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NUCLEAR REGULATORY COMMISSION

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BRIEFING ON SEVERE ACCIDENT MASTER INTEGRATION PLAN

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PUBLIC MEETING

Nuclear Regulatory Commission
One White Flint North
Rockville, Maryland

Friday, May 10, 1996

The Commission met in open session, pursuant to notice, at 10:04 a.m., Shirley A. Jackson, Chairman, presiding.

COMMISSIONERS PRESENT:

SHIRLEY A. JACKSON, Chairman of the Commission
KENNETH C. ROGERS, Commissioner
GRETA J. DICUS, Commissioner

STAFF PRESENT:

JOHN C. HOYLE, Secretary of the Commission

KAREN D. CYR, General Counsel

PRESENTERS:

JAMES TAYLOR, EDO

ASHOK THADANI, Associate Director for Inspection and Technical Assessment, NRR

THEMIS SPEIS, Deputy Director, Office of Nuclear Regulatory Research

CHARLES ADER, Chief, Accident Evaluation Branch, RES

MARK CUNNINGHAM, Chief, Probabilistic Risk Analysis Branch, RES

PROCEEDINGS

CHAIRMAN JACKSON: Good morning, everyone. I am pleased to welcome members of the staff to brief the Commission on the status of the integration plan for the closure of severe accident issues. The current elements of this integration plan include, first, the IPE program, the IPEEE, the severe accident research program, and the accident management program.

The severe accident research program was initiated in the early 1980s to develop an understanding of severe accident phenomena and to provide a technical basis for regulatory decisions.

A number of key issues associated with our understanding of severe accidents have been resolved over the last several years or are close to resolution, I understand. These issues include the liner melt for BWRs and direct containment heating for PWRs. The research program has emphasized those specific severe accident phenomena that could result in early containment failure and code development, and has benefited from various cooperative agreements on severe accident research with other countries.

Today's briefing will focus on staff accomplishments since the issuance of the last program plan update in January of 1995. The briefing will cover the current status of severe accident issues.

I would also request that the staff emphasize findings that have resulted from the research activities as well as closure plans for the remaining key severe accident issues.

My understanding is that copies of the viewgraphs are available at entrances to the room.

Any opening comments?

[No response.]

CHAIRMAN JACKSON: Please, Mr. Taylor, proceed.

MR. TAYLOR: Good morning. With me at the table are Themis Speis, Mark Cunningham, and Charlie Ader, all from the Office of Research, and Ashok Thadani from NRR.

A portion of our presentation will cover the individual plant examination program and some of the insights will be discussed. We believe those insights will be very important as the staff proceeds on a path of more use of risk in our regulatory and licensing activities.

CHAIRMAN JACKSON: Use of risk insights.

MR. TAYLOR: Insights, right. I was stumbling over that. Risk informed.

CHAIRMAN JACKSON: Not use of risk, but risk insights.

MR. TAYLOR: Right.

Dr. Speis will discuss the individual plant examination program as well as severe accident research. He

will summarize some of the more important ongoing activities in the research area, including mention of the international cooperative activities, which have been very important.

Ashok Thadani will follow with a discussion of the accident management program, which is also an important part of the severe accident integration plan.

Dr. Speis.

MR. SPEIS: Thank you, Mr. Taylor.

Chairman Jackson, Commissioners, the first viewgraph shows the outline of today's presentation.

[Slide.]

MR. SPEIS: I will summarize the status of the IPE program. I will briefly touch on the goals as set forth in Generic Letter 88-20 and whether the program goals have been achieved.

Then I will summarize the IPE program elements, the reviews, what we are doing with the database, the regional coordination, which we think is very important, because we want to share with the regions the insights gained from the programs, especially the plant-specific insights with the inspectors themselves, and then say something about the insights program.

Then, of course, I will discuss the individual plan examination for external events.

Then I will get to the severe accident research,

summarize the phenomena issues which the research program has been addressing in the last few years, including the state of these activities, and more important, the direction that the program is taking or should be taking in the next few years. Then I want to say more about the cooperative severe accident research program, because, as Mr. Taylor said, we think it's very important.

Then Mr. Thadani will discuss the severe accident management.

The next viewgraph goes into the IPE and IPEEE goals and accomplishments.

[Slide.]

MR. SPEIS: The IPE is a very important and key element of the Commission's program for the closure of severe accident issues for existing plants. The licensees were to conduct a systematic examination of the plant design, operation, maintenance and emergency operations.

The important thing was that the Commission wanted the utilities to develop an appreciation of severe accident behavior. You will recall that this program was started after TMI, and after the Chernobyl accident there was intense anxiety about severe accidents. We wanted to make sure that the plants themselves understood the issues relating to severe accidents.

They took the initiative to see how their plant

behaved, how it responded to severe accidents, and how they could use those insights in accident management procedures and other things that could reduce their occurrence or mitigate their consequences.

Other things that I have listed here. To understand the most likely severe accident sequences that could occur at their plants and gain a more quantitative understanding of the probability of core damage and fission product releases.

All this was to provide the technical basis for reducing the core damage and fission product release probabilities, and if necessary, then modify their plant either by hardware of by procedural efforts.

[Slide.]

MR. SPEIS: On the next viewgraph I briefly summarize the accomplishments.

All utilities have performed Level 1 and Level 2 PRAs.

CHAIRMAN JACKSON: I know, but could you define for the audience and the Commission what Level 1 and Level 2 PRA means?

MR. SPEIS: Level 1 PRA addresses the probability of getting into a core damage situation, what are the sequences, whether it's a small break LOCA or a station blackout that would lead into a core damage situation.

Level 2 takes those sequences and analyzes them in terms of their evolution into a severe accident regime and what are the subsequent loads that could ensue from that evolution and how those loads could challenge the containment.

Level 3 is, given a radioactive source term in the containment and consequential failure of the containment, what is the radioactivity that gets into the environment and what are the consequences from that radioactivity.

Getting back into the accomplishments, all utilities have performed Level 1 and Level 2 PRAs. More important, the plant staff participated in the performance of that PRA, some of them to a larger extent than others, of course.

Thus most of them have developed in-house staff PRA capabilities. Generally, most of them have indicated their intention of maintaining and updating the PRA, bringing it up to date once they make changes in the plant, and folding them into the PRA.

Based on our reviews of the PRAs, all IPEs have identified improvements as a result of the IPE or PRA. I use those words interchangeably. IPE, of course, which stands for individual plant examination, uses the PRA as the vehicle to do the examination.

Some of the improvements have been implemented

even while doing the IPE itself, and they took credit for those improvements while they were performing the IPE. So the final results in some cases show the improvements that were evaluated and implemented. Most improvements, or a number of them, have not been implemented yet and the utilities are still evaluating them.

COMMISSIONER ROGERS: When this program was first started, if I recall, we did not require that a licensee perform a PRA. We required that they do an IPE, an individual plant examination. There was considerable discussion at that time as to whether using a probabilistic risk approach was a valuable thing to do and whether it was worthwhile, and so on. We didn't make it a requirement, but we certainly had hoped that most plants would do that. It's my understanding now that everybody has concluded that that is a good thing to do, or a good way to satisfy our requirement, at any rate.

Is there anything that comes out of that decision to go from some other method of conducting an individual plant examination to the use of risk analysis? Is there anything that came out of that consideration that is valuable for the future in some way?

CHAIRMAN JACKSON: That's what you are going to talk about, isn't it?

MR. SPEIS: Yes. Let me address the question

specifically. We asked them to do an examination using a methodology which the industry had developed. Basically it was a truncated PRA. When we reviewed the methodology, we came to the conclusion that it needed enhancements in order to do what we wanted them to do. Once you start adding the enhancements you find yourself in PRA space. So more or less they decided to do a PRA.

CHAIRMAN JACKSON: Let me ask you this question since you made this point about a generally indicated intention of maintaining and updating an IPE and the PRA. Obviously there are no specific requirements in that regard. Nonetheless, I am aware of the fact that there are regulatory requests that are made of the NRC, sometimes using the IPE/PRA results as a basis. At the same time, as I have visited plants sometimes I have reviewed the PRAs and the IPE, and they have dates on them, some of which date back five and six years. Nonetheless, there are plant changes every year, some significant, some less significant.

What is the position relative to the need to in fact for certain kinds of regulatory requests have a fully updated IPE that reflects the latest changes or at least those that would be relevant to the particular request?

MR. THADANI: This issue is explicitly addressed under the PRA implementation plan. The industry in fact has developed what I would call a draft procedures guide for

application of these techniques to some decisions. The industry document itself encourages maintaining the IPEs to reflect the current plan conditions.

Our view is, and this is what we are picking up as part of any application, if IPE is used for a specific application, the licensee then has the responsibility to make sure with time the assumptions that are part of that application are in fact maintained throughout the life of the plant.

That basically forces the utilities to update them as modifications are made to make sure that the previous decisions are still valid.

CHAIRMAN JACKSON: Do we know if that is done on a consistent basis?

MR. THADANI: At this stage we don't know. Quite frankly, we haven't gone far enough in terms of applications to be able to say where the industry is, but there is very clear recognition on the part of the industry that in order to take advantage of these techniques and decision-making there are some responsibilities that go along with that, which is maintaining them to reflect the plant as is.

CHAIRMAN JACKSON: Are you saying that as of today you have it in the PRA implementation plan?

MR. THADANI: Yes.

CHAIRMAN JACKSON: Would you further say that as

of today we make no use of them in terms of their being updated for any regulatory decisions?

MR. THADANI: I guess I would say that the industry has made some uses of the IPEs and in fact in many cases they have come in and they have said that they intend to maintain the probabilistic safety assessments. I will give you an example.

Recently we worked on some of the South Texas tech spec issues. There was a clear statement on the part of the licensee that they were planning to maintain the IPE for that application. By and large their commitment is to maintain the IPE.

CHAIRMAN JACKSON: You keep talking to me about their commitment. I'm talking to you about what we do, what use we make of whether the IPEs or the PRAs are updated or not in our own regulatory decision-making.

MR. THADANI: Where we apply the IPEs in coming to a decision we make the point explicitly that they have to maintain that.

CHAIRMAN JACKSON: Let me make sure I understand you. That is to say, then, you do not make use of a non-updated IPE in making a regulatory decision.

MR. THADANI: I believe that's correct. I think that's pretty accurate.

