UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

***

BRIEFING ON SEVERE ACCIDENT

MASTER INTEGRATION PLAN

***

PUBLIC MEETING

***

Nuclear Regulatory Commission
Commission Hearing Room
11555 Rockville Pike
Rockville, Maryland

Tuesday, October 14, 1997

The Commission met in open session, pursuant to notice, at 1:03 a.m., the Honorable SHIRLEY A. JACKSON, Chairman of the Commission, presiding.

COMMISSIONERS PRESENT:

SHIRLEY A. JACKSON, Chairman of the Commission
GRETA J. DICUS, Member of the Commission
EDWARD McGAFFIGAN, JR., Member of the Commission
NILS J. DIAZ, Member of the Commission

STAFF AND PRESENTERS SEATED AT COMMISSION TABLE:

ANNETTE VIETTI-COOK, Assistant Secretary
KAREN D. CYR, General Counsel
BRIAN SHERON, NRR
MARK CUNNINGHAM, Office of Research
ASHOK THADANI, Program Oversight, Investigations & Enforcement
CHARLIE ADER, Office of Research
ROBERT PALLA, NRR

P R O C E E D I N G S

[1:03 p.m.]

CHAIRMAN JACKSON: Good afternoon, ladies and gentlemen. I am pleased to welcome members of the staff to brief the Commission on the status of the integration plan for closure of severe accident issues. The current element of this integration plan include, first, the severe accident research program, second the IEEE program and, third, the accident management plan.

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.

These issues include the liner melt for BWRs, boiling water reactors, and direct containment heating for pressurized water reactors. The research program has emphasized those specific severe accident phenomena that could result in early containment failure and code development and has benefitted from our cooperative agreements on severe accident research with other countries.

Today's briefing will focus on the status of and the progress in implementing the elements of the integration

.   4

plan for closure of severe accidents. The briefing will cover the current status of the 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. I understand that copies of the viewgraphs are available at the entrances to this room.

If none of my colleagues have questions or comments at this time, please proceed.

MR. THADANI: Thank you very much. Good afternoon.

With me at the table are Charlie Ader and Mark Cunningham, from the Office of Research and Brian Sheron and Bob Palla from NRR.

Could I have viewgraph number 2, please?

I will briefly go over the background and then we will jump right into the severe accident research program first and follow up with the status of IPEEE in particular as well as accident management.

Viewgraph number 3, please.

As you noted, the Commission's involvement in addressing severe accident issues has actually grown over the years, I'd say both in terms of scope as well as sophistication for treatment of severe accidents.

In the mid-'80s, the Commission issued a policy

.   5

statement on severe accidents and concluded that the existing plants did not pose undue risk. However, there were two major questions that needed to be cleared up. One of the major questions had to do with plant-to-plant variation with the over 100 reactors of different designs. There was a question, could there be some outliers in terms of design implications. And that's what led to program on individual plant examination for internal events as well as for external events.

The other major program -- oh, by the way, that was -- the Commission noted that the licensees were best prepared to address those plant-specific issues.

On the other hand, it was recognized that there were some significant voids in our knowledge in terms of containment response as well as risk implications to public health and safety and the Commission had an ongoing, continued to work on this severe accident research program as well as the source program. Those were two major components it was recognized that the agency would be pursuing.

The idea to make sure that we look at issues in an integral manner was essential and in late '80s, as a matter of fact -- could I have viewgraph number 3, please? -- it was clear there were some key elements -- I thought for a moment it wasn't there so I wanted to be sure.

The key point to note here is that three major factors that we thought would lead to closure of severe accidents on operating reactors. One had to do with IPE and IPEEE as a very central element in that. And the two other important elements were the severe accident research program as well as the accident management program.

It was recognized that the -- it was essential to get early information on some key challenges to containment as part of the severe accident research program. Thus, containment performance initiative was one part of the severe accident research program, an important part of the program.

Since we have had some discussion about budget issues in the recent past, I thought I would like to share some of my thoughts with you up front and then we will pick up the specific as you asked us to address.

CHAIRMAN JACKSON: Okay. Let me ask you, as you are going through, to also talk about how you came to closure on the non-highlighted bullets here.

MR. THADANI: The --

CHAIRMAN JACKSON: On containment performance. The fact that you are not discussing them explicitly, you have them as arrows in the viewgraph material that we got. So I assume what you are going to focus on are things in bold face that are highlighted?

MR. THADANI: Yes.

CHAIRMAN JACKSON: Now, that means you're not going to focus on the others. The question is, does that mean that you have come to closure on the others or that they are subsumed topics in the ones that are highlighted?

MR. THADANI: The individual -- let me address each of them.

CHAIRMAN JACKSON: Okay.

MR. THADANI: Individual plant examinations, we will cover very briefly but the focus will be on external events because that's where much of the work is going on.

In terms of containment performance and improvements, we will touch upon that as part of the briefing to indicate what some of the insights are that have come out of this.

Improved plant operations is our more or less day-to-day activities. Those are ongoing activities and they will continue to go on, continue to focus on operations. So that's why it is identified there because it is an important part of this continued oversight of operating reactors that plays -- gives one some sense of confidence. It's not like we've finished everything, we're not paying attention to operations. The idea here was it is essential that we pay continued attention to operations and that that will just keep going.

CHAIRMAN JACKSON: All right.

MR. THADANI: In fact, I would like to -- having come from NRR in the recent past, in research, and in my current position here, I can reflect a little bit on some of the value of the program that I saw when I was at NRR and continued to believe in the importance of this effort.

We were faced with -- we have been faced with a number of issues over time and you addressed a couple of them. The Mark I liner melt-through issue is quite significant. There was a lot of debate, a lot of interest. How do Mark I containments respond to severe accidents? And the initial thinking was that any accident that leads to substantial damage of the core could lead to melt through the liner and thus lead to significant early releases.

The research program has put that issue to bed. It required certain accident management strategies, a fairly simple strategy, actually, to deal with this issue and, quite frankly, had it not been for the program and the experiments and the analysis that were done through this program, one would be thinking about design changes and, in fact, we were thinking about design changes until we got better understanding of how one could in fact terminate corium movement through the liner.

You will hear some more about direct containment heating issue. Several years ago, there was this concern

.   9

that one could have a high pressure core melt sequence that could potentially lead to almost an instantaneous failure of the containment from direct containment heating aspects. That has some geometry implications and so on and while the program on direct containment heating is not complete but much of the information has pointed out that certainly for large dry containments, this is not an important consideration. The probability of such conditions happening is pretty low and one could be quite confident about low risk and not high risk.

There are other examples. One that we were involved in had to do with containment venting for Mark I containments again and there were some design changes made, backfits were imposed because it as believed that the risk, early -- large early release probability may be fairly high unless one were to provide some hardened vent path and that would not only filter and reduce the activity level but also would reduce probability of accidents initiated by high containment pressure.

So these, and of course you have heard a great deal about NUREG 1465, the new source term, and the idea of rebaselining and looking at plants, where to go. So these I see are examples of the value of the program and I have tried in my mind to tie this concept with the increased use of risk-informed thinking in our decisions.

.   10

In the policy statement on PRA, we said we should be using risk-informed thinking in all activities to the extent they can be supported, the analyses can be supported by data, methods and so on. So a careful use of this. And in that policy statement we also say that the analyses should be done as realistically as one can do and not in some conservative manner.

I think in my -- again, I see severe accident research program as helping us through development of codes, doing analyses in as realistic a manner as we can. And thus it seems to me it would continue to play an important part in the learning process.

Today, we are still at a point where we think there are a number of uncertainties in some challenges to containment which could lead to -- potentially lead to large releases. So I think selected parts of severe accident program, at least in my mind, are quite valuable. We are going to take a very hard look, we are taking a very hard look to see if we can develop some priorities in what we are doing and in the priorities, we are also looking at what are some of the international implications if we were to terminate certain portions of the programs and so on. And we owe you that information, I believe, by the end of this month.

Another point I asked for some information on

. 11

budget. The severe accident research program budget in fiscal year '95 was $12.4 million NRC funds and $4.6 million of funds that were provided by international community to us. In '96, $9.7 million is our budget and $2 million provided by other countries to us.

CHAIRMAN JACKSON: You say 9.7. That means 9.7 is the total program of which 2 million is international or is it 9.7 plus 2 million?

MR. THADANI: It's 9.7 plus 2 million.

CHAIRMAN JACKSON: Okay, that's all I wanted to know. Okay.

MR. THADANI: Again, in '97, NRC funding level was 6.4 million and international funding provided to us was 2.5 million.

