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NUCLEAR REGULATORY COMMISSION

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Briefing on Accident Source
Term Reassessment

(Public Meeting)

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D I S C L A I M E R

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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BRIEFING ON ACCIDENT SOURCE TERM REASSESSMENT

- - -

PUBLIC MEETING

Room 1130

1717 H Street, N.W.

Washington, D.C.

Wednesday, July 24, 1985

The Commission met, pursuant to notice, at 10:05 a.m.

COMMISSIONERS PRESENT:

NUNZIO J. PALLADINO, Chairman of the Commission

THOMAS M. ROBERTS, Commissioner

FREDERICK M. BERNTHAL, Commissioner

JAMES K. ASSELSTINE, Commissioner

LANDO W. ZECH, Jr., Commissioner

STAFF AND PRESENTERS SEATED AT COMMISSION TABLE:

H. PLAINE, General Counsel

S. CHILK, Secretary

W. DIRCKS, EDO

H. DENTON, NRR

D. ROSS, OR

J. MITCHELL, ASTPO

M. SILBERBERG, ASTPO

AUDIENCE SPEAKERS:

None

* * *

P R O C E E D I N G S

CHAIRMAN PALLADINO. Good morning, ladies and gentlemen. We have with us today representatives from the Staff to discuss the present status of the Staff source term assessment, and anticipated future source term program actions. Work on source terms has been a long-range and multi-pronged effort. We have had previous public discussions with representatives of the Atomic Industrial Forum, the American Nuclear Society, the American Physical Society, interested groups and NRC Staff, the most recent being the discussions with industry and non-industry groups on April 3, 1985.

Today's discussion with the Staff will focus on the present status and anticipated future actions with respect to the Staff's forthcoming Source Term Technology Report, NUREG-0956, which is to assess the extensive body of new information with respect to the validity and potential applicability of this information to the regulatory process.

We had originally hoped that NUREG-0956, together with a companion paper, would be issued for public comment by June of this year, but the work has been delayed and we look forward to getting a better feel of what the schedule is now.

Of particular interest to the Commission in today's meetings are the advances which have been made in the improvement of the source term, computer model and the present

Staff thoughts on the development of a methodology for application of current source term data to specific cases.

If my fellow commissioners agree, I would like to spend the last 10 minutes or so of today's meeting discussing the amount of work remaining to be done and the Staff's schedule. A clear understanding of critical issues and the prioritization being afforded to them would be very worthwhile.

I understand that Region II has requested to listen by telephone, and I understand they are connected.

Do any of my fellow commissioners have any additional opening remarks? I should point out that Commissioner Asselstine will be joining us but he was delayed and asked us to start without him.

Any other comments?

COMMISSIONER ROBERTS: No.

COMMISSIONER ZECH: No.

COMMISSIONER BERNTHAL: No.

CHAIRMAN PALLADINO: Well then, let me turn the meeting over to Mr. Dircks.

MR. DIRCKS: I would point out, Mr. Chairman, this is a discussion of where we are in source term reassessment; it is not a reassessment of source terms today.

Denny Ross is going to do most of the talking. Harold Denton is here to answer questions, but we are not

ready to talk about the regulatory implications of this work, and that won't be until sometime probably in the spring of next year.

Denny?

[Slide.]

MR. ROSS: We have slide number 1. The material that we'll discuss today is a work product of the Accident Source Term Program Office which was set up a couple of years ago for this purpose.

I also will note that since Region II is listening in, I am taking this more detailed presentation to Region II and Region IV next week. I have been to Region I about six weeks ago discussing source term, and I will be visiting Regions III and V in the near future so they will all be fully informed of where we are, and more importantly, where we are going to go.

[Commissioner Asselstine enters the meeting.]

[Slide.]

MR. ROSS: We showed this same slide to the Commission in our last briefing. Since then, we have made some progress that I'd like to discuss briefly.

On the slide there are sort of rectangles that discuss various work products, either of our contractors or special works formed for this purpose. The last item in the lefthand column is, of course, the APS Review. All six of

these items are now complete. The last of the documents are either published or going to the Public Document Room and printer this month.

Where we are today is the circle in the middle of the chart labeled NUREG-0956. We expect to send that to the printer next week, probably about Tuesday or Wednesday, and there should be many hundreds of copies available about seven days later.

We are, as Mr. Dircks said, starting the work on regulatory applications. A very important ingredient is the circle at the bottom of the chart marked "Severe Accident Risk Reduction Program," where we apply the methods of the source term code suite, as we call it, to five reference plants. And we will be recomputing the accident frequencies as well as the accident source terms for these frequencies, and a convolution of these items would produce the rebaselining risk.

That information then feeds across the dotted line to the righthand side of the graph, which is in general the 1986 work and it is the applications in the regulatory arena. That work will be discussed in the future.

We regard what we have here today, NUREG-0956, as basically a science and engineering report. There's some brief discussion of risk insights but it's fundamentally a description of the new source term methodology.

We have labeled the "Severe Accident Risk

Rebaselining Report" as NUREG-1150, although we haven't yet written the first world. We use that as a catch-all so that we can describe our work. And I expect we will be prepared to discuss progress on that in probably three or four months.

COMMISSIONER BERNTHAL: Denny, can you give us a milestone date for these two? Maybe you're planning to do tha at some later point here, but exactly when do you expect to have NUREG-0956 out? I know that that's very close, I guess, to being out, but then what about these further milestones?

MR. ROSS: Okay. August 7th is the nominal coming out of the printer's date for NUREG-0956. And two points on that. First, we have ordered a large number of copies and we expect to have an extensive mailing list. And we will be emphasizing, hopefully, or re-emphasizing this is being issued for comment, and we are envisioning -- we'll publish a Federal Register notice, and of course, we have an extensive mailing list already.

We would envision a 90-day comment period, and then after analysis of the comments, then we would probably reissue that in final form, say, the first of next year.

The bottom circle, Severe Accident Risk Reduction Program, which I call NUREG-1150, is scheduled to be -- it's an essential ingredient to NRR and the technical results will be given to them as they accrue in a linear fashion, starting probably September and October. The report itself in draft

form would also go out for comment, I'd estimate on the order of March or April 1986. However, NRR will have the material for its auditing purposes earlier.

Now we have a very detailed milestone schedule for that work, but that is small increments of work. We do plants one or two at a time, and then the work comes out one or two plants at a time.

COMMISSIONER BERNTHAL: I guess my concern is that I think originally, -- it sounds like we're already a year behind from where we wanted to be at this point on the 1150 effort, and I'm sure there are good reasons for that. But your slide makes it graphically evident that the bottleneck is going to be these two documents before we can move ahead with things that we need to do on the regulatory front. And that's why I'm concerned that we be able to meet some kind of deadline here for 1150.

MR. ROSS: Well, that's not quite the case, Commissioner Bernthal. The regulatory intent -- and this is fully consistent with the Severe Accident Policy Statement -- is to have available what we call the individual plant methodology. These five plant are nothing more than an audit.

The industry, through IDCOR, is developing its individual plant methodology. They also are doing several reference plants, and they are just at the point -- in fact, they're meeting this very day on this topic -- of trying to

approve a proposal for how to analyze specifically each plant in a systems role, how you can extrapolate or do additional calculations or whatever is needed to justify the generic extension.

We have looked at the work in a very brief fashion last week. It looks very promising. They have yet to agree that that's the right formula, they have yet to test it. They don't expect to tender it to Licensing until early next year as their proposal for individual plant analysis.

What Harold needs is our five calculations for audit purposes, and woven throughout this is working with IDCOR to get consensus or agreement or, if necessary, imposition of a regulatory solution on each of the technical issues.

So it's a close race. But I don't regard our work as pacing. I think both the NRC and IDCOR are working very hard for the start in the spring of 1986 of doing what was called out in the last few pages, pages 15 and 16 of the Severe Accident Policy Statement. That is, doing each specific plant for vulnerabilities that might be peculiar to that plant. I don't think we're pacing, but it's close.

MR. DIRCKS: Well, you are right in a way. Last year there was heady optimism about this whole thing, that we were going to move through this like a hot knife through butter, and I think that was conveyed by many people on the outside.

We have reached the Promised Land -- there are going to be factors of 10 reductions, the source term was going to be reduced.

COMMISSIONER ASSELSTINE: In fact, we got a letter from Warren Owens urging that very point not very long ago. So the ardor doesn't seem to have worn off.

MR. DIRCKS: Well, I think as we've moved into it, we're not alone. I think the industry group, the IDCOR, has confirmed much of the complexity that people were predicting sometime ago. I think we've seen in almost every major nuclear country in the world the same cautious progress. I've seen work coming out of the OECD, CS&I work, and almost you can see this curve decreasing as they get into this science.

We saw the indication of it with the American Physical Society report that said wait a minute, you've got some uncertainties here, you've got to go back and look at plant-specific data. And I think if anything, that's been a major factor here. And the containment performance is the other major factor.

So we can move on the methodology, but when you get back into getting the results out, you're going to go almost plant by plant. And I think this is where we are today.

COMMISSIONER BERNTHAL: Well, I don't want to leave the impression here that I want to rush into something that doesn't have supporting data. My concern is that we have a

structured, coherent, milestoned program that gets us where we want to go and allows us to keep our eye on the ball.

I guess a good point in relation to that to be mentioned as well -- and I hope we'll discuss this a bit more as we go along here -- is how many of these specific issues that APS and others have pinpointed as being fundamental questions that are still attached to source term research do we have some sort of reasonable assessment on? How long is it going to take now to carry out the recommendations of the study group, of the distinguished study group, that studied the steam explosion issue some months ago and came to a conclusion? Do we have a program laid out that will get at the answers for that?

A similar question can be asked about core-concrete interaction, and a similar question can be asked about the so-called direct heating effect, I guess -- you guys know more about this than I do, the atomization of core and all that stuff. And how many other things like that are there. And have we got some sort of timetable laid out, have we got a program to review so that we know where we're going with this stuff and it gets done?

MR. DIRCKS: Okay. I think you've laid out the basic questions. I think as we move through the briefing we can hit most of them, and then if we don't hit them let's go back and take them up one at a time.

CHAIRMAN PALLADINO: As long as we have interrupted, in considering the relationship between NUREG-0956 and NUREG-1150, one can't help but notice that you have a program of ongoing research indicated in 0956 that has milestones out to 1987. Now, this would imply that there is important research work to be done before you can really make some of the assessments that you're looking for.

I guess my question is: is it basic to making your assessments, or is much of this confirmatory work?

MR. ROSS: We regarded much of it as confirmatory, and I think it will show up in '86 and '87 as we can better quantify the uncertainty.

However, the NUREG-1150, the Risk Rebaselining Program, will use today's source term code package, not next year's research.

CHAIRMAN PALLADINO: But when you say today's profile, what do you mean?

MR. ROSS: The methodology, in fact, is depicted on the next slide.

CHAIRMAN PALLADINO: All right. Well, maybe we'll pick these up.

COMMISSIONER ASSELSTINE: Just before we go to that, though, Bill, let me make sure I understand your position. I think that upper righthand box, which is Changes in Source Term-Based Regulation, I take it the Staff's position is still

that at this point, we've got some more things to do. We have to go through this fairly careful process of analysis that you've described here, and that now we still aren't able to rush to judgment in terms of rolling back some of those regulations.

MR. DIRCKS: Well, I think what we're saying is yes, we do have analysis to do and we've got work to do, and we're not only doing it ourselves; we're relying very heavily on the work of IDCOR. And I think our programs and IDCOR's are very heavily intertwined. So we're doing it in pace with them.

And it's essential I think also to put a plug in here for the continuation of the IDCOR effort, because that work is basic and needed to any progress we're going to make on our front.

COMMISSIONER BERNTHAL: Are we going to talk about these three or four areas that I mentioned, and then also about any others of which you are aware that I am not, and get some sense of exactly what your program is? And starting with the steam explosion thing where you are a little ahead of the others, I should think, at least in planning?

MR. ROSS: Yes. What we had intended to do is we have looked at the different phenomena that, taken collectively, represent the source term method, just to point out some work. And we do have -- you mentioned milestones. We have a backup slide where we take the eight measure areas

of research -- and of course, our report has more details -- and we show little triangles which are milestones, stretching from here through the end of fiscal '87. So we have done the work that says what are the key milestones, when will they occur, and more importantly to us, how much is going to cost and how are we going to get the money. Because there is obviously an interlocking between getting the work done and getting the budget to fund it.

And we have details available if we have the time and the necessity to go into that.