CHAIRMAN JACKSON: Thank you.

MR. SPEIS: I don't want to exacerbate this, but I would like to add that for some decisions you don't need to update it. The IPE is good enough.

CHAIRMAN JACKSON: All of this is relative to where it needs to be updated. That's the way I posed the question.

MR. SPEIS: The next viewgraph shows four boxes.

[Slide.]

MR. SPEIS: It shows the IPE review program and its relationship to the database program, the regional coordination, and the insights program. Let's go to page 7 so I can start talking about each one of them separately.

[Slide.]

MR. SPEIS: The reviews themselves. Our review looks at the IPEs for completeness and the results of the studies themselves for reasonableness. The focus has been on whether the licensees have met the intent of Generic Letter 88-20.

Additional review is required if the IPE is to be used for other purposes which the IPE itself does not meet.

CHAIRMAN JACKSON: Do you do a detailed look at things like assumptions, methodology, uncertainty and how it's treated?

MR. SPEIS: We look at those things in general and those things will be put into the insights report. When the

industry comes forward and they want to address a specific issue, we will probably have to go back and look at that issue, because maybe when we looked at it more generically we weren't focusing on that specific issue. So when a specific issue comes in front of us, whether it is tech specs or some other regulatory issue that we have to use the IPE to evaluate, we will have to go back and see whether there is a need to scrutinize that IPE further, or as a result of the scrutiny, whether we want them to upgrade it or to add more.

CHAIRMAN JACKSON: At this point, this is kind of a high level review?

MR. SPEIS: Yes.

CHAIRMAN JACKSON: And it doesn't really get into these?

MR. SPEIS: Yes.

MR. TAYLOR: That's right. The decision was made sometime ago that because of the sheer volume an in-depth total review by staff of each IPE was a task that we weren't prepared for, nor have we said that we have done it. But we didn't just put them on the shelf. There were reviews.

CHAIRMAN JACKSON: I appreciate that. I think what we are trying to get at is delineating how the thing got started and what seemed to be reasonable at that time relative to how we are migrating forward and to what use

they may be put. That is all I am trying to clarify. It is not a criticism of anything that has been done to this point. I am just trying to clarify where things are.

MR. THADANI: At an earlier Commission briefing we talked about the mid-1980s thinking and then more recent thinking about making better use of risk-informed decisions. In the mid-1980s our biggest focus was to make sure that the licensees themselves participated in the process of going through and developing these studies, because there is a great deal of learning one can get through just participating.

The focus by and large was for the industry to learn and use these concepts and for the NRC it was to see if there was a big problem out there on a specific plant, sort of a peak that we had better look at. That was the thinking then. Now we are talking about regulatory decisions. For that reason the reviews have to be much more in depth. Instead of reviewing all these studies in depth, which, as Mr. Taylor said, would be very difficult to do, what we are going to do is decide on the basis of application.

CHAIRMAN JACKSON: You are going to make it regulatory application-specific.

MR. THADANI: Yes. It's driven by that.

MR. SPEIS: Ashok, it might be worthwhile to show

the backup viewgraph number one to capture graphically what we are talking about.

[Slide.]

MR. THADANI: This viewgraph we used at a previous Commission brief. In fact, I think it was last year's. I would say the top part where it is called "IPE Program" the mid-1980s thinking is reflected there. Generic Letter 88-20, as Dr. Speis noted, had very specific and narrow goals. With those goals in mind, our role with that had to be limited.

We looked at these studies by and large to see if they followed a reasonable process. That was an important issue, to make sure they were actually involved in these studies. So there was some attention given to process and I would say somewhat of a reasonable look at the reasonableness of the analysis, the assumptions, and so on. That is why we call it a limited scope of the staff review.

In the mid-1980s the Commission issued a policy statement. In that policy statement the Commission concluded that the operating reactors are safe. However, we recognized there may be some plant to plant variations and maybe some significant vulnerability out there. That was the motivation for issuing Generic Letter 88-20.

We did want to see in our reviews if there was a significant safety matter that we had to act on promptly.

There were cases where significant safety issues were identified, but fortunately, as Dr. Speis said, they were identified by the licensees. In fact, they were corrected before the submittals were given to us. They did identify the modifications that they had to make, of course.

The important part of that review process that I think will help us down the road in a very significant way is the insights report, trying to normalize these studies, trying to see if there are differences in assumptions, and so on. Failure of pump seal is an example of where I think there have been different assumptions made by different licensees. But issues like that will likely come out of the insights programs and will help us as we go forward in these more detailed evaluations. Of course the lower part we discussed recently is where we are going now and what the process is.

CHAIRMAN JACKSON: Thank you.

MR. SPEIS: Can we go back to slide 7, please?

[Slide.]

CHAIRMAN JACKSON: This is a good viewgraph, by the way.

MR. THADANI: NRR made it.

MR. SPEIS: No, it was Research and NRR.

[Laughter.]

MR. TAYLOR: And we seldom do it this way.

MR. SPEIS: We have completed the preliminary view of all 75 IPE submittals and we have issued 52 staff evaluation reports and the remaining are to be issued in September 1996.

Following completion of our reviews we issue an evaluation report to each licensee. The bottom line is whether they meet the intent of Generic Letter 88-20.

Item number three here says that we could not conclude that the licensee met the intent of the generic letter on 11 IPEs. Our interactions with those licensees has indicated that those licensees are addressing the staff concerns, and we expect the issuance of the final SERs by December of 1996.

COMMISSIONER ROGERS: Could you characterize the shortfall? Are they different for these 11, or is there something in common with them that led to our conclusion that they failed to meet the intent?

MR. SPEIS: The primary reason for the deficiencies is the way they analyzed human actions. I would like to have Mary Drouin, who is the section leader of the IPE organization, go into some more details.

MS. DROUIN: On these 11 plants, when we looked at the results, the results weren't appearing reasonable such that we weren't able to have a lot of confidence that the dominant accident sequences were the actual sequences for

these plants. There were various reasons among these 11 IPEs, but there was one primary one that seemed to be common among them, and that was their treatment of human reliability analysis.

We saw some inappropriate applications of the methods, inappropriate assumptions that were being made. Some examples of this is that when you looked at the results, you would see very complex human actions where the human error probabilities were very low. So you saw complex human actions with operators having human reliability, whereas you would see these very simple, routine actions and you would see very high unreliability. Intuitively that didn't make sense.

When we looked into further detail, what we were seeing was inappropriate treatment of cognitive actions, not taking into consideration diagnosis and detection, inappropriate treatment of time, not looking at dependencies not taking plant-specific performance-shaping factors into account, not putting the accident sequences into the proper context. These were some of the things.

We have had discussions with each of these licensees. In all cases they are addressing our concerns. In some cases they are completely redoing the IPE and in some cases just having to redo part of the IPE.

As Dr. Speis said, we expect to be completed in

December 1996.

MR. SPEIS: Also, as part of the IPE reviews we focus on certain generic issues which we ask the licensees to look at. An important one has been the issue addressing the reliability of decay heat removal. We explicitly address that issue in the SERs that we write.

[Slide.]

MR. SPEIS: Page 8 tells something about the IPE database. We think that it is very important that useful IPE information should be collected and stored for use, and we are doing that.

The type of information that we store involves plant design, dependencies, success criteria, core damage frequency, and containment performance as examples.

We have used the system in such a way that you don't need software to read the information. Also, the information is cross-linked so we can ask for information on different plants with the same loops or different loops. It's user friendly and we think it is going to be an important database for future use.

We are preparing a workshop to brief our people internally. Also, this coming summer we will be having a workshop with the public and industry.

CHAIRMAN JACKSON: As part of the tracking in this database do you track all regulatory uses of IPE results, or

is that being tracked anywhere?

MR. THADANI: That is not part of this database. We would have to do that at NRR, track those decisions.

CHAIRMAN JACKSON: Are you currently doing that?

MR. THADANI: Currently we are not doing it.

COMMISSIONER ROGERS: It could be very valuable.

MR. THADANI: I think it would be very valuable, yes.

MR. TAYLOR: I think we should take a look at that. It's a good question, because we are really in that beginning time of doing it. I think we should do it.

CHAIRMAN JACKSON: That would be good. Then one database could query the other database.

MR. THADANI: It would be interesting to see if there is a feedback effect even on the initial insights as you go around.

MR. TAYLOR: We want to be careful how we use it.

MR. THADANI: The process will be the one described in the Commission's policy statement.

CHAIRMAN JACKSON: It seems to me that this would have to be a core tool.

MR. THADANI: Yes.

CHAIRMAN JACKSON: For example, a question would be, have licensees used their IPEs to determine for purposes of the maintenance rule the risk-significant system,

structures and components in their plants?

MR. THADANI: Yes.

MR. TAYLOR: Yes, and outage times and that sort of thing.

CHAIRMAN JACKSON: Those are two pieces that could be tracked.

MR. THADANI: That's right. As part of the maintenance inspections we would look at how they went about splitting high safety significant and low safety significant structures, systems and components too.

COMMISSIONER ROGERS: Could you say something about when and where the workshops will be held?

MR. CUNNINGHAM: The workshops for the staff are in the next couple of months here inside the buildings. The public workshop is later on in the summer. I don't think we have set a place for that as yet. But it is all going to happen in the next three or four months.

CHAIRMAN JACKSON: You mentioned that depending upon the regulatory use, and you indicated this is tracking forward into the future, that more in-depth reviews might be required, depending upon that. Will those be reviewed by Research and the same group in Research? Have you figured out how you are going to do that?

MR. THADANI: By and large, those reviews are conducted in NRR. I would expect that if the industry goes

in sort of a big way to apply these techniques, we will have to stay back and see how best to review, because the scope may be pretty significant then. We will have to reassess.

CHAIRMAN JACKSON: So the answer is that it is being or will be done within NRR?

MR. THADANI: Yes.

CHAIRMAN JACKSON: How does that link back to the reviews that Research has done?

MR. THADANI: In some cases even now we ask for support from NRR, but once the IPE review work is complete, then we will have to stay back and decide.

CHAIRMAN JACKSON: I guess what I am really asking is, do you kind of a do a de novo review or do you draw on what Research has done?

MR. THADANI: We draw on what Research has done. In fact, we also look at the reports that are put together by Research. In some cases we have some NRR staff also participating with Research in the review process.

CHAIRMAN JACKSON: Okay.

