to do if all one ever has to cope with is an ISLOCA. But that, of course, is not the case.

It seems to me that this sort of thing, if you're serious about using the results, must take into account the total plant and the total control board and not just an

ISLOCA.

MR. BURDICK: That's -- that's a very, very good point. We are, again, attempting to do the best job we can within constraints we have. To do another global study, to get a -- get a handle on these particular scenarios --

MR. KERR: I'm simply saying that you run the risk of making things worse if you don't do a system-wide study.

MR. BURDICK: I understand the problem.

MR. SULLIVAN: Could you go back to that for just a second. Can you tell me how you quantify the first bullet, first sub-bullet as --

MR. GERTMAN: This one is the addition of cautions, notes and warnings?

MR. SULLIVAN: Yes. How do you -- how do you quantify that? I got a -- I can go through every one of them and ask the same question, but I'd just like to get a sense.

MR. GERTMAN: Okay. If I give the simplest case, which is maybe going back to the data tables. You have, in the area for -- where actions are -- are guided by procedures, you have different values, depending on how long a procedure is, how detailed the procedure is; whether or not there's a second person behind the first; whether or not the people are operating strictly off the procedure, or have to go off into a knowledge-base realm and see, by analogy or otherwise, where they should go on their next step.

There are different values ascribed to this. Likewise, based on time, based on the interface, how well the information is presented, you have either higher or lower failure rates. So, actually, it's not all that difficult to do, just because of the manner in which the tables are set up for that particular source.

MR. SULLIVAN: I have never seen a table that said if you add cautions or notes that you would modify it any way.

MR. GERTMAN: I guess what I would say to that is that --

MR. SULLIVAN: You must have made some assumption.

MR. GERTMAN: Okay. I guess my point would be, is if it doesn't refer me to the impact, I would say that assessing there is a potential impact there is a step not covered within that particular procedure. It is expected knowledge base of that person and they have to recall that, versus reading it. It's not saying that things ought to be spoon-fed, but if they -- have a -- a high consequence and they aren't typical, spelling out adds a margin of recovery to the execution of the overall procedure.

MR. SULLIVAN: You can go ahead.

[Slide.]

MR. GERTMAN: Because of unique approach we took in terms of a team composition, working with an integrated group with the human factors and PRA systems engineer and the emphasis we placed on errors of commission, using new identification techniques such as Sneak and modules such as the commission of entry, and making use of existing quantification techniques and calling into play, performance shaping factors, we were able to reach the following findings and conclusions:

First of all, we think Sneak analysis is a general technique that offers promise for the identification of errors of commission and I would suggest that this applies outside of ISLOCA and for PRAs in general. Secondly, the errors of commission and latent errors prove to be risk dominant for ISLOCA at this particular B&W plant. It may not be the case in another one that you were to look at.

Third, the results supported the inspection team's findings about training and procedures and extended them to error quantification. Lastly, if we go back to some of the thoughts on the sensitivity analysis slide, the one before this, we believe there are some practical measures which might be available to lessen the risk related to the human error that was identified.

Lastly, I'd like to add that none of this really would have been possible unless we had gone way beyond the level of HRA as it's practiced in contemporary PRAs. Quite simply, the job hasn't been extensive enough to date, and that's why you don't have errors of commission represented in other studies. It's not that people don't commit them. You can go to the LARs and see a lot of examples of that.

That concludes the presentation that I have.

MR. CATTON: Thank you.

MR. GERTMAN: Any questions?

MR. KERR: Is the Sneak analysis that you mentioned something new to this study, or have others used it for this same purpose?

MR. GERTMAN: Others have not used it in this context.

MR. KERR: Do you expect to publish that in some journal or other, or does it deserve that?

MR. GERTMAN: It was accepted last month in Reliability In Engineering System Safety, Apostalakis' [ph.] journal out of UCLA, so that will be available soon. If people need copies or would like to see it, we'd be happy to provide anybody with them.

MR. KERR: I would like to see a copy.

MR. GERTMAN: Is that true for the whole panel?

MR. BOEHNERT: Send me a copy and I will distribute it.

MR. CATTON: Now that you mention Apostalakis' [ph.] Journal, I read a series of editorials in it a few months ago, maybe even a year ago where all of the different people that you were citing as you walked through this, took pot shots at each other.

MR. GERTMAN: Yes.

MR. CATTON: After reading that, I would suggest that even though you have E to the minus 4, your uncertainty might be 10 to the plus 4.

MR. GERTMAN: I'd say error factors of 5 and occasionally 10 are not uncommon in some of the estimates.

MR. CATTON: That's plus or minus E to the 1, a factor of 10; you're in really good shape.

MR. GERTMAN: Yes.

MR. CATTON: Much better than any of the rest of the analysis. I'm not sure I believe that.

MR. SULLIVAN: Would you say you're pushing the state of the art?

MR. GERTMAN: Yes.

MR. CATTON: Thank you. You're going to tell us about the B&W plant?

[Slide.]

MR. GALYEAN: I would like first to just quickly go through the entire process and then go through it a second time more slowly and in more detail. Initially --

MR. KERR: What is the process that you're going to discuss?

MR. GALYEAN: The analysis process that we went through when we looked at the B&W plant.

MR. KERR: Thank you.

MR. GALYEAN: Initially, after we did sort of a general background education where we looked at the historical experience, the LERs and collected what information we could on operational events and sort of educated ourselves to types of errors that are possible and could potentially occur at the plant we were looking at, we reviewed the B&W plant systems and operations.

Based on that, we put together or we postulated sequences that could occur that could lead to an ISLOCA situation. We developed event trees to model these sequences. We then approached the quantification part of it where we first looked at the initiation of these sequences. That can be either a hardware initiator; that is, a valve fails, or a human error initiator; that is, if an operator inappropriately opens a valve, or some combination of the two.

Then we looked at the systems that would be exposed to the high pressure RCS water. INPEL performed their fragility calculations. We did the local system pressure predictions, combining the two to generate system rupture probabilities.

Based on that, then we took a look again at the human operator to estimate his performance in detecting diagnosis, isolation and mitigation. From that then, we can generate core damage frequency. At the same time --

MR. CATTON: Out of curiosity, you put the operator downstream of the probability distribution, if I track through those blocks.

MR. GALYEAN: I guess I don't understand. The operator appears both as an initiating event and then as a recovery event. Calculating consequences then, we took the approach where we relied mostly on existing literature.

We utilized the Oconee PRA for containment bypass Source Term. We scaled it to the plant we were looking at. We then normalized the consequences to an average site, as was alluded to before. Combining the core damage frequency and the conditional consequences, we then calculated risk.

We went on to perform some sensitivity studies which, again, I will get to in a little more detail later on, and generated some conclusions or observations.

MR. CATTON: An interesting study was done for BWR stability. They looked at all the possible paths you could go through and then they did the calculations all the way through that path. Then you go back and calculate the probabilities.

Then you wouldn't have to fool around with that distribution, would you?

MR. GALYEAN: I guess I don't understand the reference you're making to instabilities. I guess --

MR. CATTON: Boiling water reactor instability has been under study. One of the questions that comes up is; what's the bottom line, given you have a whole bunch of paths to get somewhere? The concern was that if -- you should track the thermal hydraulics through each one of these paths that you can follow. Then you can separately estimate the probabilities associated with it.

When you do that, any time you look at a given piece of equipment or something in your system, you have a really best guess at what its environment is. I get the feeling here that that was kind of separated.

MR. GALYEAN: I mean, we looked at the thermal hydraulic issues. I guess I still don't understand the point you're trying to make.

MR. KERR: Don't feel bad; I don't either.

MR. CATTON: For the boiling water reactor stability question -- whether it's a safety issue or not is separate -- what they did was, they went through and they looked at what the operator actions could be at a number of different stages as one of these things could evolve; he did something good, he did something bad, whatever he could do.

Then they would follow through this sort of decision process, actually doing the thermal hydraulic calculations, so you had the thermal hydraulic environment that your equipment is exposed to, all along the path. This way, if you have to estimate a failure of something or other, you have the true conditions at that time.

MR. GALYEAN: I think I understand what you're getting at. The types of calculations you're suggesting, at least according to my understanding, is that they are very -- it's very expensive and time consuming to assemble these models. The actual code run may not take -- the RELAP or a lot of these codes do take a lot of computer time, and the number of scenarios that you could postulate is -- well, there are many, many of them.

To handle them all in this computer model intensive way is simply beyond our resources. That's something for the NRC to take up, I think.

MR. SULLIVAN: He's just telling you a different way. You get to the end result the same way.

MR. CATTON: A lot of it depends on what the operator does.

MR. SULLIVAN: No. Let him finish and then I think you'll be able to see.

MR. MINNERS: Don't you calculate the consequences of each branch of your event tree? Isn't that your question?

MR. GALYEAN: Yes.

MR. CATTON: Well, I'm wondering if he tracks thermal hydraulics through each one of those branches.

MR. MINNERS: That's what I mean. The pressure flow --

MR. CATTON: No, I didn't get that.

MR. GALYEAN: We didn't do detailed TH calculations on the aux building, for example. okay? We looked at the flows and the leaks, you know, the pressures inside the system, the ruptures and the leak rates, and then we said, Well, if it wasn't isolated, it goes to core damage and core melt, and then subsequently, a release to the environment occurs, and you have off-site consequences. That's what we did. I really can't speak to, you know, what you're referring to.

MR. SULLIVAN: Ivan, why don't you wait until you go to the event tree, because I think he's doing the same thing.

MR. CATTON: Okay. Continue.

[Slide.]

MR. GALYEAN: To just briefly go through the historical experience that we collected, we loosely use the term ISLOCA precursor loosely there. We collected information on approximately 18 events that basically involved human errors, combinations of hardware faults and human errors. One was even a generic materials problem.

MR. WILKINS: Wait a minute. Eighteen events?

MR. GALYEAN: Yes.

MR. WILKINS: You only listed 14, though.

MR. GALYEAN: I'm sorry.

[Laughter.]

MR. GALYEAN: Well, I just tried to summarize the most common, okay? There are a number of events that occurred somewhat unique, okay, and those are not listed here. That's just to give you an idea of the education process that we went through to familiarize ourselves with the types of things that are happening out in the industry, and the types of things that we can then, in turn, you know, look for in our analysis.

[Slide.]

MR. GALYEAN: When we looked at the B&W plant, we identified the ISLOCA interfaces and sequences that seemed most likely. We had a screening criteria that we applied, and that was one inch in smaller lines, and where the potential for a leak was smaller than 200 gallons per minute, we did not pursue it any further. This criteria is based on these items here, and that is that you would have so much time available that eventually, the operators would be able to recover the situation.

MR. MICHELSON: Why do you use Schedule 160 for your criterion on pipe size? That would be true on the primary side, but not --

MR. GALYEAN: What we're trying to do is account for flow losses, okay, in a pipe.

MR. MICHELSON: Yes, but it's the pipe that ruptured that's going to be 50 feet long, and it's going to be out in the auxiliary building somewhere.

MR. GALYEAN: That's right, and --

MR. MICHELSON: And it's not necessarily Schedule 160 if it's on the suction side of a pump. It very likely would not be.

MR. GALYEAN: That's right. Along the way, you will likely have more than 50 feet; you will likely have a number of flow restricting devices. Even an open valve will restrict flow. You have even friction losses in the pipe. You have release valves along the way. You have restricting orifices. So this was just sort of a rule of thumb that we put together that we can then use and constrain the problem we're looking at.

MR. MICHELSON: Now, the 200 gallons a minute is being driven by reactor pressure and temperature?

MR. GALYEAN: That's right.

MR. MICHELSON: And you're flashing it at a break point.

MR. GALYEAN: Into atmosphere pressure.

This then led to the identification of three interfaces: the high pressure injection and low pressure injection lines, and then the DHR letdown line. These three then comprised five possible sequences which, from here on, I'll identify as the high pressure injection sequence, the make-up sequence, the LPI, and the start-up and shut-down sequences. I'm going to briefly go through each of these five sequences and just describe them.

[Slide.]

MR. GALYEAN: This is the high pressure injection interface. At the B&W plant, there are two trains of high pressure injection. Each train branches into two injection lines. This then represents one pair of those injection lines for one of those HPI trains.

Items to take note of is that these check valves -- here is the containment boundary. These check valves are welded back to back and cannot be individually leak tested. In our analysis, we treat them basically as a single valve, a single check valve, since you can only ensure that the pair is functioning as an isolation, not each valve is functioning independently.

There's a normally closed gate valve in the injection line. The check valve then further prevents back leakage back to the high pressure injection pump. There is a recirculation line back to the borated water storage tank.

A couple of operational issues to take note of are that these motor operated valves are stroke tested quarterly, okay. So four times a year, they open this valve, and this -- basically what we loosely refer to as a single check valve -- is providing the pressure isolation between the high and low pressure.

MR. MICHELSON: That's a non-loaded test, though?

MR. GALYEAN: That's right. In this case, it's a non-loaded test. Also monthly, the pump is flow tested, which means that this check valve has flow through it once a month.

They open up this recirc line back to the borated water storage tank for this test. So the danger or the potential is there that this recirc line is left in the open position inadvertently, that this check valve could stick in the open position, or that this check valve could stick in the open position when the month -- when the quarterly stroke test of this valve takes place, that you could have a back flow through this check valve, and either back to the borated water storage tank or back to the high pressure injection pumps.

MR. MICHELSON: You never convinced me I knew that the check valve receded. Do you have some means of knowing that?

MR. GALYEAN: Which check valve?

MR. MICHELSON: Twenty-two.

MR. GALYEAN: Twenty-two? No. And that's right.

MR. MICHELSON: They could be unseated for years.

MR. GALYEAN: That's right.

MR. MICHELSON: The same argument over here on these back-to-back ones?

M' GALYEAN: Well, the pair of them are leak tested on every start-up, okay? So when the plant's starting up, they do leak test the pair to make sure that there's a positive isolation across this.

MR. MICHELSON: It's done through a leak-off?

MR. GALYEAN: That's right.

MR. SULLIVAN: What is the probability you use for those valves?

MR. GALYEAN: These valves?

MR. SULLIVAN: Yes.

MR. GALYEAN: Okay. It was an hourly failure rate somewhere on the order of ten to the minus eight per hour, okay, and then a yearly fault exposure time, I think is -- I'd have to check to make sure, but --

MR. SULLIVAN: Did you give them credit for both valves?

MR. GALYEAN: No. We treated this as a single valve, okay, because, as I said, they cannot be individually tested.

MR. SULLIVAN: Even when you went to the probability tables?

MR. GALYEAN: That's right. That's right. The problem is that, you know, the assumptions -- I suppose the assumption to make is that through the entire history of the plant, that the leak test verifies that a single valve is functioning. The second valve then basically has a fault exposure time of the entire -- since it was installed, okay, which, in this case, it would be about 15 years, I believe.

MR. SULLIVAN: What you're assuming, really, is that one of those valves is always failed.

MR. GALYEAN: That's right. That's right.

MR. SULLIVAN: Which is probably not really correct.

MR. MICHELSON: It turns out, in some cases in operation, two or three of them have been found open, which we think is an extremely low probability finding, but nevertheless the case.

MR. SULLIVAN: You know, in the probability sense, in the best estimate sense --

MR. MINNERS: In 15 years, what's the probability, even if it's ten to the minus eight per valve?

MR. GALYEAN: Fifteen years worth of hours, 15,000 hears.

MR. SULLIVAN: Yes, but what he's doing is assuming one of them is always failed.

MR. GALYEAN: Yes.

MR. SULLIVAN: He's assuming one is failed all the time in 15 years.

MR. GALYEAN: That's right.

MR. MINNERS: No, he's doing it per reactor year.

MR. GALYEAN: What we are assuming is that one of these two valves is in the failed state, simply because you cannot verify that they are both functioning.

MR. KERR: One of them would go through 15 years without failure, and the other one has always failed?

MR. GALYEAN: That's right. That's the assumption we're making, as I said, since we cannot verify that they are both functioning.

MR. KERR: That seems somewhat unlikely, physically.

MR. MICHELSON: But he's testing them once a year. Leakage was every three years, or one year?

MR. GALYEAN: Well, they do leak testing --

MR. MICHELSON: I thought you said at the beginning of each startup.

MR. GALYEAN: That's right, at the beginning of each startup.

MR. MICHELSON: And how many times is that, about once a year?

MR. GALYEAN: About once a year.

MR. MICHELSON: So you know once a year they're tight.

MR. GALYEAN: We know once a year the pair of them are tight.

MR. KERR: And that pair has never been disturbed for repair or anything since the plant started up.

MR. GALYEAN: Well, that may be. I don't know.

This is the other half --

MR. MICHELSON: How frequently are those valves used for other than addressing an accident, the back-to-back check valves? When else do you have flow through them, during normal plant operation?

MR. GALYEAN: Not.

MR. MICHELSON: Not at all?

MR. GALYEAN: Not at all.

MR. MICHELSON: No filling of tanks or anything else is done through them?

MR. GALYEAN: No. They inject into the reactor coolant system.

[Slide.]

MR. GALYEAN: This is the other half of the high-pressure injection system. This is treated separately, because one leg is also used for normal makeup. So you've got a normal supply of makeup water into the reactor coolant system through this injection leg. The arrangement otherwise is similar. You've got the two check valves rolled in back to back; you've got the normally-closed motor-operated valves, which are also stroke-tested monthly. And in this particular case -- or quarterly. Stroke-tested quarterly.

In this particular case, when this HP-2A valve is stroke-tested, the normal makeup continues. So this line is always pressurized to 2200 PSI. When this valve is opened, you then pressurize back to the check valve, and this portion of the piping, as a matter of routine.

Then you have the same possibility of the pump discharge check valve failing to see, and of the bypass lin being inadvertently left open. In this case, then, it's just the single opening of this injection valve, and you would get your normal makeup water would be diverted, either back this way or back through the borated water storage tank.

In addition, since this line is used during normal makeup, you'd normally have to flow through these check valves so they are open, and then if that flow is diverted, these check valves are demanded to close, which is a higher failure rate, kind of failure mode, than if they are seeded and leak and --

MR. MICHELSON: But you don't know if they close?

MR. GALYEAN: That's right.

MR. MICHELSON: Close fully, at least.

MR. GALYEAN: That's right.

MR. MICHELSON: Now, I assume the makeup is a full-pressure makeup?

MR. GALYEAN: That's right.

MR. MICHELSON: And the suction side of the HP pump is what pressure, design pressure?

MR. GALYEAN: I believe -- I have to check -- but it's probably about 600 psi; but I'm not positive of that. I'd have to check.

MR. MICHELSON: So if the check valve sticks open, then you get the overpressurization?

MR. GALYEAN: That's right.

MR. MICHELSON: How about back to the borated water storage tank? Is that 2200 back through a restricting orifice?

MR. GALYEAN: There is a restricting orifice, and the borated water storage tank is vented to the atmosphere. So there is no chance of over-pressurizing the borated water storage tank.

MR. MICHELSON: Except for the pipe downstream --

MR. GALYEAN: That's right, except for the pipe that leads into it.

MR. MICHELSON: Yes. And that's the 300, 600, or

--

MR. GALYEAN: Yes, that's lower, that's probably 300. Again, I'd have to check. It changes design rating as you move through the pipe.

[Slide.]

MR. GALYEAN: This is a diagram of the low-pressure injection interface. This probably closely, most closely comes to the Event V or V-sequence case. We've got two check valves normally open MOV.

And again, you've got two variations. You can have the failure of these check valves, the random hardware failure of the check valves and then back leaking into the low-pressure injection line, or you can have this pair of check valves fail, in which case you back leak to the core flood tank, which is inside containment.

There is a small relief valve here, but not enough to protect the system.

MR. SULLIVAN: The core flood tank would be identified quickly, right?

MR. GALYEAN: Yes. That was our assumption, was that the core flood tank, if it started to pressurize, would be identified relatively quickly.

MR. MICHELSON: What's the design pressure outside of containment on that system, the one you just had on?

MR. GALYEAN: The low-pressure injection system?

MR. MICHELSON: Yes, going to the left, where it is -- that's all 2,200 pounds?

MR. GALYEAN: No. It changes schedule right here at this check valve.

MR. MICHELSON: Inside of containment?

MR. GALYEAN: That's right.

MR. MICHELSON: So the interface, in this case, between high and low pressure, is inside of containment?

MR. GALYEAN: That's right.

MR. MICHELSON: Okay.

[Slide.]

MR. GALYEAN: Likewise, that's the case on the DHR letdown, which is this diagram here. Here's the containment boundary, and the schedule or the design change is right here at the second isolation valve, which again is inside containment.

This, okay, this is the reactor coolant system on this end. You go through, there's a pair of motor-operated isolation valves; there is a four-inch relief valve off of the 12-inch line. You go through the containment wall and into the DHR pump suction lines. There is a 2-1/2 inch bypass line, again, connecting to the 12-inch line.

These letdown isolation valves have a bypass around them where there are two locally-manually operated valves. This is installed so when they are shut down they can perform, for example, MOVATS testing on these motor-operated valves and still keep their DHR running.

MR. MICHELSON: From the viewpoint of the containment isolation criteria, I guess the suction valves on the DHR are the outboard isolation? It's the only one you show outboard.

MR. GALYEAN: I'm sorry?

MR. MICHELSON: The containment usually requires an isolation valve inboard and another one outboard of the penetration.

In this case, I guess outboard of the penetration is way over there to the valves on the right-hand side; is that the plan?

MR. MINNERS: He's not a regulator. He doesn't know.

MR. MICHELSON: But you know.

MR. MINNERS: No, I don't know. I'm a researcher.

[Laughter.]

MR. MICHELSON: It's clearly not a good penetration; clearly the valve is, like I said, a little while back, a long way from the penetration. That one there I would guess is a long way. But it might not be. But it's got to be quite a ways just to put in the branches and all the other things he's showing.

MR. MINNERS: They just took it as it was.

MR. MICHELSON: And that's also low-pressure piping, the 12-inch, and if things go wrong, it's going to get the 2,200-pound impact.

MR. GALYEAN: Right. The sequence that we're postulating here is that as the plant is starting up, one pair or the other pair of these valves could be left open inadvertently, the plant could pressurize and result in a pressurization downstream.

I just might add that this particular sequence did not contribute very much because there's a very high likelihood that if they pressurized about 320 psi, that this relief valve would actuate and dump into the emergency containment sump and alert the operators that they have a situation on their hands before they would reach a pressure that could potentially rupture downstream equipment.

MR. MICHELSON: Now, how slowly do you think this is moving?

MR. GALYEAN: This is during plant startup, when the operators are pressurizing the primary system.

MR. MICHELSON: Okay. It's during startup, and then they're starting to fill the sump before he ever got the reactor pressure on up high enough to worry about.

MR. GALYEAN: That's right.

MR. MICHELSON: Okay.

MR. GALYEAN: That's right.

[Slide.]

MR. GALYEAN: The other sequence that we postulate for this DHR letdown line is during plant shutdown and that is that either the control room crew is depressurizing the primary system, shutting the plant down and they go enter into DHR cooling prematurely; that is, before the approximate 300 PSI threshold or point at which they would normally do so.

MR. MICHELSON: I thought there was a requirement on valve applications of that type, wherein when you were above the design pressure [illegible] the downstream side, that the power had to be disconnected from the valves.

MR. GALYEAN: That's right.

MR. MICHELSON: The worry was fire and so forth. In these cases, is that true also?

MR. GALYEAN: Yes.

MR. MICHELSON: What they did is, they didn't follow that part of the procedure, I guess.

MR. GALYEAN: No. These valves are normally kept in a disabled state, but the important error, I guess, or the significant error is being made by the control room operators. They make a conscious decision to go into DHR shutdown, at which time they then go through the procedures.

MR. MICHELSON: You've got to go downstairs to do it. He can't do it from the control room.

MR. GALYEAN: Well, no, they can do it from the control room.

MR. MICHELSON: No, no, then he hasn't done it right, because the fire problem was fire in the control room or in the adjacent are that they were worried about. Therefore, they went to the breakers and disconnected the power at the breaker and you couldn't -- you had to go back and rack in the breaker to get started?

If they did it that way, then those acts would have to be omitted for this to happen. Either that or I guess he left the valves open and pulled the power.

MR. GALYEAN: No, that's not what we're postulating here.

MR. MICHELSON: All right.

MR. GALYEAN: We're saying that the valves are closed and they're in the position they're supposed to be in; that is, the control power is removed and the circuit breakers are open. The operators are shutting the plant down and they sa", okay, it's time to enter into DHR cooling.

Now, what we're postulating is that they make that decision at an inappropriate time. Once they make that decision, then they go through the procedures and do what they have to do to open the valves; that is, close the circuit breakers, restore control power and then open the valves.

MR. MICHELSON: They did it too early?

MR. GALYEAN: That's right.

MR. MICHELSON: That's a lot of things to do wrong.

MR. GALYEAN: Well, we've had a lot of discussion on this, and really it's only one wrong decision that's being made. Once they make that decision, then they pursue that course of action.

MR. MICHELSON: They had plenty of time to think about it while they were doing it because you can't do it quickly. It takes half an hour to go through that.

MR. GALYEAN: In the handout are the event trees for each of these five sequences. I was not planning on going through them individually unless someone has a question.

MR. WILKINS: Is this kind of event that you and Mr. Michelson were just discussing, what you call intentional error?

MR. GALYEAN: That's right. This is a cognitive error of commission, I guess, in the HRA.

MR. MICHELSON: If you've got a lot of time to think about it while you're carrying it out, then it's different than if it only requires a flip of the switch. That kind, you don't think about till later. This one, you're doing a lot of things and somebody hopefully catches it before you get done.

MR. MINNERS: Is this what happened at TMI?

MR. MICHELSON: Oh, yes, at TMI, they just watched it for hours, sure. I don't say it can't happen. I'm just saying that there's a chance of catching it as opposed to those you can do quickly.

[Slide.]

MR. GALYEAN: The first one on my list here is the first sequence we talked about and that was the high pressure injection.

MR. CATTON: That's fine. When I look at that and take, operators failed to detect ISLOCA, and you've got 2 times 10 to the minus 5.

MR. GALYEAN: Yes. This is really -- we were not real precise in our semantics here. What we're really saying is that the operators failed to detect an abnormal event. It's subsequent here that they then diagnose it as an ISLOCA.

MR. CATTON: Now, if I look down, I see that every one of them is the same.

MR. GALYEAN: In this particular sequence, that's right.

MR. CATTON: If I go to the next step, you go back. Again, it says that operators failed to diagnose

ISLOCA. I get the same number all the way down.

MR. GALYEAN: That's right, in this particular sequence, that's true. If you look at one of the others, you'll see that these numbers will vary, dependent on what happened previously. In this particular sequence --

MR. CATTON: The question I asked earlier is; how do you get there? Do you sort of track through the thermal hydraulics along that tree?

MR. GALYEAN: We track through the sequence of events through this tree, okay? For example, here we start out and say, there are three lines exposed to this potential failure during the course of the year. We say, okay, one pair of those back-to-back check valves could leak.

Okay, if that leaks, then the -- normally open -- this is the stroke testing of that injection valve and so on. The decisions -- these events depend on what happened before.

MR. MINNERS: He wants to know if you calculated the consequences along that tree?

MR. CATTON: I don't think he does. I think he's answered my question.

MR. MICHELSON: Are you asking about environmental consequences or reactor conditions?

MR. CATTON: I was just curious that when you have a t like this and you somewhere down within the tree have got a pipe that might rupture and you can get to it in a number of different ways.

MR. HANSON: There is only one event on that tree where the pipe ruptures. That's the one about right in the middle.

MR. CATTON: This is pretty much independent of thermal hydraulics; is really what it gets down to.

MR. HANSON: In that one event, the whole thermal hydraulics are centered in that one event.

MR. CATTON: Are there any events where that's not the case.

[Slide.]

MR. GALYEAN: This is the event tree for the low pressure injection sequence. If you notice, now the numbers in some cases are the same, but these vary and these vary, okay, which means that there's a dependency on the previous failures. When we get to this point, we say, well, what's the probability of this event, given this particular sequence of events which occurred previously?

MR. MINNERS: That wasn't the question.

MR. CATTON: You calculate your way through that?

MR. GALYEAN: Yes.

MR. HANSON: The thermal hydraulics aren't changing in the system up to the point of rupture. Then that's the event up there that says interfacing system ruptures and that's where all your thermal hydraulics are centered, just in that one event.

MR. CATTON: In this particular case, you really don't have to?

MR. HANSON: That's right.

[Slide.]

MR. GALYEAN: I'll return now to that premature shutdown and I'd like to explain a little bit further, some of the issues that were addressed.

MR. SULLIVAN: Can I ask you another question about the -- you don't even have to turn back to it, I don't think. Those operator failures at 10 to the minus 5, have you seen numbers that low?

MR. GALYEAN: Well, that's what we used as our lower bound and if you -- you can postulate a potential sequence of events and be so specific in the context in the operating mode and things like that, that it's never happened, okay? What do you do in a case like that?

Our approach is to do it analytically, okay, and many times we get very low numbers, 10 to the minus 5. That's -- in our opinion, we use that as the lower bound on our operator error, and I don't know how else to do it.

MR. MINNERS: What do you mean by "seeing?" Do you mean in operating experience?

MR. SULLIVAN: For operating experience.

MR. MINNERS: I don't think you've seen that; that's my opinion.

MR. GERTMAN: What I wanted to say is; the situation is such that you may have five indicators up there for the operator or crew to view and for some time, perhaps hours. The possibility exists that if not the person, the second person or the third person is going to look at the indication and come to the correct decision.

Even if you say you don't need all five, if you needed to fail on detecting any of the five, then you'd multiply them out and you're out at E-14 or something of that nature, just through the modeling. If you say you require three out of five indicators to exists as a signature so that you could come to the correct conclusion, even so, you still come out with an almost negligible rate.

For the time horizon sufficiently short such as like one hour, one and a half hours or something like that, you would have a different rate. It's just the opportunity is great because it takes so long to get to core uncovering that we have those kinds of rates.

MR. KERR: Remember, Harold, he is breaking new ground.

MR. CATTON: That's true. They even have a probability on one of these of 3.98. That's really breaking new ground.

MR. GALYEAN: We don't mean to imply that kind of precision, it's just a calculation precision.

MR. CATTON: I think 3.98 is bigger than one.

MR. GALYEAN: Well, those are not probabilities; those are frequencies.

MR. CATTON: It says sequence probability.

MR. GALYEAN: Excuse my sloppy semantics then. Those are frequencies.

MR. CATTON: Incidence per year, so this particular one will happen four time a year?

MR. GALYEAN: That's right. I think that's identified as an okay entity. That's not a failure.

Getting into the premature entering the DHR cooling, we had no reason for picking a particular primary system pressure which the operators would get into or open those isolation valves Therefore we put together a probability distribution as a function of RCS pressure so that we could weight the likely RCS pressure and carry that through to the calculating probability of a rupture.

Our feeling was that it was more likely the operators would go into DHR cooling a little bit early, contrasted with going into DHR cooling a lot early. Hence we put together this probability distribution which I am showing as a histogram, since that is how we used it.

It's just exponential with relative -- if you assume a relative weight at 400 psi of one, the relative weight at 2200 psi would be ten to the minus three, so we are saying it's a thousand times less likely that they would go in the DHR cooling at 2200 compared to 400.

This is not the human error probability. This is simply the probability distribution of the human error -- if that makes sense -- I guess of the HEP -- the probability of a probability.

MR. WILKINS: Say that over again!

[Laughter.]

MR. GALYEAN: This is not the human error probability. This is how we weight the human error probability. We take the human error probability from the human reliability analysis, okay? That was generated. In this particular case it's two times ten to the minus three, okay, for the operators prematurely entering DHR cooling.

That says nothing about at what pressure they enter DHR cooling.

We then take that two times ten to the minus three and weight it by this probability distribution.