In fiscal year '98, our initial budget was $4.6 million and it looks to us like we will have about 1 million from international community. That's a very uncertain accident. But that's the information I wanted to provide to you.

CHAIRMAN JACKSON: Commissioner McGaffigan.

COMMISSIONER McGAFFIGAN: Provided by the international community? You mean, these are experiments that we participate in where others also participate and provide funds? No one is transferring funds to us.

MR. THADANI: No, some of it is actual transfer of

. 12

funds that we can use in this country to conduct work that helps the overall severe accident program.

COMMISSIONER McGAFFIGAN: How much is that as opposed to all of us participating in RASPLAN or something --

MR. ADER: If I can, the numbers that Ashok is citing for contributions, that's funding, actual funding contributed to the NRC for application to our severe accident programs, either codes, in some cases they are specific projects that we may be a bilateral with a country. But the majority of that is coming in under what we call the Cooperative Severe Accident Research Program, which is a number of bilateral --

CHAIRMAN JACKSON: It's actually dollars?

MR. ADER: That's actual dollars.

CHAIRMAN JACKSON: Right.

Why don't we do the following. We can't get into getting into all the details. Why don't you codify this information, if it is not already here at the Commission, just provide it and break it down because the focus here is to kind of understand where we are. We can take the dollars and decide that, you know, what has to happen. But it is important here for the Commission to understand what the program has accomplished, what questions have been answered, what issues have been closed out, what remains, you know,

. 13

how significant are they. And if you can answer it what ones need to be done here or by us versus our being able to get the information from somewhere else, then let's just leave the dollars aside because we can go back and forth and

I would rather you have the exact information to provide to the Commission, okay?

MR. THADANI: Thank you.

With that, we will go to Charlie to go through the severe accident portion.

MR. ADER: Thank you, Ashok.

If I can have slide 5, please?

As was mentioned, severe accident research program over the years has provided a lot of information, has really been key to our understanding of risks for plants out there in doing probability risk assessments and moving into risk-informed regulation.

As you mentioned, a number of issues have been closed. Mark I liner was one of the issues that was mentioned. I guess the fundamental question, why have we been doing the research and the obvious answer is that the risk studies, WASH 1400, NUREG 1150 and the IPEs continue to show that severe accident is where the risk is to the public. That is the dominant contributor. And the early containment failure, as has been mentioned, is of that contribution primarily early containment failure.

The understanding of severe accidents is going to be key and has been key in moving into the areas of risk-informed regulation. We have closed issues. Mark I liner was one of the containment performance improvement areas. At the time that the IPE program was started, there was not a real understanding of whether water addition would prevent a liner failure or not so licensees were holding back on accident management strategies, not sure to modify the plant to add water.

The program came to conclusions on -- you know, narrowed the uncertainties and had provided the information which was incorporated through a generic letter and through the IPE program to provide to licensees. They have subsequently been able to go forward in accident management with the strategy of adding water. DCH, which I will talk about in a minute, is another one of the key issues.

The experimental work or the severe accident program has really been a two-part. We have been trying to build the analytical capabilities, the codes to give the staff the capabilities to deal with issues as they arise, to resolve new issues that may come up and to respond to industry initiatives. In doing that, the experimental program has been important in providing data and information for validating the codes.

Where we are focusing now, we are trying to look

at some of the areas of remaining uncertainty and those that are the biggest risk contributors. A lot of the experiments are geared toward providing the data. We continue to need to assess the models and provide better analytical tools for the Commission, for the staff.

The long-term question that we have been facing for a number of years is how do we maintain this expertise available either in house, out of house or through bilateral agreements so we have access to information and have the capabilities to respond when we need it.

CHAIRMAN JACKSON: Let me ask you a question. I mean, in terms of your second, third, fourth and fifth bullets, basically, the middle ones, is our current understanding of severe accidents sufficient to support our moving to risk-informed regulation from a technical perspective? Or at least moving in certain directions along that path? Or is there, you know, a lot more additional work required either by us or others that we could draw on in order to support that?

MR. ADER: I think it has clearly provided the basis to move forward into risk-informed regulation. There will be areas that there are uncertainties in or estimates in. We will have to deal with those. It may mean that you cannot move as far as either industry or we might like because of residual uncertainties or remaining

. 16

uncertainties. There may be some areas that we may not be ready to make a decision. I mean, they are going to be case specific.

CHAIRMAN JACKSON: Case specific.

MR. SHERON: An example of that is the steam generator area, which you will hear about hopefully in about a month.

CHAIRMAN JACKSON: Okay.

MR. SHERON: Where we found when we did the analysis that there was a large uncertainty in terms of the tube failure likelihood and the approach we are taking is basically to ask the utilities on a case-specific basis they will have to analyze their plants.

CHAIRMAN JACKSON: Okay. Commissioner Diaz?

COMMISSIONER DIAZ: Yes, when you talk about uncertainties that are, you know, significant so we might not be able to move in an area, you're talking about an order of magnitude, a factor of two, or would you like to be -- what is uncertainty?

MR. ADER: It obviously is going to be situation and accident scenario specific. The uncertainty in the steam generator case that was mentioned, the initial judgment of that uncertainty was fairly high. The early numbers and analyses that were coming out were showing a very high likelihood of tube failure. That was an area that

. 17

we were able to build on our expertise and capabilities that we have today, refine the analysis, combine it with some of the material testing that was going on in a different part of research and provide information into NRR's regulatory analysis and narrow those uncertainties.

That one, it was more we were focusing on temperature, the temperature difference at which would lead to failure or not lead to failure. So it was not really an order of magnitude, it was just a few hundred degrees. But that was very key for that particular application.

MR. THADANI: If I may add to that, the key issue there was, in fact, temperature in the steam generator, hot gasses coming in, what temperature are we talking about. And that was a very sensitive parameter in terms of tube response. And the other factor that was critical also was the initial condition of the tubing material, if it had certain flaws, what type of flaws.

So there was -- there was the part here we're discussing in terms of severe accident research program was a thermal hydraulic aspects. The material aspects were dealt with through testing at Argonne National Laboratory. When I say "dealt with," at least we got better understanding of the material behavior.

Another example I could give you where we make clearly a very conservative assumption today, that if there

. 18

is substantial core damage has taken place, we assume the vessel will fail so the experiments were looking at trying to get information on geometry and heat transfer to see if in fact one can initiate accident management strategies, cooling the vessel from outside, downward heat transfer and so on to try to get better understanding of in fact could one maintain corium in vessel? I mean, it has two very significant things in my mind.

One is -- and I am not suggesting that we will end up with an answer that says, yes, indeed, one can maintain the damaged core in vessel. But the potential benefit is so significant, in terms of risk analysis, health effects and so on, because now even for severe accidents we can say we're not just relying on containment, we could maybe rely on pressure vessel itself as well.

COMMISSIONER DIAZ: Really, the direction of the question is I wonder if we would not serve the program and the NRC better if we wouldn't be talking of convergence of uncertainty rather than that uncertainty, per se. In other words, because of the difference in the phenomenology and the time-dependent processes, any one of these things will have significant uncertainties. I think what we are talking about is you perform analyses and experiments, you converge it to where you have a confidence and that uncertainty is within the bounds that you want.

Twenty percent, okay, would be a very good estimate of what direct containment heating is and therefore we can estimate within 20 percent we are probably right. So I think it is how we converge rather than what the uncertainty value is.

CHAIRMAN JACKSON: That was my understanding of what you were saying.

MR. ADER: Clearly. I will go back to Mark I liner. At the time that issue came up, the experts that looked at it said that even with water on a molten core, the liner will fail. Other experts said it will not fail. The central estimate was somewhere in between but it was a bimodal type of it will or will not and the research came to conclusions on that. So we can move forward.

COMMISSIONER DIAZ: So you had convergence.

MR. ADER: Convergence, yes.

CHAIRMAN JACKSON: Maybe, Mr. Cunningham, you have some edifying comments in this discussion.

MR. CUNNINGHAM: Well, Charlie used a good example in the BWR Mark I liner, that that was an issue back in NUREG 1150 that the experts, we owed and got information from a lot of experts and there was a good bit of difference of opinion in some cases and it showed dramatically in the risk measure of conditional probability of containment failure, given a core melt. And the research they have been

doing since then has really tackled that question directly.

CHAIRMAN JACKSON: I believe Commissioner McGaffigan had a question?

COMMISSIONER McGAFFIGAN: Could I ask, it is related to Commissioner Diaz's question in a way, but how do the uncertainties today that you are dealing with compare to what they were in the early 1980s? I am trying to prepare for hard questions about, you know, how much is enough, but were the uncertainties much greater several years ago and now we are working on marginal uncertainties compared to the large uncertainties there were when we started spending, whatever it was, 100 million plus in this area?