[Slide.]

MR. SPEIS: The next viewgraph shows our interactions with the regions. Here the objective is to make effective use of the IPE insights to ensure that plant-specific insights from IPEs are considered in NRC activities at plant sights. We had staff teams from both

NRR and Research visit each region to present the plant-specific insights to the regional people, especially to the inspectors themselves. So in essence, we are trying to familiarize the regional personnel.

Phase I of the effort. We had the lead with NRR participation of the presentation and discussion of the IPE results and our insights in each region. This will be followed up by NRR to deal with site-specific activities.

We have visited each regional office and completed discussions on 20 different IPEs, and we expect to complete the remaining briefings by December 1996.

[Slide.]

MR. SPEIS: The next one shows the insights program. Basically the IPE insights program involves the documentation of the significant safety insights from our examination of the IPE results.

From this program we should be able to provide information and perspectives to industry, to the staff and all the actors that would make use of the IPE results.

An important question to be addressed is what has been the impact of the IPE program on reactor safety. Mr. Thadani already mentioned that a number of plants have identified vulnerabilities.

By the way, when we talk about vulnerabilities we don't have a very precise and unique definition. We left it

up to the licensees to define what was meant by vulnerabilities. I will give you some examples. Some of them define that as having a core damage frequency of more than 10 to the 4 per reactor year; some of them the sequence leading to core damage was more than 50 percent; and things of that sort.

In essence, what we mean by vulnerabilities is some type of weakness where you are susceptible to damage. An example is one of the plants, Surry, found out that upon failure of the circulating water system they could flood the turbine building, and in one of those rooms they had very important electrical equipment which was necessary to perform safety functions. In that case the licensee itself identified and fixed it.

CHAIRMAN JACKSON: Right. I saw the fix.

MR. SPEIS: There were other examples. Instrument air systems at Kewaunee.

COMMISSIONER DICUS: Was there any kind of common vulnerability?

MR. SPEIS: They were plant specific. In fact, that kind of justified the individual plant examination.

As I said earlier, all plants identified improvements. Those improvements involved primarily changes to operations involving procedural changes. In some cases hardware changes.

Item number 2, reactor and containment design and operation. That will be documented in the insights program. Specific insights by plant class and containment type will be included in the report. Examples are, given core melt and vessel failure, what are the containment failure probabilities?

For example, if two Mark I containments come forward and give us different probabilities, we will have to ask the question why. Or even if they are the same and we happen to know that there are some equipment or some other activities that indicate that they are different, then we will ask the question again why.

So our insights program is focused on why, why is something the same or different. We are trying to get to the root, and these are things that will help us later on in risk-informed regulation.

[Slide.]

MR. SPEIS: On the next page I say more about the IPEs with respect to risk-informed regulation even though we talked about it.

We feel that generally the IPEs or the PRAs are robust with respect to identified dominant accident sequences, whether the dominant one is a small break LOCA or station blackout or something like that.

The general areas of weakness involve the lack of

use of plant-specific failure data. Most of them have used generic data. And analysis of common cause failures and human reliability. These items are more manifested in those 11 plants that Mary discussed already.

CHAIRMAN JACKSON: The lack of the use of plant-specific data, you are saying, is not an across the board concern and the human reliability analysis is something that is strong in the others?

MR. SPEIS: These three things are primarily strong in those 11 plants?

CHAIRMAN JACKSON: I thought the human reliability area was an area that even the experts could not come to closure on.

MR. SPEIS: It's how robust you are, looking at the synergism between human and the design itself. I will give you some examples. There are some plants that involve systems. The switch from injection to circulation. There is a group of Westinghouse plants that gave us different human reliabilities. We think that some of them scrutinized the plant very carefully and they decided where was this place the operator had to go to make the switch? How long did it go? Did they have good procedures?

Some of them didn't do as good a job. So there is a lot of common sense that has to be applied in these kind of human actions and what times you allow for operators to

act, and things like that.

MR. THADANI: Except for the ones where they really misuse human reliability techniques, by and large I think they are all good decisions for screening purposes. I think a good number of them, maybe even most of them, may be good enough for relative ranking. I am hedging on that because I know in some cases they made different success/failure assumptions. So I think there may be something we can still learn that might change the relative importance of certain accident sequences.

I am, of course, speaking from where we have to make regulatory decisions. If it were to come to relying on quantification, then I think our confidence level is not that high. Therefore, we will review it in detail to be more comfortable.

CHAIRMAN JACKSON: Maybe the young lady who spoke earlier can give the Commission some sense of where things stand. You seemed to be speaking quite knowledgeably relative to human reliability earlier. I don't want to put you on the spot, but I am interested in where things stand in terms of that whole subject in this context.

MS. DROUIN: The subject of human reliability?

CHAIRMAN JACKSON: Correct, and how well developed is it.

MS. DROUIN: If you look at the other techniques

that are in a PRA and try to do a relative comparison, I certainly wouldn't say that it is as advanced, for example, as other areas of PRA. We do have within the Office of Research the major programs that are ongoing to advance the state of the art of human reliability. It is an area that needs work. That goes without question.

CHAIRMAN JACKSON: Thank you.

COMMISSIONER ROGERS: Before we leave this list of three, I could understand the human reliability analysis being shaky because of what has been said, and also the lack of use of plant-specific failure data if they haven't really accumulated that database, but I am really kind of troubled about the analysis of common cause failures. It seems to me that is really the one that involves an understanding of the plant. I wonder if you have anything to say about that.

MR. CUNNINGHAM: First of all, the concept of common cause failure is interpreted by different people very broadly or very narrowly. What we were talking about here was really not the common cause failures, like loss of a DC bus and that causes just by definition failure of certain equipment. This is the analysis of the more subtle environmental causes. For example, failure of two pumps because they are in a common environment or because of common maintenance or something like that.

So it's a subset of the broad category of common

cause failures.

CHAIRMAN JACKSON: Has that also been applied in the digital control area?

MR. CUNNINGHAM: It's certainly a big consideration in digital.

CHAIRMAN JACKSON: I mean in terms of applying the PRAs as part of the IPEs of the plants that have done digital control.

MR. CUNNINGHAM: There are not that many in our review process we got into looking at the digital aspects of very much. If I were going to name a second area of concern in PRA where the methods are not very sophisticated, it's common cause failure analysis of these more subtle failure modes. It's not unrelated to the data question in that there are very few data points on how these common cause failures occur. AEOD started a program in the last year or two to try to collect internationally more information on these types of failures. That could be a big jump forward in terms of what we know and what we can understand about this area.

CHAIRMAN JACKSON: Dr. Thadani.

MR. THADANI: By and large, I guess for fairly simple digital systems, if it's a single train with some sort of a programmable logic controller or something, it's fairly straightforward. I think one can show with very

little difficulty that a single train digital system is very much better. It's when you get into multiple trains, and particularly when you get to software issues. There is general agreement among the experts, I would say, that if you are looking for very reliable systems, highly reliable systems such as reactor protection systems, and so on, then there is no agreement among the experts that one can actually quantify unreliability of the software system. So they generally go to other methods to try and make these systems as robust as they can be with different groups going through the same kind of process.

Also, in terms of software, it's really not the same thing to say unreliability. It's not a random process. If there is a problem with their software, it's there every time. It is hard to talk about something like that in probabilistic terms.

Today I don't think there are very good techniques for highly reliable systems to quantify and have confidence in the quantification.

What we are doing, of course, is making sure that if the licensees are installing any digital equipment, certain types of key factors that can lead to multiple failures are considered and testing is done on EMI and other things, smoke, and so on, that can disable such systems.

MR. SPEIS: We are still on page 11. In summary,

we have seen quite a bit of variability in the IPE results. We will scrutinize that to ask the questions why and to summarize some of the differences we think are due to the assumptions.

The core damage definition and success criteria have been utilized differently by different licensees. What I mean by core damage definition is whether core damage begins at 2200 degrees Fahrenheit or something else, or degree of oxidation.

Operator reliability. What values they have assigned to it varies all over the place.

System component operability, as Mr. Cunningham mentioned; the performance of systems and components under a variety of environmental conditions.

The level of detail. How far they have gone into truncating the fault trees.

Last but not least, the database, whether it was generic or plant specific.

COMMISSIONER DICUS: You have indicated with some additional review or effort that there would be a sufficient quality to use this in a different way. Can you elaborate a little bit on how much additional staff or licensee effort you are looking for?

MR. SPEIS: This goes back into the viewgraph that I provided. That would depend on the issue itself. Ashok

mentioned that for South Texas we had to review in detail the use of the PRA for tech spec purposes. In that case we did a very intensive review. I don't know how long it took.

MR. CUNNINGHAM: The original South Texas was probably a year or so of just the review part of it.

MR. THADANI: Or maybe even longer.

I think we have to be careful in this area, because we were going into somewhat of a new territory. As you know, PRAs are basically static; they don't reflect the dynamic nature of day-to-day activities, and so on. Today the industry is going into rolling maintenance. That is sometimes different than what might have been in the IPE or PRA.

We were trying to make sure in those applications that those elements are addressed. Because it was the first time, it did take a very long time, very extensive effort. I am hopeful that in the future it will take less of an effort.

CHAIRMAN JACKSON: Aren't there going to be these industry pilots?

MR. THADANI: Yes.

CHAIRMAN JACKSON: Might that not be a methodology for beginning to quantify more from our point of view the answer to the Commissioner's question?

MR. THADANI: Absolutely. Those are the three

categories the draft regulatory guides and the standard review plans were designed for. By the end of this year they should be available.

[Slide.]

MR. SPEIS: The next viewgraph shows the IPE insights schedule. We have provided the Commission paper, SECY-96-051, discussing the status of the IPE and the IPEEE programs.

We are putting together a NUREG report which presently is undergoing internal review.

We are having ACRS briefings, discussions with the ACRS in May and June of this year.

Our plan is to have a draft report ready for public comment to be published in October of 1996.

We will have a workshop later on to finalize the report.

[Slide.]

MR. SPEIS: I want to say a few things about the IPEEE program, which is the individual plant examination of external events. This was started back in 1991 with Supplement 4 to the generic letter. It requested all the licensees to perform an IPEEE to identify plant-specific vulnerabilities to severe accidents caused by external events.

So far we have received 46 submittals. We will

receive an additional 17 in 1996, 11 in 1997, and one with a date to be determined. If you add all these, you come up to 75.