MR. WILKINS: So you sample from some distribution to get the RCS pressure.

MR. GALYEAN: That's right.

MR. WILKINS: Then you log normal distribution, right? Having picked that pressure then you decide --

MR. GALYEAN: No. This is before that.

MR. WILKINS: Then I really didn't understand it.

MR. GALYEAN: We use this to then postulate what the RCS pressure is.

MR. WILKINS: Ah, not the other way.

MR. GALYEAN: And then once we have a postulated RCS pressure, well, then we go through and do the Monte Carlo simulation to calculate the probability of a rupture.

[Slide.]

MR. GALYEAN: Combining this weighting of the HEP and the probability of getting a rupture, I've displayed on this table here, this shows numerically what you just saw on the previous graph. We took the HEP of two time ten to the minus three, weighted it over the range of RCS pressures. We then, we also tabulated the probability of rupturing the DHR system as a function of pressure. We then multiplied these two to get the weighted system rupture probability.

These numbers are the numbers then that appear on the event tree for this particular sequence.

[Slide.]

MR. GALYEAN: After going through the quantification of the event trees or doing the quantification of the event trees, every event tree end state was attached a plant damage state category.

The plant damage state categories we used are large releases, mitigated, releases, a LOCA inside containment, a leak but no core damage, and an OK-overpressure where you have overpressurized the system but you did not generate any ruptures, and then a final category was just an OK, where nothing detrimental happened.

The core damage frequency then is just the sum of the large releases and the mitigated releases. We then went on to calculate the risk.

The risk measures we used were early fatalities, latent cancers and population dose.

MR. MICHELSON: Where's the LOCAs outside of containment?

MR. GALYEAN: These would be categorized as isolated LOCAs outside containment and would fall into the release category.

If you had a rupture which was then isolated and core damage prevented, that would fall into the leak but no core damage category.

In a case where you had a LOCA inside containment for example, if you overpressurized the core flood tank and it ruptured and resulted in a leak inside containment we did not pursue that further. As you will see, those numbers are quite small and they are basically within design basis. If you multiple that by the availability of ECCS system it would go even smaller, so we did not pursue those further explicitly.

MR. MICHELSON: I thought you said that if you had a rupture outside of containment and you isolated it you now call it a leak category?

MR. GALYEAN: A plant damage state. We categorized that plant damage state as a leak but no core damage.

MR. MICHELSON: How long can it persist without being isolated before it changes from a leak without core damage to a leak with core damage?

MR. GALYEAN: For the two high pressure -- well, for the two HPI and makeup and purification sequences, okay, which we postulate eight hours to be available.

MR. MICHELSON: You're back to that eight hour idea that nothing is harmful that's done to the environment out there for eight hours?

MR. GALYEAN: That's right.

MR. MICHELSON: Because nothing is harmful to the core because we had plenty of makeup to the core.

MR. GALYEAN: That's right. For the low pressure sequences, the LPI and the two DHR sequences we assumed that there is four hours available. These were based on some simple hand calculations done that estimated that would calculate the time to core uncovery.

MR. MICHELSON: Yes, but you never did determine what was happening to the environment that might effect core makeup capability.

MR. GALYEAN: We only postulated --

MR. MICHELSON: Beyond the room in which the event was occurring.

MR. GALYEAN: That's right.

MR. MICHELSON: That is an extremely serious shortcoming, at least in my view. When you start talking four to eight hours that is an extremely short-sighted view of the problem.

[Slide.]

MR. GALYEAN: The core damage frequency calculations generated this distribution due to or from the five sequences. That is, the DHR shutdown sequence that is prematurely entering DHR shutdown contributes 70 percent. The low pressure injection sequence is about 23 percent and this is the makeup and purification sequence -- it's about 6 percent.

MR. MICHELSON: You only got into trouble if you had a makeup problem, core uncovery problem?

MR. GALYEAN: Right. Core uncovery we equate to core damage.

[Slide.]

MR. GALYEAN: This just shows numerically what you saw on the previous chart. This has a little bit more information in that the non-core damage sequences are also depicted here. That is, the LOCA inside containment sequences are also shown here. As I mentioned, very little probability.

The sequences that ended in a leak outside containment but no core damage, see, are quantified here, and the cases where you had an overpressure but did not generate a leak were also quantified.

MR. MICHELSON: And that is a fairly high frequency on your leaks with no core damage?

MR. GALYEAN: That's right, that's right.

This is consistent with the operational experience where we have seen -- these could be categorized as ISLOCA precursors similar to the kinds of events we have seen.

MR. MICHELSON: Well, there is a whole set out there that you don't see fortunately, and that's the case where you get these big leaks but get them isolated right away. Then again they appear as a no core damage leak. That's the next-to-the-last column, if I understood what you said.

Now what is the probability that when experiencing this very large break you are going to get the valve closed and get the breaks shut off. Well, that doesn't appear anywhere here.

MR. GALYEAN: I guess I don't understand your comment.

FROM THE FLOOR: You overpressurize in the last column, don't you?

MR. MICHELSON: You overpressurize in the next-to-the-last column too.

MR. GALYEAN: This is where you have generated a rupture in the low pressure system --

MR. MICHELSON: You've got it isolated.

MR. GALYEAN: But then you subsequently isolate it and prevent core damage.

MR. MICHELSON: But he does the isolation with an extremely high probability of success.

MR. CATTON: If you used the German data, that number would jump by a factor of ten.

MR. MICHELSON: At least.

MR. CATTON: Well, they said 8 percent on reliability rather than the ten to the minus three.

MR. MICHELSON: It begins to get to be troublesome -- now you are using, I think, about ten to the minus three range

MR. CATTON: That's what their tree shows, ten to the minus three.

MR. KERR: I think the assumption is we always have to close against this total differential.

MR. CATTON: In this case, I am not sure what the differential is, but if you vent through the pipe, you're closing against flow.

MR. MICHELSON: You're closing against virtually total differential.

MR. KERR: It depends on what's happened to the pipe.

MR. CATTON: Of course. I think that's what I said.

MR. KERR: You said ruptured it.

MR. CATTON: They have ruptured the pipe.

MR. GALYEAN: The isolation valves that we're relying on in this case have all been examined in light of the valve testing that's going on.

MR. CATTON: You didn't say that when we asked the question several times before.

MR. MICHELSON: You said the motor size was checked. That's all.

MR. GALYEAN: That's right.

MR. CATTON: If you have checked the motor size and you've checked the torque testing against the manufacturer's specifications, then you don't know that the valve will close, because the testing that's been done shows that it won't.

MR. GALYEAN: Let me explain what we did. Okay?

MR. CATTON: It might help.

MR. GALYEAN: The valve testing program going on -- the tests are actually being done in Germany. Most of the work is sponsored by the NRC through the INEL. Okay?

And those people are putting together analytical models to reflect the results of the valve-testing program, and what we did, we collected the information from the utility, gave it to these people doing the valve testing, and said will these valves operate? Or tell us what the threshold is at which these valves will cease to operate? And in all cases, it was above 2,200 psi. Okay?

They took things such as friction factors, you know, the number of threads on the valve stem, the torque set limits.

MR. CATTON: Okay. That's enough.

MR. MICHELSON: It was under flow.

MR. GALYEAN: Yes. Well, to them, yes, it was under flow. It's the flow that you would see with whatever delta P would result.

MR. MICHELSON: What the earlier discussion was was what effect, if any, did this reflect, and how did it reflect, if at all, into the probability numbers, and the answer was no, you use the non-loaded probability numbers.

MR. GALYEAN: That's right. We went to these people doing the valve testing and said would these valves operate under these conditions? And they looked at it and analyzed it, and they said yes. They told us what the threshold was at which they would cease to operate.

MR. CATTON: Did you tell them what the torque settings were?

MR. GALYEAN: Yes.

MR. CATTON: Okay. I thought it was a simple question, needed a one-line answer.

MR. MICHELSON: Well, it's a lot deeper question, I think, Ivan.

The problem is that you don't know -- even if the motor is big enough and even if you correct for friction factor, you don't know how to correct the probability of closure unless you use the non-loaded probability of closure.

MR. CATTON: Carl, the test I saw when I was in Germany, if they put two times the manufacturer's setting, the valve closed. It just carved its way shut.

Now, what this gentleman is saying is that apparently the torque settings are high enough to do that.

MR. MICHELSON: No, he didn't say that.

MR. CATTON: Didn't you just say that?

MR. GALYEAN: At the plant we're looking at, they use limit switch settings.

MR. CATTON: Are the limit switch settings high enough?

MR. GALYEAN: Yes.

MR. MICHELSON: You don't set those high.

MR. CATTON: He says they do. Either he is mistaken or --

MR. GALYEAN: The limit switch setting measures the length of travel the valve goes. Okay? When the valve is fully shut or 98-percent shut or whatever, it actuates a limit switch, and that then tells the valve operator to stop operating. Okay? It has nothing to do with torque.

MR. MICHELSON: You have the full torque of the motor available.

MR. GALYEAN: Exactly.

MR. MICHELSON: Now, the question is how much margin is there between what's needed for that condition and what the motor can produce? All you told me was the motor was bigger than what was needed. You didn't tell me if it was 5 percent bigger or 100 percent bigger. You said double, and I never heard them say that it was that kind of margin in these motors. He just says it was more than they calculated. Maybe 1 percent, I don't know.

MR. GALYEAN: I think those results -- I believe they're in the copy you have. The results of this calculation are in the report, in the appendix. I believe it's at the end of the system description appendix, which I believe is Appendix C.

MR. CATTON: That report is awful thick.

MR. GALYEAN: I know.

[Slide.]

MR. GALYEAN: Once we had the core damage frequencies calculated, we then went on to calculate consequences, as I alluded to before. The information on the B&W plant was taken from the Oconee PRA. We used the Sandia Siting Study to generate a site, a nationwide average site.

We then took this site average and compared it to the NUREG-1150 sites, so that we would then have a max input deck to use for calculating consequences. It turns out that Surry is very close to the national average, for a wind-weighted population density.

[Slide.]

MR. GALYEAN: The conditional consequences were calculating using MACCS. The Surry evacuation strategy and Oconee source term and release timing were used. We calculated conditional consequences for a range of decontamination factors. We equated a large release to a DF of 1 and a mitigated release to a DF of 10.

The mitigated release simply refers to some form of scrubbing of the release before it's released to the environment. The likely sources of this scrubbing could, for example, be aux building fire-protection spray system, the sprinkler system, or if the release was considered -- would be submerged.

MR. KERR: The dilution factor or whatever it's compared to what?

MR. GALYEAN: I'm sorry?

MR. KERR: You talk about a DF of 1. It's compared to what?

MR. GALYEAN: Well, no scrubbing. It's just the source term --

MR. KERR: Is this a source term in the vessel, the source term at the point of pipe rupture, or none of the above?

MR. GALYEAN: At the point of -- in the vessel. Well, it's not the inventory.

We took the source term from the Oconee PRA, and that was the containment bypass source term, what they had postulated for Event V, the V sequence. That's the source term we used.

MR. KERR: That was the actual release outside of containment?

MR. GALYEAN: In this particular case, it would be the release inside containment, would be a good analogy. It's not what we use, because by definition, we're talking about releases outside containment.

MR. CATTON: The vessel release out?

MR. MINNERS: You can't use the source term into the pipe, and the decontamination factor is just the -- the source term is what he used going into the pipe. Okay? And the decontamination factor just tells you what came out.

If it had a DF of 1, that means you multiply it by 1, or you divide by 1.

MR. KERR: I understand that, Warren. I just didn't know whether what you used as going into the pipe was the full inventory of fission products.

MR. GALYEAN: No.

MR. KERR: What do you assume attenuated it, then?

MR. GALYEAN: Deposition inside the vessel.

MR. KERR: Okay. So, you don't take any credit for deposition along the piping.

MR. GALYEAN: No.

MR. KERR: And you don't take any credit for deposition inside the aux building.

MR. GALYEAN: That's right.

MR. SULLIVAN: In other words, those numbers have been determined.

MR. GALYEAN: I'm sorry?

MR. SULLIVAN: They have determined what the DFs in the aux building are.

MR. GALYEAN: We have looked at the available literature on aux building DFs. Those numbers -- well, these numbers are consistent with what's published in the available literature. Some of the literature is not referenceable, and I don't know what else to say about it.

MR. CATTON: Why is that?

MR. GALYEAN: It's EPRI proprietary. They refer to it as licensable material.

MR. MICHELSON: Well, if they're using the same numbers, then are they simply saying that it's all occurring within the pipe, also?

MR. GALYEAN: Well, they did very detailed -- they used MAAP. Okay? And they have put together very detailed models of the aux building.

They looked at different aux building configurations. For example, are there three major compartments or two major compartments?

MR. MICHELSON: Why did they end up with the same answer you ended up with?

MR. GALYEAN: It's not the same answer. It is consistent, I think.

MR. MICHELSON: What does that mean?

MR. GALYEAN: It means we're in the same ballpark.

MR. MICHELSON: That means a factor of 10?

MR. GALYEAN: Yes.

MR. SULLIVAN: The numbers that I have seen of them are not those numbers.

MR. GALYEAN: That's right. But they're talking about different aux building configurations. They're talking about the availability of fire-protection sprays. They're talking about the likelihood that the risk will occur in a submerged pool of water.

MR. MICHELSON: Why did they think that?

MR. GALYEAN: Well, for the different scenarios or sequences that they postulated, and the particular configuration of aux building they looked at.

MR. MICHELSON: The pipe was always below water level.

MR. GALYEAN: Not always.

MR. MICHELSON: Below water release mains, I thought.

MR. GALYEAN: They did a number of sensitivity studies. I don't remember the exact number. Maybe it would be around 15-20 different variations, whether it's a large-break, a small break, the configuration of the aux. building, whether or not it would be submerged or not submerged. For the cases that most closely, are closest to the situation we're looking at, these numbers are consistent with what was done in the EPRI work.

[Slide.]

MR. GALYEAN: I don't believe that we got to this one. But the risk that was calculated -- again, this is on a per-reactor year basis -- the 50-mile population dose, the latent cancers and early fatalities, in the situation that we looked at, all releases would be large releases. There was no potential for mitigating the release. We show it up there just for completeness sake, but in our particular situation, there would not be any mitigation. The release would not be submerged and there are no fire protection sprays in the area of the postulated release.

MR. KERR: What is the significance of total grid as associated with latent cancers?

MR. GALYEAN: This is NUREG 1150 terminology. Total grid refers to 1,000 miles from the plant site.

MR. KERR: I was going to say, the world is bigger than that, isn't it?

[Laughter.]

[Slide.]

MR. GALYEAN: Once we went through our analysis, we then sent back and said well, what areas are we most concerned about, which are the highest contributors to risk, and where are we most uncertain?

We picked two major areas to go back and perform sensitivity studies on.

The first was the effect of pipe rupture pressure uncertainty. The base case assumes a logarithmic standard deviation for a beta value of .036.

We said well, suppose we could reduce that to 0.1. This, it turns out is probably overly optimistic improvement in the uncertainty of the pipe rupture pressure.

We also then went back, and I showed you that probability distribution --

MR. KERR: Excuse me. What effect would the reduction of uncertainty have?

MR. GALYEAN: Well, it means your distribution of pipe failure pressures is much narrower.

MR. KERR: Yes. So what effect would this have on the results you found?

MR. GALYEAN: Well, I'll get to that in just a minute.

MR. KERR: Oh, okay.

MR. WILKINS: You chose to consider reducing the standard deviation --

MR. GALYEAN: That's right.

MR. WILKINS: -- rather than increasing it.

MR. GALYEAN: That's right. Well, IMPEL did the best job they could. They tried to be as realistic as they could. We have no reason to doubt their calculations.

MR. WILKINS: I just want to test my own intuition here. It seems to me that if you increase the standard deviation, you'd make things worse.

MR. GALYEAN: It depends if you're talking about failure, if you're talking about exposing the system to pressures less than the median failure pressure. Okay. If you're on the --

MR. WILKINS: Other side.

MR. GALYEAN: -- the other side --

MR. WILKINS: -- the bigger pressure --

MR. GALYEAN: That's right. If you're talking about pressures greater than the median failure pressure, then narrowing the uncertainty can in fact increase the probability of failure, you see.

MR. WILKINS: All right. It's tricky.

MR. GALYEAN: The human factor sensitivity studies that we chose to perform were on that probability distribution that I showed you earlier, where you said well, suppose the distribution was, well, slightly different. And I'll get to that in just a minute.

[Slide.]

MR. GALYEAN: This is just a repeat of the graph you saw earlier this morning, which shows the system failure pressure for the DHR system.

I would just point out again the median failure pressure is about 1100 psi which says that if the operators enter, prematurely enter into DHR cooling at 1100 psi primary system pressure, there is a 50-50 chance that you will get a large rupture versus a small rupture.

[Slide.]

MR. GALYEAN: Changing that uncertainty parameter from .036 to 0.1 generated this failure probability graph. And you see that the median failure pressure has shifted down or up, but just slightly. You're now at about 1300 psi. So what we're saying is that improving the uncertainty, probably more than is feasibly possible, results in a small difference in the system rupture pressure.

MR. CATTON: If I miscalculate the flow to the relief valve, I can make a significant difference in these numbers.

MR. GALYEAN: Yes

MR. CATTON: Because the slopes are really steep.

MR. GALYEAN: That's right. That's right.

[Slide.]

MR. GALYEAN: This just numerically displays the results of this particular sensitivity study in terms of core damage frequency and in terms of the plant damage states.

And you can see that the base case for this particular sequence, which is the DHR shutdown sequence, went from "1.6 times 10 to the minus 6" to "5.6 times 10 to the minus 7." So we're talking, well, basically a factor of 3 reduction, not an order of magnitude.

MR. CATTON: It seems to me you ought to look at the sensitivity of your calculations of the flow rates. That would have a much more dramatic impact.

MR. GALYEAN: It would likely increase the pressure experienced in the interfacing system by a few hundred psi, probably.

MR. CATTON: It could easily be a factor of 2.

MR. MICHELSON: Of course they totally ignored the possibility the adverse environment is going to get beyond the room in which it's located, and that may throw these off many orders of magnitude, depending on the plant-specific case.

MR. CATTON: One at a time.

MR. MICHELSON: We're looking at the little ones. Although they're all big.

MR. CATTON: Well, it has to break before you get the adverse impact, so we'll do it sequentially.

MR. MICHELSON: All right. Touche.

[Slide.]

MR. GALYEAN: This, then, -- we went and did two variations on this probability distribution for the HEP. The base case is shown in blue, which is the same graph I showed you earlier. And that assumes a relative difference between 400 and 2,200 of about 1,000.

The case one looks at the situation where that relative weight is increased to 10,000, and that is more heavily weighting it towards the lower pressures. That's depicted, as I said, as the red bar.

The green bar assumes a linear probability distribution, where it goes from 400 down to 1,000, and we say that it's impossible or they're not going to prematurely enter DHR cooling above 1,000 psi, that it's all going to happen, you know, below 1,000 psi.

MR. MICHELSON: Aren't there pressure interlocks on those valves as well, to prevent opening above a certain pressure?

MR. GALYEAN: Yes.

MR. MICHELSON: So even if the operator makes a human error, I'm not sure you can open them at 1,000.

MR. GALYEAN: I should have touched on this when I was talking about the sequences. There are two valves, DH-11 and 12, motor-operated valves.

One valve, the interlock apparently has a large dead band on it that inhibits it opening above 266 psi.

Now the plant procedures instruct the operators that at about 300 psi you enter DHR cooling.

Now, since this valve, since the interlock on this valve will not let it open above 266, the procedure has written into it a step that says if this valve won't open, jumper out the interlocks.

MR. MICHELSON: You mean the tech spec allows it? If that interlock is not functional, I thought you had to fix it in some certain time or the system becomes inoperable, and would you would go into a limiting condition.

MR. MINNERS: We don't have the regulators here today.

MR. MICHELSON: You can't operate with that interlock not working and do it so consistently that you even write a procedure to get around it.

MR. GALYEAN: We have copies of the procedures. And, as I said, it's written into the procedures.

MR. MICHELSON: It's unbelievable.

MR. GALYEAN: The error that we're actually postulating is that the operators make decisions to enter DHR cooling and inappropriately jump route both valves instead of just the one valve. And that's basically the error that we're postulating here.

MR. MICHELSON: The switch was working all right on one of the valves, it just wasn't on the other one?

MR. GALYEAN: Well, the term that the utility used was there was a large dead band on it.

MR. MICHELSON: Well, that means it's just not working right.

But apparently, that didn't affect but one of the two valves as far as being able to open it at the proper pressure, which I think is around 325, something in that neighborhood.

MR. KERR: Is this sequence a significant contributor?

MR. GALYEAN: This is the highest contributor.

MR. KERR: Does the interlock turn out to be a major contributor?

MR. GALYEAN: Obviously, postulating that the operators would bypass these interlocks is fundamental to this error.

MR. MICHELSON: Are there any regulators in the room today?

[No response.]

MR. MINNERS: This is just the B&W plant.

MR. MICHELSON: That's got nothing to do with it.

[Slide.]

MR. GALYEAN: Now, using those three probability distributions, the base case and the two sensitivity cases, these are the results that were generated. As I said, as you saw before, the base case probability for the DHR shutdown is 1.6 times 7 to the minus 6.

Using the case 1, which, as I said, more heavily weights the same distribution but more heavily weights it towards the low pressures, reduces that down to 1 times 10 to the minus 6, and then using the linear model that says it's impossible, that they're going to do it above 1,000, that it will occur between 400 and 1,000 psi, effectively yields the same probability.

MR. MICHELSON: Now, since this is one of the more serious sequences, are there special recommendations that go with this particular one? You don't make recommendations for this report, I guess.

MR. GALYEAN: That's right.

MR. BURDICK: No. We're not going to make any recommendations in this report.

We do have a separate cost-benefit analysis that we -- where we will be looking at the -- at various combinations of fixes and quotes.

MR. MICHELSON: Is that a generic issue? No, it wasn't a generic issue, was it? It is?

So, when we see the generic issue resolution, that's when we'll see these results?

MR. BURDICK: That's correct.

MR. GALYEAN: Just to reiterate a little bit, this indicates that most of the risk occurs at -- that the operators would open the DHR let-down line in the lower pressure range.

That concludes my talk on the results for the B&W plant analysis.

MR. CATTON: If there are no questions, I'd like to take a 10-minute break.

[Brief recess.]

MR. CATTON: Let's hear about Westinghouse.

[Slide.]

MR. KELLY: Good afternoon.

My name is Dana Kelly. I'm from the Idaho National Engineering Laboratory.

I'm going to present some preliminary results from our ISLOCA analysis of a Westinghouse plant. It was a four-loop Westinghouse plant with an ice condenser containment.

[Slide.]

MR. KELLY: This presentation is going to be somewhat briefer than the ones that Bill gave. I'm not going to reiterate a lot of the details of the methodology. I am just going to focus on the results.

I'll talk first about the ISLOCA core-damage frequency, the scenarios that we examined in our screening analysis of the plant.

We looked at, first of all, overpressurization of the ND or the RHR system. This is the licensee's designation for the RHR system, looking at overpressurization of the ND system during startup, looking again at possibility of premature entry into shutdown cooling, a la the results for the B&W plant, and looking at failure of check valves at the RCS pressure isolation boundaries.

[Slide.]

MR. KELLY: I'm going to quickly go over some simplified flow diagrams for the interfacing systems that came out of the screening analysis.

The first of these is the RHR or ND system. It's divided into two trains; one pump, one heat exchanger per train; suction for the train can be from either hot leg; two isolation valves inside containment; no manual maintenance bypass valves around these MOVs -- this is a later design; a relief valve on each one of the suction lines that relieves to the pressurizer relief tank located inside containment.

The containment boundary is not shown on this drawing, but it's just downstream of that relief valve tie-in.

MR. MICHELSON: The relief valve is inside of containment.

MR. KELLY: Yes, sir.

The discharge can be either to any of the four RCS cold legs or to two of the hot legs, which is normally during the recirculation phase of a loss-of-coolant accident. The discharge is cross-connected, and these valves are normally open during normal power operations, Mode 1.

[Slide.]

MR. KELLY: This slide shows the tie-in for the cold leg injection accumulators, four accumulators, one on each loop. It also shows the normal makeup from the two centrifugal charging pumps. One of these valves is incorrectly labeled. One is normally open during normal operations.

The tie-in is separate, not through the pressure isolation valves for the high-pressure safety injection system, as it was at the B&W plant.

MR. MICHELSON: What is the significance of the -- I don't understand this one symbol. It's kind of two slash marks, where another line goes through in the other direction. Is that a cross-over or something?

MR. KELLY: Which one is that?

MR. MICHELSON: The previous.

MR. KELLY: This is just a cross-over, an Auto-Cad symbol for a cross-over, yes.

MR. MICHELSON: And I don't understand why you've got -- okay, I've got it.

MR. KELLY: These symbols here just indicate that the flow can go either direction. They're not indicated to be a three-way valve or anything like that.

Right here, for example, this is just the coming together of two flow paths, not a valve.

[Slide.]

MR. KELLY: The high pressure safety injection system, again, divided into 2 trains with 2 pumps, suction either from the refueling water storage tank, which is the injection phase, or piggy-backed off of the discharge of the ND pumps during the recirculation phase. Discharge to either the cold legs or the hot legs.

Again, we have the pressure isolation valves on each of the injection lines, 2 check valves. Each of the check valves is individually leak rate tested during start-up. This is somewhat different from some of the valves at the B&W plant that were welded together and could only be tested as a pair.

MR. MICHELSON: One of those check valves is some kind of a unique valve with a funny little symbol. What kind of valve is it?

MR. KELLY: I'd have to check.

MR. MICHELSON: You're giving 156 valve there. Funny looking symbol.

MR. KELLY: I cannot recall what the difference is between these 2 without going back and checking the details.

MR. MICHELSON: It could be that it's got an external actuator that rotates the flap or something --

MR. KELLY: I'm not sure.

MR. MICHELSON: But then the slash line in it doesn't make sense.

MR. KELLY: It's -- it's not an external actuator, I know that, but I'm not sure exactly what the difference is.

MR. MICHELSON: All right.

MR. KERR: Are you sure this is not a circuit diagram for a transistor radio?

[Laughter.]

MR. MICHELSON: It is strange.

[Slide.]

MR. KELLY: This is a close-up of the interface that turned out to be -- contributor to ISLOCA risk at this Westinghouse plant. This shows the injection from each one of the RHR or ND trains going into either of the 4 cold legs through the 2 pressure isolation check valves. I put that up just because I know those flow diagrams are a little hard.

MR. MICHELSON: Where was the -- where was the interface on that drawing between high and low pressure? Was it at the -- the first check valve?

MR. KELLY: It's right here. It's right -- the pressure -- the break is right there on the RHR side of the second check valve.

MR. MICHELSON: Not the code class -- where did the pressure rating change?

MR. KELLY: Right there.

MR. MICHELSON: Right there, okay.

[Slide.]

MR. KELLY: There is an event tree for the dominant scenario in the slides. I didn't intend to go over it, but I'm willing to answer questions from it. I will be presenting the results for that dominant scenario.

MR. KERR: You said ND was their nomenclature for --

MR. KELLY: For the RHR system. It's also low-pressure safety injection as well.

MR. KERR: What does ND stand for, do you know?

MR. KELLY: I believe it's like nuclear decay heat or something along those lines. I'm not a hundred percent sure.

MR. KERR: Thank you.

[Slide.]

MR. KELLY: The first results of the ISLOCA core damage frequency results. We had 1 dominant contributor to core damage frequency with a mean core damage frequency of 2.5 times 10 to the minus 6 per reactor year. That sequence involved failure of a pair of the injection check valves at the boundary between the ND system and the RCS. This is a classical Event V Sequence.

All the other sequences that we quantified were, on an individual basis, less than 10 to the minus 8 per reactor year, and in most cases, they were very much less than that.

We did not find any credible human errors that could initiate an ISLOCA. This is a significantly different result from the B&W plant.

We found that the flange gaskets were not likely to fail when they were exposed in this dominant scenario to essentially full RCS pressure. This was primarily a factor of a different type of bolt being used; a stronger bolt with a higher torque value. This came out of the IMPEL results.

We found that a large break was most likely to occur at the tube-side cylinder of one of the ND heat exchangers. Remember, there are 2 trains and the 2 heat exchanges are essentially in parallel because of the open discharge cross-connect valves.

MR. MICHELSON: When you talk about flange gaskets, you're referring to valve bonnets?

MR. KELLY: No, sir. I'm talking primarily about piping flange gaskets.

MR. MICHELSON: Okay. You're not saying anything about the valves, in that case?

MR. KELLY: Not in this bullet here, no.

We have a 90 percent confidence interval on this core damage frequency that I've shown here. These are a per reactor year, frequencies per reactor year.

[Slide.]

MR. KELLY: For the consequence analysis, we took a different approach than was used for the B&W plant, primarily because we had a different set of information available. We had a NUREG-1150 analysis in Sequoyah that was almost a sister plant to the plant that we were analyzing. We had available to us the full 1150 suite of codes and we used SEQSOR, in combination with partition, to generate, parametrically generate source terms for our dominant sequence.

MR. KERR: The -- as I remember, the Sequoyah source term, for this sequence, was an adaptation of the Surry source term?

MR. KELLY: Yes, sir, I believe that's correct.

MR. KERR: Yes. This is Surry twice removed.

MR. KELLY: You could probably make that characterization.

Again, we used version 1.5.11 of MACCS to generate offsite consequences, again, using meteorological input data from the Surry site.

For our base case we assumed an auxiliary building decontamination factor of 1. This was based on a walk-down examination of the auxiliary building. We'd found no general area fire protection sprays and, for our break location, we could not determine any way that it would be flooded.

We did run some sensitivities on decontamination factor and I'll talk about those in a few moments.

The results from the consequence analysis, and these are conditional on the occurrence of core damage, are shown here. We report early and late in fatalities, then the 50-mile population dose.

MR. MICHELSON: Since the utility had done some work required to address the effects of pipe break, I assume that they had also done some work to determine what the environments are from -- from these interfacing system LOCA locations. Is that the case, or did you go and look or ask the utility if they'd done any analysis to tell you what the environment might be and the extent to which the environment might go?

MR. KELLY: The only analysis they had was the high energy line break analysis that they do. They did not have an analysis for us for --

MR. MICHELSON: This is a high energy line break.

MR. KELLY: Yes it is, but it was not included in their high energy line break analysis, because it's not a high energy line unless you have a failure of the isolation valves.

MR. MICHELSON: They must have broken -- oh yes it is. You have to analyze it as a high energy line break and then take credit for isolation of it, but -- if it's normally open, and some of these lines are normally open. Did you look at their analysis of the high energy line break? They must have taken one at least at the terminal points?

MR. KELLY: We did not find this break location included in their high energy line break analysis.

MR. MICHELSON: Well, how about one close by, let's put it that way?

MR. KELLY: Excuse me?

MR. MICHELSON: How about 1 in the same room, at least?

MR. KELLY: I cannot say that we examined every line in the room with the heat exchanger, no.

MR. MICHELSON: No, but did you ask them if they had taken any high energy line breaks in the room where you found that you had an interfacing system LOCA?

MR. KELLY: No, we did not.

[Slide.]

MR. KELLY: The risk is of course obtained by multiplying the core damage frequency by the conditional consequences. These are the results on a per reactor year basis. Again, the same three risk measures.

MR. KERR: What do you consider to be the uncertainties in the results of the MCCS code?

MR. KELLY: These are mean values reported out of MACCS. We have not looked at the uncertainty on either the source term generation or on the consequence analysis.

MR. CATTON: Has anybody?

MR. KELLY: For this study?

MR. CATTON: For the MACCS code.

MR. KELLY: MACCS -- I am going to conditionally answer that question as yes and try and leave it at that. It's a tough question to answer.