MR. ADER: The uncertainties in the '80s, surely, after TMI, were very large. We basically did not understand a lot of the phenomena. We did not understand how an accident would progress, what the challenges to containment were.

We are to the point that we have been able to incorporate it into risk studies. 1150 had an extensive process, it was an expert elicitation. And we have been able to move on and come to conclusions. Some of those have still had to be conservative and the question is, to the extent of conservatism, we may want to incorporate to account for these remaining areas. That is somewhat the question we are facing.

The other one is maintaining the expertise so we can respond. Severe accident codes, I will address a little bit, are very complicated codes. They are not something you can put on a shelf and when you need them you pull off, somebody reads a manual and runs them and really can give you a good understanding. So the other portion is how do we maintain that capability in the staff.

COMMISSIONER McGAFFIGAN: So this bullet, the fourth bullet, really should read, remaining internal work addresses areas of largest remaining uncertainty rather than implying that there is large uncertainty. Most of the uncertainties, the largest uncertainties at the start of the program have been whittled down.

MR. ADER: Correct.

COMMISSIONER McGAFFIGAN: Now we have some -- you are, of course, as you did at the start of the program, looking at the largest remaining uncertainties and trying to whittle those down?

MR. ADER: Correct. That was one I looked at that, after I had time to look at it at leisure, I said I would have -- there are a couple bullets I would have rewritten. You caught one of them. I may not tell you the others.

CHAIRMAN JACKSON: Well, do go on.

MR. ADER: Slide six, please.

The areas of emphasis that were covered in the Commission paper, and I will touch on each of these in the briefing. The codes I have mentioned, they are the key to the analytical tools for the staff. Direct containment heating has been mentioned. Most of these have been mentioned. Lower head, debris coolability.

Cooperative severe accidnet research program, I am going to jump right to the bottom, is kind of an umbrella program where we have been very active internationally. The U.S. program has been recognized for a long time as really the leader in severe accident research. Countries were coming to us for access to our information.

I will touch on each of these. I won't read the list.

CHAIRMAN JACKSON: Excuse me. Let me ask you a couple questions.

Were any of these severe accident issues dominant risk contributors in the IPE or IEEE in which containment failure was explicitly evaluated?

MR. ADER: DCA, direct containment heating, some of the IPEs have shown that as a contributor still. Fuel cooling interaction or steam explosions have been shown as contributors. In 1150, steam explosions and direct containment heating were contributors to the early containment failures.

Some of these areas, some of the research has been directed toward issue resolution like direct containment heating. Other areas of research, lower head integrity, desbris coolability, is really focusing on trying to assess the effectiveness of accident management strategies that could potentially remove our perception of challenges to containment as we have now. As Ashok said, we may not be able to totally remove them but they are showing some promise. But we are a little ways away.

CHAIRMAN JACKSON: How has risk analysis been used in the prioritization or sunsetting of severe accident research programs?

MR. ADER: DCH was one of the issues that came out of the draft 1150, early 1150. It was not a phenomena that was in NUREG -- or WASH 1400, as I remember it. So the risk studies and the perception back in late '80s, early '90s, was that was an area that was a challenge to early containment failure. The fuel/coolant interactions have been shown to be a contributor.

Now, albeit if you go back to 1150 and plants will meet the safety goals so they are not issues that we have gone out and said, you know, we don't have time to pursue and better understand. Generally, those are the areas that we focused the research on.

CHAIRMAN JACKSON: Are these in any kind of

priority order?

MR. ADER: I started to say that when asked that question before but cooperative severe accident research program is really kind of an umbrella type of program so I would not say that because it is the last thing it's the lowest priority. The codes clearly would be the top of the list and they are there for that reason. Direct containment heating, we are near resolution, hopefully near resolution on. Lower head integrity, desbris coolability, there is some order going down here but I wouldn't hold it as rigid.

CHAIRMAN JACKSON: See, the difficulty we have is this. The difficulty is, when you list out these topics, we don't have a sense, okay, of, to use Commissioner Diaz's terminology, how much the uncertainty has been narrowed. We don't have a sense of what things have shown up as dominant risk contributors in accident sequences or from IPE or IEEE considerations. And then once you've gotten that prioritization, that's why I asked the question about risk analysis being used to prioritize what we do. Once one has gotten that priority, then we don't have a sense of what's come to closure or what has narrowed the uncertainty to a point that we can live with it and what's still wide open, particularly what may be wide open higher up on the list.

I think this is what we are trying to get out of you and if you can tell us today, it would be useful for you

and useful for us. And I think that's really kind of what we need to know.

MR. THADANI: Yes, indeed. And I think as we go through the presentation, you will see some areas, for example hydrogen combustion area, what basically has been concluded.

CHAIRMAN JACKSON: Yes, but see, I want to know first what's most important. That's number one from a risk point of view. Does it vary with classes of plants, are they all equally important depending upon what classes of plants I look at or are there some that are clearly standouts. That's number one. Number two, given those, what degree of closure do we have by whatever measure, whether it is narrowing uncertainties or just, you know, sufficiently we understand how to manage it, et cetera? That's the way one has to go through here, otherwise it is topics that have come up within the context of the severe accident research program that may hark back to TMI or some other accident but it's not possible just sitting here to extract from that where is the risk, what degree of closure do we have and are there things that have been found out recently or phenomena from abroad that have called into question the degree of closure we think we have on these or have they given us more comfort that there is more closure than we might have expected? That is the kind of thing, I

think, it is important for the Commission to understand.

Then the last thing I wanted to ask you, which you may not be able to answer but, given there is a discussion within the context of plutonium disposition and discussion about renormalizing the source term, are there any subtleties there that come into play that would call into question our results relative to the rebaselining of the source term? I think it's very important.

So I don't know if you can tell us today or if you are going to put it in a paper but as much as you can tell us today I think is very important in terms of all these questions.

Commissioner Diaz.

COMMISSIONER DIAZ: Thank you, Chairman. That is just what I was going to point out. Maybe I can bring it back to when you were asked to give us a breakdown of the cost and things.

What I really think we need is really a three or four dimensional matrix that shows, you know, by emphasis, our understanding in this investment, you know, how is the emphasis correlated with the risk? How is it converged as a function of time to a value? And that will give us some priority.

MR. THADANI: Fine, I understand. I think we can address some of it today but not all.

CHAIRMAN JACKSON: I think you need to propagate something to the Commission that lays that out. I mean, otherwise -- and you should make it part of this paper that you have provided.

MR. THADANI: Yes, end of October, yes.

CHAIRMAN JACKSON: Commissioner McGaffigan?

COMMISSIONER McGAFFIGAN: Just a point of clarification. We are defining severe accident research here and we have a bunch of items under it.

My recollection when the budget was presented to us was that for some reason or other, hydrogen combustion was separate from severe accident and we made two different decisions on it in the context of the upcoming budget. There was a little piece of hydrogen combustion I thought back buried in this section. Am I wrong on that?

MR. THADANI: I believe it was part of the severe accident program but I better check with Charlie to be sure.

MR. ADER: At least from my perspective, hydrogen combustion has been part of it.

COMMISSIONER McGAFFIGAN: I may be forgetting.

The other thing, you know, you have this paper by the end of the month. By December, you have a much broader paper due to the Commission that was going to look at, I believe, 39 different technical areas that you had -- several of which are in the severe accident space and others

of which aren't, the majority of which. And you were going to use the matrix that you had given to us in the earlier paper that's out in the public domain and apply that to all the 39 areas.

Have you given any thought at all to the possibility of getting those two papers into better phase so that when we look at severe accident program, we can do it in a context? Or is that asking the impossible?

MR. THADANI: I will look into it but I would be surprised if, given, quite frankly, this morning, ACRS has asked for a meeting on November 4 to go over a number of issues related to research. They have asked some very good questions and he was telling me that it was going to be very difficult to meet on November 4 because we have so much on our plate that we have to do by the end of this month and early next month.

Given what he told me this morning, I am going to check with them but I believe it is going to be difficult.

MR. ADER: Let me move to slide 7. You asked the question of priority somewhat in what we need. There are issues of closure and there are issues of capability.

Severe accident codes bridges everything. It embodies the knowledge we have gained from years and years of research. With the exception of resolving a few issues, that's where we try to capture our understanding of severe

accidents. That's the analytical capabilities the agency would use in the future for dealing with issues as they come up, either risk informed or an issue like steam generator that came up that we need to deal with.