Currently we have 24 of them under review.

[Slide.]

MR. SPEIS: The IPEEE review process for the remaining 51 submittals has been revised. Basically, we have used the lessons that we have learned from the IPE program itself, the insights that we have gained from the small number of the IPEEE reviews underway.

Also, we recognize that we have to look more carefully at some issues that were subsumed in the IPEEE reviews that need to be reviewed very carefully.

Taking all these things into account, we will have put together teams of RES and NRR people with help from some contractors to do these type of reviews. First, we will be doing screening reviews to focus on the quality and completeness of the submittals. As I said already, then we will be assessing whether the generic issues that have been subsumed into those IPEEEs have been carefully considered and resolved.

Possibly some additional reviews may be required for some of the IPEEEs which are poorly documented or have technical deficiencies.

[Slide.]

MR. SPEIS: We will also have an IPEEE insights program. Maybe not as extensive as the IPE, but we will see as we go along.

We still want to summarize the significant findings from the IPEEE efforts and identify generic observations, summarize lessons learned about the methods used, and assess the usefulness of the IPEEE analyses for regulatory applications.

COMMISSIONER ROGERS: Do you have any idea what the schedule for completion of that study might be?

MR. SPEIS: Mark.

MR. CUNNINGHAM: I think we are trying to get the reviews done by about the end of 1998. So this would be in the 1998-99 time frame.

CHAIRMAN JACKSON: For both of these?

MR. CUNNINGHAM: For the reviews and the insights.

MR. SPEIS: This completes our summary presentation on the IPE program. Now I would like to go to the severe accident research program.

[Slide.]

MR. SPEIS: Before I get into the viewgraph, I will provide some general comments about severe accidents. When we talk about severe accidents, of course, we are talking about accidents beyond the design basis which involve core melt and potential containment failure. Those

types of accidents were first systematically examined in WASH-1400 using probabilistic risk assessment techniques. Classic examples of clear accidents are the TMI and the Chernobyl accidents.

To the extent possible, the severe accident phenomena are evaluated as realistically as possible. They have been shown to dominate risk.

Although not specifically evaluated during the licensing of existing plants, because at that time they were thought to be incredible, severe accident considerations have been incorporated in many regulatory actions and decisions since the TMI-2 accident, including risk studies of high population density sites, Zion, Indian Point, Limerick.

We promulgated the so-called hydrogen rule to ensure that containments with smaller volume and pressure capability were able to accommodate the consequences of a hydrogen burn, hydrogen being one of the earliest and more important manifestations of a severe accident.

Severe accidents have been considered in the emergency planning rule in the containment performance improvement program, and of course in the individual plant examinations which we just finished talking about.

The program the last few years has been focused on issues which are important and which could lead to early

failure of the containment.

Why are we focusing on early failure of the containment? There are two reasons. One of them, the radioactive source term is the highest at that time. Of course, the other one, even if you have a severe accident and the containment fails later on, there is time to intervene, but if it fails early on, there is no time.

So most of the work the last five years both here and abroad has been focusing on early failures, the phenomena which could lead to containment failure early on. I have listed some of them, direct containment heating being one of the most important ones.

Other issues that we have been addressing is lower head integrity/debris coolability. This is whether, given a degraded core accident, you can retain the degraded core inside the vessel itself.

Fuel-coolant interactions are very important.

The hydrogen combustion I mentioned already.

The source term.

The codes themselves.

The cooperative severe accident research program.

I will spend a few minutes on each one of these very briefly.

CHAIRMAN JACKSON: Do you have a comment?

MR. THADANI: I want to make a note that this

research was in fact what we utilized in the decisions we made on the advanced light water reactor issues, particularly early challenges to containment, and providing the means to be able to deal with those challenges. This was very, very useful for us to be able to make those decisions.

MR. SPEIS: I have tried to capture the overall direction of the severe accident research program on page 18.

[Slide.]

MR. SPEIS: As the Chairman already indicated in her introductory remarks, the research on major issues is complete or nearing completion.

The remaining experimental work is directed at areas of largest uncertainty or some confirmatory work which is important for code assessment. We would like to have a stable of codes that we can use when the need arises.

The remaining major experimental programs are cooperative efforts with international partners.

The remaining analytical work is directed toward completion of code development and assessment.

For the longer term we have to decide the type of expertise that we want to retain in this area, what type, how much, where, how much in house, how much in laboratories, how much faith we should put in our

international cooperative efforts. These are the important questions that the office is addressing right now.

[Slide.]

MR. SPEIS: Direct containment heating. This is an issue that can arise under high pressure conditions. If you have a station blackout as opposed to a large break LOCA where you depressurize the system and the accident proceeds to a core melt under high pressure conditions. Then if you fill the vessel, you can imagine that all that molten core can be expelled violently into the containment itself and you can transfer the heat in the corium directly into the environment. That heat, of course, can translate itself into pressurization which could lead to failure of the containment.

These were the early notions about the issue itself. Our early calculations indicated that it only took 20 percent of the molten core to lead to the containment failure pressure. We have done extensive work. One of the things that was missing early on was to do some modeling involving real configurations. When we started doing that, we found out that most of the material is entrapped or is collected in the compartments that exist below the cavity.

Based on extensive analytical work and experimental work, we feel confident that this issue is not as important as it was. In fact, we have resolved it for

Westinghouse plants. We don't think that this issue is one that would lead to early containment failure.

CHAIRMAN JACKSON: So the direct containment heating that might lead to early containment failure is no longer an issue for Westinghouse large dry or sub-atmospheric containments?

MR. SPEIS: Yes. We are looking at some Combustion plants which have some differences, but based on what we know already, we don't think that will be an issue.

CHAIRMAN JACKSON: What about for BWR containment types?

MR. SPEIS: This issue is important when you have high pressure conditions. BWRs have the automatic depressurization system. So we don't think that is an important issue for BWRs.

[Slide.]

MR. SPEIS: I would say one of the important issues that the severe accident program is looking at both nationally and internationally is under what conditions we can retain the molten core inside the vessel. You will recall that in the TMI accident approximately 50 percent of the core got into a molten state and yet the vessel was able to retain it. Early on we thought that the moment you had an initiating accident the processes are so coherent that the vessel melts and there isn't any time.

From the TMI accident as well as the program that we put together to examine the vessel and the scenarios we realized that the vessel itself is an important defense boundary. So in our program now we are trying to explore that further and enhance the capability. We are looking at all the different conditions that could ensue. We want to get some assurance that we can retain a molten core inside the vessel. Of course that is much easier when the core has a lower power than a large one. That will be a much easier thing to accomplish for AP600, for example, than for existing vessels.

So we have a number of programs in these areas. An important one, which is under the OECD auspices, is done in Russia. It involves melting large amounts of corium or uranium, up to 200 kilograms, to study the natural circulation at the bottom of the vessel itself, to assess the thermal loads on the vessel itself.

CHAIRMAN JACKSON: Let me ask you a question. You say if the reactor pressure vessel fails, what is the likely failure mode location and timing? Help me understand which of the tests are oriented to addressing that issue.

MR. SPEIS: One of the first things we have to know is how is the heat distributed inside the vessel. That is very important. You could have preferential hot spots. The RASPLAV program will tell us something about that.

Based on that, we can identify specific locations in the vessel.

Then we have programs that examine how a specific location thermally could enlarge, how a small hole could enlarge itself.

CHAIRMAN JACKSON: I guess what I am really asking you is, can you give us a delineation of what failure mode you are looking at?

MR. SPEIS: Whether the failure mode is thermal penetration or whether it's structural. You weaken the vessel and then as a result of the thermal loads and the pressure loads it would fail in a global way. These are the type of things we are talking about.

Do you want to say any more about that, Charlie?

CHAIRMAN JACKSON: I guess what I am really interested in is the delineation of the failure modes you are examining and then how the various projects are structured to look at that.

MR. ADER: Between the two slides, the OECD RASPLAV, the in-vessel debris coolability experiments, and the external flooding are looking at retaining the melt in vessel, either through internal cooling or external. The lower head failure experiment, which is on the next slide, will deal with the way the vessel would fail if it is not cooled and retained. The ex-vessel debris coolability

experiment, the MACE, will deal with coolability of debris on the containment floor. That is how they are delineated. I don't want to take away from Dr. Speis' presentation on the details, but that's the breakdown.

CHAIRMAN JACKSON: Thank you.

MR. SPEIS: This is the program. Again, we think this is an important issue, and it is being pursued aggressively both nationally and internationally.

[Slide.]

MR. SPEIS: On page 23 I describe the program dealing with fuel-coolant interactions. When molten core comes in contact with water, the molten core can either quench in a mild way or it can lead to an energetic process. This energetic process was identified early on by WASH-1400 and it was named the Alpha Containment Failure Mode where you generate enough energy inside the vessel which could lead to the failure of the vessel head, which could become a missile and penetrate the containment itself.

This issue has been studied very extensively nationally and internationally because it's a potentially early containment failure mode.

Our latest finding is that this issue is not as important as it was once thought.

CHAIRMAN JACKSON: It's not important for all types of reactors?

MR. SPEIS: For all types of reactors as far as leading to containment failure, but the fuel-coolant interaction process itself could have an effect even if it is milder by changing the sequence of an accident and things of that sort, or they could affect the coolability of corium under some conditions. We are pursuing that in general, but at the end of the spectrum, the dynamic process itself which would lead to a missile which would penetrate the containment, we have been convinced that is of low probability.

COMMISSIONER DICUS: You mentioned a couple things that are being pursued internationally as well. Are they having the same findings?

MR. SPEIS: Yes. If I can have backup viewgraph number 7.

[Slide.]

MR. SPEIS: We will be having steam explosion review groups every two or three years.

CHAIRMAN JACKSON: Was Chernobyl a steam explosion?

MR. SPEIS: To some extent, yes, it was.

This shows Steam Explosion Review Group Number Two, which took place in 1995. The first one was in 1985. Substantial work was done between 1985 and 1995. So we got together in 1995 to assess the results and the conclusion.

The numbers shown under SERG-2 are the conditional failures of the containment given a core melt.

On the left you see the participants from the United States and different countries. These are the experts worldwide in this area.

We feel confident that this issue has been resolved from a risk perspective.