MR. KERR: You can always say no.

MR. KELLY: Well, I'm not sure that --

MR. KERR: Or maybe.

MR. KELLY: I think yes is closer to the truth than no.

MR. CATTON: Or you could say I don't know.

MR. MICHELSON: That would have been perfect.

[Slide.]

MR. KELLY: We looked at some sensitivity studies. The first of these was on the aux building DF.

We looked at a range of what we thought to be credible DFs for aux buildings of this particular design.

At the high end of the range we would be including buildings with fairly large area general fire sprays for example.

We modified SEQSOR to include the new DF and regenerated the source terms and then recalculated the consequences with MACCS.

The results, I've got some slides that follow this that show the results graphically. I wasn't going to cover those in detail but I'll summarize.

We found that the revaporization release that is modelled in SEQSOR turns out to be very important for the latent risk measures such as latent fatalities in the 50 mile dose.

We found that increasing the DF beyond the --

MR. KERR: That's degradation where?

MR. KELLY: This is once the release, the fission products, have come out of the break, deposited on surfaces within the aux building, and then the volatile fission products over time because of their decay heat revaporizing the atmosphere and then leave the aux building.

It is a very slow release and that is about all I wanted to go into unless there are more detailed questions.

MR. KERR: Has there been any detailed treatment of the deposition inside the piping once the fission products leave the vessel, because there was not for Sequoyah, I believe.

MR. KELLY: Not to my knowledge. I believe one of the parameters in the SEQSOR equation does account for deposition within the RCS but even if that were the case and I believe it is, it's still a parametric treatment. It's not a deterministic treatment by any means.

MR. KERR: That possibility is simply an unknown.

MR. KELLY: Yes, sir.

MR. KERR: That would seem to be, unless you know it to be negligible a fairly important thing to look at.

MR. KELLY: Possibly yes.

MR. MINNERS: People have looked at main steamline linkage valves on PWRs so that calculation has been done.

MR. KERR: If the information exists it would seem to me not a bad idea to include it in the consideration of this problem.

MR. KELLY: As I said, I think it is included as a parameter in the SEQSOR equation.

MR. KERR: I don't know what that means.

MR. CATTON: What is the SEQSOR equation?

MR. KELLY: It is essentially a parametric equation to give you a release fraction and by varying parameters you can vary things like the RCS, amount of RCS deposition, the fraction of iodine released in-vessel, those sorts of things.

MR. CATTON: And that is in the MACCS code?

MR. KELLY: No. It is in the SEQSOR code.

MR. KERR: Indeed, it is an empirical fit to calculations made for the 1150 plants as I remember.

MR. KELLY: Yes. There were a series of source term code package runs made and then the information was extrapolated to fit into the SOR series of codes.

[Slide.]

MR. KELLY: The other sensitivity that we looked at, the uncertainty in the component failure probability, our base case in the IMPEL analysis assumed that there was a ten to the minus three probability of piping failure, heat exchange or cylinder failure, et cetera, when the applied stress was equal to the yield stress and that is how the logarithmic standard deviation on the failure pressure was arrived at.

We looked at sensitivities. IMPEL cautioned in their work that this could be a conservative assumption that if this turned out to dominate risk then you could look at other values. We decided to take a look at some other recommended values of ten to the minus four and ten to the minus five, generated new logarithmic standard deviation, and we found that there was no variance in the core damage frequency with these other assumptions. The primary reason that's driving that is the large failure probability given overpressurization of the tube side cylinder of the RHR heat exchangers.

MR. KERR: And there was no uncertainty in the failure pressure of that component?

MR. KELLY: Relatively little. It is fairly narrow.

That is all I intended to present.

Bill Galyean in his next presentation is going to go over some general observations comparing both plants.

MR. SULLIVAN: Could you go back to the slide that you presented earlier. It says no credibility -- credible human errors identified.

Remember when you said that?

MR. KELLY: Yes.

MR. SULLIVAN: Can you give me the big picture of why that is true?

MR. KELLY: I don't want to steal too much of Bill's thunder but I can try.

I can give you -- let me do it by means of an example.

At the B&W plant you have the dominant sequence that is initiated by human error. It involves early entry into DHR in which one valve in a pair is fairly routinely bypassed by procedural instruction. The postulate would be and correct me if I stray here that if the operators had the intention to go on to DHR early, earlier than they should in terms of reactor pressure, that this procedural instruction to bypass one valve sort of conditions them to jumpering out interlocks.

Therefore, they might be led to jumper out the interlock on the second valve. Is that a correct characterization?

MR. MICHELSON: Are you saying this pertains to Sequoyah as well?

MR. KELLY: No, we are not talking about Sequoyah other than for generation of the source terms.

MR. MICHELSON: Okay.

MR. KELLY: At the Westinghouse plant that we analyzed we looked into this same sequence in detail because it had been a dominant contributor at the B&W plant.

We did not find any kind of procedural instructions there to allow bypassing of interlocks in such a manner.

We found on the contrary there were numerous caution statements, administrative control of keys to, as Mr. Michelson pointed out, go down and restore power to these valves.

The training was such that operators if we even brought this up as a possibility, the reaction was very negative -- no, I would never do that, ever, under any circumstances. Their safety culture, if you want to call it that, was just contra-indicative to doing such a thing.

Everywhere we turned in looking at initiators that could bring about an ISLOCA, a core damage sequence ISLOCA, we found a similar situation.

Now there is the situation where you could leave the valves open during startup, and we found there that that was somewhat more likely but as was the case at the B&W plant, the relief valve protection essentially prevents you from ever getting into serious trouble in that situation. It's just too unlikely that that would ever proceed to core damage even given that they do leave them open too long.

Does that answer your question, Mr. Sullivan?

So?

MR. CATTON: I have got just one more question. It's not really related to what you were talking about.

You are at Idaho, aren't you?

MR. KELLY: Yes, sir.

MR. CATTON: Do you have full documentation on the MACCS code?

MR. KELLY: We have a complete set of user manuals, programmer references and model runs.

MR. CATTON: Models and the correlations documentation?

MR. KELLY: Yes, sir.

MR. CATTON: And code assessment?

MR. KELLY: We have the MACCS verification, line by line verification that was done at Idaho.

MR. CATTON: Not the QA of the code but where they compared it with something else to get a feeling for its capability to predict things accurately.

MR. KELLY: I am not aware where MACCS has been validated against the CS&I standard problem or anything like that.

MR. CATTON: Okay. Thank you.

MR. KELLY: If you are aware of it, I would like to see it because I've been curious about that too.

[Slide.]

MR. GAYLEAN: I am going to try to summarize the insights and observations that we have collected during the course of this program. This will include both the analysis on the B&W plant and the analysis on the Westinghouse plant.

[Slide.]

MR. GAYLEAN: Just to summarize the historical experience and the education we received when we looked it over, I'd like to just to point out that the historical experience -- specifically things like LERs and event descriptions -- indicate that improper valve lineups and operator errors in mispositioning valves are relatively likely, and these types of events typically occur during plant evolutions, specifically during startup and shutdowns when a lot of things are going on.

Random, catastrophic failures of redundant valves and standby check valves where you've got to dump the P across it and you know it's seated; these types of failures are not supported by historical experience. We just don't see random, catastrophic failures of valves in this type of service, in the standby service.

We believe that this is attributable to the leak testing that occurs during startup which ensures thereby a positive isolation of the pressure boundary and that when leaks do occur, they tend to grow slowly and are detected at an early time.

[Slide.]

MR. GAYLEAN: Excuse my typo on the slide here. I think there might be a couple more. I was making changes on these last night. The B&W plant analysis generated findings that are dominated -- or, that is, that the core damage and risk are dominated by human error initiated sequence, specifically human errors during shutdown and routine testing, for example, the stroke testing of those motor-operated isolation valves on the injection lines.

The hardware failure initiated sequences are important, but were not dominant. We believe that the lack of procedures and training contributes to this ISLOCA risk; that is, a general lack of awareness contributes to the occurrence of precursors and initiators and in all cases that we looked at, there would be hardware available for isolating and recovering from a postulated rupture.

[Slide.]

MR. GAYLEAN: We believe that at least for the B&W analysis that changes to procedures and training and instrumentation may reduce the plant ISLOCA risk and that based on our analysis, that damage from flooding and spraying and area effects was not risk-significant because of equipment separation of power level trains and redundant systems.

MR. MICHELSON: What is your basis for that conclusion?

MR. GALYEAN: Well, as I said, based on the analysis that we made, okay, --

MR. MICHELSON: But you didn't tell me you made that analysis.

MR. GALYEAN: We looked at the area local to the rupture, okay? We confined our analysis to the room in which the rupture occurred.

MR. MICHELSON: Did you determine the environment in the room in which the rupture occurred?

MR. GALYEAN: We said that, worst-case, everything in that room fails.

MR. MICHELSON: Okay, you just assumed there was a bad environment, but you didn't calculate it?

MR. GALYEAN: That's right. There are redundant, parallel trains and alternate systems that the operators would have available to maintain a covered core; that the heat exchangers and the large diameter low pressure piping were most likely places where a rupture would occur in these sequences.

[Slide.]

MR. GAYLEAN: The analysis on the Westinghouse plant; we found that administrative controls and general operator awareness greatly reduces the possibility or probability of human error initiated ISLOCA sequence. The core damage frequency and risk are dominated by the hardware failure of the pressure isolation check valves.

However, for the Westinghouse analysis, there would be much less time available for the operators to recover from an ISLOCA sequence and in addition, their procedures would require them to use a lot of their time in verifying and checking a number of other plant functions and indications, using up some of this time.

By the time they got to the point where they were identifying and diagnosing an ISLOCA, there would not be very much time available for actually isolating it.

MR. KERR: Do they have to identify it before they can follow their symptom-based procedures?

MR. GALYEAN: Well, they get into their symptom-based procedure and it leads them to look at various indicators to, first, maintain that emergency core cooling systems are functioning, to go in and try to identify the source of the abnormal event. It says to look at these indicators, look in these areas, and then eventually they will get to a point where they say, okay, look at this indicator.

In fact, I think the next slide goes into a little more detail on this.

[Slide.]

MR. GAYLEAN: The symptom-based procedures for the Westinghouse plant; once the operators are in them, as I said, they are instructed to look and verify a number of plant functions and indicators and eventually get to the point where they start looking outside containment as the source of the rupture. There's a single computer alarm that's referenced, and, in fact, it's on the last page of their procedure.

Once they identify this radiation alarm, they can diagnose the situation as an ISLOCA and then attempt to recover from this particular situation. They do have to diagnose it first, before they can recover from it.

This is in contrast to the B&W analysis where the procedures -- a slightly different approach was taken. The procedures do not specifically address the scenarios that we postulate.

The approach taken was to look at the indicators available to the operators and then to postulate what a reasonable person would do to characterize the situation. Also at the B&W analysis, there will be a lot more time available for the operators to recover from an event.

[Slide.]

MR. GAYLEAN: This is my last slide. Just to wrap this up, this comparison. Although precursor frequencies are relatively high; that is, the probability of having an ISLOCA type of an event is relatively high, there is also a very high probability of recovering before core damage begins.

MR. CATTON: You really dealing with the small difference between two big numbers?

MR. GALYEAN: I guess I don't understand what you're referring to.

MR. CATTON: A high probability of doing something that gets you in trouble and a high probability of recovery?

MR. GALYEAN: that's right.

MR. WILKINS: You need to multiply those numbers to calculate the probability that you get into trouble and out of it. Both of them is close to one, so the product is close to one.

MR. GALYEAN: For some specific plants, we believe that the ISLOCA analysis typically found in PRAs is an incomplete description of ISLOCA risk composition; that human factors issues have potentially dominant influences on ISLOCA risk. That is, some plants are less likely to initiate an ISLOCA.

For example, in our Westinghouse analysis, that's what we found. But some plants are more likely to recover from an ISLOCA which is applicable to the B&W analysis that we did.

That concludes my presentation. If there are any questions or any other points you'd like to go over --

MR. CATTON: Are there any further questions?

MR. MICHELSON: May I missed it, maybe I wasn't here, or whatever.

In the case of RHR and heat exchangers, I think, as I recall, you said that the leak point was, of course, tube-side pressure.

MR. KELLY: Tube-side cylinder.

MR. MICHELSON: What's a tube-side cylinder?

MR. KELLY: That's come up before.

In what I call the heat-exchanger water box, where the primary coolant enters, goes it through the tubes, back out and out again, there is a divider plate and then a tube sheet. The cylinder is the outer part of the heat exchanger there, the cylindrical portion of the heat exchanger on the water box boundary.

MR. MICHELSON: Okay. That's just unique to that particular design. There are several other RHR heat exchanger designs.

MR. KELLY: Yes, sir. This analysis was for a specific RHR heat exchanger.

MR. MICHELSON: Now, you looked at the tubes to see what their capability might be.

MR. KELLY: Yes, sir.

MR. MICHELSON: What did you find the capability of the tubing to be in terms of X times design before rupture?

MR. KELLY: Offhand, I don't recall what the value was. It was high enough that it did not present itself as a dominant failure mode.

MR. MICHELSON: Well, that's because the particular heat exchanger probably had a rather weak water box, and not all of them are designed that way.

MR. KELLY: Let me check. Just a second.

MR. MICHELSON: I just wondered, for the tubing itself, if you looked. I'm looking for some rules of thumb again. I have heard what these numbers are, but I haven't heard them verified.

MR. KELLY: I don't have the tube numbers with me. Sorry.

MR. MICHELSON: Typically, the studies that I have seen, they come out with rupture levels of much less than four times design for the tubes. The reason is because you've got to skinny up tubes as much as you can in designing heat exchangers, because there's a heat transfer that you're trying to accomplish. So, they come out about two times design.

Now, if this water box was less than two times design, then it would be the weak point. If it came out like three, then I would question whether you really looked at the tubes or whether these heat exchangers had very heavy-walled tube for some reason.

MR. KELLY: Well, we did look at the tubes. I can assure you of that. I don't have the data, though.

MR. MICHELSON: I would like to get that answer, if you could j - send it to Paul, and I'd like to know how many time design pressure for the heat exchanger will the tubes take before they rupture.

Apparently, it's a rather precise number, because these are drawn tubes. They're very homogeneous. You can make a real loop calculation and they could tell you almost exactly at what pressure they are rupturing.

MR. KERR: It's going to be a log normal distribution no matter what you call it.

MR. MICHELSON: If they're corroding, then it will get that way. Otherwise, it won't be quite that situation.

But I just wondered if you came up with the same conclusion this study came up in terms of how many times design the tube will handle, and the reasons were -- they gave all the reasons why it was a pretty low number, and they all sounded like good rational reasons, because the heat transfer was controlling the design of those tubes.

There was no over-design from the wall-thickness viewpoint because of the heat-transfer problem.

[Slide.]

MR. BURDICK: This is Gary Burdick again.

I just want to briefly run over the schedule for the remaining studies.

Also, you'll notice that we plan to put the B&W study out as a NUREG/CR. The other two studies will be coming out as letter reports. This is a little cost-saving measure.

We hope to have all three of these plant studies by April of '91. The question mark there is there because we're uncertain as to when we're going to get some information from the CE plant. We understand they're starting to go into a refueling outage, and people are going to be very tied up there.

Another question mark here: We have an ISLOCA evaluation procedures NUREG/CR planned. This will encapsulate all the insights, if you will, that we have gleaned from all these other analyses and possibly even from an abbreviated BWR study, if that looks like a reasonable way to go.

If not, there will be a larger BWR study similar to -- in scope to what we have done for the P's. In that case, this would be delayed somewhat.

I would like to take this opportunity to thank the team from Idaho. I think they have done a superb job for the agency. I am very proud of that team, and I think they did some very innovative, groundbreaking work, and I hope the Subcommittee here agrees with me.

I would like to thank the -- you, Mr. Chairman, and the Subcommittee members for taking the time to look at the draft report and to meet with us here today and give us your comments.

We would like to meet with you again sometime around the April timeframe, when we have all three studies, hopefully, completed by then.

MR. CATTON: Hopefully, by then, you will have some idea what the resolution is going to be?

MR. BURDICK: Hopefully, by then, we would have some idea of the resolution, yes.

MR. CATTON: Because it seems to me that that's probably the next point at which we ought to meet.

MR. BURDICK: Right. We would like to come down there at that point with a proposed resolution to the issue.

MR. CATTON: The probabilities are so low that I'm wondering just what you are going to resolve or whether there is anything that needs resolution.

MR. BURDICK: Well, that's a very good point. If things continue the way they are going, it could be that the NRR information notice itself could suffice.

MR. CATTON: Thank you, Gary, and I'd like to thank the speakers from Idaho, as well, for very enlightening discussions.

I think the next thing on the schedule is Subcommittee discussion.

I think we can go off the record.

[Whereupon, at 3:50 p.m., the meeting was adjourned.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission

in the matter of:

NAME OF PROCEEDING: NRC Program In Interfacing Systems Loca

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, Maryland

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

Marilynn Estep

Official Reporter
Ann Riley & Associates, Ltd.

INTERFACING SYSTEM LOCA PROGRAM

PRESENTED TO

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
THERMAL HYDRAULIC PHENOMENA SUBCOMMITTEE
DECEMBER 12, 1990

WILLIAM BECKNER, CHIEF
RISK APPLICATIONS BRANCH
OFFICE OF NUCLEAR REACTOR REGULATION
(301) 492-1089

BACKGROUND

- GI-105, "INTERFACING SYSTEMS LOCA FOR LIGHT WATER REACTORS"

- OPERATING EVENTS OBSERVED, BOTH IN THE U.S. AND ABROAD, SEEMED TO INDICATE THAT THE LIKELIHOOD OF AN ISLOCA WAS HIGHER THAN ESTIMATED BY PRAs.

- NRR INITIATED AN ACCELERATED EFFORT TO EVALUATE ISLOCA RISK.
  - AEOD REVIEW OF RECENT OPERATING EXPERIENCE
  - NRR INSPECTIONS AND ROOT CAUSE ANALYSES
  - RES ENGINEERING AND PRA ANALYSES

TODAY's MEETING

- REGULATORY PERSPECTIVE
- STATUS REPORT
  - INSPECTION FINDINGS
  - RESEARCH RESULTS
- FUTURE SCHEDULES AND MILESTONES
- SUMMARY OF INITIAL FINDINGS (SPECIFIC ACTIONS TO BE RECOMMENDED MUST AWAIT FINAL RESULTS).

REGULATORY PERSPECTIVE

- PRELIMINARY FINDINGS SUGGEST THAT RISK FROM ISLOCA MAY NOT BE AS GREAT AS ORIGINALLY PERCEIVED. THEREFORE, NO FIRM BASIS FOR ACCELERATED REGULATORY ACTIONS. NRR WILL WAIT TO SEE WHAT REGULATORY ACTIONS, IF ANY, RECOMMENDED BY THE GI-105 PROGRAM.

- WHILE RISK FROM ISLOCA MAY NOT BE AS HIGH AS INITIALLY ANTICIPATED, NRR IS STILL CONCERNED ABOUT HIGH RATE OF ISLOCA PRECURSORS.

- ISLOCA PROGRAM HAS GENERATED USEFUL INFORMATION THAT SHOULD BE MADE AVAILABLE TO INDUSTRY.

- NRR HAS PREPARED A DRAFT INFORMATION NOTICE IN ORDER TO PROVIDE INITIAL FINDINGS TO UTILITIES AND TO INITIATE DISCUSSIONS WITH INDUSTRY GROUPS.

- TIMING OF SUCH DISCUSSIONS IS GOOD SINCE NRC's PROGRAM IS NEARING COMPLETION AND INDUSTRY EFFORTS MAY ALSO HAVE PRODUCED INITIAL RESULTS.

ACRS LETTER ON ISLOCA OF 1/18/90

- CONCERN ABOUT HOW RESULTS WILL BE USED
  - CAUSES AND OPTIMAL MITIGATION STRATEGIES MAY BE HIGHLY PLANT-SPECIFIC
  - INVOLVE COMPLEX HUMAN ACTIONS NOT WELL MODELED IN PRAs
  - PRAs USED BY LICENSEES FOR IPE MAY NOT DEAL ADEQUATELY WITH ISLOCA ISSUES

- POSSIBLE APPROACHES FOR RESOLVING
  - INFORMATION DEVELOPED BY THE STAFF COULD BE USED IN PRAs PERFORMED FOR IPE TO ANALYZE ISLOCA - MAY NOT BE PRACTICAL AND COULD DELAY THE IPEs.
  - RESOLUTION SEPARATE FROM THE IPE - MAY UNNECESSARILY BURDEN LICENSEES.
  - INFORMATION DEVELOPED BY THE STAFF FURNISHED TO LICENSEES FOR INCORPORATION IN IPE WITHOUT EXPECTATION THAT IT BE COMPREHENSIVELY INCLUDED IN PRAs. RECOGNIZES THAT PRA IS ONLY ONE PART OF IPE PROCESS.

RES STAFF PRESENTATION
TO
THE ACRS

ISLOCA RESEARCH PROGRAM

BY

GARY BURDICK
SENIOR TECHNICAL ADVISOR
DIVISION OF SAFETY ISSUES RESOLUTION
OFFICE OF NUCLEAR REGULATORY RESEARCH

DECEMBER 12, 1990

INTRODUCTION TO RES PRESENTATION

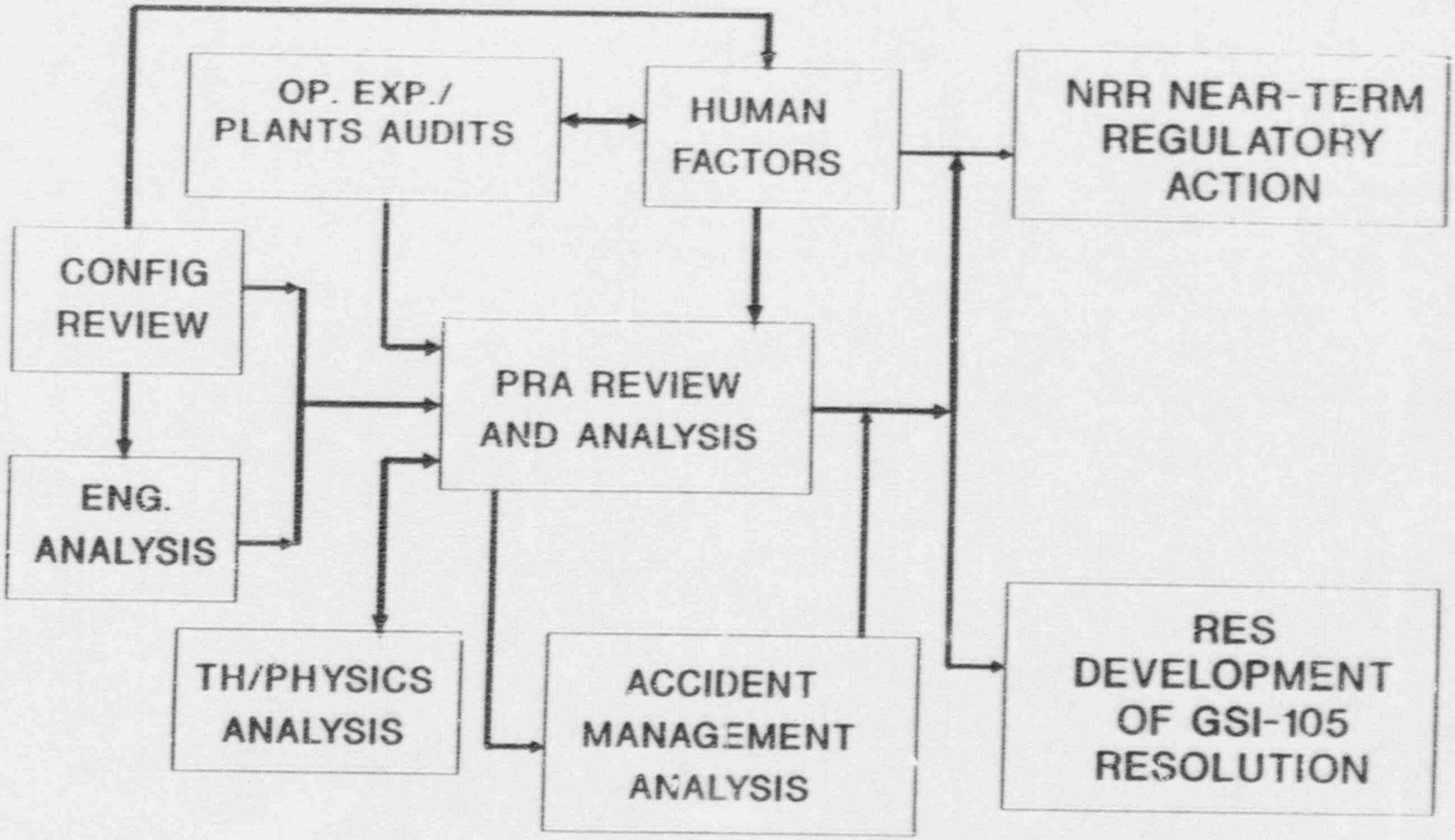
- IOU TO ACRS ON PROGRAM STATUS
- DRAFT OF B&W PLANT STUDY DISTRIBUTION TO SUBCOMMITTEE AS AGREED
- FINAL DRAFT FOR EXTERNAL REVIEW (1/91)
- FINAL DRAFT WILL DIFFER SIGNIFICANTLY
  - QUANTIFICATION
  - EXPOSITION
  - PLANT IDENTIFICATION

PAST ISLOCA ANALYSES AND PRAs

- DID LITTLE OR NO MODELING BEYOND PIVs
- MADE RISK-IMPORTANT HARDWARE ASSUMPTIONS:
  - BREAK LIKELIHOODS
  - BREAK LOCATIONS
  - BREAK SIZES
- DID NOT ACCOUNT FOR TYPES OF HUMAN ERRORS SEEN IN RECENT EVENTS
- NARROW HARDWARE FOCUS
  - PIV LEAK TESTING COST/BENEFIT

ISLOCA (GI-105) RESEARCH PROGRAM

- EVALUATE LOW PRESSURE SYSTEMS FRAGILITIES UNDER HIGH PRESSURES/TEMPERATURES TO IDENTIFY LIKELY FAILURE LOCATIONS.
- IDENTIFY SPECIFIC HUMAN ACTIONS AND ROOT CAUSES IMPORTANT TO ISLOCA FOR RECOMMENDING RISK REDUCTION ACTIONS.
- DETERMINE ISLOCA SEQUENCE TIMING, FLOW RATES, ACCIDENT MANAGEMENT STRATEGIES, AND ISLOCA EFFECTS ON OTHER EQUIPMENT.
- DEVELOP IMPROVED PRA FRAMEWORK TO EVALUATE HUMAN AND HARDWARE CONTRIBUTIONS TO ISLOCA.
- ESTIMATE ISLOCA CONSEQUENCES AND IMPORTANT FACTORS FOR CONSEQUENCE REDUCTION.



OP. EXP./
PLANTS AUDITS

HUMAN
FACTORS

NRR NEAR-TERM
REGULATORY
ACTION

CONFIG
REVIEW

PRA REVIEW
AND ANALYSIS

ENG.
ANALYSIS

TH/PHYSICS
ANALYSIS

ACCIDENT
MANAGEMENT
ANALYSIS

RES
DEVELOPMENT
OF GSI-105
RESOLUTION

RES ISLOCA PROGRAM FLOW CHART

GI-105 RESOLUTION APPROACH

- ASSESS ISLOCA RISK FROM PWRs
  - EX-CONTAINMENT ISLOCA INTERNAL EVENTS ANALYSIS (B&W, WESTINGHOUSE, CE PLANTS)
  - ADD EXTERNAL EVENTS ANALYSIS
  - INSIDE CONTAINMENT ISLOCA ANALYSIS
  - COST BENEFIT ANALYSIS
- ASSESS ISLOCA RISK FROM BWRs
  - PROGRAM FORMULATION PENDING
  - LESSONS LEARNED FROM PWRs ASSESSMENTS
  - COMPLETING PRIORITIES

ISLOCA RESEARCH PROGRAM

SCHEDULE

B&W PLANT (NUREG/CR)	2/91
WESTINGHOUSE (LETTER RPT.)	3/91
CE (LETTER RPT.)	4/91 ?
INSIDE CONTAINMENT (LETTER RPT.)	2/91
EXTERNAL EVENTS (B&W APP.)	2/91
COST BENEFIT (LETTER RPT.)	2/91
ISLOCA EVAL PROC. (NUREG/CR)	4/91 ?

ISLOCA RESEARCH PROGRAM PRESENTATION

- OUTSIDE CONTAINMENT ISLOCA ANALYSIS APPROACH
- OUTSIDE CONTAINMENT ISLOCA ANALYSIS RESULTS ON A B&W PLANT
- PRELIMINARY OUTSIDE CONTAINMENT ISLOCA ANALYSIS RESULTS ON A WESTINGHOUSE PLANT

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BACKGROUND AND APPROACH FOR ISLOCA EVALUATIONS

Duane J. Hanson

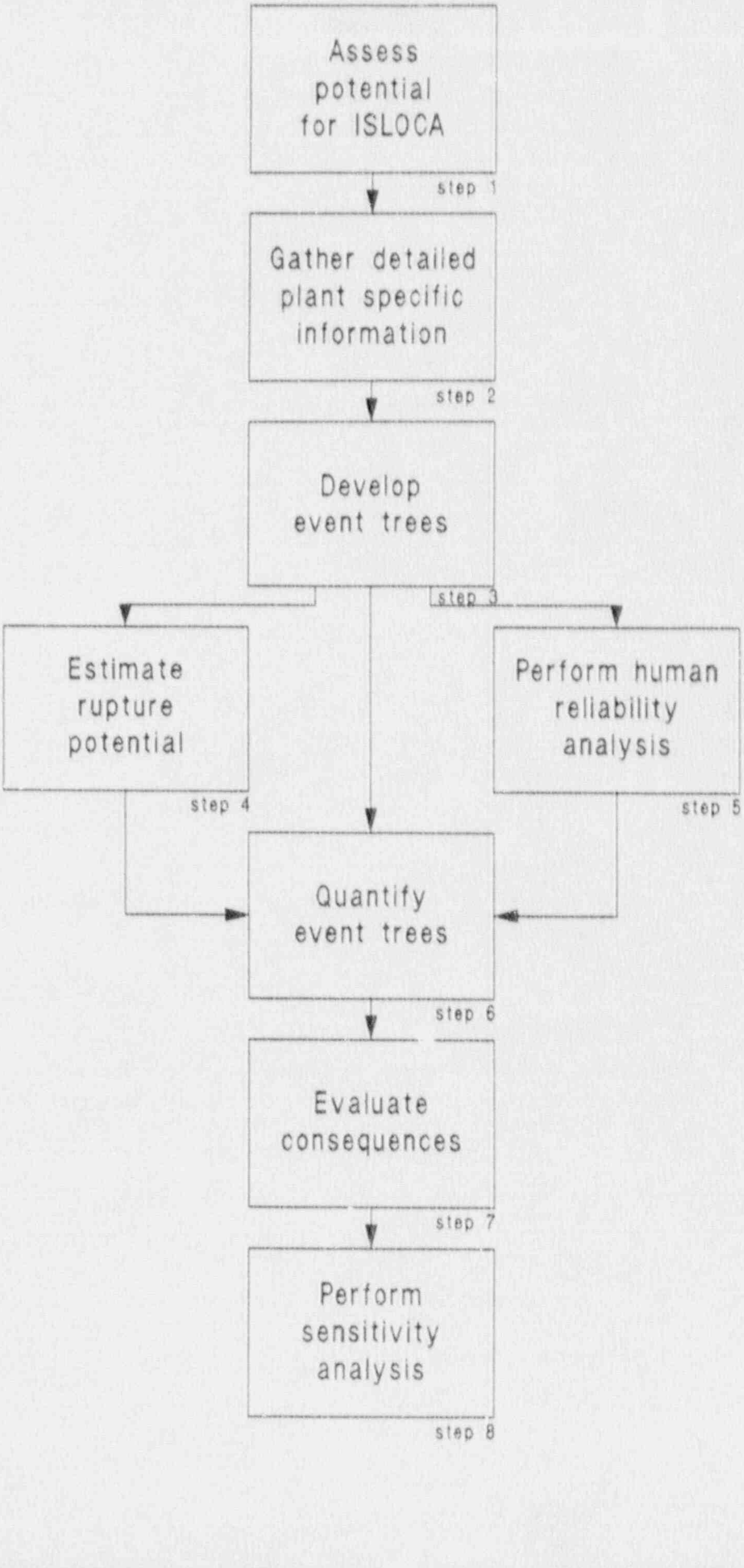
December 11, 12 1990

EG&G Idaho, Inc.