The codes are very involved, very complicated. There is a certain level of resources to have a capable code group available that -- I hate to put that in terms of closure and resolving an issue because that's just the fundamental -- I view it as a fundamental tool that we maintain.

CHAIRMAN JACKSON: How many NRC staff can, in fact, run, maintain or update the codes?

MR. ADER: Most of the code, the project managers I have, most of the code work is done at the national labs or maybe with some university support. Most of the project managers for the major codes, MELCOR several people can run it, VICTORIA -- I'm jumping ahead on the codes a little bit -- can run it.

Others have run the code in the past and more recently have been focusing on support for AP600 or something else and their capabilities have gotten a little rusty. We are trying to get back into the mode of being able to run and do the analysis work much more.

The modeling, we are much further away from being able to do the code development, the model development in

the severe accident codes because of the number of different areas.

CHAIRMAN JACKSON: So aside from some ability to run the codes, we basically are dependent on outside sources?

MR. ADER: Heavily dependent at this time.

CHAIRMAN JACKSON: But you developed a plan to migrate to in-house capability more and more, is that what you are telling me?

MR. ADER: We are trying to get more and more people and do more of the analysis in house. It has been a slow process due to competing demands and we really need on these codes to almost go away for a while and just work them and play with them and understand them.

MR. THADANI: My goal is very clear. It is the same here as we had in our thermal hydraulic analysis, core development analysis. The intention is to, in the long run, to make sure we can do the analysis, we can make the changes that are necessary to these codes. So that is the intention.

But we are not, as Charlie said, we are much further along in the thermal hydraulic codes than in severe accident codes in that area.

CHAIRMAN JACKSON: So have any of them been developed in house?

.   31

MR. ADER: No.

MR. THADANI: No.

CHAIRMAN JACKSON: How much of the work in this area -- and you can answer it later in terms of severe accident research more broadly -- have we committed to through bilateral agreements?

MR. ADER: The code work, we have one, one agreement, a code called GASFLO. It is a finite difference containment thermal hydraulic hydrogen distribution code. DOE is supporting it and FZK in Germany is supporting it. We are basically leveraging our resources at fairly low level to try to develop this as a tool that could be used in the future to replace or supplement the contained code which is the containment thermal hydraulics.

CHAIRMAN JACKSON: Okay.

MR. ADER: The other codes we are basically -- our contribution to the SESARP program that international countries are funding us to help develop the codes.

As far as running the codes, I will mention I had a discussion with my division director just this morning and he was telling me I need to really make sure we move this capability along. So I am getting that message loud and clear from several sources.

We currently are maintaining a two-tiered approach of the codes just through the capabilities. The MELCOR code

.   32

is an integrated code that will really cover from beginning to end of an accident. But not in the details of the SCDAP, RELAP and the contained code. Much more mechanistic and the capabilities are such that we can't put it all in one code at this time and have anything that really runs in a reasonable amount of time so we build on it.

Let me move on to a --

CHAIRMAN JACKSON: Let me ask you one quick and last question. How much access to experimental work is needed to keep the suite of codes current?

MR. ADER: You need the experimental work to assess the models that you are developing to take care of comments we've gotten from peer review processes or known weaknesses. Some of that is experiments that have been done but there are experiments going on worldwide and access to that dat is key to being able to move the codes forward and to improve them.

CHAIRMAN JACKSON: Do we have to be part of the groups experimentally in order to have access to the data?

MR. ADER: In most cases, yes. We need to either be a participant or have a cooperative agreement. A certain amount of access, we can get by just us having the codes to trade. Some of the programs, the FARO program, I will mention later and the RASPLAV, those are pretty much, you belong to get the information or it is not available.

If I could move to the next slide, 9?

The steam generator is an example of a recent issue. It started out as an aging issue, it became rapidly a severe accident concern. The concern being a tube could fail in a severe accident situation leading to a containment bypass, which is an early containment failure.

We used the SCDAP RELAP code both to provide the initial conditions for the material tests that were being done at Argonne and then to provide the test data coming out of the tube tests with the thermal hydraulic conditions to assess the likelihood or the probability of tube failure. This is a case where we built on the work that had been done for DCH. We had capabilities that we had put together through those studies that we were able to quickly turn around and access to respond to the needs of NRR. The MELCOR and VICTORIA codes were part of the analysis to look at the releases off site.

Move to slide 10.

Direct containment heating is an issue that came up in 1150. The concern that if the vessel failed at high pressure, the lower head would melt through, you would inject molten debris into the containment atmosphere, you would get rapid heat transfer and fail the containment due to overpressure and hydrogen combustion effects. From the draft 1150, here is an example. Here is a case where we

have narrowed uncertainties.

Even though the containment failure probability was low, the early failure was estimated to contribute 80 percent of the early fatality risks. The final NUREG 1150 partly because of the severe accident research and other issues that were looked at between draft and final, that estimate was 20 percent but it was still viewed to contribute 20 percent of the risk.

COMMISSIONER DIAZ: And directly what caused the reduction? What element was critical?

MR. ADER: From the severe accident end, the loading on the containment was not reduced that much but the assessment of the likelihood of failing another part of the primary circuit to depressurize, the hot leg failure based on a better understanding, a better assessment of the progression of a severe accident, lowered the probability of having DCH as an event that would challenge it.

At that point in time, the view was still that the loads could potentially fail the containment.

CHAIRMAN JACKSON: What is the range of early containment failure probability due to direct containment heating? What you have here is early fatality risk. I am interested in early containment failure probability.

MR. ADER: I don't remember the percentage from direct containment heating as opposed to bypass. I think

the steam explosion was also a load for -- Mark was more involved in 1150.

MR. CUNNINGHAM: I believe, thinking back for Surrey, it was conditional probability of early containment failure given a core melt, given all core melts, if you will. I believe DCH was a few percent, steam explosion was around -- let me back up. In the case of Zion, steam explosion was about the same amount, a few percent if you will, for the PWRs.

CHAIRMAN JACKSON: How much of our severe accident research has -- what's been the cross-feed between that and the IPE programs?

MR. THADANI: The generic letter that we issued and the guidance we gave the industry?

CHAIRMAN JACKSON: That's right.

MR. CUNNINGHAM: Going back though, the generic letter was issued in 1988 so we were still in the middle of finishing NUREG 1150. There was still a lot of this -- this change was still happening coincident with sending out the generic letter. So the -- I believe the licensees had the opportunity to make use of what was used -- what came out of 1150 in their programs to say, if I think my plant is sufficiently similar to Surrey or Zion, that I could use that as a basis to say I do or I don't have any severe accident vulnerabilities or a piece of the basis to see

whether or not I have any severe accident vulnerabilities.

Other plants went a somewhat different route. They went, I would say, beyond 1150 but considered other factors and weighed factors that weren't weighed so heavily in 1150, for example from the -- some of the industry programs that were perhaps a little more or less pessimistic if you will about the probabilities of some of these events. So you had -- it was kind of a mixed bag at that time.

CHAIRMAN JACKSON: So I mean, I guess I am trying to get some sense of how often what we get quantitatively out of our severe accident work and what comes out of the -- what has come out of the IPEs lineup with each other.

MR. ADER: Some of this, if I can, Mark, was timing. As Mark said, both DCH and liner melt through, when the IPE generic letter was put out, these were issues that there was not enough agreement on to really tell industry to analyze it based on these assumptions because there was such wide differences that these -- those two issues were kind of left to staff to resolve. It's been a couple years since I was directly involved with the IPE program but Mark I liner was an example.

I saw some IPEs where licensees took the 1150 assumptions, which showed a reasonable probability of liner melt through, even with water on top, and characterized their plant that way. Other licensees took advantage of the

research results that have been published around that same time and dismissed liner melt through referencing the NUREG CRs that we had issued and came up with a different perception.

DCH, I don't remember them picking the results quite as much because it has been more of an ongoing and more of a recent program drawing to conclusion.

MR. THADANI: Two points. Number one, that the industry analyses were basically utilizing the results of research at that time, generally, I think. And that is basically what we indicated in the generic communication to the industry.

The second part is the one that Charlie is talking about. There are some very significant issues in terms of early challenges. Liner melt through was one of those, where our understanding did change during that period and changed very significantly. At one time, people were talking about conditional probability being fairly close to one of liner melt through given core melt. And with accident management strategies and getting water in, in a reasonable type period, a certain amount, the conditional probability is fairly close to zero. We said something like 10 to the minus 3 or some very low conditional probability of containment failure.