MR. THADANI: I would like to make one comment. As we went forward on the advanced light water reactor reviews and decisions that were made the approach and the boundary conditions were actually established. The Commission approved how far we could go in terms of likelihood of core damage as well as in terms of conditional probability of containment failure in dealing with those early challenges that we talked about. In fact, as Dr. Speis said, in terms of the steam explosion issue, based on all the work that had been done, we did say it had very low probability of occurrence.

On the other hand, in some European countries they may be going much further in terms of the level of safety that they demand. In some cases that may be much more than what we have done. In terms of those decisions, they may go further in their approaches. I think that is an important point.

COMMISSIONER ROGERS: Are those being driven by

any kind of analytical calculations or experiments such as these or is it really kind of a public acceptance issue?

MR. THADANI: I think it's very much a public acceptance issue, the challenges they have in terms of population densities and other countries being in the neighborhood. Most of those decisions, at least up to now, are being driven by that consideration. Some countries are even talking about containment that cannot fail, period, and looking into what it would take to get there.

CHAIRMAN JACKSON: Are there efforts to reduce these uncertainties, it's less than a certain amount, and how likely is it that that could be done?

MR. SPEIS: There is a joint program on the next viewgraph.

[Slide.]

MR. SPEIS: Viewgraph 24 addresses some of these issues. We are participating. Even though we are not involved in some of these programs in the United States, we participate internationally to make sure that if there are any surprises we know about them and we can explain them to the Commission and to the public. In fact, in some areas that is an important motivation. Later on I will discuss the PHEBUS program. That is an important reason we participate.

CHAIRMAN JACKSON: Are these results from the

research programs consistent with what we have in NUREG-1150?

MR. SPEIS: When it comes to steam explosions, these results are consistent, yes. In fact, we are more confident even than what was in 1150 in this area. Even WASH-1400 identified this as a 10 minus 2 conditional failure given a core melt, but there were many disagreements among the experts at that time. That is an additional motivation to pursue extensive research in this area.

[Slide.]

MR. SPEIS: On page 25 I talk about the hydrogen combustion. As I said already, this is one of the earliest and most important manifestations of a severe accident. Upon core uncovery the oxidation of the zirconium cladding leads to the generation of hydrogen. Hydrogen was generated in the TMI accident, 400 kilograms. It led to a global combustion, which led to a pressure of 30 psig.

In fact, as a result of that the Commission decided to backfit some of the low pressure, low volume containments with controlled burning to ensure that the hydrogen as it comes out is burning in a controlled manner and it doesn't lead to accumulation and global conflagration.

MR. THADANI: It issued a regulation on that.

MR. SPEIS: Yes.

We have done most of the work in this area. Right now we are looking at some residual issues addressing, for example, what is the effect of temperature on combustible limits and under what conditions in a containment could you get to detonation characteristics. Detonations are much more severe than burning. You can have pressures which are twice as much as burning.

From what we have seen so far we don't believe that the conditions exist, but there are a number of small programs. So we want to maintain capability in this area.

[Slide.]

MR. SPEIS: In some areas it's retaining capabilities. We have an expert who helps us at Cal Tech on some of these issues. We took advantage of some Russian large facilities to do some experiments to confirm some of the things that involve detonation characteristics.

Also, we have been doing the last year and a half some confirmation testing asked of us by NRR dealing with the AP600 hydrogen issues. One of them, which we completed a year ago, involved the condensation of steam inside the containment and the appearance of large amounts of hydrogen and whether the burning will take place according to our understanding of combustion or whether the concentration will be high all of a sudden and lead to a detonation. That didn't turn out to be the case.

Right now we are confirming the functionality and effectiveness of passive autocatalytic recombiners which are to be used in AP600 for both design basis and severe accidents. These are recombiners that don't need a source of power. They use palladium as a catalyst to recombine the hydrogen and the oxygen gases into water vapor upon contact with the catalyst, and the energy from this recombination is released at a relatively slow rate. They function just like the igniters that we have in our Mark III's and ice condensers. We are doing that work right now.

COMMISSIONER ROGERS: Could you make a comment on the relative importance of this hydrogen combustion in PWRs and BWRs?

MR. SPEIS: The problem with hydrogen, the first thing is concentration. When you have a large volume like a PWR containment, you are talking about three million cubic feet. It barely reaches the concentration for combustibility. The smaller PWR, the ice condenser, we were concerned, and therefore the Commission backfitted controlled burning to ensure that the hydrogen burns in a controlled way and it does not lead to the high pressures that could come from the global combustion.

Similarly for the smaller BWR containment, Mark I's and II's. They are inerted, so there is no problem there. For the Mark III's we have controlled burning there

also.

The question is concentration, whether you reach the combustible limits, or whether you even exceed them and go to detonation. There is no problem for large PWRs.

CHAIRMAN JACKSON: For BWRs?

MR. SPEIS: PWRs. We looked into that, whether you could reach high concentration in small compartments. We didn't feel that was an important issue. In fact, that was a generic issue, and we resolved that.

But again, hydrogen played an important role in severe accidents. In fact, the Europeans are still arguing what to do with this issue. Even though Ashok earlier talked about the future designs will be proof against all types of loads, here is an issue we think is important, and the Europeans think it's important, but for some reason they haven't implemented hydrogen control measures yet.

MR. THADANI: The point I would like to make is this research work was extremely valuable to us on System 80+, for example, where we had to deal with the hydrogen issue, both in terms of location of igniters as well as response. If the sprays were to be actuated which would condense steam and you perhaps end up with a large concentration of hydrogen, what would happen? That research really was the key for us to be able to close that issue.

The passive autocatalytic recombiners are proposed

for the AP600 for design base accidents. It's really that motivation that has led us to ask Research to run some experiments to see how well these recombiners would behave.

The Europeans have done some research and we have seen some of those results, but we thought we would like to confirm before we move.

[Slide.]

MR. SPEIS: Page 27, Source Term Research. We basically have completed extensive research in this area. We are not doing any ourselves in this country right now. We are participating in the PHEBUS program, which is a loop type test reactor with a driver core which allows the melting of fuel and then the radioactivity that is released is transported into a model of the primary systems and the containment and appropriate measurements are made. We are following that; we are participants; and we are helping them in the pre-analysis. We want to ensure that there are no surprises and the information that will come from it will help us ensure that our models are okay or we will have to revise them if need be.

CHAIRMAN JACKSON: We recently made a source term revisions, right?

MR. SPEIS: Yes.

CHAIRMAN JACKSON: Are there specific additional questions that we think need to be addressed that might

impact on any future provisions? Is that what we are doing with this program?

MR. SPEIS: I don't think so. The source term is the one that is used for design basis. We have done enough work on its timing and its chemistry. The chemistry is an important consideration.

CHAIRMAN JACKSON: I guess what I am saying is, we are just kind of staying in the game here.

MR. SPEIS: Yes, we are staying in the game.

CHAIRMAN JACKSON: So there are no specific questions that we are looking to specifically address in the PHEBUS program; is that correct?

MR. SPEIS: Yes.

[Slide.]

MR. SPEIS: Severe Accident Codes. The objective is to have the capability to model plant accidents and transients to ensure that if things happen or if issues come up we are able to provide understanding and analysis. I have listed some of the severe accident codes, the MELCOR, the SCDAP/RELAP5, CONTAIN, and VICTORIA. These codes are being used by our severe accident partners in Europe. In fact, I would like to get to page 31 where I would like to spend a little bit of time discussing the cooperative severe accident research program.

[Slide.]

MR. SPEIS: This program is an international program which is sponsored by NRC. Joining the program may involve contributing cash payment. For example, if a country does not have a research program of its own in this area and they want to participate, they pay to join. Other countries that have related programs, they join and provide their results. There is also something in between. Some countries that have some research but not enough, they contribute cash as well as in kind. I will give you some examples.

The United Kingdom is providing mostly in kind. For example, the VICTORIA code which evaluates the source term inside the primary system and the behavior of aerosols. The people in the U.K. are developing specific models dealing with aerosol physics which will be put into the VICTORIA code. We have similar examples with other partners.

Maybe Mr. Ader, who is the branch chief of the Severe Accident Branch, can say more about this.

MR. ADER: This week and finishing up this morning as we speak, we had the Cooperative Severe Accident Research program down in Bethesda. It has been a four and a half day meeting. We had around 66 international participants from 19 countries plus a number of our own staff and contractors here. It was four very packed days of presentations and

overviews. It has been a very successful program. It gives us opportunities to keep abreast of what is going on internationally.

Early on the NRC was really the leader in this area. The countries were coming here to tap our expertise. Now it is becoming much more of a forum for sharing information, and it has proved to be very valuable and very successful.

CHAIRMAN JACKSON: Does it include severe accident codes as part of that?

MR. ADER: Yes. A lot of the partners value the codes. Some of the countries are developing their own suite of codes, but there are a lot of the international partners that are using the U.S. developed codes. Actually, the week before there was a three day what we call the MCAP, the MELCOR Cooperative Assessment Program. That had around 16 countries represented, users, and some of those countries have several organizations that were here. It started out as a group to help provide assessment of the code utilizing a greater number of parties than domestic. It is turning out also as a users group. So there is a lot interchange of ideas. There have been recommendations to do that for some of the other codes, which we are exploring.

CHAIRMAN JACKSON: Maybe you just told me, but how are we going to maintain our own expertise with the decline

in our large experimental programs? How are we going to maintain our expertise?

MR. ADER: That is a question that is being looked at as we speak as part of efforts that you have underway, that Dr. Morrison has underway, looking at the activities and balancing out all of the needs. I wish I had the answer.

CHAIRMAN JACKSON: So the answer is, you are giving the question back to us.

MR. SPEIS: One of the answers, Chairman Jackson, will be that we cannot go down to zero in all activities and expect to be truly participants.

CHAIRMAN JACKSON: I was waiting for that answer. Thank you.

MR. SPEIS: With that, this brings to conclusion the severe accident research program. One of the big questions is how we structure a maintenance capability in the longer term.

MR. THADANI: Viewgraph number 33, please.

[Slide.]

MR. THADANI: As you have heard, the Three Mile Island accident led to whole range of requirements that the NRC developed, one of which was to develop procedures to deal with multiple failures. In fact, current emergency operating procedures do incorporate several sequences with

multiple failures. Boiling water reactors go a long way towards addressing some severe accidents as well.