A REVIEW OF HISTORICAL PLANT OPERATING DATA PROVIDED INSIGHTS FOR DEVELOPING FRAMEWORK

- Identify and evaluate Licensee Event Reports that involved:
  - Pressure isolation valve failures resulting from hardware or human causes
  - Misalignment of motor operated valves that had safety implications
  - Occurrence of ISLOCA precursors
- Results provided information on:
  - Potential types of human errors and hardware failures important for an ISLOCA
  - Information on failure rates of some types of pressure isolation valves
- Results were not adequate to develop human error failure rates

Approach for Evaluation of ISLOCA



Assess potential for ISLOCA

step 1

Gather detailed plant specific information

step 2

Develop event trees

step 3

Estimate rupture potential

step 4

Perform human reliability analysis

step 5

Quantify event trees

step 6

Evaluate consequences

step 7

Perform sensitivity analysis

step 8

EC000001

STEP 1 - ASSESS THE POTENTIAL FOR AN ISLOCA

- OBTAIN PLANT SPECIFIC INFORMATION ON HARDWARE AND OPERATIONS
- IDENTIFY ALL SYSTEMS THAT INTERFACE WITH THE RCS AND HAVE COMPONENTS THAT MAY FAIL AT HIGH PRESSURE
- DETERMINE THE MAXIMUM INTERFACING SYSTEM BREAK SIZE THAT WOULD NOT RESULT IN CORE DAMAGE AND SCREEN THE SYSTEMS
- DEVELOP PRELIMINARY EVENT TREES FOR ISLOCA INITIATORS AND SEQUENCES

STEP 2 - GATHER DETAILED PLANT SPECIFIC INFORMATION

- INFORMATION ON CAPABILITIES AND LIMITATIONS OF HARDWARE THAT COULD BE INVOLVED IN AN ISLOCA

- INFORMATION ON PROCEDURES AND GUIDELINES DURING STARTUP, POWER OPERATION, SHUTDOWN, AND EMERGENCY OPERATING PROCEDURES THAT MAY AFFECT ISLOCA

- INFORMATION ON MAINTENANCE AND IN-SERVICE TEST PRACTICES

- INFORMATION ON FACTORS THAT COULD INFLUENCE HUMAN PERFORMANCE FOR DETECTION, PREVENTION, AND MITIGATION

STEP 3 - DEVELOP FINAL EVENT AND FAULT TREES

- COMBINE HARDWARE FAULTS AND HUMAN ERRORS FOR IMPORTANT SEQUENCES (STARTUP, POWER OPERATION, SHUTDOWN)

- DEVELOP TREES BASED ON THREE POSSIBLE TYPES OF EVENTS
  - INITIATING EVENTS THAT RESULT IN THE BREACH OF PRESSURE ISOLATION BOUNDARIES
  - EVENTS THAT DETERMINE RUPTURE PROBABILITY, LOCATION, AND SIZE
  - EVENTS THAT INVOLVE DETECTION, DIAGNOSIS, ISOLATION, AND MITIGATION

- ESTIMATE EVENT THERMAL-HYDRAULIC TIMING

STEP 4 - ESTIMATE RUPTURE POTENTIAL

- ESTIMATE THE MEDIAN FAILURE PRESSURE, ITS EXPECTED DISTRIBUTION AND VARIANCE, AND THE POTENTIAL LEAK RATE FOR EACH COMPONENT
- ESTIMATE THE PRESSURE EACH COMPONENT WILL BE EXPOSED TO BASED ON THE POTENTIAL INITIATING EVENTS AND PRIMARY SYSTEM CONDITIONS
- DEVELOP AN EVENT TREE FOR EACH SYSTEM TO COMPARE THE EXPECTED LOCAL PRESSURE AND ESTIMATED FAILURE PRESSURE FOR THE IMPORTANT COMPONENTS
- ESTIMATE THE RELATIVE FREQUENCY OF EQUIPMENT FAILURES USING A MONTE CARLO SIMULATION TO RANDOMLY SELECT A SYSTEM PRESSURE AND COMPARE IT TO A RANDOMLY SELECTED COMPONENT FAILURE PRESSURE

STEP 5 - PERFORM HUMAN RELIABILITY ANALYSIS

- ENSURE THAT THE INITIAL EVENT TREES REPRESENT THE HUMAN ACTIONS
- IDENTIFY AND SCREEN HUMAN ACTIONS THAT CAN INFLUENCE SAFETY DURING AN ISLOCA
- DEVELOP DETAILED DESCRIPTIONS OF THESE IMPORTANT HUMAN ACTIONS
- SELECT AND APPLY AVAILABLE TECHNIQUES TO MODEL THE IMPORTANT HUMAN ACTIONS
- DEVELOP NEW MODELS WHERE EXISTING TECHNIQUES DO NOT REPRESENT POSSIBLE HUMAN ACTIONS
- ESTIMATE HUMAN ERROR PROBABILITIES (HEPs) AND ESTABLISH UNCERTAINTY RANGES

STEP 6 - QUANTIFY EVENT TREES

- SEQUENCE INITIATORS
  - GENERIC HARDWARE FAILURE DATA
  - HRA RESULTS
- RUPTURE PROBABILITIES
  - ESTIMATES OF EQUIPMENT FAILURE FREQUENCIES
- DETECTION, DIAGNOSIS, ISOLATION, AND MITIGATION
  - HRA RESULTS
  - VALVE CAPABILITIES
  - CAPABILITY OF SYSTEMS TO SCRUB FISSION PRODUCTS

STEP 7 - NORMALIZE CONSEQUENCES TO AN AVERAGE SITE

- ESTABLISH SOURCE TERMS BASED ON EXISTING INFORMATION

- SELECT A SITE BASED ON EXISTING MACCS MODELS
  - IDENTIFY AN AVERAGE SITE FOR THE UNITED STATES BASED ON THE WEATHER WEIGHTED POPULATION DENSITY IN THE SANDIA SITING STUDY
  - SELECT A SITE FROM THE FIVE NUREG-1150 PLANTS BASED ON THE CLOSEST MATCH TO THE AVERAGE POPULATION DENSITY

- CALCULATE HEALTH EFFECTS USING THE MACCS CODE

STEP 8 - SENSITIVITY STUDIES

- EVALUATE THE SENSITIVITY TO PARAMETERS THAT HAVE A RELATIVE LARGE UNCERTAINTY IN THEIR VALUES
- ESTIMATE THE CHANGE IN CORE DAMAGE FREQUENCY FROM POTENTIAL CHANGES TO PLANT HARDWARE AND OPERATIONS
- EXAMINE ALTERNATIVE METHODS OF ESTABLISHING PROBABILITIES

ADDITIONAL ANALYSES ARE BEING PERFORMED BASED ON COMMENTS ON THE DRAFT REPORT

- DEVELOP LESS CONSERVATIVE THERMAL-HYDRAULIC ESTIMATES OF LARGE AND SMALL BREAK TIMING
- PERFORM ADDITIONAL HRA TO INCORPORATE REVIEWERS COMMENTS AND TO REFLECT DIFFERENCES IN TIMING
- MODIFY THE QUANTIFICATION APPROACH TO ALLOW PERFORMANCE OF UNCERTAINTY ANALYSES
- EXAMINE ADDITIONAL SENSITIVITIES

IMPORTANT RESULTS TO CONSIDER DURING THE FOLLOWING PRESENTATIONS

- Effect of human actions as initiators for ISLOCA
- Relative contribution of human errors and hardware failures to ISLOCA CDF and risk
- Components that would fail when exposed to overpressure
- Importance of detection, diagnosis, isolation, and mitigation in reducing risk
- Influence of procedures, instrumentation, and training on the capabilities of plant personnel to reduce ISLOCA risk

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RUPTURE PROBABILITY CALCULATIONS

W. J. GALYEAN

DECEMBER 12, 1990

EG&G Idaho, Inc.

INEL

COMPREHENSIVE ISLOCA ANALYSIS REQUIRES ACCURATE ESTIMATION OF RUPTURES

ISLOCA EVALUATION REQUIRES PREDICTION AND UNDERSTANDING OF INTERFACING SYSTEM RESPONSE TO OVERPRESSURIZATION.

O NEED TO IDENTIFY:

- WHICH COMPONENTS ARE LIKELY TO RUPTURE
- LIKELY RUPTURE LOCATION
- SIZE OF RUPTURE

OVERPRESSURE RUPTURES OF INTERFACING SYSTEMS ARE TREATED PROBABILISTICALLY

- UNCERTAINTIES (BOTH TOLERANCE AND CONFIDENCE) IN SPECIFIC CONDITIONS PRECLUDES REALISTIC-DETERMINISTIC ANALYSIS:
  - COMPONENT PRESSURE CAPABILITIES (E.G. PRE-EXISTING FLAWS),
  - EXPECTED LOCAL SYSTEM PRESSURES (E.G. VARIATIONS IN SYSTEM CONFIGURATIONS AND OPERATIONS).

RUPTURE PROBABILITY CALCULATIONS REQUIRE BOTH STRESS AND STRENGTH INFORMATION

RUPTURE PROBABILITY DETERMINED BY TWO FACTORS:

- O PRESSURE CAPACITY OF INTERFACING SYSTEM COMPONENTS
  - PERFORMED BY ABB-IMPELL.
- O PRESSURES SEEN BY INTERFACING SYSTEM COMPONENTS
  - INCLUDES EFFECTS OF RELIEF VALVES AND FLOW RESTRICTIONS (ORIFICES, PIPE SIZE, CHOKE PLANES).

INEL

PRESSURE CAPACITY EVALUATION HAD THREE MAJOR OBJECTIVES

- DEVELOP A METHODOLOGY TO PROBABILISTICALLY ASSESS FLUID SYSTEM COMPONENTS WHEN SUBJECTED TO HIGHER THAN DESIGNED PRESSURES AND TEMPERATURES.
- DETERMINE MEDIAN FAILURE PRESSURE (LOGNORMAL) AND ASSOCIATED UNCERTAINTY FOR FLUID SYSTEM COMPONENTS.
- FOR POSTULATED FAILURES DETERMINE EXPECTED LEAK RATES OR LEAK AREAS.

ALL MAJOR COMPONENTS IN INTERFACING SYSTEMS WERE EVALUATED

DECAY HEAT REMOVAL - LOW PRESSURE INJECTION, HIGH PRESSURE INJECTION, AND MAKEUP & PURIFICATION SYSTEMS EXAMINED.

- PIPES (ALL STAINLESS STEEL)
- TANKS, VESSELS AND HEAT EXCHANGERS
- FLANGES
- VALVES (PACKING, FLANGED BONNETS)
- PUMPS (CASING, SEALS)

ESTIMATING REALISTIC FAILURE PRESSURES WAS A PRIME CONSIDERATION

- PRESSURE CAPACITIES BASED ON MATERIAL PROPERTIES OR ACTUAL TEST DATA (RATHER THAN CODE OR DESIGN).
- PRESSURE CAPACITY ASSUMED TO BE A LOGNORMAL RANDOM VARIABLE.
- QUASISTATIC PRESSURE AND TEMPERATURE CONDITIONS ASSUMED:
  - BASED ON RUNS OF SIMPLE RELAP5 MODELS OF INTERFACING SYSTEMS

MANY LOW PRESSURE RATED COMPONENTS NOT CAPABLE OF WITHSTANDING RCS PRESSURES

MEDIAN LARGE-RUPTURE FAILURE PRESSURES:

o 12" SCHEDULE-20 PIPE	1660 PSIG
o 18" SCHEDULE-10 PIPE	843 PSIG
o 12" 300-PSI FLANGE	2250 PSIG
O DHR HEAT EXCHANGER:	
- TUBE SHEET FLANGE	893 PSIG
- PLASTIC COLLAPSE HEAD BUCKLING	1030 PSIG
- CYLINDER RUPTURE	1630 PSIG

LOCAL INTERFACING SYSTEM PRESSURES PREDICTED USING SIMPLE RELAP5 MODELS

RELAP5 MODELS OF INTERFACING SYSTEMS WERE BUILT AND RUN.

- INTERFACING SYSTEMS NORMALLY KEPT FILLED
- CALCULATIONS ASSUMED STEADY STATE RCS
  - JUSTIFIED (VERY SLIGHTLY CONSERVATIVE) BY RAPID PRESSURIZATION OF INTERFACING SYSTEM (I.E. 5-7 SECONDS)
- PRESSURE EQUILIBRIUM ESTABLISHED VERY QUICKLY - DEAD ENDED (CLOSED) SYSTEMS PRESSURIZE VIRTUALLY INSTANTANEOUSLY.
- SMALL RELIEF VALVES IN COMBINATION WITH FLOW RESTRICTIONS MAY PROTECT PORTIONS OF SYSTEMS.

INTERFACING SYSTEM EVENT TREE MODEL USED TO SIMULATE O.P. RESPONSE

- EACH INTERFACING SYSTEM COMPONENT REPRESENTED BY AN EVENT ON THE EVENT TREE

- INTERFACING SYSTEM LOCAL-PRESSURES ESTIMATED BY RELAP5 RUNS
  - OVERPRESSURE REPRESENTED AS "INITIATING EVENT"

- PROBABILITY DISTRIBUTIONS ASSUMED FOR BOTH FAILURE PRESSURE AND LOCAL SYSTEM PRESSURE:
  - COMPONENT PRESSURE FRAGILITIES MODELED LOGNORMALLY,
  - LOCAL SYSTEM PRESSURES ARE A FUNCTION OF RCS PRESSURE, WHICH IS ASSUMED TO BE NORMALLY DISTRIBUTED.

INTERFACING SYSTEM RUPTURE PROBABILITIES ESTIMATED BY MONTE CARLO SAMPLING EVENT TREE

EVNTRE-CODE DEVELOPED DURING NUREG-1150 PROGRAM UTILIZED FOR CALCULATION.

- LOCAL SYSTEM PRESSURE SAMPLED FROM POSTULATED NORMAL DISTRIBUTION (E.G. MEAN 2100 PSIG, STD-DEV 50 PSI).
- COMPONENT FAILURE PRESSURE SAMPLED FROM POSTULATED LOGNORMAL DISTRIBUTION, E.G. 12-INCH SCH20 PIPE: MEDIAN 1660 PSIG, LOG-STD-DEV 0.36.

INTERFACING SYSTEM RUPTURES ESTIMATED BY MONTE CARLO SAMPLING EVENT TREE (CONTINUED)

FOR EACH COMPONENT IN THE INTERFACING SYSTEM, MONTE CARLO ROUTINE SAMPLES A LOCAL SYSTEM PRESSURE, A FAILURE PRESSURE AND COMPARES THE TWO, IF:

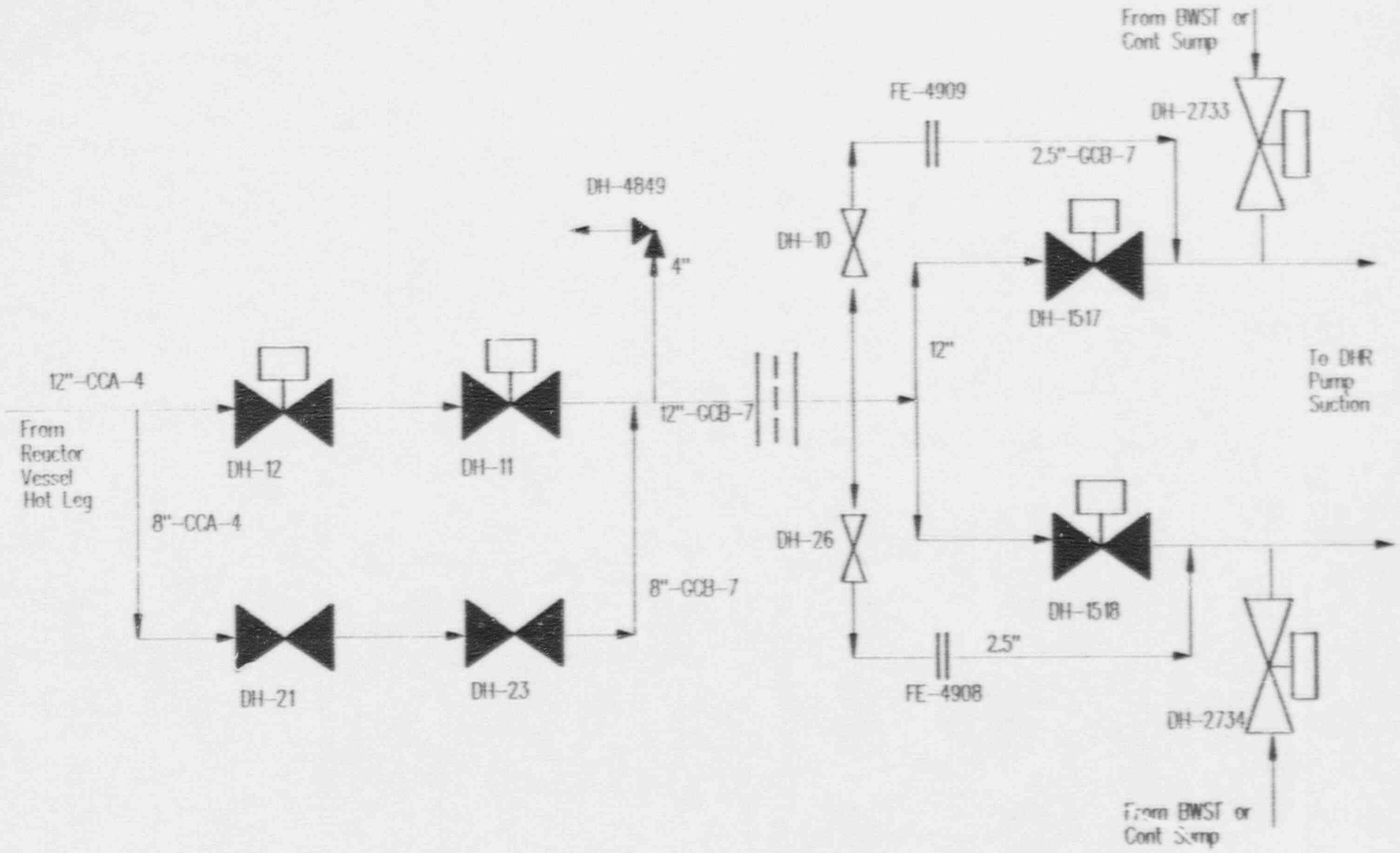
- $P_L > P_F$, THEN COMPONENT RUPTURES,
- $P_L < P_F$, THEN COMPONENT DOES NOT RUPTURE.
- RUPTURE PROBABILITY IS FRACTION OF MONTE CARLO OBSERVATIONS RESULTING IN RUPTURES.

COMPONENT FAILURE PROBABILITIES CAN BE CALCULATED UTILIZING SEISMIC FAILURE EQUATION

- PROBABILITY OF FAILURE AT 2100 PSIG FOR A 12-INCH SCH20 PIPE (MEDIAN = 1660 PSIG, LOG-STD-DEV = 0.36)

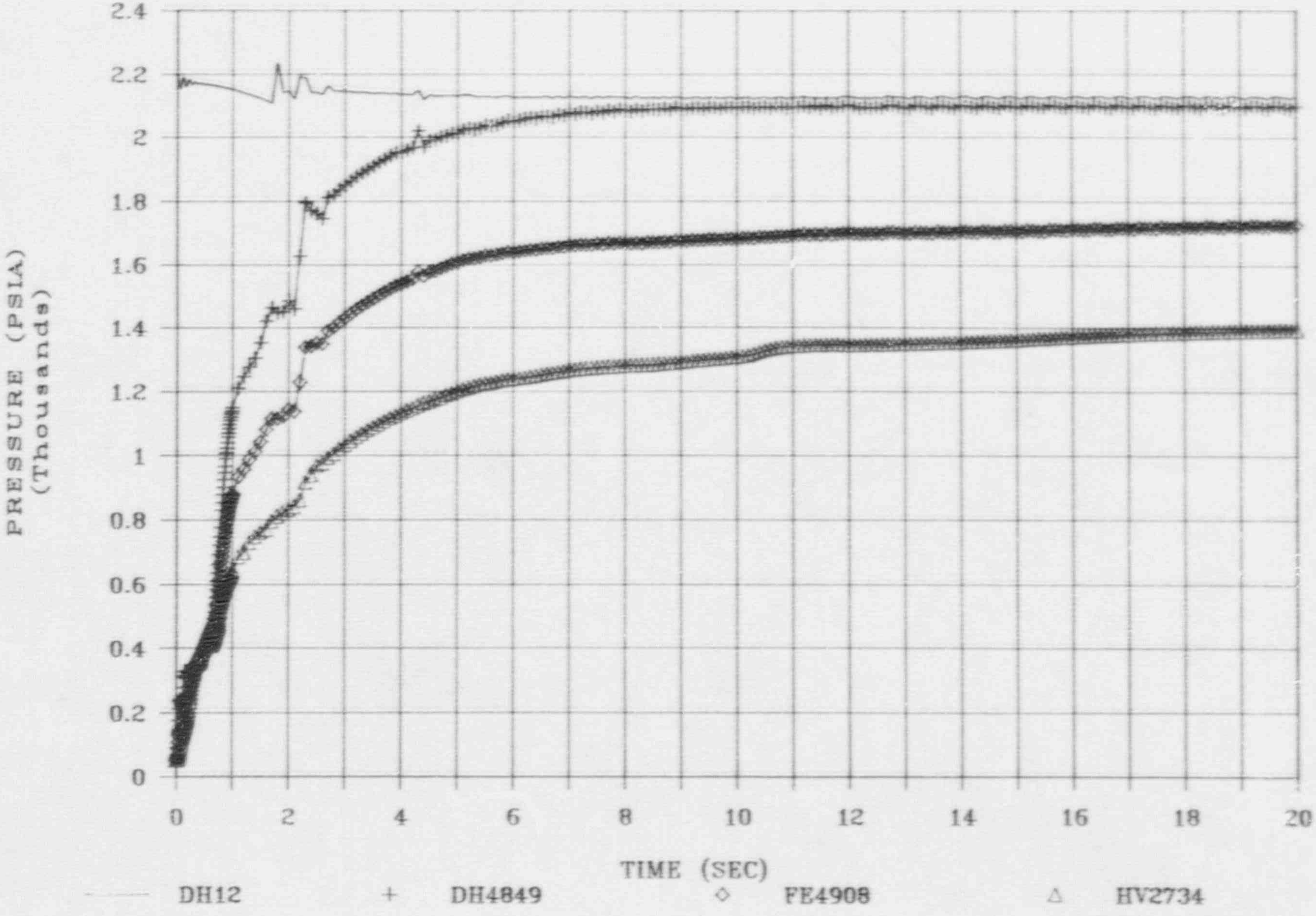
PROB(FAIL PRESS < 2100 PSIG) = PHI((LN(2100)-LN(1660))/0.36)
= PHI(0.65)
PROBABILITY OF RUPTURE = 0.742

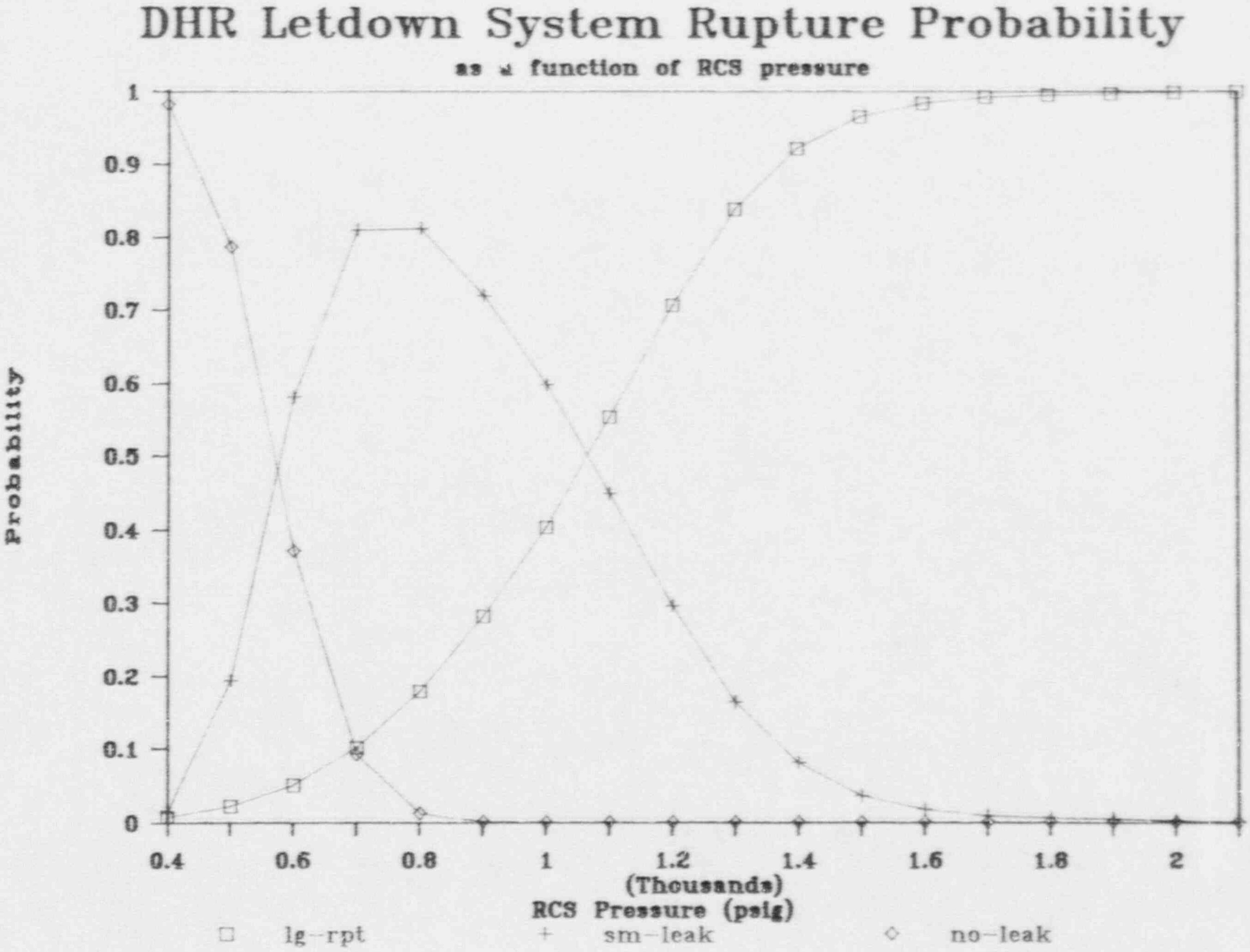
- (REF: R. P. KENNEDY ET AL, NUCLEAR ENGINEERING AND DESIGN, VOL.59, NO.2, AUGUST 1980.)


From BWST or
Cont Sump
FE-4909
DH-2733
2.5"-GCB-7
DH-4849
DH-10
4"
DH-1517
12"
To DHR
Pump
Suction
12"-CCA-4
From
Reactor
Vessel
Hot Leg
DH-12
DH-11
12"-GCB-7
8"-CCA-4
DH-26
DH-1518
8"-GCB-7
2.5"
DH-21
DH-23
FE-4908
DH-2734
From BWST or
Cont Sump

DHR SHUTDOWN

2200 PSIA, 600 F




DHR Letdown System Rupture Probability

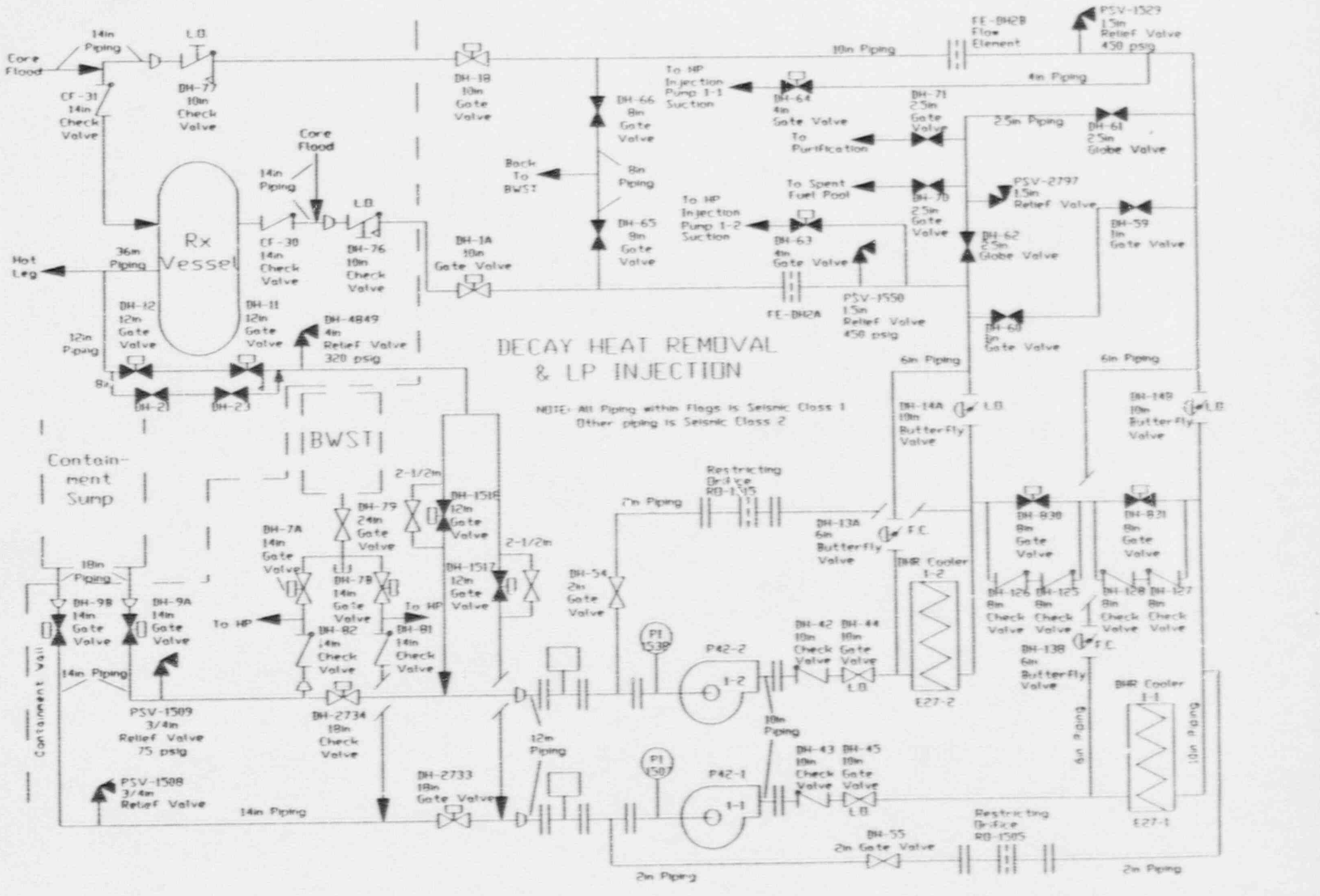
as a function of RCS pressure

DHR LETDOWN SYSTEM COMPONENT RUPTURE DATA

Median RCS press = 1250 (uniform between 300 and 2200 psi).
Median system pressure at DH-4849 = 1188. psia.
Median system pressure at DH-2734 = 818. psia.