MR. DIRCKS: Yes. We will hit the details because I think it's important to try to get through that.

MR. ROSS: Let's go to slide number 3.

[Slide.]

We also showed this slide at the last Commission meeting. This represents a collection of models. Each model has its own name. And taken together, this collection really is the source term methodology. Some of these codes have been used for a number of years and have been modified, some of them were created in the last two or three years especially for this purpose.

And the flow is starting with the upper lefthand corner where you see the word ORIGEN. The general flow is to calculate the fission product inventory in the fuel; how is it released from the fuel following an inadequate core cooling

situation; if it's released from the fuel how does it behave in the reactor coolant system before it gets out; if the vessel is failed due to molten core debris penetrating the vessel and the core ex-vessel debris winds up on the bottom basemat, how does it interact with the concrete; and what fission products are released in this ex-vessel situation. And then, for all of the fission products that are released to the containment, how do they behave before the containment fails.

And there's special applications if you have a suppression pool or if you have any ice condenser.

So these -- I have some what I call tutorial slides on several of these models and we'll go through them. Again, this is the methodology. Manuals for these codes are available, fully available.

We believe that collectively, these methods represent a major advance over the Reactor Safety Study methods and we'll discuss why. I would point out that there are uncertainties that remain, and these are the subject of the continuing research and we'll discuss those areas.

So with that introduction, what I want to do is go through about six tutorial slides.

COMMISSIONER ASSELSTINE: But Denny, before you leave that one, just a couple of general questions on the codes as a group.

When I look at information and some of the reports we have been getting, like the April 1985 report on the research program from Sandia and a couple of the other information notices referring to some of the British work on radiation effects on the release of iodine, it appears to me that some of these things are bringing to light phenomena that are or may not be accounted for properly in the codes.

I guess I am wondering what you are doing to correct those deficiencies and when, if you have got a timetable and a program for reaching a decision that in fact these codes have now been validated to take into account all the phenomena that we are now aware of.

MR. ROSS: Well, the best illustration, I think, on a particular point is to be -- if you look at the code marked VANESA, which is one of the models that the APS had particular difficulty with because it wasn't well described in a manual -- in fact, the manual has only recently been released for comment, this code is well-founded, and in fact, we believe it has the right chemistry in it.

I think there are two things that one would look at to get the good, warm feeling that indeed the VANESA model is the right chemistry. What it does is provide the source term from the ex-vessel pool of corium up into the containment, and there are all sorts of high temperature chemistry reactions going on.

In order to get, say, the broad input from people around the world, one thing we do is we widely circulate the manual that describes the code, which has a lot of information. It's a very detailed manual on the basic chemistry.

Now, within the NRC family we also have an experimental program where we take, for example, molten UO2 doped with stable isotopes that could be representative of fission product species and heat it up to high temperature and dump it on concrete and measure what happens.

I think a coupled analytical experimental program is what is really needed, and if you take that with a wide circulation of the manual and its physics and chemistry, you get the confirmation you are looking for.

Now, to the extent we widely circulate all the manuals and to the extent we finish the experimental confirmation of some of these things, I think we shall have done our work.

COMMISSIONER ASSELSTINE. Okay. But in terms of, say, the April 1985 report from Sandia, though, they talk about carbon monoxide and hydrogen generation as a result of one of those experiments, and they say this is a significant observation in light of current codes that failed to account for reducing the nature of the oxidic core debris.

Does that mean that in those cases, you have gone

back and you have now revised the code to account for that phenomenon as well as some of these others?

I guess what I am wondering is are we in the process of a continually evolving set of codes or are we to the point where we can say with a fair degree of assurance that for all of the natural phenomena that we are aware of now, as a result of all the experimental programs under way, we have gone back and corrected the codes wherever that was needed and we are truly in a process now of simply just doing a few more experiments to validate or provide assurance that we have covered everything, or are we still in the learning process with these things?

MR. ROSS: I think I will get Mel Silberberg to answer your first point.

MR. SILBERBERG: Commissioner Asselstine, we have at this point corrected in what we call the Source Term Code Package those principal items that have been pointed out during the peer review process, and the ones that we immediately have the capability to do in terms of data or improved models.

We are on the alert as we proceed to the research program and get what I would call a truly landmark result or a result that would dictate a need to make such a change in what we have, or at least to take the insides from that information and judge the results that we have and take that into account

in the utilization of the codes. But if it's an important effect that comes from the research program, then we would take steps to change that.

We feel that at this point, we have enough stability with the information we have to proceed forward, but again, with a watchful eye as closely coupled to the research program.

COMMISSIONER ASSELSTINE: How about the example that I gave? Have they been able to go back and make the changes in the codes so that you account for that phenomena?

MR. SILBERBERG: I believe you were referring to chemical changes within the core-concrete reaction.

COMMISSIONER ASSELSTINE: Yes.

MR. SILBERBERG: Which, in fact, are now taken into account in the VANESA Code. In other words, the detailed chemistry of hydrogen and carbon dioxide coming from the core-concrete interaction, in fact, is treated in an equilibrium fashion within the VANESA Code.

COMMISSIONER ASSELSTINE: Did Sandia just not realize that, or was that a change that was made in the VANESA Code after April 1985 when they issued their report?

MR. SILBERBERG: That's a little puzzling because I believe that that particular accountability had already been in the code.

MR. ROSS: We can check. The text that you read ma

have been referring to codes in other places other than VANESA. They didn't call that, as you read it, a deficiency. The other countries --

COMMISSIONER ASSELSTINE: Right, but they say in light of current codes --

MR. SILBERBERG: Yes, we will have to check that.

COMMISSIONER ASSELSTINE: Well, I mean there is a collection of these that I have sort of collected over the past few months. There is another one that was highlighted in a weekly information report for the week of December 14, which talks about chemical modification of cesium iodide containing aerosols during a hydrogen burn, and that one again concludes that demonstration of copious generation of free iodine in this manner may have an impact on current source term modeling.

Is that another one where you have gone back and changed the models or the codes to reflect the phenomena that was described there?

MR. SILBERBERG: That is a case where --

COMMISSIONER ASSELSTINE: Again, the Sandia experiments.

MR. SILBERBERG: Yes. The information has come in. It is being reviewed, obviously, within our community and discussed between the staff and the contractors. It is one of those things that one wouldn't necessarily make a change the

next month, but at some point as the evidence builds to be convincing and having people check, then we would have to take that into consideration.

COMMISSIONER ASSELSTINE: Fred mentioned earlier some of the APS concerns, and one of them that I remember that stood out in my mind when Professor Wilson made his presentation was the need that he noted to assure internal consistency within the codes. I remember the example he gave about doing basic conservation of energy calculations, that it didn't appear that those codes used consistent bases throughout them.

Is that something that you have now corrected?

MR. SILBERBERG: Yes. For example, the MARCH Code had been using a subroutine called INTER for the core-concrete interaction, and that inconsistency we were obviously all aware of over the past several years, and certainly it has been pointed out during our peer reviews.

What we have now done in the Source Term Code Package is gone and made that change -- in effect, taken INTER out -- and have now coupled MARCH with CORCON, so that is an example of consistency.

COMMISSIONER ASSELSTINE: You were aware of that one. Have you done a review of all the codes now so that you can say with confidence that you are satisfied that all these codes conform to fundamental scientific principles and that

they all use consistent internal assuptions?

MR. SILBERBERG: Pretty much so, right, at this juncture. Absent any new data or building up of new data, in terms of consistency, we feel we have now done it. For example, having coupled the thermal hydraulics with fission product deposition, MARCH and TRAPMELT. They are closely coupled because of the thermal hydraulics. We have made that change.

COMMISSIONER ASSELSTINE: I guess what I'm trying to get a sense for is, both from the standpoint of the concerns that APS had raised and from the standpoint of the experimental work that has been going on for the past several months and that is likely to continue for the next couple of years, how confident are you that these codes now really are validated, that new information is not going to result in significant changes to the codes, so that I can understand the basis for your later statements in the presentation that really go to the heart of the extent to which the codes can now be used?

MR. ROSS: I have two comments. We had assembled, shortly after the APS report, a list of internal checks that were made on the various codes for consistency. I think quite a bit was done in a manner internal to the individual laboratories. It was not reported and perhaps not appreciated outside.

I am just looking at a partial list here from the MARCH Code, and we have other checks, doing an energy balance to check the in-vessel steam generation rate, and doing an energy balance for the containment pressure and temperature, verifying the hydrogen production against the fraction of the zircalloy oxidized, and is a relatively long list of internal checks.

The APS did comment that there had been enough people look at it that they felt that no major phenmenon overlooked, and that's our position.

Now, the way that we will get more detailed knowledge is when we start applying our more detailed codes. The computer code MARCH models the meltdown progression of the core. We have a much more detailed core thermal model under development that can do a portion of what MARCH does. This code will model a melt progression up to a point. It's developed at Idaho.

We have a more detailed melt progresssion code that would take over from there and go all the way through the vessel. It has got more detail and more sophistication than MARCH does.

We don't think it would modify the basic scenario. It could modify the timing. For example, we have a very detailed melt progression code called MELPROG being developed at Sandia. It might shed further light on the

timing and mode of bottom head failure. MARCH, I think, releases it all at once.

There are theories and contentions that you burn a small hole through which rapidly progresses to a larger hole, and you have a time-dependent release.

When we are comfortable with this code and have started applying it in a more detailed fashion, I think we will get some different answers. We don't think it will make a major difference, but the key to more detailed understanding is to pursue these more detailed codes, and that's why we are doing it.

CHAIRMAN PALLADINO: But in response to Commissioner Asselstine's point, you are keeping abreast of the research and you are giving attention to information that ought to be reflected.

MR. ROSS: Right. I think, for example, one of the big issues, I think, that everybody has focused on is the ex-vessel situation. We have a long list of experiments we are running, mostly at Sandia, but some are in cooperation with the Federal Republic of Germany.

As the data develop and are compared with the code predictions, then undoubtedly new models will be put in and old ones will be taken out, and what is left will be modified or revised. So we will be continually updating the code. That we have.

I think what we have to be sensitive to is something so startling coming up in the future as to alter the fundamental severe accident scenario, and that is where we are alert to and it is part of our program. We don't expect it, but we are certainly looking.

CHAIRMAN PALLADINO: Let me suggest for the moment that we go on, and we can come back to any further questions on the codes.

COMMISSIONER ASSELSTINE: Yes, that's fine, although at some point I would like to hear also what the Staff has done to answer or respond to the APS comment about doing additional peer review work on the codes so that there could be some independent review and confirmation of the codes.

MR. ROSS: That is built into the discussion.

Okay, now let's go to slide 4.

[Slide.]

What we are going to have is a number of slides where we illustrate one of the meltdown sequences. The sequence that we have chosen for illustration is sometimes called the Station Blackout. The letters TMLB stand for a transient loss of main feedwater, loss of auxiliary feedwater, and at least loss of enough AC power that the accident progresses. So it's a few hours loss of AC power.

The Greek letter delta follows that, which stands for the containment failure by overpressure. Depending on how

you input the code, you can either get an earlier or late overpressure, and we have conditional probabilities for both.

The example we are going to show here is early overpressure. The containment failure process, of course, would have to be done separately. The Source Term Code Package does not calculate the expected failure pressure for a containment. That is done elsewhere.

Now, this sequence happens to be one of the dominant sequences for some PWRs, but the sequences taken as a whole in 0956 were not selected to be the risk-dominant sequences for the five plants but were a broad range of sequences, high pressure and low pressure, containment bypass. The purpose was to challenge the methods.

So we have for this illustration a complete loss of feedwater, and if you will turn to the next page, it illustrates the type of information that comes from MARCH. MARCH is sort of the driver code for the whole suite, and among other things, it computes such things as shown on this table. So you see, as the accident progresses, your steam generator dries out.

The reactor system is at high pressure because there has been no failure yet, and the coolant is being lost through the relief and safety valves, and after you uncover the core, it will melt, slump, collapse onto the bottom head. Eventually the bottom head fails, in this calculation about

2-1/2 hours. In this illustration, the containment fails shortly thereafter.

As a user input, you can select a containment failure pressure, which MARCH calculates the containment pressure. You can get an early or late failure because you want to be able with the rest of the code family to calculate the fission product source term.

Now, in this I think the failure pressure was down around 85 psia, whereas the Surry failure pressure is somewhat higher.

The actual containment failure probabilities will come from NUREG-1150.

So this illustrates some of the information that MARCH would provide, and it is essential to the rest of the scenario.