Over the years there was a lot of debate whether there was a need for a severe accident rule to layout all the requirements to be able to deal with severe accidents.

After a great deal of debate, an approach that could lead to closure of the severe accident issues was proposed that had three major elements. There are other elements, but there are three major elements.

The first one was to conduct IPEs and IPEEEs to see if there were some significant vulnerabilities. In this country we do not have standard designs, so there was an obvious concern that some plants may have significant vulnerabilities.

Beyond that, it was expected that the IPEs and the IPEEEs would identify some insights that could and should be used by the utilities in development of their procedures to deal with such accidents.

The second element was what Dr. Speis has basically gone through, a containment performance initiative, which was largely an NRC initiative looking a research, trying to better understand what the containment challenges would be, how you would want to deal with those challenges.

The third element was accident management. The

idea behind accident management was for the utilities to take all the information they get out of the individual plant examinations of internal and external events, all the information on containment challenges, and to develop guidelines that could then be turned into procedures by individual licensees to be better prepared for potential accidents of this nature.

The scope of accident management is really very broad. It starts out with what does one need to do to try and prevent core damage accidents, and if there is a core damage accident, what are the right things to do to try and maintain the corium in vessel. Again, some of the things that Dr. Speis was talking about.

Then, should corium get ex-vessel, what are the right things to do to try and maintain containment integrity.

Finally, making decisions in terms of offsite releases, what are the more sensible things to do.

These were really lessons learned from the Three Mile accident. The preplanning and being prepared to be able to deal with these kind of eventualities was the focus of the accident management program.

It was also recognized that these guidelines would have to be applied, by and large, with the existing hardware and systems that are in place. The intention was not to

make large scale changes to the existing reactors.

Viewgraph number 34, please.

[Slide.]

MR. THADANI: The accident management program takes these insights and then converts them into guidelines, and these guidelines are provided to individual licensees who can then use those general guidelines for their specific plant, knowing exactly what hardware they have in their plant by way of instrumentation systems, and so on.

As I said, today's EOPs, or emergency operating procedures, do include multiple failures. These emergency operating procedures are executed by the control room operators.

The site emergency plan covers the technical support center staff and the management of accidents overall. As we learned, there were a number of accident processes which had not been considered. The accident management was going to sort of fill that void to make sure that was covered.

In order to diagnose and develop an appropriate course of action one needs some tools and information base. It was clear to us that that kind of an activity would be very difficult for the control room operators to have to carry out. So by and large the accident management assessment, diagnosis, course of action is to be done by the

technical support center staff. However, industry has broken it down into two parts.

Accidents that can lead to fairly early core damage such as large loss of coolant accidents or anticipated transients without scram, for those it was clear that the control room operators had to have the information, had to be trained, because the technical support center may not be fully staffed and functional. But for all other accident scenarios, the technical support center was to do analyses and provide some guidance.

The control room operators have to clearly understand what the transition phase is when they are going to start to rely on guidance from the technical support center, and then they have to also have a reasonably good understanding that if they have to implement some actions based on guidance that they had better have some early training on that as well.

Under the accident management program there is a set of training and requirements for the control operators and a set of training and requirements for technical support center staff as well as management that would be trying to deal with these issues.

CHAIRMAN JACKSON: Are there clear guidelines on the communications between the control room and the technical support center?

MR. THADANI: We are trying to make it as clear as it can be. It is an industry program, but we are doing enough of a review to focus in on issues like that, because the worst thing one can end up with would be confusion and then doing the wrong thing. Those are the areas where we are actually focusing attention.

I brought this to give you an idea. This was done by the Westinghouse Owners Group. This is one of two volumes. These are severe accident guidelines. These are the documents that individual licensees will take and try to convert through good human factors considerations, and so on, to procedures.

CHAIRMAN JACKSON: That is not complete yet?

MR. THADANI: No, that is not complete.

CHAIRMAN JACKSON: How far from complete?

MR. THADANI: In fact, that is my last viewgraph.

[Slide.]

MR. THADANI: The schedule for completion is by the end of 1998. We have a schedule from every licensee. We require that they provide us that information.

A good number of licensees are going to be completing this by June of 1997. Then there is another large group that goes to December of 1997, and then June of 1998 and December of 1998. So there are groups of plants.

CHAIRMAN JACKSON: What has taken so long?

MR. THADANI: These studies are pretty complex. They have required making sure of all the information that the industry could put together before developing these guidelines. These guidelines do incorporate a lot of the understanding that is coming from research programs. By and large, I would say that has been one reason. Another reason, of course, is they are going to incorporate IPEEE insights as well as IPE insights.

In the meantime, many of the utilities as they have finished their IPEs, if they have identified significant procedural issues, they have incorporated those in their procedures from IPEs. The process has taken longer than I like, of course.

CHAIRMAN JACKSON: Twenty years, or will have.

MR. THADANI: Will have by the time it's done. Our intention is to do four or five inspections as soon as some of the plants have implemented this program. We are preparing a temporary instruction that will be used to do these inspections. After four or five inspections are done, we will reassess and have a workshop and develop an inspection procedure that will be followed to take a look at all the plants and see how well this program has been implemented by the industry. That is basically the status.

CHAIRMAN JACKSON: I want to thank all of you. You have given the Commission quite a comprehensive review

and you have been commended. I know that some of the questions have been difficult, but I think it has helped clarify many things, and I think it has particularly helped to inform Commissioner Dicus and me, because we were not here at the beginning of time.

COMMISSIONER ROGERS: I wasn't either.

[Laughter.]

CHAIRMAN JACKSON: I apologize. Touche.

Let me commend you for your accomplishments to date as well as the international leadership that you have provided in this area. Even as the worm turns and things migrate, as you say, we were the leaders and now there are other leaders. Nonetheless it's clear that we have provided outstanding international leadership in this area.

Let me just make a couple of remarks. It really is important to establish clear criteria for bringing the remaining programs to closure. Closure can mean a maintenance mode, but we have to be clear on those. It is important to continue engaging the international community in the analytical and, especially, it seems more and more for us, experimental programs when there is mutual benefit.

I am told that we have over 50 international cooperative research agreements. Somehow they all can't be equally important to our issues. So the question is, what kind of prioritization template do we apply in terms of

getting the most bang for the buck? I think we have to think about it. I'm not asking you for an answer today.

I think you have heard about the importance of tracking the regulatory uses of the IPEs and PRAs, establishing such a tracking methodology, particularly as we are about to go into potential uses such as the maintenance rule.

And the importance of linked databases. You've heard the Commission speak before when there have been joint presentations between NRR and Research or NMSS and Research of the need to have consistent regulatory frameworks, that what you do is not the baby of one office; it draws on the different responsibilities and different expertise of the different offices; but in the end it has to be part of one coherent program. So I ask you to think about that, and I think you have gotten some of that from the Commission today.

Again, I might urge you to look at the various initiatives underway, particularly these pilots, as to how they might inform our regulatory program, particularly relating to Commissioner Dicus' question about resource requirements and the extent to which they can begin to help inform that, because that helps us in doing our planning going forward both from a resource point of view as well as the full implementation of a PRA implementation plan.

Commissioner Rogers or Commissioner Dicus, do you have any additional questions?

COMMISSIONER ROGERS: I have no additional questions.

COMMISSIONER DICUS: Nothing additional.

CHAIRMAN JACKSON: Thank you very much. We are adjourned.

[Whereupon at 11:48 a.m. the briefing was adjourned.]

CERTIFICATE

This is to certify that the attached description of a meeting of the U.S. Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING ON SEVERE ACCIDENT MASTER INTEGRATION PLAN - PUBLIC MEETING

PLACE OF MEETING: Rockville, Maryland

DATE OF MEETING: Friday, May 10, 1996

was held as herein appears, is a true and accurate record of the meeting, and that this is the original transcript thereof taken stenographically by me, thereafter reduced to typewriting by me or under the direction of the court reporting company

Transcriber: Michael Paulus

Reporter: Michael Paulus

SEVERE ACCIDENT INTEGRATION PLAN

May 10, 1996

T. P. Speis
Office Of Nuclear Regulatory Research

A. C. Thadani
Office Of Nuclear Reactor Regulation

OUTLINE

IPE PROGRAMS

- Goals and Accomplishments
- IPE Program Elements
  - Reviews
  - Database
  - Regional Coordination
  - Insights

IPEEE PROGRAM

SEVERE ACCIDENT RESEARCH

- Phenomena/Issues
- Analytical Codes
- Cooperative Severe Accident Research Program

SEVERE ACCIDENT MANAGEMENT

IPE and IPEEE Programs

IPE/IPEEE Goals & Accomplishments

GOALS

Primary Purpose Is For Licensees To Identify Vulnerabilities To Severe Accidents And Cost-Effective Safety Improvements To Reduce Or Eliminate Them

Specific Generic Letter Objectives For Licensees:

1. Develop An Appreciation Of Severe Accident Behavior

2. Understand The Most Likely Severe Accident Sequences That Could Occur At Their Plant(s)

3. Gain A More Quantitative Understanding Of The Probability Of Core Damage And Fission Product Releases

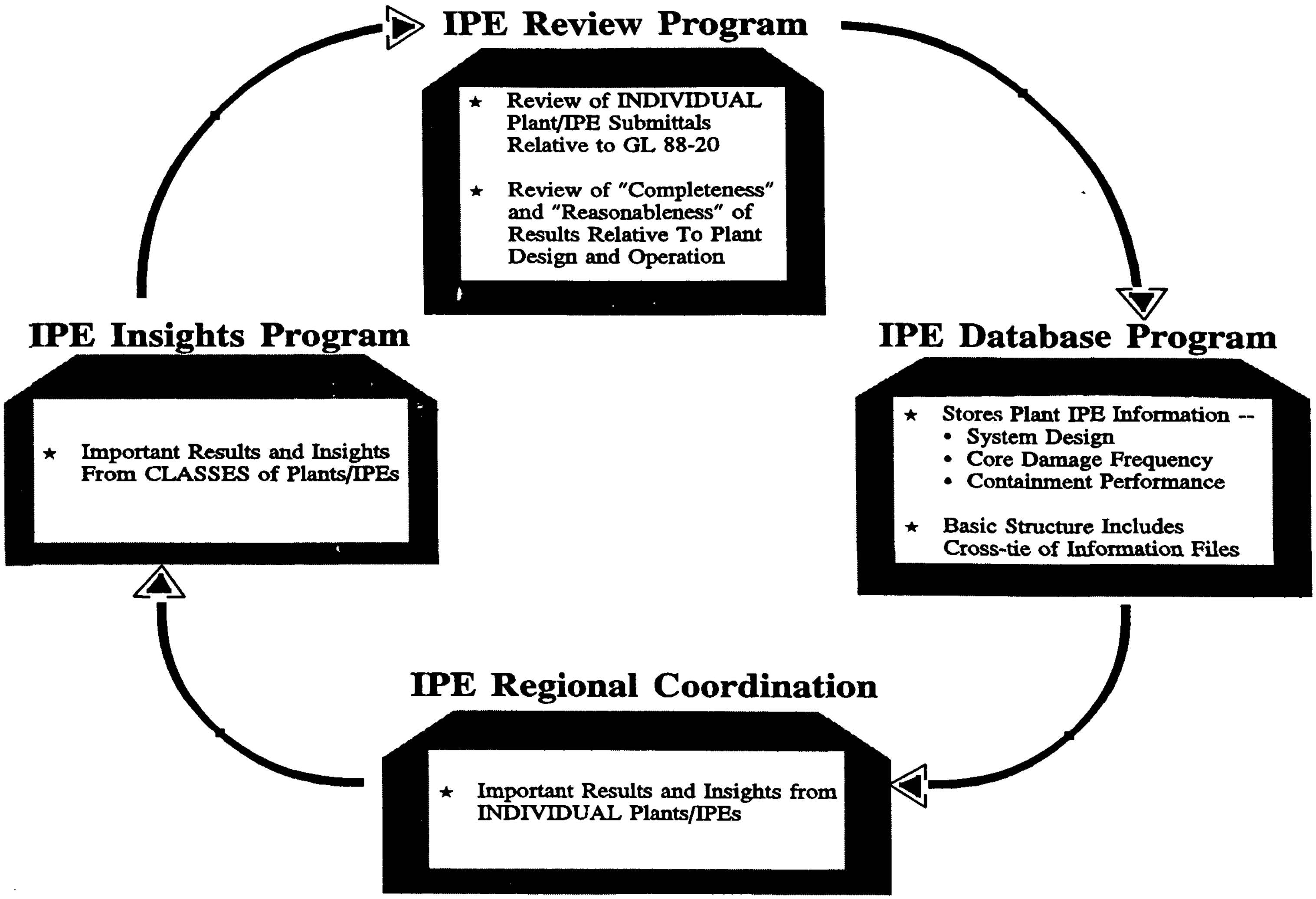
4. If Necessary, Reduce The Probabilities By Modifying Hardware And Procedures

IPE/IPEEE Goals & Accomplishments
(Continued)

Accomplishments

Utilities Have:

- Performed Level 1 And Level 2 PRAs
- Developed In-House Staff PRA Capabilities
- Generally Indicated Intention Of Maintaining And Updating IPE/PRA
- Identified Plant Improvements As A Result Of IPE


IPE Review Program
★ Review of INDIVIDUAL Plant/IPE Submittals Relative to GL 88-20
★ Review of "Completeness" and "Reasonableness" of Results Relative To Plant Design and Operation
IPE Database Program
★ Stores Plant IPE Information --
• System Design
• Core Damage Frequency
• Containment Performance
★ Basic Structure Includes Cross-tie of Information Files
IPE Regional Coordination
★ Important Results and Insights from INDIVIDUAL Plants/IPEs
IPE Insights Program
★ Important Results and Insights From CLASSES of Plants/IPEs

IPE REVIEWs

- Review Information For "Completeness" And Results For Reasonableness" Focusing On Whether Licensee Met Intent Of Generic Letter Objectives. Additional review required if IPE is to be used for other purposes.

- Completed Preliminary Review of All 75 IPE Submittals, Issued 52 Staff Evaluation Reports, Remaining To Be Issued September 1996

- Could Not Conclude Licensee Met Intent Of Generic Letter On 11 IPEs, Licensees Addressing Staff Concerns, Expect Issuance Of These Final SERs December 1996

- Plant specific resolution of GSI A-45 "Decay Heat Removal"

IPE DATABASE

- A Collection Of Linked Files Based On Contents Of The IPE Submittals
- Stores Information About Plant Design, Core Damage Frequency And Containment Performance (At System Level Of Detail)
- Support Detailed Queries Into Above Characteristics For Desired Classes Of Plants
- Database "Menu Driven" Allowing User-Friendly Access
- Database Now Available, Workshops Being Scheduled

IPE REGIONAL COORDINATION

- To Ensure That Plant-Specific Insights From IPEs Are Considered In NRC Activities At Plant Sites

- Familiarize Regional Personnel, Including Resident Inspectors, via Two Phase Process

  — Phase I (RES Lead) -- Presentation And Discussion Of IPE Results And Insights On An Individual Plant Basis In Regional Offices

  — Phase II (NRR Lead) -- Ongoing Advice And Support For Site-Specific Activities

- Have Visited Each Regional Office And Completed Discussions on 20 Different IPEs, Expected To Complete Remaining Briefings (Phase I) December 1996

IPE INSIGHTS PROGRAM

Provide Information and Perspectives to industry and staff On:

(1) Impact Of The IPE Program On Reactor Safety

- Few Plants Identified "Vulnerabilities" — Licensee Defined What Is Meant By Vulnerability
- All Plants Identified "Improvements"
- Improvements Primarily Involve Changes To Operations, Involving Modifications to Operating Procedures And Training
- Many Of The improvements are yet to be implemented or are Under Evaluation For Implementation

(2) Reactor And Containment Design And Operation

- Specific insights, by plant class and containment type, to be included in insights report.

IPE INSIGHTS PROGRAM
(Continued)

(3) IPEs With Respect To Risk-Informed Regulation

- IPEs/PRAs Generally Robust With respect To Identification Of Dominant Accident Sequences

- General Areas Of "Weakness" In The Core Damage Frequency Estimation From The IPEs
  - Lack of Use Of Plant-Specific Failure Data
  - Analysis Of Common Cause Failures
  - Human Reliability Analysis

- Many Of The IPEs/PRAs (With Regard To Core Damage Frequency), With Some Additional Review, Appear To Be Of Sufficient Quality To Be Used In More Quantitative Applications

IPE INSIGHTS SCHEDULE

- Commission Paper (SECY-96-051) Issued
- Draft (For Public Comment) NUREG Report Now In Internal Review And Comment
- ACRS Briefing On Draft NUREG June 1996
- Draft For Public Comment To Be Published October 1996
(to Commission for Information - September 1996)
- Public Workshop To Be Scheduled (~January/February 1997)

IPEEE PROGRAM

- Generic Letter 88-20, Supplement 4 with guidance (NUREG-1407), issued on June 28, 1991, requested all licensees to perform an IPEEE to identify plant-specific vulnerabilities to severe accidents caused by external events.

- Received 46 IPEEE submittals, and will receive an additional 17 submittals in 1996, 11 in 1997, and one with a date to be determined.

- Currently, 24 submittals are under review.

IPEEE PROGRAM (CONT.)

- IPEEE review process for the remaining 51 submittals has been revised:

  * Initial Screening Review

    Staff (RES and NRR) and its contractors will perform screening reviews focusing on: (a) quality and completeness of the submittals and (b) assessments and resolution of generic issues subsumed in the IPEEE.

  * Second Level Review of Selected Plants

    Additional reviews may be required for some IPEEEs which are poorly documented or have technical deficiencies.

IPEEE PROGRAM (CONT.)

- IPEEE Insights

  Staff will initiate limited IPEEE insights study:

  . Summarize the significant IPEEE findings and identify generic observations

  . Summarize lessons learned about the methods used

  . Assess the usefulness of the IPEEE analyses for regulatory applications

SEVERE ACCIDENT RESEARCH

SEVERE ACCIDENT RESEARCH

SEVERE ACCIDENT RESEARCH has focused on phenomena and issues to understand and quantify phenomena and potential challenges to reactor vessel and containment integrity

- Direct Containment Heating
- Lower Head Integrity/Debris Coolability
- Fuel-Coolant Interactions
- Hydrogen Combustion
- Source Term
- Analytical Codes
- Cooperative Severe Accident Research Program

OVERALL DIRECTION OF SA RESEARCH PROGRAM

- Research on major issues complete or nearing completion
- Remaining experimental work is directed at areas of largest uncertainty or confirmatory work for code assessment.
- Major remaining experimental programs are international cooperative efforts.
- Remaining analytical work is directed toward completion of code development and assessment
- Long term issue is maintenance of expertise

DIRECT CONTAINMENT HEATING

ISSUE:

- Early containment failure of PWR reactor containments due to high pressure melt ejection and heating of containment atmosphere.

STATUS:

- Completed large scale integral and separate effects tests simulating the Zion and Surry plants and completed evaluation of containment loads versus containment structural capability.

- Issued peer reviewed reports, NUREG/CR-6075 and NUREG/CR-6109 for Zion and Surry. Issued peer reviewed report, NUREG/CR-6338 which applied issue resolution methodology to all Westinghouse plants with large dry or subatmospheric containments (41 plants). Issue resolved with finding of no significant failure probability for these plants

DIRECT CONTAINMENT HEATING
(Continued)

PLANS:

- Resolution of DCH for CE and B&W plants underway; large scale integral testing completed; analysis of test results ongoing, plant analysis and issue resolution to be complete by September 1996
- DCH issue resolution for ice condenser plants to be completed by the end of 1996
- Issuance of CSNI state of the art report on high pressure melt ejection and DCH by December 1996

LOWER HEAD INTEGRITY/ DEBRIS COOLABILITY

ISSUES:

- Under what conditions can molten core material be retained in the reactor pressure vessel (RPV) through internal or external cooling (e.g., ex-vessel flooding for AP600) or cooled ex-vessel?

- If the RPV fails, what is the likely failure mode, location, and timing?