What we are doing as followup to the IPE reviews,

this is one of the action items that we are looking at to make sure that we go back to those plants if they, in fact, have -- do they have the strategies in place, accident management. If not, why not. My understanding is that they have the strategy in place but that it is an issue of calculations but we are going to follow up as a result of that, one of the IPE followup issues.

MR. ADER: Slide 11, please.

I guess the bottom line on direct containment heating or close to the bottom line, we have completed the testing, we have completed a lot of the issue resolution for the Westinghouse large drys and subatmospheric plants. We would like to say that that issue now, DCH does not challenge those containments. So we can even that 20 percent to early fatality risk that was in 1150. We could eliminate that.

Now, I caveat that because I do need to mention we have a differing professional view in that we are reviewing if it is challenged or some of the analysis methods. So that came up just this summer and we are having to go back and look at that. If that had not come in, I wouldn't be able to tell you we have eliminated that challenge. Hopefully, we can still be to that point. We will have to wait and see.

CHAIRMAN JACKSON: So are you saying then that

there are no PWR containment types for which the direct containment heating is a threat?

MR. ADER: Well, the CE, B&W and the Westinghouse ice condensers, we are nearing resolution on. The results on the CE, B&W, they have a different cavity configuration is why they were separated out, is that DCH will still be for several plants a small challenge given the core melt, high pressure melt injection. But we have also gone back and revisited the likelihood of being in that situation and we are close, I think, to saying that we can resolve it for those plants without it being a serious challenge.

The ice condensers, because of their small size, there may be issues with hydrogen that even if DCH is eliminated, they have the problems with the hydrogen challenge resulting from the high pressure injection.

CHAIRMAN JACKSON: When you do this kind of analysis, you look at the kinds of things like the hole size of the reactor vessel and the composition of the melt and gas, et cetera?

MR. ADER: There are a number of what they call splinters where they will look at the amount of the corium, the content, metallic content versus acidic, looking at the hole size of the lower head, trying to characterize that. Potentially preexisting water in the cavity, preexisting hydrogen. So there are a number of issues that they will go

through.

We had a peer review group to help go through the experiments and the design and the issue resolution that will deal with, you know, have we considered the issues, have we considered a wide enough range.

I would mention we do have -- we have completed most of the experiments. We have a very small effort, two experiments remaining out at Sandia National Laboratories. That is a cooperative program with the French and the Germans. They have come to us based on some questions they had. We have some issues we are going to pursue. They wanted to take advantage of our expertise and our facilities and are sponsoring two-thirds and we are sponsoring the remaining one-third. They are paying two-thirds of these additional tests.

This whole program, hopefully, will be wrapped up mid- to late summer of next year.

COMMISSIONER DIAZ: You are talking about depressurization, you are talking about the primary? When you talk about depressurization, are you talking about the primary?

MR. ADER: Primary system, yes.

COMMISSIONER DIAZ: Just the primary. This does not include the possibility of dumping the steam into the condenser and have that mitigating actually the releases?

. 41

MR. ADER: No.

Slide 12.

Another fairly recent issue over the last several years is an issue of lower head integrity. Can we retain a molten core in vessel? The TMI vessel investigation project found a hot spot in the lower head of TMI. There was about 20 tons of molten material that was in the lower head. The analysis at the time said the lower head would have failed but it did not and they saw indications of some rapid cooling part way through.

The question is, can we understand that mechanism? Is there a way that we can go back and revisit the lower head and say, if you have water inside the vessel, you will not fail the lower head or what are the conditions.

Another part of this program is looking at can you cool the vessel from external flooding. AP-600 has proposed that as a management strategy. At least one IPE, as I remember, had proposed that. I think at the time they had proposed it, people weren't ready to entertain it because we didn't have the information.

The third piece of this program is, if you can't retain it in vessel, can you -- can we narrow the range of uncertainties in the failure size of the failure of the vessel because that is really a key to the subsequent phenomena in the containment, or can we confirm our

. 42

assumptions.

Go to slide 13.

CHAIRMAN JACKSON: What's the impact of not being able to -- I mean, so where do you stand on reducing that uncertainty further and what's the impact?

MR. ADER: Okay, this is somewhat of a two-part program. One is to just look at the uncertainty of the hole size, the failure. But right now the severe accident analysis assumes that you will melt through the lower head and you will fail, that you will disperse debris either high pressure or low pressure into the cavity. If it's in the lower cavity, you will eventually fail base mat through core-debris interactions or you will overpressurize the containment due to the heat and the gaseous products coming off. That's what is in the current risk assessments and those are the assumptions we have been dealing with. So those would continue.

The hope would be here that there is a mechanism that shows you can avoid those containment challenges. There may be a mechanism that you can retain it in vessel through appropriate accident management strategies. So there is a resolution and there is an accident management component.

To deal with this type of issue, there are a number of questions that need to be looked at.

Moving to slide 13.

Heat loads internal to the vessel, the heat removal external to the vessel, can we explain this mechanism of what happened at TMI, is there a gap that formed to get cooling in between. And then the program to look at the lower head failure.

The OECD RASPLAV is a cooperative program. I think there was a recent Commission paper during the summer about Phase II of this program to go forward with three additional tests under the sponsorship of the OECD. We were looking at the in-vessel mechanisms in a program in cooperation with EPRI and a couple international partners out at Fauske Associates out in Chicago.

We have had a program at Penn State that is looking at the heat removal external to a vessel, the boiling on an atmosphere. And then the program at Sandia National Laboratories is looking at the failure under pressure temperature loads, how it will fail. Here is a case where we are trying, again, to get data that we can use to validate the models to predict lower head failure.

Lower head failure experiments at Sandia is another example of a program where the international community has looked at what we have done and said, we are very interested in that. There was a meeting last week that a deputy division director was at, at OECD, and there still

seems to be considerable interest to proceed with this as an OECD project, assuming that we are able to participate. Those discussions will happen over the next several months.

Moving to slide 14.

MR. ADER: As I mentioned, if you cannot retain the corium in vessel, and it fails, then you have what is currently in the risk assessments of late failure, late containment failure through either base mat meltthrough or overpressure of the containment.

The program we're involved in dealing with this again, it's an EPRI-sponsored program, a number of international participants called the MACE program, Melt Attack Coolability Experiments out at Argonne National Laboratory. The last experiment was run in January using prototypic corium, actually UO2 materials. There was evidence of several cooling mechanisms, both failure of the crust, water ingression, and bulk cooling. Discussions are under way regarding the next test in this series.

CHAIRMAN JACKSON: I know that the EPRI utility requirements document contained a spreading criterion for debris coolability. How does that comport with what the actual experimental results show?

MR. ADER: The results at this point in time are -- give indications of cooling. They are not conclusive enough to conclude that you can or cannot cool.

MR. THADANI: Basically our view was that one could not really depend on the value in the EPRI requirements document, which I think was .02 meters squared per megawatt. So we did not --

CHAIRMAN JACKSON: How much per --

MR. THADANI: It was .02 meters squared per megawatt. I think that was the value. And given the available information, we couldn't say yes or no.

CHAIRMAN JACKSON: Okay.

MR. ADER: And this is another example of a program looking to assess the effectiveness of possible accident management strategies, and can we through something like this show that another what we perceive as a containment challenge is not going to happen, and eliminating another failure mechanism.

Slide 15.

Fuel coolant interactions. As we mentioned earlier, NUREG 1150, some of the IPs, especially some of the BWR, had steam explosions. Energetic fuel coolant interaction is one of the challenges to containment integrity. This is an area where the uncertainty in the understanding is still -- or the uncertainty is still large, the understanding is still not as good as some of the other areas. There's a lot of work going on internationally in this arena. We have been making progress trying to bound

and understand and eliminate some of the challenges. We have eliminated one of the major ones, but there are still the failures ex-vessel in a lower cavity that could challenge containment.

CHAIRMAN JACKSON: Is this going to require more elaborate coolant calculations?

MR. ADER: The codes for fuel coolant interaction are not very mature I guess would be the right term. It's not a very well understood phenomenon. Depending on which end you're coming from, some people say we understand it much better than we used to, but there's a lot we still don't understand as far as capabilities of predicting. The codes that you see, what's called international standard problems, where a number of countries, a number of codes, will try to reproduce experimental results, and you see some wide variations. They don't track as well as some of the thermal hydraulic codes, the containment temperatures, pressures, and others.

COMMISSIONER DICUS: It goes back to some of the questions that were asked very early on. I'm trying to prioritize what efforts are done, and with this particular one I'm looking at the bullet on Slide 15 in which you say steam explosions rupturing the reactor vessel and containment have been considered significant in risk assessments, and I guess my question is to define

significant, and in light of the fact you said this is also one of the areas where you still have a great deal of uncertainty. Does this mean this is one of the areas that needs to be emphasized?