Component	Description	Med. Fail Press	Failure Prob.
DH-4849			
12"-GCB-7	Pipe, sch. 20	1660	* 0.2553
DH-2734			
DH-1517	12" MOGV, 300 psi	1704	0.013 sm
18"-GCB-8	Pipe, sch. 20	1488	* 0.1072
DH-2733	18" MOGV, 300 psi	2277	5.0E-4 sm
18"-HCB-1	Pipe, sch. 10S	843	* 0.447
14"-HCB-1	Pipe, sch. 10S	1090	* 0.2695
DH-81	14" SwCV, 150 psi	1445	0.0675 sm
12"-GCB-8	Pipe, sch. 20	1660	0.0712
12GCBa	Flange, 300 psi	2250	0
12GCBb	Flange, 300 psi	2250	0
12GCBc	Flange, 300 psi	2250	0
P42-1	DHR pump 1-1	2250	3.0E-4 sm
10"-GCB-1	Pipe, sch. 20	1984	0.0315
10GCB1a	10" flange, 300 psi	2485	0
DH-43	10" SwCV, 300 psi	2016	2.5E-3 sm
DH-45	10" HWGV, 300 psi	2170	9.0E-4 sm
E271T	DHR Hx tube sht	432	* 0.8546 (50% sm)
E271P	DHR Hx plastic col	1030	0.05988
E271C	DHR Hx cyl. rupt.	1630	0.0448
E271A	DHR Hx asym hd. bkl	2030	9.2E-4 sm
E271a	10" out-f, 300 psi	2485	0
E271b	10" in-f, 300 psi	2485	0
6"-GCB-10	Pipe, sch. 10S	1585	0.0822
10"-GCB-10	Pipe, sch. 20	1984	0.0295
8"-GCB-10	Pipe, sch. 20	2503	7.3E-3
DH-128	8" SwCV, 300 psi	1242	0.142 sm
4"-GCB-2	Pipe, sch. 10S	2075	0.022
FE-DH2B	10" FE, 300 psi	2485	0

INEL


DECAY HEAT REMOVAL
& LP INJECTION
NOTE: All Piping within Flags is Seismic Class 1
Other piping is Seismic Class 2
Core Flood
14in Piping
L.B.
CF-31 14in Check Valve
DH-77 10in Check Valve
DH-1B 10in Gate Valve
10in Piping
FE-DH2B Flow Element
PSV-1529 1.5in Relief Valve 450 psig
4in Piping
To HP Injection Pump 1-1 Suction
DH-64 4in Gate Valve
DH-66 8in Gate Valve
DH-71 2.5in Gate Valve
2.5in Piping
DH-61 2.5in Globe Valve
To Purification
Back To BWST
8in Piping
To Spent Fuel Pool
DH-70 2.5in Gate Valve
PSV-2797 1.5in Relief Valve
DH-59 1in Gate Valve
Core Flood
14in Piping
L.B.
Rx Vessel
CF-30 14in Check Valve
DH-76 10in Check Valve
DH-1A 10in Gate Valve
DH-65 8in Gate Valve
To HP Injection Pump 1-2 Suction
DH-63 4in Gate Valve
DH-62 2.5in Globe Valve
Hot Leg
36in Piping
FE-DH2A
PSV-1550 1.5in Relief Valve 450 psig
DH-12 12in Gate Valve
DH-11 12in Gate Valve
DH-4849 4in Relief Valve 320 psig
12in Piping
DH-68 1in Gate Valve
8in
DH-21
DH-23
6in Piping
6in Piping
DH-14A 10in Butterfly Valve
L.B.
DH-14B 10in Butterfly Valve
L.B.
BWST
Containment Sump
Restricting Orifice RO-1515
2in Piping
2-1/2in
DH-1518 12in Gate Valve
DH-79 24in Gate Valve
DH-7A 14in Gate Valve
2-1/2in
DH-13A 6in Butterfly Valve
F.C.
DH-830 8in Gate Valve
DH-831 8in Gate Valve
18in Piping
DH-7B 14in Gate Valve
DH-1517 12in Gate Valve
DH-54 2in Gate Valve
DHR Cooler 1-2
DH-9B 14in Gate Valve
DH-9A 14in Gate Valve
To HP
To HP
DH-82 14in Check Valve
DH-81 14in Check Valve
PI 1538
P42-2
1-2
DH-42 10in Check Valve
DH-44 10in Gate Valve
L.B.
DH-126 8in Check Valve
DH-125 8in Check Valve
DH-128 8in Check Valve
DH-127 8in Check Valve
DH-13B 6in Butterfly Valve
F.C.
Containment Wall
14in Piping
PSV-1509 3/4in Relief Valve 75 psig
DH-2734 18in Check Valve
12in Piping
10in Piping
E27-2
DHR Cooler 1-1
6in Piping
10in Piping
PI 1587
P42-1
1-1
DH-43 10in Check Valve
DH-45 10in Gate Valve
L.B.
PSV-1508 3/4in Relief Valve
14in Piping
DH-2733 18in Gate Valve
Restricting Orifice RO-1505
DH-55 2in Gate Valve
E27-1
2in Piping
2in Piping
]

LARGE RUPTURES OF INTERFACING SYSTEMS ARE LIKELY FOR MOST ISLOCA SEQUENCES

WHEN EXPOSED TO FULL RCS PRESSURE AND TEMPERATURE RUPTURES ARE EXPECTED TO OCCUR VERY RAPIDLY

- O INTERFACING SYSTEMS WILL REACH MAXIMUM PRESSURE WITHIN 5 TO 7 SECONDS
  - RELIEF CAPACITY IS NOT ADEQUATE TO PROTECT INTERFACING SYSTEM
- O FLANGE AND SEAL LEAKS ARE POSSIBLE BUT ARE NOT EXPECTED TO BE LARGE ENOUGH TO PROTECT OTHER EQUIPMENT
- O PIPE RUPTURES AND FAILURES OF HEAT EXCHANGERS ARE MOST LIKELY

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AN APPROACH TO IDENTIFYING AND QUANTIFYING HUMAN ERROR IN SUPPORT OF ISLOCA

HAROLD S. BLACKMAN
DAVID I. GERTMAN

DECEMBER 11TH AND 12TH, 1990

EG&G Idaho, Inc.

OBJECTIVE OF THE HRA WAS TO IDENTIFY THE SPECTRUM OF ERRORS ASSOCIATED WITH ISLOCA

		Failure Mode Dimension	
		Omission	Commission
Activity Dimension	Latent		
	Active		

RECENT EVENTS AT OPERATING REACTORS HAVE IDENTIFIED HUMAN ERRORS AS ISLOCA PRECURSORS.

HUMAN ERROR CONTRIBUTED TO THESE EVENTS THROUGH SEVERAL MECHANISMS:

- IMPROPER VALVE ASSEMBLY
- ATTEMPTING TO SEAT CHECK VALVE BY OPENING MOV ON LOW PRESSURE SIDE TO INCREASE DIFFERENTIAL PRESSURE
- IMPROPER WIRING OF RHR LETDOWN INTERLOCK
- MISCOMMUNICATION BETWEEN CONTROL OPERATOR AND I&C TECHNICIANS

AN INTEGRATED APPROACH TO HRA WAS USED

- Ensure all Types of Actions were considered for preliminary event trees
- Identify and Screen Human Interactions which May be Risk Significant
- Develop a Detailed Description of Important Human Actions
- Select and Apply Appropriate Modeling Techniques
- Develop new Models where Existing Techniques do not Represent Possible Human Actions
- Quantify the Probabilities for the Various Human Actions
- Document the Information for Traceability

THE MATRIX FOR ACTIVITY AND FAILURE MODE DIMENSIONS WAS APPLIED

- FIVE ERROR CATEGORIES CORRESPONDING TO EVENTS WERE REVIEWED

    1. INITIATING ERRORS

    2. ERRORS IN DETECTION

    3. ERRORS IN DIAGNOSIS

    4. ERRORS IN ISOLATION

    5. ERRORS IN MITIGATION

ERRORS OF COMMISSION ARE NOT USUALLY MODELED IN CONTEMPORARY PRA EFFORTS

- METHODS FOR IDENTIFYING AND QUANTIFYING ERRORS OF OMISSION FOR USE IN CONTEMPORARY PRA ARE WELL DEVELOPED

- METHODS FOR IDENTIFYING AND QUANTIFYING ERRORS OF COMMISSION ARE LESS WELL DEVELOPED

- PRESENT STUDY SOUGHT METHODS TO IDENTIFY, MODEL, AND QUANTIFY ERRORS OF COMMISSION

THREE METHODOLOGICAL STEPS REQUIRED DIFFERENT APPROACHES FOR ERRORS OF COMMISSION

- Error Identification
- Error Representation
- Error Quantification

ERROR IDENTIFICATION BROADENED TO INCLUDE PROBABLE ERRORS OF COMMISSION

- Errors are Normally Identified Through Task Analysis
- Data Collection is Keyed to HRA Quantification Techniques
- Study Applied a Variation of Sneak Analysis to Identify Potential Errors

SNEAK ANALYSIS EMPLOYS STRUCTURED QUESTIONS TO IDENTIFY UNDESIRABLE PATHS AROUND THE INTENDED PATH

Example Questions From Sneak Analysis are:

- Is it Possible for the Operator to Take Actions Other Than Those which are Intended?
- Are There Barriers to Prevent the Operator From Taking Improper Actions?
- Can the Barriers be Circumvented?

EXAMPLE FINDING FROM SNEAK ANALYSIS: THE POTENTIAL FOR EARLY ENTRY INTO DHR COOLDOWN

- We Found
  - Administrative Barriers not Identified
  - Operators Routinely Bypass Physical Barriers by Jumpering Interlocks
  - Procedurally Sanctioned to Jumper One PIV
- This Suggested a Sneak Path for the Error of Commission Related to Prematurely Opening Valves

ERROR REPRESENTATION

- Important to Model Intentional Errors of Commission Somewhat Differently than Commission Errors which are Simple Execution Errors

- Once an Error of Intention is Made and a Course Established Continuing to Successfully Follow that Course Continues the Error

- Any Additional Error (Omission or Commission) Allows Recovery From the Original Error

- Trees must Model Crew Performance after the Decision Error has been made

- Thus the Probability of the Operators Successfully Opening the Valves Must be Combined with the Probability of the Operators Deciding to Commit the Error

QUANTIFICATION OF INTENTIONAL ERRORS OF COMMISSION

- Insufficient Operational Data Exists to Support the Quantification of Errors of Commission Related to Erroneous Intent

- Errors of Intent are not Time Driven but are Conscious Decisions on the Part of the Operator

- Errors are Cognitive in Nature and are Influenced by Performance Shaping Factors Such as Quality of Procedures, Training, and More Nebulous Concepts such as ISLOCA Awareness

- Errors Occur in the Thinking as Much as in the Doing

- Therefore the Analyst Must Use Expert Judgement Techniques for Human Error Quantification

THE B&W HRA ANALYSIS FOR OUTSIDE CONTAINMENT ISLOCA LED TO THE IDENTIFICATION OF POTENTIAL LATENT ERRORS

- ERRORS INVOLVED INAPPROPRIATE VALVE LINEUPS
- MOST LATENT ERRORS INVOLVED LOCALLY OPERATED VALVES
- LACK OF PROCEDURAL TIE-IN TO POTENTIAL FOR ISLOCA

A SENSITIVITY ANALYSIS IS BEING CONDUCTED WHICH WILL EVALUATE THE EFFECTS OF THE FOLLOWING POTENTIAL MODIFICATIONS:

- PROCEDURES
  - CAUTIONS, NOTES, AND WARNINGS ADDED
  - HYPOTHESIZE A PROCEDURE FOR ISLOCA
  - PRECLUDE JUMPERING OF INTERLOCKS
- INSTRUMENTATION
  - ADDITION OF VALVE STATUS BOARD
  - PRESENTATION OF INFORMATION ON PRESSURES, TEMPERATURES, LEVEL, AND FLOW
- TRAINING
  - FORMAL TRAINING ON ISLOCA, ASSOCIATED ALARMS, NEW PROCEDURES
- RECOVERY
  - ALL TASKS COVERED BY PROCEDURES, CHECKOFFS, AND INDEPENDENT VERIFICATION

HRA FINDINGS AND CONCLUSIONS

- Sneak Analysis shows promise for the Identification of Errors of Commission
- Errors of Commission and Latent Errors Proved to be Risk Dominant for ISLOCA at this B&W Plant
- Results Support the Inspection Team Findings Regarding Training and Procedures and Extend Them to Error Quantification
- Practical Measures to Lessen the Risk Related to Human Error have been Identified

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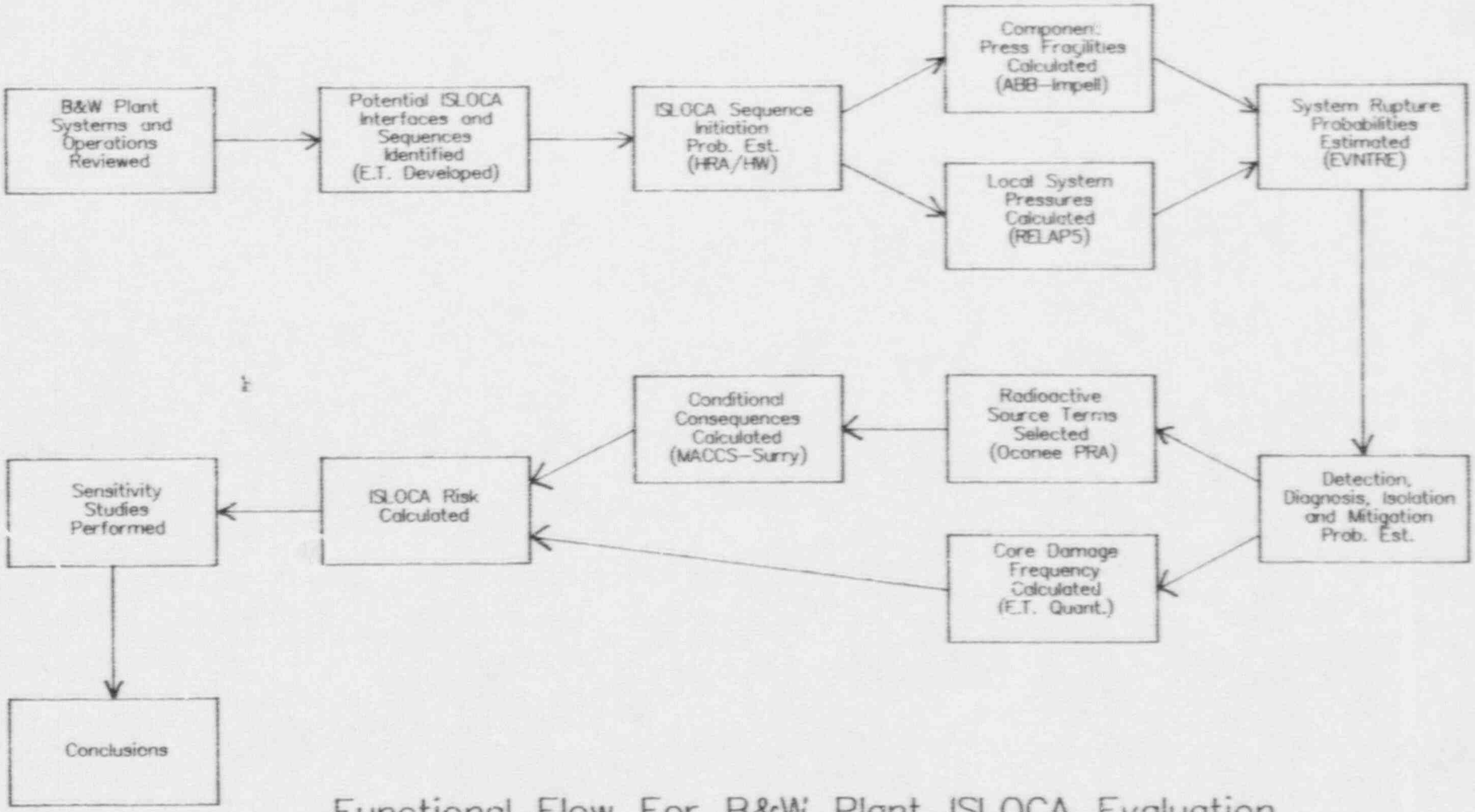
B&W Plant RESULTS

W. J. Galyean

December 12, 1990

EG&G Idaho, Inc.

INEL



Functional Flow For B&W Plant ISLOCA Evaluation

18 "PRECURSOR" EVENTS WERE EXAMINED IN DETAIL

OF THE 18 EVENTS:

- SIX INVOLVED A PRE-EXISTING LEAKING VALVE THAT WAS DETECTED WHEN PERIODIC TEST OPENED INJECTION VALVE.
- THREE INVOLVED AN OPEN CHECK VALVE THAT WAS DETECTED WITHOUT VIOLATION THE PRESSURE ISOLATION FUNCTION.
- THREE RESULTED WHEN CR OPERATORS ATTEMPTED TO DEPRESSURIZE THE RHR (LEAKING CHECK VALVE ALLOWED RC TO BACKFLOW INTO THE RHR).
- TWO INVOLVED A GENERIC PROBLEM OF STRESS CORROSION CRACKS ON ANCHOR DARLING VALVE RETAINING BLOCKS.

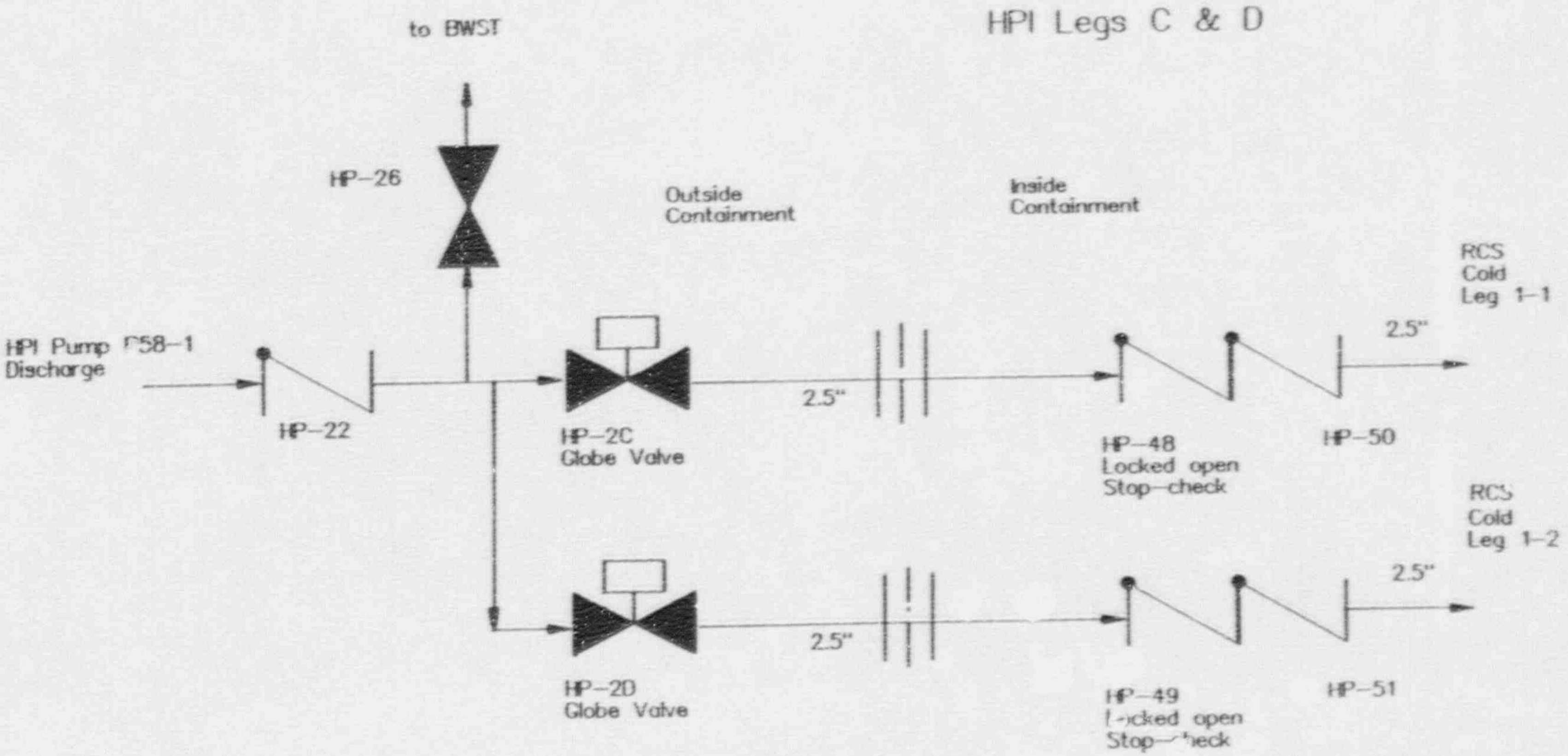
REVIEW OF B&W SYSTEMS AND OPERATIONS LEADS TO IDENTIFICATION OF ISLOCA INTERFACES AND SEQUENCES

- 1-INCH AND SMALLER LINES, AND <200 GPM DEEMED RISK INSIGNIFICANT
  - 50-FOOT 1"-SCH160 PIPE WILL PASS ABOUT 200 GPM
  - BWST ABOUT 450,000 GAL W/ MAKEUP OF ABOUT 150 GPM
  - MU&P PUMPS RATED AT 150 GPM EACH

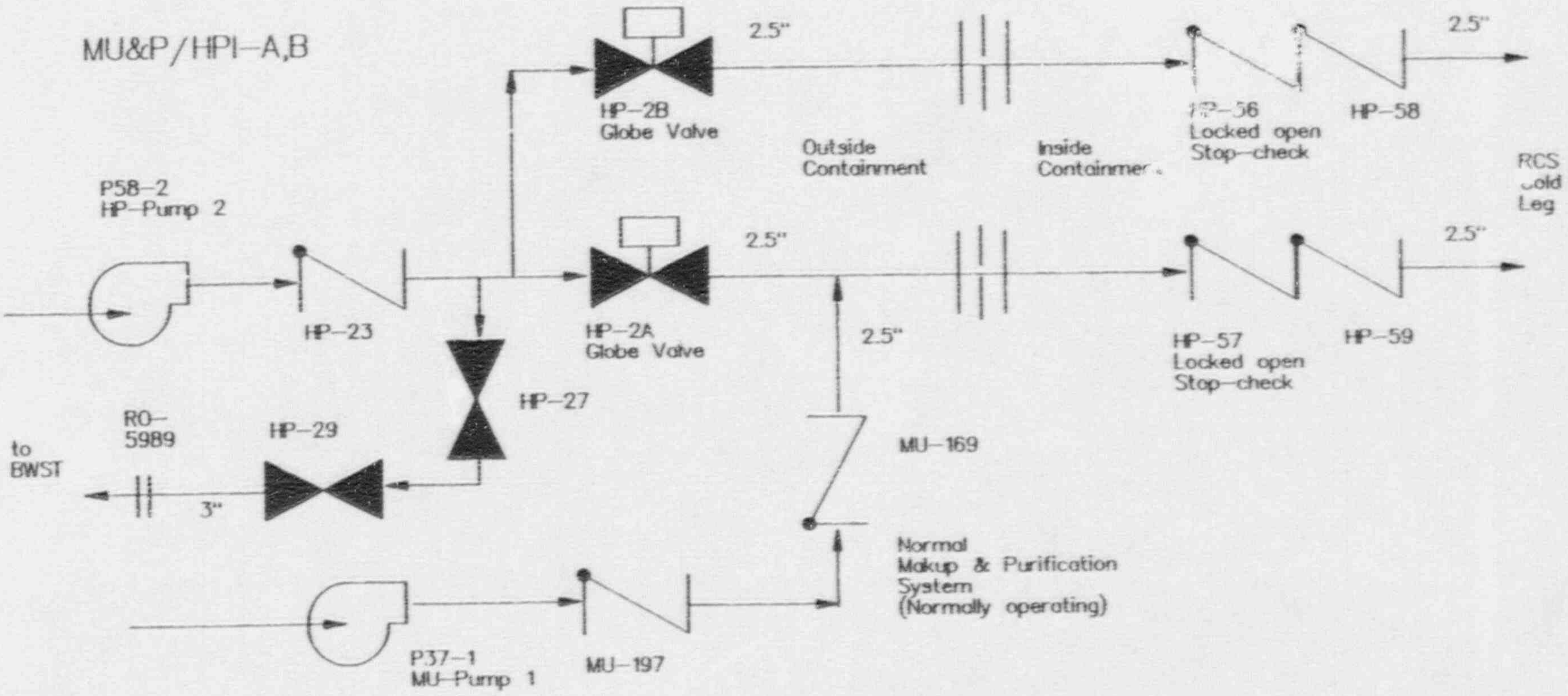
- THREE ISLOCA INTERFACES IDENTIFIED: HPI, LPI, AND DHR LETDOWN

- FIVE POSSIBLE ISLOCA SEQUENCES IDENTIFIED:
  - HPI
  - MU&P/HPI
  - LPI
  - DHR-STARTUP
  - DHR-SHUTDOWN

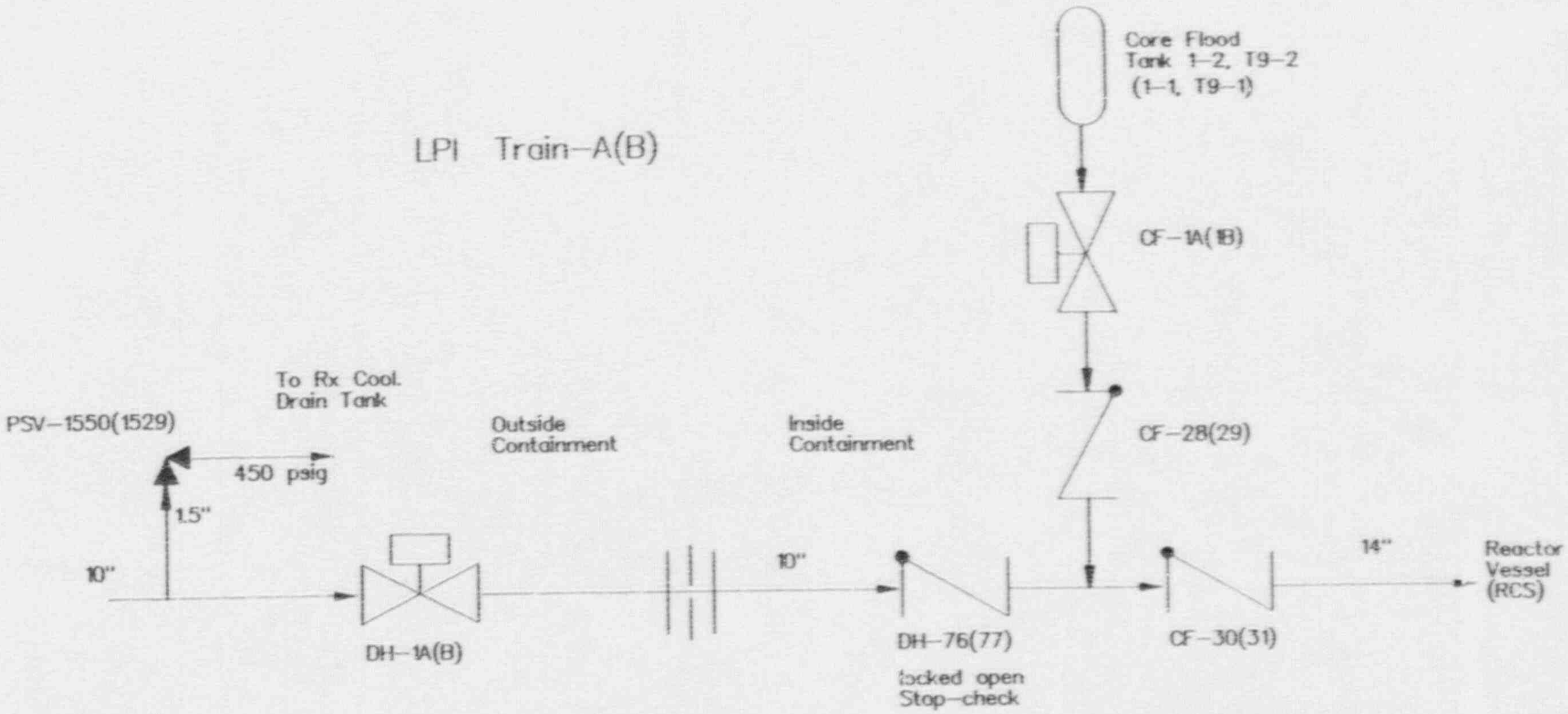
HPI Sequence Initiated by MOV Stroke Test in Combination With Backleakage of Two Check Valves



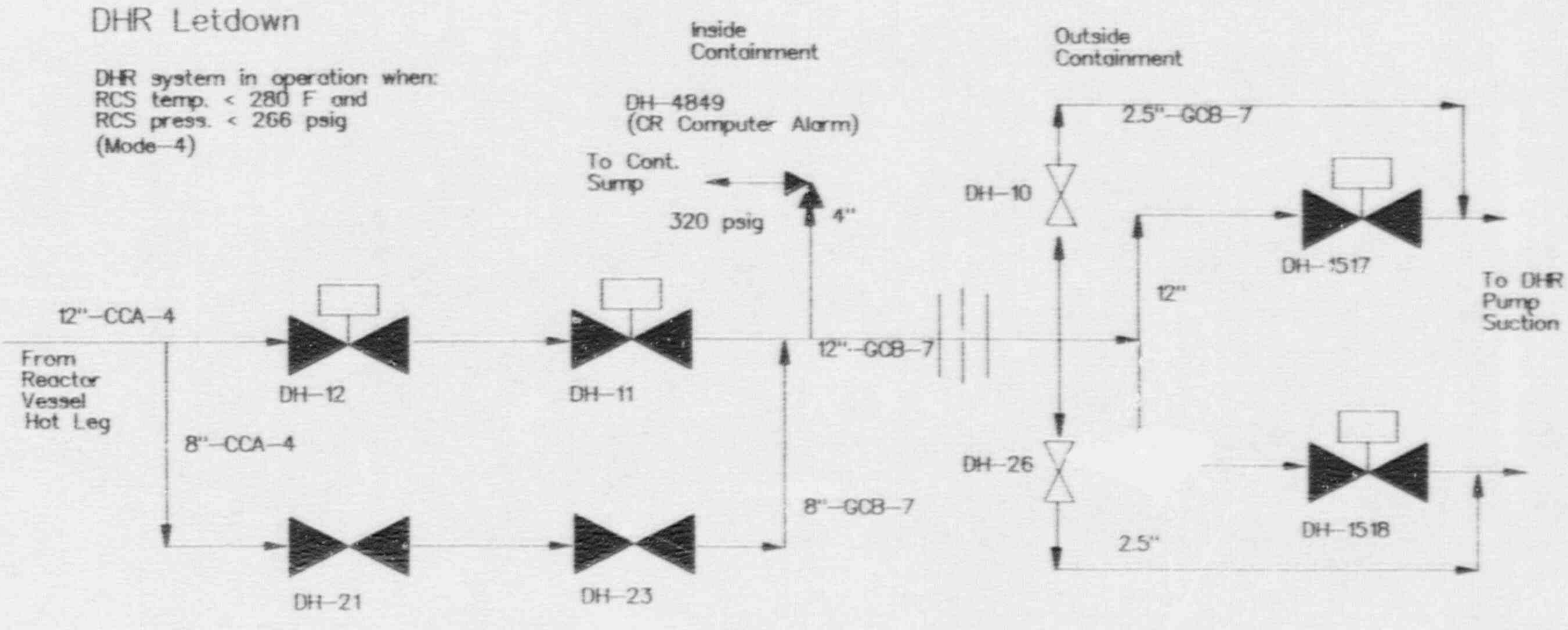
MU&P Sequence Initiated When HP-2A is Stroke Tested and HP-57/59 Fail to Close