COMMISSIONER ASSELSTINE: How would this change, say, for a B&W plant, if you used Davis-Besse instead of Surry?

MR. ROSS: Well, we can talk about this up to a point. Obviously, the steam generator will dry up much sooner, and then up until bottom head failure, then you could just accelerate everything. By the way, we have not modeled a B&W plant in our reference plants. Once the bottom head fails, then everything else that follows is plant specific.

The cavity design for B&W and Westinghouse is

different. The containment failure pressure obviously is plant specific. The mode of concrete attacked is cavity dependent, so it's hard to speculate.

COMMISSIONER ASSELSTINE: But you haven't run one of these for a B&W?

MR. ROSS: We have not.

CHAIRMAN PALLADINO: When you talk about bottom head containment failure, are you talking about gross failure?

MR. ROSS: Gross failure, yes; that's right. It's a gross failure.

CHAIRMAN PALLADINO: Do you consider it to be a complete loss of the containment?

MR. ROSS: Yes. We considered at one time whether there might be a --

CHAIRMAN PALLADINO: Is that the way these containments fail?

MR. ROSS: Yes. That is our current belief.

As you know, there is what we call sort of colloquially an Appendix J leakage. Appendix J, which is the small, few tenths of a percent leakage, we think the leakage would go up some, because you are higher than the design pressure. But we don't think at present that there would be a leak before break where you sort of self-relieve the containment.

Our current belief is that you would go up to some

pressure and then fail in a dramatic fashion.

Now we have one test series that confirms this. We have had a series of scale model experiments.

COMMISSIONER ROBERTS: Oh, the one at Sandia?

MR. ROSS: Yes. We have not yet done the reinforced concrete model, and we hope to.

CHAIRMAN PALLADINO: That's the one I was thinking of.

MR. ROSS: Right. We have a special containment performance working group that looked at this very issue, and they more or less conclude that you get relatively small leakage until you have some gross deformation, and then you get relatively large leakage.

COMMISSIONER ASSELSTINE: Did you also get containment failure by personnel error or maintenance error in terms of leaving valves open?

MR. ROSS: Yes. And when we look at what we call our containment event tree, this is the so-called beta bypass failure mode. We modeled that as a conditional probability.

I think our current modeling is 2 times 10 to the -3 as the so-called beta mode failure probability. There has been a lot of work on that, and there have been a few instances around the world where it has occurred. Pacific Northwest Laboratory did an assessment, and it turns out, the values used today and in the reactor safety study are about

the same.

[Slide.]

Page 6 illustrates some ingredients of two of the codes, ORAGEN and CORSAR. We just illustrated some of the radioactive species. I have six of them listed.

And some important points on this, the ORAGEN code calculates the species inventory. For each of the species, when you go to do some kind of risk or health effects calculation, you have to then use the right radial toxicity for each of the species, which varies very widely.

The computer code, CORSAR, then, models the release of each of these species. It is temperature-dependent.

I would note here that the cesium -- there is sort of what you might call a relative to iodine, a surplus of cesium, so the iodine is shown as being bound with the cesium, and the rest of the cesium would be cesium hydroxide. And if you look at the boiling points, you can sort of classify the cesium iodide, cesium hydroxide, and telerium as relatively high volatile, relative to the last two items, the strontium and lanthanum, which have very high boiling points, and they would be relatively low volatile.

COMMISSIONER BERNTHAL: When you say inventory and, in fact, when you list species, I assume you are referring to the usual, canonical isotopic species. Or are you referring to9 all of the xenon isotopes produced in the core?

MS. MITCHELL: These are the sum total of all of the xenon -- for instance, both the stable and unstable.

MR. ROSS: Since the fission product release from fuels is temperature-dependent, this also illustrates the fact that you need a core thermal model from MARCH to get the temperature, so you can drive the fission product release from the core.

[Slide.]

Page 7 illustrates the path of the fission products once they are released from the core. We'll use the TRAPMELT code to model this deposition reactor coolant system. This illustration is again for the TMLB', and the flowpath before the bottom head fails is up through the pressurizer, through the exist pipe, and down to the quench tank, and that's the heavy black line on your figure.

And the various physical phenomena that are modeled are shown on the left side -- vapor condensation, chemical reaction, aerosol formation, agglomeration and growth, settling and deposition on walls.

None of this collection of phenomena was modeled in the reactor safety study.

CHAIRMAN PALLADINO: You say none of them?

MR. ROSS: None of this has been modeled. There was no treatment in the reactor safety study.

Now, of course, this sequence-dependent as well as

plant-dependent. In other sequences, the flowpath would be different, and again, this is for the deposition prior to failure of the bottom head.

COMMISSIONER BERNTHAL: It seems to me, the clear question here -- this is all very interesting, but the key question is not so much whether these programs are going to change as time goes on, because they will -- we will learn new things -- and it's maybe not even so much whether there are specific things that have been fixed that people have pointed out, but rather whether the overall concern that APS and others have raised about benchmarking and verifying these codes, whether that systematic deficiency, in your judgment, has been remedied over the last year.

It may be that these are all great, but if I ordered this suite of codes now from -- well, not a disinterested observer, but a very interested observer, let's say, in Europe somewhere, and you sent the package to me, how would I verify that it had been adequately reviewed and benchmarked and that I could believe what was in it?

That, in fact, was the problem at the APS. It wasn't so much that they questioned that things were right or wrong. It's just that they couldn't find out whether they were right or wrong.

Has that deficiency been adequately addressed now?

MR. ROSS: I'm going to give it what I call a

conditional yes, because your question had a lot of facets to it.

One thing that we think is inadequately addressed is the coupling. In other words, they had a comment that there were bits and pieces. The source term code package couples these such that there is not artificial linkage going back and forth. They remarked that some of the routines had to be done differently and separately from some of the other routines. So I think that part is done.

We did have an independent laboratory do a QA effort and see if they could take the code package -- it was before it was a code package -- and reproduce the work. And they did. They could.

COMMISSIONER ASSELSTINE: Who did that?

MR. ROSS: Brookhaven.

MR. SILBERBERG: Let me just add that in the putting together of what we call now the source term code package, which takes into account changes that are appropriate and identified over the last several years, we have, in parallel, an ongoing QA and benchmarking effort at Brookhaven now, running lockstep with the Battelle/Columbus people as the get this code out on the street and into the 1150 process, which is, in fact, happening right now.

MR. ROSS: Now the individual manuals discuss model verification, and in addition, on Slide No. 2, one of the

balloons that was completed was Oak Ridge's report, which is the assessment of the codes. I think you have to take all of these together.

The reason I gave you a conditional yes is that there is more verification yet to be done. There are more experiments to be done. And so I think the verification will get better.

The reason that we are advocating use at this time is, we believe that there is a plateau that we have reached that is much higher than the reactor safety study. And as the APS said, we don't think we have neglected any major phenomena, it's just relatively marked improvement over the reactor safety study. We think it makes it advisable that these codes can be used at this time.

COMMISSIONER BERNTHAL: Have you taken steps to remedy the deficiency in forums for publication of such codes and data and developments?

We talked about this a year ago, and, of course, the APS raised that point as well. There are two kinds of peer review, after all. There is one that is sort of a closed-shop kind, where you ask somebody of your choosing to take a look at it. And the other is where you have a legitimate community, all with their own special interests and points of view, that review these things in the open literature. And so far, it appears there may not even be an appropriate forum for

that to be done.

Have we thought about that at all?

MR. ROSS: Let me comment on that. In our Conclusion IV, which we will be coming to, which relates to this topic, I think first let's look at the publicly available. All of the manuals will be publicly available.

We hope that by circulating 0956 broadly, we can at least make people aware of a good portion of the science. They would need these manuals if they wanted to take it any further.

COMMISSIONER ASSELSTINE: Are the codes themselves publicly available?

MR. ROSS: Yes.

COMMISSIONER ASSELSTINE: Okay. So the codes and the manuals.

MR. ROSS: Yes.

COMMISSIONER BERNTHAL: But you know, public available --

MR. ROSS: Well, I'm not through.

COMMISSIONER BERNTHAL: Okay.

MR. ROSS: The thing that the APS focused on is wider publication and archival peer review journals. And we certainly -- it's been recommended, and we certainly intend to encourage it, and I've had some initial discussion with Professor Theofanous, who edits such a journal, as to whether

his journal would be available. I think it's "Nuclear Engineering and Design." And he indicated that he thought it could be.

Now whether, in fact, these -- you know, the journal, which has its own referee process, would accept these or not, I don't know. I think the best we could do is encourage our contractors to submit them, which we are doing and will continue to do, and we will try to find appropriate journals for this purpose.

CHAIRMAN PALLADINO: I should point out, archival journals are interested in making sure that what is presented is worthwhile, and the process takes quite a bit of time. You don't get results immediately published in an archival journal.

MR. ROSS: Yes.

CHAIRMAN PALLADINO: I'm not saying one shouldn't do it, but I think that's more a confirmatory or check process than it is a complete peer review.

MR. ROSS: Yes. I think we made it clear that sometimes it would be two or three years before it would show up.

COMMISSIONER BERNTHAL: You're right. But that shouldn't deter you from doing it. I mean, there's a time lag of a year or two, to be sure, and then the preprint is available publicly, but we're doing that already. The point

is that there is a special effort and attention that goes into the actual publication, and things change sometimes between preprint and publication.

MR. ROSS: Well, I believe we're doing this. I made what I think is a special effort to solicit from Professor Theofanous a proposal, and we have had discussions with our contractors. We are encouraging them. I think this will just have to proceed. I think to the extent that nothing shows up, we may just have to encourage a bit harder or change the verb.

COMMISSIONER BERNTHAL: Well, we have mentioned this before, but if there is a deficiency here, and if there simply is not an appropriate forum -- and I don't know whether the Theofanous journal is appropriate or not -- maybe the NRC should, as a matter of policy, seek to get an appropriate forum established and take the lead.

MR. ROSS: Well, I submit that we have already done that. We call it the Water Reactor Safety Meeting. I don't know I could be any broader than that. And it has the additional advantage of being timely. The work that is reported there may not be more than two or three months old.

COMMISSIONER BERNTHAL: How can it get peer reviewed in two or three months?

MR. ROSS: Well, if you want it to be timely and you want to get, let's say, what I call a frank and open opinion of the researchers, then you get what you get at the Water

Reactor Safety Meeting. A person comes in, he runs a new experiment, he may have run it three months ago, his work is not -- it is unfettered. He reports his stuff. It's not the NRC giving a speech, except at the opening and closing. The rest of it is the researchers.

COMMISSIONER BERNTHAL: But then -- you know, I don't want to belabor the point -- but then, we are still lacking a step. Whether it's that or something else, I simply don't know, Denny, whether there is an appropriate forum or not. But if there's not and if there is a void in the literature that needs to be filled and encouraged by this agency, even to the point of supplying some funding perhaps, I think we ought to do it, so that the process is carried through the way it ought to be.

MR. ROSS: So do I. That's why I even offered to this "Nuclear Engineering and Design" journal, if they needed a grant to help them with the administrative expenses, we would do it.

I am not wedded to that journal either. I am just, you know, trying anything we can find.

COMMISSIONER BERNTHAL: Sure.

CHAIRMAN PALLADINO: I think there is a fundamental problem here. If we don't find an appropriate forum, the implication is, well, then, maybe we ought to start one. But I am not sure that those are the things that people read. The

people that we are hoping will read don't necessarily read those kinds of journals. So it is important to get them into the journals where the specialists have an interest. Otherwise, our own journal would be not much different from the reports that we put out.

COMMISSIONER BERNTHAL: No. You misunderstand me. I'm not saying that the NRC should start publishing the equivalent of a physical review or something. I'm saying we might foster whoever it would be. Maybe North Holland or somebody. Most of these journals tend to be supported by page charges indirectly by funding agencies anyway.

So as long as you can -- if there's a need -- I don't know if there's a need, but if there is a need and a void in the literature, people will read it if there's a void and it's established as a legitimate scholarly journal.

I just don't know. I'm asking the question.

MR. ROSS: Well, we're just going to have to watch and see how successful we are with the journals we have. If it doesn't work, we'll have to do something else.

MR. DIRCKS: But just to remind you, you know that it was at the initiative of this agency that we got the American Physical Society involved in this. If we carried on with our normal procedures, we might have just published NUREG documents and gotten comments and gotten the normal laboratory circulation.