MR. ADER: The significant, as Mark said earlier, the early failures for say example Surry were fairly low, and that plant met the safety goal. But the contributors to early failure, DCH was one of the major contributors, the steam explosion was one of the major contributors, bypass I think is by far probably the largest contributor. So to the extent that we're trying to eliminate or understand early containment failures, as they are the risks significant, it's one of the more dominant contributors to the extent that it's a large contributor to risk. When you put it in terms of the safety goal it becomes, you know, the probability of failure is low.

MR. THADANI: If I may say, maybe in different words, and I think this goes partially towards the question you raised, also, Chairman, and that is you see a list of these issues. I think what we should have done was to have broken down the list in probably three categories: one that leads to -- potentially could lead to early containment failure and fairly significant health effects. Second category would be it's an issue with late containment failure and unlikely to lead to significant health effects.

The third category would be capability to actually analyze accidents and what might happen or not. And that is one or two of the issues that you see on the list, core coolability, I think the -- debris coolability, I mean -- is more of a late containment type issue. So intuitively one would assign it lower priority because of the lower consequences associated with that.

We will try and put some metrics together to cover these issues and tie them to the status where we are.

COMMISSIONER DIAZ: Restating that, you know, this Commission is getting very concerned about the word "significant." We like to know what lies between zero and significant and what lies above significant.

MR. THADANI: Thank you. Good comment.

COMMISSIONER McGAFFIGAN: Could I --

CHAIRMAN JACKSON: Yes, please.

COMMISSIONER McGAFFIGAN: One of the problems in this area I think, and you can correct me, is getting experimental data can be either straightforward if it's a small-scale thing or impossible, you know, or wildly expensive if it's -- how many of these areas is it -- have you made a judgment that you and probably the rest of the world, EPRI, DOE, your international colleagues that it's just too expensive to narrow this uncertainty, it isn't worth the large expense that, you know, a large-scale

experiment would involve to get the data?

MR. ADER: I think core melt -- what was called a core melt progression was the most recent experimental program that we stopped funding a couple years ago in the U.S. You were getting into issues where you needed reactors, you were taking actual fuel, you were focusing -- the largest uncertainties were in the late phase of the core-melt progression, trying to understand what happened when you got a crucible of molten material that would fail and how that would interact. They were becoming basically prohibitively expensive, and we were finding we -- many of the issues like direct containment heating we were able to take kind of a bounding type of approach. We'd look at the extremes to deal with it. It was again, the value gained for the dollar, that was when we made a decision on it.

COMMISSIONER McGAFFIGAN: Are any of the ones we're talking about today in similar situations where, you know, you could conceive of very expensive experiments which aren't worth it, therefore you've been -- you're taking bounding approaches but you're never going to get perfection, or --

MR. ADER: For the other areas we've moved much more into the real cooperative where there's still a fair amount of interest internationally. We can leverage our resources. A number of these experiments we could not fund

. 50

and we would not fund ourselves if we can leverage resources, you know, $10 for $1 or something on that order. You know, in the past we've judged the value gained, has it been worth the expenditure. That's clearly something we'll revisit.

COMMISSIONER DIAZ: The issue in modeling is always the problem of internal heat generation versus a standard, you know, thermohydraulic model with external heat generation. Is that what causes the problem in your modeling?

MR. ADER: For the last phase there's questions of, as you melt the zirconium and the steel do you get a blockage down below, will you get a debris bed which will form on top of that, well, you know --

COMMISSIONER DIAZ: This configuration is not the internal heat generation. It's just giving you --

MR. ADER: It's not a question of decay heat, it's more, you know, the material interactions, natural circulation, where you fail through sidewall as they did at TMI or will it melt through.

CHAIRMAN JACKSON: Go on.

MR. ADER: Moving on to Slide 16.

Very briefly, fuel-coolant interaction was an area that one of the main failure modes, the steam explosion invessel that failed the upper head and failed containment,

. 51

which was a contributor in WASH-1400 and a contributor -- I will remove the word "significant" -- a contributor in NUREG-1150.

Research had progressed in that area enough for at least the experts to conclude that that was not a high risk. Here was a case of order of magnitude uncertainties. Earlier estimates were 10 to the minus 2, 10 to the minus 3, given a situation more recent experts went anywhere from 10 to the minus 3 to physically unreasonable. I am not sure what number I would put on that but it is small.

They also indicated we didn't have a good enough handle on looking at the impacts of steam explosions in the lower head that may fail the lower head and challenge it, or exvessel in a reactor cavity and here is a program, the FARO/KROTOS program is a cooperative program. It's European Commission or European Union funded program at ISPRA in Italy that's using prototypic material. We leveraged ourselves in and are a participant in that program.

Then we have a small program at the University of Wisconsin and a program at Argonne looking at some of the chemical augmentation impacts of fuel-coolant interaction.

Slide 17, please.

Source term research is an area that a lot has been done over the years. The level we have right now is, that we are sponsoring is really fairly small.

. 52

Source term refers to the magnitude, the timing, the chemical form of fission products released, commonly referred to as the source term, but the source term is where the consequences come from -- the fission release and that understanding.

There's activities ongoing in the regulatory sense in the re-baselining effort, taking all of that knowledge that had been built upon over the years, looking to move that into the licensing arena, taking the old TID 14-1844 source term which was a very simplistic source term and trying to make it a little bit more realistic. It's still kind of a composite of severe accident sequences.

The main program ongoing internationally that we participate in is the PHEBUS program in France at Cadurache. Commissioner Diaz, I believe you have visited that recently.

We are supporting them or they are actually coming to some of our experts at Sandia to help them design the experiments and analyze the experiments.

This is more of a confirmatory program and it is confirming our understandings, but here is a program that three years ago, I believe, right when we were getting ready to issue NUREG-1465, the revised source term, there were some preliminary results that came out of PHEBUS that were announced at a press conference that said our understanding of iodine releases is different than what we were getting

53

ready to publish. If we had not been a participant of that -- I mean some of the people in the Branch sat in Ashok's office when he was at NRR -- and tried to assure him why we could go forward and issue the NUREG.

It was their expectations of iodine release that the numbers they got were much larger. They were within the range of what we had assumed but when they saw they were getting some elemental iodine as opposed to what they viewed as no iodine, this was -- I don't remember whether it was significant or unexpected -- but by being a participant we were able to react to it and move on.

CHAIRMAN JACKSON: Does using other than uranium oxide fuel change anything?

MR. ADER: There have been questions. We have not looked at the MOX question. There have been questions on high burnup fuel that we were planning on trying to go back and revisit over the next year or two, looking at either past experiments.

There are some proposed experiments in Japan and potentially in France that may look at the higher burnups that we would, our plan would be to get access to that and fold that in to what we would be doing.

CHAIRMAN JACKSON: Higher burnups of UO2, base field.

MR. ADER: UO2, correct.

54

CHAIRMAN JACKSON: No issues with MOX? I mean what are the French doing with that? They use the MOX.

MR. ADER: I'm not sure what they have done. They have a program called VERCOR and I would have to go back to look to see if they have had MOX in there.

It is an issue we have not been focusing on here recently.

CHAIRMAN JACKSON: Well, the reason I asked is it is a question that has been put to me in a number of fora relative to our support of it, what we might do vis-v-vis the use of MOX fuel in a plutonium disposition program, and so, you know, I mean is it not an issue?

MR. THADANI: I think we just looked back to see if Tom King was there.

CHAIRMAN JACKSON: He is there.

MR. THADANI: I think he's there, and my understanding is we are looking at the issue.

I am not sure we can answer the question.

CHAIRMAN JACKSON: Tom, what can you say?

MR. KING: This is Tom King from Research.

I know the French and the Japanese are doing extensive test programs with MOX. We have looked into what they are doing on reactivity insertion events and basic fuel performance.

We have not at this point looked into their source

term activities related to MOX but that is something we will do as part of gathering information on MOX fuel, so I can't answer your specific question but I know that they do have extensive test programs.

CHAIRMAN JACKSON: Okay. How interested is the industry in using the revised source term for design basis accidents?

You said that it is being requested by operating plants, but how much interest is there?

MR. ADER: My sense is there has been a fair amount of interest. I think NRR has been a little closer to dealing with the licensees.

MR. SHERON: My understanding is that there are several plants that are very interested in using it.

MR. THADANI: And having had some discussions during Reg Information Conference, where we had break-out sessions on source term, by the number of utilities attending and having dialogue, I would say there was a fair amount of interest.

MR. ADER: Slide 18, please.