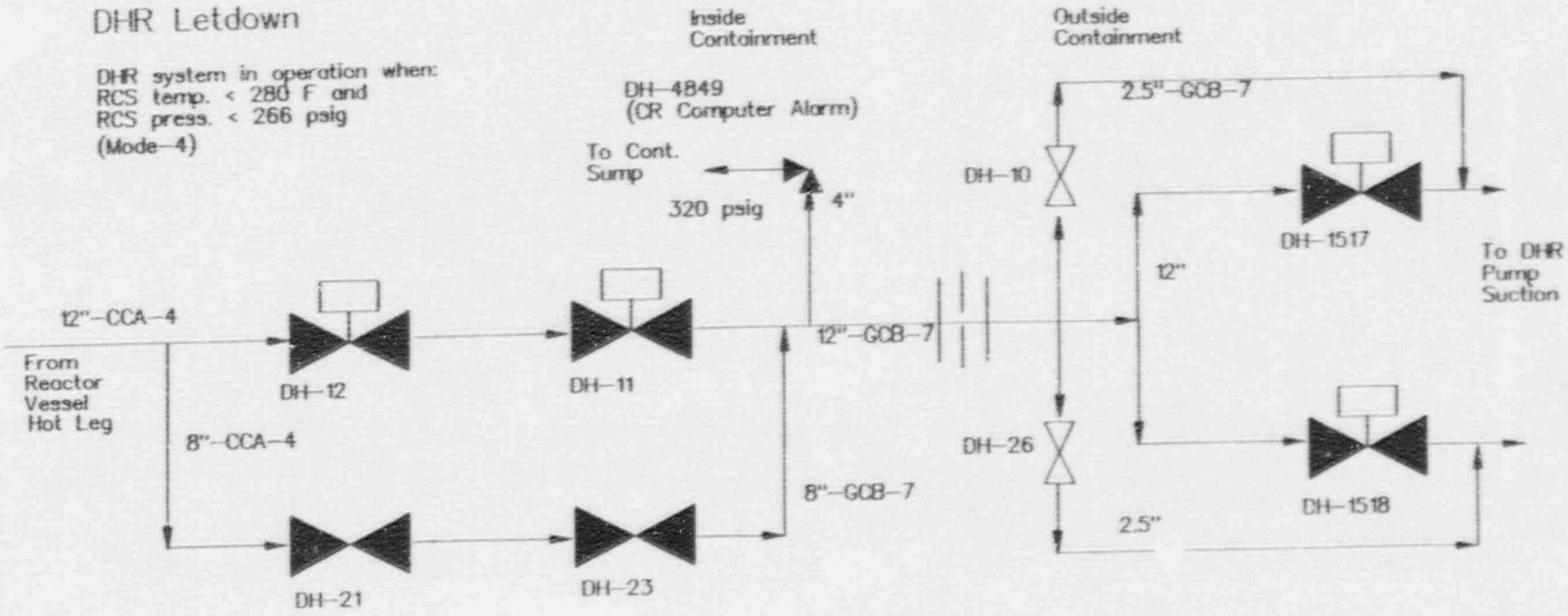
LPI Sequence Comprises the Hardware Failure of Two Series Check Valves



DHR-SU Sequence Characterized by Plant Startup (RCS Pressurization) With Letdown Valves (DH-11/12 or DH-21/23) Left Open

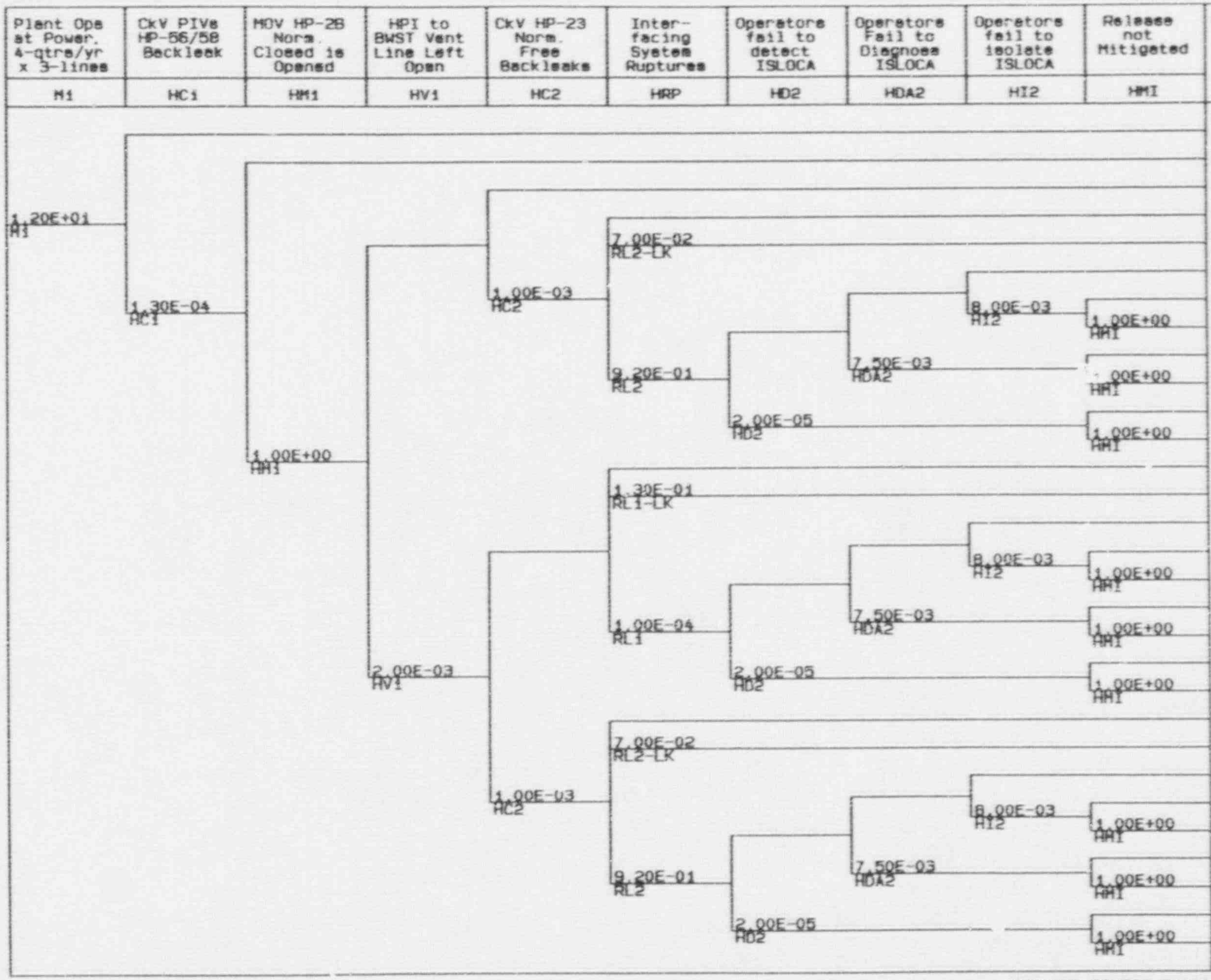


DHR–SD Sequence Involves the Premature Opening of the Letdown MOVs (DH–11/12) During Shutdown



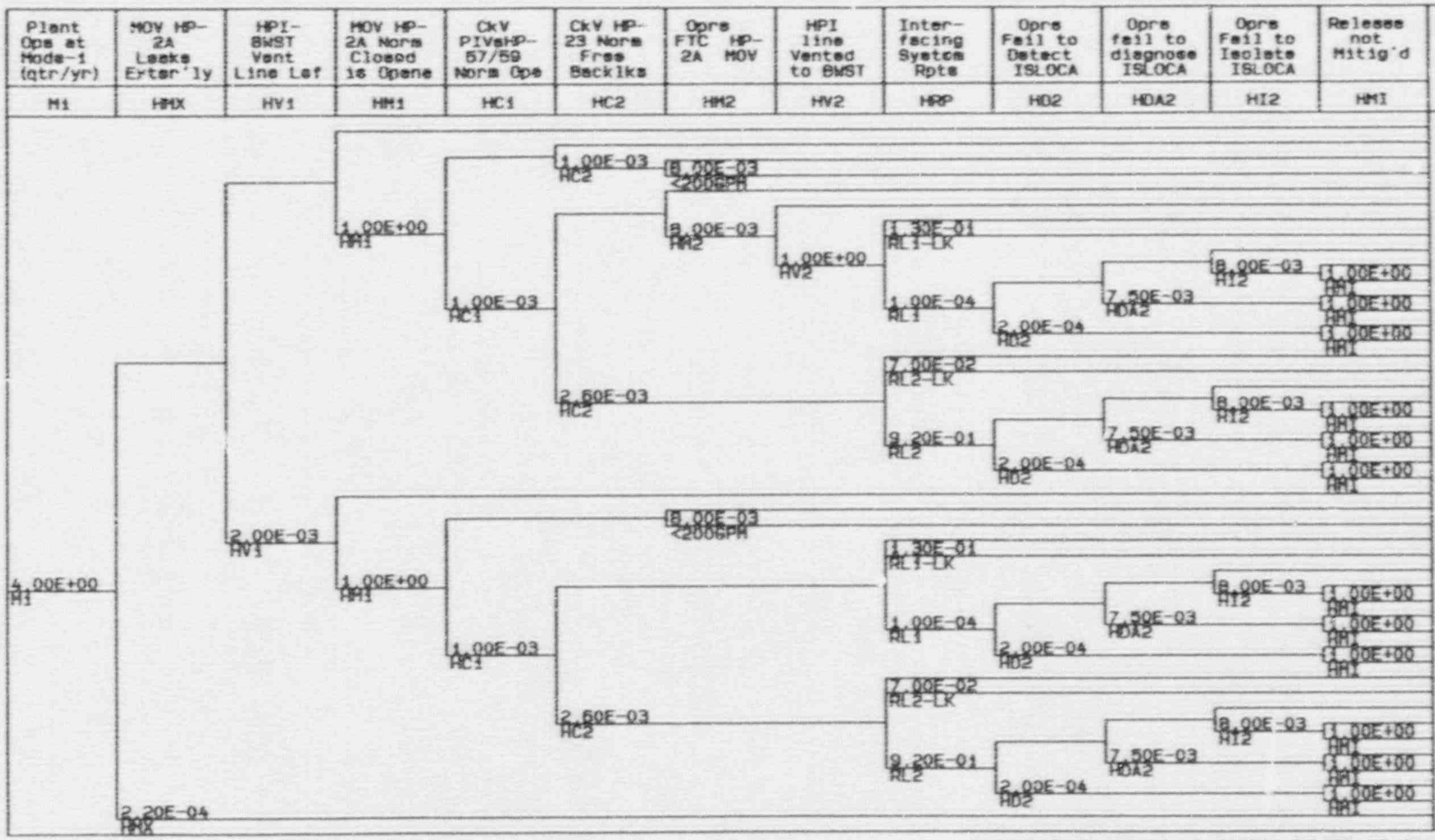
DHR Letdown

DHR system in operation when:
RCS temp. < 280 F and
RCS press. < 266 psig
(Mode–4)



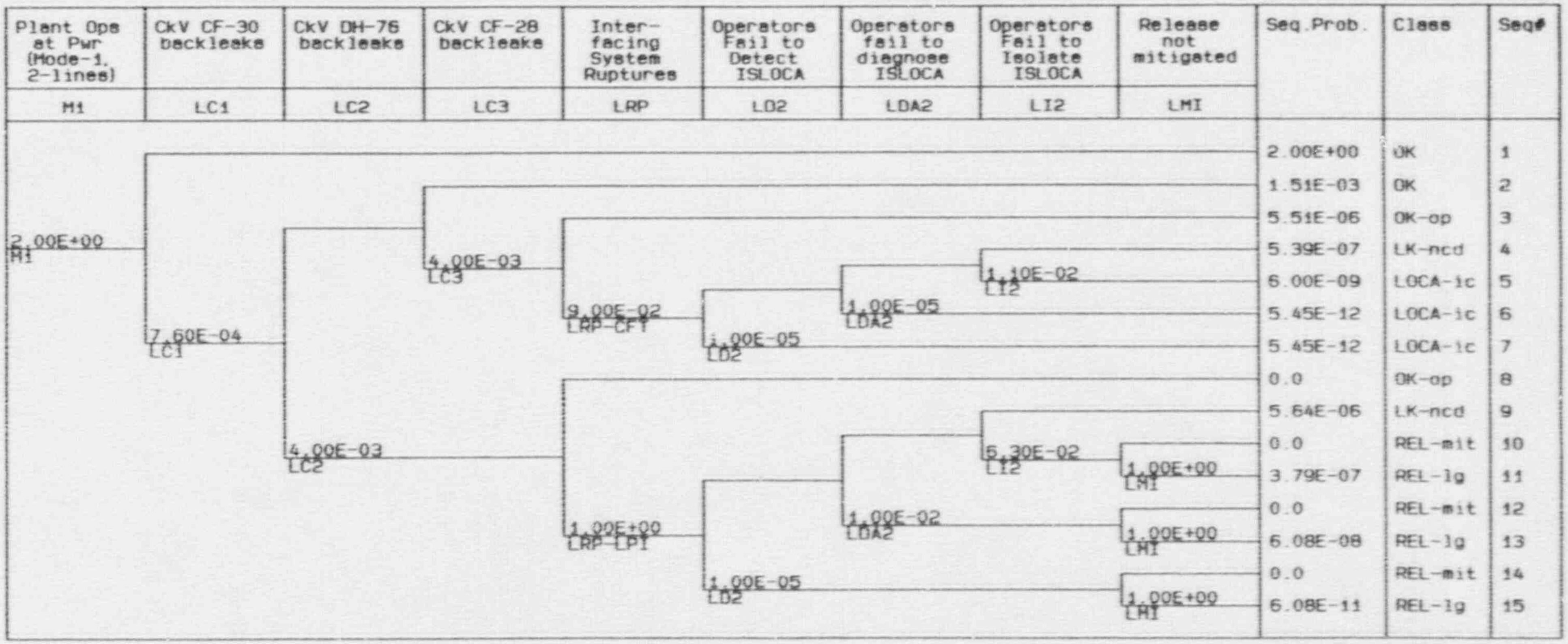
Seq.Prob.	Class	Seq#
1.20E+01	OK	1
0.00E+00	OK	2
1.56E-03	OK-op	3
1.56E-08	OK-op	4
1.09E-07	LK-ncd	5
1.41E-06	LK-ncd	6
0.00E+00	RL2-mit	7
1.14E-08	RL2-lg	8
0.00E+00	RL2-mit	9
1.07E-08	RL2-lg	10
0.00E+00	RL2-mit	11
2.86E-11	RL2-lg	12
2.71E-06	OK-op	13
4.05E-07	LK-ncd	14
3.07E-10	LK-ncd	15
0.00E+00	RL1-mit	16
2.47E-12	RL1-lg	17
0.00E+00	RL1-mit	18
2.34E-12	RL1-lg	19
0.00E+00	RL1-mit	20
6.23E-15	RL1-lg	21
3.12E-11	OK-op	22
2.18E-10	LK-ncd	23
2.83E-09	LK-ncd	24
0.00E+00	RL2-mit	25
2.28E-11	RL2-lg	26
0.00E+00	RL2-mit	27
2.15E-11	RL2-lg	28
0.00E+00	RL2-mit	29
5.74E-14	RL2-lg	30

B&W HPI ISLOCA Event Tree BW-HP.TRE 12/07/90

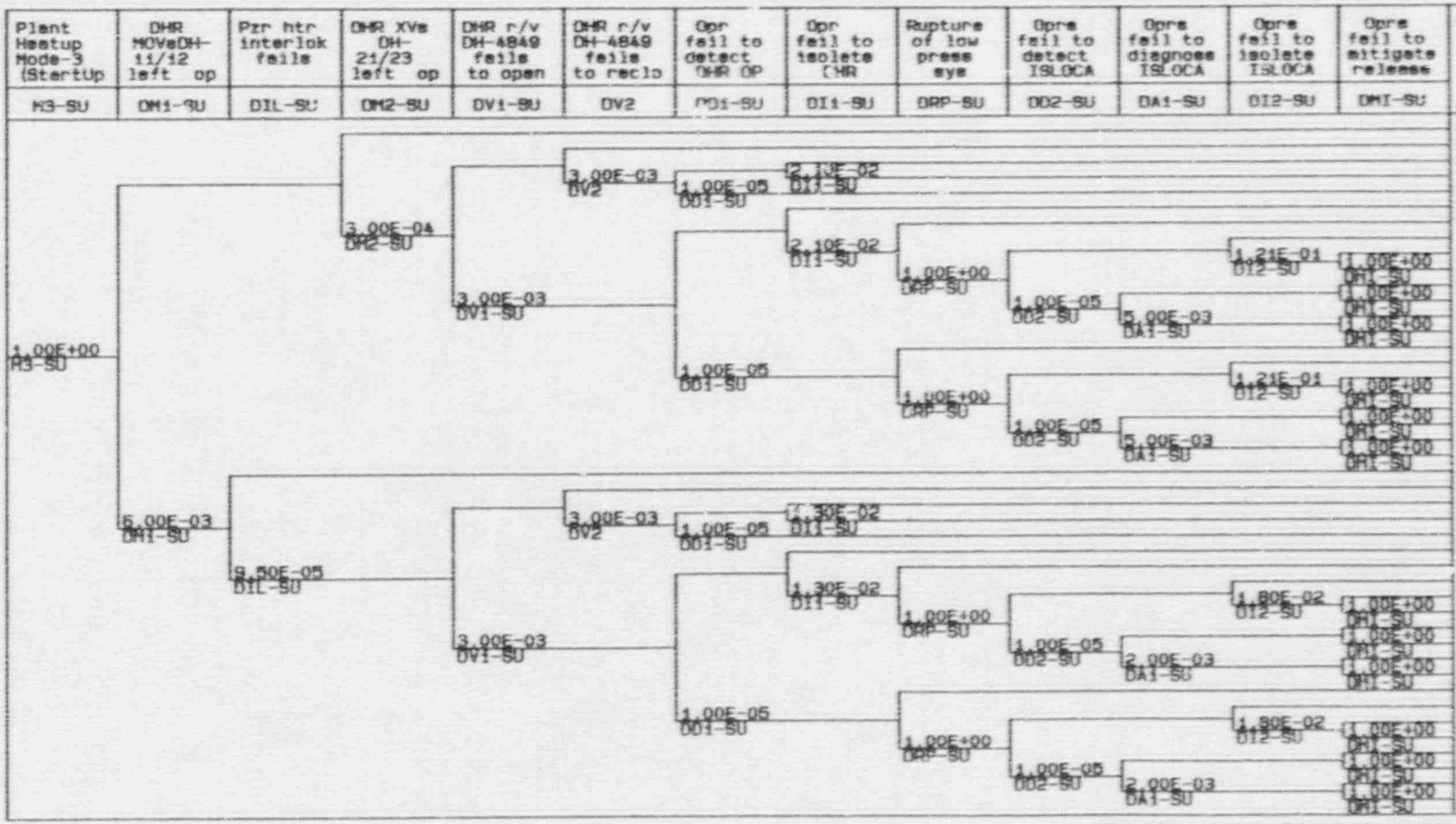


Seq.Prob.	Class	Seq#
0.0	OK	1
3.98E+00	OK	2
3.96E-03	OK-op	3
3.19E-05	LK-ncd	4
3.95E-03	OK	5
0.0	OK	6
2.77E-05	OK-op	7
4.14E-06	LK-ncd	8
3.13E-09	LK-ncd	9
0.0	RL1-mit	10
2.53E-11	RL1-lg	11
0.0	RL1-mit	12
2.39E-11	RL1-lg	13
0.0	RL1-mit	14
6.37E-13	RL1-lg	15
1.04E-07	OK-op	16
7.26E-07	LK-ncd	17
9.40E-06	LK-ncd	18
0.0	RL2-mit	19
7.58E-08	RL2-lg	20
0.0	RL2-mit	21
7.16E-08	RL2-lg	22
0.0	RL2-mit	23
1.91E-09	RL2-lg	24
0.0	OK	25
7.93E-03	OK-op	26
6.39E-05	LK-ncd	27
6.94E-06	OK-op	28
1.04E-06	LK-ncd	29
7.85E-10	LK-ncd	30
0.0	RL1-mit	31
6.33E-12	RL1-lg	32
0.0	RL1-mit	33
5.98E-12	RL1-lg	34
0.0	RL1-mit	35
1.60E-13	RL1-lg	36
2.08E-10	OK-op	37
1.46E-09	LK-ncd	38
1.88E-08	LK-ncd	39
0.0	RL2-mit	40
1.52E-10	RL2-lg	41
0.0	RL2-mit	42
1.43E-10	RL2-lg	43
0.0	RL2-mit	44
3.83E-12	RL2-lg	45
8.80E-04	LK-ncd	46

Makeup & Purification System ISLOCA ET for B&W. BW-MU.TRE 12/07/90

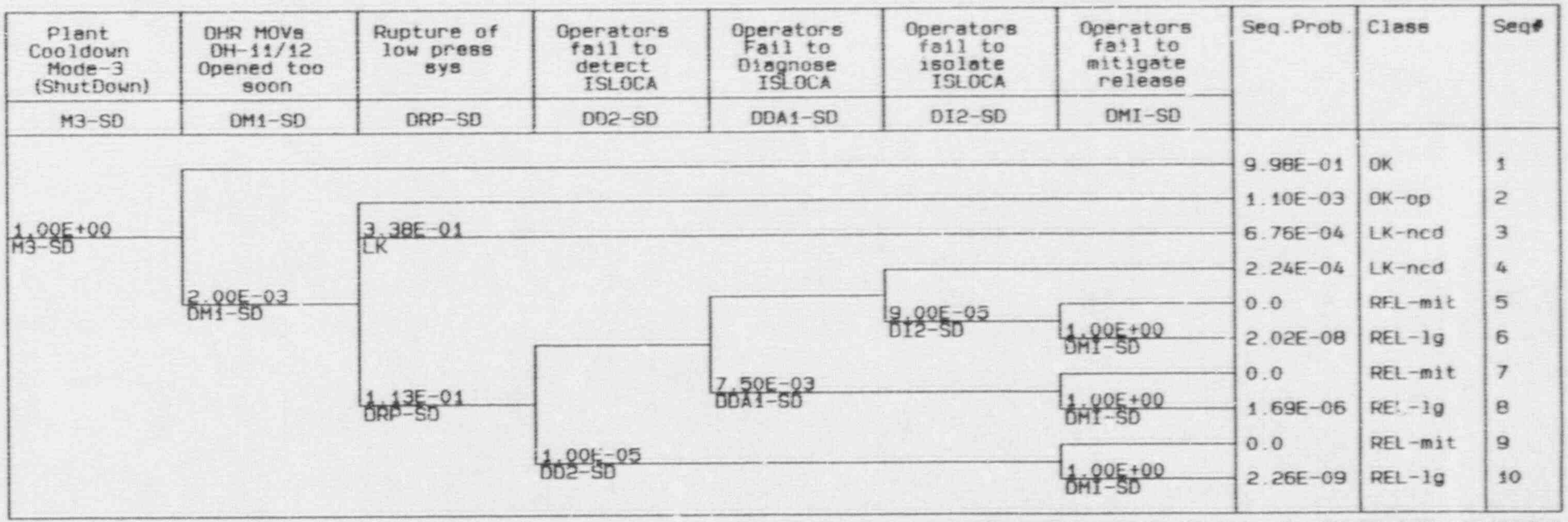


B&W LPI ISLOCA Event Tree BW-LP.TRE 12/07/90



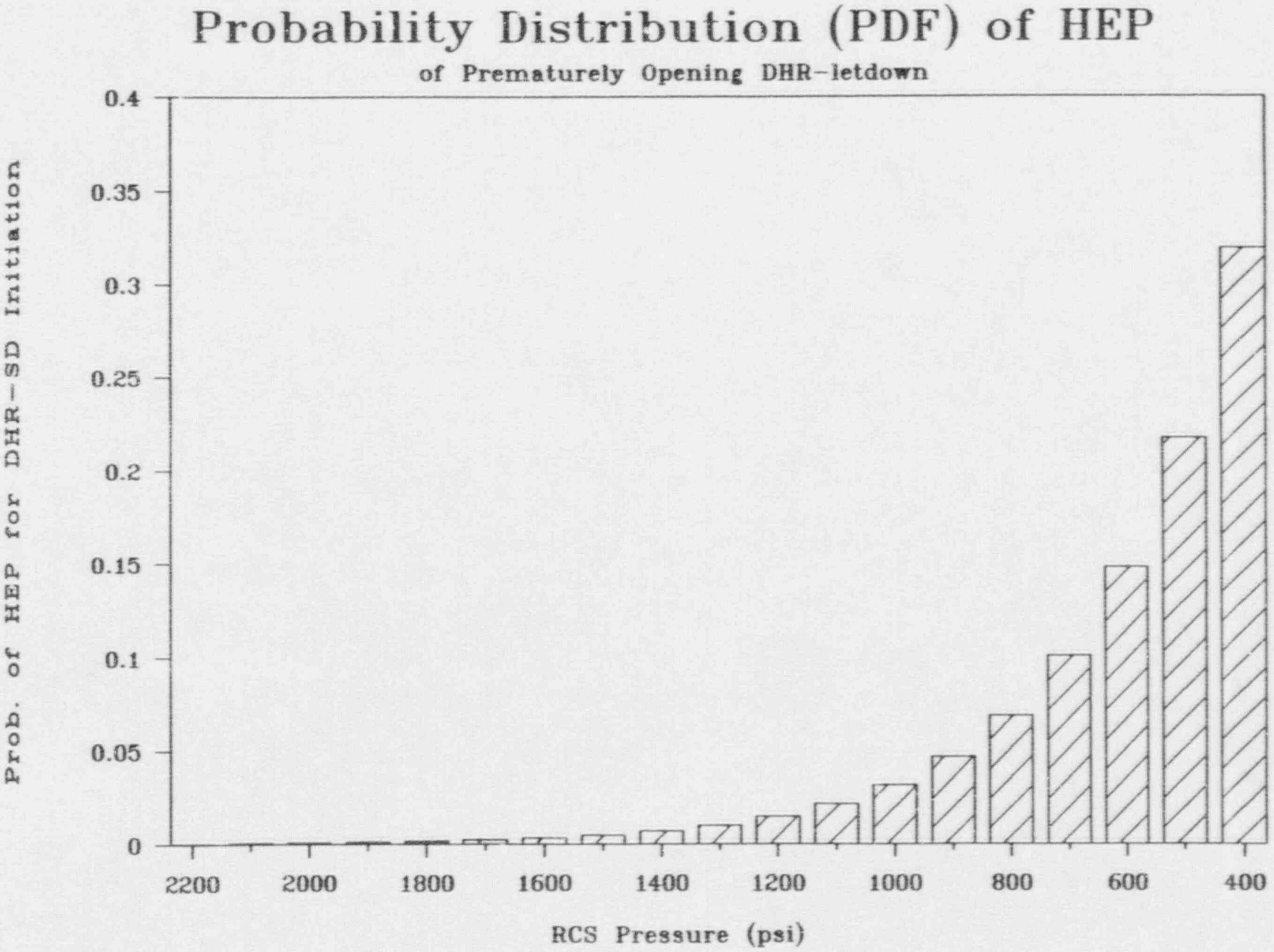
Seq.Prob.	Class	Seq#
9.94E-01	OK	1
2.98E-04	LK-ncd	2
8.73E-07	LK-ncd	3
1.87E-08	LOCA-ic	4
8.92E-12	LOCA-ic	5
8.76E-07	OK-op	6
0.0	OK-op	7
1.65E-08	LK-ncd	8
0.0	REL-mit	9
2.27E-09	REL-lg	10
0.0	REL-mit	11
1.87E-13	REL-lg	12
0.0	REL-mit	13
0.0	REL-lg	14
0.0	OK-op	15
7.86E-12	LK-ncd	16
0.0	REL-mit	17
1.08E-12	REL-lg	18
0.0	REL-mit	19
0.0	REL-lg	20
0.0	REL-mit	21
0.0	REL-lg	22
6.00E-03	OK	23
5.67E-07	LK-ncd	24
1.68E-09	LK-ncd	25
2.22E-11	LOCA-ic	26
1.70E-14	LOCA-ic	27
1.69E-09	OK-op	28
0.0	OK-op	29
2.18E-11	LK-ncd	30
0.0	REL-mit	31
4.00E-13	REL-lg	32
0.0	REL-mit	33
0.0	REL-lg	34
0.0	REL-mit	35
0.0	REL-lg	36
0.0	OK-op	37
1.68E-14	LK-ncd	38
0.0	REL-mit	39
0.0	REL-lg	40
0.0	REL-mit	41
0.0	REL-lg	42
0.0	REL-mit	43
0.0	REL-lg	44

B&W DHR Letdown (Startup) ISLOCA E.T. BW-SU.TRE 12/07/90



Seq.Prob.	Class	Seq#
9.98E-01	OK	1
1.10E-03	OK-op	2
6.76E-04	LK-ncd	3
2.24E-04	LK-ncd	4
0.0	REL-mit	5
2.02E-08	REL-lg	6
0.0	REL-mit	7
1.69E-06	REL-lg	8
0.0	REL-mit	9
2.26E-09	REL-lg	10

ISLOCA E.T. for B&W DHR Letdown (Shutdown) BW-SD.TRE 12/07/90



Probability Distribution (PDF) of HEP
of Prematurely Opening DHR-letdown
Prob. of HEP for DHR-SD Initiation
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2200
2000
1800
1600
1400
1200
1000
800
600
400
RCS Pressure (psi)

DHR System Rupture Probabilities (Weighted by the HEP of prematurely opening DH-11/12) as a Function of RCS Pressure

(Pipe failure pressure log-std-dev = 0.36)

RCS PRESSURE (PSIG)	HEP	SYSTEM RUPTURE PROB.			HEP-WEIGHTED SYSTEM RUPTURE PROB.		
		LARGE	SMALL	NO-LEAK	LARGE	SMALL	NO-LEAK
2200	6.5E-07	1	0	0	6.5E-07	0	0
2100	9.4E-07	0.999	0.001	0	9.4E-07	9.4E-10	0
2000	1.4E-06	0.997	0.003	0	1.4E-06	4.2E-09	0
1900	2.0E-06	0.995	0.005	0	2.0E-06	1.0E-08	0
1800	3.0E-06	0.994	0.006	0	3.0E-06	1.8E-08	0
1700	4.2E-06	0.991	0.009	0	4.2E-06	3.8E-08	0
1600	6.5E-06	0.983	0.017	0	6.4E-06	1.1E-07	0
1500	9.4E-06	0.964	0.036	0	9.1E-06	3.4E-07	0
1400	1.4E-05	0.920	0.080	0	1.3E-05	1.1E-06	0
1300	2.0E-05	0.836	0.164	0	1.7E-05	3.3E-06	0
1200	3.0E-05	0.705	0.295	0	2.1E-05	8.9E-06	0
1100	4.2E-05	0.551	0.449	0	2.3E-05	1.9E-05	0
1000	6.5E-05	0.403	0.597	0.0001	2.6E-05	3.9E-05	6.5E-09
900	9.4E-05	0.281	0.718	0.001	2.6E-05	6.8E-05	9.4E-08
800	1.4E-04	0.178	0.810	0.012	2.5E-05	1.1E-04	1.7E-06
700	2.0E-04	0.100	0.809	0.091	2.0E-05	1.6E-04	1.8E-05
600	3.0E-04	0.050	0.580	0.370	1.5E-05	1.7E-04	1.1E-04
500	4.2E-04	0.021	0.193	0.786	8.8E-06	8.1E-05	3.3E-04
400	6.5E-04	0.007	0.012	0.981	4.6E-06	7.8E-06	6.4E-04
	0.002				0.113	0.338	0.549

SEQUENCES QUANTIFIED BY PDS, CDF AND RISK

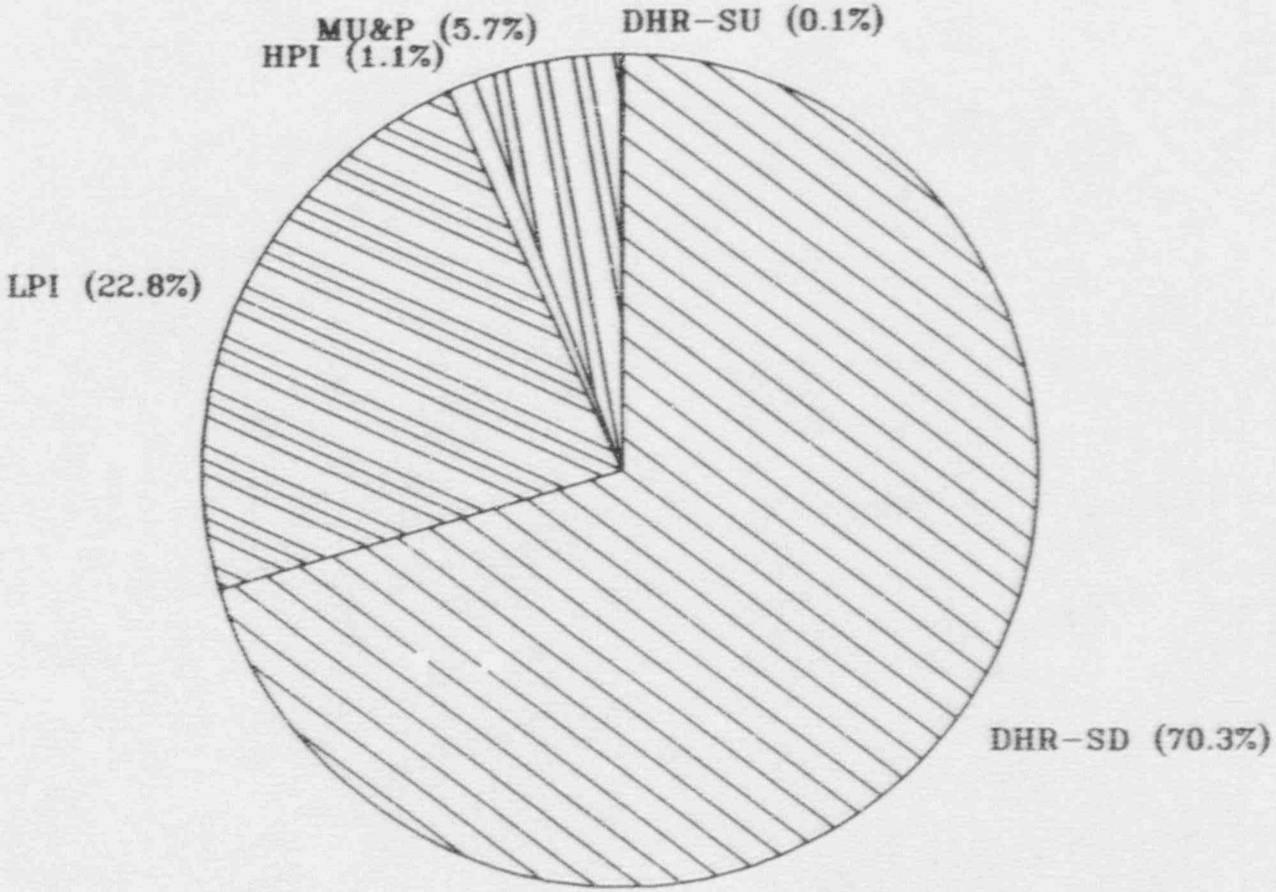
- EVENT TREES USED TO GENERATE PLANT DAMAGE STATE FREQUNCIES:
  - RELEASE-LARGE,
  - RELEASE-MITIGATED,
  - LOCA-INSIDE CONTAINMENT,
  - LEAK-NO CORE DAMAGE
  - OK-OVERPRESSURE

- CORE DAMAGE FREQUENCY SUM OF RELEASE-LARGE (REL-LG) AND RELEASE-MITIGATED (REL-MIT) PLANT DAMAGE STATES (PDS).