But I think it was to get this extra effort that we went to the American Physical Society. I think that gave us a great number of benefits, and it does show that when you get one of these learned societies interested, you can get good results out of it.

I think we have gotten the feeling that we've got to do more of this and get more of these societies interested in the work. That's one reason why we've gone to the National Academy of Science, too -- to get them interested in getting their community interested in our program.

CHAIRMAN PALLADINO: I think we've said enough on this point for the moment.

COMMISSIONER ASSELSTINE: Denny, have you been able to go back to some of the people that served on the APS review -- Professor Wilson and others -- and talked to them about the steps that you have taken to try and address some of the concerns that were raised and get a sense for the degree to which they are satisfied that those efforts do address the concerns?

Reproduceability is an example. You have described what you have done.

MR. ROSS: No, we haven't done that. I think by sending them 0956 for comment, that will be a good forum to do that. But I have had no contact with them.

COMMISSIONER ASSELSTINE: It might be worth doing

that specifically -- I mean, for us to have a sense, if Professor Wilson were sitting here today, whether he would say, "Yes, the efforts that have been undertaken since February have really addressed the concerns that we had, concerns about validation of the codes, concerns about seeking greater independent peer review, the concerns about reproduceability, and those things."

CHAIRMAN PALLADINO: Do you want only Wilson's --

COMMISSIONER ASSELSTINE: No. What I'm saying is, some of the people --

COMMISSIONER ASSELSTINE: I think it's the committee, because I have a feeling that you'll get different opinions from the various members of the committee.

MR. DIRCKS: I think what we could do is make sure we get the document to them and then perhaps organize a meeting with them where we could sit down with them and go over the 0956 after they've had a chance to go over it and go through some sort of a question-and-answer.

COMMISSIONER ASSELSTINE: I think that would be useful. And I also think, on the point that we were just discussing, our concerns about seeking this kind of archival review and following through on the APS effort shouldn't be viewed as a criticism of what you've been doing. It sounds to me like you've really been trying to make an effort in that area.

The problem may not be lack of effort. The problem just may be finding journals and organizations who are willing to help us.

MR. DIRCKS: Well, we could do this reassembling of the peer group.

CHAIRMAN PALLADINO: I believe in the interest of time it would be better if we allowed the next twenty minutes or so for you to complete the presentation and then come back to some of these issues, because that is exactly what I wanted to do, as I indicated in my opening remarks.

MR. ROSS: Let's go to Slide 8.

[Slide.]

This shows in a tutorial fashion the features that are modeled by the CORCON-VANESA pair. At this point, the presumption is that the molten core, together with steel from the bottom head of the vessel, has come to rest on the basemat of the containment.

We show in this picture the reactor cavity wall, which is the term you would use if it were a PWR. For a boiler, you'd use the term pedestal. This is just symbolic of the code.

The molten core debris interacts with the concrete and produces various gases and attacks and goes on through.

I might note, for the PWR basemats that are on the order of ten or twelve feet thick, there is now a good belief

that the more likely event is that you would not get basemat penetration. This is probably expressly useful in terms of the China Syndrome. With the treaty signed last night, maybe this will improve relations there also. I don't know.

[Laughter.]

The temperature of the molten core debris and concrete is all-important because it affects the computer code, VANESA, and its modeling of fission product releases. The gas flow is equally important.

So this just illustrates the next step in the fission product path. We've modeled various concretes, and we think we've made a major advance in modeling with respect to the reactor safety study.

[Slide.]

Now if we go to Slide 9, which is the last of the tutorial slides, we are now -- what's modeled here is a PWR containment, and you have the fission products that, before vessel failure, came out whatever penetration was opening, like the relief and safety valve, and after vessel failure, you have fission products coming as predicted by the VANESA routine. And up until the point of catastrophic containment failure, you have processes going on that would tend to reduce the containment source term, such as settling and deposition on walls. And if you have AC power, you'd have performance of engineering safety features, such as sprays and filters.

If it happened to be a plant with a suppression pool or an ice condenser, then you'd have some retention there also.

Now this illustrates the main code now, and for boilers, the SPARK is the suppression pool code, and you have a special routine for ice condensers.

[Slide.]

Now taken together on Slide 10, I think we've illustrated the major advances in the source term technology, listed by these seven items. These are advances since the reactor safety study. I think we've discussed these in some detail already, except possible the fourth item, aerosol behavior in containment.

Ten years ago, the empirical model, CORRAL, was used. Now we have what we think is a very strong mechanistic model with much more data.

CHAIRMAN PALLADINO: You call these major advances in source term technology. Does this mean it's all done?

MR. ROSS: No. The next slide, there are still some uncertainties. We don't consider that we're through.

CHAIRMAN PALLADINO: Okay.

MR. ROSS: It's just that it's such an advance, we think it's a good replacement because it's so much better.

I think I've talked individually about these advances, and I think in the interest of time, we ought to

point out on Slide 11, there are still some areas of uncertainty.

[Slide.]

Now these eight areas are discussed in more detail in Chapter 7 of our report, in that we have a research program that we think addresses all of the remaining areas of uncertainty.

The general feeling is that as this research is completed, these areas of uncertainty will narrow. We do have a special program to continue the uncertainty study, and we discussed it somewhat with you last time, an uncertainty study done at Sandia. Taking the existing code package, we are starting a program at Brookhaven to extend and refine and enhance and enlarge the uncertainty, and we hope to come up with a work product with an uncertainty bound on the source term.

About a year from now, we will have done two plants, several sequences, one boiler and one PWR, and we hope to be able to issue a new quantitative estimate of uncertainty then.

COMMISSIONER BERNTHAL: I hope that -- I shouldn't take this too literally. These are major areas of uncertainty. I trust that they are areas where we still have more to learn, because it looks like it covers almost everything.

MR. ROSS: Well, yes, we fussed a little bit with

the word major, and we thought that it's relative to the other work we do. There is some other work going on in the severe accident decision. These are the most important areas that remain.

CHAIRMAN PALLADINO: If we're going to use the word "uncertainty" -- we use the word "uncertainty" to imply a number of things.

Are these areas where more knowledge is needed? Are they areas of ignorance?

MR. ROSS: Well, let me give you an example. We had a graph that, I believe, Mr. Chairman, you referred to as the so-called mosquito graph, because the first time we showed it, it looked like a mosquito, and as we looked at it, sure enough it did.

It's the containment inventory as a function of time, and when we looked at the uncertainty on this, if we make some conservative assumptions or some optimistic assumptions or best estimate, we can see a big range -- a large range, as a function of time, between the top and the bottom of the curve.

Now that means, if there's a large range -- in this case, it could be two or three decades -- that the uncertainty range is large, and research, if properly done, can narrow the uncertainty range. That's what we meant here.

CHAIRMAN PALLADINO: I see. Well, I don't know how

you reduce uncertainty, unless you have a lot of various experiments and you have enough data to discern what brings about differences in consequences.

MR. ROSS: But we think, as we do the remaining work, which we can call confirmatory, like the illustration I just had for the containment inventory of fission products, we think we're too pessimistic, and we would take out some pessimistic models and replace them with what we think is more realistic, and that narrows the uncertainty range, and that's what we're trying to do.

CHAIRMAN PALLADINO: One of the problems, I guess, we're all having is trying to figure out what it is that still needs to be done, and you look at the two lists, the major advances and the areas of uncertainty, and there's a great deal of overlap. And maybe at the end, you could somewhere along the line indicate, either by example or a couple of examples.

COMMISSIONER ASSELSTINE: It does sound like what the staff is saying, though, is that we've made a lot of progress in these areas, but we still have a long way to go.

CHAIRMAN PALLADINO: Well, but no, that's my problem. I'd like to know what do we have to do to get there, and how far away are we?

MR. ROSS: We think that the work that we need to finish is well-defined in our "Further Research" chapter,

which is Chapter 7.

All of these areas of uncertainty are not only in the reactor safety study, but they're much worse. Some of the items, Item 4 on this slide, retention and revaporization of the reactor coolant system, was culled out by the APS. We have a program to model that, make some experiments, and we're running the experiments.

Based on that, we'll have to decide whether and how or even if we should put it in one of our future predictive codes.

COMMISSIONER BERNTHAL: Now I can understand why that particular item is a major area of uncertainty, because it's extraordinarily complicated and difficult business.

Why is natural circulation in the vessel a major area of uncertainty?

MR. ROSS: Well, the thing that's important here is the temperature of the internals, and as the internals heat up, the TRAPMELT code is less effective. So right now there's a feeling that you'll get some flow in the vessel that would be up from the center of the core and down through the edge of the bundles, and this will promote some circulation and give you a different thermal history than we are now modeling.

COMMISSIONER BERNTHAL: Is the uncertainty in the thermal progression itself, or is the uncertainty just in the ability of the codes to model it? I mean, that stuff is

pretty easy compared to the other point, the retention and revaporization business, it would seem to me at least.

MR. ROSS: Well, when we look at the computer codes that we would tend to use for this, like the loss of coolant codes, we hadn't applied to it. Sometimes the high-temperature properties are just not even built into the code, because we're talking -- they were designed for --

COMMISSIONER BERNTHAL: So the codes are inadequate; is that what you're saying?

MR. ROSS: Well, we're in the process of changing, but they were -- the codes that we started with weren't designed for this, and we had to -- like they wouldn't have -- they wouldn't handle metal surfaces at 2000 degrees, because they didn't ever expect that to happen.

COMMISSIONER ZECH: It seems to me what you're saying in this slide is that there are areas in all of these listed items of some uncertainties, but certainly in other areas listed, you have a certain degree of confidence about properties and characteristics and interactions.

But I think you're trying to tell us that in this list, there are areas of uncertainties, but not the whole, not everything is uncertain that you're giving us.

MR. ROSS: That's correct. That's right. They contribute to the width of the uncertainty band.

A good example is the last one, containment failure

modes. A lot of people will glibly say that the failure pressure for containment is two to four times design. Okay, we've run a series of tests on steel, and we got up to five times design.

What's the right number? It could make a difference.

COMMISSIONER ZECH: Right.

MR. ROSS: So we'd like to -- saying two to four or two to five times design, it seems too large. We ought to be able to characterize it better than that.

COMMISSIONER ZECH: Right.

COMMISSIONER ASSELSTINE: It seems to me we need to understand not only what you're doing to address or reduce these uncertainties, but also what you are proposing in terms of how the codes address those uncertainties, take them into account now, and how you propose to make decisions with the codes, given those uncertainties.

You mentioned areas where there are variations between a low and a high range that may cross several orders of magnitude.

I think at some point we need to understand what you do. Do you just pick the middle?

MR. ROSS: I think we have a very good program on that. The severe accident risk reduction program has built into it, and has had for several years, the requirement to

characterize the cost/benefit ranges, so the point value will be shown, as well as the extreme. So if we look at any prevention or mitigation feature that could be applied to an existing reactor, and we compute the cost and the benefit of that feature, we will show now a point, but a complete uncertainty range, and as this range starts to come up into the cost/benefit ratio of 1, then I think the regulator will have to pay a lot more attention to it. I'm talking about the extreme of the range, not the point value.

So that is part of the severe accident risk rebaselining program, and it should be coming out. It's part of the NUREG-1150, and it all ought to be available in six months or so.

COMMISSIONER ASSELSTINE: Okay.

MR. ROSS: Okay, let's go to Slide 12 now.

[Slide.]

And this is one point where we might save a bit of time. We have a number of conclusions. The first five are lumped together under the title, "Source Term Science." The next four are lumped under the title, "Source Term Insights." We have two that are lumped under the title, "Risk Insights;" two for "Continuing Research." We have thirteen conclusions and three recommendations.

I don't propose to read the slide. On Slide 12, they emphasize -- we have talked about Conclusion 4 already

for publication.

I wanted to emphasize on Conclusion 5 that a lot of detailed plant knowledge is required to apply these codes, and generic extension is something that we just haven't -- is not yet available. It's a part of the IDCOR effort.

There are a couple of things I would like to point out on the source term insights on Slide 13.

[Slide.]

On Conclusion 6, we used the term -- we calculated source term for selected accident sequences. Just to remind you, we have not done these yet for all of the risk-dominant sequences for the referenced plants. That work is in process.

And on Conclusion 7, we've discussed the containment behavior. Equally important, perhaps, under some sequences, is reactor coolant system retention.

On Conclusion 8, I give some examples on plant design. There is a sequence called the V sequence, where you have the interfacing LOCA, where the reactor would melt, and there is a leakage path bypassing containment. At the end of that leakage path, the outlet may be underwater or it may be abovewater, and the difference is plant-dependent, and it makes a big difference on the source term. The concrete cavity details make a big difference. The engineered safety features make a big difference.