STATUS:

- OECD RASPLAV Project

  - Experimental work (with prototypic corium composition) and analysis of natural pool convection and heat flux distribution on RPV lower head. Large-scale integral test planned (summer 1996)

- In-vessel debris coolability experiments

  - Cooperative experimental program on in-vessel cooling of RPV wall and core debris in lower head region

LOWER HEAD INTEGRITY/ DEBRIS COOLABILITY
(Continued)

- External flooding
  - Experimental work on ex-vessel flooding (e.g., data and analysis of downward facing boiling and critical heat flux
- Lower head failure experiments
  - Experimental work on RPV creep rupture failure Conducted first experiment (March 1996)
- Ex-vessel debris coolability experiment:
  - Melt Attack and Coolability Experiments (MACE) 3b-test late 1996

FUEL-COOLANT INTERACTIONS (FCI)

ISSUES:

- Assess the consequences of FCIs (ranging from mild quenching to energetic steam explosions)

STATUS:

- Issue addressed recently by CSNI specialists meeting and SERG-2 workshop (NUREG-1529, draft)
  - General agreement that α-failure is of very-low likelihood; future efforts (experimental/analytical) should be focused on ex-vessel fuel-coolant interactions.

FUEL-COOLANT INTERACTIONS (FCI)
(Continued)

- Cooperative research at JRC/Ispra under the FARO/KROTOS program extended to 1998
- Limited experimental work underway to explore steam explosion enveloping parameters and chemical augmentation
- Continue model assessment/experimental program considering SERG-2 recommendations
- Continue participation in international cooperative research, maintain appropriate level of expertise

HYDROGEN COMBUSTION

ISSUE:

- Assess potential challenges to containment integrity resulting from various modes of hydrogen combustion during severe accidents

STATUS — EXPERIMENTS:

- Completed high temperature, high speed hydrogen combustion experiments at BNL on inherent detonability, deflagration to detonation (DDT) with and without venting. (joint NRC/NUPEC support)

HYDROGEN COMBUSTION
(Continued)

- Continuing hydrogen combustion experiments at Cal Tech on diffusion flame stability and expansion of high speed jet into explosive mixture and large scale experiments at Russian Research Center to study effects of scale on H_2 combustion.

- Experiments on passive autocatalytic recombiners (PAR) to confirm PAR performance for controlling combustible gases in containment (NRR user need)

  - Complete initial PAR confirmatory test matrix (June 1996)

SOURCE TERM RESEARCH

- Ongoing PHEBUS integral experiments being used to confirm our general understanding (if needed, upgrade computer codes) of fission product release and transport.
  - PHEBUS FPT-O (fresh fuel) conducted 1993, PHEBUS FPT-1 (irradiated fuel) scheduled for June 1996; program extending thru 2002

SEVERE ACCIDENT CODES

INTEGRATED CODE

MELCOR

DETAILED CODES

SCDAP/RELAP5 | CONTAIN

VICTORIA

Thermal Hydraulics	Core Melting	FP Release from Fuel	FP Transport in RCS	Reactor Vessel Integrity	Core-Concrete Interactions	Release from Fuel Debris	FP Transport in Containment	Containment Loads

←— IN-VESSEL —→ ←— EX-VESSEL —→

PROGRESSION OF ACCIDENT PHENOMENA —→

SEVERE ACCIDENT CODES

OBJECTIVE:

- To provide the capability to model plant accidents and transients to assist the NRC in resolving safety issues and in incorporating research results into the regulatory process

NRC-SUPPORTED CODES:

- MELCOR: Integral systems level code to analyze severe accidents and consequences in nuclear power plants from initial core uncovery, through reactor vessel failure and containment response

- SCDAP/RELAP5: Detailed mechanistic code to analyze in-vessel severe accident progression including thermal hydraulics, core melting, and reactor vessel failure

SEVERE ACCIDENT CODES (Continued)

- CONTAIN: Detailed code for analysis of severe accident phenomena inside containment, including aerosol and fission product behavior, flammable gas combustion, melt-concrete interactions and direct containment heating.

- VICTORIA: Detailed code to analyze fission product release and transport in the reactor coolant system during a severe accident including vapor deposition, resuspension and revaporization

Cooperative Severe Accident Research Program

- Cooperative Severe Accident Research Program (CSARP) is an international program sponsored by the NRC

  - Purpose is to provide for cooperation and exchange of information in the area of severe accident research

  - Implemented through bilateral agreements

  - Includes participants from nineteen (19) countries

Accident Management

ACCIDENT MANAGEMENT: A DEFINITION

- Actions taken by the plant staff during an accident to:
  - Prevent core damage
  - Terminate core damage and retain the core within vessel
  - Maintain containment integrity
  - Minimize offsite releases

- Involves pre-planning and preparatory measures:
  - Accident management (A/M) guidance and procedures
  - Minor equipment mods to facilitate procedure implementation
  - Severe accident training

FUNDAMENTAL OBJECTIVE OF A/M PROGRAM

- **To have each NRC licensee implement an accident management plan which provides a framework for:**
  - **Evaluating information on severe accidents**
  - **Preparing and implementing severe accident operating procedures and guidance**
  - **Training operators, technical support staff, and managers in the procedures and guidance**

ACCIDENT MANAGEMENT STATUS

- A/M program has led to industry-developed severe accident management strategies and guidance for use by utilities
- Although some development efforts still ongoing, industry products sufficiently complete to begin implementation
- Industry implementation is proceeding pursuant to NEI initiative, with scheduled completion by end of 1998
- NRC will confirm adequacy of implementation through inspections and accident management drill observations

Risk-Informed Regulation

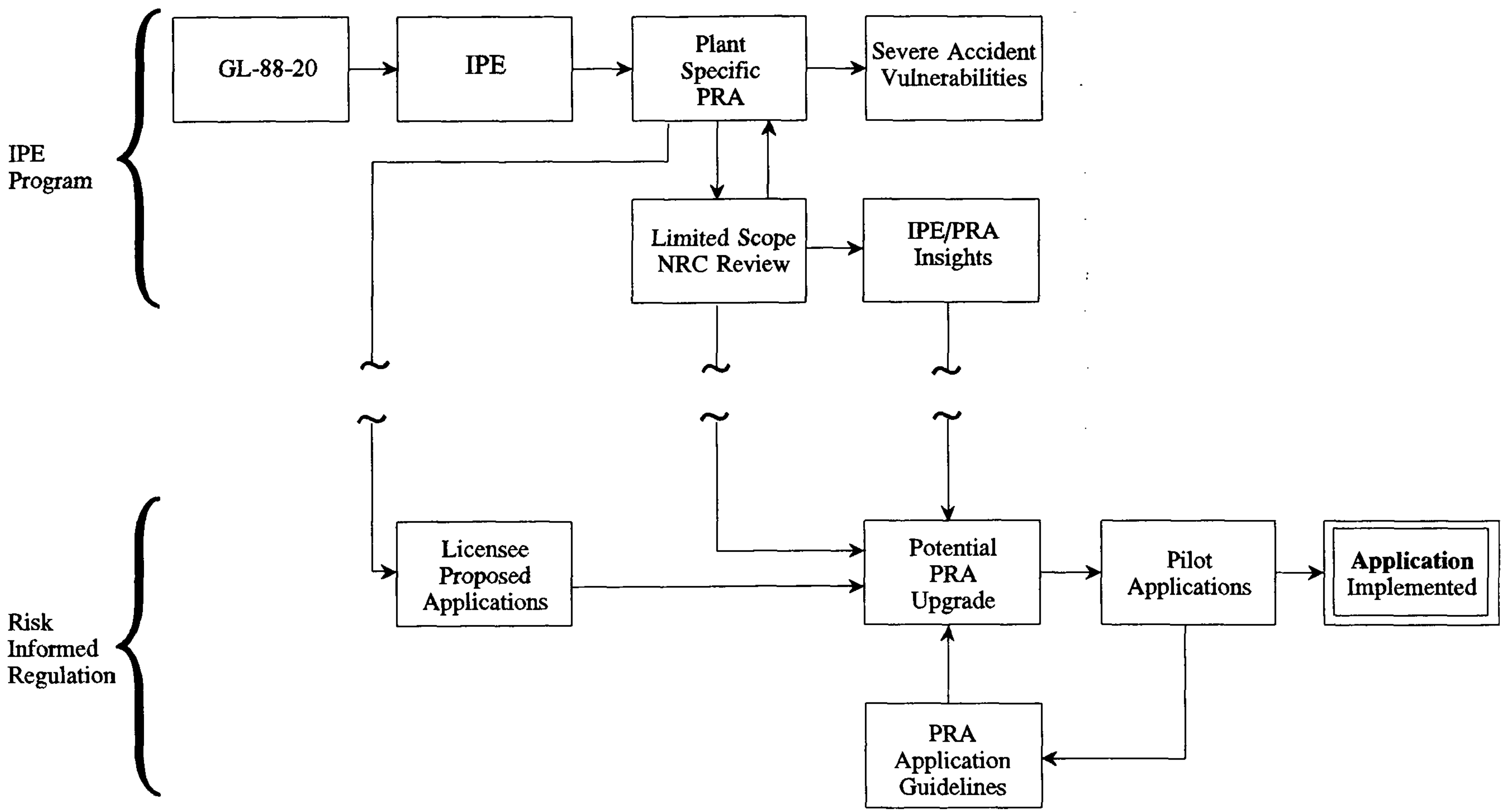


Table E.1 - Alpha-Mode Failure Probability Estimates Following a Core Melt Accident

Participant	SERG-1 (1985)	SERG-2 (1995)	View on Status of Alpha-Mode Failure Issue
Bankoff (USA)	$< 10^{-4}$	$< 10^{-5}$	Resolved from risk perspective
Berthoud (France)	--	Very low	No statement on resolution
Cho (USA)	< WASH-1400*	$< 10^{-3}$	Resolved from risk perspective
Corradini (USA)	10^{-4} - 10^{-2}	$< 10^{-4}$	Resolved from risk perspective
Fauske (USA)	Vanishingly small	Vanishingly small	Resolved from risk perspective
Fletcher (Australia)	--	$< 10^{-4}$	Resolved from risk perspective
Henry (USA)	--	Vanishingly small	Resolved from risk perspective
Jacobs (Germany)	--	Probably low	Not resolved from risk perspective
Sehgal (Sweden)	--	Physically unreasonable	Resolved from risk perspective
Theofanous (USA)	$< 10^{-4}$	Physically unreasonable	Resolved from risk perspective
Turland (UK)	--	$< 10^{-3}$	Resolved from risk perspective
*** WASH-1400 best estimate $< 10^{-2}$, SERG-1 consensus estimate $< 10^{-3}$**			