- RISK MEASURES:
  - EARLY FATALITIES
  - LATENT CANCERS (TOTAL GRID)
  - POPULATION DOSE (50-MILE)

B&W Plant ISLOCA CDF Distribution

ISLOCA Sequence Total 2.3E-6/Rx-yr



B&W PLANT DAMAGE STATE FREQUENCIES FROM ISLOCA SEQUENCES (PER RX-YR)

SEQUENCE	CDF	REL-LG	REL-MIT	LOCA-IC	LK-NCD	OK-OP
DHR-SD	1.6E-6	1.6E-6	0.0	0.0	9.2E-4	1.1E-3
MU&P	1.3E-7	1.3E-7	0.0	0.0	1.1E-3	1.2E-2
HPI	2.4E-8	2.4E-8	0.0	0.0	2.1E-6	2.9E-3
DHR-SU	2.0E-9	2.0E-9	0.0	1.7E-8	2.8E-4	8.3E-7
LPI	5.2E-7	5.2E-7	0.0	9.1E-9	1.1E-5	1.1E-5
TOTALS	2.3E-6	2.3E-6	0.0	2.6E-8	2.3E-3	1.6E-2

INEL

SOURCE TERMS AND SITE DATA ESTIMATED UTILIZING EXISTING INFORMATION

- INFORMATION ON B&W PLANTS IS LIMITED, SOURCE TERM AND RELEASE TIMING TAKEN FROM OCONEE PRA (NSAC/60)
- INDUSTRY-WIDE AVERAGE SITE POPULATION ESTIMATED USING SANDIA SITING STUDY (NUREG/CR-2239)
- NUREG-1150 SITES COMPARED TO AVERAGE POPULATION, SURRY SELECTED AS REPRESENTING AVERAGE SITE (FOR MACCS INPUT)

CONDITIONAL CONSEQUENCES CALCULATED USING MACCS AND NUREG-1150 SECOND DRAFT

- MACCS-PC VERSION 1.5.11

- SURRY EVACUATION STRATEGY (NUREG-1150), OCONEE SOURCE TERM AND RELEASE TIMING (NSAC/60)

- CONDITIONAL CONSEQUENCES CALCULATED FOR A WIDE RANGE OF DECONTAMINATION FACTOR (1-1000)
  - LARGE RELEASE DF=1
  - MITIGATED RELEASE DF=10

- CONSEQUENCE MEASURES:
  - EARLY FATALITIES
  - LATENT CANCERS (TOTAL GRID)
  - POPULATION DOSE (50-MI.)

ISLOCA RISK (PER RX-YR) FOR B&W PLANT
(OCONEE SOURCE TERM SCALED TO B&W PLANT POWER,
AND THE SURRY SITE)

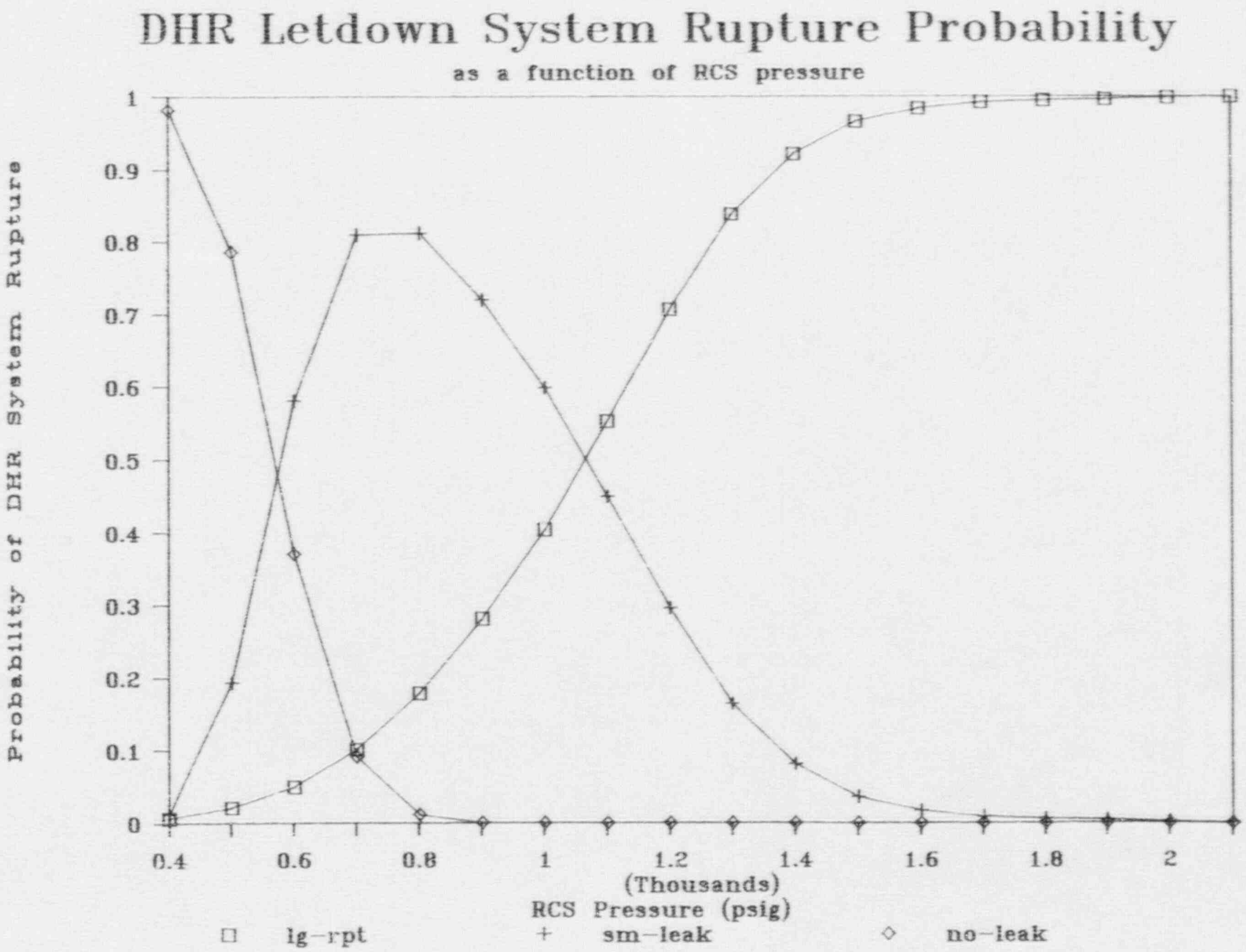
RISK MEASURE	REL-LG DF=1	REL-MIT DF=10	TOTAL
POPULATION DOSE (PERSON-REM, 50-MI.)	6.4	0.0	6.4
LATENT CANCERS (TOTAL GRID)	1.0E-2	0.0	1.0E-2
EARLY FATALITIES	8.1E-8	0.0	8.1E-8

SENSITIVITY STUDIES PERFORMED ON TWO KEY ASPECTS OF ANALYSIS

- SENSITIVITY ISSUES CHOSEN BECAUSE THEY ARE SIGNIFICANT CONTRIBUTORS TO RISK AND THERE EXITS RELATIVELY LARGE UNCERTAINTY IN THEIR ESTIMATION.

- EFFECT OF PIPE RUPTURE PRESSURE UNCERTAINTY ON DHR-SD CDF:
  - BASE CASE LOGARITHMIC STANDARD DEVIATION = 0.36,
  - SENSITIVITY CASE LOGARITHMIC STANDARD DEVIATION = 0.1.

- HUMAN FACTORS SENSITIVITIES:
  - PDF OF HEP FOR INITIATION OF DHR-SD SEQUENCE.

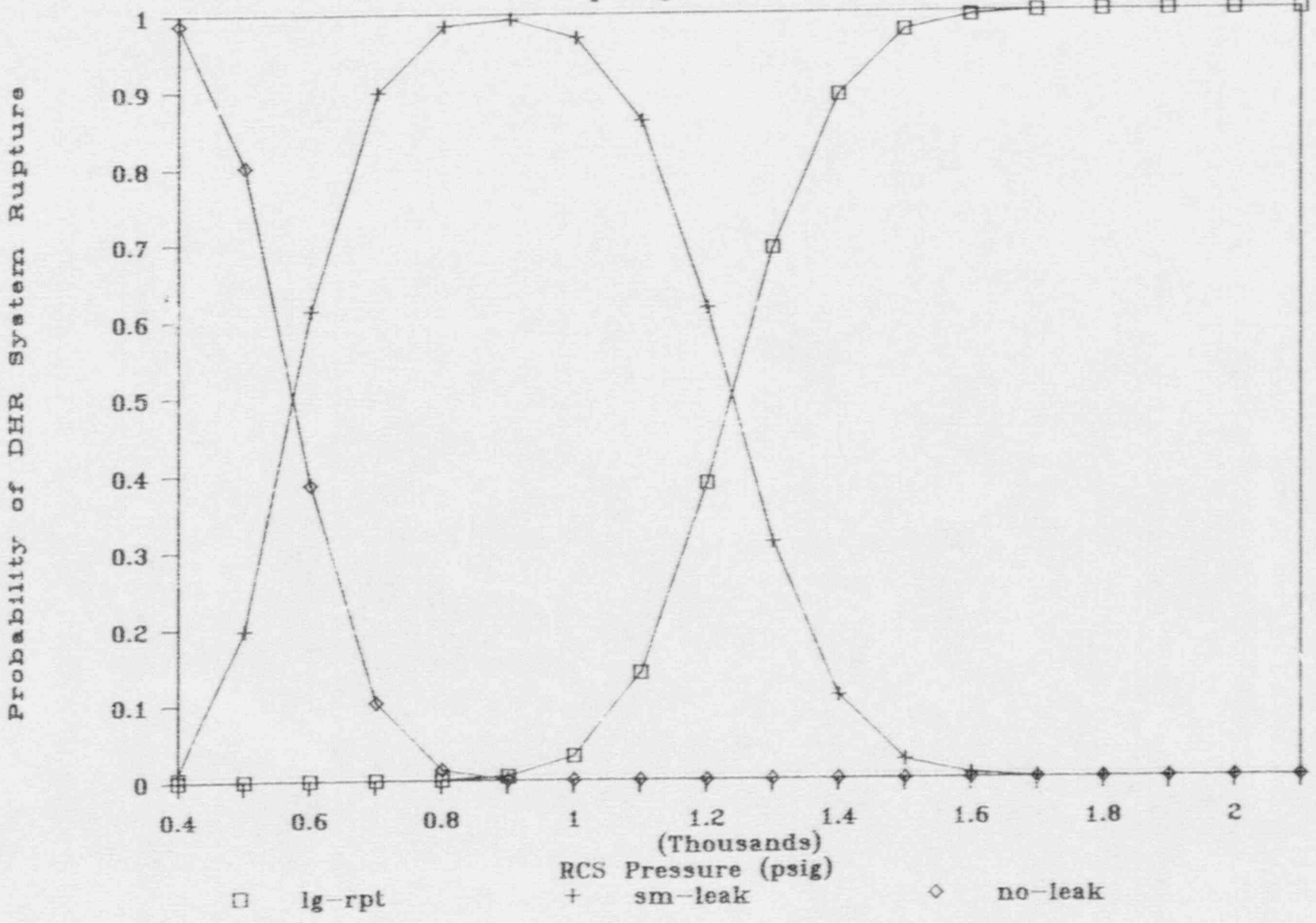


DHR Letdown System Rupture Probability

as a function of RCS pressure

DHR Letdown Sys Rupt Prob vs RCS Press

for Pipe log-std-dev = 0.1

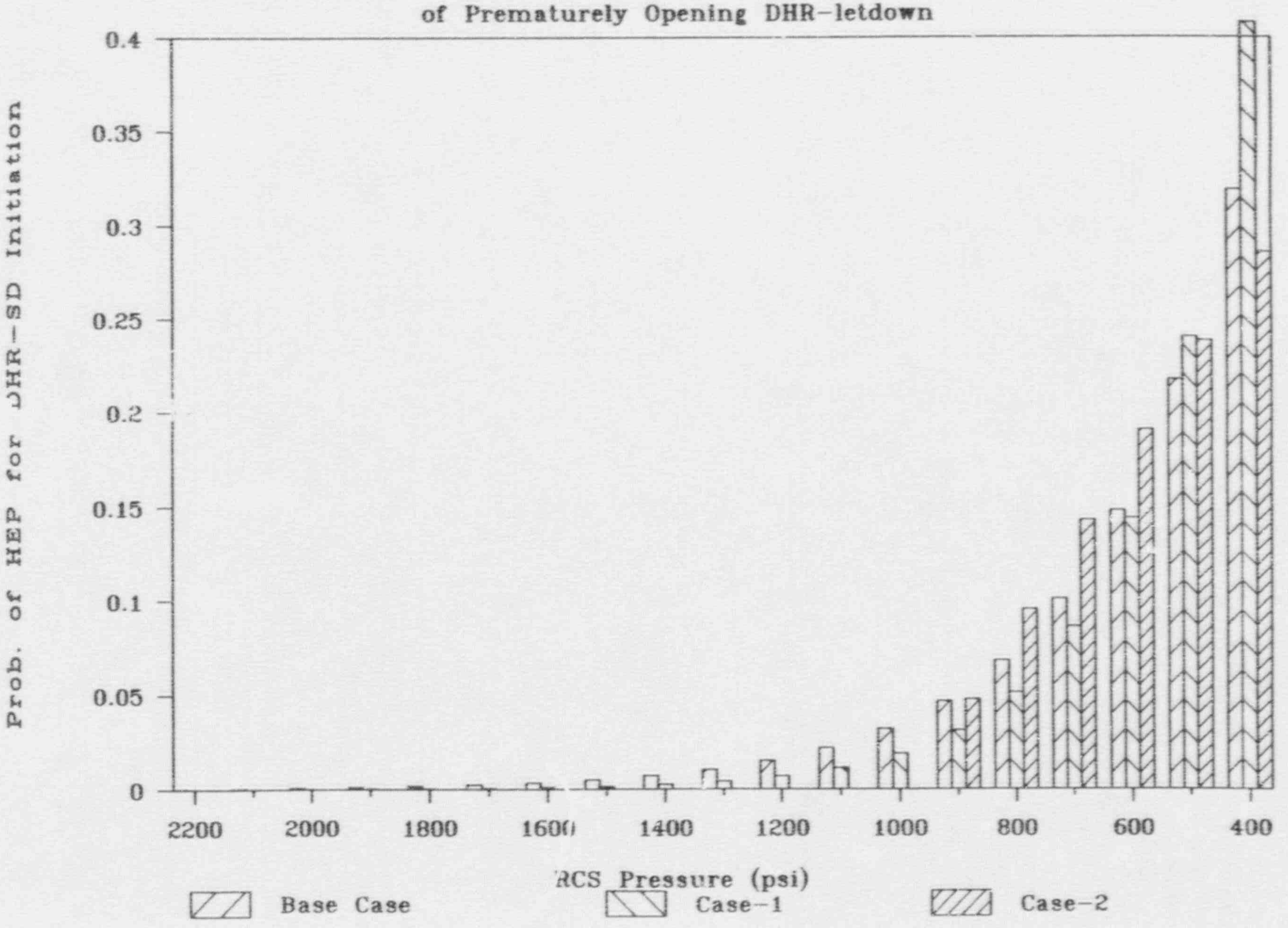


SENSITIVITY OF PIPE RUPTURE PRESSURE UNCERTAINTY ON DHR-SD SEQUENCE CORE DAMAGE FREQUENCY (PER RX-YR)

BASE CASE, LOG-STD-DEV = 0.36
SENSITIVITY CASE, LOG-STD-DEV = 0.1.

DAMAGE STATE	BASE CASE	SENSITIVITY CASE
OK-OP	1.1E-3	1.1E-3
LK-NCD	9.2E-4	8.8E-4
LOCA-IC	0.0	0.0
REL-MIT	0.0	0.0
REL-LG	1.6E-6	5.6E-7
DHR-SD TOTAL CORE DAMAGE	1.6E-6	5.6E-7

INEL



Probability Distribution (PDF) of HEP

of Prematurely Opening DHR-letdown

SENSITIVITY OF PRESSURE DEPENDENT HEP ON DHR-SD SEQUENCE CORE DAMAGE FREQUENCY (PER RX-YR)

BASE CASE: HEP RELATIVE WEIGHT AT 2200 PSIG = 1E-3.
SENS. CASE #1: HEP RELATIVE WEIGHT AT 2200 PSIG = 1E-4.
SENS. CASE #2: HEP LINEAR BETWEEN 400-1000 PSIG.

DAMAGE STATE	BASE CASE	CASE #1	CASE #2
OK-OP	1.1E-3	1.3E-3	1.1E-3
LK-NCD	9.2E-4	7.1E-4	9.0E-4
LOCA-TC	0.0	0.0	0.0
REL-EXT	0.0	0.0	0.0
REL-LG	1.6E-6	1.0E-6	9.2E-7
DHR-SD TOTAL CORE DAMAGE	1.6E-6	1.0E-6	9.2E-7

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PRELIMINARY RESULTS OF ISLOCA ANALYSIS OF A WESTINGHOUSE FOUR-LOOP REACTOR

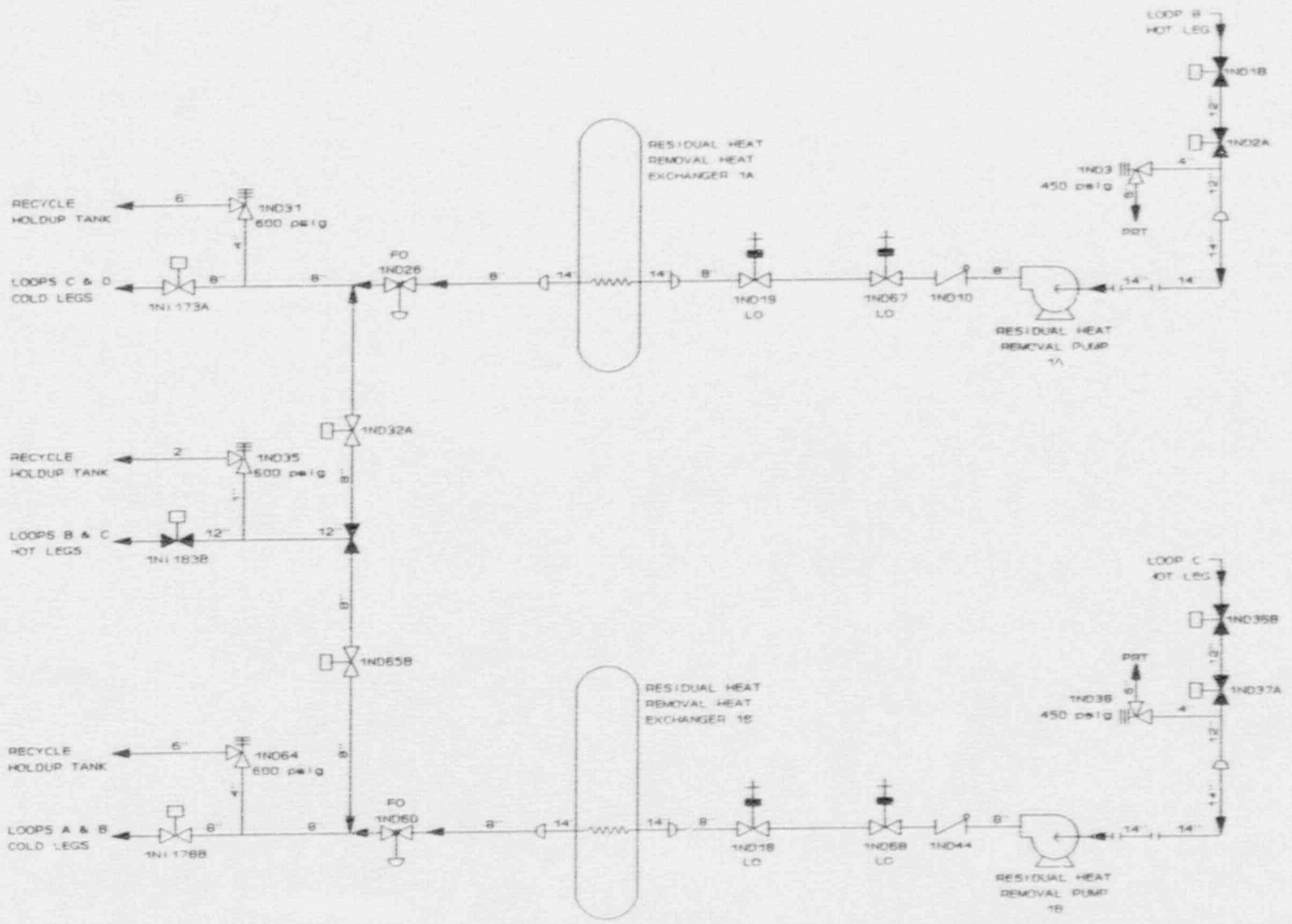
DANA L. KELLY

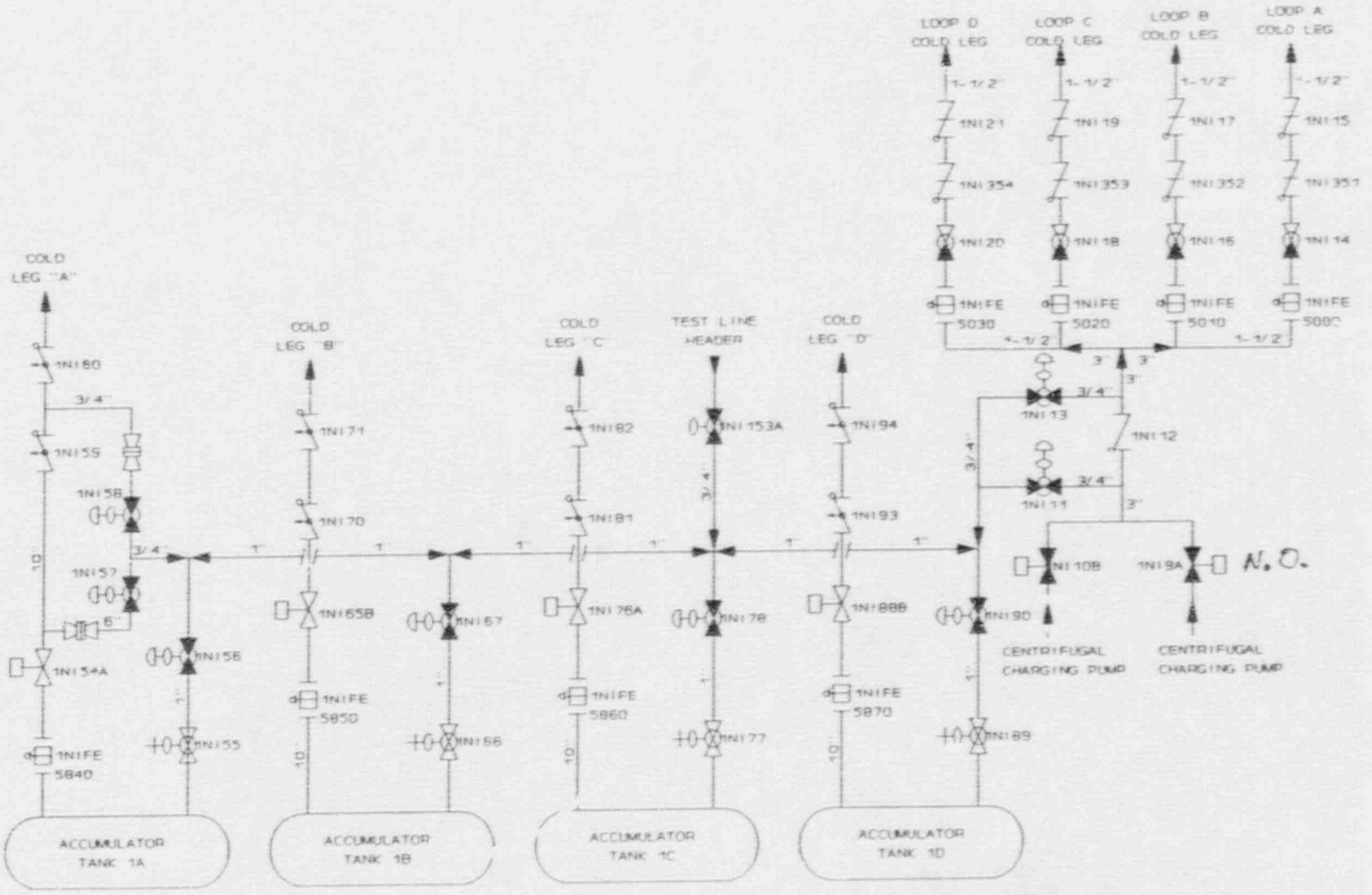
DECEMBER 11 AND 12, 1990

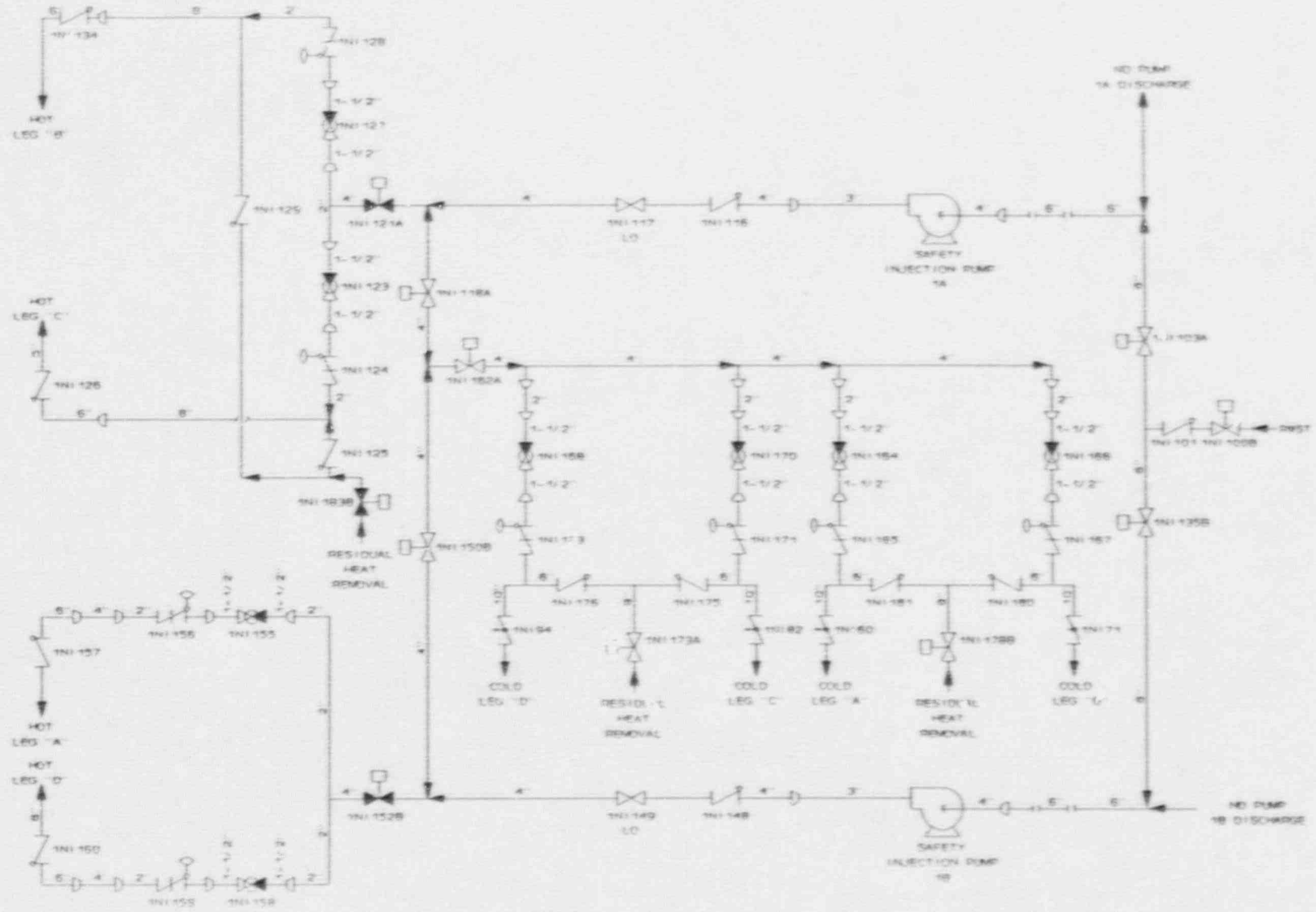
EG&G Idaho, Inc.