So I would emphasize in Conclusion 8, more detailed

models are needed, more time on plant design and construction.

COMMISSIONER ASSELSTINE: Is this a significant factor in terms of deciding how detailed a review you have to do of individual plants --

MR. ROSS: Yes.

COMMISSIONER ASSELSTINE: -- in order to resolve these issues? Indeed, whether the more detailed reviews -- I guess the PRAs that have bee done -- are sufficiently detailed to reach those kinds of conclusions.

Would they have picked up some of the vulnerabilities that we see from time to time when they crop up?

MR. ROSS: From what I've seen of the IDCOR proposal, their methodology would pick up vulnerabilities. They're very serious. The work of the outline is very detailed. I think they equally share the concern about generic extension. It would be a quite expensive, time-consuming job.

CHAIRMAN PALLADINO: How do you factor in the human intervention, for example, at Three Mile Island. If they had let the safety features work, you might have had a different result. They intervened, and things got worse.

At Davis-Besse, they intervened, and things got better.

COMMISSIONER ASSELSTINE: They got worse and then

better.

CHAIRMAN PALLADINO: Yes, worse and then better, but nevertheless, the intervention of the human being is an important factor.

What I guess I'm getting at is, do you make assumptions about the failure of the engineered safety features.

MR. ROSS: Yes. And in fact, on Conclusion 9, there will be some operator actions that have to be considered. There is a belief that in the boiling water reactor that some of the important sequences can be mitigated by proper operator action, and they are developing what they call emergency procedure guidelines for this purpose, which would then be converted into plant operating emergency procedures.

What we will have to do -- in the first place, the guidelines and procedures have to be reviewed, and then in some way we have to model how likely we think it is to produce a success, and if we think it works, then we'll model it and give a certain conditional probability to it. And more importantly the NRR and the Region will have to make sure the procedure is in place and that it works.

But operator action, it has to be modeled.

COMMISSIONER BERNTHAL: I guess I think that Conclusion 6 ought to be reworded somehow. I'm not sure that calculating new source terms provides a sufficient test of the

codes. It might be a needed test, but I don't think you can conclude from that that they are sufficiently tested, can you?

COMMISSIONER ASSELSTINE: Or at the minimum, you have to explain what justifies the conclusion.

MR. ROSS: Okay, then I will explain. Sufficiency, in our terms, was high-pressure, low-pressure containment bypass. It was a broad range of thermohydraulic challenges. Perhaps a necessary test -- the thing is, if we could come up with a different sequence that had new phenomena that we haven't tested, then Conclusion 6 would be wrong.

COMMISSIONER BERNTHAL: As a matter of curiosity on this suite of codes or the codes that line up there, are names of individuals ever associated with those or is it just organizations? I mean is it recognized -- do people put their names on these and take responsibility for them, or is it just a laboratory or a group or an organization?

MR. ROSS: I think in general the manuals have names. There is a name on the cover, in general. The principal investigator. I think in many cases the NRC research engineer is listed also as the project monitor.

On Slide 14, Jocelyn Mitchell, who has labored long and hard over 0956 for the last few months, is going to have a discussion.

MS. MITCHELL: We wanted to provide a perspective of how the analytical procedure that we have talked about so far

could produce changes in what we might perceive as the risk of a plant.

[Slide.]

At this point it is an illustration only. We had a available for one plant of the five that were studied two things. This was for the Surry plant. We had a good coverage of the risk-dominant sequences for this plant because we did in BMI-2104 four sequences and investigated several different failure modes for the containment. So it was possible to put those together with a preliminary evaluation of a containment event tree from the Severe Accident Research Program and to try to make a prospective of what this new procedure would mean.

We have no reevaluation today of the sequence frequencies for Surry. That will come. It is being done now under the Severe Accident Research Program, and it will be absorbed into NUREG-1150, which you have heard about, with new frequencies. So we took as given for this comparative study the individual sequence frequencies from the Reactor Safety Study for Surry.

We did change the site model to make it a Surry-specific site and not a set of sites, as was used in the safety study itself, and therefore we had a three-step process, which is illustrated on Slide 14, where we started off using the WASH-1400 source terms as they were given in the

document, along with its view of the containment event tree.

This is to provide a base case to compare using our new site model.

We then changed the source term analytical procedure but kept the Reactor Safety Study view of how the containment event tree would go, and we provided the second step in that table.

And finally, we combined the same sequence frequencies with the same source term evaluation but we absorbed the new containment event tree from this preliminary SARP program, and we produced the third line on the slide.

We compared the base case with the final slide, and you will find for the two measures of the many possible offsite consequences that we chose to look at, early and latent fatalities, that there is a reduction factor of 10 for early fatalities and a factor of 4 for latent fatalities.

When you see our third recommendation in a little while, you will see that we suggest that for any application, you certainly oughtn't to leave without a discussion of the uncertainties. We have to leave you with a promise for the future.

We have talked about our programs that are in place for NUREG-1150 to do a good job on the uncertainties, but I did want to tell you that for any risk uncertainty, we have

four areas that will contribute: from the event frequencies, from the calculation of the source terms themselves, from the containment behavior and from the calculation of the consequences.

For this particular comparative study, since we have used a comparable site model and we have used identical sequence frequencies, those two particular areas are not as germane to this particular comparison as the other two are.

If we can go to Slide 15 --

COMMISSIONER ASSELSTINE: On the uncertainties, before you leave that one, have you been talking with the ACRS about how you intend to treat uncertainties in NUREG-1150? And I am mindful of the discussion we had with the ACRS not too long ago on their concerns about our ability to treat uncertainties or to explain how we treat uncertainties in these kind of analyses.

MS. MITCHELL: We are definitely talking with the ACRS about all parts of this. We have had one meeting with them and another is upcoming in the next week, next week. That will definitely be a part of it. So far, we have been working on the analytical procedure, the technical issues at the moment.

COMMISSIONER ASSELSTINE: Given what the ACRS said to us at our last meeting with them, I think that's a very important part, to explain this as clearly as we can, how

uncertainties are being considered and treated in making these kinds of judgments so that they can get a sense and we can get a sense here, as well, for the adequacy of our treatment of uncertainties because right now I don't think we have done a very good job in explaining how we do it.

COMMISSIONER BERNTHAL: Are you willing to give a wild estimate, at least, at this point, 95 percent confidence level, the certainties that would attach to these numbers?

MS. MITCHELL: No.

[Laughter.]

COMMISSIONER BERNTHAL: That is succinct.

COMMISSIONER ASSELSTINE: Or could you give us numbers that you would attach a 95 percent confidence level to? Would they be these numbers?

CHAIRMAN PALLADINO: You don't attach confidence level to lack of data, and I hope we always lack data on some of these things because we are talking about improbable events. If we get a lot of data, then they become very probable events, and then you can do a great job of assessing the confidence limit.

COMMISSIONER BERNTHAL: Let me try again. Without being so specific, would you make a guess that nobody could hold you to, 95 percent confidence level: Is the difference we are seeing between WASH-1400 and BMI 2104 -- this is a qualitative answer now -- in your judgment, is that

difference, which is something less than an order of magnitude, likely to be a difference considerably -- or let's just say a difference larger than the envelope of uncertainty, or is the envelope of uncertainties attached to each likely to envelop that difference pretty well?

MS. MITCHELL: As long as you promise not to read the transcript after this is over --

COMMISSIONER BERNTHAL: A very qualitative statement.

MS. MITCHELL: -- I would say the uncertainties are large, and I think before you attach a great deal of confidence to whether it is a factor of 3 here and 4 there, you ought to be very careful.

I do want to point out one other thing before we do leave this slide, that from the three-step process for this plant, there seems to be as much change due to the source term analytical procedure as to the containment behavior. That might not be the case for other plants. It happens to be the case for this one, but other plants may be very different.

COMMISSIONER BERNTHAL: Fair enough. Thanks.

[Slide]

MS. MITCHELL: Moving right along. I have told you about conclusion 10, which concerns the fact that the Surry risk reduction shows about equally from source term and from containment behavior. I did want to say again that the source

term coverage for the other plants that were looked at in BMI-2104 was not comparable to that from Surry. In particular for Peach Bottom we looked at one containment failure mode rather than several containment failure modes, and that particular failure mode was for release directly to the environment and not for any release that might go from the containment into the reactor building.

We are redoing the Peach Bottom analyses taking this into account, and also making some changes in the plant model, but for none of the other plants is it possible to give any analyses before you can draw any conclusions about changes in estimated risk.

However, I would note that for some of the plants, for Peach Bottom, the analyses that have been done so far do not show a large reduction compared to the reactor safety study results, and that would indicate that caution should be used before trying to extend what we have done for Surry to any other plant.

COMMISSIONER ASSELSTINE: Does Conclusion 10 for Surry mean that everything went down? How about the telluriums and the actinides?

MS. MITCHELL: I think there are some chemical element groups for which the number is numerically higher for Surry for some sequences, however, it is not significant.

COMMISSIONER ASSELSTINE: How do you compare the

containment reevaluation, your ability to do that as compared with, I gather, the difficulty in coming up with, at least at the present time, with containment performance criteria, the fact that we are still in the process of being a few years away? How much confidence can you have in the containment reevaluation given our inability, so far, at least, to say here are criteria for evaluating containment performance?

MS. MITCHELL: I think they try to look at what is the status of the particular plant. This effort in relooking at the containment event analysis is a very much more structured kind of an analysis. It is laid out where other people could now go and see exactly how it was done and agree or disagree.

Right now it is a judgment. They ask, I think, for Surry 59 questions, how likely is it that the pressure vessel will fail at high pressure versus low pressure, and they go around and get from many handfuls of different sources insights that they can find from other PRAs, from the containment loads working group studies, from the containment performance working group studies, and get an answer to that question.

They have made three separate estimates, one which is a conservative estimate that maximizes the probability of the earlier containment failure modes, one that is an optimistic estimate and minimizes the earlier containment

failure modes, and one which is the central. The one we have used here is the central estimate.

COMMISSIONER ASSELSTINE: Okay. That's what you used in calculating the numbers on the preliminary slide. You picked the middle.

MS. MITCHELL: That's right. They evaluated what they called a central estimate and we used that. But that is undergoing peer review now. The evaluation of the tree needs to go along with how the accident is perceived to go, so the whole analysis should be interlocked starting with the people who determine the probabilities, how likely is it that this paricular component will fail.

Everybody ought to go together, and when you get finished, they all ought to be modeling the same exact sequence or series of sequences.

MR. ROSS: I think you need NUREG-1150. I think the ACRS needs it before we pick up the subject of the containment criteria. Turning to page 16, there are a couple of conclusions on continuing research. In our report we are addressing Chapter 7.

Conclusion 12 is we think we have a program addressing the areas, and Conclusion 13 picks up on the major conclusion of the American Physical Society that work ought to go on.

Unless we decide to come back to this topic for more

details, that's all I wanted to say on this slide.

COMMISSIONER ZECH: In the research area, have you been able to get anything conclusive at all yet from that experiment that was done in Idaho on the plant that was purposely melted down?

MR. ROSS: The test was run in LOFT fission product 2 about a month ago, and the initial judgment was it seemed to be a very successful test in that the center bundle went up to very high temperatures, above 4000 degrees Fahrenheit, and released a good quantity of fission products. It will be useful in verifying some of our codes, but the data just aren't cranked out yet.

COMMISSIONER ZECH: I see. But you are attempting to get ahold of that. You are communicating with them and you will factor that in.

MR. ROSS: Yes. It appears to be a very useful test.

CHAIRMAN PALLADINO: But are you going to try to apply your codes to see if you get the same results they got?

MR. ROSS: Oh, they were applied as a pre-test prediction. So that's even harder. It would be interesting to see how that comes out.

[Slide.]

COMMISSIONER ZECH: Thank you.

MR. ROSS: On Slide 17 there are some

recommendations. Again, since this report is going out for comment, we will be asking for comment on these recommendations, and in particular we would expect people like the ACRS to comment, and from today's discussion, maybe the APS would have some comment.

CHAIRMAN PALLADINO: APS?

MR. ROSS: American Physical Society.

CHAIRMAN PALLADINO: Well, are you going to send this report out for comment by the APS and any other program plans that you have to see whether or not we have heard them correctly in terms of their recommendations?

MR. ROSS: Yes, I am now. I think it's a good idea.