Hydrogen combustion is an area -- hydrogen has been considered a threat to containment. Plants have been inerted -- MARK Is, MARK IIs. Igniters have been installed on the ice condensers in the MARK IIIs.

I think the belief is that the threat to the large

drives is hydrogen and the global combustion has not been a threat.

Here was an area that some of the test program at high temperature at Brookhaven and the larger scale tests in the Russian Research Center RUT facility.

We are trying to confirm some of the understanding and narrow some of the uncertainties.

The new issue in hydrogen that has come up is the use of passive autocatalytic recombiners for combustion control for design base accidents. They have been proposed on AP-600.

There is a lot of activity internationally to use what is called PARS, so there's active research programs there with the activity -- I don't know if it is from AP-600 or internationally but at least one utility has, I understand, has expressed interest in replacing some of their design base recombiners with passive autocatalytic recombiners.

I have been asked by others whether this is something we are accepting, and whether that means there is wide industry interest or limited industry interest I would not care to venture, but that is the new issue, where we are not trying to narrow uncertainties.

We are trying to understand the performance of the PARS, understand the issues that are involved in someone

using them as far as the mixing, the depletion rates, the performance, whether they could ignite hydrogen in a severe accident scenario even though they are being used in a design base accident scenario, to try to provide at least the knowledge base to NRR to deal with applicants or utilities that propose to use them, so again it is not a narrowing of uncertainties but it is trying to deal with the issue.

CHAIRMAN JACKSON: When do you expect to actually complete these experiments at Brookhaven and the Russian?

MR. ADER: The experiments at Brookhaven are months away in the Spring, late Spring, although there had been interest by the Koreans to extend that experimental program to try to do some of the experiments that we were not going to do because -- and he was another area I think funding -- we had kind of chopped the program and they wanted to continue the matrix, so they were looking to either jointly or maybe fund part of it.

The Russian research was really over this year, although I think they were delayed a little bit, so it would be extending into the early part of next year.

The program at Cal Tech was a very small program, trying to maintain just some capabilities in that area, for a small amount to increase their knowledge incrementally.

The power testing we hope to be done with by

mid-summer unless new issues come up or NRR has new needs in the area.

Finally, the Cooperative Severe Accident Research Program, as I mentioned, is an umbrella program. We have roughly 19 countries. There are several that are renegotiating to renew. There are some other countries -- South Africa is one that has expressed interest, I think Argentina is in the process of joining Brazil and Mexico have discussed potential membership, so the membership could go up or down depending on the renewals of some of the current members.

We have a meeting next Thursday, the day after the water reactor safety meeting. We have a one-week meeting in the spring and we have a one-day meeting in the fall, just to try to give them the status of our program, so there will be a number of international participants at that meeting.

This program, as I mentioned earlier, is bilateral arrangements. We get in-kind and funding through our program.

COMMISSIONER DIAZ: Is it ongoing? Do we know how many years are our agreements?

MR. ADER: I think originally it was a program that got started and had maybe a three-year renewal. The countries have come back and some have renewed for five years. Some have delayed renewal for a year and then they

renew for three, so they have started to get staggered.

That completes the briefing on severe accidents.

MR. CUNNINGHAM: The next five slides cover the IPEEE program and we hadn't intended to cover IPE specifically in these but perhaps this is a good time to go back and address the issue of closure on IPEs that Chairman Jackson asked earlier.

With respect to the IPE program, I think we defined closure accomplishing two things. First, we reviewed all of the submittals that came in from the licensees. There were 75 submittals. All but three of those are now done. We expect two of the remaining three will probably be done by the end of next year. We have one last one that is kind of dragging out a little bit. So we have looked at the individual submittals from the licensees.

We also have gone back and tried to look broadly at all of the submittals to see what they would tell us about perspectives from the frequencies of different types of core damaging accidents, are the generic issues that have been identified coming out of the program either -- are there generic issues that have been resolved or are there new ones coming up and that type of thing.

All of that type of general discussion has been embodied in the draft NUREG that we sent out about a year ago, NUREG 1560. The title was something like perspectives

on IPE programs or something like that. That was sent out last year. We had public comment on that, we had a public workshop in April I believe and now we are just finishing the final version of that document and it's coming, parts of it are coming up to the Commission as part of the quarterly update of the implementation, PRA implementation plan.

So between those two pieces, I think that is how we defined closure for that program. Individual reviews and then a generic look at everything. All of these submittals.

Now, there will be some items that Ashok mentioned earlier, what we call IPE followup actions, that are going to be tracked in the implementation plan that are specific items to either follow up on some generic issues that didn't seem to quite get addressed completely, to do some audits of the improvements that licensees said they were going to make to see if in fact they did make them and that type of thing. So there will be a few items like that but, by in large, we are not calling that necessarily the rest of the IPE program, they are just followup items.

So with that, I will turn to the IPEEE program. Supplement four to generic letter 8820 requested licensees to extend their IPEs out to consider plant-specific severe accident vulnerabilities that were initiated by what we call external events. That includes earthquakes, high winds, tornadoes, that type of thing, external flooding, floods to

the plant, and fires that are internal to the plant which, for a long legacy of bad reasoning is called an external event.

At any rate, supplement four was issued in 1991. Since then, licensees have been extending their IPEs to consider these other initiators. The last of those is due in in June of next year. We've gotten 63 so far, actually 64 as of today, and we've got about 50 of those under review. Our goal now is to have the reviews completed by June of 1999.

In parallel with that, we have been developing what we call the IPEEE insights report, kind of the analog to what I talked about a few minutes ago as NUREG 1560. We have an interim report due to the Commission in November that will cover what we've seen from the first 24 submittals. And the rest of the slides I have today are giving you a hint of what you will see in November in more detail.

Slide 22, please.

As we saw in the IPE program, most of the plants in the IPEEE program have proposed or identified and proposed and have made or are making improvements to their plant to deal with the not so much vulnerabilities but the core damage sequences that they see there, either initiated by seismic events or fires or others.

In the area of seismic, they are doing such thing as improving the anchoring of equipment such as motor control centers and that type of thing. They are going through and trying to pick up on certain relays that have been found to chatter, what's called chatter, in earthquakes and replace those types of relays, other things like that. Not major changes to their design but places where they, for relatively low cost, can improve the design.

Likewise, in fire, they are finding cables that they can move to other places to reduce the vulnerability to common cause failure of redundant cabling or something like that, improving their procedures. Getting portable equipment to cope better with fires and that type of thing.

Slide 23.

There are also a few things coming up in terms of plant improvements related to the other what we call the HFOs, the other type of external events. Most of the emphasis in IPEEE has really been on the seismic and the fire because people -- that's where people have seen significant core damage frequencies. HFOs are in there also. We have seen a few things such as people building up and improving the stacks on fossil units that happen to be adjacent to the nuclear units and that type of thing.

Out of this, out of the ones we have looked at so far, only two plants have identified vulnerabilities.

Again, in IPEs, IPEEEs as well as IPEs, we didn't come in and say here is the definition of vulnerability. The plants were allowed to define for themselves what vulnerability meant. At any rate, it was intended to be something that would be a fairly high scenario or a problem in the plant that had a fairly high associated core damage frequency.

Haddam Neck identified a seismic vulnerability related to some of the capacities of some of the equipment to take -- to -- or the capacity to perform in big earthquakes or not perform as the case may be. And Quad Cities identified a fire vulnerability. This is relating to fires in the turbine building either oil initiated, lube oil initiated or electrically initiated.

Some of the contributors to the vulnerability was the lack of separation of some redundant cabling in divisions. A reliance on equipment in the other unit to help shut down the plant during a fire and very much related to that a very complex, human-intensive way of having to shut the plant down safely in the event of certain fires. So it led to what they defined as a vulnerability.

They came to the staff in I believe February or March of last year. The licensee has identified three things, three programs, one of which they have initiated and two others they are working on now to reduce the core damage frequency from this fire vulnerability and to make the whole

process of coping with fire simpler in their plant.

Slide 24, please.

From a methods standpoint or an overall core damage frequency assessment standpoint, it is a little harder to say what we are saying from the IPEEEs relative to the IPEs because there is a greater variability in the methods that are being used to estimate the frequency, core damage frequencies from fires and earthquakes. So you see, it's a more complicated thing and some of the -- it's harder to compare something that was done with a five analysis, the EPRI-developed five method versus a standard PRA. So it is much more complicated in that respect.

However, we are seeing what we kind of expected to see, that we do have significant core damage frequencies coming from earthquake-initiated accidents and fire-initiated accidents. So it is kind of a confirmation of what led us to issue supplement four to the generic letter.