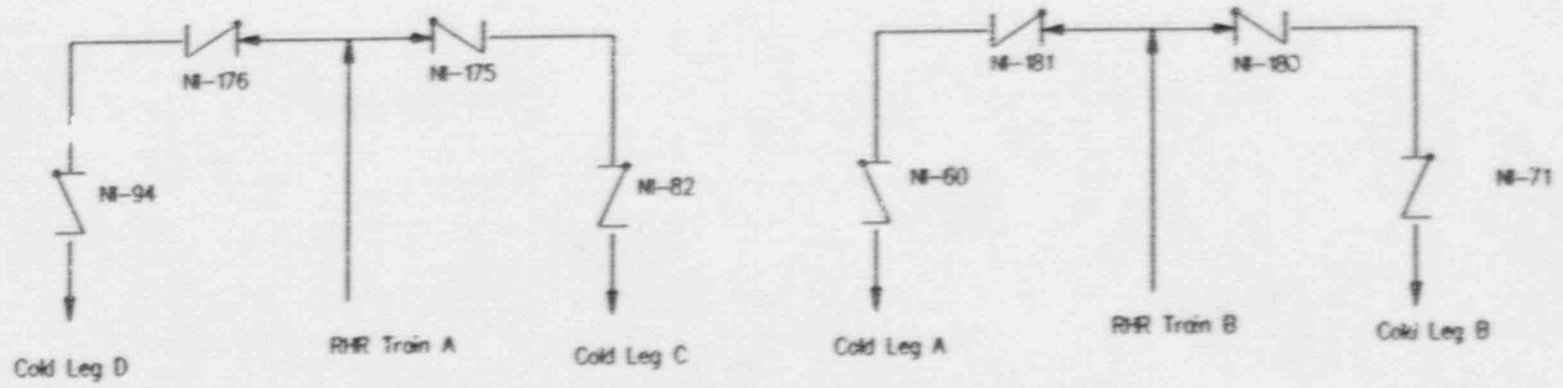
CORE DAMAGE FREQUENCY

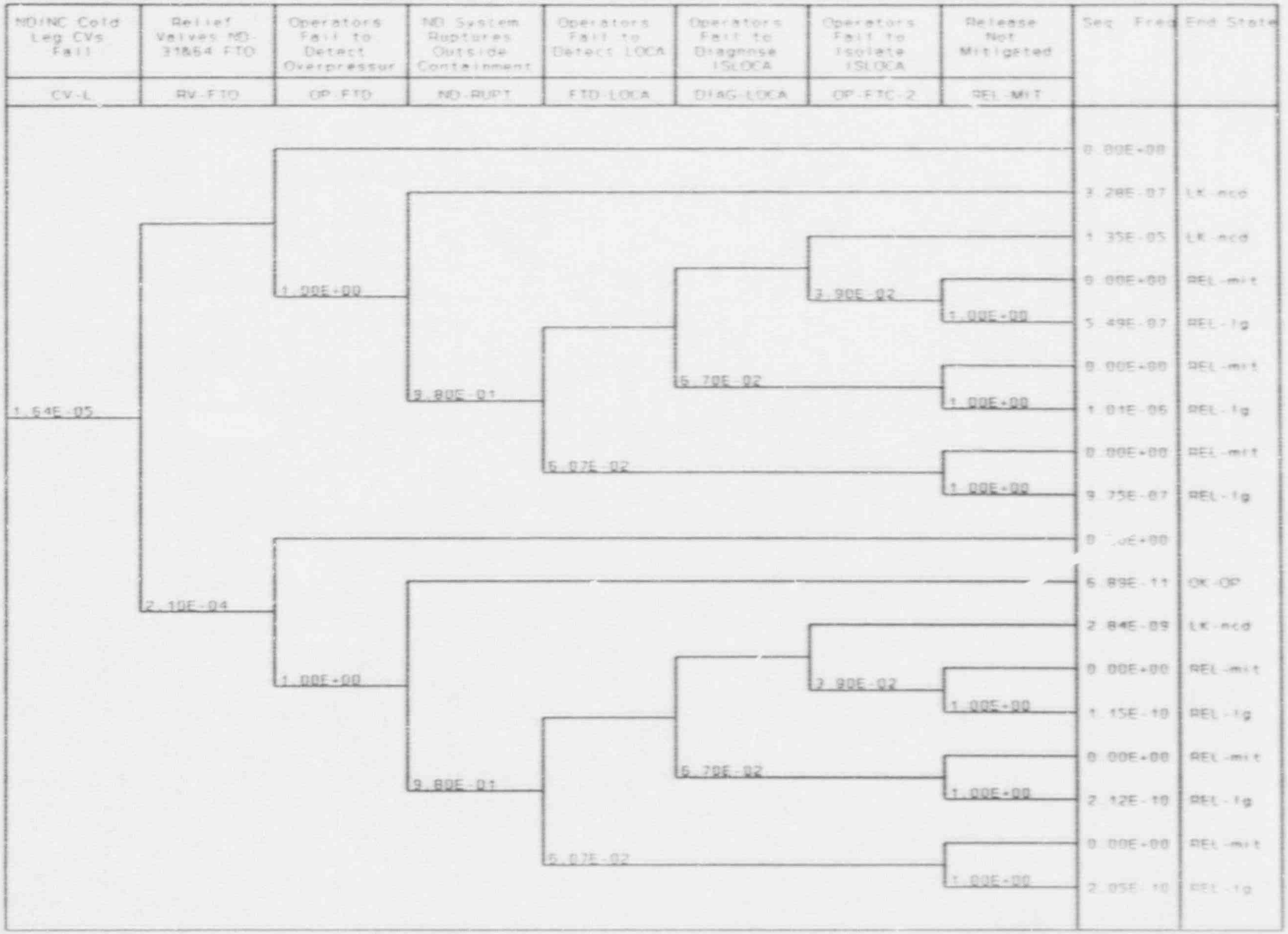
- Scenarios examined in screening analysis
  - Overpressurization of ND system during startup
  - Pre[illegible] entry into shutdown cooling
  - Failure of check valves at RCS pressure isolation boundaries


LOOP B HOT LEG
1ND1B
12"
1ND2A
4"
1ND3
450 psig
6"
PRT
12"
14"
14"
14"
RESIDUAL HEAT
REMOVAL PUMP
1A
8"
1ND10
1ND67
LO
1ND19
LO
8"
14"
RESIDUAL HEAT
REMOVAL HEAT
EXCHANGER 1A
14"
8"
FO
1ND26
8"
8"
1N1173A
LOOPS C & D
COLD LEGS
4"
1ND31
600 psig
6"
RECYCLE
HOLDUP TANK
1ND32A
8"
1ND35
600 psig
2"
RECYCLE
HOLDUP TANK
1"
12"
12"
1NI183B
LOOPS B & C
HOT LEGS
8"
1ND65B
8"
LOOP C
HOT LEG
1ND35B
12"
1ND37A
4"
1ND36
450 psig
6"
PRT
12"
14"
14"
14"
RESIDUAL HEAT
REMOVAL PUMP
1B
8"
1ND44
1ND68
LO
1ND18
LO
8"
14"
RESIDUAL HEAT
REMOVAL HEAT
EXCHANGER 1B
14"
8"
FO
1ND60
8"
8"
1NI178B
LOOPS A & B
COLD LEGS
4"
1ND64
600 psig
6"
RECYCLE
HOLDUP TANK


COLD LEG "A"
1NI80
3/4"
1NI59
1NI58
3/4"
10"
1NI57
6"
1NI54A
1NIFE 5840
1NI56
1"
1NI55
ACCUMULATOR TANK 1A
COLD LEG "B"
1NI71
1NI70
1"
1"
1NI65B
1NIFE 5850
10"
1NI67
1"
1NI66
ACCUMULATOR TANK 1B
COLD LEG "C"
1NI82
1NI81
1"
1NI76A
1NIFE 5860
10"
ACCUMULATOR TANK 1C
TEST LINE HEADER
1NI153A
3/4"
1"
1NI78
1"
1NI77
COLD LEG "D"
1NI94
1NI93
1"
1NI88B
1NIFE 5870
10"
ACCUMULATOR TANK 1D
1NI90
1"
1NI89
3/4"
LOOP D COLD LEG
LOOP C COLD LEG
LOOP B COLD LEG
LOOP A COLD LEG
1-1/2"
1-1/2"
1-1/2"
1-1/2"
1NI21
1NI19
1NI17
1NI15
1NI354
1NI353
1NI352
1NI351
1NI20
1NI18
1NI16
1NI14
1NIFE 5030
1NIFE 5020
1NIFE 5010
1NIFE 5000
1-1/2
1-1/2
3"
3"
3"
3/4"
1NI13
1NI12
3/4"
1NI11
3"
1NI10B
1NI9A
N. O.
CENTRIFUGAL CHARGING PUMP
CENTRIFUGAL CHARGING PUMP


NO PUMP
1A DISCHARGE
NO PUMP
1B DISCHARGE
SAFETY
INJECTION PUMP
1A
SAFETY
INJECTION PUMP
1B
1NI 117
LO
1NI 116
1NI 149
LO
1NI 148
1NI 103A
1NI 101
1NI 100B
RWST
1NI 135B
1NI 118A
1NI 152A
1NI 150B
1NI 121A
1NI 152B
1NI 128
1NI 127
1NI 123
1NI 124
1NI 125
1NI 126
1NI 134
1NI 183B
RESIDUAL
HEAT
REMOVAL
HOT
LEG "B"
HOT
LEG "C"
HOT
LEG "A"
HOT
LEG "D"
1NI 157
1NI 156
1NI 155
1NI 160
1NI 159
1NI 158
1NI 168
1NI 170
1NI 164
1NI 166
1NI 173
1NI 171
1NI 165
1NI 167
1NI 176
1NI 175
1NI 181
1NI 180
1NI 94
1NI 173A
1NI 82
1NI 60
1NI 178B
1NI 71
COLD
LEG "D"
RESIDUAL
HEAT
REMOVAL
COLD
LEG "C"
COLD
LEG "A"
RESIDUAL
HEAT
REMOVAL
COLD
LEG "B"
1-1/2"
2"
3"
4"
6"
8"
10"


NI-176
NI-175
NI-181
NI-180
NI-94
NI-82
NI-60
NI-71
Cold Leg D
RHR Train A
Cold Leg C
Cold Leg A
RHR Train B
Cold Leg B


ND/NC Cold Leg CVs Fail
Relief Valves ND-31&64 FTO
Operators Fail to Detect Overpressur
ND System Ruptures Outside Containment
Operators Fail to Detect LOCA
Operators Fail to Diagnose ISLOCA
Operators Fail to Isolate ISLOCA
Release Not Mitigated
Seq Freq
End State
CV-L
RV-FTO
OP-FTD
ND-RUPT
FTD-LOCA
DIAG-LOCA
OP-FTC-2
REL-MIT
1.64E-05
2.10E-04
1.00E+00
9.80E-01
6.07E-02
5.70E-02
3.90E-02
1.00E+00
1.00E+00
1.00E+00
1.00E+00
9.80E-01
6.07E-02
5.70E-02
3.90E-02
1.00E+00
1.00E+00
1.00E+00
0.00E+00
3.28E-07 LK-ncd
1.35E-05 LK-ncd
0.00E+00 REL-mit
5.49E-07 REL-lg
0.00E+00 REL-mit
1.01E-06 REL-lg
0.00E+00 REL-mit
9.75E-07 REL-lg
0.[illegible]E+00
6.89E-11 OK-OP
2.84E-09 LK-ncd
0.00E+00 REL-mit
1.15E-10 REL-lg
0.00E+00 REL-mit
2.12E-10 REL-lg
0.00E+00 REL-mit
2.05E-10 REL-lg

CORE DAMAGE FREQUENCY RESULTS

- One dominant contributor to CDF
  - Mean CDF of 2.5×10^{-6}/y
- All other sequences $< 10^{-8}$/y
- No credible human errors identified that could initiate an ISLOCA
- Flange gaskets and seals not likely to fail
- Large break most likely at ND heat exchanger tube-side cylinder
- 90% CDF confidence interval of 6.1×10^{-10} to 7.9×10^{-6}

CONSEQUENCE ANALYSIS

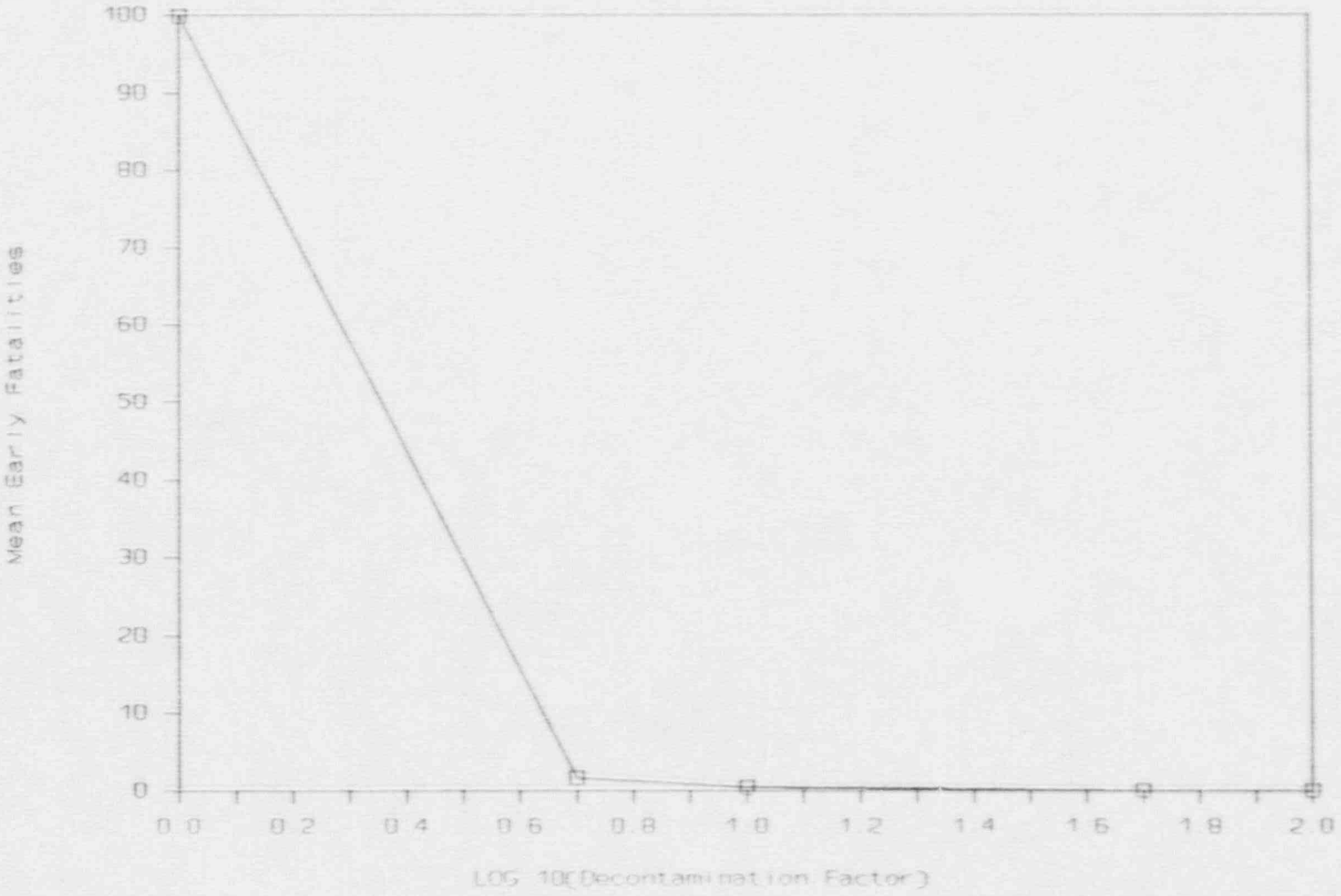
- SEQSOR/PARTITION USED TO GENERATE SOURCE TERMS (AS IN NUREG-1150)
- MACCS 1.5.11 USED TO CALCULATE OFFSITE CONSEQUENCES BASED ON SURRY SITE
- AUX. BLDG. DF OF 1.0 IN BASE CASE
- RESULTS - CONDITIONAL ON CORE DAMAGE
  - 100 EARLY DEATHS
  - 5360 LATENT DEATHS
  - 50-MILE DOSE OF 6.1 X 10^6 PERSON-REM

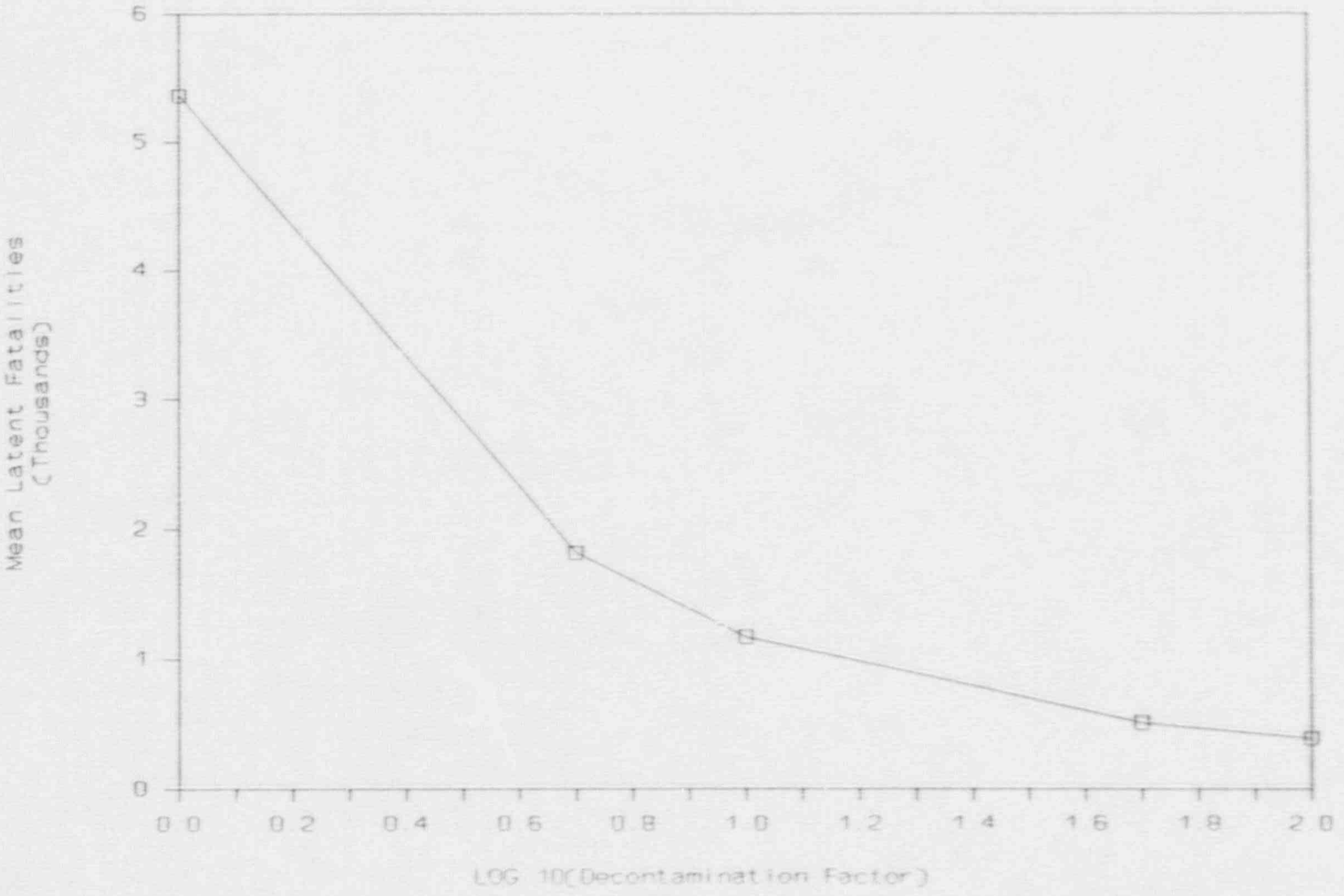
OFFSITE RISK

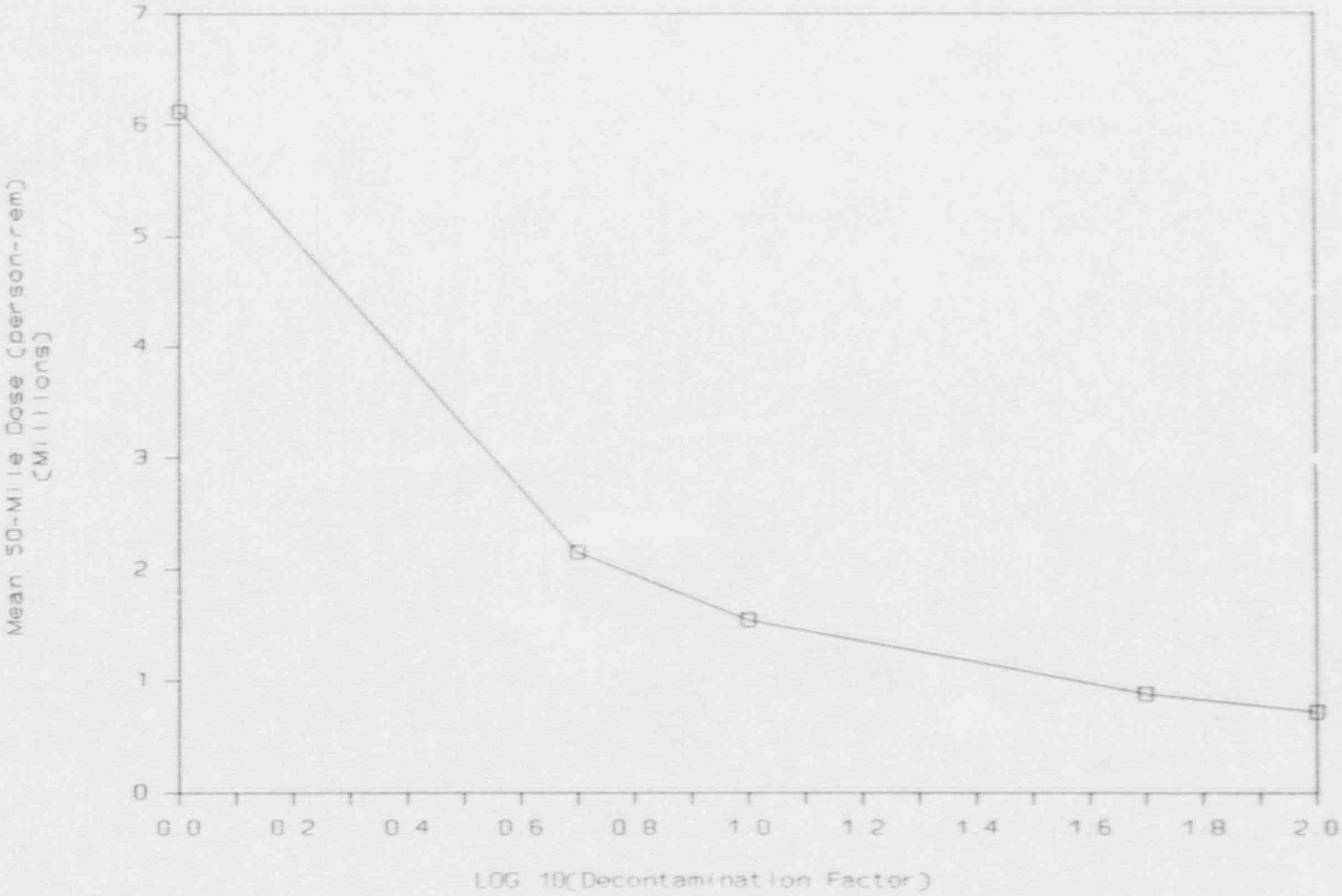
- RISK = CDF X CONSEQUENCES
- RESULTS - PER REACTOR-YEAR
  - 2.5×10^{-4} EARLY DEATHS
  - 1.3×10^{-7} LATENT DEATHS
  - 50-MILE DOSE OF 15.3 PERSON-REM

SENSITIVITY STUDIES

- o AUX. BLDG. DF
  - RANGE OF CREDIBLE DFS SELECTED (1-100)
  - SEQSOR MODIFIED AND NEW SOURCE TERMS GENERATED
  - NEW CONSEQUENCES CALCULATED WITH MACCS
  - RESULTS
    1) REVAPORIZATION IMPORTANT FOR LATENT RISK MEASURES
    2) INCREASE IN DF (>5) HAS LARGEST EFFECT ON EARLY FATALITIES, SMALL EFFECT ON OTHER RISK MEASURES


Mean Early Fatalities
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
LOG 10(Decontamination Factor)


Mean Latent Fatalities
(Thousands)
6
5
4
3
2
1
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
LOG 10(Decontamination Factor)


7
6
5
4
3
2
1
0
Mean 50-Mile Dose (person-rem)
(Millions)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
LOG 10(Decontamination Factor)

UNCERTAINTY IN COMPONENT FAILURE PROBABILITY

- Base case assumed 10^{-3} probability of failure at yield
- Sensitivities assumed 10^{-4} and 10^{-5} probability of failure at yield
- Results in no variance in CDF
- Failure of ND heat exchanger tube-side cylinder dominates

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OBSERVATIONS

W. J. GALYEAN

DECEMBER 12, 1990

EG&G Idaho, Inc.

ISLOCA PRECURSORS INITIATED BY MULTIPLE HUMAN ERRORS OR COMBINATIONS OF HUMAN ERRORS AND HARDWARE FAULTS

HISTORICAL EXPERIENCE INDICATES:

- IMPROPER VALVE LINEUP AND OPERATOR ERRORS IN MISPOSITIONING VALVES - RELATIVELY LIKELY.
  - EVENTS TYPICALLY OCCUR DURING PLANT STARTUP AND SHUTDOWN OPERATIONS.
- RANDOM-CATASTROPHIC FAILURES OF REDUNDANT VALVES IN STANDBY - NOT SUPPORTED.
  - LEAK TESTING DURING STARTUP ENSURES POSITIVE ISOLATION BETWEEN RCS AND LOWER PRESSURE RATED SYSTEMS.
  - LEAKS DO OCCUR, BUT GROW SLOWLY AND ARE DETECTED WHILE VERY SMALL.

B&W PLANT OBSEVATIONS FOR ISLOCA OUTSIDE CONTAINMENT

- CDF AND RISK DOMINATED BY HUMAN ERROR INITIATED SEQUENCE
  - HUMAN ERRORS DURING SHUTDOWN AND ROUTINE TESTING
  - HARDWARE FAILURE INITIATED SEQUENCES IMPORTANT BUT NOT DOMINANT
- LACK OF PROCEDURES AND TRAINING CONTRIBUTES TO ISLOCA RISK
  - GENERAL LACK OF AWARENESS CONTRIBUTES TO OCCURRENCE OF ISLOCA PRECURSORS AND INITIATORS
  - HARDWARE WOULD LIKELY BE AVAILABLE FOR ISOLATING AND RECOVERING FROM A RUPTURE

B&W PLANT OBSERVATIONS (CONTINUED)

- O CHANGES TO PROCEDURES, TRAINING AND INSTRUMENTATION MAY REDUCE ISLOCA PLANT RISK.

- O DAMAGE BY FLOODING OR SPRAYING OF ADJACENT EQUIPMENT IS NOT RISK SIGNIFICANT OWING TO ADEQUATE EQUIPMENT SEPARATION AND REDUNDANT SYSTEMS.

- O HEAT EXCHANGERS AND LARGE-DIAMETER, LOW-PRESSURE PIPING (ON PUMP SUCTION SIDE) MOST LIKELY TO RUPTURE IN A ISLOCA SEQUENCE.

PRELIMINARY WESTINGHOUSE PLANT OBSEVATIONS

- ADMINISTRATIVE CONTROLS, OPERATOR TRAINING AND FUNCTIONING INTERLOCKS GREATLY REDUCE THE PROBABILITY OF HUMAN ERRORS INITIATING ISLOCA SEQUENCES.

- DOMINANT CONTRIBUTORS TO CDF AND RISK ARE HARDWARE FAILURES OF PIV CHECK VALVES.

- FOR SOME ISLOCA SEQUENCES, RELATIVELY LITTLE TIME AVAILABLE INCREASES THE "FAIL-TO-RECOVER" PROBABILITIES.

PRELIMINARY WESTINGHOUSE PLANT CONCLUSIONS (CONTINUED)

RELATIVELY HIGH HEP'S FOR DETECTION, DIAGNOSIS AND ISOLATION A RESULT OF THE FOLLOWING:

- O LIMITED NUMBER OF CONTROL ROOM INDICATIONS AVAILABLE FOR ISLOCA SEQUENCES
    - ISLOCA INDICATION RELIES MAINLY ON SINGLE ALARM (RADIATION)
- O PROCEDURES RUN OPERATORS THROUGH POSSIBLE INSIDE-CONTAINMENT LOCA'S BEFORE CONSIDERING POSSIBILITY OF ISLOCA
    - ALARM NOT REFERENCED UNTIL LAST PAGE OF PROCEDURE
- O OPERATOR WORKLOAD VERY HIGH AND THREAT STRESS PRESENT (PROCEDURES CALL FOR SITE EVACUATION)

GENERIC OBSERVATIONS

- ALTHOUGH "PRECURSOR" FREQUENCIES ARE RELATIVELY HIGH, THE PROBABILITY OF RECOVERING BEFORE CORE DAMAGE BEGINS IS ALSO VERY HIGH.

FOR SPECIFIC PLANTS:

- ISLOCA ANALYSES TYPICALLY FOUND IN PRAs MAY BE INCOMPLETE DESCRIPTIONS OF ISLOCA RISK COMPOSITION.
- HUMAN FACTORS ISSUES (PSFs, ERRORS OF COMMISSION, INSTRUMENTATION, ETC.) HAVE POTENTIALLY DOMINANT INFLUENCES ON ISLOCA RISK.
  - SOME PLANTS ARE LESS LIKELY TO INITIATE AN ISLOCA
  - SOME PLANTS ARE MORE LIKELY TO RECOVER FROM AN ISLOCA

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AUTH.NAME	AUTHOR AFFILIATION
WILKINSON,I.E.	Limitorque Corp.
RECIP.NAME	RECIPIENT AFFILIATION
	Office of Nuclear Reactor Regulation, Director (Post 870411

SUBJECT: Part 21 rept re potential for failure of SMB 00 torque switch roll pins depending on operating conditions.Utils requested to perform review of std operating conditions of installed actuators w/heavy spring packs.

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