CHAIRMAN PALLADINO: Yes. And to follow up the point that Commissioner Asselstine made, I think that we should overtly ask them.

MR. ROSS: Yes, we will.

MR. DIRCKS: I think we will not only ask them, but if we can organize some sort of a seminar with them, we would like to sit down and exchange information.

CHAIRMAN PALLADINO: Yes.

MR. ROSS: Recommendation 2 is to get more detailed insight. You have to run the more mechanistic codes. In some cases these are recommendations to ourselves. We did note that we had not intentionally biased the code package one way or the other towards conservative or optimistic, and we do

need very good coupling to get the uncertainties.

It appears likely that the uncertainty allowance in the regulatory arena will depend on the regulatory purpose. So, depending on whether it is rulemaking for Part 100 or for emergency planning or equipment qualification or backfits, the uncertainty allowances will probably be different for different applications.

COMMISSIONER ASSELSTINE: Does that mean, Denny, that in those areas where you have this range of uncertainty, a pessimistic or an optimistic bound, that your approach has consistently been throughout the codes to select the middle?

MR. ROSS: Yes, and carrying along with it whatever knowledge you would have on the range.

On Slide 18, this is what we envision doing in the next few months.

[Slide]

Issue for comment. Continue meeting with the ACRS. We think having this document bound together where it looks like it's reasonably coherent will help our ACRS review and then we will continue upgrading our models to reduce uncertainties.

CHAIRMAN PALLADINO: When you talking about using means or median, are you recognizing that when you use factors rather than plus or minus certain increments, that you have a very distorted distribution? And if you have a plus or minus

of a factor of 10 of something, let's say measured 100 miles, that means on one end it's 10 miles and on the other end it's 1000 miles. So there is quite a distortion.

And yet I think you are using symmetric distributions. At least most of the formulations that I have seen.

COMMISSIONER ASSELSTINE: Is that right?

MR. ROSS: I don't think so.

CHAIRMAN PALLADINO: I guess I'm coming back to whether or not you should be talking in terms of factors of 10. I haven't thought about it too much.

MR. ROSS: We are talking about -- For example, the chart on fatalities, two points. Acute radiation injury is a threshold phenomenon, so if you put a sensitivity factor, in one case it may go up very much and in another case it may disappear. So that makes it difficult.

The distribution function, which will be reported in Appendix D of our report for fatalities, or for latent fatalities, we will have the distribution in the report, but I would say in general they are not symmetric. The table Jocelyn showed you was mean values, but the way, not median.

That is our direct presentation, so we are ready for questions.

CHAIRMAN PALLADINO: Well, I had said early that we want to talk about where you are going, but I guess that's

what you have been telling us. You have answered the question when do you expect 0956 out, at least sometime early August.

MR. ROSS: Yes.

CHAIRMAN PALLADINO: And you have indicated 1150 probably possibly March of April of '86.

MR. ROSS: Yes.

CHAIRMAN PALLADINO: We didn't touch on, and maybe you are not prepared to touch on when we would be getting into the right side of that box you showed, the boundary that you showed earlier. This is trying to apply source term information to particular applications.

MR. DENTON: Our plan, Mr. Chairman, is to wait until closure is achieved on the methods and models that have been discussed this morning. We have been reluctant to get out front of Research in this area because there still appear to be uncertanties in some areas, and when we have meetings on these topics, there are still individual laboratory researchers who have views on one side or another of the approach being taken.

So what I feel we need in NRR is a technical basis which is acceptable to the Commission for us to begin applying the changed regulations, but it seems to me I shouldn't go proposing changed regulations until you are satisfied that there is an adequate technical basis for understanding the difference.

Going back to what Commissioner Bernthal was talking about, we need, in effect, a consensus that this information is now the proper set of information to use to reevaluate.

So we will be moving in parallel with Research. I think the present plan is they would give us next spring the results for the five or six plants that they recalculated, and if everyone is in agreement by that time that that's the way to go, we would then pick those up and begin to apply that approach over the next year or two with IDCOR to all the individual plants on a per-plant basis, and also look at what regulations perhaps need to be changed.

It does appear the results are going to be plant-dependent, containment design-dependent, and we are waiting for a consensus.

CHAIRMAN PALLADINO: Well, I can't argue with you. You have to reach a threshold of knowledge before you try to apply it, and I recognize also that there will always be improvements in the knowledge, but one could look ahead to the extent of saying, well, it is going to take certain kinds of very important information that we ought to start accumulating, basically preparing to get a running start when the report comes out.

MR. DENTON: We are doing that, and I think we and IDCOR are working along with a great deal of coordination, waiting for final closure on some of these areas of

uncertainty that have been mentioned. There are cases, I think, still, Denny, where two or three researchers in a lab might have different views. I have called the lab director and said: Which one of the three do you recommend we use? And he says: That's your problem. You know, wait five or ten years and science will settle down.

So we have not had a great deal of success, I think, in some of these areas about getting closure. I guess there we would tend to take whatever the consensus Staff view is, how we interpret those areas where there is not uniform agreement.

I think what happens in the licensing case, there are mechanisms to get closure. We have hearings. We have boards and so forth. What we have got here is a mechanism moving toward closure but closure hasn't been achieved. You talked about peer journals and that type of thing. It's very difficult because of the number of specialties involved in this to get closure that's acceptable to everyone.

MR. DIRCKS: That was our original intent when we had this controversy two or three years ago, is to try to get closure by going to the scientific society. I think it helped. It identified where we needed to do work, where there were certainties and where we should close some gaps.

I think we have taken those factors into consideration, and I think on the next round we are going to

have to go out and get some more input from the scientific community. The problem is as long as you have individual researchers, we are going to have the debate going on.

CHAIRMAN PALLADINO: Let me make a word of caution. We are not in a scientific field even though we are using scientific approaches and scientific information. In the end, it is an engineering field, where you have to accept uncertainties and you provide for them in your design.

Now, I do agree you can't go and undertake an engineering project until you have enough knowledge to begin to deal with it, but we are never going to have the perfect science because we are talking about modes of failure, and failures take place in a lot of different ways.

MR. DENTON: I think the way that the research results are coming in, there is more agreement on large, dry containments and what I call simpler designs to analyze than there are of a more complex design, and it's possible we can make a lot more progress on a plant similar to Surry than we might on, say, MARK II containments, for example, which seem to require a lot more attention.

So we might make some staged progress, depending on the type of plants.

COMMISSIONER ZECH: To me it is very important. It seems to me that we ought to take a cautious and prudent approach, which I think we are taking, and certainly we want

to wait for the data and be as confident as we possibly can; but it does seem to me that we ought to give priority to this program, and I think we are doing that. I hope we are doing that. I think that's what you are telling us.

And also, though, as we develop something that is fairly conclusive that we can make a judgment on, it seems to me that perhaps we should really seriously consider doing it in staged approaches and not waiting for the final, complete program to satisfy everyone. I don't think that will probably ever happen, but if we can be confident ourselves, if the Staff can be confident that the general conclusion is that certain plants perhaps we can make decisions on, then it's my view that that is the approach we should take.

MR. DENTON: From talking to industry, I think their main interest is getting closure on the severe accident issue. They are not that interested in reevaluating the adequacy of existing engineered safety systems, for example, whether they should take a filter out or leave it in kind of question. They sort of assume they have got the plants, plants are built, and the question is, is their plant safe enough to operate in view of all we have learned?

So their main interest with IDCOR is working with us as this information comes out on individual plants or classes of plants. Changes in our regulations for future plants, I don't think IDCOR is that interested in as the industry.

CHAIRMAN PALLADINO: But I think the source term is so fundamental to our mission that we need to get as good a handle on it, good or bad or indifferent.

COMMISSIONER BERNTHAL: Could you answer a question for me that I referred to early on? Answer it briefly, I hope. If we pick the steam explosion issue, as an example, what are we doing right now based on this rather careful review that was done on the issue, and at what date would you predict that we will have answers on that and at what cost?

And can you make similar appraisals or are you proposing to make similar appraisals of core-concrete -- oh, I always forget what the right words are -- I guess it's their direct heating effect and whatever else there is out there that is fundamental and generic to nearly every plant?

MR. ROSS: Yes. If you look at what we are doing in particular on the steam explosion, the main recommendation was that carefully controlled experiments should continue, and there was uniform consensus on that, and lack of consensus on the need for a very big experiment.

We do intend -- you know, given availability of funds -- to do just that, and I think by paying more attention to a confined versus an open experiment, better instrumentation, which should be done in fiscal '86 --

COMMISSIONER BERNTHAL: Should be finished?

MR. ROSS: Should be finished in '86. The

obligation we have at that time, which is roughly a year from today, is to reexamine the issue. What do we know better now and do we want to consider the matter closed, or do we really have to run a much bigger experiment? That issue is open.

COMMISSIONER BERNTHAL: But right now you have set a course and have in mind a set of experiments that you hope are designed, at least, to achieve closure on that issue by the end of fiscal year 1986.

MR. ROSS: Yes, and at moderate scale. There will still be some people a year from today who will have to believe that much larger scale experiments are necessary.

COMMISSIONER BERNTHAL: Okay. The next question is what about the other areas, at least those two, and there may be others that I mentioned? Are we going to have a similar review there? Will there be a similar timetable and cost attached?

MR. ROSS: I would like if we could have B-16 back up. This is just sort of a road map to what will be in Chapter 7.

[Slide.]

For each of the eight issues we have a timeline, and we have a little triangle as far as A through H. And each of these little triangles is just illustrative. What we do in Chapter 7 is we spell out what each of these mean. For example, if we were on line 7, Milestone C says, "Complete

tests on direct heating of containment atmosphere," and 7C shows up in early '87, and these are calendar years.

So the complete report will define all of this in detail.

CHAIRMAN PALLADINO: In 0956?

MR. ROSS: 0956, yes. Did we put the money in 0956? We have the money. It's just not in the report.

For each of these triangles, we have assessed the amount of money required to do it.

COMMISSIONER BERNTHAL: So basically what you are saying is that every one of those eight issues, which sound to be broader issues than the ones I mentioned, but nevertheless, those eight you feel should be closed and can be closed based on your current projections by the end of '87.

MR. ROSS: Yes. And my recollection is the integral of the money for '86 and '87 put together is about $60 million.

Now, there is one thing that we didn't answer. As we come to what appears to be technical resolution, would we convene a review group like the Steam Explosion Review Group? We haven't decided to do that yet. What we have decided to do is to revitalize the Research Review Groups, and the revitalized Steam Explosion Review Group meets in about 30 days at Madison, Wisconsin. We are adding people of a more diverse nature, revitalizing, and I think that will be what

will provide the technical review.

COMMISSIONER BERNTHAL: Well, where, for example, is core-concrete? Which category is that in here?

MR. ROSS: That would be 5.

MR. SILBERBERG: Let me just note, Commissioner Bernthal, that the reason why these may seem broad -- For example, item 7, pressure loads, would include within it steam explosion, the hydrogen question, as well as direct heating. So it's coupled. In other words, a number of phenomena are coupled under each category.

COMMISSIONER BERNTHAL: And are every one of those eight pacing items in one way or another for you to be able to reach your final conclusions on 1150 or whatever the report number is?

MR. ROSS: Oh, no. These are not coupled to 1150 at all. This is the final truth if you would, in severe accidents. This is what we [illegible]s the best we will ever do in getting the uncertainty down.

COMMISSIONER BERNTHAL: I don't think you will get the final truth, but we hope some approximation.

[Laughter.]

COMMISSIONER ASSELSTINE: Following up on Fred's question, is it possible under these eight categories to get a listing of the key technical questions, the areas that you think need to be answered and questions that need to be

answered in order to reach the broad conclusions in each of these eight categories?

MR. ROSS: Yes.

CHAIRMAN PALLADINO: Are these questions in 0956?

MR. ROSS: Yes. And further, we have broken them down into what we call the fin level, which is the contract level, and for each contract, you start with what the question is, the regulatory objective and the research objective. The answer is yes.

COMMISSIONER ASSELSTINE: So we will be able to see that in 0956.

MR. ROSS: Yes. If we don't have all the detail, we might have to provide it as a supplement.

CHAIRMAN PALLADINO: Well, we will be looking forward to receiving copies, and I am sure you will welcome any comments that we may have. We are not the technical experts, but sometimes we see things from a different point of view.

I think this has been a very valuable session. It demonstrates the Commission's interest in this subject, and we may be looking to the fall to have a repeat, and we will bring that matter up at agenda planning.