MR. THADANI: Bob?

MR. PALLA: Yes, okay. I wanted to talk about the status of the accident management program.

NRC has worked cooperatively with industry since 1988 to develop guidance and strategies to respond to severe accidents. This effort has involved NEI, the owners group for each reactor design, INPO and EPRI. The efforts

culminated in generic severe accident management guidelines for each reactor design and related training materials and this, these guidelines embody many of the strategies that you've heard discussed a few moments ago such as depressurizing the reactor coolant system to avoid DCH and temperature-induced steam generator tube rupture, flooding the reactor cavity to try to enhance the potential for retaining core debris in vessel and preventing core/concrete interactions and adding water to the dry well of Mark I containments to prevent liner melt through.

These severe accident guidance, in effect, extends the scope of emergency guidance beyond the design basis in the current EOPs into the severe fuel damage regimes. The integration of these insights into each licensee's emergency response organization is the focus of the accident management program. Key elements of the program consist of preparing plant-specific severe accident management guidance and procedures. Training operators, technical support staff and managers in the guidance and procedures and maintaining accident management capabilities through periodic drills and refresher training.

Industry implementation is proceeding pursuant to a voluntary industry initiative. Commitments and schedules for completing implementation have been provided by each licensee on their dockets and approximately a third of the

sites will complete implementation by the end of this year. The balance of sites will complete implementation by the end of 1998.

COMMISSIONER DIAZ: You say voluntary?

MR. PALLA: The mechanism is one that NEI has undertaken. It involves the consent of 80 percent or more of their members. All of the industry's utilities are members. And approval of basically what they call a formal industry position, which articulates what they are committing to do. They brought this issue through that process and committed to undertake a course of action in this regard.

COMMISSIONER DIAZ: And that's where it is. Because I understood that voluntary was the other one in which they did not obtain 80 percent approval. This is, when they generate 80 percent approval is recommended action.

MR. THADANI: That's right. This is what I believe they call a binding initiative on the part of NEI and they have agreement and all licensees are going to implement accident management.

CHAIRMAN JACKSON: I think you meant voluntary, if I can paraphrase you, in the context that it was not done pursuant to a regulatory requirement.

MR. PALLA: Correct.

CHAIRMAN JACKSON: And that's the difference. When he says "voluntary," he means it is not pursuant to a regulatory requirement. How industry organizes the response and what's voluntary and what's not within that context is a separate issue and that is what you were speaking to.

MR. PALLA: Slide 27.

The status of the programs.

In SECY 97-132, the staff outlined plans to assure the adequacy of licensee implementation and confirmed that licensee commitments have been met. This process involves information gathering visits at a number of plants, the completion of a temporary instruction for guiding an inspection of the implementation, pilot inspections for a limited number of plants and, finally, an inspection of accident management implementation at the remaining plants.

Toward the first step of better understanding the nature and status of industry activities to implement accident management, NRC staff participated in industry-sponsored public workshop on accident management implementation in March of this year and this was an industry forum on issues that have been -- have arisen as licensees proceed to implement the programs. It gave us an opportunity to hear first hand of the plant-specific approaches that are being used and some of the issues that licensees are encountering as they implement.

On the second item, we subsequently participated in accident management demonstration visits at two plants. These demonstration visits were organized by NEI and hosted by licensees whose implementation activities were substantially complete. Comanche Peak and North Anna were the two plans that volunteered for this, both being Westinghouse plants.

The demonstration visits included two key ingredients. The first was an overview of licensee activities to develop and implement their plant specific guidance and the related training materials and how that training was administered to the various cadre of staff because training that we are talking about is -- it is commensurate with responsibilities in a severe accident. There is some training for the licensed operators. There is proportionally more training, for PWRs, more training for technical support staff, people that would be relied on to make the assessments and provide recommendations. And then there is some training also given to decisionmakers. So this training is parsed out in a way that is an attempt to be commensurate with responsibilities using a systematic approach to training.

These demonstration visits are kind of the next step for bringing us up the learning curve to better understanding what is this industry effort actually

producing. The third item, we are continuing to monitor licensee implementation and to interact with NEI to address implementation issues.

Our interactions with industry remain principally through NEI. We have some interactions with the BWR Owners Group, as I will mention in a moment, with regard to review of the severe accident guidance for BWRs but principally we are working with NEI at this point in the program.

Let me just go to slide 28.

A key remaining action is to complete the review of the boiling water reactor, what's called the emergency procedure and severe accident guidelines. These guidelines will, when implemented, essentially supersede emergency procedure guidelines, REV 4, that is currently in place. Fundamentally, the emergency procedure and severe accident guidelines are the same as the emergency procedure guidelines REV 4 with regard to the earlier parts of the procedure but what the Owners Group has done is develop the transition point in which -- beyond that, they have provided additional information on severe accident guidelines. They have basically created a two-part document that consists of basically the EPGs as we know them today and then they connect up to the severe accident guidelines where additional information on severe accidents is contained.

The BWR Owners Group submitted REV 0 of the

emergency procedure and severe accident guidelines in August of 1996 and a high level audit type review is still under way. We expect to complete this review in early 1998.

On the second item, we also plan to conduct -- we had two demonstration visits. These both involved Westinghouse plants. We intend to conduct several additional accident management demonstrations for combustion engineering, B&W and BWR plants. These demonstration visits are considered necessary since the generic materials that licensees for these designs are provided are different in many regards. The training materials similarly have basically gone to different levels of sophistication and detail. So we want to get out there and see what the implementation looks like at the CE, B&W and BWRs to get a good overview of the industry as a whole, rather than being fixated on just Westinghouse plants. We know there are a lot of other plants out there.

We anticipate that these visits will occur in late 1997 and will wrap into early 1998.

The last bullet regarding inspections of the plants, implementation. We plan to confirm the adequacy of licensee accident management implementation. As mentioned in SECY 97-132. Following completion of the demonstration visits, we will reassess the planned inspection approach and refocus that as necessary, if necessary. We would then

follow through with whatever inspection scope is deemed appropriate.

We anticipate that the inspections will be completed in the year 2000. Of course, this is dependent on resources to pursue it.

That basically concludes my comments.

CHAIRMAN JACKSON: Thank you very much.

Commissioner Dicus.

COMMISSIONER DICUS: Yes, just one question.

Recognizing, of course, that FEMA doesn't have any responsibility for the plants, that's our responsibility, but in light of what we are doing in discussing here with accident management and because it does have, and in source term as well, off-site, potential off-site implications, have we discussed this at all with FEMA, do you know? You may not be the right person for me to ask. I was just curious.

CHAIRMAN JACKSON: The question is on the table.

MR. THADANI: I don't know the answer but we will get the answer.

CHAIRMAN JACKSON: Commissioner Diaz?

COMMISSIONER DIAZ: Yes. Just trying to put these things together, it just occurred to me that you started with kind of a defense of the severe accident program and I think that might need to be addressed.

What I keep hearing as a theme is that whatever you do you are actually ending up with some accident management guidelines, directives, scenarios, that can be put in practical terms to mitigate the consequences of accidents. And I think that's an important component of what this program should be achieving and it should be really kind of a bottom line of why the program exists because there is no regulatory basis for it, but it is a practical side in utilizing these things.

In fact, I might just mention one because I still at heart am an old mechanical engineer. Quoting, you know, something you said several times, this is a variety of cooling mechanisms that you always find. I would say that you would always find them in whatever you do in the plant, because there is no way to have anything that is hot that won't get cool and many times we just focus on a specific cooling mechanism but all the others are there.

You should leverage this knowledge and this information that has come out of these programs to apply them into many other areas that actually need to have updated models and things and I think you are doing yourself and maybe the Commission a disservice by narrowly looking at how the information is used for the severe accidents.

You are actually doing a great job in applying them in accident scenarios. I would say there is a lesson

in there that is broader than just the severe accident.

CHAIRMAN JACKSON: Well, thank you very much for a very informative briefing on the NRC's severe accident research program. In fact, I believe the staff should be commended for your efforts to date and your accomplishments as well as your international leadership in this area. I do want to emphasize the importance of establishing a clear criteria for bringing the remaining programs to closure and the Commission will look for this information and the other information that has been asked for in the course of the briefing, particularly relative to prioritization as an aid in decisionmaking.

But, having said that, I would also stress the continuing importance of engaging the international community in the analytical and experimental programs of when there is mutual benefit because it does allow the kind of leveraging that you have talked about.

So unless there are any further comments or questions, we're adjourned.

Thank you.

[Whereupon, at 2:51 p.m., the briefing was concluded.]