COMMISSIONER BERNTHAL: Yes. This has been very useful. I appreciate all the work effort that has gone into preparing it.

I wouldn't mind doing this quarterly, Joe? I think it's terribly important that we keep abreast of what is going on.

CHAIRMAN PALLADINO: Yes. That's what I have in mind.

COMMISSIONER ZECH: I kind of agree with that.

COMMISSIONER ASSELSTINE: Well, I certainly think after 0956 comes out, after the ACRS has had a chance to look at it, that we might to hear both from them and get back together with the Staff again and talk about IDCOR.

CHAIRMAN PALLADINO: All right. Well, thank you very much, folks. Unless there is more to come before the Commission, we will stand adjourned.

[Whereupon, at 11:55 a.m. the Commission meeting was concluded.]

CERTIFICATE OF OFFICIAL REPORTER

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of: Commission Meeting

Name of Proceeding: Briefing on Accident Source Term Reassessment (Public Meeting)

Docket No.:

Place: Washington, D. C.

Date: Wednesday, July 24, 1985

were held as herein appears and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission.

(Signature) Suzanne B. Young

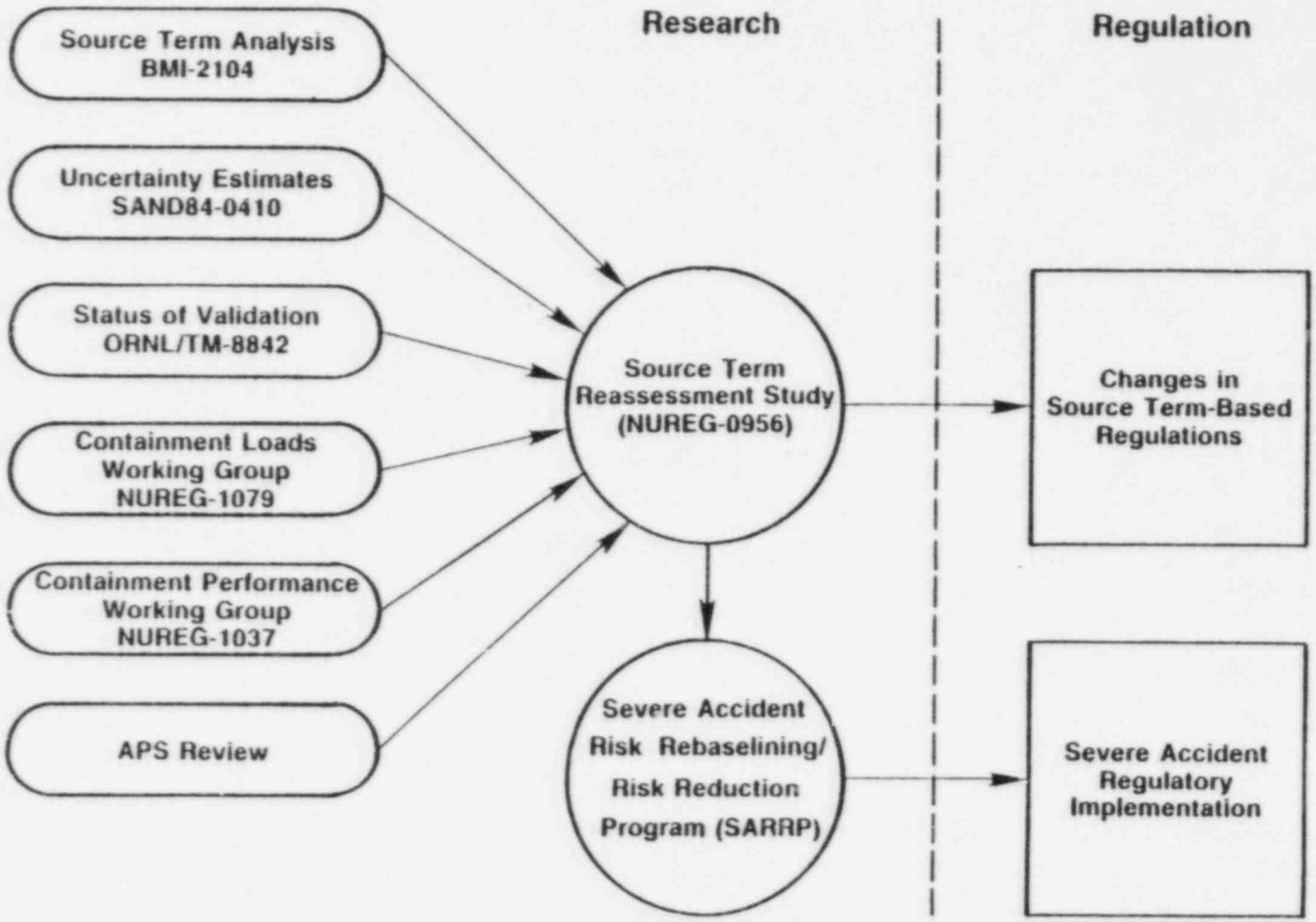
(Typed Name of Reporter) Suzanne B. Young

Ann Riley & Associates, Ltd.

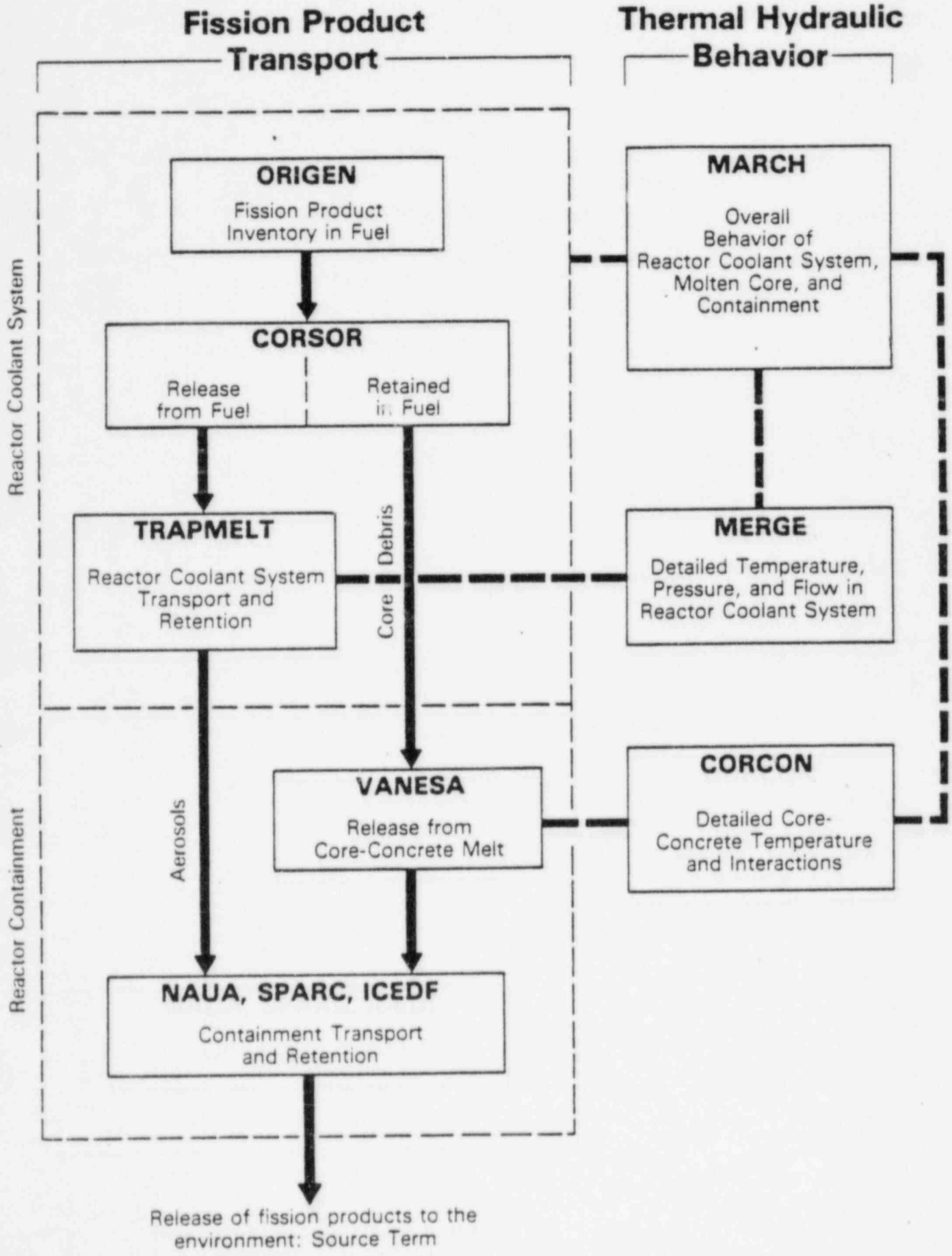
Source Term Reassessment Study

Accident Source Term Program Office

Program Relationships



Source Term Code Suite



Example Core Meltdown Sequence

TMLB′ δ Sequence—Surry Plant

Transient Initiated Sequence

Loss of All Off-Site and On-Site AC Power

Failure to Remove Heat Through the Steam Generators

Accident Event Times

Event	Time, Minutes
Steam Generator Dry	67.5
Core Uncovery	95.5
Start Melt	118.3
Core Slump	146.3
Core Collapse	148.0
Bottom Head Failure	152.8
Containment Failure	152.9
Reactor Cavity Dry	177.2
Start Concrete Attack	254.2

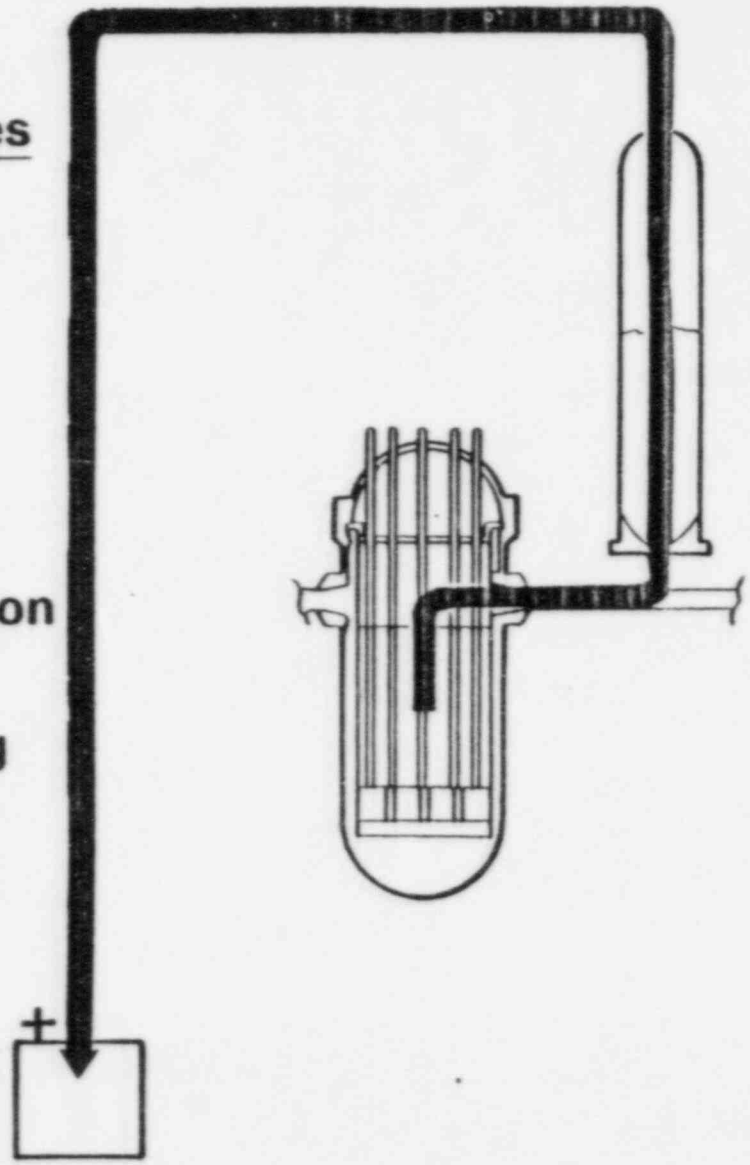
Inventories and Properties of Important Fission Product Species

Species	Inventory (kg)	Melting Point (°C)	Boiling Point (°C)
Xe	260	−112	−107
CsI	25	626	1280
CsOH	133	315	990
Te	25	450	988
SrO	56	2430	3249
La_2O_3	73	2315	>4000

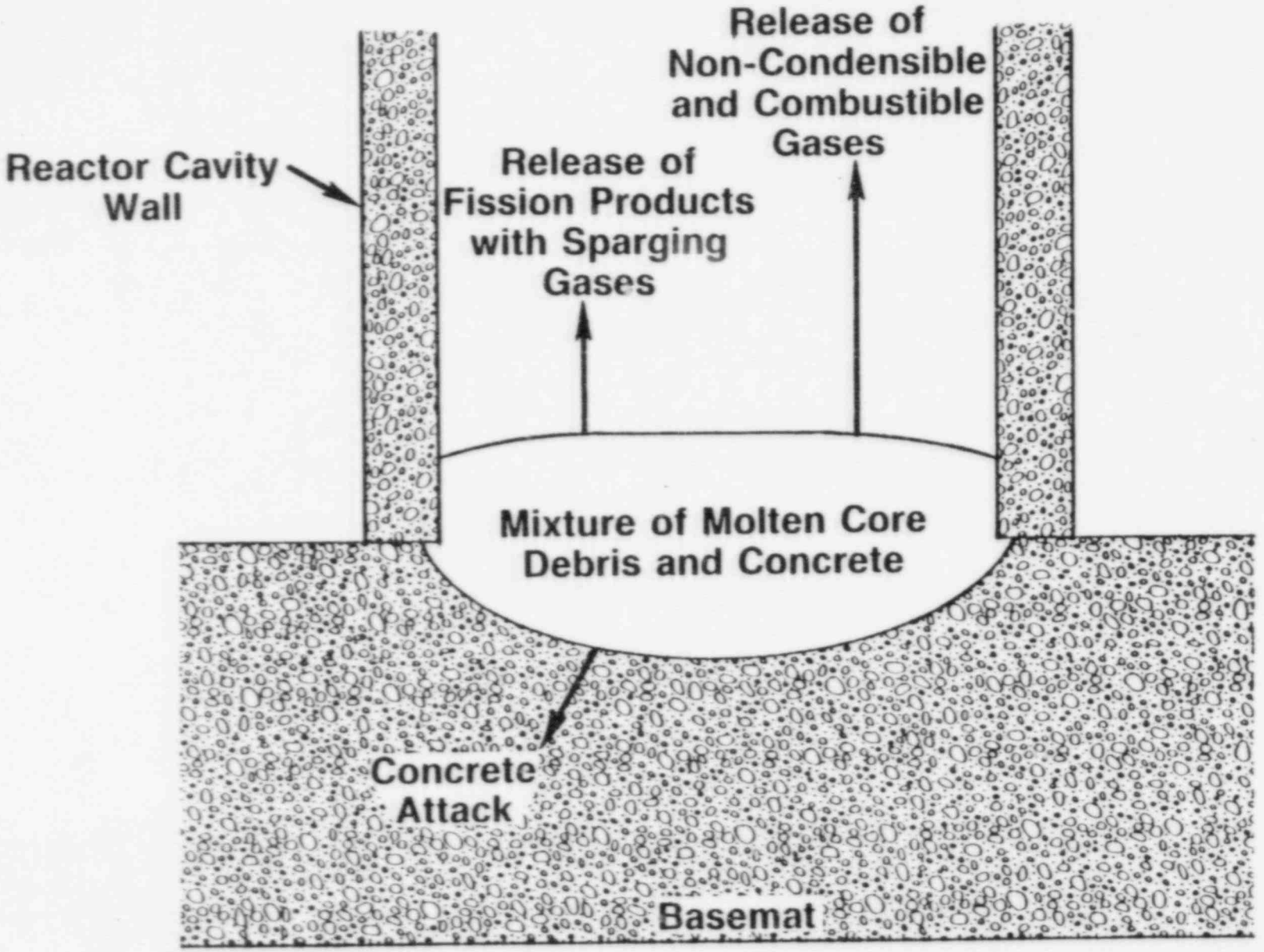
Fission Product Deposition in the RCS

Fission Product Deposition Processes

- Vapor Condensation on Surfaces
- Chemical Reaction with Surfaces
- Aerosol Formation
- Aerosol Agglomeration and Growth
- Gravitational Settling
- Deposition on Walls



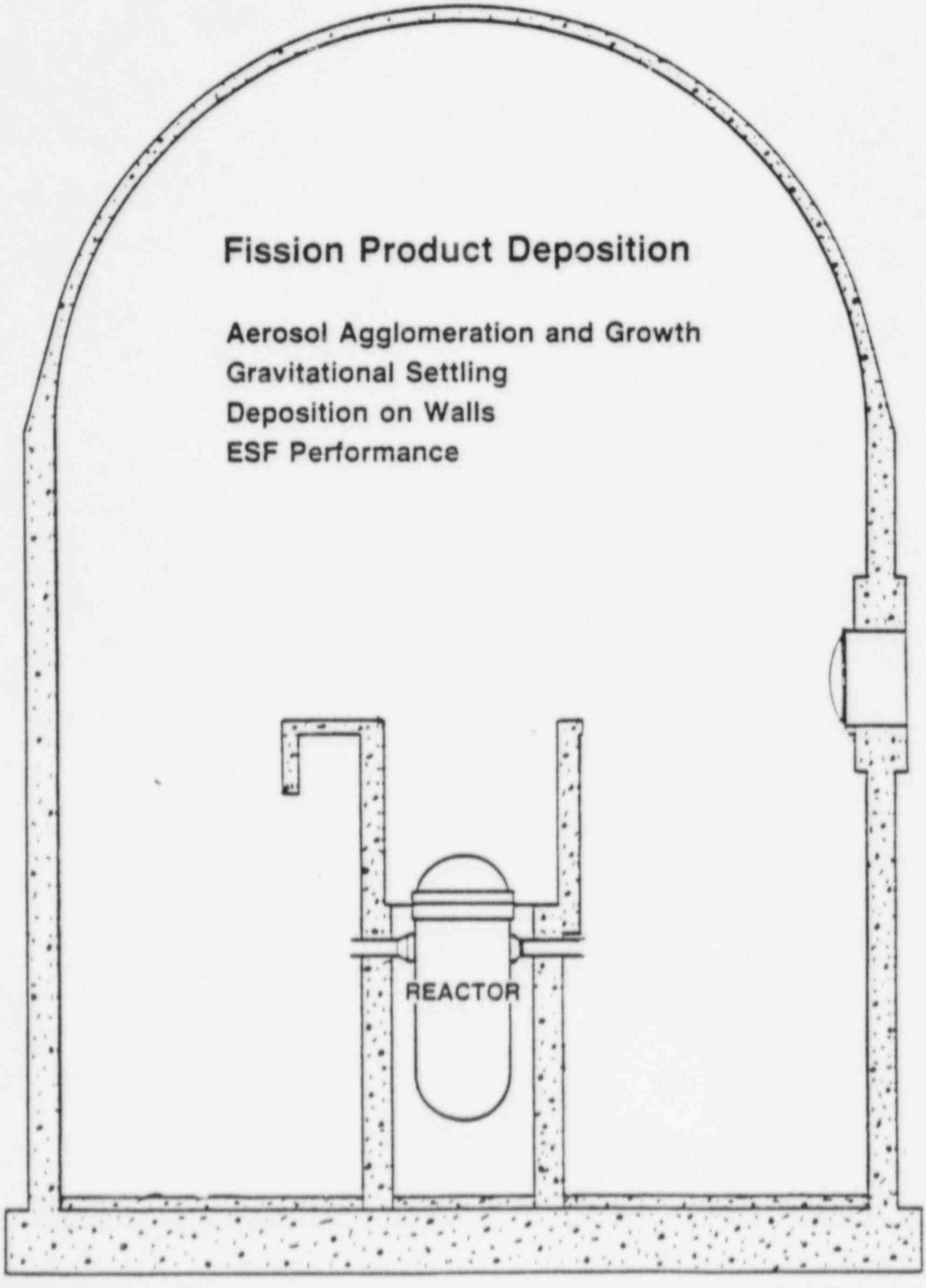
Vaporization Release of Fission Products During Core-Concrete Attack



Containment Deposition Processes

Fission Product Deposition

Aerosol Agglomeration and Growth
Gravitational Settling
Deposition on Walls
ESF Performance



Major Advances in Source Term Technology

- Fission Product Chemistry
- Retention in Reactor Coolant System (RCS)
- Core Melt Progression
- Aerosol Behavior in Containment
- Fission Product Release from Fuel
- Core-Concrete Interactions
- Containment Pressure Loads

Major Areas of Uncertainty

- Natural Circulation in the Vessel
- Core Melt and Hydrogen Generation
- In-Vessel Releases from Fuel
- Retention and Revaporization in RCS
- Core-Concrete Interactions
- Scrubbing by Pools and Ice Compartments
- Containment Pressure Loads
- Containment Failure Modes

Source Term Science

Conclusion 1. The BMI-2104 Suite of Computer Codes Represents a Major Advance and Can Be Used to Replace the Reactor Safety Study Methods.

Conclusion 2. Principal Omissions and Oversimplifications in the Reactor Safety Study Methods Have Been Corrected.

Conclusion 3. Remaining Areas of Uncertainty Have Been Identified and Indicate Areas of Research that Should Be Pursued.

Conclusion 4. The New Analytical Procedures Have Been Extensively Reviewed (Including an APS Review) and Documented.

Conclusion 5. The Analytical Procedure is Complex, and Successful Application Requires a Thorough Understanding of the Problem.

Source Term Insights

Conclusion 6. New Source Terms Have Been Calculated for Selected Accident Sequences, and These Sequences Have Provided a Sufficient Test of the Computer Codes.

Conclusion 7. For Most Accident Sequences, the Largest Single Factor Affecting Source Terms Is Containment Behavior.

Conclusion 8. Source Terms Were Found to Depend Strongly on Plant Design and Construction Details, Thus Making Development of Useful Generic Source Terms Difficult.

Conclusion 9. New Source Terms for Many Accident Sequences Were Found to Be Lower than Those in the Reactor Safety Study, but Some Were Larger. Therefore, Generalizations Are Inappropriate.

Updated Risk Estimates for the Surry Plant Using WASH-1400 Accident Frequencies

Analytical Method	Early Fatalities (per reactor year)	Latent Fatalities (per reactor year)
WASH-1400 Source Terms WASH-1400 Containment Evaluation	4.0×10^{-5}	1.6×10^{-2}
BMI-2104 Source Terms WASH-1400 Containment Evaluation	1.1×10^{-5}	6.7×10^{-3}
BMI-2104 Source Terms Containment Reevaluation	3.1×10^{-6}	3.4×10^{-3}

- Sources of Uncertainty
  - Event Frequencies
  - Source Term Analytical Procedures
  - Containment Behavior
  - Consequence Calculations
- Uncertainties Will Be Taken Into Account in NUREG-1150

Risk Insights

Conclusion 10. A Comparative Risk Appraisal for the Surry Plant Using BMI-2104 Source Terms and a Containment Reevaluation Shows a Reduction in Estimated Risk Compared with the Reactor Safety Study.

Conclusion 11. For the Other Plants, Further Analyses Need to Be Made Before Any Conclusions Can Be Drawn About Changes in Estimated Risk, and Significant Reductions May Not Be Found in all Cases.

Continuing Research

Conclusion 12. Research Programs that Address the Remaining Major Areas of Uncertainty in the Source Term Technology are Currently in Place and Being Pursued by the NRC.

Conclusion 13. A Major Conclusion of the American Physical Society Study Group Confirms the NRC Staff Position that Source Term Research Must Be Continued in Order to Complete the Regulatory Actions Being Considered.

Recommendations

Recommendation 1. The New Source Term Analytical Methods Should Be Used to Reevaluate Regulatory Practices While Additional Confirmatory Research is Being Completed.

Recommendation 2. The Source Term Code Package is the Recommended Tool for NRC Analyses. Additional Insights Can Be Obtained with the NRC's Detailed Mechanistic Codes and Their Experimental Data Bases.

Recommendation 3. The Source Term Code Package Provides Best-Estimate Results (i.e., Without Intentional Bias). Close Coupling Between the Research Effort and the Regulatory Effort Will Be Required in Assessing Uncertainties and Evaluating Technical Issues.

Near-Term Staff Actions on Source Term Science

- Issue NUREG-0956 for Public Comment on Entire Report Including Conclusions and Recommendations.
- Continue Meetings with ACRS on Source Term Science.
- Improve Analytical Models and Reduce Uncertainties Through Further Research.

12/82

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